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MINERALS YEARBOOK

1962

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

UNITED STATES DEPARTMENT OF THE INTERIOR • Stewart L. Udall, Secretary

BUREAU OF MINES • Marling J. Ankeny, Director

Created in 1849, the Department of the Interior—America's Department of Natural Resources—is concerned with the management, conservation, and development of the Nation's water, wildlife, mineral, forest, and park and recreational resources. It also has major responsibilities for Indian and Territorial affairs.

As the Nation's principal conservation agency, the Department works to assure that nonrenewable resources are developed and used wisely, that park and recreational resources are conserved for the future, and that renewable resources make their full contribution to the progress, prosperity, and security of the United States—now and in the future.

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FOREWORD

MINERALS YEARBOOK, 1962, 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 developments.

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

Volume I includes chapters on metal and nonmetal mineral commodities except mineral fuels. In addition, it contains a chapter reviewing these mineral industries, a statistical summary, and chapters on mining and metallurgical technology, employment and injuries, and technologic trends. The former "Minor Metals" and "Minor Nonmetals" chapters have been combined in one chapter on "Minor Metals and Minerals."

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

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

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

MARLING J. ANKENY, *Director.*

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

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

West Virginia: West Virginia Geological and Economic Survey.
Wisconsin: Wisconsin Geological Survey.
Wyoming: The Geological Survey of Wyoming.

Except for the four review chapters, this volume was prepared by the staff of the Division of Minerals. All manuscripts were reviewed to insure statistical consistency among the tables, figures, and text, between this volume and volume III, and between this volume and those for former years, by a staff supervised by Kathleen J. D'Amico, who was assisted by Julia Muscal, Helen L. Gealy, Helen E. Tice, Mary E. Daugherty, Nellie W. Fahrney, Robert E. Anderson, and Joseph Spann.

The assembly and preparation of data for world production tables were supervised by Berenice B. Mitchell, Division of Foreign Activities.

Minerals Yearbook compilations are based largely on facts provided by the mineral industries. Acknowledgment is made of the willing contribution by both 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 Kung-Lee Wang [2]

Contents

FOLLOWING the rapid recovery of previous years, the U.S. economy continued the upward trend and moved forward moderately and sporadically during the first half of 1962. There was a slowdown in the recovery rate, which was especially notable in the third quarter. The economy recovered in the fourth quarter, and by the end of 1962 the gross national product amounted to $555 billion, a new high, 7 percent above that of 1961. Production, employment, personal income, and corporate profits all achieved new peaks, but unemployment continued high and the prospects for improvement remained poor. The economy again failed to use its full potential; 1962 was a good year, but not good enough.

During 1962, all industrial production climbed from the low in January to a high in late summer which lasted through the fall, and declined slightly at yearend. Mining production followed this pattern closely and most sectors were approaching record highs. Most minerals gained in value and volume of production. The steel-associated minerals group was the only exception, and it sustained a small net loss. The nonfuel minerals industry opened the year at a high level, maintained this high level until late summer, with the peak in May, and drifted downward toward the end of the year. The gains recorded by nonferrous metal mining partly offset the loss of ferrous metal mining, resulting in a small gain for metal mining as a whole. The upsurge of construction material minerals output was primarily responsible for the substantial increase in production of nonmetals other

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

than fuel minerals. Despite a drop in anthracite output, the output of solid fuels was the highest since 1957. Together with significant gains made in petroleum and natural gas, mineral fuels recorded notable increases above previous years.

Net supply of minerals, metals, and fuels generally increased, and imports and exports also gained slightly. Consumption of all minerals and related products generally rose over 1961, except for a small decline in steel-associated minerals and products. Consumption of nonferrous metals and chemical minerals increased the most, whereas construction material minerals made only moderate gains.

Overall physical stocks increased to a limited degree. The changes in stocks were affected principally by iron ore and other ferrous minerals, whereas sulfur was mainly responsible for stock changes in 1961. Prices were mixed, but somewhat weak. Ferrous metal prices declined moderately; nonferrous metal prices were mixed; construction material prices were steady; and prices of major chemical minerals were strong, with some significant gains.

Costs of machinery and material used in mining were steady, but mixed with little changes in prices compared with 1961. Cost of fuel and electric energy declined a little, whereas cost of labor, adjusted for productivity, rose slightly.

Mining labor productivity continued the gradual upward trend. Total employment in the mineral industries continued the gradual downward trend from the 1960 peak, and reached a new low by the end of the year. Average annual earnings for all employees continued to increase gradually, and total wages and salaries earned in the mineral industries made modest gains. Total employment and earnings in mining again lagged behind that of all industries.

Income generated by all mining industries declined again. This was contrary to the increasing trend of the national economy, and their percentage shares of all industries decreased further. Income from metal mining dropped significantly, whereas nonmetallic minerals income decreased moderately. Similar situations existed in the average annual profit ratio for nonfuel minerals industries.

Expenditures for new plant and equipment in the mining industry (including fuels) reversed the 1961 performance, increased significantly, and was better than all manufacturing. The value of U.S. investment in foreign mining and smelting industries increased slightly but lagged behind all industries. U.S. mining companies abroad again relied principally on internally generated funds abroad to finance capital investments and foreign operation. Direct foreign investments by U.S. (nonfuel) mining and smelting companies were expected to be much higher than in 1961.

On July 11, the U.S. Treasury Department announced a fundamental change in the basis of accelerated depreciation for Federal income tax purposes and enabled the mineral resources industries to claim an additional $635 million of corporate depreciation allowances in 1962.

The Revenue Act of 1962 granted a tax credit for investment in depreciable machinery and equipment used in the United States. In 1962, the mineral resources industries received approximately $146 million of investment credit which reduced the income by a similar amount.

Research and development in the mining industry, as a whole, gained moderately, but expenditures continued to be insignificant by comparison with those of other industries. However, the Bureau of Mines made a notable contribution, and as in previous years, the bulk of its funds for mining research and development were expended on applied research.

Activity under the Defense Mobilization Program increased substantially in 1962. The Defense Production Act was extended for 2 years until June 1964. National Strategic Stockpile data were declassified, and a new policy for disposing of excess Government stockpile was announced. Stockpile objectives were reviewed and revised downward. A lead and zinc mining stabilization program went into effect. The barter program was reviewed and revised to include new and broader national objectives, principally foreign policy and balance of payments considerations.

The U.S. Tariff Commission rejected the injury claims of the cement industry against imports from the Dominican Republic. The commission released detailed investigation reports on the fluorspar, mercury, lead and zinc, cobalt, beryllium, and manganese industries. It recommended no change in lead and zinc import quotas.

The total value of U.S. foreign trade of nonfuel minerals and products declined 11 percent from that of 1961. Imports gained moderately, but exports suffered a significant drop of 31 percent from 1961. The sharp reduction of exports of ferrous and nonferrous scrap and, to a lesser extent, of molybdenum were responsible for the notable decline. The Trade Expansion Act of 1962 was enacted and many minerals products were to be negotiable items under this Act.

World mineral industries had generally improved since 1961. Again world production of minerals gained moderately, whereas that of the United States rose more. The United States continued to be the world's leading consumer and an important producer of most minerals and products. Consumption increased at a slower rate worldwide than in the United States. World mineral trade increased slightly. Iron ore gained, whereas nonferrous ores and metals declined. World stocks declined significantly, while those of the United States decreased slightly. World prices declined slightly more than those of the United States.

DOMESTIC PRODUCTION

Value of Mineral Production in Current Dollars.—The value of all mineral production (metals, nonmetals, and fuels) in current dollars continued the upward trend that began in 1959, with another notable gain of 3 percent over that of 1961, and achieved another record high in U.S. mineral history. The increases of fuels and nonmetals were also responsible for this gain.

Despite a slight drop in anthracite output, mineral fuels increased 3 percent over the 1961 output. Hydrocarbon fuels accounted for the major part of the increase, and bituminous coal and lignite contributed the remainder.

Nonfuel minerals value increased 4 percent compared with 1961 and registered another record high. Again they furnished 32 percent of the total value of mineral production. Nonmetals continued to strengthen their position with a 6-percent gain over that of 1961. Most construction and chemical materials made substantial gains in output and counteracted the 5-percent decline in the production of all forms of sulfur. A small gain was registered in the metal segment of the industry for nonferrous minerals, and molybdenum generally increased; however, ferrous metals remained stagnant or declined slightly.

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

(Million dollars)

Mineral groups [2]	1953-57 (average)	1958	1959	1960	1961	1962	Change in 1962 from 1961 (percent)
Metals and nonmetals except fuels:							
Nonmetals	2,987	3,466	3,861	3,868	3,946	4,118	+4.4
Metals	1,976	1,594	1,570	2,022	1,927	1,937	+.1
Total	4,963	5,060	5,431	5,890	5,873	6,055	+3.1
Minerals fuels	11,081	11,589	11,950	12,142	12,357	12,779	+3.4
Grand total	16,044	16,649	17,381	18,032	18,230	18,834	+3.3

[1] Beginning with 1953 Alaska and Hawaii are included.
[2] For details see table 2 in the chapter "Statistical Summary of Mineral Production" of the 1962 Minerals Yearbook.

Value of Mineral Production in Constant Dollars.—A new table of value of mineral production in U.S. constant dollars (1954=100) is presented. The implicit price deflators for gross national product, published by U.S. Department of Commerce, Office of Business Economics, were used to compile this table.

The value of metallic minerals production in 1954 prices showed an upward trend from World War II, reached a peak in 1956, dropped sharply in 1958–59, recovered in 1960, and has declined since. Value of metal output in 1962 continued downward and decreased nearly 1 percent from that of 1961.

The value of nonmetallic minerals in constant dollars has risen since the end of World War II and reached an alltime high in 1962, nearly 5 percent above that of 1961. During these 16 years, it had increased 116 percent from $1,612 million in 1947 to $3,484 million in 1962.

The total value of nonfuel minerals recovered from the post-war recession by 1950, continued upward gradually to a post-war peak in 1956, slumped during the 1957–58 recession, recovered strongly in 1960, and gained 3 percent in 1962 over previous years to account for 32 percent of the total value of all minerals. Nonfuel minerals increased their share of the total value of all minerals from 25 percent in 1947 to from 31 to 32 percent in the early 1960's. The mineral fuels registered sporadic gains from 1947 to 1957 when a peak was reached. Since 1957, the value has remained relatively static at a lower level. The value of 1962 output was 2 percent higher than that of 1961.

The total value of all minerals in 1954 constant dollars closely followed the U.S. economy. It reached an alltime high in 1957, dropped during the 1958 recession, and then began a gradual rise through 1962. All minerals gained 2 percent in 1962 over the value for 1961.

TABLE 2.—Value of mineral production in the United States [1] by mineral groups, in 1954 prices [2] [3]

(Million dollars, 1954 prices)

Year	Gross national product implicit price deflator [3]	Nonmetals (except fuels)	Metals	Nonfuel total	Mineral fuels	Total minerals
1947	83.0	1,612	1,306	2,918	8,660	11,578
1948	88.5	1,754	1,377	3,131	10,737	13,868
1949	88.2	1,768	1,248	3,016	8,980	11,996
1950	89.5	2,036	1,509	3,545	9,709	13,254
1951	96.2	2,161	1,737	3,898	10,165	14,063
1952	98.1	2,205	1,648	3,853	9,802	13,655
1953	99.0	2,374	1,829	4,203	10,361	14,564
1954	100.0	[3] 2,630	1,518	4,148	9,919	14,067
1955	101.2	[3] 2,922	2,031	4,953	10,652	15,605
1956	104.6	[3] 3,122	2,254	5,376	11,225	16,601
1957	108.4	[3] 3,014	1,971	4,985	11,724	16,709
1958	110.8	[3] 3,020	1,439	4,459	10,459	14,918
1959	112.6	[3] 3,305	1,394	4,699	10,613	15,312
1960	114.2	[3] 3,268	1,771	5,039	10,632	15,671
1961	115.7	[3] 3,324	1,666	4,990	10,681	15,671
1962	116.9	[3] 3,484	1,652	5,136	10,885	16,021

[1] Excludes Alaska and Hawaii, 1947–53.
[2] Value in current prices divided by the implicit price deflator for gross national product. Council of Economic Advisers. Economic Report of the President. January 1963, p. 178; U.S. Department of Commerce, Office of Business Economics. Survey of Current Business. V. 43, No. 7, July 1963, p. 37.
[3] Total adjusted to eliminate duplicating value of raw materials used in manufacturing cement and/or lime.

Volume of Mineral Production.—The Bureau of Mines index of physical volume of mineral production increased 3 points in 1962, a 3-percent increase, and achieved a new record high in U.S. mineral history. The metals index rose 3 points, a 3-percent gain over that of 1961. Ferrous metals suffered the only decline in the index with a drop of 2.5 points, or a loss of nearly 3 percent. Manganese and molybdenum were responsible for the loss. Nonferrous metals gained 6 points, a 6-percent increase. Other nonferrous metals gained nearly 30 points, about a 31-percent rise, which was attributed entirely to the remarkable improvement in magnesium production. All base metals except lead contributed to the 4-percent increase over that of previous years. Nonmetals gained 6 points, a 5-percent rise. Construction materials increased 8 points, a 7-percent rise, and was principally responsible for the gain of all nonmetals, whereas chemical mineral material and other nonmetals made only nominal increases. The fuels index rose nearly 3 percent over that of 1961 and helped the all-minerals index achieve a high.

The Federal Reserve Board (FRB) mining indexes (tables 3 and 4) showed a similar trend. Weight differences between these indexes and the Bureau of Mines index, as well as some differences in coverage and base years, can result in relative movement between the indexes. However, the revised FRB indexes followed the revised Bureau of Mines all-minerals index closely except for slight differences in metal mining and nonmetallic mining.

The major advantage of the Bureau index is that it is available on a comparable basis since 1880. However, FRB indexes are available monthly on a seasonally adjusted basis and include mineral manufacturing industries which the Bureau index does not cover.

The FRB index of mineral manufacturers showed that the iron and steel industry gained 4 percent over 1961; nonferrous metals industries, 11 percent; stone, clay, and glass products, 4 percent; and total industrial production, 8 percent. Industrial production registered a new alltime high.

TABLE 3.—Indexes of the physical volume of mineral production in the United States, by groups and subgroups[1]

(1957-59=100)

Year	All minerals	Metals						Nonmetals				Fuels
		Total	Ferrous	Nonferrous				Total	Construction	Chemical	Other	
				Total	Base	Monetary	Other					
1953	93.5	122.4	145.8	107.6	103.4	112.8	137.3	74.7	69.1	89.1	98.0	94.6
1954	89.6	100.3	104.5	97.6	93.5	107.4	119.0	80.9	76.6	93.9	89.2	90.5
1955	98.9	118.2	134.4	107.9	107.2	109.3	112.5	89.0	85.5	97.5	105.5	99.0
1956	104.5	120.4	127.6	115.7	116.5	108.9	120.0	95.4	90.5	109.0	112.4	104.8
1957	104.8	122.1	133.7	114.7	114.1	106.7	133.4	97.1	95.2	102.3	103.7	104.6
1958	95.9	93.3	86.8	97.6	98.6	100.8	84.0	97.4	98.4	95.1	92.4	95.9
1959	99.4	84.5	79.6	87.6	87.3	92.6	82.7	105.4	106.4	102.5	103.8	99.6
1960	102.1	107.5	114.2	103.2	105.5	94.9	96.6	108.0	108.2	108.5	103.1	100.3
1961	102.9	103.3	94.6	[2]108.8	113.4	93.7	91.5	[2]110.3	[2]110.6	112.0	[2]96.8	101.2
1962	106.2	106.1	92.1	115.0	117.8	95.3	120.3	116.3	117.9	113.9	97.1	104.1

[1] For description of index see Bureau of Mines Minerals Yearbook 1956. V. 1, 1958, pp. 2-5.
[2] Revised figure.

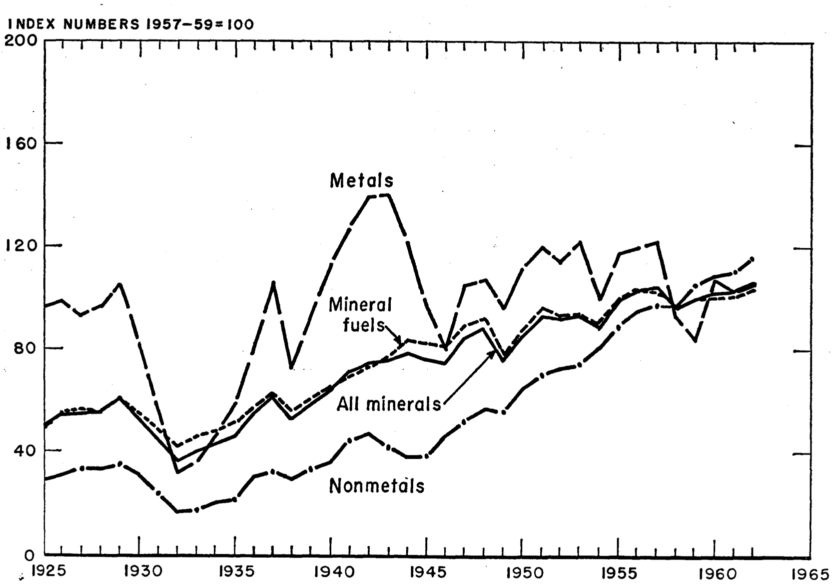

FIGURE 1.—Indexes of physical volume of mineral production in the United States 1925-62, by groups.

TABLE 4.—Indexes of production of mining, primary metals, clay, glass, and stone products, and total industrial production [1]

(1957–59=100) [2]

Year	Mining	Coal, oil, and gas	Metal, stone, and earth minerals	Metal mining	Stone and earth minerals	Primary metals	Iron and steel	Nonferrous metals and products	Clay, glass, and stone products	Total industrial production
1947	79.9	82.5	66.5	84.8	53.9	90.7	93.9	78.1	67.0	65.7
1948	84.0	86.6	70.4	87.5	58.6	94.3	98.2	79.8	71.3	68.4
1949	74.5	76.1	65.6	78.6	56.7	79.4	83.8	64.0	66.5	64.7
1950	83.2	84.5	75.3	90.6	64.8	99.9	103.3	86.2	80.5	74.9
1951	91.3	93.0	81.6	97.4	70.8	108.7	115.5	85.7	88.9	81.3
1952	90.5	92.3	80.4	89.9	73.9	99.3	101.7	88.2	85.0	84.3
1953	92.9	94.3	86.2	100.0	75.9	112.5	117.1	95.8	87.1	91.3
1954	90.2	91.7	82.9	81.9	83.6	91.3	91.9	88.9	83.8	85.8
1955	99.2	99.8	96.4	103.8	90.9	118.4	121.4	107.6	95.6	96.6
1956	104.8	105.1	103.0	109.4	98.2	116.4	118.5	108.5	100.1	99.9
1957	104.6	104.5	105.4	115.5	97.9	112.2	114.8	102.6	98.4	100.7
1958	95.6	95.6	95.9	95.3	96.4	87.5	86.5	90.9	93.2	93.7
1959	99.7	99.9	98.7	89.1	105.8	100.4	98.7	106.6	108.4	105.6
1960	101.6	99.7	110.7	111.8	109.8	101.3	100.9	102.8	107.8	108.7
1961	102.6	100.9	110.5	111.9	109.4	98.9	96.5	107.5	106.3	109.8
1962	105.0	103.8	110.9	112.6	[3] 109.7	104.6	100.6	119.1	111.1	118.3

[1] Federal Reserve board. Industrial Production 1957–59 Base and Federal Reserve Bulletin, May 1963, p. 694.
[2] Index rebased from 1957=100 to 1957–1959=100.
[3] Preliminary figure.

The monthly indexes for all mining made modest and gradual gains in the first 4 months, fell in May, recovered and rose to a higher plateau during the next 5 months, and slumped to a new low at yearend with the 1962 average gain only 2 percent over 1961 figures. Nonfuel mining increased during 1962 until May when it declined gradually to a low for the year in December, so that the year ended with an insignificant gain of 0.3 percent over 1961. Metal mining began very strong in 1962, reached a peak in February, gradually declined to a low in October, recovered at yearend, and made only a small gain for the year. Stone and earth mineral mining started the year with a low, increased to a peak during late summer, declined to another low by the end of the year, and resulted in no change of the annual average from 1961.

NET SUPPLY

Net Supply.—Generally, the net supply[3] of minerals and metals increased. Manganese, nickel, lead, tin, platinum metals, titanium—ilmenite, uranium, and gypsum were notable exceptions. The increases were attributed to general improvement of domestic production and imports. Of the 36 commodities included in the net-supply tabulation, 27 increased and 9 decreased. The net-supply analysis clearly indicated that 1962 was relatively a good year. The small increase of exports made the year more favorable.

Source of Supply.—Imports continued to be an important source of new supply, most noticeably in the metal group. Of the commodities shown in table 5, the import contribution of 19 increased, 8 decreased, and 9 showed no change.

[3] Summary of primary shipments, secondary production, and imports, minus exports.

TABLE 5.—Monthly indexes of production, mining, nonfuel mining, metal mining, stone, and earth minerals, seasonally adjusted

(1957–59=100) [1]

Month	Mining [2]			Nonfuel mining [3]			Metal mining			Stone and earth minerals		
	1961	1962	Change from 1961 (percent)	1961	1962	Change from 1961 (percent)	1961	1962	Change from 1961 (percent)	1961	1962	Change from 1961 (percent)
January	102.2	103.8	+1.6	117.0	108.2	−7.5	125.9	115.9	−7.9	110.4	102.4	−7.2
February	101.6	104.2	+2.6	114.6	111.4	−.3	124.2	118.2	−4.8	107.6	106.4	−1.1
March	101.4	104.8	+3.4	114.4	113.3	−1.0	122.4	120.0	−2.0	108.6	108.3	−.3
April	101.7	105.4	+3.6	106.6	115.3	+8.2	106.0	124.4	+17.4	107.1	108.5	+1.3
May	101.5	105.1	+3.5	105.8	116.7	+10.3	99.9	126.2	+26.3	110.2	109.7	−.5
June	101.9	105.2	+3.2	108.0	114.4	+5.9	102.6	119.4	+16.4	112.0	110.7	−1.2
July	102.2	106.5	+4.2	108.7	113.9	+4.8	103.9	118.3	+13.9	112.2	110.6	−1.4
August	102.7	105.4	+2.6	107.6	111.3	+3.4	103.6	110.7	+6.9	110.6	111.7	+1.0
September	102.4	105.7	+3.2	110.4	107.8	−2.4	108.5	101.1	−6.8	111.8	112.7	+.8
October	104.4	105.2	+.8	113.1	105.9	−6.4	115.5	96.8	−16.2	111.3	112.6	+1.2
November	105.2	105.7	+.5	113.9	106.8	−6.2	122.4	99.1	−19.0	107.7	112.5	+4.5
December	104.7	103.2	−1.4	111.9	105.1	−6.1	125.0	104.1	−16.7	102.2	105.8	+3.5
Annual average	102.6	105.0	+2.3	110.5	110.9	+.4	111.9	112.6	+.6	109.4	[4] 109.7	+.3

[1] Rebased from 1957=100 to 1957–59=100.
[2] Including fuels.
[3] Metals, stone, and earth minerals.
[4] Preliminary figure.

Source: Federal Reserve Board. Industrial Production 1957–59 Base and Federal Reserve Bulletin. Industrial Production Indexes. January 1963, May 1963, p. 697.

Source of Imports.—Our traditional best suppliers, Cananda and Mexico, expanded their share of the U.S. nonfuel mineral imports for 12 principal commodities, lost in 6, and maintained their position in 6. The East and South Pacific areas increased their share of the market slightly, and Western Hemisphere sources maintained their share of the market. Other free world sources decreased their shares by losing in 16 principal commodities, gaining in 6, and maintaining their position in 1. The Soviet bloc slightly improved its supply of chromite, but its supply of platinum declined appreciably. Significant shifts in sources of imports occurred in iron, manganese, nickel, tungsten, copper, platinum-group metals, crude barite, and potash.

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TABLE 6.—Net supply of principal minerals in the United States and components of gross supply [1]

(Thousand short tons unless otherwise stated)

Commodity	Net supply			Components as a percent of gross supply (gross supply=100)						Exports as a percent of gross supply	
	1961	1962	Change from 1961 (percent)	Primary shipments [2]		Secondary production [3]		Imports [4]			
				1961	1962	1961	1962	1961	1962	1961	1962
Ferrous ores, scrap, and metals:											
Iron (equivalent) [5]	[7] 90,064	93,762	+4	51	47	[6] 29	[6] 28	20	25	4	5
Manganese (content)	1,023	991	−3	4	5	--------	--------	[8] 96	[8] 95	1	1
Chromite (Cr_2O_3 content)	590	612	+4	5	--------	--------	--------	95	100	1	(9)
Cobalt (content) thousand pounds	[10] 10,673	[10] 12,640	+18	(11)	(11)	[12] 2	[12] 2	98	98	(9)	(9)
Molybdenum (content) do	33,436	34,762	+4	100	100	--------	--------	(9)	(9)	52	31
Nickel (content)	146	142	−3	9	9	4	4	87	87	(13)	(13)
Tungsten ore and concentrate (W content) short tons	4,917	6,447	+31	76	61	--------	--------	[8] 24	[8] 39	5	1
Other metallic ores, scrap, and metals:											
Copper (content)	[7] 1,602	1,783	+11	57	58	20	20	[8] 23	[8] 22	22	16
Lead (content)	[7] 1,113	1,079	−3	23	22	40	41	[8] 37	[8] 37	1	(9)
Zinc (recoverable content)	941	1,064	+13	46	46	6	5	[8] 48	[8] 49	6	4
Aluminum (equivalent) [14]	2,515	2,711	+8	[15] 10	[15] 9	4	4	[16] 86	[16] 87	[16] 8	[16] 8
Tin (content) long tons	[7] 60,052	58,104	−3	(9)	(8)	19	20	81	80	1	1
Antimony (recoverable content) [17] short tons	[7] 34,503	37,073	+7	5	5	56	52	[8] 39	[8] 43	(9)	(9)
Beryl ore (BeO content) do	998	990	−1	[7] 3	2	[7] 3	3	94	95	1	(9)
Cadmium (content) [18] do	[7] 5,196	5,520	+6	37	40	(19)	(19)	[8] 63	[8] 60	6	6
Magnesium (content)	[7] 43,715	74,498	+70	[20] 82	[20] 85	16	12	2	3	12	8
Mercury 76-pound flasks	[7] 52,063	63,515	+22	60	41	16	9	[8] 24	[8] 50	1	(9)
Platinum-group metals thousand troy ounces	951	821	−14	4	3	[21] 8	[21] 15	87	82	6	7
Titanium concentrate:											
Ilmenite and slag (TiO_2 content)	[7] 547	531	−3	[7] 75	79	--------	--------	[7] 25	21	--------	--------
Rutile (TiO_2 content)	32	40	+25	22	18	--------	--------	78	82	4	3
Uranium concentrate (U_3O_8 content) short tons	30,314	28,688	−5	57	59	--------	--------	42	41	--------	--------
Nonmetals:											
Asbestos	666	726	+9	8	7	--------	--------	92	93	[22] 1	(9)
Barite, crude	1,407	1,597	+14	57	54	--------	--------	43	46	--------	--------
Boron minerals and compounds, finished products (gross weight)	333	354	+6	100	100	--------	--------	(9)	(9)	45	45
Bromine and bromine in compounds million pounds	170	189	+11	100	100	--------	--------	(9)	(9)	6	2

Clays	46,986	47,312	+1	100	100	----------	----------	(9)	(9)	1	1
Flourspar, finished	[7] 714	837	+17	28	25	----------	----------	72	75	(9)	(9)
Gypsum, crude	14,197	12,661	−11	65	57	----------	----------	35	43	(9)	(9)
Mica (except scrap) thousand pounds	[7] 8,382	11,498	+37	[7] 6	3	----------	----------	[7] 94	97	4	4
Phosphate rock (P_2O_5 content) thousand long tons	5,179	5,552	+7	99	99	----------	----------	1	1	7	7
Potash (K_2O equivalent)	[7] 2,276	2,556	+12	90	89	----------	----------	10	11	17	17
Salt (common)	26,115	29,516	+13	96	95	----------	----------	4	5	2	2
Sulfur, all forms (content) [23] thousand long tons	[7] 5,710	5,951	+4	[7] 89	88	----------	----------	[7] 11	12	[7] 22	21
Talc and allied minerals	705	756	+7	96	97	----------	----------	4	3	6	6
Crushed and broken stone	613,000	629,000	+3	100	100	----------	----------	(9)	(9)	(9)	(9)
Sand and gravel	752,000	769,000	+2	100	100	----------	----------	(9)	(9)	(9)	(9)

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

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

[3] From old scrap only.

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

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

[6] 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] Sum of secondary production and imports only.

[11] Figure withheld to avoid disclosing individual company confidential data. Figure is not included in net and gross supply.

[12] Consumption of purchased scrap.

[13] Mostly manufactured products and scrap, therefore, impossible to determine net content of nickel.

[14] Includes 88 percent of bauxite mine production (rather than shipments) and imports, and 92 percent of alumina import, both converted to estimated aluminum equivalent (3.973 long tons bauxite and 1.901 short tons of alumina to 1 short ton aluminum) in 1961; 87 and 92 percent in 1960 (3.836 and 1.897 conversion factors). These percentages are based on estimated proportions used in producing the metal. To avoid a duplicate adjustment for nonmetallic use, exports of bauxite to Canada were excluded from exports.

[15] Mine production of bauxite.

[16] Includes ingot equivalent (weight × 0.9) of imports of scrap, largely scrap pig. Some duplication occurs because of small quantity of loose scrap imported, which is also reflected in secondary production. See also footnote 15.

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

[18] Primary shipments are estimated as a percentage of total primary production of metal, decreasing with increasing imports of lead and zinc; imports are represented by sum of remaining percentage of such production plus imports of metal. In 1961 the ratio was 41:59; in 1960, 45:55. Primary compounds not made from metal, data for which cannot be disclosed, are excluded for both years. Secondary includes recovery from both old and new scrap. Secondary data cannot be disclosed and are included with primary.

[19] Secondary statistics are included in the primary statistics to avoid disclosing company confidential data.

[20] Primary production of metal.

[21] Recovery from both old and new scrap.

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

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

TABLE 7.—Percentage distribution of imports of principal minerals consumed in the United States, by country of origin [1]

Commodity	Canada and Mexico		East and South Pacific [2]		Other Western Hemisphere		Other free world		Soviet bloc [3]	
	1961	1962	1961	1962	1961	1962	1961	1962	1961	1962
Ferrous ores, scrap, and metals:										
Iron (equivalent) [4]	37	49	15	13	44	35	4	3	(5)	(5)
Manganese (content)	7	6	1	1	32	43	60	50		
Chromite (Cr_2O_3 content)					(5)		98	97	2	3
Cobalt (content)	8	3	(5)				92	97		
Nickel (content)	89	92					11	8		
Tungsten ore and concentrate (W content)	1	9	16	30		1	83	60		
Other metallic ores, scrap, and metals:										
Copper (content)	22	26	67	70	(5)		11	4		
Lead (content)	42	40	37	34	3	3	18	23		
Zinc (recoverable content)	69	64	17	18	2	8	12	10		
Aluminum (equivalent) [6]	[9] 4	7			85	84	11	9		
Tin (content)	(5)		4	4	(5)		96	96		
Antimony (recoverable content) [7]	26	27	7	9	1		66	64		
Beryl ore (BeO content)			4	3	44	55	52	42		
Cadmium (content) [8]	57	89	8	5			35	6		
Mercury	25	25	1		(5)		74	75		
Platinum-group metals	18	47	(5)		3	2	53	39	26	11
Titanium concentrates: Rutile, ilmenite, and slag (TiO_2 content)	56	57	25	42			19	1		
Uranium (U_3O_8 content)	68	61	(10)	2			32	37		
Nonmetals:										
Asbestos	93	93	(5)	1			7	6		
Barite, crude	46	63	18	14	3	2		21		
Fluorspar, finished	69	75					31	25		
Gypsum, crude	90	86			10	14				
Mica (except scrap)	(5)		(5)		16	14	84	86		
Potash (K_2O equivalent)		13	1	1			96	84	3	2
Sulfur (content)	100	100								

[1] Data are based on imports for consumption and are classified as net new supply shown in table 5. U.S. Department of Commerce, Bureau of Census. U.S. Imports of Merchandise for Consumption—Commodity by Country of Origin 1961. Rept. Ft 110, May 1962 and 1963. Imports that are less than 5 percent of net new supply are omitted.

[2] West coast of South America (Salvador, Chile, 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, North Korea, and North Viet Nam.

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

[5] Less than 0.5 percent.

[6] See footnotes 15 and 17, table 6.

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

[8] Metal and flue dust only.

[9] Revised figure.

[10] Imports from Australia were included in other free world imports.

CONSUMPTION

Patterns.—Domestic consumption of minerals generally gained over the 1961 figures. Declines were marked in only four commodities as shown in tables 7 and 8. The rest of the commodities rose, but seven gained insignificantly (less than a 2.5-percent increase). The steel-associated minerals except cobalt, molybdenum, and tungsten, remained unchanged with some losses. This was caused by stagnant domestic iron and steel production which remained virtually the same as in 1961. Consumption of nonferrous metals and minerals increased notably. Bauxite rose 23 percent; aluminum, cadmium, and mercury, 17 percent; slab zinc, 11 percent; refined copper, 9 percent; and refined lead, 8 percent. Consumption of nonmetallic minerals improved. Excellent gains were recorded for fertilizer and chemical minerals. Salt rose 13 percent, potash 12 percent, phosphate rock 9 percent, bromine 7 percent, and sulfur and boron minerals 6 percent. Nonmetallic minerals used in construction generally gained over 1961. Cement rose 4 percent, clays 1 percent, gypsum 9 percent, crushed stone 7 percent, sand and gravel 3 percent.

Estimated 1975 Consumption.[4]—The Bureau of Mines estimated U.S. consumption of major mineral products for 1975. These estimates reflected a growing demand based on population and labor force increases, changing technology and innovation, rising gross national product, projection of construction activity, and other

TABLE 8.—Reported consumption of principal metals and minerals in the United States

Commodity	1961	1962	Change from 1961 (percent)
Antimony [1] ... short tons	12,697	15,452	+21.7
Barite, crude ... thousand short tons	1,391	1,210	−13.0
Bauxite ... thousand long tons, dried equivalent	8,621	10,577	+22.7
Beryl [2] ... short tons	9,392	7,758	−17.4
Chromite ... thousand short tons, gross weight	1,200	1,131	−5.8
Cobalt ... thousand pounds	9,596	11,268	+17.4
Copper, refined ... thousand short tons	1,463	1,600	+9.4
Fluorspar, finished ... do	[3] 688	653	−5.1
Iron ore ... thousand long tons, gross weight	99,254	99,562	+.3
Lead ... thousand short tons	1,027	1,110	+8.1
Magnesium, primary ... short tons	45,533	45,951	+.9
Manganese ore ... thousand short tons, gross weight	1,718	1,873	+9.0
Mercury ... 76-pound flasks	55,763	65,301	+17.1
Mica splittings ... thousand pounds	5,514	6,728	+21.9
Molybdenum, primary products [4] ... thousand pounds, Mo content	32,621	35,674	+9.4
Nickel, exclusive of scrap ... short tons	118,515	118,677	+.1
Platinum-group metals (sales to consumers) ... thousand troy ounces	823	866	+5.2
Silver [5] ... million troy ounces	161.4	187.7	+16.2
Tin ... long tons	78,250	79,085	+1.1
Titanium concentrate:			
Ilmenite and slag ... thousand short tons, estimated TiO_2 content	590	600	+1.6
Rutile ... do	28	30	+7.1
Tungsten concentrate ... thousand pounds of contained tungsten	11,128	13,691	+23.0
Zinc, slab ... thousand short tons	931	1,032	+10.8

[1] Includes primary content of antimonial lead produced at primary lead smelters and antimony content of alloys imported.
[2] Beryl ore of 10–12 percent BeO content.
[3] Revised figure.
[4] Comprises ferromolybdenum, molybdic oxide, and molybdenum salts and metal.
[5] Total consumption for coinage, industry, and the arts.

[4] Bureau of Mines. Mineral Facts and Problems, Outlook Section Bull. 585.

TABLE 9.—Apparent consumption of metals and minerals in the United States [1]

Commodity	1961	1962	Change from 1961 (percent)
Aluminum [2] thousand short tons	2,321	2,704	+16.5
Asbestos, all grades [3] do	666	726	+9.0
Boron minerals and compounds [4] thousand short tons, gross weight	333	354	+6.3
Bromine and bromine in compounds million pounds	171	183	+7.0
Cadmium, primary thousand pounds, Cd content	[5] 10,289	12,082	+17.4
Cement million barrels	332.8	346.2	+4.0
Clays thousand short tons	[5] 46,986	47,312	+.7
Crushed stone million short tons	[5] 609.6	654.2	+7.3
Gypsum, crude [6] do	[5] 14,197	15,410	+8.5
Phosphate rock thousand long tons, P_2O_5 content [7]	4,358	4,731	+8.6
Potash thousand short tons, K_2O equivalent	[5] 2,276	2,556	+12.3
Salt, common thousand short tons	26,115	29,516	+13.0
Sand and gravel million short tons	751.8	776.7	+3.3
Sulfur (all forms) thousand long tons, S content	[5] 5,893	6,247	+6.0
Talc and allied minerals thousand short tons	[5] 741	756	+2.0

[1] Covers commodities for which consumption is not reported.
[2] Includes 1961 shipments to Government of 52,138 short tons; 1962, 41,544 short tons.
[3] No adjustment for national stockpile acquisitions.
[4] Reported as finished products.
[5] Revised figure.
[6] Computed as crude mined plus crude imports for consumption less crude exports less the change in stocks.
[7] Estimated at 31 percent of gross weight.

pertinent factors. New estimates were added and revisions made to adjust for new or additional information.

Estimated 1975 steel ingot consumption was revised downward from 160 million tons to 130 million tons. The principal reasons for the revision were as follows: The trend toward increasing use of high-strength steel, which requires considerably less tonnage than regular-strength steel, was progressing more rapidly than previously anticipated. The success of thinner tin-plate products and the growing use of better quality structural steel strengthened that trend. The pattern of materials components for U.S. defense, national security, and aerospace expenditures was changing, and less and less steel was being used. New technological improvements for using less steel were being introduced into steel-consuming industries. The increasing use of thin-walled automobile engine blocks, aluminum, reinforced concrete, and other steel substitutes was making serious inroads into steel markets. Competing industries were making a determined and aggressive effort to displace steel from such traditional steel markets as tin cans, flat-rolled products, steel tubular goods, and structural steel shapes and forms with increasing success. The downward revision of steel ingot consumption resulted in an overall reduction in consumption of steel-associated minerals. Molybdenum was a notable exception, and the estimate of its consumption was increased 20 percent. Molybdenum consumption is closely related to alloy-steel production, which accounts for an ever-increasing percentage of total steel output.

Estimated primary antimony consumption was revised downward by 39 percent. This was caused principally by the continuously declining trend in lead consumption in producing batteries, which require hard lead, an antimonial lead alloy. Estimated silver consumption was revised upward 29 percent because of the increasing demand for coinage as well as for industry and the arts. The esti-

TABLE 10.—Estimated United States consumption of major mineral products for year 1975

Mineral products		Quantity
Ferrous:		
Steel ingot	million short tons	[1] 130
Pig iron	do	[1] 85
Ferrous scrap	do	[1] 55
Iron ores	million long tons	[1] 150
Manganese ores	thousand short tons	3,000
Chromite ores:		
Metallurgical grade	do	1,850
Refractory grade	do	650
Chemical grade	do	200
Molybdenum	million pounds	[1] 63
Tungsten	short tons	12,500
Nonferrous:		
Bismuth	thousand pounds	2,000
Copper, primary, refined	thousand short tons	2,000
Lead	do	1,350
Zinc, slab	do	1,400
Aluminum	do	7,200
Alumina	do	12,000
Bauxite	do	25,000
Antimony, primary	short tons	[1] 11,000
Antimony, secondary	do	[1] 20,000
Silver	thousand troy ounces	[1] 200,000
Platinum	do	1,100
Titanium, ilmenite including titanium slag	thousand short tons	1,600
Titanium, rutile	do	150
Uranium (U_3O_8 content)	short tons	[2] 5,500
Nonmetals:		
Abestos	thousand short tons	1,000
Cement	thousand barrels	500
Clays	thousand short tons	59,700
Lime	do	22,000
Phosphate rock (P_2O_5 content)	do	9,000
Potash (K_2O content)	do	6,000
Sulfur	do	8,000
Salt	million short tons	50
Crushed stone	do	[1] 1,200
Sand and gravel	do	[1] 1,300

[1] Revised figure.
[2] The estimated amount of oxide required to provide initial inventory and makeup requirements for civilian nuclear powerplants. Does not include military requirements or exports and is based on a plutonium recycle mode of operation. Derived from U.S. Atomic Energy Commission. Civilian Nuclear Power—A Report to the President—1962. Appendix table 4, p. 38.

Source: Bureau of Mines, Staff. Mineral Facts and Problems, Bull. 585, 1960, pp. 24–25, 40, 68, 83–84, 108, 174, 196–197, 210–211, 257–258, 302–303, 418–420, 442–443, 471, 508–509, 546, 640, 650, 658, 713, 743, 763, 787–790, 810–811, 832–833, 899–900, 916–917, 938–939, 993.

mated crushed and broken stone and sand and gravel consumption was revised downward 14 percent. This decrease was anticipated from the changing character and methods of construction activities.

Sales and Orders.—Seasonally adjusted sales of the primary metals industry started strongly in 1962, rose to a peak in March, declined to a lower level in June, and maintained that level. Sales for the year increased 5 percent from those of 1961, an increase of $1.3 billion. Sales of products from the stone, clay, and glass manufacturing industries rose 8 percent from that of 1961 or $750 million. Seasonally adjusted net new orders in the primary metal industry reversed the 1961 upward trend with a 4-percent loss in 1962, or $1.1 billion less than that of 1961.

STOCKS

Index of Stocks of Mineral Manufacturers, Consumers, and Dealers.—The index of physical stocks of nonfuel minerals held by mineral manufacturers, consumers, and dealers at yearend was rebased from 1955=100 to the new base 1957–59=100. All commodities were

TABLE 11.—Sales, primary metal industry, stone, clay, and glass industry, and new orders, primary metal industry

(Million dollars)

Year and month	Primary metal		Stone, clay, and glass sales
	Sales	Net new orders	
1958	22,949	22,504	7,658
1959	26,567	28,978	8,687
1960	25,790	22,420	8,740
1961	24,770	26,110	9,080
1962: [1]			
January	2,270	2,840	800
February	2,410	2,330	800
March	2,460	2,210	780
April	2,370	1,750	800
May	2,190	1,830	790
June	2,000	1,760	810
July	2,040	1,900	830
August	2,060	2,060	820
September	2,050	1,970	820
October	2,070	2,170	840
November	2,170	2,070	870
December	2,040	2,000	860

[1] Seasonally adjusted data; therefore, will not add to 1962 total.

Source: U.S. Department of Commerce. Survey of Current Business, Office of Business Economics. V. 43, No. 3, March 1963, pp. S-5, S-6.

valued at 1955 primary market prices, which were used as weights in the index. The index of consumers stocks included aluminum, arsenic, bauxite, bismuth, cadmium, cement, chromite, copper, ferrous scrap and pig iron, fluorspar, iron ore, lead, manganese ore and ferromanganese, mercury, molybdenum primary products, nickel, platinum-group metals, tin, titanium concentrates, tungsten concentrates, and zinc.

The 1962 index of physical stocks of manufacturers, consumers, and dealers declined 1 point, or 1 percent, from that of 1961. In ferrous metals, stocks of iron equivalent remained the same, whereas other ferrous metals stocks declined 8 percent from 1961. The decline was attributed to the large depletion of manganese and molybdenum stocks. In nonferrous metals, refined copper was primarily responsible for the 6-percent increase in the base nonferrous metals index from the 1961 figure. The reduction of aluminum, tin, and nickel stocks was the cause of the 16-percent decline of other nonferrous metals stocks index from that of 1961. The total metals index declined 1 percent in 1962. The increase of cement stocks was the cause of the 5-percent gain of nonmetals stock index from that of 1961.

Index of Nonfuel Minerals Stocks of Primary Producers.—The index of physical stocks of crude (nonfuel) minerals at mines or in the hands of primary producers at yearend was revised from 1955=100 to the new base of 1957–59=100. All commodities were still valued at 1955 average mine values, which were used as weights in this index. The index of stocks of primary producers included antimony, bauxite, fluorspar, gypsum, iron ore, mercury, molybdenum, phosphate rock, potassium salts, sulfur, titanium concentrates, and tungsten.

Stocks held by primary producers at yearend decreased 2 points, or nearly 2 percent, as compared with the 1961 figure. Iron ore

TABLE 12.—Index of stocks of crude minerals at mines or in hands of primary producers at yearend

(1957-59=100) [1]

Yearend	Total minerals [2]	Metals				Nonmetals
		Total	Iron ore	Other ferrous	Nonferrous	
1949	75	94	76	170	94	66
1950	63	74	81	39	90	58
1951	66	76	79	45	120	61
1952	72	76	78	60	103	70
1953	77	87	81	99	106	72
1954	83	94	100	49	125	77
1955	73	64	61	30	144	77
1956	90	78	77	46	140	95
1957	105	102	96	123	104	106
1958	102	99	100	103	90	104
1959	93	99	104	74	106	90
1960	110	154	175	64	161	90
1961	121	134	146	63	169	115
1962	119	147	164	73	148	105

[1] Index rebased (1957-59=100). The weight remains in 1955 prices.
[2] Excluding fuels.

TABLE 13.—Index of stocks of minerals of mineral manufacturers, consumers, and dealers at yearend

(1957-59=100) [1]

Yearend	Total metals and nonmetals [2]	Metals					Nonmetals
		Total	Iron	Other ferrous	Base nonferrous	Other nonferrous	
1949	68	69	63	61	84	48	50
1950	62	63	61	54	70	53	46
1951	58	58	62	51	60	42	61
1952	69	70	73	65	72	53	58
1953	81	82	82	81	88	62	67
1954	76	77	79	88	79	61	56
1955	77	78	78	75	83	60	60
1956	86	86	80	74	97	81	76
1957	100	100	99	92	102	108	96
1958	101	101	102	98	102	97	101
1959	99	99	99	110	96	95	103
1960	110	110	107	108	108	127	118
1961	99	97	99	98	87	124	120
1962	98	96	99	90	92	104	126

[1] Index rebased (1957-59=100). The weight remains in 1955 prices.
[2] Excludes fuel.

stocks rose 12 percent, and other ferrous metal stocks gained nearly 16 percent in 1962. Nonferrous metal stocks declined 12 percent, whereas nonmetallic mineral stocks declined 9 percent. These declines more than offset the gain in ferrous metals stocks.

Value of Inventories.—The value of seasonally adjusted inventories held by firms in the primary metals industry in December was 3 percent lower than that in December 1961. Inventories were strong at the beginning of 1962, reached an alltime high in March, declined gradually to the lowest point in November, and rose again slightly by yearend. The value of inventories held by firms in the stone, clay, and glass products industry increased 5 percent in December over that of December 1961. The year 1962 started with a gradual increase that reached its highest plateau in September through November then declined slightly in December.

TABLE 14.—Seasonally adjusted book value of inventory, primary metal industry and stone, clay, and glass

(Million dollars)

Year and month	Primary metal	Stone, clay, and glass	Year and month	Primary metal	Stone, clay, and glass
1958: December	4,111	1,200	April	4,866	1,490
1959: December	4,120	1,360	May	4,850	1,500
1960: December	[1] 4,500	1,440	June	4,830	1,520
1961: December	[1] 4,780	1,470	July	4,800	1,530
1962: December	4,620	1,540	August	4,770	1,540
January	4,840	1,480	September	4,740	1,550
February	4,890	1,480	October	4,670	1,550
March	4,910	1,490	November	4,600	1,550

[1] Revised figures.

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business. V. 43, No. 2, February 1963, p. 5-6, No. 5, May 1963, p. 5-6.

LABOR AND PRODUCTIVITY

Employment.[5]—Total employment in the mineral industries continued the gradual downward trend from the 1960 peak. The marked reduction in noniron and noncopper metal mining employment was primarily responsible for the decline. Quarrying and nonmetallic mining employment followed the seasonal pattern but declined slightly. Employment in iron mining remained unchanged, employment in copper mining declined slightly from its 1961 peak, and employment in other metal mining—primarily lead and zinc and uranium mining—continued its steady decline since 1956. The pattern of the mineral manufacturing industries was mixed; employment in the fertilizers, cement, and iron and steel industries waned insignificantly, whereas employment in the nonferrous metals industry increased by 2 percent over that of 1961.

The average of all employment in other metal mining was as follows:

Year	Thousands	Change from previous year (percent)	Year	Thousands	Change from previous year (percent)
1955	38.1	+4.7	1959	32.6	−3.3
1956	40.4	+4.0	1960	31.8	−2.4
1957	39.7	−1.7	1961	30.7	−3.5
1958	33.7	−15.1	1962	28.2	−8.1

[5] Source. U.S. Department of Labor, Bureau of Labor Statistics. Employment and Earnings Statistics for U.S. 1909–60. Bulletin #1312, 1961. Employment and Earnings, vol. 8, No. 8, February 1962 to vol. 9, No. 11, May 1963.

The following tabulation shows percentage changes in average total employment compared with 1961.

	Percent
All industries	+2.3
Mining (including fuels)	−2.9
Metals and minerals (except fuels)	−1.9
Metal mining	−3.3
Nonmetallic mining and quarrying	−.9
Fuels	−3.4
Coal mining	−7.7
Crude petroleum and natural gas	−1.4
Mineral manufacturing [1]	−.3

[1] Based upon categories listed under mineral manufacturing in table 14.

Employment in all mineral industries again compared unfavorably with all industries and continued the downward trend of 1961. Primary nonferrous smelting and refining, which gained 2 percent, was the single exception. The drop in metals and nonfuel minerals was attributed to shrinking employment in lead and zinc and uranium mining.

Hours and Earnings.—Average weekly hours of production workers in the mining industry increased nearly 1 percent over that of 1961. Both hourly and weekly earnings rose 4 percent. Weekly hours in all mining categories, except copper mining, followed the similar gradually increasing pattern in respective hours and earnings. Average weekly hours in copper mining diminished nearly 2 percent from that of 1961. Mineral manufacturing industries also registered similar increases in hours and earnings.

Labor Turnover Rates.—Accession rates generally increased, and separation and layoff rates were mixed in the mineral and related industries. This trend closely followed the pattern of the strong recovery of the mineral industries in 1962 and slightly exceeded all manufacturing.

Wages and Salaries.—In the mining industry, wages and salaries checked the downward trend started in 1961 and improved slightly but still lagged behind all industries. Metal mining continued the decline started in 1961 but at a lower rate, whereas primary metal industries reversed the 1961 decline with a strong upsurge in 1962. Nonmetallic mining and quarrying advanced 4 percent over 1961 and carried nonfuels mining to a slight gain. The stone, clay, and glass products industries recovered from a 1961 low and achieved a new peak. The average annual earnings of full-time employees in the mineral and related industries increased moderately in 1962 and followed the gradual upward trend in all industries, reflecting gains in productivity.

Productivity.—Metal mining reflected increased productivity. All indexes reached record highs except usable recovered metal of iron ore per man-hour, which declined. This decline in usable recovered metal indicated the mining of lower grade iron ores.

TABLE 15.—Total employment in the mineral industries (nonfuel) in the continental United States, by industry

(Thousands)

Year and month	Mining				
	Total	Nonmetallic mining and quarrying	Metal		
			Total [1]	Iron	Copper
1959	203.2	119.6	83.6	27.7	23.3
1960	212.8	119.5	93.3	33.2	28.3
1961	[2] 202.0	[2] 114.9	[2] 87.1	[2] 27.5	28.9
1962:					
January	187.8	102.3	85.5	27.8	28.4
February	186.9	100.9	86.0	27.9	28.8
March	189.5	103.7	85.8	27.7	28.8
April	198.6	111.7	86.9	28.4	28.9
May	207.8	119.3	88.5	29.7	28.9
June	209.8	120.6	89.2	29.8	29.2
July	208.0	120.2	87.8	29.0	28.8
August	206.7	122.9	83.8	28.3	28.8
September	201.3	121.0	80.3	26.4	27.9
October	198.5	119.1	79.4	25.9	27.7
November	195.3	116.4	78.9	25.1	27.8
December	186.5	108.2	78.3	24.4	28.0
Year (average)	198.1	113.9	84.2	27.5	28.5

Year and month	Mineral manufacturing			
	Fertilizers	Cement, hydraulic	Blast furnaces, steel works, and rolling mills	Primary metals, nonferrous smelting and refining
1959	36.2	43.9	515.3	68.0
1960	35.5	42.8	577.5	70.8
1961	35.5	[2] 40.0	530.3	67.4
1962:				
January	34.0	37.3	562.9	68.0
February	35.9	36.0	573.4	68.6
March	38.5	36.3	578.0	68.6
April	44.3	39.0	577.2	68.5
May	42.8	40.0	550.2	68.6
June	33.3	41.3	523.6	68.8
July	30.6	41.5	502.0	67.8
August	31.2	41.7	499.7	68.9
September	33.5	41.4	498.8	69.4
October	33.9	40.8	490.3	69.1
November	32.7	40.3	486.1	68.7
December	33.5	37.9	490.6	68.2
Year (average)	35.3	39.5	527.7	68.6

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

Source: U.S. Department of Labor, Bureau of Labor Statistics. Employment and Earnings. V. 8, No. 8, February 1962 to V. 9 No. 11, May 1963. Employment and Earnings Statistics for the United States, 1909-60. Bull. #1312, 1961.

TABLE 16.—Average hours and gross earnings of production and related workers in the mineral industries (nonfuel) in continental United States, by industry

Year	Mining								
	Total [1]			Metal					
				Total [2]			Iron ores		
	Weekly		Hourly earnings	Weekly		Hourly earnings	Weekly		Hourly earnings
	Earnings	Hours		Earnings	Hours		Earnings	Hours	
1958	$91.26	41.2	$2.23	$94.96	38.6	$2.46	$98.81	35.8	$2.76
1959	97.94	42.8	2.30	102.77	40.3	2.55	107.34	37.4	2.87
1960	103.26	42.9	2.41	111.19	41.8	2.66	114.73	39.7	2.89
1961	[3] 105.85	42.8	2.48	113.44	41.4	2.74	[3] 115.08	[3] 38.6	[3] 3.00
1962	110.55	43.1	2.57	117.86	41.5	2.84	122.49	39.9	3.07

Year	Metal—Continued			Quarrying and nonmetallic mining			Mineral manufacturing		
	Copper ores						Fertilizers, complete and mixing only		
1958	$94.17	39.4	$2.39	$88.33	43.3	$2.04	$73.78	42.4	$1.74
1959	105.90	42.7	2.48	94.57	44.4	2.13	77.51	43.3	1.79
1960	116.77	44.4	2.67	96.58	43.7	2.21	79.55	43.0	1.85
1961	119.03	43.6	2.73	[3] 100.09	[3] 43.9	2.28	81.37	42.6	1.91
1962	120.98	42.9	2.82	105.20	44.2	2.38	85.40	42.7	2.00

Year	Mineral manufacturing—Continued								
	Cement, hydraulic			Blast furnaces, steel and rolling mills			Nonferrous smelting and refining		
1958	$93.09	40.3	$2.31	$108.54	37.3	$2.91	$99.88	40.6	$2.46
1959	98.98	40.9	2.42	123.38	39.8	3.10	104.81	41.1	2.55
1960	102.87	40.5	2.54	117.04	38.0	3.08	108.09	41.1	2.63
1961	106.52	40.5	2.63	[3] 123.84	38.7	[3] 3.20	[3] 109.48	40.7	[3] 2.62
1962	112.48	40.9	2.75	127.98	38.9	3.29	114.67	41.1	2.79

[1] Weighted average of data computed, using figures for production workers as weights.
[2] Includes other metal mining, not shown separately.
[3] Revised figure.

Source: U.S. Department of Labor. Bureau of Labor Statistics. Employment and Earnings, V. 8, No. 8, February 1962. V. 9, No. 8, February 1963, tables B-2 and C-7. Employment and Earnings Statistics for the United States. 1909-60. Bull. #1312, 1961.

TABLE 17.—Monthly labor-turnover rates in the mineral industries

(Per 100 employees)

Turnover rate	All manufacturing	Hydraulic cement products	Blast furnaces, steel and rolling mills	Nonferrous smelting and refining	Metal mining	Iron ores	Copper ores
Total accession rate:							
1961 average	4.1	2.9	3.5	2.6	2.7	3.2	1.9
1962:							
January	4.1	2.8	3.8	2.0	2.9	3.6	1.6
February	3.5	4.3	2.7	2.0	2.6	1.7	3.0
March	3.7	6.1	2.1	2.2	2.4	1.7	1.7
April	4.0	6.7	1.5	2.1	4.1	5.7	2.1
May	4.3	3.9	1.7	2.5	3.4	3.5	2.2
June	5.0	4.6	2.1	3.6	3.8	2.1	3.4
July	4.5	2.4	2.9	2.1	2.4	2.4	1.5
August	5.1	2.3	3.2	3.4	2.4	1.8	1.8
September	4.9	1.7	2.4	2.0	2.9	2.2	2.0
October	3.9	.9	2.7	2.2	2.7	1.0	3.0
November	3.0	1.3	3.0	1.5	2.9	2.4	2.9
December	2.3	.8	2.8	1.2	2.0	1.0	1.9
Average	4.0	3.2	2.6	2.2	2.9	2.4	2.3
Total separation rate:							
1961 average	4.0	3.0	2.4	2.7	3.1	4.2	2.4
1962:							
January	3.9	7.4	1.8	2.5	2.4	1.8	2.1
February	3.4	5.3	1.3	1.5	1.9	1.0	1.8
March	3.6	3.2	1.7	1.9	2.3	1.4	1.8
April	3.6	2.1	3.6	2.3	2.5	1.5	2.1
May	3.8	2.5	6.7	1.9	2.6	2.3	1.8
June	3.8	2.1	6.4	2.1	3.2	4.1	1.8
July	4.4	1.9	4.7	2.0	3.2	3.7	2.4
August	5.2	2.2	3.6	2.6	4.9	5.4	3.6
September	5.0	2.4	4.0	3.1	6.0	6.5	6.0
October	4.3	2.4	4.2	2.1	3.6	5.6	1.8
November	4.0	4.0	3.2	2.2	3.8	5.4	2.0
December	3.8	8.1	2.6	2.5	5.6	11.4	2.1
Average	4.1	3.6	3.7	2.2	3.5	4.2	2.4
Layoff rate:							
1961 average	2.2	2.2	1.5	1.4	1.4	2.7	.9
1962:							
January	2.1	6.6	.9	1.5	.7	.9	.6
February	1.7	4.5	.5	.6	.3	.4	.3
March	1.6	2.3	.8	.9	.6	.7	.3
April	1.6	1.3	2.6	.9	.4	.5	.2
May	1.6	1.5	5.8	.6	.7	1.4	.1
June	1.6	1.4	5.5	.8	1.4	3.1	.2
July	2.2	1.0	3.9	.6	1.2	2.6	.6
August	2.3	.6	2.8	.8	2.4	4.6	1.6
September	1.9	.6	3.1	.8	3.0	4.8	3.4
October	2.2	1.7	3.4	.8	1.8	4.6	.3
November	2.3	3.3	2.6	1.1	2.3	4.8	.8
December	2.5	7.4	1.9	1.6	4.2	10.7	1.1
Average	2.0	2.7	2.8	.9	1.6	3.3	.8

Source: U.S. Department of Labor. Employment and Earnings. V. 8, No. 9, March 1962 through V. 9, No. 9, March 1962, table D-2.

TABLE 18.—Wages and salaries in the mineral industries in the United States

(Million dollars)

Industry	1961	Change from 1960 (percent)	1962	Change from 1961 (percent)
All industries	$278,821	+2.8	$297,133	+6.6
All mining	3,740	−2.4	3,763	+.6
Nonfuel mining	1,151	−1.2	1,163	+1.0
Metal mining	550	−3.2	539	−2.0
Nonmetallic mining and quarrying	601	+.7	624	+3.8
Fuel mining	2,589	−2.9	2,600	+.4
Manufacturing	87,469	+.1	94,174	+7.7
Primary metal industries	7,199	−3.6	7,692	+6.8
Stone, clay and glass products	2,992	−1.6	3,155	+5.4

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business. V. 43, July 1963.

TABLE 19.—Average annual earnings in the mineral industries in the United States

Industry	1961	Change from 1960 (percent)	1962	Change from 1961 (percent)
All industries	$4,843	+2.9	$5,013	+3.5
All mining	5,885	+3.5	6,030	+2.5
Nonfuel mining	5,824	+2.6	6,026	+3.5
Metal mining	6,395	+4.7	6,537	+2.2
Nonmetallic mining and quarrying	5,414	+1.6	5,622	+3.8
Fuel mining	5,830	+2.6	6,032	+3.5
Manufacturing	5,509	+3.1	5,715	+3.7
Primary metal industries	6,551	+3.3	6,813	+4.0
Stone, clay, and glass products	5,470	+2.5	5,674	+3.7

Source: U.S. Department of Commerce. Office of Business Economics. Survey of Current Business, v. 43, July 1963.

TABLE 20.—Labor-productivity indexes for copper- and iron-ore mining [1]

(1957-59=100)

Year	Copper, crude ore mined per—		Iron, crude ore mined per—	
	Production worker	Man-hours	Production worker	Man-hours
1953-57 (average) [2]	87.2	81.8	97.1	92.2
1958	98.9	103.1	92.5	97.5
1959	110.0	105.8	100.9	101.6
1960	116.9	108.2	122.7	116.3
1961	117.9	111.1	135.8	132.4
1962 [3]	125.8	120.7	140.7	133.0
	Recoverable metal [4] per—			
1953-57 (average)	91.7	85.9	109.9	104.3
1958	101.8	106.2	90.6	95.3
1959	105.3	101.3	93.9	94.6
1960	112.9	104.5	112.0	106.2
1961	116.2	109.5	112.8	110.0
1962 [3]	124.1	119.1	112.5	106.4

[1] Indexes have been revised and adjusted to benchmark indexes derived from the Census of Mineral Industries for the years 1939, 1954, 1958.
[2] 5-year average figures were computed by the Bureau of Mines from the statistical data. Source: U.S. Department of Labor, Bureau of Labor Statistics.
[3] Preliminary figure.
[4] Figures refer to usable ore rather than recoverable metal. For iron, usable ore is that product with the desired iron content (by selective mining, mixing of ores, washing, jigging, concentrating, sintering).

PRICES AND COSTS [6]

Index of Mine Value.—The average unit mine value of all minerals (including fuels) remained unchanged for the fourth consecutive year. A 1-point drop in the ferrous metals index from 1961 was counteracted by a 1-point gain in the nonferrous metals index. This resulted in no change in the overall metals index. The stability of the index was sustained by a 1-point rise in the fuels index, which balanced a 1-point decline in the nonmetals index.

[6] Section on Fringe Benefits for Mine Workers is not repeated this year. No new data are available this year. Bureau of Labor Statistics conducts this study only once in a 2- to 3-year period. For 1960 information, refer to 1961 Minerals Yearbook chapter, "Review of the Mineral Industries (Metals and Nonmetals Except Fuels)."

The 1-point gain in the nonferrous subgroup was the result of gains made in base and monetary indexes which outweighed the loss sustained by other nonferrous minerals. The increased mine value of silver was responsible for the 8-point increase in the monetary nonferrous minerals subgroup.

The stability of the average unit mine value index was in accord with the trend of wholesale price indexes; the average unit value of wholesale prices was 100.3 in 1961 and 100.6 in 1962.

The difference between the average unit mine value index and other published indexes was illustrated by the monetary metal index. The U.S. Treasury price of gold and silver had not changed from year to year, but the index had.[7] The variations were caused by movements in the differential between smelter purchase price of ores and refined metal prices. The index of mine value was believed to reflect more accurately the actual per-unit mine return.

TABLE 21.—Index of average unit mine value of minerals produced in the United States, by group and subgroup [1]

(1957-59=100)

Year	All minerals	Metals							Nonmetals				Fuels
		Total	Ferrous	Nonferrous					Total	Construction	Chemical	Other	
				Total	Base	Monetary	Other						
1952	89	85	73	102	105	93	74		89	93	83	86	89
1953	93	88	81	99	101	94	80		93	95	91	84	93
1954	93	90	83	101	104	96	86		94	95	95	86	92
1955	94	101	85	121	127	94	94		95	95	99	89	92
1956	97	110	92	135	144	94	97		98	98	100	97	95
1957	102	101	98	106	107	99	105		99	99	101	101	102
1958	99	97	100	92	90	101	96		99	99	100	99	100
1959	98	102	102	102	103	101	99		101	102	99	100	98
1960	98	105	102	107	109	102	99		102	104	100	101	[2] 97
1961	98	103	105	99	98	[2] 104	100		102	[2] 103	101	101	97
1962	98	103	104	100	99	112	99		101	104	99	102	98

[1] For description of index see Review of Mineral Industries, BuMines Minerals Yearbook, 1959. V. 1, 1960, p. 22–24.
[2] Revised figure.

Index of Implicit Unit Value.—The index of implicit unit value [8] reflected the unit price change implied in the Bureau of Mines Index of Physical Volume of Mineral Production and its value series of total mineral production. To construct the index, it was necessary to compile a value of mineral production index using total values published in the Statistical Summary chapter of the Minerals Yearbook. The implicit unit index number was obtained by dividing the index of value by the index of physical volume.

This index differed from other price indexes because it was not constructed on the basis of any actual price quotations, but was constructed from measures of quantity and value as measured by indexes of change.

[7] Starting in November 1961, the U.S. Treasury stopped selling silver in the open market. The price of silver has been fluctuating upward since that date.
[8] Designed by William A. Vogely, Chief, Division of Economic Analysis, formerly Chief Economist.

Implicit unit value of all minerals increased insignificantly. The small increase in mineral fuels offset the 2.6-point decline in the metals segment.

TABLE 22.—Index of implicit unit value of minerals produced in the United States by group [1]

(1957-59=100)

Year	All minerals	Total metals	Total nonmetals	Total mineral fuels
1952	84.2	79.0	86.0	84.9
1953	89.2	83.7	91.3	89.8
1954	90.7	85.6	94.3	90.7
1955	92.3	96.0	96.4	90.1
1956	96.1	110.8	99.4	92.8
1957	99.9	99.0	97.6	100.6
1958	99.7	96.7	99.7	100.0
1959	100.3	105.2	102.5	99.3
1960	101.4	106.4	100.3	100.2
1961	[2] 101.8	105.6	[2] 101.2	[2] 101.1
1962	102.0	103.0	101.2	101.2

[1] For description of index see Review of Mineral Industries. BuMines Minerals Yearbook 1961. V. 1, pp. 19-20.
[2] Revised figure.

Prices.—Mineral commodity prices were steady but weak. All annual prices of ferrous metals declined moderately except iron and steel scrap, which dropped 18.5 percent in 1962. Prices of nonferrous metals were mixed. Prices of refined copper and zinc slab made small gains, whereas the price of pig lead declined 11 percent and that of aluminum ingot 6 percent from 1961. Prices of nonmetallic construction materials recorded insignificant gains. Prices of chemical nonmetallic minerals were mixed. Fuels and related products declined slightly, whereas the prices of all commodities increased slightly. The 1962 prices of mineral commodities declined from January to December with only nonmetallic construction materials registering a moderate gain.

Costs.—Cost items shown in table 24 were mixed, with little change in prices compared with 1961 prices. Lumber had the greatest increase, nearly 2 percent, rising gradually throughout 1962, a reversal of the 1961 downward trend. Explosives, gas fuels, construction machinery and equipment, and coke made little or no gain. Prices of petroleum products and industrial chemicals declined in 1962. With the largest decrease, industrial chemicals continued the downward trend started in 1961.

In general, prices of mining, construction, and material-handling machinery and equipment, with the exception of specialized construction machinery, portable air compressors, and mixers, pavers, and spreaders, increased insignificantly over those of 1961. The percentage changes from 1961 for major items were as follows:

	Percent
Mining machinery and equipment	+0.6
Construction machinery and equipment	+.3
Power cranes, draglines, shovels, etc	+.7
Tractors, other than farm	+.5

Relative Labor Cost.—The index of labor cost per pound of recoverable metal again declined rather sharply in copper mining,

TABLE 23.—Price relatives for selected metals and mineral commodities, January and December 1961, and annual averages

(1957-59=100)

Commodity	1962 January	1962 December	Change from January (percent)	Annual average 1961	Annual average 1962	Change from 1961 (percent)
Metals and metal products	100.7	99.3	-1.4	100.7	100.0	-0.7
Iron and steel	100.6	98.7	-1.9	100.7	99.3	-1.4
Iron ore	98.1	93.2	-5.0	98.1	93.9	-4.3
Iron and steel scrap	87.1	62.7	-28.0	84.7	69.0	-18.5
Semifinished steel products	101.8	101.8		101.8	101.8	
Finished steel products	101.5	101.3	-.2	101.7	101.4	-.3
Foundry and forge shop products	103.4	103.8	+.4	103.4	103.6	+.2
Pig iron and ferroalloys	91.9	87.3	-4.5	94.7	91.1	-3.8
Nonferrous metals	100.5	97.7	-2.8	100.4	99.2	-1.2
Primary metal refinery shapes	101.7	99.8	-1.9	100.9	100.7	-.2
Aluminum, ingot	95.7	89.7	-6.3	101.7	95.2	-6.4
Copper, ingot, electrolytic	106.1	106.1		103.7	106.1	+2.3
Lead, pig, common	77.0	77.0		83.6	74.1	-11.4
Zinc, slab, prime western	108.3	104.0	-4.0	104.4	105.1	+.7
Nonferrous scrap	99.9	93.8	-6.1	99.9	96.7	-3.2
Nonmetallic mineral products	101.9	101.5	-.4	101.8	101.8	
Concrete ingredients	102.8	103.2	+.4	102.8	103.2	+.4
Sand, gravel and crushed stone	102.7	103.7	+1.0	102.4	103.4	+1.0
Concrete products	102.4	102.5	+.1	102.5	102.6	+.1
Structural clay products	103.4	103.5	+.1	103.2	103.5	+.3
Gypsum products	105.0	105.0		103.8	105.0	+1.2
Other nonmetallic minerals	101.7	102.4	+.7	102.2	102.2	
Building lime	108.0	109.5	+1.4	105.2	108.8	+3.4
Insulation materials	92.6	95.3	+2.9	95.0	94.5	-.5
Asbestos cement shingles	110.6	110.8	+.2	110.6	110.6	
Bituminous binders (1958=100)	100.0	100.0		100.0	100.0	
Fuels and related products and power	101.0	100.8	-.2	100.7	100.2	-.5
Fertilizer materials	105.8	99.6	-5.9	104.3	101.9	-2.3
Nitrogenates	103.0	95.2	-7.6	101.2	97.8	-3.4
Phosphates	108.0	105.3	-2.5	107.4	106.6	-.7
Phosphate rock	120.4	118.9	-1.2	117.0	119.4	+2.1
Potash	114.4	112.9	-1.3	112.8	115.5	+2.4
Muriate, domestic	111.4	111.4		110.8	113.5	+2.4
Sulfate	119.0	108.8	-8.6	112.3	113.9	+1.4
All commodities other than farm and food	101.0	100.7	-.3	100.8	100.8	
All commodities	100.8	100.4	-.4	100.3	100.6	+.3

Source: U.S. Department of Labor, Bureau of Labor Statistics. Wholesale Price Index. Annual and monthly releases; also published currently in Monthly Labor Review.

TABLE 24.—Price relatives for selected cost items in nonfuel mineral production; January and December 1962 and annual averages

(1957-59=100, unless otherwise specified)

Commodity	1962 January	1962 December	Change from January (percent)	Annual average 1961	Annual average 1962[1]	Change from 1961 (percent)
Coal	98.7	98.3	-0.4	97.7	96.8	-0.9
Coke	103.6	103.6		103.6	103.6	
Gas fuels (January 1958=100)	118.1	123.1	+4.2	118.7	119.2	+.4
Petroleum and refined products	99.6	98.6	-1.0	99.3	98.2	-1.1
Industrial chemicals	97.3	95.9	-1.4	98.4	96.3	-2.1
Lumber	94.0	95.8	+1.9	94.7	96.5	+1.9
Explosives	108.5	108.5		108.4	108.5	+.1
Construction machinery and equipment	107.7	108.3	+.6	107.5	107.8	+.3

[1] Preliminary figures.

Source: U.S. Department of Labor, Bureau of Labor Statistics, Monthly Labor Review and Wholesale Price Index.

whereas labor cost rose significantly in iron-ore mining. The index of labor cost per dollar of recoverable metal declined 6 percent in copper mining and increased 12 percent in iron-ore mining. The index of value of recoverable metal per man-hour gained remarkably in copper mining and achieved a peak, but declined notably for iron ore mining.

TABLE 25.—Mining construction and material handling machinery and equipment

(1957-59=100)

Year	Construction machinery and equipment	Mining machinery and equipment	Oilfield machinery and tools	Power cranes, draglines, shovels, etc.	Specialized construction machinery	Portable air compressors	Scrapers and graders	Contractor's air tools, hand-held	Mixers, pavers, spreaders etc.	Tractors other than farm
1953-57 (average)	85.1	80.7	89.2	85.8	87.5	84.3	86.5	80.8	86.7	83.6
1958	100.1	100.2	100.1	99.9	100.0	100.2	99.6	98.9	99.9	100.4
1959	103.6	104.9	100.2	102.9	103.7	104.6	104.0	108.2	104.4	103.9
1960	105.8	106.4	100.3	105.1	106.9	105.4	104.7	108.2	106.7	106.4
1961	107.5	107.8	101.8	105.4	107.8	114.1	104.4	113.5	[1] 108.4	108.0
1962	107.8	108.4	103.2	106.1	107.4	113.7	105.3	113.5	110.3	108.5

[1] Revised figure.

Source: U.S. Department of Labor, Bureau of Labor Statistics. Wholesale Price Index Section. Published and unpublished data.

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

(1957-59=100)

Year	Labor costs per pound of recoverable metal [1]		Value of recoverable metal per man-hour [2]		Labor costs per dollar of recoverable metal [3]	
	Copper	Iron ore	Copper	Iron ore	Copper	Iron ore
1952	91	66	71	80	108	83
1953	103	76	79	89	104	88
1954	105	89	82	78	102	101
1955	99	73	116	102	77	82
1956	109	81	124	104	76	85
1957	104	89	97	108	101	88
1958	94	105	95	96	105	104
1959	102	111	107	96	96	109
1960	105	99	116	107	95	98
1961	104	99	114	111	100	98
1962	99	105	126	102	94	110

[1] Index computed from data in tables 15 and 19.
[2] Index computed from data in table 19 multiplied by price of electrolytic copper and iron ore.
[3] Index computed by using index of value and data in table 15.

Source: U.S. Department of Labor, Employment and Earnings. Bureau of Labor Statistics. Bull. 1312.

Index of Principal Metal Mining Expenses.[9]—Since this index excludes capital costs and contract work, it does not represent changes in total unit cost of metal mining. It does, however, gage the impact of labor cost, production changes, and fluctuations in prices of current supplies, and fuels used by the mining industry. Reflecting the slightly increased cost of labor (adjusted for productivity), no change in cost of supplies, and a small decline in cost of fuel and power, total

[9] This index is for iron ore and copper mining only.

costs gained moderately in 1962 to return to the 1960 level. The small increase in the total index was attributed to increased labor cost.

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

(1957-59=100)

Year	Total	Labor	Supplies	Fuels
1952	85	77	96	93
1953	89	87	88	96
1954	94	95	89	95
1955	88	84	91	94
1956	94	93	95	97
1957	97	95	99	103
1958	100	99	100	99
1959	105	106	102	99
1960	102	101	102	100
1961	101	100	101	101
1962	102	101	101	100

[1] Indexes constructed by author, using weights derived from the 1958 Census of Mineral Industries, and using data from U.S. Department of Labor, Bureau of Labor Statistics. Wholesale Price Index. Annual and monthly releases and labor cost index from table 23. This index is for iron and copper ores only.

INCOME

National Income Originated.—Despite the rising trend of all industries, income originating in the mining industry declined again and its percentage share of total income for all industries decreased proportionately. All manufacturing increased noticeably. Mineral related manufacturing followed the overall upward trend but at a much slower rate, and consequently its percentage share in all industries income continued to decline.

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

Industry	Income, million dollars			
	1960 [2]	1961 [2]	1962	Change from 1961 (percent)
All industries	414,497	426,062	453,695	+6.5
Metal mining	873	828	774	−6.5
Nonmetallic mining and quarrying	869	809	793	−2.0
Total mining except fuels	1,742	1,637	1,567	−4.3
Total mining including fuels	5,510	5,411	5,218	−3.6
Manufacturing	121,025	120,129	130,546	+8.7
Primary metal industries	10,449	9,837	10,136	+3.0
Stone, clay, and glass products	4,313	4,224	4,382	+3.7
	Percent			
All industries	100.00	100.00	100.00	
Metal mining	.21	.19	.17	
Nonmetallic mining and quarrying	.21	.19	.17	
Total mining except fuels	.42	.38	.35	
Total mining including fuels	1.33	1.27	1.15	
Manufacturing	29.20	28.20	28.77	
Primary metal industries	2.52	2.31	2.23	
Stone, clay, and glass products	1.04	.99	.97	

[1] U.S. Department of Commerce, Office of Business Economics, Survey of Current Business. V. 43, July 1963. To arrive at national income, depletion charges are not deducted; this affects data for mining industries.

[2] Revised figures.

Profits and Dividends.—The annual profit rate on stockholders equity (after corporate income taxes) of all mineral manufacturing industries, except chemical and allied products, trailed all manufacturing again in 1962. Primary iron and steel industries declined more than 11 percent, whereas all other mineral manufacturing industries gained. Similar situations existed for dividend distributions. Mineral manufacturing, except chemicals, once more lagged behind the gain made in all manufacturing. Primary iron and steel was the only loser.

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

Industry	Annual profit rate (percent)			Total dividends (million dollars)		
	1961	1962	Percent change, 1962 from 1961	1961	1962	Percent change, 1962 from 1961
All manufacturing [2]	8.8	9.8	+11.4	8,551	9,281	+8.5
Primary metals	6.5	6.2	−4.6	926	886	−4.3
Primary iron and steel [3]	6.2	5.5	−11.3	627	574	−8.5
Primary nonferrous metals [3]	7.1	7.5	+5.6	300	314	+4.7
Stone, clay, and glass products	8.8	8.9	+1.1	304	312	+2.6
Chemical and allied products	11.8	12.4	+5.1	1,274	1,447	+13.6

[1] Federal Trade Commission, Securities and Exchange Commission, and Quarterly Financial Reports for Manufacturing Corporations, 1st Quarter, 1962 and 1963, tables 4 and 8.
[2] Except newspapers.
[3] Included in primary metals.

Business Failures.—Mining failures declined sharply and reversed the post-World War II upward trend. The current liabilities of the firms that failed increased 287 percent over 1961 and nearly 2.5 times more than the previous peak year of 1960 to establish a post-war high. Mining industries did not conform to the manufacturing and all industries patterns. The sharp increase of current liabilities of the firms in the mining industry that failed compared unfavorably with other industries that failed in 1962.

TABLE 30.—Industrial and commercial failures and liabilities

Industry	1960	1961	1962
Mining: [1]			
Number of failures	98	103	85
Current liabilities ... thousand dollars	19,650	16,814	48,278
Manufacturing:			
Number of failures	2,514	2,722	2,490
Current liabilities ... thousand dollars	269,985	[2] 309,098	351,723
All industrial and commercial industries:			
Number of failures	15,445	17,075	15,782
Current liabilities ... thousand dollars	938,630	1,090,123	1,213,601

[1] Including fuels.
[2] Revised figure.

Source: Dun & Bradstreet, Inc. Monthly Business Failures. New York, N.Y., January 1961, 1962, and 1963.

INVESTMENT

New Plant and Equipment.—Expenditures for new plant and equipment by fuel and nonfuel mining firms increased by $100 million compared with 1961, but was still $163 million below the peak year

1957. The expenditures of the mining industry increased 10 percent in 1962 and exceeded those of all manufacturing, the expenditures of which for new plant and equipment increased by only 7 percent. Primary nonferrous metal manufacturing and stone, clay, and glass manufacturing gained substantially with 19-percent and 14-percent increases, respectively, in 1962, whereas primary iron and steel manufacturing and chemicals and allied products manufacturing reversed the upward trend of all-manufacturing and mining with losses of 3 and 4 percent, respectively.

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

(Billion dollars)

Industry	1960	1961	1962	1962			
				January-March	April-June	July-September	October-December
Mining [1]	0.99	0.98	1.08	0.26	0.27	0.28	0.27
Manufacturing	14.48	13.68	14.68	3.14	3.69	3.72	4.13
Primary iron and steel	1.60	1.13	1.10	.22	.28	.29	.31
Primary nonferrous metals	.31	.26	.31	.06	.07	.08	.10
Stone, clay, and glass products	.62	.51	.58	.12	.16	.14	.16
Chemicals and allied products	1.60	1.62	1.56	.37	.40	.37	.43
Petroleum and coal products	2.64	2.76	2.88	.62	.69	.76	.80

[1] Including fuels.
Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business. V. 42, No. 3, March 1962, p. 7; V. 43, No. 3, March 1963, p. 7.

Issues of Mining Securities.—The mining industry (including fuels) was the source of 2.1 percent of all new corporation securities offered; a slight improvement over the 2.0 percent of 1961, but below the 2.5 percent of 1960. The percentage distribution between types of securities in mining changed from the last 2 years, as financing shifted noticeably from preferred stock to common stock financing. Total gross proceeds from all corporate offerings decreased by $2,377 million, compared with 1961, but mining proceeds declined only $37 million. The 14-percent decline in the mining industry proceeds was not as severe as the 18-percent drop in total corporate offerings and the 20-percent decline in manufacturing compared with those of 1961.

TABLE 32.—Estimated gross proceeds of new corporate securities offered for cash in the United States in 1962 [1]

Type of security	Total corporate		Manufacturing		Mining [2]	
	Million dollars	Percent	Million dollars	Percent	Million dollars	Percent
Bonds	9,016	83.7	2,880	87.7	146	64.9
Preferred stock	436	4.1	50	1.5	2	0.9
Common stock	1,318	12.2	353	10.8	77	34.2
Total	10,770	100.0	3,283	100.0	225	100.0

[1] U.S. Securities and Exchange Commission. Statistical Bulletin. V. 22, No. 5, May 1963, p. 13. 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.

Prices of Mining Securities.—The index of common stock annual average prices of all mining (including fuel) securities gained 6 percent over that of 1961, whereas the composite and manufacturing indexes declined in 1962. The prices of crude petroleum mining securities were responsible for all gains made in the all mining index. The 17-percent decline in other mining (metal, coal, sulfur, and nonmetallic) indexes led the downward trend of the composite and manufacturing indexes, 5 percent and 7 percent, respectively, whereas the crude petroleum extraction index made a substantial (22-percent) gain over 1961.

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

(1957-59=100)

Year	Composite [2]	Manufacturing	Mining [3]	Crude petroleum production	Other mining (metal, coal, sulfur)
1958	93.2	92.5	97.9	99.5	94.8
1959	116.7	116.5	95.0	92.0	105.8
1960	113.9	110.9	73.8	65.8	88.5
1961	134.2	126.7	92.5	84.1	108.4
1962	127.1	118.0	98.0	102.3	90.0

[1] Council of Economic Advisers. Economic Indicators (prepared for the Joint Economic Committee). April 1963, p. 34 and unpublished data from U.S. Securities and Exchange Commission. Indexes are yearly averages of weekly closing-price indexes of common stock on New York Stock Exchange.
[2] In addition to mining and manufacturing, covers transportation, utilities, trade, finance, and service.
[3] Including fuels.

Foreign Investment.[10]—The value of U.S. (net) direct private investment in mining and smelting in foreign countries increased $135 million during 1961, 1962 data not available. The largest gain ($49 million) occurred in Canada, with West Africa ($30 million) and Peru ($18 million) next in importance. During 1961, the United States decreased its mining and smelting investments in Chile by $14 million in the form of net capital outflow. The 1961 increase of $135 million in the value of U.S. foreign assistance in mines and smelters was $79 million, less than that of the 1960 increase, or a drop of 37 percent. Net capital movements accounted for only 53 percent of the increased values in 1961, compared with 73 percent in 1960. The 1961 net capital movement declined $86 million from 1960, and the 1961 total undistributed earnings of subsidiaries increased $7 million over 1960. Both earnings and income from U.S. foreign investment declined 9 percent and 12 percent, respectively, from 1961. In 1961, direct private investment of U.S. foreign mining and smelting industries lagged behind all industries in all categories—value, net capital flow, earnings and income.

The foreign plant and equipment expenditures of American mining firms, excluding petroleum, on the basis of company projections was expected to be higher in 1962 than in 1961. Increases were reported mainly in Canada (iron ore resources), Surinam and Jamaica (bauxite and alumina production), Central and West Africa (iron ore and bauxite resources), and to a limited extent in Australia (iron ore and

[10] U.S. Department of Commerce, Office of Business Economics. Survey of Current Business. V. 42, No. 9, September, 1962, p. 18.

TABLE 34.—Direct private investments of the United States in foreign mining and smelting industries, 1961 [1]

(Million dollars)

Country and areas	Mining and smelting					All industries				
	Book value	Net capital outflows	Undistributed earnings of subsidiaries	Earnings [2]	Income [3]	Book value	Net capital outflow	Undistributed earnings of subsidiaries	Earning [2]	Income [3]
Canada	1,380	12	37	90	48	11,804	297	284	684	409
Latin America, total	1,284	35	9	205	200	9,109	168	251	1,032	805
Mexico	130	1	−1	8	8	822	45	8	50	45
Chile	503	−14	(4)	41	43	725	−15	1	53	59
Peru	242	18	(4)	41	43	437	12	7	65	58
Europe	48	(3)	−1	8	9	7,655	676	314	841	511
Africa, total	285	27	11	44	33	1,070	122	51	28	−23
West Africa	155	25	5	18	14	341	30	21	28	7
Rhodesia and Nyasaland	75	−1	5	13	8	87	(4)	6	14	8
South Africa, Republic of [5]	50	2	2	12	10	304	−2	20	59	39
Far East	27	(4)	3	4	1	1,240	24	72	207	133
Oceania, total	36	(4)	3	8	4	1,101	88	20	91	65
Australia	36	(4)	3	8	4	951	80	15	77	55
All other countries	(3)	(4)	------------	------------	------------	2,703	93	54	816	773
Total all areas [6]	3,061	72	63	359	296	34,684	1,467	1,046	3,700	[7] 2,672

[1] Figures may not add to total owing to rounding. All figures are preliminary.
[2] Earnings is the sum of the U.S. share in net earnings of subsidiaries and branch offices.
[3] Income is the sum of dividend, interest, and branch profits.
[4] Less than $500,000.
[5] The value of direct investments in the Union of South Africa had been adjusted downward by $36 million because of a loss suffered by an American mining company in the liquidation of their South Africa operation.
[6] Excludes Cuba and Soviet bloc countries.
[7] Sum of total of all areas only.

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business. V. 42, No. 8., August 1962, pp. 22-23.

bauxite resources) and Chile and Peru (copper mining and smelting and iron ore). It was expected that 1963 estimates would be lower.

In order to finance fixed capital outlays, working capital, including receivables, dividends, accumulation of inventories and other assets, U.S. mining companies abroad relied principally on internally generated funds. Of the total $813 million needed for these requirements in 1961, about $684 million came from company resources, mainly cash flows from depreciation and depletion charges and from retained earnings. The 1961 total source of funds ($813 million) was $202 million less than 1960, a drop of 20 percent.

TABLE 35.—Plant and equipment expenditures of direct foreign investments, by country and major industry, 1960–63

(Million dollars)

Area and country	1960			1961 [3]			1962 [4]			1963 [4]		
	Mining and smelting	Petroleum	Manufacturing	Mining and smelting	Petroleum	Manufacturing	Mining and smelting	Petroleum	Manufacturing	Mining and smelting	Petroleum	Manufacturing
All areas, total	426	1,467	1,337	320	1,572	1,681	395	1,829	1,866	343	1,811	1,735
Canada	290	360	384	165	340	361	200	345	391	175	360	390
Latin American Republics, total	53	297	206	72	270	248	75	305	298	59	283	277
Mexico, Central America and West Indies, total	10	20	39	8	21	47	6	27	49	7	24	45
Mexico	8	1	37	7	2	44	5	2	46	6	2	42
Other countries	2	19	2	1	19	3	1	25	3	1	23	3
South America, total	44	277	167	64	249	201	69	278	249	52	259	232
Argentina	(1)	63	51	(1)	60	89	(1)	60	128	(1)	45	118
Brazil	2	5	63	2	5	62	1	5	72	1	5	69
Chile [1]	25	(1)	3	28	(1)	6	30	(1)	6	24	(1)	5
Colombia	(1)	25	21	(1)	22	15	(1)	21	14	(1)	18	12
Peru	11	17	9	27	28	10	29	31	7	18	21	7
Venezuela	(1)	160	17	(1)	128	17	(1)	150	19	(1)	160	18
Other countries	(2)	(1)	3	2	(1)	2	1	(1)	4	1	(1)	3
Other Western Hemisphere	24	44	1	23	39	1	33	57	1	31	61	1
Europe, total	2	345	608	1	438	856	3	597	968	1	549	864
Common Market, total	(2)	145	328	(2)	186	475	(2)	285	596	(2)	313	464
Belgium and Luxembourg	(2)	20	15	(2)	7	21	(2)	9	22	(2)	10	26
France	(2)	32	66	(2)	31	68	(2)	48	73	(2)	51	76
Germany	(2)	55	205	(2)	70	318	(2)	140	432	(2)	128	284
Italy	(2)	18	20	(2)	64	40	(2)	38	50	(2)	64	51
Netherlands	----------	20	22	----------	14	28	----------	50	20	----------	60	28
Other Europe, total	2	200	280	1	252	381	3	312	372	1	237	400
Denmark	----------	17	2	----------	19	2	----------	32	2	----------	22	2
Norway	(2)	21	5	(2)	7	5	(2)	9	7	(2)	9	8
Spain	(2)	3	4	(2)	3	6	(2)	8	5	(2)	8	6
Sweden	----------	17	4	----------	18	10	----------	34	9	----------	25	8
Switzerland	----------	4	8	----------	3	19	----------	6	12	----------	5	16
United Kingdom	----------	100	252	----------	170	335	----------	200	331	----------	150	355
Other countries	2	39	5	1	32	4	3	24	7	1	18	5

Africa, total	44	115	10	47	171	10	67	188	12	56	169	12
North Africa	(2)	75	(2)	(2)	111	(2)	(2)	134	(2)	(2)	116	(2)
East Africa	(2)	7	(2)	(2)	9	(2)	(2)	12	(2)	(2)	13	(2)
West Africa	16	23	(2)	22	34	(2)	37	30	(2)	26	29	(2)
Central and South Africa, total	28	10	10	25	17	10	30	11	12	30	12	12
South Africa, Republic of	15	(1)	8	10	(1)	8	10	(1)	11	10	(1)	11
Other countries	13	(1)	2	15	(1)	2	20	(1)	1	20	(1)	1
Asia, total	(2)	176	72	(2)	195	114	1	243	92	1	310	83
Middle East	----------	76	13	----------	87	12	----------	111	6	----------	162	6
Far East, total	(2)	101	60	(2)	108	102	1	132	86	1	148	77
India	----------	(1)	16	----------	(1)	39	----------	(1)	22	----------	(1)	16
Japan	----------	(1)	30	----------	(1)	48	----------	(1)	49	----------	(1)	40
Philippine Republic	----------	(1)	11	(2)	(1)	9	----------	(1)	9	----------	(1)	16
Other countries	(2)	(1)	4	(2)	(1)	6	1	(1)	5	1	(1)	5
Oceania, total	12	66	56	12	64	92	16	35	105	20	39	109
Australia	12	(1)	55	12	(1)	90	16	(1)	103	20	(1)	106
Other countries	----------	(1)	2	----------	(1)	2	(2)	(1)	2	(2)	(1)	4
International shipping	----------	65	----------	----------	55	----------	----------	60	----------	----------	40	----------

1 Included in area total.
2 Less than $500,000.
3 Revised.
4 Estimated on the basis of company projections.
NOTE.—Detail may not add to totals because of rounding.

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business. V. 42, No. 9, September 1962, p. 18.

TABLE 36.—Sources of funds of direct (foreign) investment by United States mining industries 1960–61 [1]

(Million dollars)

Year and area	Net income	Funds from United States	Funds obtained abroad [2]	Depreciation and depletion	Total sources
1960:					
Canada	157	202	13	75	447
Latin America	239	−60	61	92	332
Europe	10	(3)	−1	2	11
Other areas	113	16	74	22	225
Total	519	158	147	191	1,015
1961:					
Canada	161	9	140	80	390
Latin America	219	−20	−10	102	291
Europe	8	(3)	−2	2	8
Other areas	88	27	−15	24	124
Total	476	16	113	208	813

[1] U.S. Department of Commerce, Office of Business Economics. Survey of Current Business. V. 42, No. 9, p. 22.
[2] Including domestic borrowing, increase of accrued liabilities, and other miscellaneous sources.
[3] Less than $500,000.

New Depreciation Guidelines and the Investment Tax Credit.[11]—On July 11, the U.S. Treasury Department announced a fundamental change in the basis of computing depreciation for Federal income tax purposes. The ruling resulted in accelerating amortization of depreciable equipment and machinery, including the installation cost. The change was not mandatory. Taxpayers could continue to compute depreciation as before, but they had the option of using the new rules within 3 years. The rules are contained in U.S. Treasury Department, Internal Revenue Service Publication 456 entitled "Depreciation—Guidelines and Rules."

Mining equipment and machinery have a standard life of 10 years in the new guideline, compared with the previous Bulletin F unweighted average life of about 20 years. The difference between the two lives is a rough measure of the acceleration in depreciation. Table 37 shows the new guideline life compared with the Bulletin F service life for mineral resources industries.

In general, the mineral resources industry was expected to benefit substantially from accelerated depreciation, because the industry is characterized by a relatively large equipment account. The new ruling afforded the mineral resources industry an option for a quicker return on equipment investment together with a significant tax saving. The faster writeoff, which will generate more cash flow and immediate reduction of current tax liability, which is tax savings, will be instrumental in encouraging new investment in equipment, will foster the growth of these industries, will enable them to adopt technical advances more rapidly, which will increase productivity, and will enable the industry to keep abreast of both domestic and foreign competition.

The corporate depreciation allowances of the mineral resources industries in 1962 increased by $876 million, of which $635 million was attributed to the use of the new guideline for depreciation.

[11] U.S. Department of Commerce, Office of Business Economics; U.S. Treasury Department, Office of Tax Analysis; and Internal Revenue Service.

TABLE 37.—Comparison of standards under Bulletin F and new guideline lives and current practice—production machinery and equipment used in the mineral resources industries

Industry	Bulletin F composite (years) [1]	New guidelines (years)	Decrease from midpoint of Bulletin F to the new guidelines (percent)	Actual percent practice of serviceable life (years)	Decrease from practice to the new guidelines (percent)
Mining (excluding oil and gas)	2–50	10	58	[2] 12–15	25
Petroleum and natural gas					
Drilling, geophysical and field services only	5–10	6	20	16	13
Exploration, drilling—production	5–25	14	7		
Petroleum refining	15–30	16	29	19	16
Marketing	10–33	16	26	18	11
Primary metals					
Ferrous metals	25	18	28	23	22
Nonferrous metals	17–30	14	40		
Stone, clay, and glass products					
Cement	20–25	20	11	19	16
Glass products	15	14	7		
Stone and clay products (except cement)	15–40	15	46		

[1] Specific item lives only.
[2] Bureau of Mines estimate.

Source: U.S. Treasury Department, Office of Tax Analysis, news release July 11, 1962. U.S. Treasury Department. Internal Revenue Service publ. 456, July 1962.

TABLE 38.—Depreciation deduction by guideline and nonguideline use of all corporations in the United States mineral industries, 1962 [1]

(Million dollars)

Corporations	Corporate depreciation					
	1960	1961	1962			
			Total	Using guidelines	Not using guidelines	Additional depreciation from guideline use
All corporations	22,160	23,577	27,708	14,771	12,937	2,431
All manufacturing and mining	10,559	11,202	13,623	9,323	4,300	1,723
Metal refining and mining	1,188	1,228	1,590	1,288	302	287
Iron and steel manufacturing	661	(2)	899	813	86	182
Stone, clay, and glass products	460	482	599	386	213	92
Petroleum refining and extraction	1,739	1,803	2,055	1,223	832	166
Miscellaneous manufacturing and mining [3]	1,748	1,877	2,312	1,340	972	298

[1] U.S. Department of Commerce, Office of Business Economics. OBE 63-57 July 9, 1963.
[2] Data not available.
[3] Including coal and other nonmetallic mining. It is estimated by Bureau of Mines that about 30 percent of additional depreciation from guideline use is from coal and other mining.

The metal mining and refining industry accounted for 45 percent of total additional depreciation allowances attributable to the use of guidelines, of which iron and steel manufacturing accounted for 29 percent; coal and other mining for 14 percent; stone, clay, and glass products for 15 percent; and petroleum refining and extraction industry for 26 percent.

The Revenue Act of 1962, enacted on October 16, 1962, granted a tax credit for investment in depreciable machinery and equipment used in the United States. The credit of up to 7 percent of qualified investment is allowable. The amount of taxes that can be offset in 1 year is limited to one-fourth of the total income tax liability, although a 5-year carry forward of unused credit is provided.

In 1962 the investment credit amounted to approximately $146 million, as estimated by the Bureau of Mines, of which metal refining and mining other than iron and steel manufacturing accounted for 23 percent; iron and steel manufacturing, 18 percent; stone, clay, and glass products, 20 percent; coal and other nonmetallic mining, 8 percent; and petroleum refining and extraction, 31 percent.

TRANSPORTATION

Data on rail and water transportation were unavailable for 1962 because they are not published until late fall of the year after the year reported. The data in tables 39, 40, and 41 cover 1960 and 1961. Truck transportation data for 1962 were available from Bureau of Mines sources.

Rail Transportation.—All mineral products constituted 60 percent of the total tonnage carried by rail during 1961, of which metal and other nonfuel minerals were 30 percent and mineral fuels, 30 percent. The overall tonnage carried by rail diminished by 46.2 million tons from the 1960 tonnage; total mineral products declined by 40.4 million tons. Both fuels and nonfuel minerals shared primary responsibility for the overall decrease. Metals and nonfuel minerals lost 26.9 million tons. All nonfuel mineral commodities, except iron and steel scrap, crushed stone, and metals and alloys accounted for the unfavorable 1961 showing.

Index of average freight rates of mineral products increased slightly. Iron ore and stone accounted for the rise which offset the declines, whereas the mineral manufacturing freight rate index went down slightly. The average revenue per ton of mineral and related products shipped remained fairly stable in 1961 with only small changes.

Water Transportation.—All mineral products were 84 percent of total tonnage shipped by water during 1961, of which metal and other nonfuel minerals comprised 23 percent, and minerals fuels 61 percent. Overall tonnage shipped by water declined nearly 4 percent in 1961, whereas total mineral products shipped increased insignificantly. Metals and nonfuel minerals shipments decreased nearly 10 percent in 1961. Iron and steel scrap, cement, sulfur, and other miscellaneous increases were insufficient to overcome the large decline in iron ore shipments by water.

Great Lakes Shipping.—The Great Lakes had almost 85 percent of the dry-cargo tonnage of domestic water commerce, and coastwise traffic included about 90 percent of the tanker tonnage. Mineral commodities supplied 95 percent of the total Great Lakes traffic in 1961, practically the same percentage as in 1960, but the total tonnage shipped declined sharply. The change was attributed mainly to the large decrease of iron ore shipments in 1961. All other mineral products shipments diminished in a much smaller degree.

Truck Transportation.—Truck transportation was the most important means of transportation of major nonmetallic mineral products used in construction. In 1962 shipments by truck in total shipment of sand and gravel, crushed stone, portland cement, and blast furnace slag industries were 88 percent, 69 percent, 62 percent,

TABLE 39.—Rail and water transportation of mineral products in the United States, by products

(Thousand short tons)

Product	Rail[1]			Water[2]		
	1960	1961	Change from 1960 (percent)	1960	1961	Change from 1960 (percent)
Metals and minerals, except fuels:						
Iron ore	96,847	77,417	−20.0	70,552	56,668	−19.7
Iron and steel scrap	20,279	23,390	+15.3	1,739	1,898	+9.1
Metals and alloys	10,133	10,337	+2.0	}		
Other ores and concentrates	20,626	19,897	−3.5	} 4,318	[5] 3,899	−9.7
Other scrap	2,332	1,971	−15.5	}		
Slag	5,776	4,967	−14.0	1,190	646	−45.7
Sand and gravel	61,967	62,276	+.5	} 59,750	58,230	−2.5
Stone, crushed except limestone	50,705	53,056	+4.6	}		
Limestone, crushed	16,161	15,017	−7.1	28,886	26,783	−7.3
Cement	27,983	24,347	−13.0	5,563	5,701	+2.5
Phosphate rock	24,321	23,085	−5.1	2,798	2,680	−4.2
Clays	9,322	9,237	−.9	2,024	1,756	−13.2
Sulfur	3,203	2,893	−9.7	4,007	4,095	+2.2
Other	27,904	22,807	−18.3	3,646	4,036	+10.7
Total	377,559	350,697	−7.1	184,473	[5] 166,392	−9.8
Mineral fuels and related products:						
Coal:						
Anthracite[3,4]	16,839	14,963	−11.1	633	320	−49.4
Bituminous[3]	304,500	296,884	−2.5	132,230	127,182	−3.8
Coke[3]	16,453	14,328	−12.9	448	331	−26.1
Crude petroleum	1,888	2,027	+7.4	74,138	78,297	+5.6
Gasoline	7,531	6,861	−8.9	92,618	92,515	−.1
Distillate fuel oil	} 7,279	6,369	−12.5	74,004	77,989	+5.4
Residual fuel oil	}			49,666	44,986	−9.4
Kerosene	} 18,747	18,292	−2.4	9,255	9,146	−1.2
Other	}			16,591	17,969	+8.3
Total	373,237	359,724	−3.6	449,583	448,735	−.2
Total mineral production	750,796	710,421	−5.4	634,056	[5] 615,127	−3.0
Grand total, all products	1,232,534	[5] 1,186,385	−3.7	760,573	732,825	−3.6
Mineral products, percent of grand total:						
Metals and minerals, except fuels	30.6	29.6	−1.0	24.3	22.7	−1.6
Mineral fuels and related products	30.3	30.3	----------	59.1	61.2	+2.1
Total mineral products	60.9	59.9	−1.0	83.4	83.9	+.5

[1] Revenue freight originated excluding forwarder and less than carlot shipments, for which data are not available. Source: Interstate Commerce Commission, Freight Commodity Statistics, Class I Steam Railways in the United States, for years ended Dec. 31, 1960, and 1961. Statements 61100 and 62100.
[2] Domestic traffic—all commercial movements between any point in the 50 States or the U.S. territories and possessions and any other points. Traffic with Panama Canal Zone, Virgin Islands, and Defense Department vehicles carrying military cargoes excluded. Source: Department of the Army, Waterborne Commerce of the United States, calendar year 1960 and calendar year 1961, pt. 5, National Summaries.
[3] Figures for rail shipments include briquets. For water shipments, briquets not reported by type of material; included with "Other".
[4] The rail statistics include anthracite to breakers and washeries (thousand short tons): 1960–6,940; 1961—5,727.
[5] Revised figure.

and 67 percent, respectively. The quantities of sand and gravel, crushed stone, and portland cement shipped by truck increased over the 1961 shipments, and all reached new peaks, but blast furnace slag shipments decreased continuously.

FOREIGN TRADE

Value.[12]—Nonfuel mineral imports gained 2 percent in value over 1961. Metals and metallic ore imports increased 8 percent, the large

[12] Due to the 1962 revision in United Nations Standard International Trade Classification (SITC), 1962 data of value of foreign trade are not directly comparable with previous years. For cross reference, see United Nations Standard International Trade Classification Revised Series M. No. 34, 1962. Starting 1963 table on Value of Foreign Trade will be presented in new United Nations SITC classification.

TABLE 40.—Indexes of average freight rates on carload traffic 1959–1960 and average revenue per ton, originated or terminated, 1959–61 in the United States

Item	Indexes [1] (1950-100)		Average revenue per ton [2] (dollars)		
	1960	1961	1959	1960	1961
Products of mines	115	116	3.13	3.03	3.03
Iron ore	138	141	2.46	2.34	2.24
Clay and bentonite	133	132	8.17	8.18	8.20
Sand, industrial	127	127	3.60	3.45	3.44
Gravel and sand, n.o.s	114	113	1.38	1.38	1.32
Stone and rock, broken, ground, and crushed	115	116	1.69	1.67	1.67
Fluxing stone and raw dolomite	140	142	1.96	2.01	2.03
Salt	114	113	6.84	9.34	6.77
Phosphate rock	95	95	2.15	1.97	2.00
Mineral nanufactures and miscellaneous [3]	115	113	11.54	11.66	11.57
Fertilizers, n.o.s	111	110	8.12	7.76	7.80
Iron, pig	133	128	5.33	5.17	4.98
Cement, natural and portland	85	83	3.74	3.38	3.47
Lime, n.o.s	124	123	6.23	5.94	5.74
Scrap iron and scrap steel	127	128	4.43	4.06	4.11
Furnace slag	110	113	1.88	1.82	2.07
Nonmineral categories:					
Products of agriculture	112	111	8.39	7.93	7.60
Animals and products	116	113	23.92	24.22	23.10
Products of forests	124	124	8.33	8.22	7.84
Forwarder traffic	122	122	41.83	38.92	37.87
All commodities	116	114	6.94	6.67	6.80

[1] U.S. Interstate Commerce Commission, Bureau of Transport Economics and Statistics. Index of Average Freight Rates on Carload Traffic.
[2] U.S. Interstate Commerce Commission, Bureau of Transport Economics and Statistics. Freight Commodity Statistics, Class I Steam Railways in the United States. Statements 60100, 1959; 61100, 1960; and 62100, 1961.
[3] All manufactures and miscellaneous.

TABLE 41.—Great Lakes shipping

(Million short tons in dry cargo ships)

Commodity	1958	1959	1960	1961
Iron ore and concentrates	52.7	45.9	68.4	55.1
Bituminous coal and lignite	32.2	32.6	33.1	31.3
Crushed limestone	20.4	23.9	25.5	23.5
Building cement	1.9	2.3	2.1	2.0
Sand, gravel, and crushed rock	1.0	1.6	1.4	.8
All other commodities	5.9	10.4	6.2	5.8
Total	114.1	116.7	136.7	118.5

Source: U.S. Department of Commerce, Maritime Administration. Domestic Oceanborne and Great Lakes Commerce of the United States. 1961, p. 20.

TABLE 42.—Truck transportation of mineral products in the United States, by major products

(Thousand short tons)

Year	Sand and gravel		Crushed stone		Portland cement		Blast furnace slag [1]	
	Shipments by truck	Percent trucked of total shipment	Shipments by truck	Percent trucked of total shipment	Shipments by truck 1,000 barrels	Percent trucked of total shipment	Shipments by truck	Percent trucked of total shipment
1958	579,697	84.7	344,858	64.7	106,444	34.7	18,280	67.5
1959	637,436	87.3	380,653	65.4	128,455	38.3	17,950	66.0
1960	622,988	87.8	417,706	68.0	147,204	47.1	19,492	68.1
1961	672,360	89.4	420,263	68.1	182,121	56.8	17,360	67.6
1962	686,386	88.4	453,869	69.4	204,183	61.5	15,614	66.6

[1] National Slag Association.

Source: U.S. Bureau of Mines.

65-percent increase in refined copper imports being the principal factor. Nonfuel-nonmetallic mineral imports sustained a 22-percent decline from 1961. The reduction of diamond and asbestos imports caused the considerable loss.

The value of nonfuel mineral exports dropped 31 percent below 1961 exports. Metals and metallic ore exports declined 35 percent from 1961. The sharp reductions of exports of iron and steel scrap, nonferrous and refined copper scrap, and, to a lesser extent, of molybdenum were responsible for the decline. Nonmetallic minerals gained nearly 2 percent in 1962.

Tariffs.—On February 12, the President concurred with the October 2, 1961, U.S. Tariff Commission judgment that no change be made in import quotas of lead and zinc or in the tariff rates for these metals and their minerals.

On April 18, the Tariff Commission reported the results of an investigation concerning the alleged injury to the U.S. portland cement industry by imports from the Dominican Republic to the United States at less than fair market value, under the meaning of section 201(a) of the Antidumping Act, 1921, as amended. It was determined by the Commission that the U.S. industry was not being, and not likely to be, injured or prevented from being established by the importation.

On May 2, the Commission released a report on its fluorspar investigation conducted under section 332 of the Tariff Act of 1930, made pursuant to Senate Resolution 206 of the 87th Congress adopted September 23, 1961. The report described the production, reserves, exports, imports, prices, and consumption of fluorspar in the United States. It also discussed channels of distribution, employment, wages, financial experience, and the Government purchase and assistance program for the domestic industry. The U.S. position in world production was also given. In May and August, the Commission released five similar detailed reports of its investigations on mercury (May 9), lead and zinc (May 15), cobalt (August 15), beryllium (August 29), and manganese (August 31) conducted under the same Senate resolution.

On October 1, in accordance with paragraph 1 of Executive Order 10401 of October 14, 1952, the Tariff Commission submitted to the President the third report on the development in trade of unmanufactured lead and zinc since the escape clause action of October 1, 1958. The Commission advised that no change be made in import quotas for these metals or in tariff rates for metals and minerals.

On October 11, the Trade Expansion Act of 1962 was enacted. It did not reduce tariffs, but it gave the President the power to negotiate with other countries for such reduction in exchange for reciprocal concessions and the power to raise tariffs in retaliation against any country which placed "unreasonable or unjustifiable" restrictions on imports from the United States. The Act also greatly broadened the Presidential power to reduce tariffs. Any duty could be reduced by 50 percent, and those that were at a rate of less than 5 percent could

707-626—63——4

TABLE 43.—Value of minerals and mineral products imported and exported by the United States, 1960–62 by commodity groups and commodities [1]

(Thousand dollars)

SITC No.[2]	Group and commodity	Imports for consumption [3]			Exports of domestic merchandise [4]		
		1960	1961	1962	1960	1961	1962
	Metals (crude): [5]						
281-01	Iron ore and concentrates	321,713	250,254	324,728	57,575	53,823	62,833
282-01	Iron and steel scrap	6,386	7,696	6,109	244,579	356,509	151,882
	Ores of nonferrous base metals and concentrates:						
283-07	Manganese	82,262	78,430	66,273	719	1,054	1,012
283-11	Tungsten	3,478	1,994	2,870	1,251	250	80
283-06	Tin	31,104	21,923	13,595	--------	--------	--------
283-01	Copper	229,264	110,285	13,032	6,832	2,475	1,045
283-08	Chromium	24,239	21,444	23,699	320	516	108
283-05	Zinc	43,666	34,711	40,543	3	124	46
283-03	Bauxite (aluminum ore) and concentrates	78,065	88,821	122,190	2,588	12,189	19,874
283-04	Lead	27,911	24,385	21,152	168	448	235
[6] 283-19	Columbium	3,687	2,306	3,405	150	52	13
283-02	Nickel	2,275	93	148	--------	495	16
[6] 283-19	Titanium:						
	Ilmenite	5,066	4,604	4,471 }			
	Rutile	3,611	2,544	2,646 }	167	190	167
[6] 283-19	Cobalt	--------	--------	56	1,313	1,881	997
[6] 283-19	Molybdenum	--------	--------	--------	39,843	48,758	22,901
[6] 283-19	Other	6,512	7,196	10,439	3,097	1,959	1,325
	Nonferrous metal scrap:						
284-01	Aluminum	1,598	1,738	1,864	26,905	26,452	20,183
	Old and scrap copper	3,524	874	2,725	31,384	18,031	6,760
	Old brass and bronze and clippings	184	174	738	[7] 52,220	[7] 52,226	[7] 15,525
	Other, not elsewhere included	3,804	1,844	4,395	6,081	4,916	4,280
285-02	Platinum-group metals	12,949	10,446	11,278	--------	--------	--------
	Total metals (crude)	891,298	[11] 671,762	676,356	475,195	582,348	309,282
	Metals (unwrought): [5] [8]						
681-01	Pig iron and sponge iron	18,992	21,199	11,636	5,354	19,400	8,563
681-02	Ferroalloys:						
	Ferromanganese	19,008	34,385	16,631	203	146	629
	Ferrochromium	14,313	7,612	10,023	5,249	2,838	1,182
	Other	1,876	1,369	3,075	4,977	9,726	3,407
682-01	Copper	117,763	142,181	234,521	273,757	252,262	202,105
687-01	Tin	87,854	98,205	103,740	1,294	1,264	840
684-01	Aluminum	75,808	91,187	128,560	128,199	57,638	66,621
683-01	Nickel (including scrap)	116,679	169,831	175,925	--------	--------	--------
686-01	Zinc	29,646	27,569	28,685	18,389	11,421	8,290

685-01	Lead	70,335	61,441	45,723	865	610	616
	Cobalt	17,093	14,867	17,073	(9)	(9)	(9)
689-01	Mercury	3,510	4	10	83	71	64
	Other nonferrous base metals	17,592	15,755	11,109	29,695	23,172	19,008
671-02	Platinum-group metals, including unworked and partly worked	21,185	26,394	21,424	4,840	2,909	1,973
	Total metals (unwrought)	611,654	[11] 711,999	808,135	472,905	[11] 381,457	313,298
	Total metals (crude and unwrought)	1,502,952	[11] 1,383,761	1,484,491	948,100	[11] 963,805	622,580
	Nonmetals (crude):						
[6] 672-01	Diamonds:						
[6] 272-07	Gems, rough or uncut	88,060	116,077	102,446	830	1,533	1,583
	Industrial	51,727	68,965	51,040	1,297	1,822	2,268
	Total	139,787	185,042	153,486	2,127	3,355	3,851
272-12	Asbestos, crude, washed or ground	63,345	58,942	13,957	845	708	578
271-02	Sodium nitrate	11,459	15,862	14,208	----	----	----
272-13	Mica, unmanufactured (including scrap)	7,547	7,410	8,905	113	142	166
[6] 272-14	Fluorspar	14,393	13,644	15,717	38	30	119
272-11	Stone for industrial uses, except dimension	9,443	9,555	11,488	687	731	736
272-06	Sulfur	15,457	17,173	20,575	42,262	36,624	37,295
271-03	Phosphates, natural, ground or unground	2,754	2,629	3,556	37,543	36,910	38,832
272-04	Clays	641	16,705	2,541	13,708	14,285	16,856
(10)	Other nonmetals (except fuels)	25,912	27,484	28,231	33,058	38,626	35,135
	Total nonmetals (crude)	290,738	354,446	272,664	130,381	131,411	133,568
	Grand total	1,793,690	[11] 1,738,207	1,757,155	1,078,481	[11] 1,095,216	756,148

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

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

[2] Due to change in SITC classifications, figures for 1962 are not directly comparable with previous figures. For cross reference see United Nations, Department of Economic and Social Affairs, Standard International Trade Classification Revised. Series M., No. 34.

[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.

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

[5] Excludes gold and silver.

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

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

[8] Includes alloys.

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

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

[11] Revised figure.

Source: U.S. Department of Commerce, Bureau of Census.

be eliminated. Duties on articles for which 80 percent of the world trade was accounted for jointly by the United States and the European Economic Community could also be eliminated. The old peril point procedure, which set a limit below which duties could not be cut, was replaced by this new procedure. Duties on mineral products became negotiable items as a result of this new legislation.

During 1962, the Office of Emergency Planning had no applications under consideration from any mineral industry under section 8 of the Trade Agreements Act, the so-called national defense clause.

RESEARCH AND DEVELOPMENT

Source of Funds.—Total research and development funds in the United States were expected to approximate $16.5 billion, a 12-percent increase over those of 1961. The total research and development fund was $14.74 billion in 1961, of which $9.65 billion was contributed by the Federal Government, $4.71 billion by industry, and $385 million by colleges, universities, other nonprofit institutions, and State and local governments.

Research and development funds have increased in relation to the gross national product (GNP) from 1.41 percent in 1953 to 2.97 percent in 1962. The following tabulation shows total research and development funds in percentage relationship to GNP at current prices for the period 1953–62.

Year:	*Percent of GNP*
1953	1. 41
1954	1. 55
1955	1. 61
1956	2. 07
1957	2. 28
1958	2. 50
1959	2. 63
1960	2. 76
1961	2. 86
1962 preliminary	2. 97

Source: National Science Foundation and Department of Commerce, Office of Business Economics.

The bulk of total funds for research and development has been going to a narrow segment of industry. About 80 percent or more has been and is directed for aircraft and missiles, electronics, and chemical and machinery industries. Much of the research effort was of the end-use variety and was oriented toward defense, national security, and aerospace programs. Only a small fraction of the total research money was directed toward studies on utilization and improvement of metals and minerals including fuels. Even including investigations in such allied fields as solid state physics, the total research expenditure for metals and nonfuel mineral materials barely reached $500 million in 1962. An additional $200 million was spent by industry and Federal Government for development of minerals recovery and processing methods. About $350 million was spent on fuels, principally petroleum refining, exploration, and extraction. An estimated total of $1.05 billion was spent on research and development in the mineral industries in 1962 and accounted for only 6.6 percent of all research and development expenditures.

Industry's share of contracted Federal funds for all research and development increased from $5.6 billion in 1959 to $6.4 billion in 1961 and continued to be 59 percent of total as in 1959. Most Federal research and development expenditures were devoted to defense, national security, and space. Consequently, 91 percent of the total research and development funds for the aircraft and missiles industry and 66 percent of the research and development funds for electrical equipment and communications were Federal funds in 1961. These two categories accounted for 80 percent of total Federal expenditures for research and development in 1961. The Government contributed 9 percent of the total research and development funds in the primary metals industry (3 percent in the primary ferrous metals industry and 18 percent in the primary nonferrous metals industry), 10 percent in petroleum refining and extraction, and 7 percent in stone, clay, and glass products during 1961.

TABLE 44.—Funds for performance of research and development, by industry and source, 1960 and 1961

(Million dollars)

Industry [1]	Total research and development funds			Federal Government			Company [2]		
	1960 [3]	1961	Percentage change 1960–61	1960 [3]	1961	Percentage change 1960–61	1960 [3]	1961	Percentage change 1960–61
Total	10,546	10,891	+3.3	6,127	6,436	+5.0	4,419	4,455	+.8
Chemicals and allied products	998	1,092	+9.4	182	218	+19.8	816	874	+7.1
Industrial chemicals	663	695	+4.8	128	133	+3.9	535	562	+5.0
Drugs and medicines	165	181	+9.7	(4)	(4)	(4)	(4)	(4)	(4)
Other chemicals	170	216	+27.1	(4)	(4)	(4)	(4)	(4)	(4)
Petroleum refining and extraction [5]	298	308	+3.4	26	32	+23.1	272	276	+1.5
Stone, clay, and glass products	(4)	104	(4)	8	7	(4)	(4)	97	(4)
Primary metals	160	161	+.6	16	15	−6.3	144	146	+1.4
Primary ferrous products	93	95	+2.2	2	3	+50.0	91	92	+1.1
Nonferrous and other metal products	67	66	−1.5	14	12	−14.3	53	54	+1.9
Fabricated metal products	107	106	−.9	33	30	−9.1	74	76	+2.7
Machinery	962	924	−4.0	378	290	−23.3	584	634	+8.6
Electric equipment and communication [6]	2,415	2,377	−1.6	1,603	1,565	−2.4	812	812	0.0
Aircraft and missiles [7]	3,637	3,964	+9.0	3,198	3,615	+13.0	439	349	−20.5
Professional and scientific instruments	400	385	−3.8	202	167	−17.3	198	218	+10.1
Other manufacturing industries	(4)	162	(4)	(4)	110	(4)	(4)	52	(4)
Nonmanufacturing industries	160	189	+18.1	118	151	+28.0	42	38	−9.5

[1] Industries are arranged in accordance with their Standard Industrial Classification (S.I.C.) Code Number, as for example, food and kindred products, 20; textiles and apparel, 22 and 23.
[2] Research and development performance financed by companies excludes by definition those research and development funds contracted by industrial firms to outside organizations. Research and development conducted by outside organizations financed by industrial firms annually amount to about 4 percent of company-financed research and development for all industries.
[3] Revisions in the 1960 figures as compared to those previously published are described in the National Science Foundation. Reviews of Data on Research & Development. No. 36, September 1962, p. 2.
[4] Not separately available but included in total.
[5] Geological and geophysical exploration activities of petroleum companies are excluded from the definition of research and development.
[6] Includes S.I.C. codes 48 and 36.
[7] Includes S.I.C. codes 372 and 19.

Source: National Science Foundation. Review of Data on Research & Development. No. 36, September 1962, p. 6.

Funds for research and development by private industry, including funds from the Federal Government, increased 14 percent—from $9.6 billion in 1959 to $10.9 billion in 1961. The primary ferrous metals industry increased expenditures by 27 percent, from $75 million in 1959 to $95 million in 1961. The primary nonferrous metals industry spent only 5 percent more, from $63 million in 1959 to $66 million in 1961. The stone, clay, and glass products industry outlays for research and development gained 44 percent, from $72 million in 1959 to $104 million in 1961. The petroleum refining and extraction industry research and development expenditures gained 13 percent during the same period. Research and development for mining alone is included in the above data but is indistinguishable in the nonmanufacturing industries category.

TABLE 45.—Percent distribution of funds for the performance of basic research, applied research, and development by industry and size of company 1960 [1]

(Million dollars)

Industry and size of company	Total research and development funds	Percent distribution			
		Total	Basic research	Applied research	Development
Total	$10,546	100	4	20	76
Distribution by industry:					
Chemicals and allied products	1,000	100	12	42	46
Industrial chemicals	664	100	12	43	45
Drugs and medicines	171	100	17	52	31
Other chemicals	165	100	6	27	67
Petroleum refining and extractions	298	100	18	40	41
Primary metals	162	100	6	44	50
Primary ferrous products	93	100	7	(2)	(2)
Nonferrous and other metal products	69	100	4	46	50
Fabricated metal products	112	100	1	30	69
Machinery	949	100	2	13	84
Electrical equipment and communications	2,434	100	3	12	84
Motor vehicles and other transportation equipment	852	100	1	(2)	(2)
Aircraft and missiles	3,621	100	1	14	85
Professional and scientific instruments	399	100	2	24	74
Other manufacturing industries	243	100	4	21	75
Manufacturing industries	154	100	(2)	27	63
Distribution by size of company (based on number of employees):					
Less than 1,000	578	100	(2)	17	78
1,000 to 4,999	855	100	5	31	64
5,000 or more	9,114	100	3	19	78

[1] With regard to the estimates of relative amounts of applied research and development performance, the relatively high imputation rates characterizing the data for most industries should be taken into account.
[2] Not separately available but included in total.

Source: National Science Foundation. Research and development in industry 1960. N.S.F. 63-7, p. 29.

Bureau of Mines.[13]—Expenditures by the Bureau of Mines for research and development during fiscal year 1963 increased 17 percent over the previous year, from $27.0 million in fiscal year 1962 to $31.6 million in fiscal year 1963.

[13] Detailed descriptions of Bureau's metals and nonmetals research and development are available in the following articles which appeared in November and December 1961 and January 1962 issues of Mining Engineering and the Journal of Metals, prepared by the Bureau's Division of Minerals, as follows: (1) The Mineral Research Program of the Bureau of Mines, by Charles W. Merrill, (2) Bureau of Mines Metallurgical Research, by H. G. Iverson, and (3) Metals and Nonmetal Mining Research in Bureau of Mines, by Thomas E. Howard.

Bureau of Mines obligations for total mineral research and development during fiscal years 1961, 1962, and 1963 were $19.2 million, $20.5 million, and $22.6 million, respectively. During this period, the percentage of total research obligations for engineering sciences was 76.4 percent; physical sciences, 21.6 percent; mathematical sciences, 0.8 percent; biological sciences, 0.6 percent; and social sciences, 0.6 percent.

TABLE 46.—Bureau of Mines expenditures for mining and mineral research and development

(Thousand dollars)

Fiscal year	Applied research	Basic research	Development	Total
1959	14,370	3,600	6,015	23,985
1960	14,392	3,602	6,030	24,024
1961	15,320	3,830	6,386	25,536
1962 [1]	16,210	4,045	6,715	26,970
1963 [2]	18,945	4,735	7,893	31,573

[1] Revised figures.
[2] Estimated figures.

Source: Bureau of Mines, Budget Office.

TABLE 47.—Bureau of Mines obligations for total research, by field of science

(Thousand current dollars)

	Fiscal years		
	1961	1962 [1]	1963 [1]
Engineering sciences	14,698	15,596	17,300
Physical sciences	4,076	4,465	4,921
Mathematical sciences	148	161	170
Biological sciences	110	120	125
Social sciences	118	125	130
Total research	19,150	20,467	22,646

[1] Estimated.

Source: National Science Foundation. Federal Funds for Science XI, Fiscal Year 1961, 1962, and 1963 pp. 116, 118, 120.

Bureau of Mines obligations for total mineral research and development during fiscal year 1963 were estimated to be 10.6 percent higher than those of 1962, compared to an increase of 6.9 percent for 1962 over 1961. The breakdown by sciences of the fiscal yearly gain over previous fiscal years was as follows:

	1962 over 1961, percent	1963 over 1962, percent
Engineering sciences	6.1	10.9
Physical sciences	9.5	10.2
Mathematical sciences	8.8	5.6
Biological sciences	9.1	4.2
Social sciences	5.9	4.0
Total research	6.9	10.6

During fiscal years 1961, 1962, and 1963, Bureau of Mines obligated expenditures averaged 6 percent of the total Federal obligated expenditures for metallurgy and materials research and development as compiled by the National Science Foundation of $80.6, $87.5, and $99.5 million, respectively, and averaged about 1.5 percent of the basic research part of the total.[14] During the same years, the Department of Defense expended 72, 70, and 70 percent of the total and 53, 52, and 50 percent of the basic research part of the total. Atomic Energy Commission spent 20, 22, and 22 percent of the total and 37, 38, and 39 percent of its basic research part of the total. Bureau of Mines ranks third in total and fifth in basic research in metallurgy and materials.

TABLE 48.—Federal obligated funds for metallurgy and materials research and development

(Thousands of dollars)

Federal agency	Fiscal year 1961		Fiscal year 1962		Fiscal year 1963	
	Basic research	Total research and development	Basic research	Total research and development	Basic research	Total research and development
Department of Defense	10,526	57,676	12,212	61,040	13,411	69,271
Atomic Energy Commission	7,417	16,312	8,977	19,204	10,589	21,632
Bureau of Mines	335	4,674	359	4,960	397	5,536
National Science Foundation	948	948	1,189	1,189	1,765	1,765
Department of Commerce [1]	492	667	546	763	709	945
Other	79	314	81	342	83	297
Total	19,797	80,591	23,364	87,498	26,954	99,446

[1] Principally Bureau of Standards.

Source: National Science Foundation.

Basic Research, Applied Research, and Development.—The research and development program of industrial firms was directed mainly toward research having specific applications rather than basic research, which adds to scientific knowledge without any particular commercial relevance. The primary ferrous metals industry and primary nonferrous metals industry devoted a comparatively small part of research and development funds toward basic research, with $6.5 million and $2.8 million, respectively, in 1960.[15] Private basic research averaged only 4 percent of the total research and development performances in each year 1953 to 1960. Federal funds for basic research accounted for 54 to 57 percent of the annual expenditure for the total basic research performed in the economy.[16] From 1958 through 1963, the Bureau of Mines spent 15 percent of its research and development expenditures on basic research, 25 percent on applied research, and 60 percent on development.

Scientific and Technical Personnel.—There were 387,000 full-time equivalent scientists and engineers in research and development in 1960. The Federal Government[17] employed 41,800 scientists and

[14] National Science Foundation revised the classification of this subgroup. Therefore they are not comparable to previous data. National Aeronautics and Space Administration (NASA) expeditures were deleted by this reclassification.

[15] Stone, clay, and glass products industries expenditures were not separately available in 1960, but were included in the total.

[16] Besides industry and Federal Government, colleges, universities, and other nonprofit institutions are the other sources of funds used for basic research.

[17] Limited to civilian personnel.

engineers, industry employed 286,000, colleges and universities employed 52,000, and other nonprofit institutions employed 7,000.[18]

On October 1, the Bureau of Mines employed 1,521 full-time scientific and technical personnel in research and development; 554 were engineers and 967 were physical scientists and other scientists and technicians.

Mineral related industries, including petroleum, employed 18,800 full-time equivalent scientists and engineers in January 1962,[19] or 5.9 percent of the total full-time equivalent in all the industries. Stone, clay, and glass products industries employed 1.3 percent of the total; primary ferrous metals industry, 1.0 percent; primary nonferrous metals industry, 0.7 percent; and the petroleum refining and extraction industry, 2.9 percent of the total.

TABLE 49.—Equivalent number of full-time research and development scientists and engineers, by industry,[1] 1961 and 1962

Industry [2]	January 1961	January 1962	Change from January 1961 (percent)
Chemicals and allied procduts	34,300	36,300	+5.8
Industrial chemicals	20,800	21,300	+2.4
Drugs and medicines	6,200	6,600	+6.5
Other chemicals	7,300	8,400	+15.1
Petroleum refining and extraction [3]	9,000	9,200	+2.2
Stone, clay, and glass products	(4)	4,300	(4)
Primary metals	5,500	5,300	−3.6
Primary ferrous products	3,100	3,100	------------
Nonferrous and other metal products	2,400	2,200	−8.3
Fabricated metal products	4,300	4,600	+7.0
Machinery	32,100	33,200	+3.4
Electrical equipment and communication [5]	71,400	73,400	+2.8
Aircraft and missiles [6]	83,300	91,200	+9.5
Professional and scientific instruments	13,800	14,000	+1.4
Other manufacturing industries	(4)	6,400	(4)
Nonmanufacturing industries	7,600	8,300	+9.2
Total	304,400	319,900	+5.1

[1] Data on the employment of scientists and engineers include those engaged full time in research and development and the full-time equivalent of those working part time in research and development.
[2] Industries are arrayed in accordance with their Standard Industrial Classification (SIC) Code numbers, as for example, food and kindred products, 20; textiles and apparel, 22 and 23.
[3] Geological and geophysical exploration activities of petroleum companies are excluded from the definition of research and development.
[4] Not separately available but included in total.
[5] Includes SIC Code numbers 48 and 36.
[6] Includes SIC Code numbers 372 and 19.

Source: National Science Foundation. Reviews of Data in Research and Development. No. 36, September 1962.

DEFENSE MOBILIZATION

Defense Production Act (DPA).[20 21]—The Defense Production Act was extended for a period of 2 years, from June 30, 1962 to June 30, 1964. Of the $2, 208. 5 million authorized borrowing authority, appropriations, and transfers, only $6.7 million had not been allocated by the Office of Emergency Planning (OEP) and predecessor agencies to the delegated agency. All of the authorized borrowing authority had

[18] Including professional research personnel employed at research centers administered by organizations under contract with Federal agencies.
[19] The number of scientists and engineers employed by the mining industry was included in nonmanuacturing industries.
[20] Executive Office of the President, Office of Emergency Planning. Report on Borrowing Authority. December 31, 1962, pp. 6-13.
[21] Joint Committee on Defense Production. 12th Annual Report. S. Rept., 87th Congress, 2d sess,. January 1963.

been committed by the delegated agencies at the end of 1962 except $114.2 million, which remained available for new programs. The probable ultimate net cost of the metals and minerals program as of December 31 was $840 million. Adding custodial costs, U.S. Treasury interest, administrative expense, and loss such as in disposal of assets, and depreciation increased the total cost of the DPA program since its inception to about $1,309 million.

National (Strategic) Stockpile Program.[22]—On February 7, the President appointed a Cabinet-level Executive Stockpile Committee to review the principles and policies that should guide the program for the stockpile of strategic materials and its relationship to the national security.

During 1962, the Committee made several recommendations to the President.[23] Two major revisions of the stockpile policy occurred during 1962.

(1) The security classification on stockpile materials objectives and quantities in all inventories on hand was removed by the Office of Emergency Planning (OEP) in March.[24]

(2) On April 25, OEP issued an amendment to Defense Mobilization Order V–7, General Policies for Strategic and Critical Material Stockpiling.[25] The amendment eliminated the implicit veto power of other agencies in stockpile disposal. The various interested Federal agencies were still being consulted, however. Any objections of the U.S. Department of State and the U.S. Department of the Interior which, after discussion, the Director of OEP did not support would be presented to the President for consideration. The amendment also added the clause "avoidance of adverse effects upon domestic employment and labor dispute."

In 1962 OEP, in cooperation with Federal departments and agencies having emergency mobilization responsibilities to develop supply requirements, initiated studies of the strategic materials for both limited and general (nuclear) wars. The revised limited war requirements of the form "Controlled Materials"—steel, aluminum, copper, and nickel—were completed by the end of 1962. These revised requirements data constituted a basic reference in analyzing the supply-requirements position of a larger proportion of the stockpile items, the objectives of which were scheduled for review during 1963. Stockpile objectives, as computed, were keyed primarily to limited war conditions, when most domestic production capacity would probably be available, but foreign supplies might be interrupted. Existing maximum stockpile objectives would be expected to meet less than one-third of the total requirements for a 3-year war period. The maximum National (Strategic) Stockpile objective was $4.2 billion as of December 31, of which $2.1 billion was for basic objectives. The acquisition cost of Government inventories of strategic and critical materials was $8.8 billion. The market value of Govern-

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[22] Executive Office of the President, Office of Emergency Planning. Stockpile Report to the Congress. January–June 1962 and July–December 1962.

[23] Refer to the following section "Barter Program".

[24] In strategic stockpile inventories data as of December 31, 1961. Wang, Kung-Lee. Review of the Mineral Industries (Metals and Nonmetals except Fuels); BuMines Minerals Yearbook 1961. V. I, 1962, p. 40. 1962 data are available in Executive Office of the President, Office of Emergency Planning. Statistical Supplement, Stockpile Report to the Congress, July-December 1962.

[25] Office of Emergency Planning. General Policies for Strategic and Critical Material Stockpiling. OEP Stockpile Report to the Congress, January-June 1962. DMO V–7, pp. 22–23.

TABLE 50.—Summary of Government inventories of raw materials, at acquisition cost and at market value

(Million dollars)

Type of acquisition	Inventory, June 30, 1961 [1]			Inventory, June 30, 1962 [2]		
	Total		Excess over stockpile objective, acquisition cost	Total		Excess over stockpile objective, acquisition cost
	Acquisition cost [3]	Market value [4]		Acquisition cost [3]	Market value [4]	
National stockpile (Public Law 520):						
Stockpile grade	5,800	5,679	1,932	5,756	5,437	1,892
Nonstockpile materials	307	146	307	294	150	294
Total	6,107	5,825	2,239	6,050	5,587	2,186
DPA inventory (Public Law 744):						
Stockpile grade	1,090	840	850	1,104	774	860
Nonstockpile materials	392	120	392	392	127	392
Total	1,482	960	1,242	1,496	901	1,252
Supplemental stockpile (Public Law 480):						
Stockpile grade	929	[5] 878	777	[5] 1,118	1,019	956
Nonstockpile materials	22	20	22	23	17	23
Total	951	898	799	1,141	1,036	979
Commodity Credit Corporation inventory (Public Law 608):						
Stockpile grade	108	106	50	94	89	40
Nonstockpile materials	1	1	1	6	6	6
Total	109	107	51	100	95	46
Federal Facilities Corporation (Public Law 608):						
Stockpile grade tin	10	10	10			
Totals:						
Stockpile grade	7,937	7,513	3,619	8,072	7,319	3,748
Nonstockpile materials	722	287	722	715	299	715
Total	8,659	7,799	4,341	8,787	7,618	4,463

[1] Joint Committee on Defense Production. 11th Annual Report. S. Rept. 1, 87th Cong., 2d sess., Jan. 23, 1962, p. 23.
[2] Joint Committee on Defense Production. 12th Annual Report. S. Rept. 1, 87th Cong., 2d sess., January 1963, p. 43.
[3] Acquisition cost of inventories includes open-market purchases at contract prices, intradepartmental transfers at market prices prevailing at time of transfer, transportation to first permanent storage location, beneficiating and processing costs, but does not cover cost of research, administrative and interest expenses, accessorial cost, storage, and handling.
[4] Because of mixed nature of individual commodities (types, quality, and grades) and lack of active trading in these materials, the market value of commodities not meeting stockpile specification and of inventory not having stockpile objectives was not calculated.
[5] Includes transfer of $27,500,000 (26,700,000 material cost and 800,000 accessional cost from the U.S. Department of the Interior inventory acquired under Public Law 733).

ment inventories was $7.5 billion at the end of 1962, of which $3.3 billion was in excess of maximum strategic objectives.

The value of metals and minerals delivered to the national stockpile during 1962 amounted to $3.6 million, of which $2.4 million helped fulfill stockpile objectives. Government cash commitments for delivery of materials involving cobalt and copper that exceeded maximum stockpile objectives were reduced by $3 million by June 30.

Sales commitments during 1962 for disposing of excess and offgrade strategic materials from the national stockpile and the DPA inventory were about $70.9 million, of which $55.5 million came from the strategic stockpile, $13.5 million from the DPA stockpile, and $1.9 million from the Federal Facilities Corporation stockpile of tin. On

June 21, the Congress approved 14 proposed disposals of materials from the national stockpile, of which 10 were metals and minerals—tin, nickel oxide powder, molybdenum, celestite, nonferrous and platinum scrap, cobalt oxide and carbonates, chromite, ferrovanadium, ferromanganese, electrolytic manganese, and miscellaneous nickel items. During 1962, 11 metals and minerals disposal plans were agreed upon by interested Government agencies. These plans covered DPA aluminum, cadmium, DPA nickel, DPA titanium sponge, low-grade tungsten ores and concentrates, DPA fluorspar and rutile briquets, magnesium ingots, molybdenum, nickel oxide powder, and manganese.

TABLE 51.—National stockpile objectives and inventory

(Value in million dollars at market prices)

Objectives	Objectives, in effect Dec. 31		Applicable inventory, on hand Dec. 31	
	1961	1962	1961	1962
Basic	2,200	2,200	2,100	2,100
Maximum	2,200	2,200	1,900	1,800
Total objectives	4,400	4,400	4,000	3,900
Excess over objectives			1,600	1,500
Outstanding commitments			5	(1)

1 Negligible.

Source: Executive Office of the President, Office of Emergency Planning. Stockpile Report to the Congress. July-December 1961, p. 7; July-December 1962, p. 6.

Office of Minerals Exploration (OME).[26]—Exploration for new domestic sources of strategic and critical mineral commodities continued to be encouraged by Government assistance under the program established in 1958. Among 79 applications received from 13 States by OME under the program of matching Government funds, 22 contracts were executed for gold, lead, zinc, silver, uranium, mercury, platinum, molybdenum, copper, iron ore, columbium, tantalum, and bauxite in 10 States. Five contracts were terminated. At the end of 1962, 32 contracts remained in force, representing maximum Government participation of $1.3 million, and 30 applications were in process.

One major change occurred in OME regulations: On July 1, copper, lead, and zinc were removed from the list of commodities eligible for exploration assistance. Gold and silver, new to the program, led in applications and contracts, displacing base metals.

In-force projects of Defense Minerals Exploration Administration (DMEA), which terminated June 30, 1958, continued to be administered by OME. At the end of 1962, all of 1,159 completed DMEA contracts were in force, of which 399 were certified for discoveries and development. The potential mineral commodities discovered under the DMEA program had an estimated recoverable value of approximately $1 billion at prevailing market prices. Net cost of the program was $32 million by the end of 1962. Royalty receipts of $350,000 per year were anticipated through 1965.

26 U.S. Department of the Interior. Office of Minerals Exploration. Eighth and Ninth Semiannual Reports and 1962 Quarterly Reports of OME.

Lead and Zinc Mining Stabilization Programs.[27]—The President signed Public Law 87–347 on October 3, 1961. The stated purpose of this act was to stabilize the mining of lead and zinc by small producers and, at the same time, conserve domestic resources of both metals in order to assure the Nation's supply in times of emergency.

On July 28, the General Services Administration was delegated to administer the program. Total payments under the law could not exceed the following amounts for the 4 calendar years of the duration of the program.

Year:	*Million*
1962	$4.5
1963	4.5
1964	4.5
1965	3.5

The maximum payment to any small producer was limited to payment on sales equal to his maximum production in any calendar year between January 1, 1950, and December 1960, as well as a maximum-quantities limit for lead and zinc for 1962–65. The payment per pound of lead and zinc was to be 75–55 percent of the difference between 14.5 cents and the average monthly market price per pound of lead and zinc, respectively.

Barter Program.[28 29 30]—The value of barter contracts negotiated by the Commodity Credit Corporation (CCC) in 1962 was $77.4 million; the principal minerals were lead, metallurgical grade Jamaican bauxite, manganese ore, metallurgical grade chromite, thorium nitrate, cadmium, beryllium, and abrasive aluminum oxide. About $125 million of strategic mineral material was delivered to CCC in 1962 together with $3 million of nonstrategic material. There were no additions to the list of mineral materials eligible for barter during 1962.

TABLE 52.—Commodities delivered under U.S. Government purchase regulations [1]

Commodity	Quantity delivered		Cumulation delivered as of Dec. 31, 1962	Total authorized purchases
	1961	1962 [2]		
Public Law 206, 83d Congress:				
Beryl ore short dry tons	310	360	3,268	4,500
Mica [3] (hand-cobbed, mica or equivalent) short tons	2,174	2,067	2,500	2,500
DPA aluminum [4] do	48,919	41,544	842,784	891,994

[1] General Services Administration, Defense Materials Service. Report of Purchases Under Purchase Regulations, as of Dec. 31, 1961, and Dec. 31, 1962. Only commodities listed for which purchases and/or deliveries were made during 1962.

[2] This program terminated June 30, 1962.

[3] The Government terminated by June 30, 1960, all DPA contracts for the procurement of foreign mica.

[4] Office of Emergency Planning. Stockpile Report to the Congress, January-June, July-December 1961–62; Statistical Supplement Stockpile Report to the Congress July-December 1962. p. 12.

On September 25, the President approved the recommendations in the Report on the Barter Program submitted by the Executive

[27] Joint Committee on Defense Production. 12th Annual Report. S. Report, 87th Congress, 2d sess. January 1963, p. 87.

[28] The Joint Committee on Defense Program. 12th Annual Report. 87th Congress, 2d sess., January 1962, pp. 68–71.

[29] U.S. Department of Agriculture, Foreign Agricultural Service, Office of Barter and Stockpile. Published and unpublished records.

[30] U.S. Department of Agriculture. Report on Barter Program submitted to the President by Executive Stockpile Committee. Press release, Sept. 28, 1962.

Stockpile Committee. These recommendations were based on a study by the Committee as part of its continuing consideration of the overall stockpile program. The Committee would reverse the present downward trend of the barter transactions and would carefully control and protect the other broader national objectives, principally foreign policy and balance-of-payments considerations.

The Committee's recommendations envision that future barter will be on a more selective basis than in the past, and that the emphasis will be shifted from the acquisition of strategic and critical materials to its use in various types of off-shore procurement programs and as an aid in assisting some of the lesser developed countries.

While the general rule would be that barter should not be used to acquire strategic and critical materials that are in excess of national stockpile objectives, certain exceptions were approved which will permit such strategic and critical materials to be taken. An example would be where the United States would find it to its advantage to take useful materials in a barter transaction rather than acquire additional foreign currencies.

The Secretary of Agriculture will consult with the Secretary of State and the Secretary of the Treasury, rsepectively, concerning the general impact that the barter program has on foreign policy and balance-of-payments considerations. In certain other specified instances, consultations will be held with appropriate department heads before a barter transaction could be consummated.[31]

WORLD REVIEW

World Production.—The United Nations index of world mining production (including fuels) was rebased from 1953=100 to 1958=100 and increased from 118 in 1961 to 120. The world increase was 1.7 percent compared with the 3.2-percent rise for the United States. Asia gained 3.9 percent over 1961, more than offsetting the 3.4-percent decrease in Latin America, and was primarily responsible for the overall world gain in 1962. Besides Asia, North America (Canada and the United States) was the only area in the world where mining production gained. The Organization for European Economic Cooperation (OEEC) index of mining production generally paralleled the index of the United Nations.

U.S. production and imports of principal minerals were again the dominant and major part of the world supply, following closely the historical trend, and the U.S. total share of the world supply oi these commodities was slightly higher than in 1961.

Free world metal production indexes were as follows in 1961.[32]

Metals:	*Index (1961=100)*
Aluminum	110
Copper	102
Lead	96
Zinc	103
Tin	103
Aggregate nonferrous metals	104
Crude steel	[1] 98

[1] Preliminary figure.

[31] The White House News Release on Barter Program. September 25, 1962.
[32] Source: United Nations Secretariat, Bureau of General Economic Research and Policies, (unpublished).

TABLE 53.—Index of world metal-mining production

(1958=100) [1]

Year	Free world [2]	North America [3]	Latin America [4]	Asia: east and southeast [5]	Europe [6]
1938	66	64	59	95	66
1948	66	77	62	57	51
1954	82	80	77	102	79
1955	94	99	95	106	89
1956	100	104	99	113	96
1957	106	112	107	115	102
1958	100	100	100	100	100
1959	104	100	103	104	98
1960	116	114	118	119	108
1961	118	113	117	129	113
1962	120	115	113	134	111
First quarter	116	106	116	130	114
Second quarter	124	126	112	134	113
Third quarter	124	123	107	137	105
Fourth quarter	[7] 118	[7] 104	[7] 117	[7] 133	[7] 111

[1] Rebased from 1953=100 to 1958=100.
[2] Excluding Albania, Bulgaria, China (mainland), Czechoslovakia, East Germany, Hungary, Mongolia, North Korea, Poland, Romania, the U.S.S.R., and North Viet-Nam.
[3] Canada and the United States.
[4] Central and South America and the Caribbean Islands.
[5] Afghanistan, Brunei, Burma, Ceylon, Singapore, the Federation of Malaya, Hong Kong, India, Indonesia, Iran, Japan, Republic of Korea, Pakistan, Philippines, Sarawak, China (Taiwan), Thailand, and the Republic of Viet-Nam.
[6] Excluding Albania, Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, Romania, and the U.S.S.R.
[7] Preliminary figure.

Source: United Nations Monthly Bulletin of Statistics. V. 17, May 1963, pp. VIII-XVI.

World Consumption.—After several years of expansion, free-world steel production declined in 1962, reducing world consumption of iron ore and several of the steel-making additive metal ores, such as those of manganese and tungsten.

Although the output of the free-world metal-using industries rose 10 percent higher than in 1961, world consumption of most nonferrous metals rose only 5 percent above 1961. United States and Canadian consumption increased about 11 percent, Western European consumption remained the same, and Japanese consumption declined 10 percent from that of 1961.

Free-world copper consumption was 1 percent lower than that in 1961. The continuous increases in consumption by the United States and Canada were unable to overcome the sharp decline in Japanese consumption and the smaller decline in Western European consumption. World consumption of lead and zinc again increased. Western European and Japanese consumption remained nearly the same, whereas U.S. consumption surged ahead and was primarily responsible for the world gain in 1962.

Free-world consumption of aluminum was 15 percent higher than that in 1961. The United States and the Western European countries accounted for all of the gain, whereas Japanese consumption declined 4 percent from 1961. World tin consumption waned slightly in 1962. Again the North American upsurge of 8 percent over that of 1961 was insufficient to overcome the considerable loss in the Federal Republic of Germany and the smaller loss in Japan.

TABLE 54.—Index numbers of production in mining and quarrying, and production in basic metal industries in selected OEEC countries

(1953=100)

Year	All member countries	Europe	Austria	Belgium	France	West Germany: Excluding Saar [1]	West Germany: Saar [2]	Canada [2]	Italy	Netherlands	Norway	Sweden	United Kingdom
Mining and quarrying													
1955	108	105	115	100	110	110	106	130	123	101	111	104	100
1956	113	108	119	100	113	115	106	149	139	102	123	115	100
1957	115	111	123	98	120	119	104	160	156	105	124	120	100
1958	108	110	118	92	128	119	102	160	159	110	123	112	95
1959	112	110	113	79	147	115	101	177	171	[4] 113	119	110	93
1960	115	115	114	79	168	118	99	178	180	120	[4] 132	128	90
1961	122	119	109	77	187	122	101	188	194	[4] 123	[4] 144	139	[4] 88
1962	121	123	(3)	77	201	124	94	202	195	119	158	133	91
Basic metal industries													
1955	111	131	143	127	133	141	120	113	148	133	127	125	117
1956	114	139	154	137	140	150	128	128	162	131	154	137	119
1957	114	145	170	131	153	154	133	120	182	135	167	140	120
1958	102	139	170	126	158	146	132	112	171	134	171	134	109
1959	113	148	180	136	158	160	136	132	184	156	191	153	114
1960	121	170	213	149	177	186	143	137	228	[4] 189	[4] 219	166	133
1961	121	174	220	148	186	187	148	139	248	182	[4] 229	[4] 182	[4] 125
1962	(3)	(3)	(3)	156	186	180	144	143	261	(3)	233	185	(3)

[1] Excluding West Berlin.
[2] The Saar and Canada were added taking the place of Greece and Turkey which were dropped as a result of insufficient data.
[3] Data not available.
[4] Revised figure.

Source: Organization for European Economic Cooperation (OEEC). General Statistics. March 1962, pp. 6, 10.

TABLE 55.—Comparison of world and U.S. production and U.S. imports of principal metals and minerals, 1962

Mineral	World production, thousand short tons unless otherwise stated	U.S. production, percentage of world production	U.S. imports, percentage of world production	Total U.S. production and imports, percentage of world production	1962 U.S. total production and imports compared with 1961 total [1]
Fuels:					
Coal	2,953,237	15	(2)	15	Same.
Petroleum (crude)...thousand barrels..	8,878,881	30	5	35	Less.
Nonmetals:					
Asbestos	3,055	2	22	24	Same.
Cement [3]...thousand barrels..	2,095,654	20	(2)	20	More.
Diamonds...thousand carats..	32,876	(4)	45	45	Do.
Feldspar [5]...thousand long tons..	1,500	33	(2)	33	Less.
Fluorspar	2,405	9	25	34	More.
Gypsum	49,965	20	11	31	Less.
Mica (including scrap) thousand pounds..	400,000	54	5	59	Do.
Nitrogen, agricultural [4 5 6]	12,790	23	12	35	Do.
Phosphate rock...thousand long tons..	46,040	42	(2)	42	Same.
Potash (K_2O equivalent)	10,700	23	3	26	Less.
Salt [3]	100,500	29	1	30	More.
Sulfur, elemental thousand long tons..	11,640	51	9	60	Do.
Metallic ores and concentrates:					
Bauxite...thousand long tons..	29,860	5	34	39	Do.
Chromite	4,805	(4)	30	30	Same.
Copper (content of ore and concentrate)	5,050	24	(2)	24	Less.
Iron ore...thousand long tons..	504,012	14	7	21	More.
Lead (content of ore and concentrate)..	2,765	9	5	14	Less.
Mercury...thousand 76-pound flasks..	244	11	13	24	More.
Molybdenum (content of ore and concentrate)...thousand pounds..	75,000	68	(7)	68	Less.
Nickel (content of ore and concentrate).	401	3	31	36	More.
Platinum group (Pt, Pd, etc.) thousand troy ounces..	1,190	2	61	63	Do.
Silver	242,400	15	32	47	Do.
Titanium concentrates:					
Ilmenite [5]	2,295	35	7	42	Same.
Rutile [5]	151	7	24	33	More.
Tungsten concentrate (60 percent WO_3) short tons..	71,100	12	3	15	Do.
Vanadium (content of ore and concentrate) [5]...short tons..	8,350	63	(7)	63	Do.
Zinc (content of ore and concentrate)..	3,870	13	10	23	Do.
Metals, smelter basis:					
Aluminum	5,555	38	7	45	Do.
Copper	5,300	25	3	28	Do.
Iron, pig	294,200	23	(2)	23	Do.
Lead	2,665	14	10	24	Less.
Magnesium	145,300	47	2	49	More.
Steel ingots and castings	397,350	25	1	26	Same.
Tin	196	[8] 3	21	24	Less.
Uranium oxide (U_3O_8) [9]...short tons..	33,550	51	35	86	More.
Zinc	3,650	24	4	28	Same.

[1] Data on 1961 imports and production for the United States are available in the 1961 Minerals Yearbook, v. I, p. 44.
[2] Less than 1 percent.
[3] Including Puerto Rico.
[4] None produced.
[5] World total exclusive of U.S.S.R.
[6] Year ended June 30 of the year stated (United Nations).
[7] Not imported.
[8] U.S. imports of tin concentrates (tin content).
[9] Percentage U_3O_8 content derived from data in the Atomic Energy Commission Annual Report to Congress for 1962, January 1963, p. 216.

Estimated 1975 Consumption.—The United Nations estimated world consumption of major mineral products for 1975.[33] The projections made were essentially long-term projections, based on a trend

[33] United Nations, Economic Commission for Europe. Long-Term Trends and Problems of the European Steel Industry; United Nations Secretariat Report. Study of Prospective Production of and Demand for Primary Commodities—Prospective Demand for Nonagricultural Commodities: Problems of Definition and Projection Methodology, 1962.

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TABLE 56.—Apparent consumption of selected nonferrous metals, refined basis, in major countries

(Index: Preceding years=100)

Country	1960 (in thousands of metric tons)					Copper		Lead		Aluminum		Zinc		Tin	
	Copper	Lead	Aluminum	Zinc	Tin	1961	1962	1961	1962	1961	1962	1961	1962	1961	1962
United States	1,225	809	1,530	790	52	108	106	103	106	117	116	106	109	96	107
United Kingdom	560	287	360	276	22	94	99	96	100	79	101	93	95	93	106
Germany (Federal Republic of)	516	240	304	297	28	109	89	98	103	95	102	103	95	93	45
France	241	165	213	172	11	101	101	99	95	95	117	110	98	90	111
Belgium	76	46	61	105	3	98	88	100	97	97	215	110	103	88	129
Italy	185	78	112	85	5	108	107	108	108	93	119	106	118	114	104
Sweden	91	44	45	31	1	102	97	101	111	91	117	88	107	81	115
Canada	107	36	104	51	4	121	107	127	97	110	104	109	107	102	114
Japan	304	95	149	189	13	123	82	129	100	129	96	129	101	110	95
India	62	26	24	60	4	109	118	100	136	119	168	117	121	113	100
World [1]	3,760	2,212	3,147	2,442	164	107	99	104	104	106	115	106	104	97	99

[1] Excluding the centrally planned countries.

Source: Compiled by United Nations Secretariat, Bureau of General Economic Research and Policies, Commodity Studies Section. International Tin Council, Statistical Bulletin, May 1963; International Lead and Zinc Study Group, Monthly Bulletin of Statistics, July 1963; British Bureau of Non-Ferrous Metals Statistics, World Non-Ferrous Metal Statistics, April 1963; American Bureau of Metal Statistics, Yearbook of American Bureau of Metal Statistics. 42d Annual Issue, 1962.

incorporating the relationship between the absorption of the minerals and some independent variables such as time, population, gross domestic product, value added in manufacturing, changing technology, and innovation—determined in some historical period. It should be emphasized, however, that although the projected values for 1975 are shown, they must not be regarded as predictions but rather as representing the average value of the variable over the surrounding period of 3 or 5 years of which these years are the midpoints. The type of demand projection considered here is the type that tends to govern investment plans rather than production decisions.

The estimated world consumption and production of crude steel by regions and major countries for 1972–75 was generally accepted for 1975. When compared with present consumption and production these projections were expected to provide some clues to the probable growth rate of steel consumption and production and the probable magnitude of world trade. The per capita steel consumption, if correlated with per capita energy consumption, would indicate some measure of the level of the standard of living and industrialization. The United States was expected to continue to lead the world in steel production and consumption in 1975. By region, Europe and the Soviet bloc countries would probably be at a par with the United States, although U.S. per capita consumption might still be nearly 1.5 times that of these countries.

TABLE 57.—Estimated world consumption and production of crude steel by regions, 1972–1975 [1]

Regions	Consumption		Production		
	1,000 metric tons	Kilograms per capita	1,000 metric tons	Surplus (−) or deficit (+) 1,000 metric tons	Kilograms per capita
North America	157,800	701	159,500	−1,700	742
Western Europe [2]	151,500	411	161,200	−9,700	437
U.S.S.R	113,000	465	117,000	−4,000	482
Eastern Europe	37,800	360	38,200	−400	364
Far East [3]	73,300	73	65,000	+8,300	66
China (mainland) and North Korea	53,000	66	52,000	+1,000	65
Latin America	22,300	89	18,700	+3,600	75
Africa	9,000	32	7,500	+1,500	26
Oceania	7,800	409	9,300	−1,500	488
Middle East	5,200	55	2,300	+2,900	27
World	630,700	189	630,700	------------	189

[1] United Nations, Economic Commission for Europe. Long-Term Trends and Problems of the European Steel Industry. Geneva, 1959. Ch. 6, 7.
[2] Including Yugoslavia.
[3] Excludes China (mainland) and North Korea and includes South Asia.

Projected world demand for major nonferrous metals for 1975 included all primary and new and old scrap sources. The importance of scrap in future demand was well illustrated.

World Trade.—Trade in iron ore in 1962 recovered notably in the United States, dropped below the 1961 level in Western Europe, and increased at a lower rate in Japan. In the aggregate, imports increased by about 6 percent over those of 1961—three times as much as in 1960.

TABLE 58.—Estimated consumption and production of crude steel by major countries, over 5 million metric tons, 1972–75 [1]

Major countries by regions	Consumption: 1,000 metric tons	Consumption: Kilograms pre capita	Production: 1,000 metric tons	Production: Surplus (−) or deficit (+) 1,000 metric tons	Production: Kilograms per capita
North America:					
Canada	12,800	625	12,000	+800	586
United States	145,000	715	147,500	−2,500	754
Western Europe:					
Belgium	5,200 (Belgium and Luxembourg)	505	9,000	−7,800 (Belgium and Luxembourg)	904
Luxembourg			4,000		11,429
France	25,000	545	28,500	−3,500	621
Italy	16,000	320	16,000	------------	326
Netherlands	6,500	524	4,500	+2,000	363
Spain	5,200	167	5,000	+200	161
Sweden	5,000	625	5,500	−500	688
United Kingdom	32,000	611	35,000	−3,000	668
Western Germany [2]	37,000	561	41,000	−4,000	621
U.S.S.R	113,000	465	117,000	−4,000	482
Eastern Europe:					
Czechoslovakia	10,700	649	13,000	−2,300	789
Eastern Germany	7,300	405	5,000	+2,300	277
Poland	11,500	390	13,000	−1,500	441
Far East:					
India	28,000	60	26,000	+2,000	55
Japan	35,000	324	36,500	−1,500	339
China (mainland) [3]	53,000	66	52,000	+1,000	65
Latin America: Brazil	6,500	86	7,000	−500	93
Africa: Republic of South Africa	5,000	256	6,500	−1,500	333
Oceania: Australia	7,000	560	9,000	−2,000	720

[1] United Nations, Economic Commission for Europe. Long-Term Trends and Problems of the European Steel Industry. Geneva, 1959. Ch. 6, 7.
[2] Including Saar.
[3] Including North Korea.

TABLE 59.—Major nonferrous metals: Free world consumption of primary metal, actual in 1959 and provisional projections for 1975 [1]

Metal	Consumption in 1959: Total (millions of tons)	Consumption in 1959: Primary (millions of tons)	Projected 1975: Total (millions of tons) [2]	New scrap [3]: Percentage of total	New scrap [3]: Millions of tons	Old scrap [3]: Percentage of total	Old scrap [3]: Millions of tons	Primary [4]: Millions of tons	Rate of growth in primary consumption 1959–75 (percentage per annum)
Aluminum	3.95	3.21	11.1	12	1.3	6	0.7	9.1	6.7
Copper	5.03	2.91	10.1	20	2.0	20	2.0	6.1	4.7
Lead	2.57	1.64	4.2	5	0.2	30	1.3	2.7	3.3
Tin	0.20	0.15	0.29	12	0.03	15	0.04	0.21	2.1
Zinc	2.89	2.20	5.4	16	0.9	6	0.3	4.2	4.1

[1] Primary and secondary metal; excluding the centrally planned countries.
[2] Based on a projection of 1950–1959 trend in the ratio of gross (primary and secondary) metal absorption to gross domestic product in 1950 dollars in each of 24 countries, accounting in 1959 for over 90 percent of total consumption, excluding centrally planned countries.
[3] Assumed ratio of generation based on 1950–59 evidence in North America and Western Europe.
[4] Total consumption minus scrap (new and old).

Source: United Nations Secretariat. Study of Prospective Production of and Demand for Primary Commodities: Prospective Demand for Non-Agriculture Commodities—Problems of Definition and Projection Methodology. 17 April 1962, pp. 75, 105.

With regard to the nonferrous ores and metals, however, the recovery of import demand in the United States (1962 compared with 1961) was insufficient to outweigh a significant reduction in Western

Europe. Nevertheless, imports into Japan, chiefly copper and copper concentrates, increased substantially and caused a 3-percent increase in trade of the metals.

TABLE 60.—World trade in major nonferrous metals

Commodity	Index [1] [2]		
	Distributor of 1960 export value (percent)	Preceding year=100	
		1961	1962 [3]
Aluminum	18	87	113
Copper	+60	103	100
Lead	5	111	106
Zinc	7	98	103
Tin	+9	97	101
Aggregate total nonferrous metals	100	100	103

[1] Indexes are based on returns of major export countries.
[2] The group includes reflect movements in the trade of commodities tested, weighted by their 1960 export values, the distribution of which is shown.
[3] Preliminary, based on less than 12 months' returns.

Source: United Nations Commodity Survey, 1962, p. 86.

TABLE 61.—Foreign trade of iron ores and nonferrous ores and metals in selected industrial countries, 1961–62 [1]

Country	Imports		Exports	
	Iron ore	Nonferrous ore and metals	Iron ore	Nonferrous ore and metals
1961 value:				
Total (millions of dollars)	1,332	3,020	114	1,304
United States (percentage of total)	19	21		28
European Economic Community (percentage of total)	43	54	100	54
United Kingdom (percentage of total)	15	23		18
Japan (percentage of total)	23	2		
Quantum index (preceding year=100)				
Total:				
1961	102	100	94	103
1962 [2]	106	100	101	92
United States 1961	75	104		89
1962 [3]	135	114		75
European Economic Community 1961	99	103	94	106
1962 [4]	98	95	101	94
United Kingdom 1961	83	91		113
1962	86	100		113
Japan 1961	141	95		
1962 [5]	110	128		

[1] Measured gross, not distinguishing imports later reexported or, in the case of the European Economic Community, imports originating within the Community.
[2] 1962 Preliminary, estimated on the basis of partial return.
[3] Based on 11 months' returns.
[4] Based on 8 months' returns.
[5] Based on 9 months' returns.

Source: United Nations Commodity Survey. 1962, pp. 87, 89.

World Stocks.[34]—The increasing activity of the free-world metal-using industry did not induce a comparable upsurge in mine or refinery output and hence the stocks of most metals were reduced. The principal exception was copper, the production of which exceeded consumption and resulted in accumulations of stocks at all levels by both producers and consumers.

There was a sharp decline in world lead stocks. With the lowering

[34] United Nations. Commodity Survey. 1962 ,pp. 95–99.

of world lead production in 1962, and a continuing effort to reduce stocks, world lead stocks were further reduced by a transfer under a barter arrangement of 95,000 tons of lead from producers in Australia and Canada to the strategic stockpile in the United States.

Decumulation of world stocks of zinc had also begun in 1961, and by March 1962 they had fallen to the early 1960 level. After March, producers resumed accumulation, but consumers continued to liquidate their stocks. The year ended with a small decline of world zinc stocks.

The decline in tin stocks during 1962 was confined to those of consumers, and producers stocks were virtually at the same low level at the end of the year as at the beginning.

Data pertaining to aluminum stocks are confined to the United States. The main expansion in industrial consumption occurred in the United States in 1962, and producers stocks declined sharply. At yearend, despite a 10-percent rise in production, producers stocks had been reduced to about half the level of 2 years earlier.

The following tabulation shows changes in producers and consumers stocks of primary nonferrous metals.[35]

Metals	Volume of stocks, 1960 1,000 metric tons	Indexes of stocks 1960=100	
		1961	1962
Aluminum [1]	235.4	80	54
Copper	686.5	97	115
Lead	527.1	103	75
Zinc	366.5	102	96
Tin	59.8	89	77

[1] Producers or exporters only.

World Prices.[36]—The United Nations price index of nonferrous metals moving in international trade drifted irregularly lower since the beginning of 1960, and at the end of 1962, it stood at the lowest level since 1958. The 1961–62 decline was most noticeable for lead and zinc. Tin prices, after a recovery in 1961, dropped in 1962 nearly to the 1961 level; aluminum prices were reduced in the United Kingdom early in 1962 and in the United States late in the year; and copper prices were stable with a slight increase in 1962 largely because of support policies pursued by major producers, such as curtailing mine and smelter output.

U.N. nonferrous base metals price indexes were as follows in 1961 and 1962.

	1961 (1960=100)	1962 (1961=100)
Aluminum	100	94
Copper	94	102
Lead	87	88
Zinc	85	87
Tin	111	101
Aggregate total nonferrous metals	98	98

Source: Unpublished data of Commodity Studies Section Bureau of General Economic Research and Policies of U.N. Secretariat.

[35] United Nations. Commodity Survey, 1962, p. 96.
[36] United Nations. Commodity Survey, 1961 and 1962.

The decline of world steel production in 1962 softened the international demand for iron ore and several of the steelmaking additive ores. The price of iron ore declined and averaged about 1 percent below the 1961 level. There was a 3-percent drop in the average price of manganese ore entering international trade, and a larger reduction (over 25 percent) in the average price of tungsten ores.

Ocean Freight Rates.—Indexes of ocean freight rates began to move downward again during the first three quarters of 1962, turned upward in the last quarter, and ended with the lowest annual average during the last decade.

TABLE 62.—Price indexes of free world commodity trade

(1958=100)

Year	Primary commodities [1]	Total minerals [2]	Metal ores	Nonferrous metals
1955	104	95	98	133
1956	105	99	105	138
1957	106	103	107	111
1958	100	100	100	100
1959	97	94	97	111
1960	97	93	98	114
1961	95	92	100	110
1962	94	92	99	109
First quarter	94	92	101	111
Second quarter	94	92	98	110
Third quarter	93	92	97	108
Fourth quarter	94	92	98	108

[1] Does not include nonferrous metals.
[2] Includes fuels and metal ores.

Source: United Nations. Monthly Bulletin of Statistics. June 1963, special tables D-I and D-II.

TABLE 63.—Indexes of ocean freight rates

(1958=100) [1]

Year	Trip charter freight-rate indexes [2]		
	General cargo	Ore	Fertilizers
1956	234	194	193
1957	168	154	158
1958	100	100	100
1959	107	100	91
1960	111	103	97
1961	118	103	105
1962	98	79	96
First quarter	106	185	100
Second quarter	104	84	99
Third quarter	88	73	[3] 90
Fourth quarter	96	75	[3] 95

[1] Index rebased from 1953=100 to 1958=100.
[2] United Kingdom indexes based upon weighted average of quotations by all nations on routes important to United Kingdom tramp fleet in 1951.
[3] Estimated figure.

Source: United Nations. Monthly Bulletin of Statistics. June 1963, special table F.

Review of Metallurgical Technology

By Rollien R. Wells [1]

A REPORT of technological advancements restricted to a specific 12-month period is impractical. Inherent in the nature and development of technology is the element of time; rarely can a new process or product be attributed to a particular year. An overall picture of general trends and pattern changes, however, is indicative of technological growth. This paper presents selected observations and discussions of current metallurgical research and practices in an attempt to develop such a picture.

Of the estimated $16.5 billion spent for research and development in the United States in 1962, at least 80 percent was earmarked for the aircraft, electronics, chemical, and machinery industries. Much of the effort was of the end-use variety and was oriented closely to the national defense and aerospace programs. Only a small fraction of the total research money was directed to studies of the utilization and improvement of metals. Even if the investigations in allied fields such as solid state physics are included, the total research expenditure for metal and mineral materials barely reached $500 million. An additional $200 million was spent by industry and government for development of minerals recovery and processing methods.

LASERS

No recent invention has fired the imaginations of scientists quite so much or so rapidly as a device that performs "light amplification by stimulated emission of radiation"—the laser. Although the concept was developed in the early 1950's, the first operating laser was made only about 2 years ago.

Lasers, to date, have been of two basic types, solid and gaseous, but liquid devices are now under development. Stated briefly, lasers consist of materials that can be energized by light or electricity to yield, through the intricate mechanics of atomic excitation and magnification by reflection, a powerful coherent beam of monochromatic (single frequency) light. Gaseous lasers comprise a gas, or mixture of gases, excited by a low-power radiofrequency discharge or by direct current. They may be operated at room temperatures without cooling systems; they emit beams that are more stable, more continuous,

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more coherent, and more easily directed than those of their solid-state lasers. A great variety of solid laser materials has been examined. Chiefly the investigations have centered on inorganic-mineral single crystals or glass doped with elemental impurities. Calcium tungstate or calcium fluoride crystals, for example, may be doped with elements such as neodymium, uranium, or praseodymium. The system that has received the greatest publicity is the ruby laser—aluminum oxide doped with chromium. Newest entries in the field of solid laser materials are semiconductor diodes. The excitation source usually is a powerful mercury or xenon lamp. Consequently, most solid laser systems employ liquid nitrogen or helium to absorb the excess heat. Some systems are capable of delivering large amounts of energy (50 megawatts) in pulses of extremely short duration (10^{-9} second). Such beams focused with a lens can create temperatures estimated at 10,000° F and can pierce a hole in thin steel sheet in a thousandth of a second.

At least 400 laboratories are engaged in laser research which, in only 2 years, has grown into a $25 million effort. Some of the research projects already have paid off in improved systems, better quality emission, and, for a few gaseous lasers, continuous emission. About 50 systems (mostly solid) have been developed. Beams of 75 different frequencies, ranging from 6,328 to 71,800 angstroms, have been emitted.

Although the laser is still only a laboratory research tool, examinations and studies are being extended to applications. A wide variety of possible uses have been suggested: Biological studies, medical applications, power transmission, radar, radio and telephone communications, satellite tracking, photopolymerization, selective chemical catalysis, woodworking, metalworking, and analysis.

The last two areas hold the most interest for metallurgists. It already has been demonstrated that lasers can cut and drill any metal quickly and precisely; refractory metals can be welded easily; machining intricate parts can be accomplished. The laser is emerging rapidly as an energy source for spectroscopy; Jarrell-Ash Co., Newton, Mass., has developed an instrument that it calls the laser microprobe with which samples as small as 50 microns in diameter have been successfully analyzed.

Commercial exploitation of the laser can be expected in the immediate future. Jarrell-Ash expects to deliver its first commercial laser-microprobe unit during 1963. Within the next year or two, equipment should be marketed that will employ lasers to shape precision parts, especially those made of the harder metals. Already lasers have had some impact on the Nation's economy; several companies are finding it profitable to supply the laser research boom with doped materials, equipment parts, and even complete systems.

HIGH-STRENGTH STEEL TREATMENT

The emergence of rocketry as a key area in this country's defense efforts has been accompanied by an assault on the problems associated with production of materials having high strength and light weight.

Two types of high-strength material, developed as a result of this research, currently are receiving wide interest.

Maraging steel (actually a high-nickel iron alloy) now is commercially available after nearly 4 years of development by The International Nickel Co. of Canada, Ltd. (Inco).

The term *maraging* is a combination of martinsite and age hardening. Maraging steel contains a maximum of 0.03 percent carbon which allows the formation of the tough cubic martensitic form of steel. In this form the steel can be cold worked to improve strength without a significant decrease in ductility, formability, and toughness. After cold working or annealing, the material is aged for 3 hours at 900° F for additional strengthening. This material has a yield strength of 200,000 to 300,000 pounds per square inch (psi), is not brittle, is easily welded, and retains its properties over an operating range of minus 420° to 800° F. It has high resistance to stress corrosion by sea water, but is susceptible to chemical atmosphere attack to the same degree as ordinary carbon steels. Like other high-strength steels, it is subject to hydrogen embrittlement. Its improved strength makes it potentially useful for high-pressure processing equipment and for lightweight pressure vessels such as cases for solid-fuel-propellent rocket motors. Commercially, its major drawback is that it costs three to four times more than stainless steels now in wide use.

Inco's series of alloys contains 18 to 25 percent nickel, 0.15 to 0.7 percent titanium, 0.05 to 0.15 percent aluminum, 7 to 9.5 percent cobalt, and 3 to 5.2 percent molybdenum. Other companies have stated, however, that equal results can be obtained more cheaply by using combinations containing less nickel.

A similar type of material, now under intensive investigation but not yet commercial, is produced by marstraining. Basically, quenched and tempered steels are subjected to a small amount of plastic strain followed by retempering or age hardening. Experimental results indicate that large increases in yield strength can be imparted to a wide variety of steels with carbon content as high as 0.5 percent. Hoop-burst strengths of 350,000 psi, higher than any previously reported, have been obtained with one type of mar-strained steel.

DISPERSION STRENGTHENING

Interest was renewed in dispersion-strengthened metals by the mid-year announcement by E. I. du Pont de Nemours & Co., Inc., from its DuPont Metals Center, Baltimore, Md., of semicommercial production of thoria dispersion (TD) nickel. The material comprises a matrix of metal in which extremely fine metal oxide particles are dispersed to restrict slippage along the crystal planes and grain boundaries.

Blocking dislocation of the structure of a metal by this method is not a new idea. Prof. N. J. Grant at Massachusetts Institute of Technology has worked along these lines with some success since the early 1950's. Alumina-coated aluminum powders (SAP and MAP), experimented with in Europe and the United States during recent years, are based upon the same principle.

DuPont, however, believes that its approach to production is revolutionary. The method involves chemical precipation of basic nickel hydroxide on the surface of tiny (0.03 to 0.1 micron) thorium oxide particles. Heat converts the nickel salt to the oxide form. The material is heated in a hydrogen atmosphere to reduce the nickel oxide to metal without affecting the thoria. The reduced powder is compacted hydrostatically into billets which are sintered and extruded. The resulting product is a matrix of nickel containing 2 percent thoria as uniformly dispersed inclusions about 1 micron apart.

The company claims, moreover, that the method is applicable for production of dispersion-strengthened material from any metal having readily reduced oxides.

The new alloy (or composite) has many properties to recommend it. It can be fabricated as easily as steel. It has high-temperature strength, stability, and resistance to creep. Thermal conductivity and corrosion resistance are similar to that of pure nickel. In the lower temperature range it appears to have little advantage over the newer nickel- and cobalt-base superalloys. Unlike conventional precipitation-hardened superalloys, however, TD nickel maintains its strength above 1,850° F and is useful up to 2,400° F. For this reason, it is receiving serious consideration for use as vanes in jet turbines, heat exchangers, and other applications where high-temperature strength over prolonged periods is a requisite.

UTILIZATION OF HIGH-TEMPERATURE METALS

Although tremendous research effort still is being directed toward development of alloys of the high-temperature metals to meet the demands of space probing, no significant advances have been reported recently. In fact, rapid developments in other areas have restricted, and perhaps minimized, the contributions made by the high-temperature metals a few years ago.

For example, advancements in fuel technology have rapidly imposed new performance requirements for rocket motors so that construction materials are becoming obsolete almost as rapidly as methods can be developed for producing the required hardware. In a few months the urgent need for large molybdenum forgings was ended by experimental developments of tantalum-tungsten alloys, tantalum sheet liners, and forged tungsten. The Bureau of Mines vapor-plated tungsten was a part of the procession, and so was "liquid-sintered" tungsten developed by Armour Research Foundation. As little as 0.5 percent nickel added to a tungsten powder compact lowers the temperature necessary for sintering by about 500° F., but it also lowers the ultimate melting point. Now, with the newer fuels, even pure tungsten is not good enough. The nozzle throats of experimental tungsten rocket liners fused during firing. Various high-melting carbides have been examined but have not been found to be sufficiently resistant to chemical erosion.

Higher flame temperatures resulting from the new fuels will require one of three approaches: (1) Cooled nozzles, probably using liquid metal coolants; (2) transpiration cooling; or (3) ablation. The first approach imposes numerous engineering and designing difficulties; the second is receiving increased attention. An example is the use of tungsten impregnated with 19 percent silver. During firing, vaporization of the silver absorbs some of the heat; a tungsten shell is left behind. Experimentation with tungsten-silver nozzles currently is using an estimated 150,000 ounces of silver per month.

The third possible approach, ablation, would mean the replacement of tungsten liners by some organic material and thus would further reduce the position of the refractory metals in the space program. Plastics, graphite, and Fiberglas already have made big inroads into metals' potential aerospace uses. All-metal rocket bodies, for example, now are used only where damp storage or rough handling conditions are anticipated. The all-important strength-to-weight ratio consideration favors reinforced Fiberglas for this job, but Fiberglas will not stand army field conditions.

For the skin of vehicles that reenter the earth's atmosphere, metals have thus far had an advantage. Even here, however, they are facing a test. Actually, this application is more demanding than for rocket nozzles, since reentry requires resistance to oxidation at extreme temperatures. The Dyna-Soar, the winged manned vehicle reaching the final development and testing stage, has a large section that must withstand 3,000° F for several minutes on reentry. And it must do it more than once since this is to be a reusable vehicle and not a one-shot job like the Mercury. The first Dyna-Soar model will use a columbium alloy protected by a silicide coating for this vital section. If this alloy is not satisfactory, it may be replaced by an ablative coating on a sheet steel backing.

CERAMIC DEVELOPMENTS

The adaptation of mineral nonmetallics and ceramics to new uses is advancing rapidly. One area that is receiving special attention is that of developing coatings for metals. The continued use of tungsten, molybdenum, tantalum, and columbium for space vehicle construction might well depend on the success of the coating studies. These four metals have excellent physical properties at high temperatures under inert or reducing conditions, but decompose rapidly in oxidizing atmospheres.

Several coating systems are being appraised. One process consists of vapor-phase reaction of the substrate with metallic elements to form a diffusion alloy. This step is followed by reaction of water vapor or volatile oxides and treatment in air to form an impervious complex oxide ceramic. Tungsten sheet coated by this method has withstood oxidizing conditions up to 3,400° F for several hours. A coating produced by plasma-arc syraying of alumina over a vapor-deposited molybdenum disilicide base coat has protected a molybdenum substrate for 1 hour at 3,100° F and for 10 minutes at 3,450° F.

Ceramics are also being used for high-temperature adhesives. Ceramic oxide whiskers and polycrystalline fibers are being employed to add strength to plastic laminates. Nonoxide fibers like silicon carbide and pyrolytic graphite also have been tried for reinforcing plastic. Hollow glass fibers have been shown to impart higher flexual rigidity to laminates than solid glass fibers. Other combinations of ceramics with metals and plastics have been developed for such uses as heat shields and rocket motor cases. Some of these combinations are graphite-ceramic composites, metal-infiltrated ceramics, ceramic foams, resin-impregnated ceramics, and various forms of cermets.

Unlike the usual brittle glassy materials, the new high-purity sintered oxide ceramics are strong and tough. In the electronics field they are playing an important role in transducers, thermoelectric elements, and microcircuits. They also are being used for nose cones, rocket nozzle inserts, and for other components subject to extreme temperature applications. For example, aluminum oxide spheres are being used in a check valve of an oxygen system over a temperature range of minus 450° to 2,000° F.

Foamed inorganics made with glass and silica have long been available commercially. New products include an array of foams based on carbides, borides, and silicides. These all have properties fitting them for specialized uses, but they are too expensive for most commercial applications. The Bureau of Mines has developed a refractory brick composed of tiny bubbles of forsterite (Mg_2SiO_4) cemented in a matrix of the same material. Pittsburgh Plate Glass Co. recently announced the development of a material for protection of structural steel beams and girders. The new product is mixed, poured, or troweled in place. It first sets up as a gel and then forms a foam which cures in 24 hours. It is reported to be stable in a furnace at 2,000° F and is only slowly vitrified by a 5,200° F flame.

DESIGN AND AUTOMATION

One of the most noticeable changes in the mineral processing industry is reflected by differences in plant design and construction. Only a few years ago many plants were erected at the least possible capital expenditure. Little attention was given to ease of operation, maintenance, or equipment replacement. As wages have increased, companies have invested additional capital and incorporated in the new plants numerous features to allow easy and speedy maintenance of machines and have provided laborsaving centralized control and automation.

For example, at the Mission plant of American Smelting and Refining Company at Sahuarita, near Tucson, Ariz., prime features are ready access to all parts of crushing equipment, overhead cranes whenever possibility exists of the need to move or replace machines, and ample floor-space in which to effect repairs. Wide use of electronic controls has allowed reduction of operating personnel to a minimum. The crushing unit, which handles 15,000 to 18,000 tons of ore per day, is controlled by one operator and two helpers per shift.

The new and recently expanded iron ore treatment plants of the Lake Superior and eastern Canada regions reflect the same careful planning; practicability and ease of operation are of primary concern. Even some of the older plants have added centralized control of equipment where space and layout make it possible. Computer control of operations is under experimental trial at several large lime and cement plants, but the metallic minerals industry has not yet reached this degree of automation.

AUTOGENOUS GRINDING

Autogenous grinding, the use of rock to grind itself, is not new. The Hadsel mill, employing this principle, was used in the United States as early as 1908. And it has long been recognized that autogenous grinding effects better intergranular breakage than conventional crushing and grinding techniques. It was not until the development of reliable automatic control devices, however, that the method became practical. Autogenous grinding has been developed along three main lines: dry primary grinding, wet primary grinding, and pebble mill secondary grinding. Dry primary grinding, exemplified by the Aerofall system, is fully autogenous grinding in which run-of-mine ore is ground to desired fineness in one step in a large-diameter mill. Under some conditions a few steel balls are added to supplement the coarse ore lumps which comprise the primary grinding medium. The fine material is swept from the mill into dry classifiers by a continuous stream of air; the oversize from the classifiers is returned to the feed. Wet primary grinding may be a one-step fully autogenous operation in a large-diameter mill (such as the Cascade mill) or may be conducted in two stages, using pebble milling as the second step. Secondary pebble milling consists of wet fine grinding of feed that has been reduced to about 6 to 14 mesh. It may be used in conjunction with conventional crushing and grinding methods or with primary wet autogenous grinding. Flint pebbles are sometimes employed, but more often the grinding medium consists of 2- to 4-inch ore that has been screened out during the crushing operation.

Primary autogenous grinding has not yet been firmly established and very little operating data are available for either the wet or dry systems. In general, the Aerofall-type system is more complex than the Cascade-type and requires both predrying of feed and an extremely large dust-collecting system. Its advocates, however, claim that these disadvantages are offset by virtually trouble-free operation and superior results on many ores. Wet autogenous grinding has at least as many proponents who point out that this method is more flexible and has the advantage of being combined with secondary pebble milling. In spite of the many claims and counterclaims, the ultimate choice for new operations probably will depend on careful evaluation of the economics of the two systems when sufficient data for each are released.

For more than a year Quebec Cartier Mining Co. has been operating twelve 18-foot diameter Cascade-type mills to prepare specular hematite ore for spiral concentration at the Lac Jeannine plant in Quebec. Although the company has had the usual problems that are inherent with the operation of new types of equipment, the system is reported to be performing satisfactorily.

Iron Ore Company of Canada, on the other hand, selected six dry Aerofall mills to reduce minus 8-inch specularite ore to 150 mesh at the Carol Lake operation on the Quebec-Labrador border. The Carol plant is a highly automated gravity concentrator with 3,456 spirals used in 3 stages. The first concentrate (66 percent Fe) was shipped last June, and by the end of the year the plant had reached its capacity of 7 million tons of concentrate per year.

At the nearby Wabush Mines plant, scheduled to begin operating in 1964, considerable experimentation was conducted to evaluate the wet and dry systems for the particular ore. Liberation of hematite from quartz is obtained at 28 mesh, a particularly difficult size for the mill man. It is coarse enough to be hard to handle with hydraulic classifiers and too fine for efficient mechanical screening. There was some concern, therefore, about the problems that might be encountered in a wet system. Testing in a small plant, however, proved that these fears were unfounded. Only a small quantity of material produced in grinding was near the 28-mesh opening size; therefore blinding was minimal, and both stationary sieve bends and mechanically vibrating screens proved to be effective. The wet system produced feed that could be beneficiated to produce a slightly higher grade of concentrate at the same recovery than did the dry system. More important, treatment of material ground by the wet system yielded a product of consistent grade despite wide fluctuations in the grade of the ore.

The new Empire operation that is being built by Cleveland-Cliffs Iron Co. in Michigan will employ two-stage wet autogenous grinding on hard, banded magnetic taconite ore. Primary grinding to 20 mesh will be done in a Cascade mill. Magnetic cobbing will reject about 60 percent of the ore with a loss of only 10 percent of the iron and will recover a rougher concentrate containing about 50 percent iron. The latter product, prior to reconcentration, will be ground to 95 percent minus 500 mesh with 1½-inch ore pebbles taken from the discharge trommel of the primary mill. This will be the first plant to use autogenous grinding of taconite ore.

Primary autogenous grinding is not restricted to use with iron ores. Boliden Mining Co. is operating a 22- by 7-foot Cascade mill on hard lead sulfide ore at the Vassbo property in Sweden. The 10-inch ore is ground to 72 percent minus 200 mesh in one stage; a cyclone is used to close the circuit. Boliden decided on the autogenous unit only after a long investigation to compare this method with conventional crushing, rod milling, and ball milling.

An Aerofall mill—the first in the British Isles—was installed in early 1962 in a glass sand plant. Approximately 700 tons of 12-inch feed is ground daily in the 12-foot-diameter mill to 96 percent minus 16 mesh.

Although primary autogenous grinding is still in the experimental stage, wet fine grinding in pebble mills has long left the experimental stage. It has been used in South Africa for 60 years and has been successfully employed in the Western Hemisphere for the last 13 years.

Pebble milling was revived on this continent in 1949 when Lake Shore Mines, Ltd., at Kirkland Lake, Ontario, replaced conventional steel-ball tube mills with pebble mills 6 feet 8 inches in diameter by 16 feet long. Screened ore was used for the grinding medium. Since that time numerous plants, chiefly in Canada, have similarly converted. Most of the pebble mills in use today range from 8 to 12 feet in diameter and are about 20 feet long. Liner and grate designs differ slightly from those used for ball milling. In all cases the conversions to autogenous pebble milling have been satisfactory. Normally, grinding is achieved with the same energy cost as with conventional mills, and the savings from reduction of ball wear has repaid the cost of changeover in less that 2 years. Some companies have reported savings in steel balls ranging from $0.18 to $0.32 per ton of ore milled. These figures do not show actual savings, however, since they do not reflect the added cost of making and handling the pebbles or the cost of higher liner wear—estimated in some cases to be nearly double that in standard ball mills.

The Anaconda Company is building a new concentrator at Butte, Mont., to replace the mill now operating at the smelter site in Anaconda. Twelve 12½- by 21-foot grate discharge mills will be used for autogenous pebble grinding of the copper sulfide ore prior to flotation. To eliminate interruption in production, the transfer of operations will be made in three stages. The first stage of the project, including one-third of the new mill and construction of a 34-inch water supply pipeline 26 miles long, will be completed by mid-1963. When finished, the concentrator will have a capacity to process 42,000 tons of ore per day.

Duval Sulfur & Potash Co. has been operating a pilot autogenous mill, in closed circuit with a Dutch State Mines sieve bend and cyclones, to determine the system's effectiveness on a porphyry copper ore from near Kingman, Ariz. Preliminary results are reported to be encouraging, but the company is still undecided whether to install only secondary pebble mills or to try the full autogenous treatment.

IRON ORE BENEFICIATION AND PELLETIZING

The desire to increase iron blast furnace capacity led to the acceptance of pelletized fine concentrate only a few years ago. Now pellets are the standard feed, and all other ores and agglomerates are compared to these pellets. The furnace operators, meanwhile, have tightened all specifications for raw materials. As a result, every major iron-ore-processing company is spending a large share of its research and development dollar in the attempt to produce improved blast furnace feed.

The furnace operators prefer a hard pellet—the harder the better. However, beyond the degree necessary to withstand transportation and to support the furnace burden, extremely hard pellets have no proven advantage. The furnace men also insist on round pellets, ½ to ⅜ inch in diameter. Most of them favor heat-treated, crystal-growth-bonded pellets rather than slag-cemented balls. On the other hand, some producers and equipment manufacturers are attempting to sell the idea of hot-pressed, pillow-shaped compacts for ores that are hard to pelletize. Laboratory men speak of the effects of pellet porosity, reduction rates, pellet size, and the shape of compacts, but there has not been adequate research to correlate any of these factors with blast furnace production rates.

Less empirical than shape, size, and hardness factors are the chemical specifications. Currently, pellets containing about 8 percent silica are acceptable. Alumina, once considered a necessary slag-forming constituent, is now looked upon as an unwanted impurity which requires additional amounts of limestone for rejection. Often alumina is added to silica in calculating the 8-percent allowance. Independent domestic producers believe that within 2 years, when the full effect of the imports of low-silica Canadian concentrates is felt, silica plus alumina will be restricted to 6 percent. Some predict that within 10 years a sizable market will exist for concentrates containing less than 2 percent silica.

Several new techniques have been adopted to lower silica content of iron concentrates. One method uses an adapted version of the Siphonsizer, which was originally developed for beneficiation of Florida phosphate ores. Basically, this machine is a teeter bed hydraulic sizer that is capable of making sharp size separations with a minimum flow of water. Operation at the Reserve Mining Co. shows that treatment of concentrate will increase the iron grade from 1 to 1½ percent and decrease the silica content about 1 percent with loss of only a fraction of 1 percent of the total iron. Similar results of tests on Empire pilot plant concentrates convinced Cleveland-Cliffs to include Siphonsizers in the flowsheet of the Empire plant.

Incidentally, the Siphonsizer is attracting interest in other areas. One chemical company has run successful tests to size accurately its crystalline product. It has been proven to be an effective sizer before tabling coal for the removal of ash. Several companies are investigating it as a unit of closed-circuit grinding.

At the Republic plant of Cleveland-Cliffs, silica is effectively reduced by a hot float cleaning step. Concentrates, produced by standard fatty-acid petroleum sulfonate flotation, are reground, sparged with steam to raise the temperature to 150° F, and refloated. Silica content is reduced from 7 to 5 percent with little loss of iron.

Erie Mining Co., Aurora, Minn., is applying anionic flotation for treatment of about one-fifth of its total magnetite concentrate. Silica content is reduced from 11 to about 5 percent. The improved product is blended with untreated concentrate to effect an overall improvement in grade. Similar treatment is being considered by other magnetic taconite processors.

Hanna Mining Co., Cooley, Minn., is taking a fresh look at the magnetic conversion (reduction roasting) method of beneficiating nonmagnetic iron ores. The pilot study includes utilization of lignite to form a part of the reducing gas in accordance with a method researched by the Bureau of Mines.

Increased popularity of pellets for blast furnaces feed has led to increased facilities for their production. At the Carol Lake operation, for example, the company selected pelletizing rather than direct sintering in spite of the costly regrind necessary to prepare the coarse gravity concentrate for balling. The pellet plant, employing balling drums and a Dravo-Lurgi straight-grate pelletizing system, will have a capacity of 5.5 million tons per year. It is expected to be in operation by spring of 1963. Hanna's Groveland mine near Iron Mountain, Mich., also is installing a Dravo-Lurgi system—the first in the United States. The grate is about 10 feet wide and 270 feet long and has an estimated capacity of 1.5 million tons of pellets per year. Startup date is planned for early summer. The success of Cleveland-Cliffs with the Allis-Chalmers Manufacturing Co. (ACL) grate-kiln pelletizing system at Republic and Humboldt mines has influenced the company to install the same system in the Empire plant. This will be the first commercial installation of ACL for magnetic taconite concentrates and there is some concern about the tendency for ring formation at about 1,900° F with such feed.

Intense interest has been shown in prereduced metallized pellet research being conducted by the Bureau of Mines at its Minneapolis Metallurgy Research Center. Magnetic concentrate, supplied by Erie Mining Co. and containing about 63 percent iron and 9 percent silica, was balled in the conventional manner. The green balls were fired with lignite or other reductant in a rotary kiln with a maximum temperature of 2,100° F. The product was hard uniform pellets that analyzed 80 percent iron of which at least 60 percent was metallic. Preliminary small-scale blast furnace tests have indicated that prereduced pellets are ideal blast furnace feed. When one-half of a furnace charge of commercial pellets was replaced by the prereduced product, metal production was increased by more than 20 percent and the coke rate was reduced nearly as much. When the charge was composed entirely of semimetallized pellets, production was up 35 percent and coke rate was down 30 percent.

Steel Company of Canada at Hamilton, Ontario, currently is producing a small tonnage of prereduced pellets. The method used differs from that of the Bureau of Mines in that fully fired hard pellets are reduced with anthracite in a Lurgi kiln. This method tends to disintegrate the pellets; 30 to 40 percent of the pellets charged are broken during treatment. Otherwise, the operation has been successful.

Approximately 200,000 tons of extremely high-grade pellets are produced each year from nickeliferous pyrrhotite ores by Inco, at its Copper Cliff, Ontario, operation. Nickel-bearing pyrrhotite concentrate is first given a fluid-bed oxidizing roast and then is treated by controlled concurrent reduction in a Lurgi kiln. Ammonia leaching at atmospheric pressure removes nickel, cobalt, copper, and selenium, and the residue is pelletized with a traveling grate system. Nominal composition of the iron pellets is 68 percent Fe, 0.15 percent Ni, 0.01 percent Cu, 0.005 percent S, 0.003 percent P, and 1.0 percent SiO_2.

The small electric furnace plant erected a couple of years ago by Consolidated Mining & Smelting Co. of Canada, Ltd. (Cominco), to produce pig iron from iron sulfide made as a byproduct at its Sullivan lead-zinc concentrator has been highly successful.

STEEL PROCESSING

Two items loom largest in the field of steel production: Oxygen and continuous casting.

The use of oxygen in steel production continues to grow rapidly. In 1961, about 40 billion cubic feet of oxygen was consumed by steel companies in the United States. It is predicted that within 4 years consumption will increase by 50 percent. Most of the oxygen is used in open-hearth furnaces; about one third of the Nation's 850 open hearths have been converted to utilize oxygen, and these converted furnaces are reported to be producing 45 to 50 percent of the total steel output. For new installations, however, the basic oxygen process (BOP) continues to gain adherents. Basic oxygen converters function much like the older Bessemer furnaces, but substitute oxygen through lances for surface blowing in place of bottom-blown air. Five companies are now using the process in this country, and the total U.S. BOP annual capacity is 7.5 million tons. With another five companies planning BOP operations within 2 years, the annual capacity will jump to 20 million tons. World BOP capacity is now about 32 million tons per year but is expected to double by 1966.

No subject in the steel industry is receiving more discussion than continuous casting. At least 37 continuous casting machines are being used for steel in 21 countries; nearly 30 additional new machines are under construction or on order. The method reportedly gives higher yield and higher quality slabs and billets; it has much lower capital cost and lower operating cost than conventional casting practice. It is generally conceded that continuous casting allows better quality control and has special advantages for producers of high-priced specialty steels. Yet steel men in the United States have been reluctant to employ continuous casting because they have considered the method too slow and too limited to handle the output of large steel plants. Recent improvements in the process, developed in Europe and Japan, however, have led many companies to reconsider their position.

At least 15 of the steel companies in the United States have the method under observation. McLouth Steel Corp., Trenton, Mich., was installing a small continuous-casting facility to take the output of its 110-ton oxygen furnace. Some companies, like United States Steel Corp., Jones & Laughlin Steel Corp., and Armco Steel Corp., have conducted intensive investigations. United States Steel, for example, has spent considerable effort in the attempt "to develop a process suitable for large annual tonnages and at the same time flexible enough to be competitive in the marketplace." Some sources believe that United States Steel is close to that objective. Others predict that, because of a peculiar set of circumstances that exists at its Aliquippa, Pa., plant, Jones & Laughlin will be the first U.S. company to install a large continuous-casting unit.

It is safe to predict that within 3 years continuous casting of steel will have made its debut at several steel plants in the United States.

COPPER RECOVERY

Standard copper flotation procedure involves making a clean tailing for rejection and a rougher concentrate which is refloated one or more times. The cleaner tailing is returned to the mill feed circuit. The returned middling, however, eventually increases the copper loss in the tailing and lowers the grade of the final concentrate, which in turn increases the cost of subsequent smelting. For years, mill men have been devising methods for the recovery of the copper in the cleaner tailings without returning them to the flotation circuit. Normally the schemes involved roasting, leaching the oxidized residue with sulfuric acid, and precipitating the copper with metallic iron. Although such methods have been investigated through the pilot plant state, no company has yet found it economical to install a full-scale treatment plant. The latest idea, now being investigated by two copper companies in conjunction with American Cyanamid Co., consists of leaching the cleaner tailing product with sodium cyanide. The method appears to have promise for ores in which copper occurs chiefly as chalcocite (Cu_2S). Copper sulfides, but not iron sulfides nor chalcopyrite ($CuFeS_2$), are dissolved readily in the cyanide solution; 90 percent of the copper is extracted in 20 minutes. Sulfuric acid treatment in the presence of additional sulfide precipitates the copper as Cu_2S and releases hydrogen cyanide for subsequent reformation of sodium cyanide. Cyanide consumption is reported to average 0.3 pound per pound of copper treated.

Kennecott Copper Corp., after years of research, is putting microbes to work to recover copper from waste mine dumps. A warm solution of ferrous sulfate and sulfuric acid containing two strains of bacteria is trickled down through piles or ore. The thiobacillus ferro-oxidans strain produces ferric sulfate, which, in the acidified solution, leaches copper from the copper minerals. Simultaneously, the thiobacillus thio-oxidans strain produces more sulfuric acid to maintain proper pH. The company claims that the presence of bacteria increases the rate of leaching materially and aids in making the waste dumps more pervious to leach solution seepage.

TITANIUM DIOXIDE PROCESSES

In view of the steady increase in the use of water-base paint and the phenomenal growth history of the titanium dioxide pigment industry, announcements by three companies that they were planning to increase titanium dioxide pigment production capacity came as no surprise.

The significant factor was that every expansion underway or officially proposed was based on a chloride treatment process instead of the established sulfate method. Du Pont reported that it would add 10,000 tons per year capacity to its plant at New Johnsonville, Tenn., and would construct a plant at Antioch, Calif., capable of producing 27,000 tons of titanium dioxide per year. Du Pont already was operating its New Johnsonville plant and part of its plant at Edge Moor, Del., with a chloride process. Cabot Corp. (Boston) and Ruberoid Co. (New York) joined forces to construct a 40,000-ton-per-year plant at Ashtabula, Ohio, with the announced intention of using a chloride-based method developed by Fabriques de Produits Chimiques de Thann et de Mulhouse (FPC) of Thann, France. A 25,000-ton-per-year plant was to be erected at Mohave, Calif., by American Potash & Chemical Corp., using a chloride process under development for several years by Laport Industries, Ltd., of England.

Although the details of the three processes differ, basically they are similar. A titanium mineral concentrate (usually rutile) is treated with dry chlorine in a fluidized bed reactor to yield a mixture of gases. Liquid titanium tetrachloride (referred to as *tickle*) is recovered and separated from the sublimated solids (chiefly iron chlorides). The tickle is purified by distillation to reject chlorides of other Group IV elements, chiefly silicon tetrachloride. The purified liquid is converted into titanium dioxide by burning with oxygen at about 2,200° F and subsequently is neutralized and treated to make it suitable for the market. The chlorine released by the oxidation step is recovered and recycled.

The chloride process, to prevent excessive consumption of chlorine by the formation of large amounts of iron chloride, is best applied to rutile concentrate (95 percent titanium dioxide) priced at about $100 per ton, whereas the sulfate process uses ilmenite (40 to 60 percent titanium dioxide) costing less than one-third as much. Present investigations are being conducted to determine if titanium-bearing slag from electric furnace processing of ferruginous ilmenite is suitable feed for the chlorination step.

Meanwhile producers using the sulfate process, including American Cyanamid Co., Du Pont, the Glidden Co., National Lead Co., and the New Jersey Zinc Co., were taking steps to improve their product. The sulfate process consists essentially of digestion of large batches of ilmenite or titanium slag in sulfuric acid to produce titanyl sulfate; the solution is clarified, ferrous sulfate is removed, and the solution then is hydrolyzed to form titanium hydroxide which is filtered, calcined, and ground. The key step is hydrolysis. Titanium sulfate reacts with water at 185° to 190° F. to form hydrated titanium dioxide as comparatively large crystals. But this reaction can be slowed to produce smaller, higher quality crystals that, when finished, yield a suitable product. A method of continuous sulfate digestion under pressure also is being investigated. It is claimed to have the potential of making a premium product with low capital investment and with operating costs competitive with the standard sulfate process.

Review of Mining Technology

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

THE THREE words, *research*, *mechanization*, and *automation* are keynote words for mining technology during 1962. Basically interrelated, they not only express the major technologic developments in mining but are the signposts pointing out the road ahead. The process represented by each of these words is evolutionary rather than revolutionary, but developments during the past year indicate a climactical stage has been reached in the process of evolution.

Mining research has progressed beyond the stage of academic discussion and is a programed activity within the Federal Government,[3] the mining colleges,[4] and many of the large mining companies.[5] Research was a major agenda item at various national and international mining meetings in 1962. A list of these meetings would include such diverse locales as the Workshop and Symposium on Computers and Computer Applications in Mining and Exploration at the University of Arizona in March; and the 5th Rock Mechanics Symposium at the University of Minnesota, in May; the Rock Mechanics Symposium at McGill University, Montreal, Canada, in September; and the Colloquium XIII, International Society for Rock Mechanics, at Salzburg, Austria, in November.

The progress in mechanization of underground coal mining during the past 25 years was well summarized in the November issue of Mechanization.[6] Before 1936, hand loading into cars accounted for 85 percent of the coal loaded underground. By 1962 the percentages were

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[1] Chief mining engineer.
[2] Assistant chief mining engineer.
[3] Howard, T. E. Metal and Non-Metal Mining Research in the Bureau of Mines. Min. Eng., v. 14, No. 1, January 1962, pp. 50–52.
McCurdy, Wayne A. Role of the Office of Coal Research. Min. Eng., v. 14, No. 9, September 1962, pp. 66–67.
Merrill, Charles W. Programing U.S. Bureau of Mines Multimillion-Dollar Minerals Research. Min. Eng., v. 13, No. 11, November 1961, pp. 1226–1227.
———. A Government Viewpoint on Basic Mining Research. Min. Cong. J., V. 48, No. 12, December 1962, pp. 56–57, 63.
Shaw, John F. Operations of a Mining Research Center. Min. Eng., v. 14, No. 3, March 1962, pp. 49–51.
[4] Manula, Charles B. Operations Research: A New Tool for Mining. Pennsylvania State Univ. Miner. Ind., v. 31, No. 9, June 1962, 8 pp.
Rinehart, John S. Types of Basic Research Needed in Mining. Mines Mag., v. 52, No. 10, October 1962, pp. 12–14.
[5] Charmbury, H. B. Finding the Answers Through Research. Min. Cong. J., v. 48, No. 9, September 1962, pp. 63–65.
Stewart, R. M. Industrial Engineering and Research in Mining. Min. Cong. J., v. 48, No. 9, September 1962, pp. 50–53.
[6] Mechanization. Twenty-five Years of Growth in Underground Mechanization. V. 26, No. 11, November 1962, pp. 50–57.

reversed in favor of mechanical loading and, more important, a major part of the mechanical mining was by so-called continuous mining, including such recent developments as the *push-button* miner, coal planer, self-advancing roof prop systems, and hydraulic mining. The mechanization of strip mining was dramatically demonstrated by the combination of large capacity shovels, draglines, and trucks, the largest being 115-yard capacity shovels and 100-ton trucks at the Peabody Coal Co. Sinclair mine in Kentucky. Progress also was being made in hard-rock mining toward a continuous cycle with development of tunneling machines, shaft and raise borers, and combination loading and transport systems.

Mechanization is a prerequisite for automation and a continuous working system is a major incentive for its application. Mining operations approached nearer to these conditions than at any time in the past. Serviceable sensing, communication, and control systems, both mechanical and electronic, were available, providing reliable mechanisms for automation. A glimpse into the future may be provided by Mobot, the underwater robot created by Hughes Aircraft Co. and used by Shell Oil Co. in underwater drilling operations.[7] Controlled by an operator at a console on the surface, the robot serves as an underwater roustabout. It can swim, propelled by three screw propellers; and it can see, hear, and sense by controlled closed-circuit television, sonar, and hydrophone. Its main purpose is to guide the drill pipe into the casing in deep offshore drilling.

Of more immediate significance are the mounting references to automated or remote controlled individual mining units, parts of mining system, and even entire mining systems. Remote control of the underground operation of mucking machines, bulldozers, and stope filling had been accomplished.[8] Automated hoisting and transport systems with central or remote control were commonplace. Experiments were under way in Great Britain on an automated longwall mining system, using remotely controlled continuous mining machines and powered self-advancing roof supports.[9] The U.S.S.R. claimed a "first" in the reported start of construction on a fully automatic coal mine. According to the report, coal will be broken at the face with hydromonitors equipped with programed devices for self-selection of the best operating conditions. The broken coal will be transported hydraulically to the surface, through pipes. Details on the status of hydraulic mining in the U.S.S.R. indicated that while planned output per manshift was 8 to 9 tons and was projected to much higher output as the system develops, the 1962 output per manshift by hydraulic mining was 4.5 tons.[10]

EXPLORATION AND SAMPLING

A geologically oriented Mobot may be the answer to undersea prospecting but geophysical exploration and subsurface drilling were still

[7] Joseph, James. Robots Under the Sea. Petroleum Today. V. 4, No. 1, fall 1962, pp. 9–10.

[8] Mining Journal. Further Developments in the Remote Control of Mining Operations. V. 258, No. 6606, Mar. 30, 1962, pp. 310–311.

[9] Tunstall, John. The British Approach to Continuous Mining. Coal Age, v. 67, No. 6, June 1962, pp. 68–72.

[10] Coal Age, Soviets Constructing Automated Coal Mine. V. 67, No. 6, June 1962, p. 37. Sharma, S. N. Hydraulic Mining in U.S.S.R. J. of Mines, Metals and Fuels (India), v. 10, No. 11, November 1962, pp. 11–20.

the mainstay for continental exploration. The large-scale seismic investigations sponsored by the Defense Department in connection with underground nuclear detonations focused attention on collection of worldwide seismic data and refinement of methods, instrumentation, techniques, and the processing and interpretation of data. While the work was not specifically oriented toward ore search, some results will undoubtedly, be reflected in geophysical mineral exploration. A central information center was established at the University of Michigan for the collection, analysis, and dissemination of seismic information. One significant development was the work on a direct digitizing seismometer to convert ground movement signals directly into digital form for input to electronic computers.

Several portable seismic refraction apparatuses suitable for use to a maximum depth of about 200 feet were on the market for exploration of near surface geologic conditions. The equipment had many uses, including determining subsurface material and conditions for outlining deposits of construction material, determining rippability, and for engineering-site investigations.

A new seismic prospecting system that eliminates explosives or dropped weights to generate vibrations was tried out in South Africa.[11] Vibration is imparted to the earth by a hydronamic oscillator, which is essentially a controlled water hammer principle. In addition to eliminating the more expensive blastings, finer resolution is obtained. Although developed for near surface prospecting, the system has capabilities for depths of 10,000 feet or more. A similar vibration system had been used in the United States by Continental Oil Co. Another approach to geophysical exploration was offered by Input (Induced Pulse Transient Airborne Prospecting system).[12] Loosely analogous to radar in that it depends on generation of high-powered electromagnetic pulses and reception of signals following the termination of these pulses, relative conductivity of a rock mass can be determined. The method was tested on porphyry deposits and other sulfide ore bodies with good results.

In the course of deep exploration between the Klerksdorp and Orange Free State areas in the Republic of South Africa, a hole depth of 14,093 feet was reached, setting a record for small-diameter exploratory drilling.[13] Six holes more than 11,000 feet deep had been drilled, of which three were deeper than 13,000 feet. Drilling speed ranged from 500 to 1,000 feet per month. Important auxiliary equipment on the job included a new electronic borehole survey unit capable of an unlimited number of hole deviation readings immediately available at the surface, and an electronic crack detector for examining drill rods. A step forward in visual examination of boreholes was achieved with the compact television camera developed by Shell Development Co.[14] The downhole television system can be operated to depths of 5,000 feet under pressure of 5,000 pounds per square inch

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[11] South African Mining and Engineering Journal. A New Seismic Prospecting System. V. 73, pt. 1, No. 3610, Apr. 13, 1962, pp. 787–789.

[12] Barringer, A. R. New Approach to Exploration. Min. Cong. J., v. 48, No. 10, October 1962, pp. 49–52.

[13] South African Mining and Engineering Journal, Drilling 14,093 Feet. V. 73, pt. 2, No. 3625, Oct. 5, 1962, pp. 727–728.

[14] Drilling. Compact New TV Camera Helps Drilling Men Look Downhole. V. 23, No. 12, September 1962, pp. 131–132.

(psi) and temperatures up to 120° F. Outside diameter of the camera housing is 4¾ inches, allowing use in 5½-inch casing.

The outlined status of an oceanic deep drilling project (Mohole) indicates that drilling may progress through a preliminary intermediate stage prior to an actual attempt to penetrate the earth's mantle.[15] This approach will assist in developing optimum drilling techniques and retrieval of scientific information.

A computer installed at the Denver Mining Research Center of the Bureau of Mines will facilitate work on the theory of sampling. Several reports on the application of statistical analysis applied to mine sampling and computer programing of ore reserve estimating techniques were published.[16]

The principles and procedures for valuation of alluvial deposits were outlined.[17] Although specifically directed to valuation of auriferous placers, the principles and techniques apply to placer deposits in general.

DEVELOPMENT

Mechanization of vertical development work for shaft sinking and raising has increased. The four major innovations in recent years were mechanical mucking devices, various raise cages, climbers, and large boring tools. Other important developments included drill jumbos, multistage sinking platforms and movable forms for concrete lining. White Pine Copper Co. in Michigan employed several of these mechanical innovations in sinking its No. 1 shaft to set a North American shaft-sinking record of 519 feet of shaft and 510 feet of concrete lining in October 1961.[18] The contractor used a four-deck sinking stage with a 1-yard clamshell grab hung from the mucker mounted on the bottom deck. Mechanical mucking and concrete lining with movable forms were being applied to inclined shaft sinking at the East Rand Proprietary gold mine in South Africa.[19] The equipment was being used to sink the Hercules shaft at a dip of 20 to 25 degrees. The shaft will follow a pilot winze to an eventual depth of 11,000 feet, which would set a record for depth of shaft. The mucking machine was a converted Gradall loader mounted on a special-design track-mounted undercarriage. It is electrically operated and can be lowered and raised in the shaft by its own power. A collapsible track-mounted steel mobile tunnel form was used.

A newly designed shaft-sinking drill jumbo was employed at the Boliden Mining Co. in Sweden.[20] Airleg rock drills were mounted on

[15] Geotimes. Status of the AMSOC Oceanic Deep Drilling Project. V. 7, No. 1, July–August 1962, pp. 8–11.

[16] Hazen, Scott W., and R. D. Berkenkotter. An Experimental Mine Sampling Project Designed for Statistical Analysis. Bu. Mines Rept. of Inv. 6019, 1962, 111 pp.

Hewlett, R. F. Computing Ore Reserves by the Polygonal Method, Using a Medium Size Computer. Bu. Mines Rept. of Inv. 5952, 1962, 33 pp.

———. Use of High Speed Data Reduction and Processing in the Minerals Industry. Bu. Mines Inf. Circ. 8099, 1962, 82 pp.

[17] Daily, Arthur. Valuation of Large Gold-Bearing Placers. Eng. Min. J., v. 163, No. 7, July 1962, pp. 80–88.

[18] Skillings, David N., Jr. Southwest Project of White Pine Copper Co. Skillings' Min. Rev., v. 51, No. 7, Feb. 17, 1962, pp. 1, 4, 5.

[19] South African Mining Journal. Greater Mechanization in Inclined Shaft Cleaning and Lining. V. 73, pt. 2, No. 3626, pp. 219–222.

[20] Mine and Quarry Engineering. Swedish Shaft Ring. V. 28, No. 10, October 1962, p. 467.

a ring of I-beams clamped to the shaft wall by three tension screws. The drills were fastened to small trolleys running on the outer flange of the ring.

Traditionally, raise driving has been a hard and hazardous part of many mining operations. The introduction several years ago of raise climbers and raise cages tended to alleviate this condition, and these devices became widely used. The newest of the devices is the Jora Lift developed by the Boliden Mining Co. in Sweden, in which a working cage, suspended on a cable passing down through an overhead drill hole, is controlled within the cage to move up and down the cable.[21] The lift was listed among the blue ribbon equipment awards by Mining World for 1961. The Tuolluvaara mine in Sweden used a combination method, employing a raise climber for shaft raising.[22] A pilot raise was driven between levels using an Alimak raise climber. The pilot raise was then enlarged to full shaft size by shrinkage mining, the climber serving as a hoist from the level above. The shaft was then timbered from a working platform lowered from the upper level.

A raise drilling machine was tested at the M. A. Hanna Co. Homer-Wauseca mine in Michigan,[23] and several raise and drift boring machines were in various stages of development and testing.[24] Basically, the raise borer works by drilling a pilot hole between levels then enlarging the pilot hole by up-drilling reaming techniques. The same general principles have been used in softer rocks, but the present machine is designed to drill 40-inch holes in hard rock.

Since 1958 more than 200 large-diameter (plus 36-inch) holes have been drilled in the United States, including many mine shafts.[25] Diameter of these holes ranged from 36 to 90 inches and the depth, from 20 to 1,432 feet.

South African miners continue to set records for development work. Completion of the No. 3 ventilation shaft at Western Deep Levels, bottomed at 9,673 feet below the surface, is the world's deepest single shaft.[26] A world shaft-sinking record of 1,251 feet in 31 days was claimed at the Eastern ventilation shaft of Buffelsfontein gold mine.[27] The Loraine gold mine set a hard-rock tunneling record of 2,552 feet in 30 days.[28]

DRILLING

Inclined drilling for bench blasting held continued interest and new models of rotary blasthole drills were designed to accommodate in-

[21] South African Mining and Engineering Journal. Jora Lift for Raise Driving. V. 73, pt. 1, No. 3612, Apr. 27, 1962, pp. 895–897.

[22] Read, C. G. Shaft Raising at Tuolluvaara. Mine and Quarry Eng., v. 28, No. 7, July 1962, pp. 312–317.

[23] Engineering and Mining Journal. Raise Borer Chews Hard Rock in Preliminary Tests. V. 163, No. 12, December 1962, pp. 78–79.

[24] Cannon, R. E. Raise and Drift Boring Methods and Equipment for Metal Mining. Paper pres. at AIME, Rocky Mountain Minerals Conf., Butte, Mont., September 1962, 26 pp.

[25] Engineering and Mining Journal. The Big-Hole Rotary—What It's Doing, What It Can Do, How It's Designed. V. 163, No. 7, July 1962, pp. 70–75.

[26] South African Mining and Engineering Journal. World's Deepest Single Shaft. V. 73, pt. 2, No. 3637, Oct. 19, 1962, pp. 858–860.

[27] South African Mining and Engineering Journal. World's Shaft-Sinking Record. V. 73, pt. 2, No. 3637, Oct. 19, 1962, p. 889.

[28] South African Mining and Engineering Journal. New Hard-Rock Tunnelling Feat. V. 73, pt. 2, No. 3622, July 6, 1962, pp. 13–16.

clined drilling.[29] The down-the-hole drills successfully used for varied surface application have been redesigned for use underground.[30] Probable applications include drilling of conduits and vents, large diameter holes in a burn-cut round, and predrilling of complete raise patterns. A major advantage over other drilling methods is the small amount of hole deviation, permitting better accuracy of a planned drill pattern. Two of these drills were used at the Butte operations of The Anaconda Company to drill down-hole drill raises, ventilation holes, cut holes for raises, water drainage holes, tailing transfer holes, and horizontal cut holes for sill headings. Bit sizes ranged from 5 to 8 inches. An average penetration rate of 23 feet per hour and a cost of less than $3 per foot was obtained.

Data presented by Reserve Mining Co. in Minnesota showed that jet piercing speed had more than doubled since 1952. Average piercing speed in 1952 was 7.7 feet per hour; speed in 1962 was 16 feet per hour.[31] Soviet engineers continued to show interest in the process of rock drilling and various means to penetrate or crush rock, as evidenced by publications recently translated in the United States.[32] A summation in one of these publications of the results of testing various methods stated that for surface mining thermal and percussion-rotational methods show the greatest promise, but detonational drilling also holds promise.

Among the innovations for drilling were horizontal wire line diamond drilling[33] and rubber-collar drill steel.[34] The collar consists of a 1½-inch diameter steel cylindrical sleeve, 2-inches long, containing a bonded rubber inset, which is pressed onto the drill steel and attached in place by epoxy cement. Fabrication costs were higher than for a forged steel but it is anticipated that this will be more than compensated for by longer drill steel life. A new processed drill diamond providing a smooth rounded contour was introduced by the Diamond Research Laboratory of South Africa and reported to drill 50 percent greater footage.[35] Improved drilling factors were also claimed for a newly developed oriented-impregnated diamond bit.[36] Two rotary blasthole drills that were claimed to be the largest of their type in the world were put in operation at the Peabody's Sinclair coal mine in Kentucky. Designed to drill holes up to 15 inches in diameter, drilling speeds of 10 feet a minute were announced.

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[29] Chapman, W. M. Blast Holes on the Bias. Min. Cong. J., v. 48, No. 10, October 1962, pp. 30–33.
Kochanowsky, B. J. Recent Developments in Inclined Drilling and Blasting. Min. Cong. J., v. 48, No. 7, July 1962, pp. 43–48.
Milosevic, M. I. Inclined Drilling Proves Best. Eng. and Min. J., v. 163, No. 3, March 1962, pp. 86–89.

[30] Adams, J. W. Downhole Drills Go Underground. Compressed Air, v. 67, No. 9, September 1962, pp. 32–34.
Bonner, Edward O. Underground Down-Hole Drilling. Paper pres. at Northwest Mining Conv., Spokane, Wash., Dec. 1, 1962.

[31] Henderson, Bernard. How Heavier Drilling and Blasting Paid Off in Taconite. Eng. and Min. J., v. 163, No. 10, January 1962, pp. 80–84.

[32] Epshteyn, Y. F., and others. New Methods of Crushing Rock. State Sci. and Tech. Pub. House for Min. and Petrol. Ind., Moscow, 1960, 130 pp.
Ostrovakii, A. P. (Deep Hole Drilling With Explosives. All-Union Scientific-Research Institute of Drilling Techniques). Translated by Consultants Bureau, 100 pp.

[33] Mining World. Wire Line Diamond Drilling Goes Underground to Drill Holes Faster and Cheaper with High Core Recovery. V. 24, No. 7, June 1962, pp. 20–23.

[34] Kennedy, Donald F. Initial Test Results at Climax Favor Rubber Collar Drill Steel. Min. Eng., v. 14, No. 8, August 1962, pp. 34–36.

[35] Engineering and Mining Journal. A New Kind of Diamond—DRL Produces Smooth Rounded Stones for Better Bits. V. 163, No. 10, October 1962, pp. 82–83.

[36] Barrett, J. L. Drilling Research Develops Low-Cost Diamond Bit. Eng. and Min. J., v. 163, No. 5, May 1962, pp. 87–92.

FRAGMENTATION

A successful system of mechanical rock fragmentation for mining would be a major forward step toward automation of the mining process. Several tunnel-boring machines developed during the past few years have shown continued progressive development in their design and function.[37] To date, their application has been limited to softer rock, ranging from shale to soft sandstone. Operating data on a boring machine used by the Hydro-Electric Commission of Tasmania to drive a 16-foot-diameter tunnel in hard mudstone showed an average advance rate of 5.01 feet per hour, with the best weekly advance of 554 feet.

Experimental work continued on breaking coal from the solid with hydraulic jets.[38] Mining tests on anthracite were made, using a nozzle that delivered 300 gallons per minute at 5,000 pounds per square inch. The jet was able to cut hard sandstone layers encountered during mining. A thermal method of fragmentation reported as a variation of electronic rock breaking was developed in South Africa.[39] Conventional drill holes were charged with a special formula of combustible metal and chemical particles and were ignited electronically, producing temperatures above 3,000° C., with resulting rock breakage.

The use of ammonium nitrate-fuel oil blasting agents was a hotly debated subject 5 years ago, after which it became an accepted practice for both surface and underground blasting. Blasting agents advanced from a do-it-yourself venture to a major product of most of the large explosives companies; one has issued instructional material on its use and safeguards.[40] Efficient use of blasting agents entails a means for mechanical placement with possible associated buildup of static electricity. Hazards were recognized, and tests were made to minimize the risks.[41] The original impetus for use of blasting agents came from surface mining operations, but underground application has been progressvely more widespread as experience defined the relative advantages and disadvantages.[42] Savings in costs of explosives from 30 to 50 percent were reported.

Research and experimentation resulted in improvements and a more systematic approach to explosive rock fragmentation. Test crater shots were used by Iron Ore Company of Canada to compare the effectiveness of various blasting agents and stemming.[43] Results

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[37] Civil Engineering. Machine Tunneling. V. 32, No. 7, July 1962, pp. 40–45.
Engineering and Mining Journal. Hard Rock Tunnel Boring Moves Ahead. V. 163, No. 6, June 1962, pp. 172–173.

[38] Buch, J. W., and I. L. Williams. Hydraulic Mining of Anthracite. Min. Cong. J., v. 48, No. 7, July 1962, pp. 22–28.
Coal Age. Successful Hydraulic Mining on 72 Degrees. V. 67, No. 1, January 1962, pp. 80–84.
McMillan, E. R. Hydraulic Jet Mining Shows Potential as a New Tool for Coal Men. Min. Eng., v. 14, No. 6, June 1962, pp. 41–45.

[39] South African Mining and Engineering Journal. Electronic Rock Breaking. V. 73, pt. 2, No. 3628, Aug. 17, 1962, pp. 335–336.

[40] E. I. du Pont de Nemours & Co., Inc. Use of Blasting Agents in Underground Mining. Secs. 1 and 2, 1962, 22 pp.

[41] Hurry, J. A. How to Combat Static Electricity in Loading AN/FO in Blastholes. Eng. and Min. J., v. 163, No. 10, October 1962, pp. 90–92.

[42] Estabrooks, H. B. Tennessee Copper Company Now Uses AN–FO for 80 Percent of Its Blasting. Min. Eng., v. 14, No. 11, November 1962, pp. 59–60.
Matson, R. P. Blasting With Ammonium Nitrade Underground. Min. Cong. J., v. 48, No. 4, April 1962, pp. 26–29.

[43] Farnam, H. E., Jr. New Application of Explosives. Min. Cong. J., v. 48, No. 3, March 1962, pp. 20–32.

from these tests determined the blasting pattern and stimulated a more systematic blasting program. Theoretical study of the relationship of velocity and hole depth to blasting results indicated several practical considerations when applied to cylindrical charges.[44] The timing of detonation and location of primers were indicated to be important parameters for efficient rock breakage. These factors could be determined through theoretical calculations and experimentation. A method was established to measure the relative effectiveness of overburden casting by explosives in strip mining by comparison of the relative distance between the center of gravity of the original bench, the blasted rockpile, and the final spoil pile.[45] Long-term experimentation at the National Lead Co. MacIntyre mine, Tahawus, N.Y., on an efficient drilling and blasting system for optimum fragmentation has increased overall efficiency and decreased costs per ton.[46] Important factors included use of ammonium nitrate-fuel oil blasting agents, inclined drill holes, higher powder factor, reduced spacing and burden of the drill pattern, and double-row blasting. Small-scale blasting experiments conducted in the laboratory by the Bureau of Mines indicated that results obtained should be useful in predicting full-scale blasting effects.[47] The advantage in time and cost of testing is obvious if the validity of small scale laboratory testing is established. In the course of investigating blasting vibration damage criteria, the Bureau of Mines advocated particle velocity versus time as a standard for measurement,[48] and recommended that vibration near residential structures should not exceed a peak particle velocity of 2 inches per second.

A method of predrilling and sectional blasting of raises used in the U.S.S.R. was described, giving advantages and disadvantages of the procedure.[49] It was stated that 9,750 feet of raises was driven by this method with increased performance and greater safety. A review of the results of underground nuclear testing as related to possible mining applications was made by Stanford Research Institute.[50] The stated cost estimates were of notable interest, and varied widely, depending on the size of the device. An estimate of the earth excavation costs for nuclear devices in alluvium ranged from $5.25 per cubic yard for a 1 kiloton device to 4 cents per cubic yard for a 1 megaton device.

MATERIALS HANDLING: LOADING, TRANSPORTATION, AND HOISTING

Traditionally, a mining operation was geared to stock items and sizes of available equipment. A most significant development concurrent with the rapid increase in mechanization was the growing

[44] Ash, R. L., and T. E. Pease. Velocity, Hole Depth Related to Blasting Results. Min. Eng., v. 14, No. 9, September 1962, pp. 71–76.
[45] Pisaneschi, Albert. Center of Gravity Method of Analyzing Vertical Blasting. Min. Cong. J., v. 48, No. 9, September 1962, pp. 54–56.
[46] Carr, J. R. Effect of Fragmentation on Crusher Performance. Min. Cong. J., v. 48, No. 5, May 1962, pp. 20–24.
[47] Johnson, J. B. Small Scale Blasting in Mortars. Bu. Mines Rept. of Inv. 6012, 1962, 22 pp.
[48] Duvall, W. I., and D. E. Fogelson. Review of Criteria for Estimating Damage to Residences from Blasting Vibration. Bu. Mines Rept. of Inv. 5968, 1962, 19 pp.
[49] Churakov, A. I. Raising By the Method of Sectional Blasting. Min. Cong. J., v. 48, No. 8, August 1962, pp. 97–99.
[50] Hoy, R. B. Application of Nuclear Explosives in Mining. Min. Eng., v. 14, No. 9, September 1962, pp. 49–56.

tendency to design and construct equipment to specified requirements of the user. A dramatic illustration was the large excavation and haulage equipment used for coal strip mining. A 115-yard shovel was placed in operation at the Sinclair Mine of Peabody Coal Co. in Kentucky, and an 85-yard walking dragline was ordered.[51] Each was the largest of its type in the world. In a sense, the Sinclair mine represents a newer concept in materials handling. The mine is one of several coal mines coupled to a primary consumer, a steam powerplant located at the mine site, on the premise that it is cheaper to "ship" electricity than coal.

The types and sizes of haulage equipment continued to increase. Fleets of 100-ton trucks were placed in operation at the Eagle Mountain iron mine in California and an iron mine in Labrador. New developments included use of aluminum bodies; new power packages, including electric drive and twin engines; and a new self-loading scraper referred to as a coal scuttle.[52] The scrapers have three individual electric drive wheels forcing forward motion while loading coal into two telescoping scuttles or bowls. Prototype aluminum truck bodies had been service tested at Canadian asbestos mines since 1959, and in 1962 they were placed in service at two iron mines. The tests indicated that the bodies gave satisfactory service under severe operating conditions.

Attention was again focused on two European conveyor developments, the German Serpentix and the British cable belt conveyor.[53] (See Minerals Yearbook chapter, Review of Mining Technology V. 1, 1955 and 1960) Representing extremes in effective application, these conveyors indicated the variety of possible conveyor applications. The Serpentix used an accordion-type belt that permitted unique capabilities for climbing, turning, and side discharge over a short tortuous route. The cable belt conveyor used a carrying belt suspended between two steel drive cables, which carry the tension. Cable belt conveyors are best suited to long straight routes and comprise the longest single-drive conveyors in the world, with installations as long as 3 miles. A recently installed system at the Craigmont mine in Canada conveying the load downgrade included provision for power generation from the conveyor.

Accumulated cost and design experience on hydraulic transport and hoisting of minerals provided data for more reliable estimates of com-

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[51] Excavating Engineer. Biggest Shovel Goes to Work. V. 56, No. 10, October 1962, pp. 26–31.

Learmont, Tom. Design Highlights of a 115 Cubic Yard Excavator. Min. Cong. J., v. 48, No. 6, June 1962, pp. 68–70, 78.

Weis, J. F. Planning An 85-Yd. Dragline. Min. Cong. J., v. 48, No. 10, October 1962, pp. 45–48.

[52] Borcherdt, E. R. Recent Developments in Open Pit Haulage. Min. Cong. J., v. 48, No. 9, September 1962, pp. 35–37.

Esmonde, R. A. Use of Aluminum in Off-Highway Truck Bodies. Min. Cong. J., v. 48, No. 11, November 1962, pp. 40–44.

Mining and Quarrying. Haulage, Standards of Capacity, Performance, and Maneuverability. V. 9, No. 11, November 1962, pp. 11–15.

[53] Engineering and Mining Journal. Cable Belt Comes to Craigmont. V. 163, No. 6, June 1962, pp. 168–169.

Klinkenborg, G. L. Conveyors That "Twist." Min. Eng., v. 14, No. 1, January 1962, pp. 46–47.

parative costs.[54] The cost to transport 1,100 tons per day of gilsonite through a 72-mile pipeline was reported as 1.39 cents per ton mile. Potential costs for hydraulic hoisting derived from the experimental pilot installation at St. Etienne, France, was 5 cents per ton to hoist 200 tons per hour (tph) of minus 4-inch coal a distance of 1,600 feet, and 6.1 cents per ton to hoist 300 tph of minus 1¼-inch copper ore a distance of 2,600 feet.

An increase in offshore mining and interest in sea-floor mineral deposits directed attention to improved dredging techniques.[55] Advances in design of component parts of bucket-line and hydraulic dredges, such as power units and control systems, improved their capacity and handling. New models of a grab dredge were designed for use in offshore depths beyond the effective limit of bucket-line and hydraulic machines.

GROUND SUPPORT AND CONTROL

Experimental and theoretical rock mechanics studies continued on an international scale to determine the factors related to ground conditions and the problems of ground support and control. Representatives of the Bureau of Mines presented papers at major rock mechanics meetings, including the Rock Mechanics Symposium at McGill University, Montreal, Canada, in September and the 13th Colloquium, International Society for Rock Mechanics, Salzburg, Austria, in November. The basic problems were of common concern, even though the details of investigations and applications varied with specific interests. The four sessions at Salzburg were directed to (1) technical description of rock masses, (2) slope stability problems, (3) dam foundations, and (4) tunnel and gallery construction. Progress was evident in these investigations, as demonstrated by increased application of theoretical considerations.[56] Mohr suggested a comparative index of standing capacity of rock, which he defined and related to a specific ground condition and required support. Coates suggested

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[54] Chapus, E. E., E. Condolios, and P. Couratin. Hydraulic Hoisting of Coal and Ores. Min. Cong. J., v. 48, No. 9, September 1962, pp. 46–49.
Koch, L. W. Solids-Carrying Pipelines, What to Consider in Their Preliminary Design. Eng. and Min. J., v. 163, No. 10, October 1962, pp. 74–78.
Mosely, T. C. Hydraulic Transport of Gilsonite Solids. Min. Cong. J., v. 48, No. 8, August 1962, pp. 79–83.
Weir, J. P. Dollars and Sense of Pipelining Coal. Min. Cong. J., v. 14, No. 9, September 1962, pp. 43–45.

[55] Erickson, O. P. Hydraulic Dredge Design Moves Ahead. Eng. and Min. J., v. 163, No. 4, April 1962, pp. 92–94.
Romanowitz, C. M. The Dredge of Tomorrow. Eng. and Min. J., v. 163, No. 4, April 1962, pp. 84–91.
Saunders, D. W. Design for a Grab Dredge. Mining Magazine (London). V. 106, No. 5, May 1962, pp. 272–279.

[56] Coats, D. F. Ground Control Around Underground Openings. Eng. J. (Canada), v. 45, No. 11, November 1962, pp. 35–40.
Dare, W. L. Measuring Changes in Pillar Strain During Pillar Recovery. BuMines Rept. of Inv. 6053, 1963, 17 pp.
Hackett, P. Rock Mechanics and the Mining Engineer. Mine & Quarry Eng., v. 28, No. 5, May 1962, pp. 215–219.
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a possible engineering design approach to underground openings, utilizing probability relationships involved in loading conditions and rock strength as a means to determine design safety factors. Meanwhile, efforts were continued to determine measuring techniques and theoretical interpretation of the phenomena involved in rock mechanics.[57]

Rockbolts gained wide acceptance for ground support, but more effective placement and anchorage was studied.[58] Effective anchorage in heavy and soft ground is difficult. Attempts to improve anchorage in this type of ground resulted in an adhesive roof bolt produced in West Germany [59] and an explosive anchored bolt under development by the Bureau of Mines.[60] Other ground support and control measures, such as filling systems, hydraulic chokes, and chemical grouts found wider acceptance and application. An automated sandfill system at the Bunker Hill mine in Idaho was controlled by one operator at the stope face. Canadian backfilling practice and relevant costs were described.[61] Greater economy and safety were obtained through the use of hydraulic jacks for temporary roof support in coal mines of the United States Steel Co.[62] Chemical grouting was used primarily to prevent water inflow but its benefit for ground stabilization was important.[63] A technique was used in South Africa to recover collapsed scraper drifts by first sealing off and cementing the collapsed section and then remining and supporting with yieldable steel supports.[64]

HEALTH AND SAFETY

The clatter of the rock drill and roar of rock blasting, noises symbolic of mining, were a subject of discussion.[65] The deleterious effects of noise on the efficiency and safety of workmen were recognized. The effects can be lessened by abatement of noise at the source and use of

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[57] Obert, L. In Situ Determination of Stress in Rock. Min. Eng., v. 14, No. 8, August 1962, pp. 51–58.
———. Effects of Stress Relief and Other Changes in Stress on the Physical Properties of Rock. BuMines Rept. of Inv. 6053, 1962, 8 pp.
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[58] Allen, G. W. Ground Support and Mine Bolts—A Study of Usage. Eng. and Min. J., v. 163, No. 8, August 1962, pp. 95–99.
Stefanko, R. New Look at Long-Term Anchorage: Key to Roof Bolt Efficiency. Min. Eng., v. 14, No. 5, May 1962, pp. 55–59.

[59] Engineering and Mining Journal. Adhesive Bolt Holds Wall in Heavy Ground. V. 163, No. 5, May 1962, 94 pp.

[60] Parsons, E. W. Design and Development of a Rockbolt Anchored by Explosive Forming. Paper pres. at Northwest Min. Assoc. Conv., Spokane, Wash., December 1962.

[61] Park, M. A. Automated Sand Fill System. Min. Cong. J., v. 48, No. 10, October 1962, pp. 24–26.
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[62] Boyle, J. A. Hydraulic Posts for Temporary Roof Support. Min. Cong. J., v. 48, No. 10, October 1962, pp. 34–36.

[63] Reed, J. J., L. A. York, and V. L. Stevens. Grouting for Control of Ground Water. Min. Cong. J., v. 48, No. 1, January 1962, pp. 49–56.

[64] South African Mining and Engineering Journal. Recovering Collapsed Drifts. V. 73, pt. 1, No. 3615, May 18, 1962, p. 1087.

[65] Daly, J. J. Underground Noise Abatement. Paper pres. at the Am. Min. Cong. Min. Show, San Francisco, Calif., September 1962.
Knoerr, A. W. How to Combat the Pending Noise Problem. Eng. and Min. J., v. 163, No. 9, September 1962, pp. 89–98.

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protective devices by personnel. Steps taken to date included redesign of drills and use of insulation and mufflers. Noise generated by surface blasting is more generally a nuisance rather than a hazard and can be minimized by proper blasting methods and by selecting of favorable weather conditions.[66]

The importance of central control and planning to combat an underground mine fire were demonstrated during the fire at the Magma mine in Arizona.[67] Rapid changes in underground conditions produced by the fire made it imperative to maintain good communications and central control for protection of personnel and for effective fire-control measures. A system of radio communication to assist underground rescue was developed by the Transvaal and Orange Free State Chamber of Mines.[68] Raise climbers eliminated many of the old hazards of raising, but introduced others. Safety precautions based on experience in the use of raise climbers were developed at the Butte mine.[69] One important recognition was that the raise climber is an elevator and should be treated as such from the standpoint of maintenance and testing. The high powerloads imposed by large-capacity excavating machines concentrated attention on the use of high voltage to permit effective power transmission to the machines. With approval of the Province of Saskatchewan, International Minerals & Chemical Corp. installed an alternating current continuous mining machine, using 4,160 volts, at the Esterhazy potash mine.[70] A special circuit was incorporated for safe operation. A battery on the mining machine was provided for monitoring the ground wire, for remote control of the contactors, and for emergency lighting in case of power failure.

High production methods in coal mines increased the importance of continuous ventilation to avoid accumulations of hazardous gas. In the event of a coal mine fan failure, power to the affected sections must be shut off to avoid possible ignition of gas accumulations. Ellsworth Division, Bethlehem Mines Corp. installed a system that monitors mine fans continuously and shuts off power in event of failure.[71]

MINING PRACTICE AND PERFORMANCE

The problems and engineering achievements in deep-level mining were described in a series of three articles on gold mining in South Africa.[72] Extensive preplanning of all phases from exploration through development and operation was evident. Mechanization of stoping operations in the narrow, tabular, flat-dipping reefs, made more difficult by conditions of high rock pressure, heat, and humidity,

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[66] E. I. du Pont de Nemours & Co., Inc. Let's Reduce the Noise From Blasting. Preprint 62AU35. Soc. of Min. Eng. of AIME, February 1962, 10 pp.

[67] Short, Bruce. Magma Mine Fire. Min. Cong. J., v. 48, No. 9, September 1962, pp. 42–45.

[68] McAdam, R. Wireless Communication Underground. Colliery Guardian, v. 204, No. 5256, Jan. 11, 1962, pp. 54–57.

[69] Colvin, L. P. Butte Develops Safety Precautions for Raise Climbers. Min. Eng., v. 14, No. 1, January 1962, pp. 35–37.

[70] Crom, R. C. W. High Voltage for Continuous Mining. Min. Cong. J., v. 48, No. 8, August 1962, pp. 71–74.

[71] Danshaw, W. Supervisory Scanner System for Mine Fan Monitoring and Mine Power Control. Min. Cong. J., v. 48, No. 5, May 1962, pp. 47–51.

[72] Black, R. A. L. Gold Mining in South Africa. Mine and Quarry Eng., v. 28, No. 5, pt. 1, May 1962, pp. 194–203; No. 5, pt. 2, June 1962, pp. 242–252; No. 7, pt. 3, July 1962, pp. 290–298.

presented the main unresolved problem. Research on strata control and ventilation was an integral part of mine planning.

Competitive pressure on underground mining in the Lake Superior iron ranges brought on a critical survey of existing conditions and practices.[73] The possibility of using a longwall top-slicing method offering higher recovery and better selectivity, safety, and opportunity for mechanization than present methods was studied. Materials handling received close attention with trials of newer methods, such as the clam-tram, a self-propelled clamshell bucket traveling on a roof suspended monorail to replace slushers. Mechanization of cut-and-fill stoping at the Henderson mine of Campbell Chibougama Mines, Ltd., in Canada cut stope development footage in half and reduced mining cost. Rubber-tired front-end loaders and Transloaders were used for mucking and hauling in the stopes.[74] The details involved in developing a large scale block-caving operation were presented in a report on the San Manuel mine in Arizona.[75] The report contained details of concrete placement underground which on the basis of comparative costs was adopted as a general means of ground support.

[73] Pearson, P. D. New Developments in Underground Mining. Skillings' Mining Review, v. 51, No. 9, Mar. 3, 1962, pp. 1, 6–8.
[74] Dayton, S. H. Cut and Fill Stope Mechanized with Diesel Equipment. Min. World, v. 24, No. 11, October 1962, pp. 12–15.
[75] Dale, V. B. Mining, Milling, and Smelting Methods, San Manuel Copper Corp., Pinal County, Ariz. BuMines Inc. Circ. 8104, 1962, 145 pp.

Technologic Trends in the Mineral Industries

(Metals and Nonmetals Except Fuels)

By Donald R. Irving [1]

ALTHOUGH the quantity of material handled at metal and nonmetal mines in the United States in 1962 was 2.7 billion tons, the same as in 1961, a larger proportion was waste. At metal mines, crude ore production declined 1 million tons and waste output rose more than 18 million tons; at nonmetal mines crude ore production declined 6 million tons and waste output rose 36 million tons.

Copper and iron ore producers increased their share of crude ore and material handled from about three-fourths to four-fifths of the national metals total, and sand and gravel and stone producers increased their share of the nonmetals total, also from three-fourths to four-fifths. Six States—Arizona, California, Florida, Michigan, Minnesota, and Utah—each handled more than 100 million tons of ore and waste, and together they accounted for 43 percent of the U.S. total. When the large-volume construction materials (sand and gravel and stone) were excluded from the totals, four States—Arizona, Florida, Minnesota, and Utah—supplied over half of the material handled.

Values for surface ores including sand and gravel and stone averaged $1.81 per ton in 1962, compared with $1.80 per ton in 1961; excluding these commodities the figures were $3.54 per ton in 1962 and $3.10 per ton in 1961. Underground ores including sand and gravel and stone were valued at $7.07 per ton in 1962 and $6.70 in 1961; excluding these commodities comparable values were $8.48 and $7.85.

In 1962, crude ore production was reported from 6,903 mines—1,362 metal and 5,541 nonmetal mines. Of these, 502 produced less than 100 tons and 9 produced over 10 million tons. During the year, an additional 777 mines—502 metal and 275 nonmetal mines—reported handling waste only. These figures are exclusive of sand and gravel operations, which are reported in the Sand and Gravel Chapter.

The Utah Copper Division of Kennecott Copper Corp. announced that for the first time in its history the company moved more than 100 million tons of material during a single year's operation at its Utah open-pit mine in Bingham Canyon, Utah. The 100-million-ton mark was reached on December 15, 1962. At that time, 90,000 tons of ore containing 0.78 percent copper and 250,000 tons of overburden were being mined daily. Operations began at this mine in 1904 and by the end of 1962 more than 15.6 billion pounds of copper had been produced from 2.2 billion tons of ore.

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[1] Acting Assistant Area Director, Bureau of Mines, San Francisco, Calif.

The grade of ore decreased and ratio of tons of waste removed per ton of ore increased at the Utah mine from 1940 through 1962, as follows: [2]

	Pounds of copper per ton of ore	*Tons of waste removed per ton of ore*
1940	19.46	1.19
1950	19.14	1.33
1960	16.22	2.12
1961	16.20	2.55
1962	15.60	2.45

These figures emphasize the increasingly difficult materials-handling problem facing the operator and the constant need to develop and use better production methods. Ideas that had been proposed for effecting such better methods include:

1. Radio control of switches and field equipment to provide greater flexibility and reliability.

2. A train reporting system, integrated by radio, with a real time display and print-out capabilities to improve scheduling.

3. Automatic track maintenance equipment to keep tracks in high speed condition and eliminate derailments and other track problems.

4. Automated, unmanned trains run by remote control.

5. Mammoth, self-propelled mining machines instead of conventional shovels and trains.

6. Data processing equipment and electronic computers for automatically running the entire mining operation.

In his paper, Mabey said, "Some of these ideas may seem far-fetched at present, but our fantastic rate of technological progress could well make today's futuristic schemes the tried-and-true conventional methods of a few years hence." He pointed out also that the transition from conventional methods to automation and computer control obviously is not easy, and many problems must be met and solved in so doing. The benefits to be gained, however, in speed, efficiency, quality, safety, and all other aspects of production, he claimed, more than justify the effort required.

Underground mining methods in 1962 were open stoping, 75 percent; caving, 24 percent; and other, 1 percent. About 15 percent of the open stoping required artificial support. As in 1961, virtually all the ore mined by surface methods was mechanically loaded and one-half had been drilled and blasted before loading.

Exploration and development was only 17 million feet compared with 22 million feet (revised figure) in 1961 and 21 million feet in 1960. Decreases were reported for all major methods except cross-cutting, which increased slightly. Drilling provided almost nine-tenths of the footage, as follows: Percussion drilling, 28 percent (27 percent in 1961); rotary drilling, 25 percent (29 percent in 1961); long-hole drilling, 18 percent (14 percent in 1961); diamond drilling, 14 percent (13 percent in 1961); and churn drilling, 2 percent (3 percent in 1961).

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[2] Mabey, Douglas R., Automation Problems in Train Haulage at Kennecott's Utah mine. Paper presented at a meeting of the National Safety Council, Chicago, Ill., Oct. 31, 1962.

Over four-fifths of the exploration and development footage was for metals, compared with about three-quarters in 1961. Principal metals, in terms of footage, were uranium, lead, copper, and iron in 1962 and uranium, iron, and zinc in 1961. Stone and clays were the leading nonmetals in terms of footage.

Material (ore and waste) removed in exploration and development, for which data were compiled for the first time, totaled 380 million tons. Almost 98 percent of the tonnage was removed by stripping.

Material Handled.—Although producers of metal and nonmetal minerals (excluding fuels) handled 2.74 billion tons of ore and waste, slightly more than the 2.69 billion reported in 1961, the crude ore figure was 7 million tons less than that of 1961. Material handled at metal mines was 17 million tons above the 1961 figure of 846 million tons. Crude ore output at metal mines declined 1 million tons; it rose 6 million tons at surface mines but decreased 7 million tons at underground mines. Material handled at copper mines was 13 million tons more than in 1961, and crude ore output increased 6 million tons. Copper and iron ore accounted for 74 percent of the crude ore and 79 percent of the total material handled at metal mines, compared with 70 and 78 percent, respectively, in 1961.

Crude ore output at nonmetal mines was 6 million tons less and waste output was 36 million tons more than in 1961. Sand and gravel and stone represented more than four-fifths of the tonnage.

Six States—Arizona, California, Minnesota, Florida, Michigan, and Utah—each reported handling more than 100 million tons of material, compared with seven States in 1961. Arizona led in 1962 with 233 million tons, followed by California (229 million) and Minnesota (196 million); in 1961 California (241 million), Arizona (227 million) and Minnesota (206 million) were the leaders. Only five States—New Mexico, Michigan, Arizona, Missouri, and Colorado—reported handling more than 10 million tons of material at underground mines. When sand and gravel and stone figures were excluded from the totals only four States—Arizona, Minnesota, Florida, and Utah—handled more than 100 million tons of material. Less than one-fifth of the crude ore and less than 2 percent of the waste came from underground mines.

TABLE 1.—Material handled at surface and underground mines, by commodities, in 1962

(Thousand short tons)

Commodity	Surface			Underground			All mines		
	Crude ore	Waste	Total	Crude ore	Waste	Total	Crude ore	Waste	Total
Metals:									
Bauxite	1,557	540	2,097	259	----------	259	1,816	540	2,356
Beryllium concentrate	35	19	54	7	4	11	42	23	65
Copper	125,399	242,965	368,364	26,006	399	26,405	151,405	243,364	394,769
Gold:									
Lode	232	3,197	3,429	2,020	1,045	3,065	2,252	4,242	6,494
Placer	46,776	3,335	50,111	4	3	7	46,780	3,338	50,118
Iron ore	139,421	127,997	267,418	19,776	2,027	21,803	159,197	130,024	289,221
Lead	18	41	59	3,898	623	4,521	3,916	664	4,580
Manganese ore	2	----------	2	14	----------	14	16	----------	16
Manganiferous ore	747	413	1,160	----------	----------	----------	747	413	1,160
Mercury	43	89	132	113	23	136	156	112	268
Molybdenum	----------	8	8	8,185	24	8,209	8,185	32	8,217
Nickel	1,109	308	1,417	----------	----------	----------	1,109	308	1,417
Silver	48	86	134	571	248	819	619	334	953
Titanium concentrate:									
Ilmenite	24,756	5,888	30,644	----------	----------	----------	24,756	5,888	30,644
Rutile	289	----------	289	----------	----------	----------	289	----------	289
Tungsten	8	1	9	651	102	753	659	103	762
Uranium	3,192	49,218	52,410	5,394	1,199	6,593	8,586	50,417	59,003
Zinc	400	57	457	9,208	971	10,179	9,608	1,028	10,636
Other [1]	1,739	4	1,743	----------	----------	----------	1,739	4	1,743
Total	345,771	434,166	779,937	76,106	6,668	82,774	421,877	440,834	862,711
Nonmetals:									
Abrasives [2]	133	12	145	36	----------	36	169	12	181
Asbestos	1,129	1,601	2,730	39	----------	39	1,168	1,601	2,769
Barite	6,261	2,649	8,910	196	13	209	6,457	2,662	9,119
Boron minerals	1,334	7,531	8,865	7	2	9	1,341	7,533	8,874
Clays	46,639	38,204	84,843	2,948	17	2,965	49,587	38,221	87,808
Feldspar	1,248	60	1,308	45	2	47	1,293	62	1,355
Fluorspar	73	142	215	507	6	513	580	148	728
Gypsum	7,575	4,956	12,531	2,617	39	2,656	10,192	4,995	15,187
Mica:									
Scrap	873	154	1,027	----------	----------	----------	873	154	1,027
Sheet	61	----------	61	160	9	169	221	9	230
Perlite	389	92	481	3	----------	3	392	92	484

Phosphate rock	63,097	103,945	167,042	1,006	86	1,092	64,103	104,031	168,134
Potassium salts				14,115	216	14,331	14,115	216	14,331
Pumice	2,295	205	2,500				2,295	205	2,500
Pyrites	113	744	857	80		80	193	744	937
Salt	701	1	702	7,728	592	8,320	8,429	593	9,022
Sand and gravel	776,701		776,701				776,701		776,701
Sodium carbonate (natural)	1,539		1,539	1,145	11	1,156	2,684	11	2,695
Stone:									
Crushed and broken	662,669	51,947	714,616	30,403	202	30,605	693,072	52,149	745,221
Dimension	6,240	1,575	7,815	169		169	6,409	1,575	7,984
Sulfur:									
Frasch-process mines	5,801		5,801				5,801		5,801
Other mines	182	15	197				182	15	197
Talc, soapstone, and pyrophyllite	326	1,051	1,377	515	13	528	841	1,064	1,905
Vermiculite	911	2,290	3,201				911	2,290	3,201
Other [3]	2,793	6,662	9,455	60	5	65	2,853	6,667	9,520
Total	1,589,083	223,836	1,812,919	61,779	1,213	62,992	1,650,862	225,049	1,875,911
Grand total	1,934,854	658,002	2,592,856	137,885	7,881	145,766	2,072,739	665,883	2,738,622

[1] Antimony, monazite, platinum-group metals, and vanadium.
[2] Emery, garnet, grinding pebbles, and tripoli.
[3] Aplite, diatomite, epsomite, graphite, greensand marl, kyanite, lithium minerals, magnesite, olivine, sodium sulfate (nat.), and wollastonite.

TABLE 2.—Material handled at surface and underground mines (including sand and gravel and stone), by States, in 1962

(Thousand short tons)

State	Surface			Underground			All mines		
	Crude ore	Waste	Total	Crude ore	Waste	Total	Crude ore	Waste	Total
Alabama	26,242	21,697	47,939	2,273		2,273	28,515	21,697	50,212
Alaska	21,090	3,208	24,298	16	29	45	21,106	3,237	24,343
Arizona	86,554	131,474	218,028	14,564	298	14,862	101,118	131,772	232,890
Arkansas	33,958	2,089	36,047	966	10	976	34,924	2,099	37,023
California	191,247	35,992	227,239	1,512	151	1,663	192,759	36,143	228,902
Colorado	23,030	6,362	29,392	10,030	448	10,478	33,060	6,810	39,870
Connecticut	15,800	67	15,867	13		13	15,813	67	15,880
Florida	111,483	91,327	202,810				111,483	91,327	202,810
Georgia	29,407	21,099	50,506	948		948	30,355	21,099	51,454
Idaho	19,028	11,168	30,196	1,486	368	1,854	20,514	11,536	32,050
Illinois	75,527	3,268	78,795	3,509	3	3,512	79,036	3,271	82,307
Indiana	41,713	4,059	45,772	1,041	26	1,067	42,754	4,085	46,839
Iowa	36,493	7,029	43,522	1,537	4	1,541	38,030	7,033	45,063
Kansas	25,072	788	25,860	2,430	37	2,467	27,502	825	28,327
Kentucky	21,351	951	22,302	5,412	3	5,415	26,763	954	27,717
Louisiana	21,242	125	21,367	2,164	106	2,270	23,406	231	23,637
Maine	11,368	5	11,373	8		8	11,376	5	11,381
Maryland	25,306	743	26,049	50	1	51	25,356	744	26,100
Massachusetts	23,219	87	23,306				23,219	87	23,306
Michigan	119,022	9,208	128,230	16,336	1,138	17,474	135,358	10,346	145,704
Minnesota	141,714	72,039	213,753	1,804	154	1,958	143,518	72,193	215,711
Mississippi	9,491	852	10,343				9,491	852	10,343
Missouri	39,460	3,441	42,901	10,855	315	11,170	50,315	3,756	54,071
Montana	29,038	2,599	31,637	3,984	219	4,203	33,022	2,818	35,840
Nebraska	16,753	665	17,418				16,753	665	17,418
Nevada	24,919	35,476	60,395	165	40	205	25,084	35,516	60,600
New Hampshire	8,559	12	8,571	16		16	8,575	12	8,587
New Jersey	28,407	334	28,741	1,026	34	1,060	29,433	368	29,801
New Mexico	17,744	19,030	36,774	17,849	668	18,517	35,593	19,698	55,291
New York	65,848	8,101	73,949	5,160	39	5,199	71,008	8,140	79,148
North Carolina	36,446	448	36,894	758	38	796	37,204	486	37,690
North Dakota	9,732		9,732				9,732		9,732
Ohio	72,876	8,826	81,702	3,987	109	4,096	76,863	8,935	85,798
Oklahoma	19,421	128	19,549	1,138		1,138	20,559	128	20,687
Oregon	34,917	1,022	35,939	3	10	13	34,920	1,032	35,952
Pennsylvania	64,684	9,366	74,050	7,144	863	8,007	71,828	10,229	82,057
Rhode Island	2,815	55	2,870				2,815	55	2,870
South Carolina	11,620	2,337	13,957				11,620	2,337	13,957

South Dakota	18,667	1,162	19,829	1,881	949	2,830	20,548	2,111	22,659
Tennessee	33,411	3,708	37,119	4,782	252	5,034	38,193	3,960	42,153
Texas	79,510	2,466	81,976	263	----	263	79,773	2,466	82,239
Utah	55,794	83,753	139,547	1,850	860	2,710	57,644	84,613	142,257
Vermont	4,595	964	5,559	206	2	208	4,801	966	5,767
Virginia	37,009	3,309	40,318	2,485	47	2,532	39,494	3,356	42,850
Washington	33,468	1,146	34,614	951	183	1,134	34,419	1,329	35,748
West Virginia	11,529	1,079	12,608	3,610	10	3,620	15,139	1,089	16,228
Wisconsin	47,431	261	47,692	1,628	158	1,786	49,059	419	49,478
Wyoming	13,973	44,392	58,365	2,045	309	2,354	16,018	44,701	60,719
Other [1]	6,871	285	7,156	----	----	----	6,871	285	7,156
Total	1,934,854	658,002	2,592,856	137,885	7,881	145,766	2,072,739	665,883	2,738,622

[1] Delaware, District of Columbia, and Hawaii.

TABLE 3.—Material handled at surface and underground mines (excluding sand and gravel and stone), by States, in 1962

(Thousand short tons)

State	Surface			Underground			All mines		
	Crude ore	Waste	Total	Crude ore	Waste	Total	Crude ore	Waste	Total
Alabama	6,660	21,307	27,967	2,202	----	2,202	8,862	21,307	30,169
Alaska	14,742	3,208	17,950	16	29	45	14,758	3,237	17,995
Arizona	66,640	131,396	198,036	14,564	298	14,862	81,204	131,694	212,898
Arkansas	2,656	1,837	4,493	455	10	465	3,111	1,847	4,958
California	48,397	32,075	80,472	518	128	646	48,915	32,203	81,118
Colorado	1,393	3,174	4,567	9,995	442	10,437	11,388	3,616	15,004
Connecticut	329	24	353	13	----	13	342	24	366
Florida	78,280	91,277	169,557	----	----	----	78,280	91,277	169,557
Georgia	7,091	20,502	27,593	34	----	34	7,125	20,502	27,627
Idaho	3,209	11,163	14,372	1,486	368	1,854	4,695	11,531	16,226
Illinois	1,904	119	2,023	1,096	3	1,099	3,000	122	3,122
Indiana	1,449	407	1,856	805	26	831	2,254	433	2,687
Iowa	2,130	2,242	4,372	165	4	169	2,295	2,246	4,541
Kansas	497	63	560	998	37	1,035	1,495	100	1,595
Kentucky	1,028	364	1,392	124	3	127	1,152	367	1,519
Louisiana	3,287	----	3,287	2,164	106	2,270	5,451	106	5,557
Maine	63	----	63	1	----	1	64	----	64
Maryland	611	60	671	4	----	4	615	60	675
Massachusetts	125	10	135	----	----	----	125	10	135
Michigan	13,119	3,728	16,847	16,336	1,138	17,474	29,455	4,866	34,321
Minnesota	108,508	71,923	180,431	1,804	154	1,958	110,312	72,077	182,389
Mississippi	1,291	633	1,924	----	----	----	1,291	633	1,924
Missouri	6,865	1,962	8,827	3,668	315	3,983	10,533	2,277	12,810
Montana	9,556	2,598	12,154	3,984	219	4,203	13,540	2,817	16,357
Nebraska	143	----	143	----	----	----	143	----	143
Nevada	16,324	35,476	51,800	165	40	205	16,489	35,516	52,005
New Hampshire	73	8	81	16	----	16	89	8	97
New Jersey	598	309	907	1,026	34	1,060	1,624	343	1,967
New Mexico	8,852	19,022	27,874	17,849	668	18,517	26,701	19,690	46,391
New York	8,375	6,965	15,340	5,058	38	5,096	13,433	7,003	20,436
North Carolina	4,628	415	5,043	758	38	796	5,386	453	5,839
North Dakota	98	----	98	----	----	----	98	----	98
Ohio	4,377	1,918	6,295	1,898	109	2,007	6,275	2,027	8,302
Oklahoma	923	37	960	350	----	350	1,273	37	1,310
Oregon	1,678	907	2,585	3	10	13	1,681	917	2,598
Pennsylvania	2,529	3,815	6,344	4,783	826	5,609	7,312	4,641	11,953
Rhode Island	----	----	----	----	----	----	----	----	----
South Carolina	1,661	1,702	3,363	----	----	----	1,661	1,702	3,363

South Dakota	413	1,106	1,519	1,881	949	2,830	2,294	2,055	4,349
Tennessee	5,296	2,575	7,871	3,532	252	3,784	8,828	2,827	11,655
Texas	10,323	1,029	11,352	263	----------	263	10,586	1,029	11,615
Utah	33,718	83,161	116,879	1,849	857	2,706	35,567	84,018	119,585
Vermont	936	453	1,389	117	2	119	1,053	455	1,508
Virginia	2,317	47	2,364	1,130	46	1,176	3,447	93	3,540
Washington	810	1,065	1,875	951	183	1,134	1,761	1,248	3,009
West Virginia	263	4	267	1,759	5	1,764	2,022	9	2,031
Wisconsin	163	2	165	1,628	158	1,786	1,791	160	1,951
Wyoming	4,599	44,392	48,991	1,865	184	2,049	6,464	44,576	51,040
Other [1]	317	----------	317	----------	----------	----------	317	----------	317
Total	489,244	604,480	1,093,724	107,313	7,679	114,992	596,557	612,159	1,208,716

[1] Delaware, District of Columbia, and Hawaii.

Surface Versus Underground Mining.—The stage of measurement of value used in table 4 is the same as that used throughout the Minerals Yearbook. Usually, the stage of measurement is mine output, the form in which the minerals first are extracted from the ground. However, for some minerals, the value of the products from auxiliary processing at or near the mines are used. Furthermore, values for gold, silver, copper, lead, zinc, and tin are assigned on the average selling price of recoverable refined metal—not the mine value; mercury is valued at the average New York price for recoverable metal. Value patterns remained essentially the same as in 1961 when this analysis was presented for the first time, with unit values of underground ores usually greater than those of surface ores. However, unit values for principal metal ores were substantially higher than in 1961, and those of most nonmetal ores were lower. Byproducts continued to contribute to the value of salable mineral products for about one-half of the mineral commodities. The value of byproducts was a significant part of the value, however, only for the metal ores of lead, silver, tungsten, uranium, and zinc, and for the nonmetal ores of fluorspar and pyrites.

As in 1961, 93 percent of the crude ore was mined from surface operations in 1962; the percentage of total material handled increased from 94 to 95 percent. Ores of only four commodities—lead, molybdenum, potassium salts, and tungsten—were mined entirely underground. Other metal ores mined substantially from underground sources were lode gold, 91 percent; manganese, 87 percent; mercury, 77 percent; silver, 95 percent; uranium, 67 percent; and zinc, 99 percent. Nonmetal ores mined predominately underground were tripoli, 59 percent; fluorspar, 89 percent; sheet mica, 72 percent; salt, 92 percent; talc, soapstone, and pyrophyllite, 62 percent; and wollastonite, 95 percent. The only States in which substantial proportions of the crude ore were mined underground were New Mexico, 50 percent; Colorado, 30 percent; West Virginia, 24 percent; Missouri, 22 percent; and Kentucky, 20 percent.

The relationship between crude ore and marketable product is given in table 7; that between total material handled and marketable product is shown in table 8.

TABLE 4.—Value of principal mineral products and byproducts of surface and underground ores mined in the United States in 1962

(Value per ton)

Ore	Surface			Underground			All mines		
	Principal mineral product	By-products	Total	Principal mineral product	By-products	Total	Principal mineral product	By-products	Total
Metals:									
Bauxite	$8.57	$0.01	$8.58	$8.19	----------	$8.19	$8.52	$0.01	$8.53
Copper	4.18	.68	4.86	6.64	$0.78	7.42	4.60	.69	5.29
Gold:									
Lode	7.01	.20	7.21	11.92	.27	12.19	11.55	.27	11.82
Placer	.20	----------	.20	6.75	----------	6.75	.20	----------	.20
Iron ore	3.43	----------	3.43	6.07	.13	6.20	3.73	.01	3.74
Lead	9.44	8.78	18.22	6.26	4.58	10.84	6.27	4.60	10.87
Mercury	51.00	----------	51.00	28.91	----------	28.91	34.17	----------	34.17
Molybdenum	----------	----------	----------	5.54	.15	5.69	5.54	.15	5.69
Silver	4.10	2.76	6.86	29.82	14.21	44.03	27.77	13.29	41.06
Titanium:									
Ilmenite	.56	.24	.80	----------	----------	----------	.56	.24	.80
Rutile	1.48	.19	1.67	----------	----------	----------	1.48	.19	1.67
Tungsten	28.71	----------	28.71	16.16	2.68	18.84	16.30	2.65	18.95
Uranium	17.53	.45	17.98	20.26	3.58	23.84	19.42	2.62	22.04
Vanadium	197.00	----------	197.00	----------	----------	----------	197.00	----------	197.00
Zinc	18.72	8.40	27.12	10.04	2.89	12.93	10.40	3.12	13.52
Other	2.25	----------	2.25	26.14	1.48	27.62	2.38	.01	2.39
Total	3.19	.27	3.46	8.11	1.28	9.39	4.05	.45	
Nonmetals:									
Abrasive stone	61.33	----------	61.33	----------	----------	----------	61.33	----------	61.33
Aplite	5.09	----------	5.09	----------	----------	----------	5.09	----------	5.09
Asbestos	4.26	.02	4.28	11.92	----------	11.92	4.55	.02	4.57
Barite	1.39	.01	1.40	7.04	----------	7.04	1.57	.01	1.58
Boron minerals	28.10	.40	28.50	74.00	----------	74.00	28.13	.39	28.52
Clays	3.27	.01	3.28	3.53	----------	3.53	3.29	.01	3.30
Emery	17.75	----------	17.75	----------	----------	----------	17.75	----------	17.75
Epsom salts	2.00	----------	2.00	----------	----------	----------	2.00	----------	2.00
Feldspar	3.74	.32	4.06	2.76	.02	2.78	3.70	.31	4.01
Fluorspar	22.73	2.20	24.93	16.12	4.88	21.00	16.71	4.64	21.35
Garnet	11.57	----------	11.57	----------	----------	----------	11.57	----------	11.55
Gypsum	3.44	----------	3.44	4.24	----------	4.24	3.65	----------	3.67
Magnesite	4.60	----------	4.60	----------	----------	----------	4.60	----------	4.60
Mica:									
Scrap	2.81	.20	3.01	----------	----------	----------	2.81	.20	3.01
Sheet	3.38	----------	3.38	6.55	.18	6.73	5.67	.13	5.80

TABLE 4.—Value of principal mineral products and byproducts of surface and underground ores mined in the United States in 1962—Continued

(Value per ton)

Ore	Surface			Underground			All mines		
	Principal mineral product	By-products	Total	Principal mineral product	By-products	Total	Principal mineral product	By-products	Total
Nonmetals—Continued									
Perlite	$6.87		$6.87	$6.67		$6.67	$6.87		$6.87
Phosphate rock	2.04		2.04	7.08		7.08	2.12		2.12
Potassium salts				6.03		6.03	6.03		6.03
Pumice	2.78		2.78				2.78		2.78
Pyrites	2.06	$1.70	3.76	4.00		4.00	2.90	$0.96	3.86
Salt	2.21	.35	2.56	6.38		6.38	6.03	.03	6.06
Sand	1.02		1.02				1.02		1.02
Sodium carbonate	1.51		1.51	13.33		13.33	7.78		7.78
Sodium sulfate	12.00		12.00				12.00		12.00
Stone:									
Crushed and broken	1.33		1.33	1.95		1.95	14.15		1.36
Dimension	13.63	.30	13.93	32.84	$0.98	33.82	1.36	.32	14.47
Sulfur:									
Frasch	19.44		19.44				19.44		19.44
Other	7.91		7.91				7.91		7.91
Talc, soapstone, and pyrophyllite	5.38		5.38	6.98		6.98	6.37		6.37
Tripoli	4.00		4.00	3.97		3 97	3.98		3.98
Vermiculite	3.61		3.61				3.61		3.61
Other	21.86	.09	21.95	13.07	.10	13.17	21.49	.09	21.58
Total	1.44		1.44	4.20	.04	4.24	1.54	.01	1.55
Grand total	1.76	.05	1.81	6.35	.72	7.07	2.06	.10	2.16
Total nonmetals (excluding stone, sand and gravel)	3.74	.02	3.76	6.22	.07	6.29	4.19	.03	4.22
Total metals and nonmetals (excluding stone, sand and gravel)	3.34	.20	3.54	7.55	.93	8.48	4.09	.33	4.42

TABLE 5.—Crude ore and total material handled at surface and underground mines, by commodities in 1962

(Percent)

Commodity	Crude ore		Total material	
	Surface	Underground	Surface	Underground
Metals:				
Antimony	100		100	
Bauxite	86	14	89	11
Beryllium	81	19	83	17
Copper	82	18	93	7
Gold:				
Lode	9	91	53	47
Placer	100		100	
Iron ore	87	13	92	8
Lead		100	1	99
Manganese ore	13	87	13	87
Manganiferous ore	100		100	
Mercury	23	77	49	51
Molybdenum		100		100
Monazite	100		100	
Nickel	100		100	
Platinum-group metals	100		100	
Silver	5	95	14	86
Titanium concetrate:				
Ilmenite	100		100	
Rutile	100		100	
Tungsten		100	1	99
Uranium	33	67	89	11
Zinc	1	99	4	96
Total metals	82	18	90	10
Nonmetals:				
Abrasives:				
Emery	100		100	
Garnet	100		100	
Grinding pebbles	100		100	
Tripoli	41	59	41	59
Aplite	100		100	
Asbestos	97	3	99	1
Barite	97	3	98	2
Boron minerals	99	1	100	
Clays	94	6	97	3
Diatomite	100		100	
Epsomite	100		100	
Feldspar	97	3	97	3
Fluorspar	11	89	30	70
Graphite	100		100	
Gypsum	74	26	83	17
Kyanite	100		100	
Lithium minerals	100		100	
Magnesite	100		100	
Marl, greensand	100		100	
Mica:				
Scrap	100		100	
Sheet	28	72	27	73
Olivine	100		100	
Perlite	99	1	99	1
Phosphate rock	98	2	99	1
Potassium salts		100		100
Pumice	100		100	
Pyrites	54	46	91	9
Salt	8	92	8	92
Sand and gravel	100		100	
Sodium carbonate (natural)	57	43	57	43
Sodium sulfate (natural)	100		100	
Stone:				
Crushed and broken	96	4	96	4
Dimension	97	3	98	2
Sulfur:				
Frasch-process mines	100		100	
Other mines	100		100	
Talc, soapstone, and pyrophyllite	38	62	72	28
Vermiculite	100		100	
Wollastonite	5	95	13	87
Total nonmetals	96	4	97	3
Grand total	93	7	95	5

TABLE 6.—Crude ore and total material handled at surface and underground mines, by States, in 1962

(Percent)

State	Crude ore		Total material	
	Surface	Underground	Surface	Underground
Alabama	92	8	95	
Alaska	100	(1)	100	(1)
Arizona	85	15	94	6
Arkansas	97	3	97	3
California	99	1	99	1
Colorado	70	30	74	26
Connecticut	100	(1)	100	(1)
Delaware	100	----------	100	----------
District of Columbia	100	----------	100	----------
Florida	100	----------	100	----------
Georgia	97	3	98	2
Hawaii	100	----------	100	----------
Idaho	93	7	94	6
Illinois	96	4	96	4
Indiana	98	2	98	2
Iowa	96	4	97	3
Kansas	91	9	91	9
Kentucky	80	20	80	20
Louisiana	91	9	90	10
Maine	100	(1)	100	(1)
Maryland	100	(1)	100	(1)
Massachusetts	100	----------	100	----------
Michigan	88	12	88	12
Minnesota	99	1	99	1
Mississippi	100	----------	100	----------
Missouri	78	22	79	21
Montana	88	12	88	12
Nebraska	100	----------	100	----------
Nevada	99	1	100	(1)
New Hampshire	100	(1)	100	(1)
New Jersey	97	3	96	4
New Mexico	50	50	67	33
New York	93	7	93	7
North Carolina	98	2	98	2
North Dakota	100	----------	100	----------
Ohio	95	5	95	5
Oklahoma	94	6	94	6
Oregon	100	(1)	100	(1)
Pennsylvania	90	10	90	10
Rhode Island	100	----------	100	----------
South Carolina	100	----------	100	----------
South Dakota	91	9	88	12
Tennessee	87	13	88	12
Texas	100	(1)	100	(1)
Utah	97	3	98	2
Vermont	96	4	96	4
Virginia	94	6	94	6
Washington	97	3	97	3
West Virginia	76	24	78	22
Wisconsin	97	3	96	4
Wyoming	87	13	96	4
Total	93	7	95	5

[1] Negligible.

TABLE 7.—Crude ore mined per unit of marketable product at surface and underground mines in the United States, by commodities in 1962

Commodity	Unit of marketable product (thousands)	Surface			Underground			All mines		
		Crude ore mined (thousand short tons)	Marketable product, units	Ratio of units of crude ore mined to units of marketable product	Crude ore mined (thousand short tons)	Marketable product, units	Ratio of units of crude ore mined to units of marketable product	Crude ore mined (thousand short tons)	Marketable product, units	Ratio of units of crude ore mined to units of marketable product
Metals:										
Bauxite	Long tons	1,557	1,160	1.3:1	259	198	1.3:1	1,816	1,358	1.3:1
Beryllium	Short tons	33	(1)	80.2:1	6	(1)	14.8:1	39	(1)	47.7:1
Copper	do	125,164	850	147.3:1	25,926	279	92.9:1	151,090	1,129	133.8:1
Gold:										
Lode	Troy ounces	162	32	5.1:1	2,018	686	2.9:1	2,180	718	3.0:1
Placer	do	46,770	261	179.2:1	4	1	4.0:1	46,744	262	178.5:1
Iron ore	Long tons	145,647	57,732	2.5:1	19,167	11,799	1.6:1	164,814	69,531	2.4:1
Lead	Short tons	18	(1)	20.8:1	3,897	131	29.7:1	3,915	131	29.9:1
Mercury	Flasks	35	9	3.9:1	112	17	6.6:1	147	26	5.7:1
Molybdenum	Pounds	----------	----------	----------	8,185	32,412	.3:1	8,185	32,412	.3:1
Nickel	Short tons	1,109	13	85.3:1	----------	----------	----------	1,109	13	85.3:1
Platinum-group metals	Troy ounces	(2)	(2)	155.9:1	----------	----------	----------	(2)	(2)	155.9:1
Rare-earth metals and monazite	Short tons	16	1	16.0:1	----------	----------	----------	16	1	16.0:1
Silver	Troy ounces	49	185	.3:1	565	15,527	0.036:1	614	15,712	0.039:1
Titanium:										
Ilmenite	Short tons	24,722	805	30.7:1	----------	----------	----------	24,722	805	30.7:1
Rutile	do	289	3	96.3:1	----------	----------	----------	289	3	96.3:1
Tungsten	do	7	(1)	38.4:1	638	7	91.1:1	645	7	92.1:1
Uranium	do	2,171	2,100	1.0:1	4,892	4,892	1.0:1	7,063	6,992	1.0:1
Zinc	do	397	31	12.8:1	9,166	399	23.0:1	9,563	430	22.2:1
Other [3]	do	(2)	(2)	1.6:1	(2)	(2)	2.1:1	(2)	(2)	1.6:1
Nonmetals:										
Abrasive stone	do	(2)	(2)	1.0:1	----------	----------	----------	(2)	(2)	1.0:1
Aplite	do	179	125	1.4:1	----------	----------	----------	179	125	1.4:1
Asbestos	do	988	51	19.4:1	39	2	19.5:1	1,027	53	19.4:1
Barite	do	6,017	672	9.0:1	197	184	1.1:1	6,214	856	7.3:1
Boron minerals	do	1,334	473	2.8:1	1	1	1.0:1	1,335	474	2.8:1
Clays	do	45,511	43,260	1.1:1	2,945	1,425	2.1:1	48,456	44,685	1.1:1
Emery	do	4	4	1.0:1	----------	----------	----------	4	4	1.0:1
Feldspar	Long tons	1,246	449	2.8:1	45	16	2.8:1	1,291	465	2.8:1
Fluorspar	Short tons	45	37	1.2:1	464	153	3.0:1	509	190	2.7:1
Garnet	do	100	12	8.3:1	----------	----------	----------	100	12	8.3:1
Gypsum	do	7,290	7,289	1.0:1	2,599	2,599	1.0:1	9,889	9,888	1.0:1
Magnesite	do	497	493	1.0:1	----------	----------	----------	497	493	1.0:1

TABLE 7.—Crude ore mined per unit of marketable product at surface and underground mines in the United States, by commodities in 1962—Continued

Commodity	Unit of marketable product (thousands)	Surface			Underground			All mines		
		Crude ore mined (thousand short tons)	Marketable product, units	Ratio of units of crude ore mined to units of marketable product	Crude ore mined (thousand short tons)	Marketable product, units	Ratio of units of crude ore mined to units of marketable product	Crude ore mined (thousand short tons)	Marketable product, units	Ratio of units of crude ore mined to units of marketable product
Nonmetals:										
Mica:										
Scrap	Short tons	827	90	9.2:1	----------	----------	----------	827	90	9.2:1
Sheet	Pounds	61	272	.2:1	160	85	1.9:1	221	357	.6:1
Perlite	Short tons	385	317	1.2:1	3	3	1.0:1	388	320	1.2:1
Phosphate rock	Long tons	62,342	18,557	3.4:1	1,005	825	1.2:1	63,347	19,382	3.3:1
Potassium salts	Short tons	----------	----------	----------	14,110	2,208	6.4:1	14,110	2,208	6.4:1
Pumice	do	2,253	2,247	1.0:1	----------	----------	----------	2,253	2,247	1.0:1
Pyrites	do	104	30	3.5:1	80	57	1.4:1	184	87	2.1:1
Salt	do	701	371	1.9:1	7,610	7,606	1.0:1	8,311	7,977	1.0:1
Sand and gravel	do	776,701	776,701	1.0:1	----------	----------	----------	776,701	776,701	1.0:1
Sodium carbonate (natural)	do	1,005	50	20.1:1	1,138	644	1.8:1	2,143	694	3.1:1
Sodium sulfate (natural)	do	2	1	2.0:1	----------	----------	----------	2	1	2.0:1
Stone:										
Crushed and broken	do	651,385	619,082	1.1:1	30,049	30,361	1.0:1	681,434	649,443	1.0:1
Dimension	do	6,084	2,555	2.4:1	169	37	4.6:1	6,253	2,592	2.4:1
Sulfur:										
Frasch-process mines	Long tons	5,508	4,917	1.1:1	----------	----------	----------	5,508	4,917	1.1:1
Other mines	do	182	151	1.2:1	----------	----------	----------	182	151	1.2:1
Talc, soapstone, and pyrophyllite	Short tons	316	303	1.0:1	513	469	1.1:1	829	772	1.1:1
Tripoli	do	25	25	1.0:1	36	36	1.0:1	61	61	1.0:1
Vermiculite	do	911	205	4.4:1	----------	----------	----------	911	205	4.4:1
Other [4]	do	1,389	624	2.2:1	60	28	2.1:1	1,449	652	2.2:1

[1] Less than 1,000 tons.
[2] Figures withheld to avoid disclosing individual company confidentia data.
[3] Antimony, manganese ore, manganiferous ore, and vanadium.
[4] Diatomite, graphite, greensand marl, kyanite, lithium minerals, olivine, and wollastonite.

TABLE 8.—Material handled per unit of marketable product at surface and underground mines in the United States, by commodities in 1962

Commodity	Unit of marketable product (thousands)	Surface			Underground			All mines		
		Total material handled (thousand short tons)	Marketable product, units	Ratio of units of material handled to units of marketable product	Total material handled (thousand short tons)	Marketable product, units	Ratio of units of material handled to units of marketable product	Total material handled (thousand short tons)	Marketable product, units	Ratio of units of material handled to units of marketable product
Metals:										
Bauxite	Long tons	2,097	1,160	1.8:1	259	198	1.3:1	2,356	1,358	1.7:1
Beryllium	Short tons	36	(1)	80.2:1	9			45	(1)	80.2:1
Copper	do	368,106	850	433.1:1	26,313	279	94.3:1	394,419	1,129	349.4:1
Gold:										
Lode	Troy ounces	3,343	32	104.5:1	2,999	686	4.4:1	6,342	718	8.8:1
Placer	do	50,003	261	191.6:1	5	1	5.0:1	50,008	262	190.9:1
Iron ore	Long tons	272,780	57,732	4.7:1	21,072	11,799	1.8:1	293,852	69,531	4.2:1
Lead	Short tons	24	(1)	27.8:1	4,483	131	34.2:1	4,507	131	34.4:1
Mercury	Flasks	76	9	8.4:1	135	17	7.9:1	211	26	8.1:1
Molybdenum	Pounds				8,185	32,412	.3:1	8,185	32,412	.3:1
Nickel	Short tons	1,417	13	109.0:1				1,417	13	109.0:1
Platinum-group metals	Troy ounces	(2)	(2)	155.9:1				(2)	(2)	155.9:1
Rare-earth metals and monazite	Short tons	16	1	16.0:1				16	1	16.0:1
Silver	Troy ounces	94	185	.5:1	763	15,527	.049:1	857	15,712	.1:1
Titanium:										
Ilmenite	Short tons	30,610	805	38.0:1				30,610	805	38.0:1
Rutile	do	289	3	96.3:1				289	3	96.3:1
Tungsten	do	7	(1)	38.4:1	739	7	105.6:1	746	7	106.6:1
Uranium	do	50,884	2,100	24.2:1	5,934	4,892	1.2:1	56,818	6,992	8.1:1
Zinc	do	454	31	14.6:1	10,090	399	25.3:1	10,544	430	24.5:1
Other [3]	do	(2)	(2)	2.7:1	(2)	(2)	2.1:1	(2)	(2)	2.7:1
Nonmetals:										
Abrasive stone	do	(2)	(2)	4.0:1				(2)	(2)	4.0:1
Aplite	do	199	125	1.6:1				199	125	1.6:1
Asbestos	do	2,424	51	47.5:1	39	2	19.5:1	2,463	53	46.5:1
Barite	do	8,665	672	12.9:1	210	184	1.1:1	8,875	856	10.4:1
Boron minerals	do	8,865	473	18.7:1	3	1	3.0:1	8,868	474	18.7:1
Clays	do	83,701	43,260	1.9:1	2,962	1,425	2.1:1	86,663	44,685	1.9:1
Emery	do	4	4	1.0:1				4	4	1.0:1
Feldspar	Long tons	1,279	449	2.8:1	47	16	2.9:1	1,326	465	2.9:1
Fluorspar	Short tons	87	37	2.4:1	470	153	3.1:1	557	190	2.9:1
Garnet	do	103	12	8.6:1				103	12	8.6:1
Gypsum	do	11,664	7,289	1.6:1	2,638	2,599	1.0:1	14,302	9,888	1.4:1
Magnesite	do	1,090	493	2.2:1				1,090	493	2.2:1

TABLE 8.—Material handled per unit of marketable product at surface and underground mines in the United States, by commodities in 1962—Continued

Commodity	Unit of marketable product (thousands)	Surface			Underground			All mines		
		Total material handled (thousand short tons)	Marketable product, units	Ratio of units of material handled to units of marketable product	Total material handled (thousand short tons)	Marketable product, units	Ratio of units of material handled to units of marketable product	Total material handled (thousand short tons)	Marketable product, units	Ratio of units of material handled to units of marketable product
Mica:										
Scrap	Short tons	979	90	10.9:1				979	90	10.9:1
Sheet	Pounds	61	272	.2:1	169	85	2.0:1	230	357	.6:1
Perlite	Short tons	476	317	1.5:1	3	3	1.0:1	479	320	1.5:1
Phosphate rock	Long tons	166,288	18,557	9.0:1	1,091	825	1.3:1	167,379	19,382	8.6:1
Potassium salts	Short tons				14,250	2,208	6.5:1	14,250	2,208	6.5:1
Pumice	do	2,457	2,247	1.1:1				2,457	2,247	1.1:1
Pyrites	do	848	30	28.3:1	80	57	1.4:1	928	87	10.7:1
Salt	do	702	371	1.9:1	8,196	7,606	1.1:1	8,898	7,977	1.1:1
Sand and gravel	do	776,701	776,701	1.0:1				776,701	776,701	1.0:1
Sodium carbonate (natural)	do	1,005	50	20.1:1	1,149	644	1.8:1	2,154	694	3.1:1
Sodium sulfate (natural)	do	2	1	2.0:1				2	1	2.0:1
Stone:										
Crushed and broken	do	703,314	619,082	1.1:1	30,251	30,361	1.0:1	733,565	649,443	1.1:1
Dimension	do	7,659	2,555	3.0:1	169	37	4.6:1	7,828	2,592	3.0:1
Sulfur:										
Frasch-process mines	Long tons	5,508	4,917	1.1:1				5,508	4,917	1.1:1
Other mines	do	197	151	1.3:1				197	151	1.3:1
Talc, soapstone, and pyrophyllite	Short tons	1,367	303	4.5:1	526	469	1.1:1	1,893	772	2.5:1
Tripoli	do	25	25	1.0:1	36	36	1.0:1	61	61	1.0:1
Vermiculite	do	3,201	205	15.6:1				3,201	205	15.6:1
Other [4]	do	7,438	624	11.9:1	65	28	2.3:1	7,503	652	11.5:1

[1] Less than 1,000 tons.
[2] Figures withheld to avoid disclosing individual company confidential data.
[3] Antimony, manganese ore, manganiferous ore, and vanadium.
[4] Diatomite, graphite, greensand marl, kyanite, lithium minerals, olivine, and wollastonite.

Magnitude of Mining Industry.—Data on the number of mines handling crude ore and waste in 1962 (excluding sand and gravel operations, which are reported in the Sand and Gravel Chapter) have been compiled and are presented in tables 9 and 10. Crude ore production was reported from 6,903 mines—1,362 metal and 5,541 nonmetal mines. Of these, 337 metal mines and 165 nonmetal mines produced less than 100 tons of crude ore during the year. Six of the metal mines and three of the nonmetal mines produced more than 10 million tons. A total of 7,680 mines produced ore and waste—1,864 metal and 5,816 nonmetal. Output of individual mines ranged from 1 ton to more than 100 million tons. Of these, 418 metal mines and 181 nonmetal mines produced less than 100 tons during the year; 20 metal mines and 9 nonmetal mines produced more than 10 million tons.

TABLE 9.—Number of domestic metal and nonmetal mines in 1962 classified by commodity and magnitude of crude ore production

Commodity	Total number of mines	Less than 100 short tons	100 to 1,000 short tons	1,000 to 10,000 short tons	10,000 to 100,000 short tons	100,000 to 1,000,000 short tons	1,000,000 to 10,000,000 short tons	Over 10,000,000 short tons
Metals;								
Bauxite	11	----------	1	2	5	3	----------	----------
Beryllium	36	16	11	8	1	----------	----------	----------
Copper	115	33	15	11	20	17	16	3
Gold:								
Lode	126	87	28	7	2	1	1	----------
Placer	155	30	40	32	32	16	4	1
Iron ore	186	3	7	21	38	82	33	2
Lead	64	28	21	8	1	5	1	----------
Manganese ore	3	----------	1	1	1	----------	----------	----------
Manganiferous ore	5	----------	----------	----------	3	2	----------	----------
Mercury	39	14	15	6	4	----------	----------	----------
Molybdenum	2	----------	1	----------	----------	----------	1	----------
Nickel	1	----------	----------	----------	----------	----------	1	----------
Platinum-group metals	1	----------	----------	----------	----------	----------	1	----------
Silver	71	34	21	8	5	3	----------	----------
Titanium minerals	8	----------	----------	1	1	2	4	----------
Tungsten	8	1	3	1	1	2	----------	----------
Uranium	449	86	155	127	59	22	----------	----------
Zinc	82	5	7	7	37	26	----------	----------
Total metals	1,362	337	326	240	210	181	62	6
Nonmetals:								
Abrasives [1]	18	5	6	3	4	----------	----------	----------
Aplite	4	----------	----------	----------	3	1	----------	----------
Asbestos	6	----------	----------	2	2	2	----------	----------
Barite	53	2	7	10	15	19	----------	----------
Boron minerals	5	----------	2	2	----------	----------	1	----------
Clays	1,234	7	81	367	660	118	1	----------
Diatomite	12	2	2	----------	4	4	----------	----------
Feldspar	62	6	18	19	16	3	----------	----------
Fluorspar	20	1	7	3	7	2	----------	----------
Gypsum	69	1	----------	7	28	33	----------	----------
Greensand	3	----------	----------	3	----------	----------	----------	----------
Mica:								
Scrap	25	1	2	6	14	2	----------	----------
Sheet	113	67	27	15	4	----------	----------	----------
Olivine	6	----------	----------	4	2	----------	----------	----------
Perlite	16	----------	4	5	5	2	----------	----------
Phosphate rock	48	----------	----------	3	9	22	13	1
Potassium salts	7	----------	----------	----------	----------	3	4	----------

Pumice	93	3	14	31	40		------	------
Pyrites	4	------	------	1	3	------	------	------
Salt	22	------	------	3	4	12	3	------
Sodium carbonate (natural)	3	------	------	------	1	------	2	------
Stone:								
Crushed and broken	3,045	24	80	365	1,106	1,379	89	2
Dimension	561	42	167	241	100	11	------	------
Sulfur:								
Frasch-process mines	11	------	------	------	------	9	2	------
Other mines	2	------	------	2	------	------	------	------
Talc, soapstone, and pyrophyllite	78	1	17	38	21	1	------	------
Vermiculite	7	2	1	1	1	2	------	------
Wollastonite	5	1	1	2	1	------	------	------
Other [2]	9	------	------	3	2	4	------	------
Total nonmetals	5,541	165	436	1,136	2,052	1,634	115	3
Grand total	6,903	502	762	1,376	2,262	1,815	177	9

[1] Emery, garnet, grinding pebbles, and tripoli.
[2] Epsomite, graphite, kyanite, lithium minerals, magnesite, and sodium sulfate (nat.).

TABLE 10.—Number of domestic metal and nonmetal mines in 1962, classified by commodity and magnitude of material (ore and waste) handled

Commodity	Total number of mines	Less than 100 short tons	100 to 1,000 short tons	1,000 to 10,000 short tons	10,000 to 100,000 short tons	100,000 to 1,000,000 short tons	1,000,000 to 10,000,000 short tons	Over 10,000,000 short tons
Metals:								
Bauxite	11	--	1	2	5	2	1	--
Beryllium	48	16	18	13	1	--	--	--
Copper	170	41	40	20	27	23	6	13
Gold:								
Lode	264	116	110	30	6	--	2	--
Placer	211	48	63	38	35	21	5	1
Iron ore	225	9	10	28	48	82	43	5
Lead	96	21	36	29	4	5	1	--
Manganese ore	3	--	1	1	1	--	--	--
Manganiferous ore	6	--	--	--	2	4	--	--
Mercury	68	31	16	15	6	--	--	--
Molybdenum	7	--	2	3	1	--	1	--
Nickel	2	1	--	--	--	--	1	--
Platinum-group metals	1	--	--	--	--	--	1	--
Silver	113	38	38	23	11	3	--	--
Titanium minerals	8	--	--	--	1	3	4	--
Tungsten	20	6	7	4	1	2	--	--
Uranium	517	86	168	156	70	26	10	1
Zinc	94	5	9	8	44	28	--	--
Total metals	1,864	418	519	370	263	199	75	20
Nonmetals:								
Abrasives [1]	21	6	6	5	4	--	--	--
Aplite	4	--	--	--	3	1	--	--
Asbestos	16	2	2	6	3	1	2	--
Barite	61	2	8	12	19	19	1	--
Boron minerals	5	--	2	2	--	--	1	--
Clays	1,296	10	91	382	658	145	9	1
Diatomite	14	2	3	1	2	4	2	--
Feldspar	69	8	14	26	18	3	--	--
Fluorspar	31	3	12	6	7	3	--	--
Gypsum	72	1	1	5	31	32	2	--
Marl, greensand	3	--	--	3	--	--	--	--
Mica:								
Scrap	31	1	6	8	14	2	--	--
Sheet	115	69	27	15	4	--	--	--
Olivine	6	--	--	3	3	--	--	--
Perlite	17	--	2	7	6	2	--	--
Phosphate rock	49	--	1	3	8	15	16	6
Potassium salts	9	1	--	--	1	2	5	--

Pumice	105	5	18	34	42	6	----	----
Pyrites	4	----	----	1	2	1	----	----
Salt	25	----	----	5	5	11	4	----
Sodium carbonate (natural)	3	----	----	----	1	----	2	----
Stone:								
Crushed and broken	3,161	28	99	403	1,123	1,389	117	2
Dimension	576	38	168	246	107	17	----	----
Sulfur:								
Frasch-process mines	12	----	----	1	----	9	2	----
Other mines	4	----	1	1	1	1	----	----
Talc, soapstone, and pyrophyllite	86	3	16	37	26	4	----	----
Vermiculite	7	1	2	1	1	1	1	----
Wollastonite	5	1	1	2	1	----	----	----
Other [2]	9	----	----	2	3	4	----	----
Total nonmetals	5,816	181	480	1,217	2,093	1,672	164	9
Grand total	7,680	599	999	1,587	2,356	1,871	239	29

[1] Emery, garnet, grinding pebbles, and tripoli.
[2] Epsomite, graphite, kyanite, lithium minerals, magnesite, and sodium sulfate (nat.).

Methods.—Open-stoping and caving methods continued to be used to mine 99 percent of the ore produced underground in the United States. The percentage mined by open stoping increased to almost 76 percent, compared with less than 74 percent in 1961; that mined by caving declined to 24 percent from 25 percent in 1961. In both years, all the bauxite and natural sodium carbonate mined underground came from naturally supported open stopes and all the molybdenum from caving stopes. In 1962, all the beryllium, tripoli, asbestos, perlite, and wollastonite mined underground came from naturally supported open stopes. In 1962, some ore was mined underground in 41 States, compared with 42 in 1961. Virtually all the ore mined by surface methods in both years was loaded mechanically; only a minor quantity was loaded by hand. Details of surface mining operations are given in tables 14, 15, and 16.

TABLE 11.—Mining methods used in underground operations, by commodities

(Percent)

Commodity	Open stoping				Caving		Other and unspecified	
	Natural support		Artificial support					
	1961	1962	1961	1962	1961	1962	1961	1962
Metals:								
Bauxite	100.0	100.0	-------	-------	-------	-------	-------	-------
Beryllium concentrate	45.5	100.0	54.5	-------	-------	-------	-------	-------
Copper	33.8	35.4	9.7	10.4	56.5	54.1	-------	0.1
Gold: Lode	3.6	3.0	96.1	96.3	.3	-------	-------	.7
Iron ore	47.0	45.7	6.5	3.6	44.6	47.1	1.9	3.6
Lead	83.5	78.3	16.5	20.0	-------	-------	-------	1.7
Manganese ore	86.4	7.7	13.6	92.3	-------	-------	-------	-------
Manganiferous ore	-------	42.8	-------	57.2	-------	-------	-------	-------
Mercury	3.4	1.8	96.6	78.4	-------	19.8	-------	-------
Molybdenum	-------	-------	-------	-------	100.0	100.0	-------	-------
Silver	11.3	1.6	88.7	98.4	-------	-------	-------	-------
Uranium	81.8	58.1	11.5	38.5	6.7	3.4	-------	-------
Zinc	80.7	73.9	19.3	25.9	-------	.2	-------	-------
Nonmetals:								
Tripoli	-------	100.0	-------	-------	-------	-------	-------	-------
Asbestos	95.5	100.0	4.5	-------	-------	-------	-------	-------
Barite	-------	-------	98.9	98.4	-------	-------	1.1	1.6
Boron minerals	100.0	85.7	-------	14.3	-------	-------	-------	-------
Clays	97.2	96.0	1.0	3.5	1.8	.5	(1)	-------
Feldspar	70.0	31.1	30.0	68.9	-------	-------	-------	-------
Fluorspar	35.5	45.1	59.3	48.6	5.2	4.7	-------	1.6
Gypsum	99.1	99.3	.9	.7	-------	-------	-------	-------
Mica: Sheet	52.0	16.3	48.0	83.7	-------	-------	-------	-------
Perlite	-------	100.0	-------	-------	-------	-------	-------	-------
Phosphate rock	33.5	25.7	63.9	71.3	2.6	3.0	-------	-------
Potassium salts	97.0	96.3	-------	-------	3.0	3.7	-------	-------
Pyrites	79.9	93.7	20.1	6.3	-------	-------	-------	-------
Salt	92.8	93.6	-------	-------	-------	-------	7.2	6.4
Sodium carbonate (natural)	100.0	100.0	-------	-------	-------	-------	-------	-------
Stone:								
Crushed and broken	95.8	99.0	1.4	.3	.1	(1)	2.7	.7
Dimension	95.3	95.9	-------	-------	4.7	4.1	-------	-------
Talc, soapstone, and pyrophyllite	83.1	79.2	15.2	17.6	.2	-------	1.5	3.2
Wollastonite	-------	100.0	-------	-------	-------	-------	-------	-------
Total	65.5	65.8	8.1	9.6	25.3	23.5	1.1	1.1

[1] Less than 0.05 percent.

TABLE 12.—Mining methods used in underground operations, by States

(Percent)

State	Open stoping				Caving		Other and unspecified	
	Natural support		Artificial support					
	1961	1962	1961	1962	1961	1962	1961	1962
Alabama	97.8	99.6			2.2	0.4		
Alaska		20.0	100.0	80.0				
Arizona	3.9	4.4	9.4	9.3	86.7	86.3		
Arkansas	76.3	80.6	23.7	19.1				0.3
California	77.2	83.5	21.0	16.4	1.0	.1	0.8	
Colorado	7.5	9.1	7.2	8.9	85.3	82.0		
Connecticut	100.0	100.0						
Georgia	99.8	100.0	.2					
Idaho	5.0	2.5	95.0	96.5		1.0		
Illinois	93.3	94.8	5.9	4.3	.8	.7		.2
Indiana	100.0	100.0						
Iowa	100.0	100.0						
Kansas	100.0	100.0						
Kentucky	98.5	98.4	1.5	1.6				
Louisiana	100.0	100.0						
Maine	36.4	12.5			63.6	87.5		
Maryland	100.0	100.0						
Michigan	73.9	74.4	5.8	6.3	18.1	15.6	2.2	3.7
Minnesota		12.9	11.3		88.7	81.0		6.1
Missouri	99.9	100.0					.1	
Montana	11.0	9.9	34.1	53.5	54.9	36.6		
Nevada	66.5	10.2	31.5	22.3		67.5	2.0	
New Hampshire	100.0	100.0						
New Jersey	64.8	89.7	35.2	10.3				
New Mexico	92.6	85.1	3.5	11.6	3.9	3.3		
New York	89.1	89.9		.1	.5	.2	10.4	9.8
North Carolina	19.0	11.2	81.0	88.8				
Ohio	100.0	99.7		.3				
Oklahoma	100.0	100.0						
Oregon	100.0	100.0						
Pennsylvania	41.3	45.4	.5	.7	47.9	53.9	10.3	
South Dakota	2.4	.4	97.4	99.4	.2	.2		
Tennessee	100.0	100.0						
Texas	100.0	100.0						
Utah	56.3	46.7	38.9	42.5	4.8	5.6		5.2
Vermont	100.0	89.3		5.8				4.9
Virginia	89.7	91.2	2.1	.7			8.2	8.1
Washington	93.2	91.9	6.8	6.5				1.6
West Virginia	100.0	100.0						
Wisconsin	32.7	42.7			67.3	57.3		
Wyoming	53.4	74.8	14.2	1.9	32.4	23.3		
Total	65.5	65.8	8.1	9.6	25.3	23.5	1.1	1.1

TABLE 13.—Mining methods used in open-pit mining, by commodities, in 1962

(Percent)

Commodity	Mechanical loading: Preceded by drilling and blasting	Mechanical loading: Not preceded by drilling and blasting	Other	Explanation of other
Metals:				
Bauxite	93.4	6.6		
Beryllium	92.9		7.1	Hand methods.
Copper	96.7	2.9	.4	Unspecified.
Gold:				
Lode	39.6	59.9	.5	Unspecified.
Placer		100.0		
Iron ore	79.1	20.9		
Lead	100.0			
Manganese ore		100.0		
Manganiferous ore	86.8	13.2		
Mercury	55.9	38.2	5.9	Hand methods.
Monazite	100.0			
Nickel	20.0	80.0		
Silver	81.5	18.5		
Titanium concentrate:				
Ilmenite	74.0	26.0		
Rutile		100.0		
Uranium	41.2	58.3	.5	Drilled or cut without blasting (0.3 percent) and hand methods (0.2 percent).
Zinc	100.0			
Nonmetals:				
Abrasives:				
Emery	100.0			
Garnet	100.0			
Grinding pebbles	33.4		66.6	Drilled or cut without blasting (33.3 percent), unspecified (33.3 percent).
Tripoli	96.0	4.0		
Aplite	67.6	32.4		
Asbestos	93.8	6.2		
Barite	11.2	88.8		
Boron minerals	100.0			
Clays	22.0	77.5	.5	Hand methods (0.1 percent), drilled or cut without blasting (0.4 percent).
Diatomite		100.0		
Epsomite		100.0		
Feldspar	85.1	7.6	7.3	Hand methods (0.2 percent) unspecified (7.1 percent).
Fluorspar	76.9	23.1		
Graphite	100.0			
Gypsum	84.7	14.4	.9	Drilled or cut without blasting (0.1 percent), unspecified (0.8 percent).
Kyanite	95.5	4.5		
Lithium minerals	100.0			
Magnesite	99.4	.6		
Marl, greensand		100.0		
Mica:				
Scrap	20.3	79.7		
Sheet	3.2	92.0	4.8	Unspecified.
Olivine	22.7	77.3		
Perlite	21.6	78.4		
Phosphate rock	.7	99.3		
Pumice	2.9	97.0	.1	Drilled or cut without blasting.
Pyrites	90.4	9.6		
Salt	79.4	19.9	.7	Hand methods.
Sand and gravel		100.0		
Sodium sulfate (natural)		100.0		
Stone:				
Crushed and broken	95.2	4.8		
Dimension	25.8	5.2	69.0	Hand methods (4.3 percent), drilled or cut without blasting (64.2 percent), unspecified (0.5 percent).
Talc, soapstone, and pyrophyllite.	66.6	33.4		
Vermiculite	38.1	61.9		
Wollastonite		100.0		
Total	48.8	51.0	.2	

TABLE 14.—Kind of surface mining operation, by commodities, in 1962

(Percent of crude ore)

Commodity	Open pit	Single bench	Multiple bench
Metals:			
Bauxite	7	81	12
Beryllium	36	----------	64
Copper	2	----------	98
Gold:			
Lode	2	1	97
Placer	51	49	----------
Iron ore	11	2	87
Lead	----------	----------	100
Manganese ore	100	----------	----------
Manganiferous ore	96	4	----------
Mercury	40	60	----------
Nickel	----------	----------	100
Silver	----------	7	93
Titanium ores:			
Ilmenite	88	1	11
Rutile	----------	24	76
Tungsten	----------	----------	100
Uranium	22	21	57
Zinc	7	----------	93
Nonmetals:			
Abrasives:			
Emery	100	----------	----------
Garnet	----------	----------	100
Grinding pebbles	----------	100	----------
Tripoli	100	----------	----------
Aplite	48	----------	52
Asbestos	2	----------	98
Barite	69	14	17
Boron	----------	----------	100
Clays	73	13	14
Diatomite	61	----------	39
Epsomite	100	----------	----------
Feldspar	24	5	71
Fluorspar	23	----------	77
Graphite	----------	----------	100
Gypsum	48	11	41
Kyanite	----------	57	43
Lithium ores	----------	----------	100
Magnesite	----------	----------	100
Marl, greensand	----------	100	----------
Mica:			
Scrap	92	2	6
Sheet	100	----------	----------
Olivine	11	85	4
Perlite	50	8	42
Phosphate rock	85	12	3
Pumice	44	52	4
Pyrites	----------	----------	100
Salt	----------	44	56
Sand and gravel	100	----------	----------
Stone:			
Crushed and broken	60	7	33
Dimension	33	8	59
Sulfur, other than Frasch	----------	----------	100
Talc, soapstone and pyrophyllite	29	33	38
Vermiculite	2	----------	98

TABLE 15.—Kind of surface mining operation, by States, in 1962

(Percent of crude ore)

State	Open pit	Single bench	Multiple bench
Alabama	84	5	11
Alaska	53	47	
Arizona	5	3	92
Arkansas	67		33
California	14	6	80
Colorado	33	27	40
Connecticut	48	38	14
Delaware			100
District of Columbia	100		
Florida	95	5	
Georgia	67	8	25
Hawaii	42	16	42
Idaho	17	14	69
Illinois	38	7	55
Indiana	38	14	48
Iowa	60	17	23
Kansas	89	2	9
Kentucky	74	7	19
Louisiana	100		
Maine	90		10
Maryland	58	12	30
Massachusetts	37	8	55
Michigan	84	1	15
Minnesota	5	2	93
Mississippi	85		15
Missouri	44	9	47
Montana	22	9	69
Nebraska	98	1	1
Nevada	6		94
New Hampshire	82	13	5
New Jersey	55	7	38
New Mexico	7	1	92
New York	53	3	44
North Carolina	90	2	8
North Dakota	100		
Ohio	67	7	26
Oklahoma	85	2	13
Oregon	21	20	59
Pennsylvania	50	11	39
Rhode Island	27		73
South Carolina	69	1	30
South Dakota	82	2	16
Tennessee	57	9	34
Texas	73	13	14
Utah	1		99
Vermont	19	1	80
Virginia	51	10	39
Washington	36	24	40
West Virginia	29	2	69
Wisconsin	53	10	37
Wyoming	46	8	46

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TABLE 16.—Characteristics of certain surface mining operations in the United States for selected commodities in 1962

Commodity	Open pit depth, feet		Single Bench					Multiple Bench			
			Face height, feet		Bench width, feet		Average No. of faces	Face height, feet		Bench width, feet	
	Weighted average	Range	Weighted average	Range	Weighted average	Range		Weighted average	Range	Weighted average	Range
Metals:											
Copper	50	18–75	29	8–36	48	6–100	19	50	15–70	106	20–300
Gold:											
Lode	204	10–300	10	8–15	22	20–30	3	60	30–60	20	20–30
Placer	17	3–70	13	4–50	352	6–450					
Ilmenite	37	20–50									
Iron ore	43	3–375	32	4–75	39	5–300	6	36	18–150	653	13–2,500
Mercury	45	9–55	10	9–60	196	20–200					
Uranium	175	12–300	31	2–80	133	20–200	4	33	2–80	195	15–600
Nonmetals:											
Barite	25	4–90	9	8–20	47	9–50	9	14	10–15	90	6–100
Clays	27	2–150	31	2–175	557	6–2,000	4	21	3–100	99	4–500
Feldspar	40	7–60	20	4–50	27	10–100	3	44	15–60	78	25–165
Gypsum	18	2–40	15	5–20	139	90–500	4	15	5–30	134	50–300
Mica:											
Scrap	28	10–100					2	10		25	
Sheet	21	10–50									
Perlite	58	8–60	14	12–60	148	40–150	3	20	12–20	81	35–150
Phosphate rock	32	3–60	16	4–80	158	20–200	3	36	30–50	25	25–25
Pumice	27	2–60	120	3–200	253	40–500	4	18	8–30	101	20–140
Stone:											
Crushed and broken	58	3–460	51	5–255	291	6–5,000	4	42	3–300	205	4–1,500
Dimension	51	1–200	66	3–250	57	2–500	6	12	2–80	84	2–450
Talc, soapstone, and pyrophyllite	35	9–80	24	8–50	80	20–200	3	22	8–40	47	10–100
Vermiculite	19	10–20					11	18	11–20	34	15–40

TABLE 17.—Exploration and development activity in the United States, by commodities

Commodity	1961		1962	
	Feet	Percent of total [1]	Feet	Percent of total
Metals:				
Beryllium	76,472	0.3	63,214	0.4
Copper	1,104,712	5.0	1,235,938	7.4
Gold	[1] 894,978	4.1	852,673	5.0
Iron ore	2,252,869	10.3	1,182,954	7.1
Lead	1,363,933	6.2	1,892,547	11.3
Mercury	32,320	.1	34,404	.2
Molybdenum	[1] 121,599	.6	72,212	.4
Nickel	12,060	(2)	12,875	.1
Silver	86,225	.4	748,843	4.4
Titanium	39,483	.2	16,500	.1
Tungsten	689,956	3.2	950,269	5.6
Uranium and vanadium	7,660,885	35.0	6,309,944	37.4
Zinc	1,611,870	7.4	438,857	2.6
Other [3]	42,171	.2	15,120	.1
Total	[1] 15,989,533	73.0	13,826,350	82.1
Nonmetals:				
Asbestos	45,313	.2	64,711	.4
Barite	41,026	.2	39,489	.2
Boron minerals	9,592	.1	5,831	(2)
Clays	1,602,154	7.3	661,805	4.0
Feldspar	81,833	.4	7,865	(2)
Fluorspar	45,795	.2	11,814	.1
Gypsum	474,574	2.2	376,619	2.2
Mica:				
Scrap	385	(2)	1,947	(2)
Sheet	2,426	(2)	300	(2)
Phosphate rock	231,456	1.1	221,411	1.3
Potassium salts	356,640	1.6	25,056	.1
Pumice	2,000	(2)	6,070	(2)
Pyrites	1,316	(2)	3,309	(2)
Salt	41,648	.2	4,885	(2)
Sodium carbonate (natural)	27,532	.1	10,810	.1
Stone	2,462,579	11.2	1,375,626	8.1
Sulfur:				
Frasch-process mines	157,642	.7	122,965	.7
Other mines	2,191	(2)	----------	----------
Talc, soapstone, and pyrophyllite	86,859	.4	20,106	.1
Other [4]	232,976	1.1	102,179	.6
Total	5,905,937	27.0	3,062,798	17.9
Grand total	[1] 21,895,470	100.0	16,889,148	100.0

[1] Revised figure.
[2] Less than 0.05 percent.
[3] Antimony, bauxite, cobalt (1961), columbium-tantalum (1962), manganese ore, manganiferous ore (1962), platinum-group metals, and rare-earth metals and thorium.
[4] Aplite (1961), diatomite, greensand marl (1961), magnesite, olivine (1961), perlite, staurolite (1961), tripoli (1961), vermiculite, and wollastonite.

Exploration and Development.—Footage reported for exploration and development of metal and nonmetal commodities was less than 17 million feet, only 77 percent of the 21.9 million feet (revised figure) reported for 1961. Notable increases for copper (from 1,105,000 to 1,236,000 feet), lead (1,364,000 to 1,893,000), silver (86,000 to 749,000), and tungsten (690,000 to 950,000) were not enough to offset decreases for iron ore, molybdenum, uranium, and zinc, among metals, and clays, feldspar, fluorspar, gypsum, potassium salts, salt, stone, and other nonmetals. Metals footage dropped from 16.0 million (revised figure) to 13.8 million; nonmetals footage, from 5.9 million to 3.1 million. Drilling accounted for 88 percent of the exploration and development footage, compared with 86 percent in 1961. More than one-half of the footage was conducted by percussion and rotary drilling; over

TABLE 18.—Exploration and development activity in the United States, by methods

Method	1961					
	Metals		Nonmetals		Total	
	Feet	Percent of total	Feet	Percent of total	Feet	Percent of total
Shaft sinking	23,712	0.2	5,393	0.1	29,105	0.1
Raising	288,706	1.8	16,117	.3	304,823	1.4
Winzing	6,363	(2)	500	(2)	6,863	(2)
Tunneling	52,389	.3	29,011	.5	81,400	.4
Drifting	922,766	5.8	364,597	6.2	1,287,363	5.9
Crosscutting	240,039	1.5	9,788	.2	249,827	1.1
Diamond drilling	2,568,807	16.1	276,323	4.7	2,845,130	13.0
Churn drilling	403,105	2.5	203,734	3.4	606,839	2.8
Rotary drilling	3,011,159	18.8	3,430,804	58.1	6,441,963	29.4
Long-hole drilling	[1] 2,644,544	16.5	362,761	6.1	[1] 3,007,305	13.7
Percussion drilling	[1] 4,955,766	31.0	913,688	15.5	[1] 5,869,454	26.8
Trenching	72,986	.5	71,589	1.2	144,575	.7
Other	799,191	5.0	221,632	3.7	1,020,823	4.7
Total	[1] 15,989,533	100.0	5,905,937	100.0	[1] 21,895,470	100.0
	1962					
	Metals		Nonmetals		Total	
	Feet	Percent of total	Feet	Percent of total	Feet	Percent of total
Shaft sinking	13,934	0.1	4,315	0.1	18,249	0.1
Raising	268,447	1.9	15,393	.5	283,840	1.7
Winzing	7,248	.1	474	(2)	7,722	(2)
Tunnelling	50,836	.4	11,254	.4	62,090	.4
Drifting	825,745	6.0	43,079	1.4	868,824	5.1
Crosscutting	255,243	1.8	9,827	.3	265,070	1.6
Diamond drilling	2,271,017	16.4	148,029	4.8	2,419,046	14.3
Churn drilling	316,309	2.3	87,415	2.9	403,724	2.4
Rotary drilling	2,449,140	17.7	1,741,662	56.8	4,190,802	24.8
Long-hole drilling	3,047,473	22.0	60,085	2.0	3,107,558	18.4
Percussion drilling	4,059,752	29.4	733,659	24.0	4,793,411	28.4
Trenching	32,458	.2	87,504	2.9	119,962	.7
Other	228,748	1.7	120,102	3.9	348,850	2.1
Total	13,826,350	100.0	3,062,798	100.0	16,889,148	100.0

1 Revised figure.
2 Less than 0.05 percent.

four-fifths was for metals, compared with about three-quarters in 1961. Almost 80 percent of the metals footage was for uranium, lead, copper, and iron; more than 85 percent of the nonmetals footage was for stone, clays, gypsum, and phosphate rock. States reporting the greatest footage of exploration and development were New Mexico, Idaho, Colorado, California, and Arizona, in that order. Together, they accounted for 57 percent of the total.

Data on the quantity of ore and waste removed during exploration and development were compiled in 1962 for the first time. Almost 98 percent of the 380 million tons was removed by stripping. About 54 percent of the quantity was removed at metal mines, and 90 percent was removed at phosphate rock, iron, copper, uranium, clays, and stone deposits.

TABLE 19.—Exploration and development by methods and selected metals in 1962 [1]

(Feet)

Metal	Method						
	Shaft sinking	Raising	Winzing	Tunneling	Drifting	Cross-cutting	Diamond drilling
Beryllium	50	200	---	214	360	300	39,072
Copper	2,755	80,316	146	2,403	174,263	6,993	747,925
Gold	1,468	19,842	574	6,737	61,736	3,946	151,924
Iron ore	541	72,464	---	3,668	136,591	21,913	228,882
Lead	1,078	16,254	1,670	2,625	53,536	21,018	415,330
Mercury	437	649	18	2,022	3,977	478	600
Molybdenum	328	601	---	1,840	13,477	1,812	47,438
Nickel	---	---	---	15	---	---	6,500
Silver	2,134	9,033	40	3,311	22,517	9,042	28,860
Tungsten	---	10,080	---	2,388	7,246	220	24,566
Uranium	4,015	36,837	4,800	24,286	304,461	183,174	401,650
Zinc	1,128	22,006	---	1,325	46,980	6,347	175,659
Other [2]	---	165	---	2	601	---	2,611
Total	13,934	268,447	7,248	50,836	825,745	255,243	2,271,017

Metal	Method						
	Churn drilling	Rotary drilling	Long-hole drilling	Percussion drilling	Trench-ing	Other	Total
Beryllium	300	16,142	150	4,004	2,352	70	63,214
Copper	73,363	102,323	18,859	13,920	4,890	7,782	1,235,938
Gold	6,767	64	44,837	542,347	10,074	2,357	852,673
Iron ore	29,312	62,420	192,988	314,705	1,900	117,570	1,182,954
Lead	133,952	7,150	25,334	1,131,783	3,404	79,413	1,892,547
Mercury	5,285	13,980	3,658	200	3,100	---	34,404
Molybdenum	105	2,587	---	---	4,000	24	72,212
Nickel	6,360	---	---	---	---	---	12,875
Silver	---	12,030	7,290	652,660	1,570	356	748,843
Tungsten	---	---	68,355	835,702	---	1,712	950,269
Uranium	3,467	2,226,376	2,593,305	524,910	1,018	1,645	6,309,944
Zinc	54,755	---	91,222	38,116	---	1,319	438,857
Other [2]	2,643	6,068	1,475	1,405	150	16,500	31,620
Total	316,309	2,449,140	3,047,473	4,059,752	32,458	228,748	13,826,350

[1] Changes in Minerals Yearbook, 1961, p. 103, table 23, should read as follows: Percussion drilling, gold 555,443 feet; molybdenum none; total 4,955,766 feet. Long-hole drilling, molybdenum none; total 2,644,544 feet. Total method, gold 894,978 feet, molybdenum 121,599 feet; grand total 15,989,533 feet.

[2] Antimony, bauxite, columbium-tantalum, manganese ore, manganiferous ore, platinum-group metals, rare-earth metals and thorium, and titanium.

TABLE 20.—Exploration and development by methods and selected nonmetals in 1962

(Feet)

Nonmetal	Method						
	Shaft sinking	Raising	Winzing	Tunneling	Drifting	Cross-cutting	Diamond drilling
Asbestos							742
Barite		1,034		180	4,379	159	345
Boron minerals		100			130		791
Clays		130		1,380	1,200	400	8,189
Fluorspar	50	747		450	3,362		6,505
Gypsum							9,459
Mica:							
Scrap	37						
Sheet	100			100	100		
Phosphate rock		5,349	389		15,266	617	7,050
Potassium salts	2,663	70			39	39	12,200
Pumice							
Pyrites							3,107
Salt	1,325			919	1,430	485	
Sodium carbonate (natural)	40			770	10,000		
Stone	100	2,991		5,519	4,268	7,664	92,541
Sulfur: Frasch-process mines							
Talc, soapstone, and pyrophyllite		4,892	85	1,936	2,640	403	2,600
Other [1]		80			265	60	4,500
Total	4,315	15,393	474	11,254	43,079	9,827	148,029

Nonmetal	Method						
	Churn drilling	Rotary drilling	Long-hole drilling	Percussion drilling	Trenching	Other	Total
Asbestos		200			43,396	20,373	64,711
Barite	7,225		500	4,500	3,500	17,667	39,489
Boron minerals		4,810					5,831
Clays	1,156	596,253	1,565	3,607	8,000	39,925	661,805
Fluorspar		600	100				11,814
Gypsum		212,341		131,025	20,000	3,794	376,619
Mica:							
Scrap		1,000		250	660		1,947
Sheet							300
Phosphate rock	60,000	108,999		13,000	8,798	1,943	221,411
Potassium salts		9,970				75	25,056
Pumice		120			1,950	4,000	6,070
Pyrites						202	3,309
Salt		491				235	4,885
Sodium carbonate (natural)							10,810
Stone	15,534	575,034	57,920	581,277	890	31,888	1,375,626
Sulfur: Frasch-process mines		122,965					122,965
Talc, soapstone, and pyrophyllite	3,500	4,000			50		20,106
Other [1]		104,879			260		110,044
Total	87,415	1,741,662	60,085	733,659	87,504	120,102	3,062,798

[1] Diatomite, feldspar, magnesite, perlite, vermiculite, and wollastonite.

TABLE 21.—Exploration and development by methods and States in 1962 [1]

(Feet)

State	Shaft sinking	Raising	Winzing	Tunneling	Drifting	Crosscutting	Diamond Drilling
Alabama							6,681
Alaska	24	468		2	876	12	51,970
Arizona	1,655	74,242	399	4,099	116,616	14,314	551,038
Arkansas		994			4,329	159	6,570
California	1,032	9,827	352	7,853	14,506	2,801	37,631
Colorado	3,438	15,725	2,311	6,898	77,024	5,729	465,193
Florida							6,193
Georgia							2,000
Idaho	1,156	12,534	794	974	31,526	16,754	49,821
Illinois		747		1,025	2,310	210	12,566
Indiana							10,324
Iowa				3,549			9,418
Kansas							2,357
Kentucky	50				1,052		609
Louisiana	1,325			919			
Michigan	312	40,634			125,079	20,674	95,303
Minnesota		1,951			16,406	859	82,716
Missouri		1,979			26,152		394,147
Montana	1,943	2,741	654	3,080	17,546	1,852	4,011
Nevada	210	762	510	1,424	2,757	3,666	20,783
New Jersey		4,948			1,338		4,569
New Mexico	575	29,427	1,861	4,811	188,968	168,995	87,684
New York	249	17,691		3,960	22,378	321	30,044
North Carolina	100	2,593		100	2,563	316	10,977
Ohio					1,430	485	7,397
Oklahoma							786
Oregon	559	302		772	636	334	212
Pennsylvania	92	23,210		2,090	20,853	987	62,678
South Dakota	294	10,755	55	92	39,117	1,770	85,616
Tennessee	1,085	5,397	25		27,880		39,668
Texas							4,435
Utah	4,010	13,091	696	14,560	66,613	13,184	149,837
Vermont		2,200	25		1,500		4,142
Virginia		3,580			5,175	6,264	60,865
Washington		4,000	40	688	13,345	3,006	40,955
Wisconsin		1,211		685	3,667	1,519	510
Wyoming	140	2,831		4,509	37,182	829	1,255
Other [2]						30	18,085
Total	18,249	283,840	7,722	62,090	868,824	265,070	2,419,046

TABLE 21.—Exploration and development by methods and States in 1962 [1]—Continued

State	Churn drilling	Rotary drilling	Long-hole drilling	Percussion drilling	Trenching	Other	Total
Alabama	10,048	42,645	—	—	—	—	59,374
Alaska	5,133	—	1,442	—	6,000	24	65,951
Arizona	72,540	136,987	53,106	21,498	6,090	290	1,052,874
Arkansas	—	2,831	—	—	—	—	14,883
California	4,932	52,568	71,741	1,037,239	45,940	49,110	1,335,532
Colorado	2,379	318,740	212,458	250,393	4,180	270	1,364,738
Florida	—	37,965	—	—	—	18,443	62,601
Georgia	7,225	305,739	—	—	—	19,455	334,419
Idaho	600	85,034	21,664	1,791,326	199	416	2,012,798
Illinois	10,066	54,072	3,380	32,100	—	3,000	119,476
Indiana	4,665	25,107	—	209,277	—	2,178	251,551
Iowa	—	72,929	—	—	—	12,794	98,690
Kansas	5,852	82,039	—	—	—	—	90,248
Kentucky	—	7,092	—	—	—	—	8,803
Louisiana	—	106,039	—	—	—	—	108,283
Michigan	—	121,621	187,755	281,895	—	—	873,273
Minnesota	11,076	68,469	—	79,649	500	111,368	372,994
Missouri	150,562	27,449	30	—	3,500	103,413	707,232
Montana	300	99,899	1,925	1,100	9,928	1,215	146,224
Nevada	5,285	28,430	3,475	76,575	31,980	5,020	180,877
New Jersey	—	—	5,233	—	—	—	16,088
New Mexico	1,100	1,101,768	2,184,624	7,179	4,857	1,847	3,783,696
New York	—	—	—	—	—	235	74,878
North Carolina	—	7,776	—	892	—	1,712	27,029
Ohio	—	32	40	—	—	1,000	10,384
Oklahoma	2,668	31,181	—	—	—	—	34,635
Oregon	6,360	1,700	46,720	110,245	118	11,990	179,948
Pennsylvania	—	5,200	23,467	—	—	141	138,718
South Dakota	—	76,900	6,595	8,754	—	40	229,988
Tennessee	66,153	139,556	4,762	43,094	—	745	328,365
Texas	1,000	152,188	—	13,856	—	3,200	174,679
Utah	—	155,369	113,074	30,597	6,040	360	567,431
Vermont	—	—	1,500	—	—	—	9,367
Virginia	—	—	—	—	—	—	75,884
Washington	1,284	200	72,574	484,069	110	554	620,825
Wisconsin	33,303	257,149	1,221	73,340	—	—	372,605
Wyoming	1,193	584,624	90,707	240,333	400	—	964,003
Other [2]	—	1,504	65	—	120	—	19,804
Total	403,724	4,190,802	3,107,558	4,793,411	119,962	348,850	16,889,148

[1] Changes in Minerals Yearbook, 1961, pp. 109-110, table 25 should read as follows: Colorado, percussion drilling 131,109 feet; long-hole drilling 236,177 feet; total 1,645,068 feet. South Dakota, percussion drilling none; total 150,870 feet. Totals, long-hole drilling 3,007,305 feet; percussion drilling 5,869,454 feet; grand total 21,895,470 feet.

[2] Maine, Maryland, Nebraska, and South Carolina.

TABLE 22.—Total material (ore and waste) produced by exploration and development in the United States, by commodities, in 1962

(Thousand short tons)

Commodity	Shaft sinking	Raising	Winzing	Tunneling	Drifting	Crosscutting	Trenching	Stripping	Other	Total
Metals:										
Bauxite								540		540
Beryllium	(1)	1		(1)	1	1	7	13		23
Copper	43	237	1	23	1,495	38	8	54,001	10	55,856
Gold:										
Lode	4	79	2	19	199	8	28	3,191	10	3,540
Placer	(1)	(1)	(1)	(1)	2	3	4	2,646	1	2,656
Iron ore	14	186		17	1,027	153	5	86,867	28	88,297
Lead	10	121	3	10	377	105	44	22	182	874
Mercury	1	2	(1)	6	10	1	7	82		109
Molybdenum	3	3		5	112	9	7	1		140
Silver	19	69	(1)	15	132	49	6	57	1	348
Tungsten		40		17	39	1		1	5	103
Uranium	19	112	26	160	1,333	525	2	45,890		48,067
Zinc	46	46		16	294	60		3	19	484
Other [2]		1		(1)	2		(1)	3,019		3,022
Total metals	159	897	32	288	5,023	953	118	196,333	256	204,059
Nonmetals:										
Asbestos							116	856		972
Barite		2		(1)	16	10	5	392	(1)	425
Boron		1			1	(1)		7,531		7,533
Clays				4	1	6	12	28,034		28,057
Diatomite								2,428		2,428
Feldspar					2		1	44		47
Fluorspar	1	3		3	11			120		138
Gypsum							30	7,430	4	7,464
Mica:										
Scrap	(1)						3	203		206
Sheet	7			1	1					9
Phosphate rock		28	1		74	2	15	99,797		99,917
Potassium salts	76	1								77
Pumice							4	87		91
Pyrites								744		744
Salt	14			53	43	7			4	121
Sodium carbonate, natural	1			10	75					86
Stone	(1)	26		288	38	288	3	22,383	2	23,028
Talc, soapstone, and pyrophyllite		26	(1)	5	10	1	(1)	1,038		1,080
Vermiculite							1	2,983		2,984
Wollastonite		(1)			2	2	4	1		9
Other [3]								567		567
Total nonmetals	99	87	1	364	274	316	194	174,638	10	175,983
Grand total	258	984	33	652	5,297	1,269	312	370,971	266	380,042

[1] Less than 500 tons.
[2] Antimony, columbium-tantalum, manganese ore, manganiferous ore, nickel, rare-earth minerals and thorium, titanium, and vanadium.
[3] Kyanite, lithium minerals, magnesite, and sulfur.

TABLE 23.—Total material (ore and waste) produced by exploration and development in the United States, by States, in 1962

(Thousand short tons)

State	Shaft sinking	Raising	Winzing	Tunneling	Drifting	Crosscutting	Trenching	Stripping	Other	Total
Alabama	--------	--------	--------	--------	--------	--------	--------	21,674	--------	21,674
Alaska	(1)	2	--------	(1)	6	(1)	21	2,512	--------	2,541
Arizona	14	201	1	17	588	47	14	53,734	1	54,617
Arkansas	--------	2	--------	--------	15	10	--------	1,322	--------	1,349
California	2	41	1	29	55	11	126	28,141	11	28,417
Colorado	16	65	12	25	315	24	23	3,082	1	3,563
Connecticut	--------	--------	--------	--------	--------	--------	--------	50	--------	50
Florida	--------	--------	--------	--------	--------	--------	--------	91,388	--------	91,388
Georgia	--------	--------	--------	--------	--------	--------	--------	21,098	--------	21,098
Hawaii	--------	--------	--------	--------	--------	--------	--------	158	--------	158
Idaho	15	102	1	4	138	81	3	8,461	1	8,806
Illinois	--------	3	--------	5	8	1	--------	2,111	--------	2,128
Indiana	--------	--------	--------	--------	--------	--------	--------	2,948	--------	2,948
Iowa	--------	--------	--------	240	--------	--------	--------	8,238	4	8,482
Kansas	--------	--------	--------	--------	--------	--------	--------	12	--------	12
Kentucky	1	--------	--------	--------	3	--------	--------	951	--------	955
Louisiana	14	--------	--------	53	--------	--------	--------	(1)	--------	67
Maine	--------	--------	--------	--------	--------	--------	--------	5	--------	5
Maryland	--------	--------	--------	--------	--------	5	--------	110	--------	115
Massachusetts	--------	--------	--------	--------	--------	--------	--------	40	--------	40
Michigan	6	114	--------	--------	1,289	142	--------	5,783	--------	7,334
Minnesota	--------	5	--------	--------	162	5	1	44,917	(1)	45,090
Mississippi	--------	--------	--------	--------	--------	--------	--------	462	--------	462
Missouri	--------	13	--------	--------	291	--------	5	1,426	203	1,938
Montana	30	25	2	26	87	13	44	3,242	10	3,479
Nebraska	--------	--------	--------	--------	--------	--------	--------	210	--------	210
Nevada	1	4	2	5	9	7	51	4,167	(1)	4,246
New Hampshire	--------	--------	--------	--------	--------	--------	--------	1	--------	1
New Jersey	--------	4	--------	--------	3	--------	--------	2	--------	9
New Mexico	3	84	10	24	898	478	11	4,568	--------	6,076
New York	5	40	--------	9	110	2	--------	4,958	4	5,128
North Carolina	7	6	--------	1	17	2	--------	498	5	536
Ohio	--------	--------	--------	--------	43	7	--------	527	--------	577
Oklahoma	--------	--------	--------	--------	--------	--------	--------	3	--------	3
Oregon	1	3	--------	3	3	3	1	738	--------	752
Pennsylvania	4	48	--------	46	202	17	--------	1,954	--------	2,271
South Carolina	--------	--------	--------	--------	--------	--------	1	2,092	--------	2,093
South Dakota	2	38	(1)	1	117	5	--------	401	--------	564
Tennessee	46	16	(1)	--------	180	--------	--------	3,708	10	3,960
Texas	--------	--------	--------	--------	--------	--------	--------	2,153	(1)	2,153
Utah	87	80	5	114	353	74	9	907	7	1,636
Vermont	--------	20	(1)	--------	6	--------	--------	284	--------	310
Virginia	--------	25	--------	--------	35	267	--------	1,330	--------	1,657
Washington	--------	15	(1)	4	63	42	(1)	1,342	8	1,474
West Virginia	--------	--------	--------	--------	--------	--------	--------	97	--------	97
Wisconsin	--------	15	--------	12	112	17	--------	240	--------	396
Wyoming	3	12	--------	34	185	10	2	38,926	--------	39,172
Total	257	983	34	652	5,293	1,270	312	370,971	265	380,037

[1]Less than 500 tons.

TABLE 24.—Exploration and development of copper, by States

State	1961		1962	
	Feet	Percent of total	Feet	Percent of total
Arizona	833,104	75.4	891,260	72.1
California	16,978	1.5	4,481	.4
Colorado	2,105	.2	(1)	----------
Idaho	(1)	----------	5,689	.5
Maine	(1)	----------	7,628	.6
Michigan	43,771	4.0	83,093	6.7
Montana	1,409	.1	5,002	.4
Nevada	17,130	1.6	7,777	.6
New Mexico	51,025	4.6	61,702	5.0
North Carolina	2,803	.2	10,798	.9
Tennessee	45,085	4.1	35,601	2.9
Texas	----------	----------	6,468	.5
Utah	84,701	7.7	114,759	9.3
Other [2]	6,601	.6	1,680	.1
Total	1,104,712	100.0	1,235,938	100.0

[1] Included with other.
[2] Missouri (1962); Washington, Wyoming (1961), and States indicated by footnote 1.

TABLE 25.—Exploration and development of iron ore, by States

State	1961		1962	
	Feet	Percent of total	Feet	Percent of total
Alabama	65,493	2.9	51,987	4.4
Alaska	18,488	.8	4,529	.4
Arizona	17,490	.8	22,124	1.9
California	28,480	1.3	3,819	.3
Michigan	926,290	41.1	621,286	52.6
Minnesota	342,378	15.2	297,904	25.2
Missouri	602,034	26.7	40,477	3.4
Nevada	36,495	1.6	13,319	1.1
New York	7,175	.3	17,636	1.5
Pennsylvania	93,067	4.1	80,991	6.8
Texas	69,176	3.1	----------	----------
Utah	4,374	.2	4,610	.4
Wisconsin	19,775	.9	7,159	.6
Wyoming	16,063	.7	8,690	.7
Other [1]	6,091	.3	8,423	.7
Total	2,252,869	100.0	1,182,954	100.0

[1] Arkansas (1962), Colorado, Idaho, (1962), New Jersey, North Carolina (1962), South Dakota, Virginia, and Washington (1962).

TABLE 26.—Exploration and development of lead and zinc, by States

State	1961		1962	
	Feet	Percent of total	Feet	Percent of total
Arizona	13,818	0.5	24,171	1.0
Colorado	38,576	1.3	40,512	1.7
Idaho	1,643,445	55.2	1,199,861	51.6
Illinois	18,605	.6	15,620	.7
Missouri	686,104	23.1	618,918	26.5
Montana	9,258	.3	5,107	.2
Nevada	34,417	1.1	6,345	.3
New Mexico	26,372	.9	26,659	1.1
New York	47,587	1.6	50,812	2.2
Pennsylvania	19,691	.7	25,734	1.1
Tennessee	135,553	4.5	70,957	3.0
Utah	82,889	2.8	52,965	2.3
Virginia	68,992	2.3	56,759	2.4
Washington	89,334	3.0	78,917	3.4
Wisconsin	58,955	2.0	37,797	1.6
Other	2,207	.1	20,270	.9
Total	2,975,803	100.0	2,331,404	100.0

TABLE 27.—Exploration and development of phosphate rock, by States

State	1961		1962	
	Feet	Percent of total	Feet	Percent of total
Florida	18,911	8.2	26,108	11.8
Idaho	76,285	32.9	103,834	46.9
Montana	14,360	6.2	24,477	11.1
Tennessee	116,780	50.5	60,000	27.1
Utah	5,120	2.2	5,862	2.6
Wyoming	----------	----------	1,130	.5
Total	231,456	100.0	221,411	100.0

TABLE 28.—Exploration and development of uranium, by States

State	1961		1962	
	Feet	Percent of total	Feet	Percent of total
Arizona	188,392	2.5	104,713	1.7
Colorado	1,486,329	19.4	1,236,653	19.6
New Mexico	4,152,242	54.2	3,653,236	57.9
South Dakota	6,770	.1	79,590	1.3
Utah	280,295	3.7	290,631	4.6
Wyoming	1,520,466	19.8	928,920	14.7
Other [1]	25,191	.3	16,201	.2
Total	7,659,685	100.0	6,309,944	100.0

[1] Alaska (1962), California, Idaho (1961), Nevada, Oregon, and Washington.

TABLE 29.—Exploration and development in Alaska, by methods

(Feet)

Method	Gold, lode	Gold, placer	Iron ore	Mercury	Other [1]	Total
1961:						
Shaft sinking [2]	4			111		115
Raising	6			1,798		1,804
Tunneling	34				8	42
Drifting				623		623
Diamond drilling	44,583		15,988		2,278	62,849
Churn drilling	1,468	1,202			2,634	5,304
Long-hole drilling		30		3,753		3,783
Trenching	240	6,012			1,900	8,152
Other			2,500			2,500
Total	46,335	7,244	18,488	6,285	6,820	85,172
1962:						
Shaft sinking					24	24
Raising				178	290	468
Tunneling					2	2
Drifting [3]	80			186	622	888
Diamond drilling	45,000		3,839		3,131	51,970
Churn drilling	1,500	300	690		2,643	5,133
Long-hole drilling				1,442		1,442
Trenching	6,000					6,000
Other					24	24
Total	52,580	300	4,529	1,806	6,736	65,951

[1] Antimony, molybdenum, nickel, platinum-group metals, stone, and uranium (1962).
[2] Includes winzing.
[3] Includes crosscutting.

TABLE 30.—Exploration and development in Arizona, by methods

(Feet)

Method	Copper	Gold	Lead-zinc	Uranium	Other [1]	Total
1961:						
Shaft sinking	2,435	252	1,039	30		3,756
Raising	79,609	260	1,313	2,409		83,591
Winzing	40		20	220		280
Tunneling	185	857	410	2,600	22	4,074
Drifting	141,689	560	4,065	7,120	130	153,564
Crosscutting	4,997	35	1,847	14,660		21,539
Diamond drilling	422,054	810	4,538	7,000	18,872	453,274
Churn drilling	28,122				550	28,672
Rotary drilling	132,090			119,477		251,567
Long-hole drilling	18,452	600	500	28,500		48,052
Percussion drilling	1,097	200	36	6,376		7,709
Trenching	2,234	100	50		900	3,284
Other [1]	100					100
Total	833,104	3,674	13,818	188,392	20,474	1,059,462
1962:						
Shaft sinking	1,149	311	75		120	1,655
Raising	72,557	20	904	711	50	74,242
Winzing		70	15	314		399
Tunneling	450	235	200	2,274	940	4,099
Drifting	106,093	100	4,174	6,033	216	116,616
Crosscutting	4,820		1,481	8,000	13	14,314
Diamond drilling	523,396		6,357	300	20,985	551,038
Churn drilling	71,688	35	300		517	72,540
Rotary drilling	85,617			48,073	3,297	136,987
Long-hole drilling	11,150		10,400	31,556		53,106
Percussion drilling	13,760	36	250	7,452		21,498
Trenching	290	1,175	15		4,610	6,090
Other [1]	290					290
Total	891,260	1,982	24,171	104,713	30,748	1,052,874

[1] Beryllium (1962), feldspar (1961), iron ore, mercury (1962), molybdenum (1962), pumice (1962), rare-earth metals and thorium, silver, stone, and tungsten.

TABLE 31.—Exploration and development in California, by methods in 1962

(Feet)

Method	Asbestos	Clays	Copper	Gold, lode and placer	Gypsum	Iron ore	Limestone	Mercury	Borate minerals	Pyrite	Talc, soapstone, and pyrophyllite	Tungsten	Other [1]	Total
Shaft sinking			144	446				417						1,007
Raising		100		1,039			79	289	120		250	7,470	25	9,372
Winzing			8	284							60		480	832
Tunneling		125	12	3,581			10	1,222				2,388	515	7,853
Drifting		1,200	65	3,247			662	2,689	169		800	5,539	135	14,506
Cross-cutting			40	1,691			573	108	39		160	120	70	2,801
Trenching	41,896			644				3,100					300	45,940
Diamond drilling		2,227	20			3,819	3,662	600	791	3,107		21,972	1,433	37,631
Churn drilling				4,932										4,932
Rotary drilling	200	6,512			1,000		32,596	5,580	6,680					52,568
Long-hole drilling		1,500		600				1,216				68,355	70	71,741
Percussion drilling		3,607	100	55,850	9,250		133,422	200				834,810		1,037,239
Other	20,373	12,830	4,092	992			10,748		75					49,110
Total	62,469	28,101	4,481	73,306	10,250	3,819	181,752	15,421	7,874	3,107	1,270	940,654	3,028	1,335,532

[1] Barite, lead, mica, nickel, silver, uranium, and wollastonite.

TABLE 32.—Exploration and development in Colorado, by methods in 1961 [1]

(Feet)

Method	Beryllium	Clays	Copper	Gold, lode and placer	Lead-zinc	Molybdenum	Stone	Uranium	Other [2]	Total
Shaft sinking	120	------	25	245	56	423	------	4,813	110	5,792
Raising	340	------	215	1,795	5,234	185	350	6,350	215	14,684
Winzing	40	------	------	44	150	------	------	1,023	20	1,277
Tunneling	------	190	------	705	1,625	------	------	5,229	1,783	9,532
Drifting	510	1,000	615	5,127	14,227	21,957	350	93,736	402	137,924
Crosscutting	------	------	85	266	2,828	------	80	3,193	119	6,571
Diamond drilling	------	268	------	1,180	9,755	23,000	2,564	490,680	1,765	529,212
Churn drilling	------	------	------	------	105	------	------	4,802	------	4,907
Rotary drilling	------	------	------	1,000	------	------	1,160	346,202	2,900	351,262
Long-hole drilling	4,200	------	1,000	174	3,106	------	700	226,997	------	236,177
Percussion drilling	200	------	------	560	750	------	------	129,299	300	131,109
Trenching	1,300	------	165	1,156	740	------	------	22,525	140	26,026
Other	------	------	------	------	------	39,115	------	151,480	------	190,595
Total	6,710	1,458	2,105	12,252	38,576	84,680	5,204	1,486,329	7,754	1,645,068

[1] Revised figures.
[2] Gypsum, iron ore, pyrites, rare-earth metals and thorium, silver, and tungsten.

TABLE 33.—Exploration and development in Colorado, by methods, in 1962

(Feet)

Method	Gold, lode and placer	Lead	Molybdenum	Silver	Uranium	Zinc	Other [1]	Total
Shaft sinking	177	------	304	10	2,885	------	62	3,438
Raising	3,436	1,842	116	346	9,190	595	200	15,725
Winzing	60	165	------	------	2,086	------	------	2,311
Tunneling	1,450	1,468	1,700	576	1,089	------	615	6,898
Drifting	10,094	3,210	11,619	1,052	49,518	1,121	410	77,024
Crosscutting	254	2,209	------	26	1,381	1,559	300	5,729
Trenching	975	2,700	------	200	------	------	305	4,180
Diamond drilling	3,106	------	38,879	9,132	388,420	25,538	118	465,193
Churn drilling	------	105	------	------	2,274	------	------	2,379
Rotary drilling	64	------	------	------	318,566	------	110	318,740
Long-hole drilling	775	------	------	294	211,039	------	350	212,458
Percussion drilling	188	------	------	------	250,205	------	------	250,393
Other	------	------	------	------	------	------	270	270
Total	20,579	11,699	52,618	11,636	1,236,653	28,813	2,740	1,364,738

[1] Iron ore, copper, beryllium, feldspar, gypsum, scrap and flake mica, and perlite.

TABLE 34.—Exploration and development in Idaho, by methods, in 1962

(Feet)

Method	Lead	Phosphate rock	Silver	Other [1]	Total
Shaft sinking	------	------	1,136	------	1,136
Raising	4,679	------	7,211	644	12,534
Winzing	794	------	------	------	794
Tunneling	632	------	260	82	974
Drifting	15,431	------	15,825	270	31,526
Crosscutting	9,939	------	6,760	55	16,754
Diamond drilling	25,801	6,000	14,720	3,300	49,821
Churn drilling	------	------	------	600	600
Rotary drilling	------	84,834	------	200	85,034
Long-hole drilling	10,913	------	5,036	5,715	21,664
Percussion drilling	1,131,533	13,000	646,793	------	1,791,326
Trenching	79	------	------	60	139
Other	60	------	356	------	416
Total	1,199,861	103,834	698,097	10,926	2,012,718

[1] Clays, copper, gold, iron ore, stone, and tungsten.

TABLE 35.—Exploration and development in Missouri, by methods, in 1962

(Feet)

Method	Barite	Clays	Copper	Iron ore	Lead	Stone	Zinc	Total
Shaft sinking								
Raising				1,329	650			1,979
Winzing								
Tunneling								
Drifting				10,272	15,880			26,152
Crosscutting								
Trenching	3,500							3,500
Diamond drilling		3,766		10,149	380,232			394,147
Churn drilling			575	11,665	133,247	2,209	2,866	150,562
Rotary drilling		12,449			7,150	7,850		27,449
Long-hole drilling						30		30
Percussion drilling								
Other	12,667			7,062	78,893	4,791		103,413
Total	16,167	16,215	575	40,477	616,052	14,880	2,866	707,232

TABLE 36.—Exploration and development in New Mexico, by methods, in 1962

(Feet)

Method	Copper	Molybdenum	Potash	Uranium	Zinc	Other [1]	Total
Shaft sinking				500	23	52	575
Raising	1,054	485	50	25,859	1,979		29,427
Winzing	61			1,745		55	1,861
Tunneling				4,161	190	460	4,811
Drifting	3,278	1,858		182,244	1,062	526	188,968
Crosscutting	527	1,800		166,376	284	8	168,995
Trenching		4,000				857	4,857
Diamond drilling	51,418	8,459	12,200		15,407	200	87,684
Churn drilling	1,100						1,100
Rotary drilling	470	2,587	7,200	1,090,511		1,000	1,101,768
Long-hole drilling	3,794			2,180,195	635		2,184,624
Percussion drilling					6,929	250	7,179
Other (combine 2 others)				1,645		202	1,847
Total	61,702	19,189	19,450	3,653,236	26,509	3,610	3,783,696

[1] Beryllium, columbium, lead, gold, pumice, pyrites, mica, and silver.

TABLE 37.—Exploration and development in Wyoming, by methods, in 1962

(Feet)

Method	Clays	Iron ore	Natural sodium carbonates	Phosphate rock	Uranium	Other [1]	Total
Shaft sinking		100	40	1,050			1,190
Raising		1,979			527	325	2,831
Tunneling		1,139	770		2,600		4,509
Drifting		5,393	10,000		21,789		37,182
Crosscutting		79			750		829
Diamond drilling					205		205
Churn drilling					1,193		1,193
Rotary drilling	14,098				570,526		584,624
Long-hole drilling					90,707		90,707
Percussion drilling					240,333		240,333
Trenching				80	290	30	400
Other							
Total	14,098	8,690	10,810	1,130	928,920	355	964,003

[1] Beryllium and stone.

Statistical Summary of Mineral Production

By Kathleen J. D'Amico [1]

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

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

TABLE 1.—Value of mineral production in the United States,[1] 1925–62, by mineral groups [2]

(Millions)

Year	Mineral fuels	Nonmetals (except fuels)	Metals	Total	Year	Mineral fuels	Nonmetals (except fuels)	Metals	Total
1925	$2,910	$1,187	$715	$4,812	1944	$4,574	$836	$900	$6,310
1926	3,371	1,219	721	5,311	1945	4,569	888	774	6,231
1927	2,875	1,201	622	4,698	1946	5,090	1,243	729	7,062
1928	2,666	1,163	655	4,484	1947	7,188	1,338	1,084	9,610
1929	2,940	1,166	802	4,908	1948	9,502	1,552	1,219	12,273
1930	2,500	973	507	3,980	1949	7,920	1,559	1,101	10,580
1931	1,620	671	287	2,578	1950	8,689	1,822	1,351	11,862
1932	1,460	412	128	2,000	1951	9,779	2,079	1,671	13,529
1933	1,413	432	205	2,050	1952	9,616	2,163	1,617	13,396
1934	1,947	520	277	2,744	1953	10,257	2,350	1,811	14,418
1935	2,013	564	365	2,942	1954	9,919	[3] 2,733	1,518	[3] 14,170
1936	2,405	685	516	3,606	1955	10,780	[3] 3,076	2,055	[3] 15,911
1937	2,798	711	756	4,265	1956	11,741	[3] 3,391	2,358	[3] 17,490
1938	2,436	622	460	3,518	1957	12,709	[3] 3,387	2,137	[3] 18,233
1939	2,423	754	631	3,808	1958	11,589	[3] 3,466	1,594	[3] 16,649
1940	2,662	784	752	4,198	1959	11,950	[3] 3,861	1,570	[3] 17,381
1941	3,228	989	890	5,107	1960	12,142	[3] 3,868	2,022	[3] 18,032
1942	3,568	1,056	999	5,623	1961	[3] 12,357	[3] 3,946	1,927	[3] 18,230
1943	4,028	916	987	5,931	1962	12,779	4,118	1,937	18,834

[1] Excludes Alaska and Hawaii, 1925–53.
[2] Data for 1925–46 are not strictly comparable with those for subsequent years, since for earlier years value of heavy clay products has not been replaced by value of raw clays used for such products.
[3] Revised figure.

[1] Statistical officer, Division of Minerals.

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

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

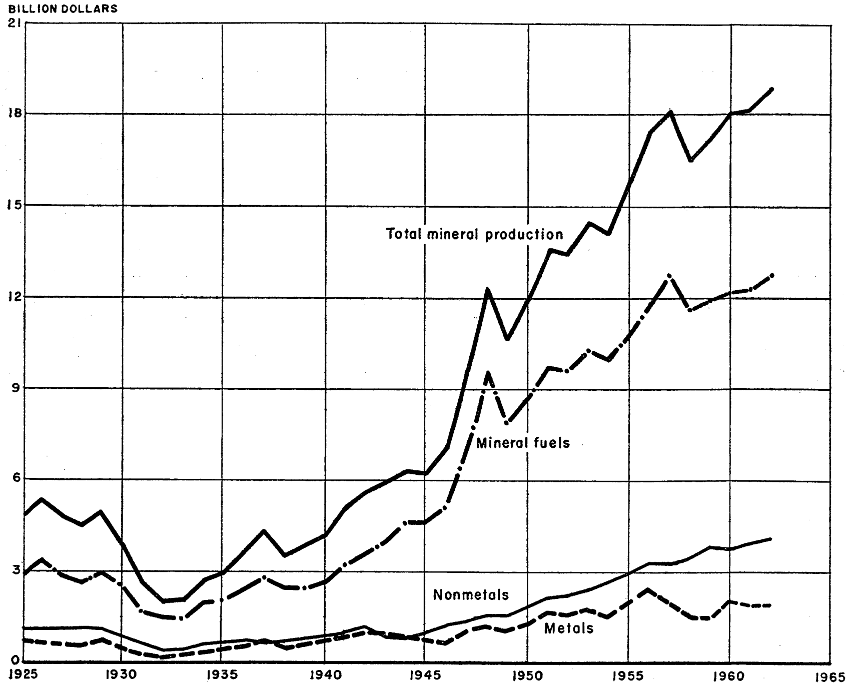

FIGURE 1.—Value of mineral production in the United States, 1925–62.

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

Mineral	1959		1960		1961		1962	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Mineral fuels:								
Asphalt and related bitumens (native):								
Bituminous limestone and sandstone ... short tons	1,518,765	$3,868	1,242,874	$3,070	1,558,792	$12,818	1,647,063	$14,601
Gilsonite ... do	379,362	9,385	383,037	10,020				
Carbon dioxide, natural (estimate) ... thousand cubic feet	485.179	71	521,169	99	545,354	82	1,144,107	146
Coal:								
Bituminous and lignite [2] ... thousand short tons	412,028	1,965,607	415,512	1,950.425	402,977	1,844,563	422.149	1,891.553
Pennsylvania anthracite ... do	20,649	172,320	18,817	147,116	17,446	140,338	16,894	134,094
Helium ... thousand cubic feet	375,408	6.144	475,179	7,768	551,785	10 263	599.519	20,905
Natural gas ... million cubic feet	12,046,115	1,556,800	12,771,038	1,789,970	13,254,025	1,996,241	13,876,622	2,145,301
Natural gas liquids:								
Natural gasoline and cycle products ... thousand gallons	5,597.102	408,694	5.842,507	416,819	6,105,463	412 019	6,244,522	444,817
LP gases ... do	7,874.706	349,802	8,444,074	391,566	9.085,465	370,186	9,409,083	353,334
Peat ... short tons	419.460	4.372	470,889	5,138	[3] 531,067	[3] 5,036	571,873	5.186
Petroleum (crude) ... thousand 42-gallon barrels	2,574,590	7,473,336	2,574,933	7,420,181	2.621.758	7,565,582	[4] 2,676,185	[4] 7,768,822
Total mineral fuels	------------	11,950,000	------------	12.142,000	------------	12,357,000	------------	12,779,000
Nonmetals (except fuels):								
Abrasive stone [5] ... short tons	3.672	315	2,539	240	2,495	238	2,653	260
Aplite ... long tons	(6)	(6)	(6)	(6)	97,465	651	125,156	912
Asbestos ... short tons	45.459	4,391	45,223	4,231	52,814	4,347	53,190	4,677
Barite ... do	901.815	10,301	714,276	8.574	[3] 796,804	[3] 9,300	860.312	9,820
Boron minerals ... do	619.946	46,150	640,591	47,550	602,613	46,936	646,613	49,336
Bromine ... thousand pounds	195,483	51,508	175,010	44,637	180,798	44,517	190,747	46.617
Cement:								
Portland ... thousand 376-pound barrels	346,675	1,144,867	321,646	1,089,134	314,821	1,048,832	325.476	1.070,371
Masonry ... thousand 280-pound barrels					19,275	55,737	19,998	57,405
Natural and slag ... thousand 376-pound barrels					269	968	402	1,611
Clays ... thousand short tons	49,383	159,659	49,069	162,411	47,389	156,829	47,797	163,012
Emery ... short tons	8,555	150	8.169	142	6,180	106	4,316	71
Feldspar ... long tons	548,390	5,372	502,380	4,779	496,808	5.120	492,476	5,076
Fluorspar ... short tons	185,091	8,680	229.782	10,391	[3] 197,354	[3] 8,940	206,026	9,166
Garnet (abrasive) ... do	14,568	1,211	10,522	986	12,057	1,036	14.166	1,172
Gem stones (estimate)	(7)	1,184	(7)	1,188	(7)	1,309	(7)	1,296
Gypsum ... thousand short tons	10,900	39,231	9,825	35,690	9,500	[3] 34,996	9,969	36,343
Lime ... do	12,498	163,890	12,935	172,731	[3] 13,249	[3] 177,463	13,753	186.754
Magnesite ... short tons	594,307	2,401	498,528	2,051	603,656	3,129	492,471	2,287
Magnesium compounds from sea water and brine (except for metals) short tons, MgO equivalent	276,309	21.636	293,454	21,903	356,384	25,545	408,129	28,742

See footnotes at end of table

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

Mineral	1959		1960		1961		1962	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Nonmetals (except fuels)—Continued								
Mica:								
Scrap .... short tons	101,541	$2,665	97,912	$2,698	99,044	$2,417	107,702	$2,639
Sheet .... pounds	706,395	3,419	[3] 587,401	[3] 3,108	[3] 526,007	[3] 3,386	360,958	1,277
Perlite .... short tons	324,669	2,737	312,153	2,665	310,338	2,664	320,330	2,663
Phosphate rock .... thousand long tons	15,869	98,758	17,516	117,041	18,559	130,535	19,382	134,304
Potassium salts .... thousand short tons, K_2O equivalent	2,383	80,393	2,638	89,676	2,732	104,464	2,452	94,859
Pumice .... thousand short tons	2,276	5,863	2,210	5,569	2,463	6,799	2,247	6,262
Pyrites .... thousand long tons	1,057	8,148	1,016	7,936	988	7,418	916	6,809
Salt .... thousand short tons	25,160	155,839	25,479	161,140	25,707	160,223	28,807	174,841
Sand and gravel .... do	730,205	728,712	709,792	720,432	751,784	751,301	776,701	794,725
Sodium carbonate (natural) .... short tons	735,261	19,078	808,624	20,865	805,828	20,444	977,584	24,330
Sodium sulfate (natural) .... do	402,743	7,689	449,631	8,706	465,814	9,296	457,881	9,092
Stone [8] .... thousand short tons	584,163	911,982	616,784	952,555	[3] 611,938	[3] 947,359	656,954	1,025,697
Sulfur:								
Frasch process mines .... thousand long tons	5,222	121,777	5,003	115,494	5,082	117,884	4,917	107,069
Other mines .... long tons	151,932	1,418	181,422	1,732	177,549	1,694	150,550	1,439
Talc, soapstone, and pyrophyllite .... short tons	791,558	5,641	734,473	5,378	[3] 762,380	[3] 5,277	771,728	5,278
Tripoli .... do	52,968	219	57,713	247	54,641	225	61,732	244
Vermiculite .... thousand short tons	207	3,082	199	3,108	206	3,350	205	3,293
Value of items that cannot be disclosed: Brucite (1959), calcium-magnesium chloride, diatomite, epsom salts from epsomite (1961–62), graphite, iodine, kyanite, lithium minerals, greensand marl, olivine, staurolite (1960–62), strontium minerals (1959), wollastonite, and values indicated by footnote 6	....	42,322	....	42,664	....	[3] 44,863	....	47,815
Total nonmetals	....	[3] 3,861,000	....	[3] 3,868,000	....	[3] 3,946,000	....	4,118,000

Metals:								
Antimony ore and concentrate........short tons, antimony content..	688	([9])	635	([9])	689	([9])	631	([9])
Bauxite..........long tons, dried equivalent..	1,700,235	17,725	1,997,827	21,107	1,228,032	13,937	1,369,007	15,609
Beryllium concentrate..........short tons, gross weight..	425	179	509	162	[10] 1,122	([9])	[10] 978	([9])
Chromite..........do....	[11] 105,000	[11] 3,765	[11] 107,000	[11] 3,813	[11] 82,000	[11] 2,939	....	....
Cobalt (content of concentrate)..........thousand pounds..	2,944	([9])	([9])	([9])	([9])	([9])	([9])	([9])
Columbium-tantalum concentrate [12]..........pounds..	189,263	([9])	....	....	....	....	....	....
Copper (recoverable content of ores, etc.)..........short tons..	824,846	506,455	1,080,169	693,468	1,165,155	699,093	1,228,421	756,707
Gold (recoverable content of ores, etc.)..........troy ounces..	1,602,931	56,103	1,666,772	58,336	1,548,270	54,189	1,542,511	53,990
Iron ore, usable (excluding byproduct iron sinter) thousand long tons, gross weight..	59,164	514,067	82,963	724,131	72,378	650,501	69,969	618,242
Lead (recoverable content of ores, etc.)..........short tons..	255,586	58,786	246,669	57,722	261,921	53,956	236,956	43,602
Manganese ore (35 percent or more Mn)......short tons, gross weight..	299,199	17,904	80,021	5,352	46,088	[3] 3,224	24,758	([9])
Manganiferous ore (5 to 35 percent Mn)..........do....	470,600	3,153	658,455	4,466	225,004	1,480	338,501	([9])
Mercury..........76-pound flasks..	31,256	7,110	33,223	7,002	31,662	6,257	26,277	5,024
Molybdenum (content of concentrate)..........thousand pounds..	51,603	64,655	69,941	87,406	66,753	87,925	50,506	69,390
Nickel (content or ore and concentrate)..........short tons..	13,374	([9])	14,079	([9])	13,133	([9])	13,110	([9])
Rare-earth and thorium concentrates..........do....	1,143	206	([9])	([9])	([9])	([9])	([9])	([9])
Silver (recoverable content of ores, etc.)........thousand troy ounces..	31,194	28,233	30,766	27,846	34,794	32,166	36,798	39,929
Tin (content of ore and concentrate)..........long tons..	50	60	10	12	([9])	([9])	([9])	([9])
Titanium concentrate:								
Ilmenite..........short tons, gross weight..	637,263	12,106	789,237	14,655	782,629	13,320	809,037	13,974
Rutile..........do....	8,648	877	9,226	957	7,664	778	8,033	933
Tungsten ore and concentrate........short tons, 60-percent WO_3 basis..	3,649	4,502	7,325	9,815	8,245	10,565	8,429	11,639
Uranium ore..........short tons..	6,934,927	141,349	7,970,211	152,188	8,041,329	148,299	7,052,870	138,294
Vanadium (recoverable in ore and concentrate)..........do....	3,719	13,278	4,971	17,749	5,343	19,076	[13] 5,211	[13] 18,605
Zinc (recoverable content of ores, etc.)..........do....	425,303	97,787	435,427	112,365	464,390	106,848	505,491	116,413
Value of items that cannot be disclosed: Chromite,[11] magnesium chloride for magnesium metal, manganiferous residuum, platinum-group metals (crude), zirconium concentrate, and values indicated by footnote 9..........	....	21,763	....	32,078	....	22,582	....	35,071
Total metals..........	....	1,570,000	....	2,022,000	....	1,927,000	....	1,937,000
Grand total mineral production..........	....	[3] 17,381,000	....	[3] 18,032,000	....	[3] 18,230,000	....	18,834,000

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2] Includes small quantity of anthracite mined in States other than Pennsylvania.
[3] Revised figure.
[4] Preliminary figure.
[5] Grindstones, pulpstones, millstones (weight not recorded), grinding pebbles, sharpening stones, and tube-mill liners.
[6] Figure withheld to avoid disclosing individual company confidential data; value included with "Nonmetal items that cannot be disclosed."
[7] Weight not recorded.
[8] Excludes abrasive stone, bituminous limestone, bituminous sandstone, and ground soapstone, all included elsewhere in table.
[9] Figure withheld to avoid disclosing individual company confidential data; value included with "Metal items that cannot be disclosed."
[10] Includes 805 tons of low-grade beryllium ore 1961, and 760 tons of low-grade beryllium ore 1962.
[11] Excludes quantity consumed by American Chrome Co.
[12] Total weight of columbite-tantalite plus $(Cb\text{-}Ta)_2O_5$ content of euxenite.
[13] Final figure, supersedes figure given in commodity chapter.

TABLE 3.—Minerals produced in the United States and principal producing States in 1962

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

TABLE 3.—Minerals produced in the United States and principal producing States in 1962—Continued

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

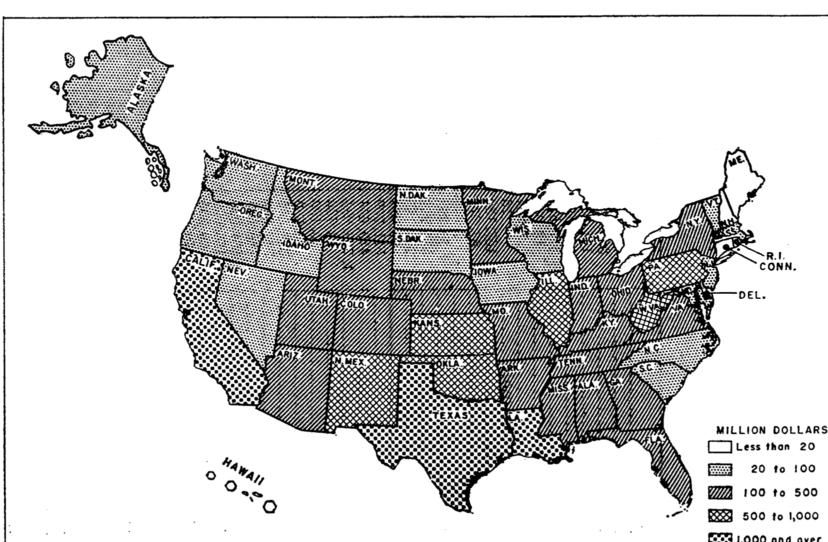

FIGURE 2.—Value of mineral production in the United States, 1962, by States.

TABLE 4.—Value of mineral production in the United States, and principal minerals produced in 1962

(Thousands)

State	1959	1960	1961	1962 Value	1962 Rank	1962 Percent of U.S. total	1962 Principal minerals in order of value
Alabama	$206,456	$221,802	$218,879	$219,837	20	1.17	Coal, cement, stone, petroleum.
Alaska	20,495	21,860	34,753	54,196	39	.29	Petroleum, coal, gold, sand and gravel.
Arizona	328,245	417,225	425,995	474,142	11	2.52	Copper, sand and gravel, cement, zinc.
Arkansas	141,833	159,519	148,267	153,785	26	.82	Petroleum, stone, bauxite, sand and gravel.
California	1,450,876	1,422,087	1,435,737	1,467,295	3	7.79	Petroleum, natural gas, cement, sand and gravel.
Colorado	317,572	345,418	346,208	308,115	17	1.64	Petroleum, molybdenum, coal, sand and gravel.
Connecticut	13,030	15,353	16,599	19,754	45	.10	Sand and gravel, stone, lime, feldspar.
Delaware	1,284	989	1,053	1,531	50	.01	Sand and gravel, stone, clays, gem stones.
District of Columbia	75	71	68	74	----------	(1)	Clays.
Florida	167,130	180,286	188,121	185,697	24	.99	Phosphate rock, stone, cement, titanium concentrate.
Georgia	87,371	92,305	96,311	107,705	29	.57	Clays, stone, cement, sand and gravel.
Hawaii	7,644	9,367	14,990	14,844	47	.08	Stone, cement, sand and gravel, lime.
Idaho	70,392	57,606	69,034	82,575	33	.44	Silver, lead, zinc, sand and gravel.
Illinois	574,914	589,874	567,393	588,335	8	3.12	Petroleum, coal, stone, sand and gravel.
Indiana	209,145	210,932	201,545	202,330	22	1.07	Coal, cement, petroleum, stone.
Iowa	92,954	99,319	94,998	96,561	30	.51	Cement, stone, sand and gravel, gypsum.
Kansas	511,209	486,534	488,598	501,076	9	2.66	Petroleum, natural gas, cement, stone.
Kentucky	419,644	414,553	383,788	399,518	15	2.12	Coal, petroleum, stone, natural gas.
Louisiana	1,768,835	1,990,895	2,168,679	2,445,329	2	12.98	Petroleum, natural gas, natural gas liquids, sulfur.
Maine	13,739	14,108	15,615	14,947	46	.08	Cement, stone, sand and gravel, clays.
Maryland	55,190	57,697	62,858	66,629	36	.35	Stone, cement, sand and gravel, coal.
Massachusetts	26,686	28,245	30,789	30,035	43	.16	Sand and gravel, stone, lime, clays.
Michigan	388,545	437,598	450,652	446,520	12	2.37	Iron ore, cement, petroleum, copper.
Minnesota	347,367	515,521	450,914	428,936	13	2.28	Iron ore, sand and gravel, stone, cement.
Mississippi	186,678	199,210	208,580	209,428	21	1.11	Petroleum, natural gas, cement, sand and gravel.
Missouri	164,025	162,244	151,288	153,307	27	.81	Cement, stone, lime, coal.
Montana	168,099	179,406	184,233	190,656	23	1.01	Petroleum, copper, sand and gravel, zinc.
Nebraska	99,335	103,942	105,445	108,249	28	.57	Petroleum, cement, sand and gravel, stone.
Nevada	70,859	80,892	81,533	83,733	32	.44	Copper, sand and gravel, diatomite, lime.
New Hampshire	4,722	5,439	5,466	6,010	48	.03	Sand and gravel, stone, mica, feldspar.
New Jersey	59,544	56,469	59,270	65,686	37	.35	Stone, sand and gravel, iron ore, zinc.
New Mexico	592,812	653,766	690,913	674,064	7	3.58	Petroleum, natural gas, potassium salts, uranium.
New York	239,953	260,922	233,833	241,892	18	1.28	Cement, stone, salt, sand and gravel.
North Carolina	40,789	45,096	50,124	54,597	38	.29	Stone, sand and gravel, tungsten, feldspar.
North Dakota	67,342	78,378	84,925	90,572	31	.48	Petroleum, sand and gravel, coal, natural gas liquids.
Ohio	412,484	406,142	382,451	393,671	16	2.09	Coal, stone, cement, lime.
Oklahoma	768,390	782,579	791,777	843,272	4	4.48	Petroleum, natural gas, natural gas liquids, cement.
Oregon	50,849	55,772	53,092	52,458	40	.28	Stone, sand and gravel, cement, nickel.
Pennsylvania	879,693	838,146	805,127	823,152	5	4.37	Coal, cement, stone, iron ore.
Rhode Island	2,333	5,727	3,079	2,994	49	.02	Sand and gravel, stone, gem stones.

South Carolina	31, 287	30, 987	31, 374	33, 901	42	.18	Cement, stone, clays, sand and gravel.
South Dakota	49, 498	47, 675	44, 007	45, 789	41	.24	Gold, sand and gravel, cement, stone.
Tennessee	143, 284	145, 538	150, 711	154, 030	25	.82	Stone, cement, coal, phosphate rock.
Texas	4, 230, 107	4, 126, 419	4, 237, 958	4, 300, 984	1	22. 84	Petroleum, natural gas, natural gas liquids, cement.
Utah	374, 544	432, 712	416, 789	410, 412	14	2. 18	Copper, petroleum, uranium, coal.
Vermont	23, 383	22, 903	24, 296	25, 130	44	.13	Stone, asbestos, sand and gravel, talc.
Virginia	227, 853	208, 880	225, 298	222, 494	19	1. 18	Coal, stone, cement, sand and gravel.
Washington	65, 830	72, 404	66, 448	68, 474	34	.36	Stone, sand and gravel, cement, zinc.
West Virginia	739, 523	722, 628	690, 250	714, 964	6	3. 80	Coal, natural gas, natural gas liquids, petroleum.
Wisconsin	72, 924	78, 760	73, 511	68, 289	35	.36	Sand and gravel, stone, cement, iron ore.
Wyoming	394, 372	439, 256	466, 247	485, 777	10	2. 60	Petroleum, natural gas, uranium, sodium carbonates and sulfates.
Total	17, 381, 000	18, 032, 000	18, 230, 000	18, 834, 000		100. 00	Petroleum, natural gas, coal, cement.

[1] Less than 0.005 percent.

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

Mineral	1959 Quantity	1959 Value (thousands)	1960 Quantity	1960 Value (thousands)	1961 Quantity	1961 Value (thousands)	1962 Quantity	1962 Value (thousands)
ALABAMA								
Cement:[2]								
Portland .... thousand 376-pound barrels..	14,819	$46,639	12,931	$42,706	12,445	$39,027	12,482	$40,164
Masonry .... thousand 280-pound barrels..					2,006	6,156	2,187	6,521
Clays[3] .... thousand short tons..	1,786	2,089	1,840	2,170	1,787	2,068	1,632	1,947
Coal (bituminous) .... do....	11,947	78,212	13,011	92,439	12,915	90,903	12,880	95,149
Iron ore (usable) .... thousand long tons, gross weight..	4,165	23,922	4,068	23,511	3,597	20,510	2,962	17,838
Lime .... thousand short tons..	579	6,847	536	6,593	579	6,871	522	6,298
Mica (sheet) .... pounds..	818	7	(4)	(5)	(4)	(4)	(4)	(5)
Natural gas .... million cubic feet..	172	17	57	4	56	4	128	13
Petroleum (crude) .... thousand 42-gallon barrels..	5,524	(4)	7,329	(4)	6,931	19,060	[6] 7,493	[6] 19,407
Sand and gravel .... thousand short tons..	4,352	4,594	4,359	4,759	5,800	6,452	4,655	4,486
Stone[7] .... do....	11,886	18,728	13,503	19,970	13,651	19,909	12,680	19,667
Value of items that cannot be disclosed: Native asphalt, bauxite, slag cement, clays (kaolin), scrap mica, salt, stone (dimension limestone, dimension marble 1959-61, shell 1959-61, crushed sandstone 1959-61), talc, and values indicated by footnote 4	....	25,401	....	29,650	....	7,919	....	8,347
Total	....	[8] 206,456	....	[8] 221,802	....	[8] 218,879	....	219,837
ALASKA								
Clays .... thousand short tons..	(9)	$1	1	$10	....	....	....	....
Coal (bituminous .... do....	660	5,869	722	6,318	737	$5,868	871	$6,409
Copper (recoverable content of ores, etc.) .... short tons..	36	22	41	26	92	55	....	....
Gem stones	(10)	18	(10)	(4)	(10)	(4)	(10)	(4)
Gold (recoverable content of ores, etc.) .... troy ounces..	178,918	6,262	168,197	5,887	114,216	3,998	165,259	5,784
Mercury .... 76-pound flasks..	3,743	852	4,459	940	4,129	816	3,719	711
Natural gas .... million cubic feet..	133	16	246	30	631	129	2,184	467
Peat .... short tons..	....	....	376	(4)	....	....	(4)	(4)
Petroleum (crude) .... thousand 42-gallon barrels..	187	295	559	1,230	6,327	17,652	[6] 10,260	[6] 31,190
Sand and gravel .... thousand short tons..	5,859	5,265	6,013	5,483	5,241	4,185	5,731	5,355
Silver (recoverable content of ores, etc.) .... thousand troy ounces..	21	19	26	23	18	17	22	24
Stone .... thousand short tons..	89	377	275	852	(4)	(4)	(4)	(4)
Value of items that cannot be disclosed: Lead (1960-61), platinum-group metals, uranium ore, and values indicated by footnote 4	....	1,499	....	1,061	....	[8] 2,033	....	4,256
Total	....	20,495	....	21,860	....	[8] 34,753	....	54,196

ARIZONA

Beryllium concentrate......short tons, gross weight..	----	----	(11)	(5)	8	$4	1	(5)
Clays [3]......thousand short tons..	120	$179	173	$260	165	240	139	$184
Coal (bituminous)......do....	7	63	6	58	----	----	----	----
Copper (recoverable content of ores, etc.)......short tons..	430,297	264,202	538,605	345,784	587,053	352,232	644,242	396,853
Gem stones......	(10)	88	(10)	120	(10)	119	(10)	120
Gold (recoverable content of ores, etc.)......troy ounces..	124,627	4,362	143,064	5,007	145,959	5,109	137,207	4,802
Lead (recoverable content of ores, etc.)......short tons..	9,999	2,300	8,495	1,988	5,937	1,223	6,966	1,282
Lime......thousand short tons..	123	1,666	148	2,430	167	2,686	174	2,914
Manganese ore (35 percent or more Mn)......short tons, gross weight..	68,183	5,727	1,626	40	----	----	----	----
Manganiferous ore (5 to 35 percent Mn)......do....	10,693	234	8,677	190	(4)	(4)	----	----
Mercury......76-pound flasks..	(4)	(4)	(4)	(4)	148	29	(4)	(4)
Mica (scrap)......short tons..	3,069	55	(4)	(4)	(4)	(4)	(4)	(4)
Molybdenum (content of concentrate)......thousand pounds..	3,181	4,019	4,359	5,211	4,878	6,232	4,412	5,864
Natural gas......million cubic feet..	----	----	----	----	----	----	230	27
Perlite......short tons..	(4)	(4)	(4)	(4)	(4)	(4)	17,749	147
Petroleum (crude)......thousand 42-gallon barrels..	25	(4)	73	(4)	73	(4)	[6] 43	(4)
Pumice......thousand short tons..	487	1,153	703	1,164	745	1,893	756	1,640
Sand and gravel......do....	13,458	11,966	14,490	14,235	[8] 17,688	[8] 16,175	15,579	17,404
Silver (recoverable content of ores, etc.)......thousand troy ounces..	3,898	3,528	4,775	4,322	5,120	4,733	5,454	5,917
Stone......thousand short tons..	2,468	3,998	4,249	5,107	3,582	4,626	4,333	6,616
Tungsten ore and concentrate......short tons, 60-percent WO_3 basis..	(4)	(4)	(4)	(4)	----	----	15	14
Uranium ore......short tons..	253,390	6,309	283,684	6,219	228,225	4,965	143,196	3,047
Vanadium (recoverable in ore and concentrate)......do....	(4)	(4)	(4)	(4)	(4)	(4)	632	(4)
Zinc (recoverable content of ores, etc.)......do....	37,325	8,585	35,811	9,239	29,585	6,804	32,888	7,564
Value of items that cannot be disclosed: Asbestos, cement, clays (bentonite, fire clay 1961–62), diatomite (1961–62), feldspar, gypsum, helium (1961–62), iron ore (1961–62), pyrites, and values indicated by footnote 4......	----	9,811	----	[8] 15,851	----	[8] 18,925	----	19,747
Total......	----	[8] 328,245	----	[8] 417,225	----	[8] 425,995	----	474,142

See footnotes at end of table.

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

Mineral	1959		1960		1961		1962	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
ARKANSAS								
Barite...short tons	338,539	$3,097	277,851	$2,578	277,855	$2,630	258,691	$2,232
Bauxite...long tons, dried equivalent	1,631,643	17,048	1,932,071	20,469	1,178,898	13,462	1,270,124	14,606
Clays...thousand short tons	782	2,406	815	2,456	773	1,758	654	1,693
Coal (bituminous)...do	441	3,482	409	3,116	395	2,888	256	1,809
Gem stones	(10)	18	(10)	38	(10)	19	(10)	15
Gypsum...thousand short tons	(4)	(4)	67	208	167	531	83	261
Iron ore (usable)...thousand long tons, gross weight	----	----	----	----	----	----	43	296
Lead (recoverable content of ores, etc.)...short tons	38	9	----	----	----	----	----	----
Lime...thousand short tons	(4)	(4)	(4)	(4)	[8] 90	[8] 1,196	350	4,542
Manganese ore (35 percent or more Mn)...short tons, gross weight	17,742	1,398	----	----	----	----	----	----
Natural gas...million cubic feet	40,674	3,539	55,451	6,599	59,547	8,039	66,213	9,866
Natural gas liquids:								
Natural gasoline and cycle products...thousand gallons	40,730	2,523	34,558	2,148	27,889	1,640	29,415	1,673
LP gases...do	55,731	3,048	73,252	3,735	75,157	3,286	69,452	2,432
Petroleum (crude)...thousand 42-gallon barrels	26,329	72,931	30,117	83,424	29,246	80,427	[6] 27,585	[6] 73,376
Sand and gravel...thousand short tons	11,696	11,857	8,192	10,262	9,389	9,074	10,847	10,006
Stone...do	8,824	10,424	10,939	13,555	12,029	12,402	20,611	19,866
Zinc (recoverable content of ores, etc.)...short tons	49	11	50	13	37	9	211	49
Value of items that cannot be disclosed: Abrasive stones, bromine, cement, soapstone, and values indicated by footnote 4	----	10,042	----	10,918	----	10,906	----	11,063
Total	----	[8] 141,833	----	[8] 159,519	----	[8] 148,267	----	153,785

Barite ... short tons	28,143	$326	16,157	$181	21,203	$295	6,945	$133
Boron minerals ... do	619,946	46,150	640,591	47,550	602,613	46,936	646,613	49,336
Cement ... thousand 376-pound barrels	[2] 43,635	[2] 138,506	[2] 39,712	[2] 128,826	[2] 41.090	[2] 129,836	43,667	139,151
Clays ... thousand short tons	2,726	5,646	2,899	5,663	3,041	6,405	3,137	7,349
Copper (recoverable content of ores, etc.) ... short tons	663	407	1,087	698	1,382	829	1,162	716
Feldspar ... long tons	76,489	824	76,010	886	(4)	(4)	(4)	(4)
Gem stones	(10)	150	(10)	150	(10)	200	(10)	200
Gold (recoverable content of ores, etc.) ... troy ounces	145,270	5,084	123,713	4,330	97,644	3,418	106,272	3,720
Gypsum ... thousand short tons	1,686	3,788	1,616	3,687	1,574	[8] 3,733	1,747	4,113
Lead (recoverable content of ores, etc.) ... short tons	227	52	440	103	103	21	455	84
Lime ... thousand short tons	358	5,817	345	5,628	[8] 503	[8] 9,062	470	8,454
Magnesium compounds from sea water and bitterns (partly estimated) short tons, MgO equivalent	87,968	6,336	86,532	6,233	90,534	6,467	76,445	6,077
Manganese ore (35 percent or more Mn) ... short tons, gross weight	19,354	1,663	----------	----------	----------	----------	----------	----------
Manganiferous ore (5 to 35 percent Mn) ... do	129	(4)	96	(4)	----------	----------	(4)	(4)
Mercury ... 76-pound flasks	17,100	3,890	18,764	3,955	18,688	3,693	15,951	3,050
Mica, scrap ... short tons	----------	----------	(4)	(4)	950	12	(4)	(4)
Natural gas ... million cubic feet	485,655	119,471	517,535	138,182	556,241	157,416	564,220	163,624
Natural gas liquids:								
Natural gasoline and cycle products ... thousand gallons	834,258	68,023	794,657	62,496	762,878	57,645	716,904	54,460
LP gases ... do	396,331	21,260	408,378	21,482	424,767	21,805	407,378	19,294
Peat ... short tons	34,604	449	33,091	481	46,348	501	33,901	331
Petroleum (crude) ... thousand 42-gallon barrels	308,946	787,812	305,352	751,166	299,609	728,050	[6] 296,572	[6] 741,430
Pumice ... thousand short tons	574	2,162	427	1,895	610	2,202	573	2,615
Salt ... do	1,388	(4)	1,443	(4)	1,601	(4)	1,643	(4)
Sand and gravel ... do	87,945	108,909	87,679	107,503	110,181	124,111	107,660	124,922
Silver (recoverable content of ores, etc.) ... thousand troy ounces	173	156	180	163	93	86	133	144
Stone ... thousand short tons	32,134	49,090	33,075	49,842	33,850	5 ,327	34,776	54,722
Talc, soapstone, and pyrophyllite ... short tons	144,816	1,490	130,539	1,396	161,068	1,524	117,912	1,339
Wollastonite ... do	(4)	(4)	(4)	(4)	4,075	42	(4)	(4)
Zinc (recoverable content of ores, etc.) ... do	78	18	465	120	304	70	322	74
Value of items that cannot be disclosed: Asbestos, bromine, calcium-magnesium chloride, carbon dioxide, masonry cement (1959–61), chromite (1959), coal (lignite), diatomite, fluorspar (1960–61), iodine, iron ore, lithium minerals, magnesite (1959–61), molybdenum, perlite, platinum-group metals (crude), potassium salts, pyrites, rare-earth metal concentrates, sodium cabonates and sulfates, strontium minerals (1959), sulfur ore, tungsten concentrate, uranium ore (1959–60), and values indicated by footnote 4	----------	73,397	----------	79,471	----------	81,051	----------	81,957
Total	----------	[8] 1,450,876	----------	[8] 1,422,087	----------	[8] 1,435,737	----------	1,467,295

See footnotes at end of table.

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

Mineral	1959		1960		1961		1962	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
COLORADO								
Beryllium concentrate, short tons, gross weight	221	$67	304	$53	[12] 819	(4)	[12] 782	(4)
Carbon dioxide, natural, thousand cubic feet	175,223	(4)	155,871	20	167,872	$19	148,940	$15
Clays, thousand short tons	417	1,160	490	1,424	556	1,241	802	1,573
Coal (bituminous), do	3,294	21,034	3,607	21,090	3,678	22,787	3,379	19,999
Copper (recoverable content of ores, etc.), short tons	2,940	1,805	3,247	2,085	4,141	2,485	4,534	2,793
Feldspar, long tons	(4)	(4)	(4)	(4)	14,129	99	(4)	(4)
Gem stones	(10)	43	(10)	45	(10)	36	(10)	45
Gold (recoverable content of ores, etc.), troy ounces	61,097	2,138	61,269	2,144	67,515	2,363	48,882	1,711
Gypsum, thousand short tons	106	385	82	296	85	320	108	383
Iron ore (usable), thousand long tons, gross weight	11	78	11	80	27	190	(4)	(4)
Lead (recoverable content of ores, etc.), short tons	12,907	2,969	18,080	4,231	17,755	3,658	17,411	3,204
Lime, thousand short tons	(4)	(4)	(4)	(4)	75	1,319	93	1,518
Manganese ore (35 percent or more Mn), short tons, gross weight	1,218	102	----	----	----	----	----	----
Mica, scrap, short tons	68	1	340	4	600	10	142	2
Molybdenum (content of concentrate), thousand pounds	36,745	46,555	51,615	65,448	47,485	63,582	32,412	45,376
Natural gas, million cubic feet	99,899	10,989	107,404	12,781	108,142	12,544	101,826	11,812
Natural gas liquids:								
Natural gasoline, thousand gallons	47,424	2,811	73,179	4,138	76,880	3,627	60,558	3,826
LP gases, do	77,637	3,671	104,275	4,938	115,410	5,498	100,787	4,411
Peat, short tons	6,674	35	9,384	37	9,894	44	12,351	68
Petroleum (crude), thousand 42-gallon barrels	46,440	134,676	47,469	137,660	46,759	134,666	[6] 42,460	[6] 122,285
Pumice, thousand short tons	40	66	32	70	44	60	76	82
Rare-earth and thorium concentrates, short tons	9	1	(11)	(5)	----	----	----	----
Sand and gravel, thousand short tons	20,897	18,817	19,053	16,882	18,360	16,946	19,313	18,926
Silver (recoverable content of ores, etc.), thousand troy ounces	1,341	1,213	1,659	1,502	1,965	1,817	2,088	2,265
Stone, thousand short tons	2,824	5,537	2,442	4,651	2,451	5,301	2,353	5,597
Tin (content of ore and concentrate), long tons	50	60	10	12	(4)	(4)	(4)	(4)
Uranium ore, short tons	1,044,089	22,546	1,149,583	23,462	1,282,462	21,509	1,135,440	18,044
Vanadium (recoverable in ore and concentrate), do	2,949	(4)	4,026	(4)	4,149	(4)	3,742	(4)
Zinc (recoverable content of ores, etc.), do	35,388	8,139	31,278	8,070	42,647	9,809	43,351	9.971
Value of items that cannot be disclosed: Cement, fluorspar, perlite, pyrites, salt, tungsten, vermiculite (1962), and values indicated by footnote 4	----	[8] 32,674	----	[8] 34,295	----	[8] 36,278	----	34,209
Total	----	[8] 317,572	----	[8] 345,418	----	[8] 346,208	----	308,115

CONNECTICUT

Beryllium concentrate----short tons, gross weight--	13	$8	16	$9	2	$1	7	$4
Clays----thousand short tons--	280	368	207	308	[3] 149	[3] 260	[3] 179	[3] 287
Gem stones----	(10)	5	(10)	7	(10)	9	(10)	8
Lime----thousand short tons--	(4)	(4)	35	616	33	589	35	635
Peat----short tons--	2,090	13	(4)	(4)	(4)	(4)	(4)	(4)
Sand and gravel----thousand short tons--	4,749	4,912	6,575	5,960	7,499	6,633	10,208	9,244
Stone----do----	4,462	7,088	5,057	8,313	5,206	8,616	5,090	8,816
Value of items that cannot be disclosed: Clays (kaolin 1961–62) feldspar, scrap mica (1961–62), sheet mica (1960–62), and values indicated by footnote 4----	----	636	----	140	----	491	----	760
Total----	----	[8] 13,030	----	[9] 15,353	----	[8] 16,599	----	19,754

DELAWARE

Sand and gravel----thousand short tons--	1,241	$1,071	1,084	$907	961	$970	1,755	$1,445
Value of items that cannot be disclosed: Nonmetals----	----	213	----	82	----	83	----	86
Total----	----	1,284	----	989	----	1,053	----	1,531

FLORIDA

Clays----thousand short tons--	[3] 245	[3] $6,171	[3] 252	[3] $6,357	513	$7,202	487	$6,741
Gem stones----	(10)	3	(10)	(5)	(10)	(5)	----	----
Lime----thousand short tons--	111	1,238	151	2,611	(4)	(4)	(4)	(4)
Natural gas----million cubic feet--	34	5	30	5	29	5	29	6
Peat----short tons--	34,446	158	39,275	162	[8] 26,673	[8] 157	21,592	138
Petroleum (crude)----thousand 42-gallon barrels--	424	(4)	369	(4)	374	(4)	[6] 418	(4)
Phosphate rock----thousand long tons--	11,564	71,208	12,321	82,530	13,789	95,590	13,949	94,595
Sand and gravel----thousand short tons--	6,674	5,177	6,757	5,559	6,530	5,577	5,924	5,179
Stone----do----	[7] 26,917	[7] 35,940	[7] 27,629	[7] 37,419	[7] 26,221	[7] 33,671	27,279	32,608
Titanium concentrate----thousand short tons, gross weight--	262	7,196	286	7,489	(4)	(4)	(4)	(4)
Value of items that cannot be disclosed: Cement, clays (kaolin and miscellaneous clay 1959–60), magnesium compounds, natural gas liquids (1962), rare-earth metals concentrates (1959, 1961–62), staurolite, stone (dimension limestone 1959, 1961, calcareous marl 1960), zirconium concentrate, and values indicated by footnote 4----	----	40,034	----	38,154	----	[8] 45,919	----	46,430
Total----	----	[8] 167,130	----	[8] 180,286	----	[8] 188,121	----	185,697

See footnotes at end of table.

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

Mineral	1959		1960		1961		1962	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
GEORGIA								
Barite...short tons..	(4)	(4)	(4)	(4)	106,914	$2,046	108,829	$1,987
Clays...thousand short tons..	3,352	$36,232	3,519	$40,160	3,569	42,025	3,801	47,462
Coal (bituminous)...do....	7	34	4	21	4	22	8	28
Feldspar...long tons..	(4)	(4)	(4)	(4)	31,128	692	35,692	795
Iron ore (usable)...thousand long tons, gross weight..	186	945	128	613	162	835	215	1,118
Manganese ore (35 percent or more Mn)...short tons, gross weight..	1,547	(4)	------	------	------	------	------	------
Mica (sheet)...pounds..	18,461	119	10,218	89	349	3	60	1
Peat...short tons..	4,288	(4)	6,904	73	[8] 1,914	(4)	(4)	(4)
Sand and gravel...thousand short tons..	2,909	2,982	3,338	3,047	3,150	3,049	3,429	3,365
Stone...do....	13,771	35,973	14.297	37,033	15,854	38,077	19,555	42,037
Talc and soapstone...short tons..	53,692	107	40,200	88	47,950	98	45,940	96
Value of items that cannot be disclosed: Bauxite, cement, gem stones, iron ore (pigment material, 1959–60), manganiferous ore, scrap mica, and values indicated by footnote 4...	------	10,979	------	11,181	------	[8] 9,464	------	10,816
Total...	------	[8] 87,371	------	[8] 92,305	------	[8] 96,311	------	107,705
HAWAII								
Cement...thousand 376-pound barrels..	------	------	113	$571	1,077	$5,574	1,128	$6,055
Gem stones...	(10)	(4)	(10)	(4)	(10)	18	(10)	(4)
Lime...thousand short tons..	(4)	(4)	(4)	(4)	14	354	15	386
Pumice...do....	276	$548	361	676	324	626	232	380
Salt...do....	------	------	------	------	(9)	4	(9)	(4)
Sand and gravel...do....	463	1,253	490	1,324	416	758	700	1,122
Stone...do....	3,034	5,480	3,535	6,443	4,429	7,656	4,071	6,883
Value of items that cannot be disclosed: Other nonmetals and values indicated by footnote 4...	------	363	------	353	------	------	------	18
Total...	------	[8] 7,644	------	[8] 9,367	------	[8] 14,990	------	14,844

IDAHO

Antimony ore and concentrate............short tons, antimony content..	678	(4)	635	(4)	689	(4)	631	(4)
Clays..........thousand short tons..	[3] 39	[3] $33	[3] 36	[3] $29	[3] 27	[3] $20	35	$70
Cobalt (content of concentrate)..........thousand pounds..	1,141	(4)	----------	----------	----------	----------	----------	----------
Columbium-tantalum concentrate..........pounds..	189,263	(4)	----------	----------	----------	----------	----------	----------
Copper (recoverable content of ores, etc.)..........short tons..	8,713	5,350	4,208	2,702	4,328	2,597	3,861	2,378
Gold (recoverable content of ores, etc.)..........troy ounces..	10,479	367	6,135	215	5,718	200	5,845	205
Iron ore (usable)..........thousand long tons, gross weight..	6	56	9	(4)	12	70	5	35
Lead (recoverable content of ores, etc.)..........short tons..	62,395	14,351	42,907	10,040	71,476	14,724	84,058	15,467
Lime..........thousand short tons..	----------	----------	----------	----------	47	658	68	801
Mercury..........76-pound flasks..	1,961	446	1,538	324	1,073	212	----------	----------
Phosphate rock..........thousand long tons..	1,610	7,412	2,177	11,044	1,440	7,984	1,912	10,635
Pumice..........thousand short tons..	93	137	56	88	60	95	43	64
Rare-earth metals concentrates..........short tons..	522	80	----------	----------	----------	----------	----------	----------
Sand and gravel..........thousand short tons..	9,184	8,080	7,088	6,594	7,305	6,793	14,321	13,029
Silver (recoverable content of ores, etc.)..........thousand troy ounces..	16,637	15,057	13,647	12,351	17,576	16,249	17,772	19,283
Stone..........thousand short tons..	1,079	1,931	1,318	2,141	1,873	3,111	1,381	2,698
Titanium concentrate..........short tons, gross weight..	(4)	(4)	2,014	30	1,873	28	(4)	(4)
Uranium ore..........short tons..	3,374	30	(4)	(4)	(4)	(4)	(4)	(4)
Zinc (recoverable content of ores, etc.)..........do....	55,699	12,811	36,801	9,495	58,295	13,408	62,865	14,459
Value of items that cannot be disclosed: Barite, cement, clays (fire clay 1959–61, bentonite 1960–61, kaolin 1961), abrasive garnet, gem stones, gypsum (1959), sheet mica (1959–60, 1962), nickel (1959), peat, perlite (1961–62), tungsten concentrate (1961), vanadium (1961–62), and values indicated by footnote 4..........	----------	[8] 4,251	----------	[8] 2,553	----------	[8] 2,885	----------	3,451
Total..........	----------	[8] 70,392	----------	[8] 57,606	----------	[8] 69,034	----------	82,575

See footnotes at end of table.

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

Mineral	1959 Quantity	1959 Value (thousands)	1960 Quantity	1960 Value (thousands)	1961 Quantity	1961 Value (thousands)	1962 Quantity	1962 Value (thousands)
ILLINOIS								
Cement:								
Portland ... thousand 376-pound barrels	9,925	$31,794	9,139	$30,732	8,595	$28,301	9,145	$30,205
Masonry ... thousand 280-pound barrels					461	1,420	440	1,320
Clays ... thousand short tons	2,229	4,950	2,357	5,479	1,982	4,166	1,929	4,151
Coal (bituminous) ... do	45,466	184,412	45,977	184,087	45,246	177,070	48,487	186,986
Fluorspar ... short tons	112,469	5,908	134,529	6,936	116,908	5,956	132,830	6,392
Gem stones	(10)	1	(10)	(4)	(10)	(4)	(10)	(4)
Lead (recoverable content of ores, etc.) ... short tons	2,570	591	3,000	702	3,430	707	3,610	664
Natural gas ... million cubic feet	13,739	1,910	11,666	1,458	9,970	1,276	10,650	1,523
Natural gas liquids:								
Natural gasoline and cycle products ... thousand gallons	(4)	(4)	16,496	1,313	16,956	1,311	13,315	1,023
LP gases ... do	(4)	(4)	358,366	19,941	340,284	16,495	327,616	13,812
Peat ... short tons	9,117	72	6,179	28	6,597	30	(4)	(4)
Petroleum (crude) ... thousand 42-gallon barrels	76,727	229,414	77,341	228,929	76,818	229,686	[6] 77,325	[6] 230,429
Sand and gravel ... thousand short tons	30,241	33,717	33,138	36,255	31,353	35,098	34,122	38,981
Stone ... do	35,294	45,081	41,721	55,593	36,361	47,939	41,293	54,411
Zinc (recoverable content of ores, etc.) ... short tons	26,815	6,167	29,550	7,624	26,795	6,163	27,413	6,305
Value of items that cannot be disclosed: Lime, tripoli, and values indicated by footnote 4		30,897		10,797		11,775		12,133
Total		[8] 574,914		[8] 589,874		[8] 567,393		588,335
INDIANA								
Abrasive stones ... short tons	5	$13	(4)	(4)	5	$14	5	$15
Cement [2] ... thousand 376-pound barrels	14,245	47,231	14,052	$48,310	13,780	47,024	12,878	42,572
Clays ... thousand short tons	1,692	2,915	1,822	3,396	1,362	2,446	1,450	2,255
Coal (bituminous) ... do	14,804	59,954	15,538	61,570	15,106	58,815	15,709	60,079
Natural gas ... million cubic feet	484	92	342	61	382	77	284	60
Peat ... short tons	15,393	202	27,486	290	57,146	502	51,710	272
Petroleum (crude) ... thousand 42-gallon barrels	11,554	34,315	12,054	35,439	11,500	34,270	[6] 11,709	[6] 34,893
Sand and gravel ... thousand short tons	20,357	17,924	20,752	18,377	19,577	16,898	21,261	18,692
Stone ... do	18,544	37,682	18,956	34,920	18,001	33,062	18,709	34,653
Value of items that cannot be disclosed: Cement (masonry 1959–61), gem stones (1961–62), gypsum, and values indicated by footnote 4		8,817		8,569		[8] 8,437		8,839
Total		[8] 209,145		[8] 210,932		[8] 201,545		202,330

IOWA

Cement:								
Portland....thousand 376-pound barrels..	13,170	$44,048	12,517	$44,204	12,108	$41,718	12,261	$42,417
Masonry....thousand 280-pound barrels..					557	1,843	568	1,786
Clays....thousand short tons..	912	1,168	1,022	1,345	1,044	1,426	1,039	1,427
Coal (bituminous)....do....	1,180	4,214	1,068	3,845	927	3,323	1,130	4,026
Gypsum....do....	1,318	5,587	1,283	5,428	1,239	5,276	1,256	5,318
Sand and gravel....do....	13,484	11,658	14,692	13,516	13,391	11,651	13,797	12,474
Stone....do....	20,501	25,759	23,185	30,321	22,018	28,916	21,618	28,244
Value of items that cannot be disclosed: Gem stones (1960-62), lime, and peat (1960-62)....	----	520	----	660	----	845	----	869
Total....	----	92,954	----	[8] 99,319	----	[8] 94,998	----	96,561

KANSAS

Cement:								
Portland....thousand 376-pound barrels..	10,405	$32,282	8,162	$26,373	8,028	$25,605	8,058	$25,134
Masonry....thousand 280-pound barrels..					379	1,156	392	1,156
Clays....thousand short tons..	1,021	1,271	894	1,224	954	1,225	895	1,091
Coal (bituminous)....do....	772	3,607	888	4,197	664	3,102	915	4,249
Gem stones....	(10)	1	(10)	(5)	----	----	----	----
Helium....thousand cubic feet..	21,643	343	21,696	350	23,251	434	42,305	1,478
Lead (recoverable content of ores, etc.)....short tons..	481	111	781	183	1,449	298	970	178
Lime....thousand short tons..	----	----	----	----	15	193	5	59
Natural gas....million cubic feet..	604,410	72,529	634,410	74,226	649,083	81,135	694,352	86,100
Natural gas liquids:								
Natural gasoline....thousand gallons..	107,814	5,576	115,868	6,694	132,180	5,790	151,360	7,696
LP gases....do....	124,874	6,658	127,270	6,343	135,643	5,916	166,769	6,295
Petroleum (crude)....thousand 42-gallon barrels..	119,543	347,870	113,453	329,014	112,241	324,376	[6] 112,076	[6] 326,141
Salt....thousand short tons..	1,123	13,670	1,213	14,109	[13] 913	[13] 11,409	[13] 944	[13] 11,654
Sand and gravel....do....	11,334	7,937	9,710	6,808	11,366	7,781	11,552	8,039
Stone [7]....do....	13,999	17,108	11,814	15,031	12,328	16,411	13,527	17,274
Zinc (recoverable content of ores, etc.)....short tons..	1,017	234	2,117	546	2,446	563	3,943	907
Value of items that cannot be disclosed: Natural cement, gypsum, pumice, salt (brine 1961-62), and stone (dimension sandstone 1959 and crushed sandstone)....	----	2,012	----	1,436	----	3,204	----	3,625
Total....	----	[8] 511,209	----	[8] 486,534	----	[8] 488,598	----	501,076

See footnotes at end of table

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

Mineral	1959		1960		1961		1962	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
KENTUCKY								
Barite short tons	26,598	$335	(4)	(4)	3,304	$30	4,097	$36
Clays thousand short tons	984	3,595	[3] 951	[3] $2,646	[3] 906	[3] 2,406	[3] 936	[3] 2,158
Coal (bituminous) do	62,810	270,139	66,846	282,395	63,032	256,158	69,212	270,875
Fluorspar short tons	18,579	887	25,855	1,173	[8] 31,169	[8] 1,420	33,830	1,492
Lead (recoverable content of ores, etc.) do	409	94	558	131	656	135	743	137
Natural gas million cubic feet	73,504	17,420	75,329	18,380	70,937	17,592	70,241	17,419
Natural gas liquids:								
Natural gasoline thousand gallons	35,868	2,133	(4)	(4)	(4)	(4)	(4)	(4)
LP gases do	213,171	12,267	(4)	(4)	(4)	(4)	(4)	(4)
Petroleum (crude) thousand 42-gallon barrels	27,272	76,634	21,147	60,268	18,344	54,482	[6] 18,122	[6] 53,460
Sand and gravel thousand short tons	5,081	5,568	5,113	5,763	5,582	5,540	6,137	5,378
Silver (recoverable content of ores, etc.) thousand troy ounces	(4)	(4)	----	----	2	2	1	2
Stone thousand short tons	[7] 16,063	[7] 22,215	[7] 15,810	[7] 21,493	17,085	23,309	19,472	27,682
Zinc (recoverable content of ores, etc.) short tons	673	155	869	224	1,147	264	1,172	270
Value of items that cannot be disclosed: Cement, ball clay (1960–62), gem stones (1960–62), stone (crushed sandstone 1959–60), and values indicated by footnote 4	----	8,202	----	22,080	----	[8] 22,450	----	20,609
Total	----	[8] 419,644	----	[8] 414,553	----	[8] 383,788	----	399,518
LOUISIANA								
Clays thousand short tons	[3] 904	[3] $904	749	$749	645	$645	638	$641
Lime do	(4)	(4)	(4)	(4)	[8] 636	[8] 6,292	624	6,519
Natural gas million cubic feet	2,670,271	411,222	2,988,414	511,019	3,271,857	611,837	3,525,456	694,515
Natural gas liquids:								
Natural gasoline and cycle products thousand gallons	846,110	60,295	875,567	66,214	931,176	61,714	1,010,137	74,726
LP gases do	540,046	25,877	606,023	28,147	806,559	33,214	862,772	29,037
Petroleum (crude) thousand 42-gallon barrels	362,666	1,145,569	400,832	1,258,138	424,962	1,338,160	[6] 483,101	[6] 1,521,274
Salt thousand short tons	4,807	20,918	4,792	21,959	4,722	23,357	5,248	27,407
Sand and gravel do	16,052	20,111	14,319	19,106	12,042	14,833	12,040	14,817
Stone do	5,670	10,874	[7] 4,691	[7] 8,882	[7] 4,641	[7] 7,656	[7] 5,711	[7] 8,067
Sulfur (Frasch process) thousand long tons	2,252	52,779	2,256	52,639	2,352	55,164	2,262	49,772
Value of items that cannot be disclosed: Cement, clay (bentonite 1959), gypsum, stone (crushed miscellaneous 1960–62), and values indicated by footnote 4	----	20,286	----	24,042	----	15,807	----	18,554
Total	----	[8] 1,768,835	----	[8] 1,990,895	----	[8] 2,168,679	----	2,445,329

MAINE

Beryllium concentrate......short tons, gross weight..	3	$2	(4)	(4)	5	$3	(4)	(4)
Clays......thousand short tons..	25	26	41	$50	43	51	48	$63
Gem stones......	(10)	10	(10)	15	(10)	20	(10)	25
Mica:								
Scrap......short tons..	157	4	171	6	80	2	15	(5)
Sheet......pounds..	22,360	237	[8] 28,860	303	[8] 9,680	88	2,017	16
Peat......short tons..	(4)	(4)	-----	-----	-----	-----	3,050	47
Sand and gravel......thousand short tons..	9,452	3,644	9,833	3,892	8,921	3,796	10,014	4,013
Stone......do....	819	2,766	1,012	3,851	998	4,694	1,127	4,249
Value of items that cannot be disclosed: Cement, feldspar, and values indicated by footnote 4......	-----	7,050	-----	5,991	-----	6,961	-----	6,534
Total......	-----	[8] 13,739	-----	[8] 14,108	-----	[8] 15,615	-----	14,947

MARYLAND

Clays......thousand short tons..	[3] 661	[3] $944	[3] 612	[3] $853	581	$997	593	$899
Coal (bituminous)......do....	842	3,188	748	2,799	757	2,868	821	3,168
Gem stones......	(10)	2	(10)	2	(10)	3	(10)	3
Natural gas......million cubic feet..	4,373	1,181	4,065	1,081	3,578	973	2,472	667
Sand and gravel......thousand short tons..	10,034	12,983	10,076	13,221	12,404	16,894	12,762	16,816
Stone......do....	7,445	15,476	7,944	16,962	[8] 10,007	[8] 20,373	11,610	22,595
Value of items that cannot be disclosed: Cement, ball clay (1959–60), diatomite (1962), lime, greensand marl, peat (1961–62), potassium salts, and talc and soapstone......	-----	21,416	-----	22,779	-----	[8] 20,750	-----	22,481
Total......	-----	[8] 55,190	-----	[8] 57,697	-----	[8] 62,858	-----	66,629

MASSACHUSETTS

Clays......thousand short tons..	101	$229	83	$71	104	$85	125	$96
Gem stones......	(10)	1	(10)	1	(10)	2	(10)	2
Lime......thousand short tons..	144	2,289	154	2,370	145	2,307	148	2,337
Peat......short tons..	773	(4)	(4)	(4)	(4)	(4)	(4)	(4)
Sand and gravel......thousand short tons..	13,210	11,786	14,789	13,013	18,061	14,958	17,566	15,026
Stone......do....	5,102	12,375	5,247	12,782	5,210	13,399	4,985	12,541
Value of items that cannot be disclosed: Nonmetals and values indicated by footnote 4......	-----	6	-----	8	-----	38	-----	33
Total......	-----	[8] 26,686	-----	[8] 28,245	-----	[8] 30,789	-----	30,035

See footnotes at end of table.

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

Mineral	1959 Quantity	1959 Value (thousands)	1960 Quantity	1960 Value (thousands)	1961 Quantity	1961 Value (thousands)	1962 Quantity	1962 Value (thousands)
MICHIGAN								
Cement:								
Portland ... thousand 376-pound barrels } Masonry ... thousand 280-pound barrels }	23,026	$77,324	22,361	$77,694				
Portland ... thousand 376-pound barrels					21,948	$75,172	22,682	$73,267
Masonry ... thousand 280-pound barrels					1,515	4,467	1,517	4,335
Clays ... thousand short tons	1,771	1,937	1,738	1,904	1,817	1,975	1,751	1,917
Copper (recoverable content of ores, etc.) ... short tons	55,300	33,954	56,385	36,199	70,245	42,147	74,099	45,645
Gypsum ... thousand short tons	1,721	6,595	1,463	5,609	1,295	5,095	1,278	4,791
Iron ore (usable) ... thousand long tons, gross weight	7,247	62,921	10,792	95,791	9,384	87,604	9,422	85,597
Lime ... thousand short tons	862	11,748	1,177	15,730	[8] 1,190	[8] 15,665	1,153	15,371
Manganiferous ore (5 to 35 percent Mn) ... short tons, gross weight	------	------	180,460	(4)	17,083	(4)	------	------
Natural gas ... million cubic feet	18,916	4,350	20,790	4,449	27,697	5,844	28,987	6,174
Peat ... short tons	191,661	2,357	214,402	2,755	[8] 210,376	[8] 2,009	257,533	2,277
Petroleum (crude) ... thousand 42-gallon barrels	10,439	30,691	15,899	46,266	18,901	55,191	[6] 17,117	[6] 48,783
Salt ... thousand short tons	4,485	35,725	4,088	33,759	3,885	31,284	4,274	33,343
Sand and gravel ... do	48,052	41,193	46,910	39,304	54,603	47,790	47,563	42,029
Silver (recoverable content of ores, etc.) ... thousand troy ounces	------	------	------	------	------	------	401	436
Stone ... thousand short tons	30,095	30,379	31,256	32,274	28,731	30,103	28,440	29,055
Value of items that cannot be disclosed: Bromine, calcium-magnesium chloride, gem stones, iodine (1961–62), magnesium compounds, natural gas liquids, potassium salts, and values indicated by footnote 4	------	49,371	------	45,864	------	[8] 46,306	------	53,500
Total	------	[8] 388,545	------	[8] 437,598	------	[8] 450,652	------	446,520
MINNESOTA								
Clays ... thousand short tons	153	$267	[3] 125	[3] $163	[3] 176	[3] $241	203	$291
Iron ore (usable) ... thousand long tons, gross weight	36,109	306,920	54,723	470,874	44,699	407,152	44,295	385,997
Manganiferous ore (5 to 35 percent Mn) ... short tons, gross weight	429,102	(4)	441,028	(4)	181,835	(4)	292,779	(4)
Peat ... short tons	------	------	1,465	72	11,091	181	12,934	307
Sand and gravel ... thousand short tons	28,486	20,726	30,302	24,611	30,690	24,143	29,399	22,656
Stone ... do	3,639	9,461	4,234	10,034	3,957	9,975	3,803	10,360
Value of items that cannot be disclosed: Abrasive stones, cement, fire clay (1960–61), gem stones, lime, and values indicated by footnote 4	------	9,993	------	9,767	------	[8] 9,222	------	9,325
Total	------	[8] 347,367	------	[8] 515,521	------	[8] 450,914	------	428,936

MISSISSIPPI

Clays .... thousand short tons..	747	$4,064	1,017	$4,786	1,104	$5,034	1,129	$5,742
Natural gas .... million cubic feet..	162,095	25,125	172,478	32,426	172,543	32,093	170,271	32,351
Natural gas liquids:								
Natural gasoline and cycle products .... thousand gallons..	23,207	1,495	23,648	1,552	25,135	1,625	25,891	1,616
LP gases .... do......	8,141	465	10,151	564	15,510	700	20,401	732
Petroleum (crude) .... thousand 42-gallon barrels..	49,620	140,921	51,673	146,235	54,688	154,220	[6] 54,471	[6] 151,429
Sand and gravel .... thousand short tons..	7,520	7,743	6,181	5,568	5,920	5,903	7,001	7,262
Stone .... do....	[7] 126	[7] 114	807	808	913	1,044	1,199	1,266
Value of items that cannot be disclosed: Certain metals and nonmetals.....	....	6,751	....	7,271	....	[8] 7,961	....	9,030
Total	....	[8] 186,678	....	[8] 199,210	....	[8] 208,580	....	209,428

MISSOURI

Barite .... short tons..	296,093	$3,924	180,702	$2,588	227,323	$3,052	303,945	$3,994
Cement:								
Portland .... thousand 376-pound barrels..	13,947	46,974	12,183	42,330	11,839	41,142	12,739	44,004
Masonry .... thousand 280-pound barrels..					437	1,398	455	1,457
Clays .... thousand short tons..	2,635	6,898	2,540	7,207	2,132	5,040	2,053	5,033
Coal (bituminous) .... do....	2,748	11,937	2,890	12,450	2,938	12,567	2,896	12,057
Copper (recoverable content of ores, etc.) .... short tons..	1,065	654	1,087	698	1,479	887	2,752	1,695
Iron ore (usable) .... thousand long tons, gross weight..	349	3,278	365	3,760	341	3,633	346	3,188
Lead (recoverable content of ores, etc.) .... short tons..	105,165	24,188	111,948	26,196	98,785	20,350	60,982	11,221
Lime .... thousand short tons..	1,324	15,714	1,254	14,701	1,173	13,873	1,176	13,703
Natural gas .... million cubic feet..	....	....	75	19	90	22	92	23
Petroleum (crude) .... thousand 42-gallon barrels..	75	(4)	75	(4)	72	(4)	[6] 55	(4)
Sand and gravel .... thousand short tons..	10,279	11,406	10,207	11,601	9,371	10,688	10,304	11,572
Silver (recoverable content of ores, etc.) .... thousand troy ounces..	340	308	16	14	12	11	491	533
Stone .... thousand short tons..	26,939	36,435	27,180	37,878	25,631	36,577	28,876	44,006
Zinc (recoverable content of ores, etc.) .... short tons..	92	21	2,821	728	5,847	1,345	2,792	642
Value of items that cannot be disclosed: Native asphalt, cobalt (1959–61), gem stones, nickel (1959–61), and values indicated by footnote 4	....	2,288	....	2,074	....	[8] 703	....	179
Total	....	[8] 164,025	....	[8] 162,244	....	[8] 151,288	....	153,307

See footnotes at end of table.

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

Mineral	1959		1960		1961		1962	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
MONTANA								
Chromite ... short tons, gross weight	[14] 105,000	[14] $3,765	[14] 107,000	[14] $3,813	[14] 82,000	[14] $2,939	----	----
Clays [3] ... thousand short tons	46	48	63	77	55	76	56	$77
Coal (bituminous and lignite) ... do	345	1,478	313	1,188	371	1,207	382	1,140
Copper (recoverable content of ores, etc.) ... short tons	65,911	40,469	91,972	59,046	104,000	62,400	94,021	57,917
Fluorspar ... do	18,542	(4)	31,273	(4)	14,905	(4)	(4)	(4)
Gold (recoverable content of ores, etc.) ... troy ounces	28,551	999	45,922	1,607	35,377	1,238	24,387	854
Iron ore (usable) ... thousand long tons, gross weight	50	254	55	293	34	209	9	62
Lead (recoverable content of ores, etc.) ... short tons	7,672	1,765	4,879	1,142	2,643	544	6,121	1,126
Lime ... thousand short tons	(4)	(4)	(4)	(4)	118	986	104	1,049
Manganese ore (35 percent or more Mn) ... short tons, gross weight	21,604	1,520	29,036	1,996	17,515	[8] 1,372	24,758	(4)
Manganiferous ore (5 to 35 percent Mn) ... do	2,415	34	676	11	2,236	33	2,264	29
Natural gas ... million cubic feet	30,743	2,306	33,418	2,373	33,901	2,509	29,955	2,217
Peat ... short tons	----	----	----	----	7,385	112	(4)	(4)
Petroleum (crude) ... thousand 42-gallon barrels	29,857	76,434	30,240	72,878	30,906	74,793	[6] 31,648	[6] 76,690
Sand and gravel ... thousand short tons	10,930	12,587	12,589	11,657	14,702	13,506	18,473	17,642
Silver (recoverable content of ores, etc.) ... thousand troy ounces	3,420	3,096	3,607	3,265	3,490	3,227	4,561	4,948
Stone ... thousand short tons	1,186	1,691	1,183	1,576	1,512	1,849	996	1,708
Uranium ore ... short tons	2,890	(4)	1,726	29	729	10	(4)	(4)
Zinc (recoverable content of ores, etc.) ... do	27,848	6,405	12,551	3,238	10,262	2,360	37,678	8,666
Value of items that cannot be disclosed: Barite, cement, chromite,[14] clays (bentonite 1959, fire clay), gem stones, gypsum, sheet mica, natural gas liquids, pyrites (1959), phosphate rock, rare-earth metal concentrates (1959, 1962), talc, tungsten (1960–62), vermiculite, and values indicated by footnote 4	----	15,248	----	15,217	----	[8] 14,863	----	16,531
Total	----	[8] 168,099	----	[8] 179,406	----	[8] 184,233	----	190,656

NEBRASKA

Clays ......thousand short tons..	131	$133	108	$109	146	$148	142	$142
Gem stones	([10])	3	([10])	4	([10])	5	([10])	5
Natural gas ......million cubic feet..	13,128	2,087	15,258	2,670	15,743	2,629	14,880	2,708
Natural gas liquids:								
Natural gasoline ......thousand gallons..	([4])	([4])	([4])	([4])	([4])	([4])	12,239	809
LP gases ......do....	([4])	([4])	([4])	([4])	([4])	([4])	28,718	1,329
Petroleum (crude) ......thousand 42-gallon barrels..	22,881	65,897	23,825	68,378	24,369	69,452	[6] 24,850	[6] 70,326
Sand and gravel ......thousand short tons..	11,202	8,301	10,876	8,746	10,094	8,250	12,853	9,797
Stone ......do....	3,236	5,235	3,336	5,651	3,622	6,324	3,670	6,626
Value of items that cannot be disclosed: Cement, lime (1961-62), pumice, and values indicated by footnote 4	....	17,679	....	18,384	....	18,637	....	16,507
Total	....	[8] 99,335	....	[8] 103,942	....	[8] 105,445	....	108,249

NEVADA

Antimony ore and concentrate ......short tons, antimony content..	10	$2	....	....	....	....	....	....
Barite ......short tons..	91,298	623	86,061	$591	129,524	$863	137,727	$954
Copper (recoverable content of ores, etc.) ......do....	57.375	35,228	77,485	49,745	78.022	46,813	82,602	50,883
Fluorspar ......do....	16,743	407	18,505	388	18.129	357	([4])	([4])
Gem stones	([10])	100	([10])	100	([10])	100	([10])	100
Gold (recoverable content of ores, etc.) ......troy ounces..	113,443	3,971	58,187	2,037	54,165	1,896	62,863	2,200
Gypsum ......thousand short tons..	818	2,738	802	2,721	729	2,625	817	2,952
Iron ore (usable) ......thousand long tons, gross weight..	698	3,712	740	3,683	845	4,608	617	3,238
Lead (recoverable content of ores, etc.) ......short tons..	1,357	312	987	231	1,791	369	771	142
Manganese ore (35 percent or more Mn) ......short tons, gross weight..	56,611	3,918	49.076	3,301	28,573	1,852	....	....
Manganiferous ore (5 to 35 percent Mn) ......do....	200	([4])	([4])	([4])	....	....	....	....
Mercury ......76-pound flasks..	7,156	1,628	7,821	1,648	7,486	1,480	6,573	1,257
Perlite ......short tons..	([4])	([4])	35,214	286	29,544	240	25,067	205
Petroleum (crude) ......thousand 42-gallon barrels..	32	([4])	27	([4])	154	([4])	137	([4])
Sand and gravel ......thousand short tons..	6,436	7,522	4,085	5,224	7,095	7,443	7,850	9,655
Silver (recoverable content of ores, etc.) ......thousand troy ounces..	611	553	707	640	388	359	245	266
Stone ......thousand short tons..	840	1,587	579	1,350	677	1,576	722	1,220
Talc and soapstone ......short tons..	5,824	50	4,882	30	3,090	33	6,157	55
Tungsten ore and concentrate ......short tons, 60-percent WO_3 basis..	([4])	([4])	([4])	([4])	([4])	([4])	156	234
Zinc (recoverable content of ores, etc.) ......short tons..	217	50	420	108	453	104	281	65
Value of items that cannot be disclosed: Brucite (1959), clays, diatomite, lime, magnesite, molybdenum, pumice, salt, sulfur ore, uranium ore (1959-61), and values indicated by footnote 4	....	8,458	....	8,809	....	[8] 10,815	....	10,307
Total	....	[8] 70,859	....	[8] 80,892	....	[8] 81,533	....	83,733

See footnotes at end of table.

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

Mineral	1959 Quantity	1959 Value (thousands)	1960 Quantity	1960 Value (thousands)	1961 Quantity	1961 Value (thousands)	1962 Quantity	1962 Value (thousands)
NEW HAMPSHIRE								
Beryllium concentrate……short tons, gross weight	20	$12	14	$8	23	$14	7	$4
Clays……thousand short tons	26	26	27	27	30	30	37	37
Feldspar……long tons	(4)	(4)	(4)	(4)	10,290	62	(4)	(4)
Gem stones	(10)	10	(10)	15	(10)	(4)	(10)	(4)
Mica:								
Sheet……pounds	119,163	1,133	[8] 80,077	[8] 1,026	[8] 105,943	[8] 1,009	35,450	374
Scrap……short tons	(4)	(4)	415	14	669	20	411	11
Peat……do	25	(4)	23	(4)	15	(4)	----------	----------
Sand and gravel……thousand short tons	5,124	2,887	6,621	3,687	7,701	3,627	8,260	4,119
Stone……do	82	488	104	594	117	684	154	1,368
Value of items that cannot be disclosed: Values indicated by footnote 4	----------	166	----------	68	----------	20	----------	97
Total	----------	4,722	----------	[8] 5,439	----------	[8] 5,466	----------	6,010
NEW JERSEY								
Clays……thousand short tons	700	$1,895	664	$1,597	657	$1,681	584	$1,476
Gem stones	(10)	6	(10)	7	(10)	9	(10)	9
Peat……short tons	28,300	278	25,100	192	21,257	212	26,066	247
Sand and gravel……thousand short tons	11,033	18,620	11,594	19,511	12,257	20,895	13,728	21,230
Stone……do	10,079	22,133	10,202	22,814	11,315	24,539	14,214	28,979
Zinc (recoverable content of ores, etc.)[15]……short tons	----------	----------	----------	----------	112	26	15,309	3,559
Value of items that cannot be disclosed: Iron ore, lime, magnesium compounds, manganiferous residuum, greensand marl, titanium concentrate (ilmenite 1962) and uranium ore (1960)	----------	[8] 16,612	----------	[8] 12,348	----------	[8] 11,908	----------	10,186
Total	----------	[8] 59.544	----------	[8] 56,469	----------	[8] 59,270	----------	65,686

NEW MEXICO

Barite ... short tons	320	$6	492	$10	600	$10	252	$4
Beryllium concentrate ... short tons, gross weight	11	6	-----	-----	24	12	34	19
Carbon dioxide, natural ... thousand cubic feet	(4)	(4)	230,115	(4)	242,903	24	826,810	74
Clays ... thousand short tons	[3] 45	[3] 77	[3] 56	[3] 132	[3] 67	[3] 165	52	156
Coal (bituminous) ... do	149	837	295	1,747	412	2,477	677	2,595
Copper (recoverable content of ores, etc.) ... short tons	39,688	24,369	67,288	43,199	79,606	47,764	82,683	50,933
Fluorspar ... do	200	7	-----	-----	-----	-----	-----	-----
Gem stones	(10)	39	(10)	40	(10)	46	(10)	45
Gold (recoverable content of ores, etc.) ... troy ounces	3,155	110	5,423	190	6,201	217	7,529	264
Gypsum ... thousand short tons	-----	-----	55	193	105	386	151	564
Helium ... thousand cubic feet	16,903	264	43,494	684	42,224	762	27,377	958
Iron ore (usable) ... thousand long tons, gross weight	(16)	(4)	1	27	(16)	(4)	9	121
Lead (recoverable content of ores, etc.) ... short tons	829	191	1,996	467	2,332	480	1,134	209
Lime ... thousand short tons	16	209	36	496	25	350	29	403
Manganese ore (35 percent or more Mn) ... short tons, gross weight	27,528	2,248	-----	-----	-----	-----	(4)	(4)
Mica:								
Scrap ... short tons	210	7	235	7	1,800	52	5,731	140
Sheet ... pounds	247	2	(4)	(4)	-----	-----	(4)	(4)
Natural gas ... million cubic feet	739,660	73,966	798,928	85,485	789,662	86,073	804,612	92,530
Natural gas liquids:								
Natural gasoline and cycle products ... thousand gallons	264,133	16,859	321,667	20,412	301,404	18,619	273,969	16,775
LP gases ... do	552,257	22,320	645,116	28,788	656,751	24,154	661,330	20,359
Perlite ... short tons	240,642	2,121	240,593	2,119	245,654	2,159	258,164	2,143
Petroleum (crude) ... thousand 42-gallon barrels	105,692	301,394	107,380	305,895	112,553	322,142	[6] 108,708	[6] 313,133
Potassium salts ... thousand short tons, K_2O equivalent	2,189	74,117	2,440	82,645	2,523	96,380	2,208	85,124
Pumice ... thousand short tons	493	1,023	365	827	339	879	308	741
Salt ... do	36	322	39	331	33	284	43	334
Sand and gravel ... do	12,460	13,332	7,419	7,459	12,523	10,049	6,889	8,021
Silver (recoverable content of ores, etc.) ... thousand troy ounces	159	144	304	275	283	261	302	327
Stone ... thousand short tons	461	542	1,277	1,692	1,853	2,206	2,004	2,782
Uranium ore ... short tons	3,269,826	53,463	3,793,494	61,827	3,631,036	62,482	3,478,238	63,504
Zinc (recoverable content of ores, etc.) ... do	4,636	1,066	13,770	3,553	22,900	5,267	22,015	5,063
Value of items that cannot be disclosed: Cement (1960–62), fire clay (1959–61), molybdenum, magnesium compounds (1959–61), manganiferous ore, vanadium, and values indicated by footnote 4	-----	3,771	-----	5,266	-----	[8] 7,213	-----	6,743
Total	-----	[8] 592,812	-----	[8] 653,766	-----	[8] 690,913	-----	674,064

See footnotes at end of table.

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

Mineral	1959		1960		1961		1962	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
NEW YORK								
Clays ... thousand short tons	1,309	$1,714	1,172	$1,717	1,037	$1,373	1,397	$1,618
Emery ... short tons	8,555	150	8,169	142	6,180	106	4,316	71
Gem stones	(10)	8	(10)	9	(10)	10	(10)	10
Gypsum ... thousand short tons	919	4,663	755	3,928	663	3,441	601	3,122
Iron ore (usable) ... thousand long tons, gross weight	2,044	28,050	2,484	32,977	1,973	25,548	2,099	24,953
Lead (recoverable content of ores, etc.) ... short tons	481	111	775	181	879	181	1,063	196
Natural gas ... million cubic feet	2,915	889	4,990	1,542	5,742	1,694	4,262	1,198
Peat ... short tons	12,875	138	10,042	146	11,209	123	16,200	113
Petroleum (crude) ... thousand 42-gallon barrels	1,970	8,353	1,813	8,412	1,658	7,892	[6] 1,789	[6] 8,229
Salt ... thousand short tons	4,011	30,958	4,008	30,763	4,149	30,761	4,456	32,236
Sand and gravel ... do	27,943	31,415	30,687	35,152	28,043	30,471	29,447	31,346
Silver (recoverable content of ores, etc.) ... thousand troy ounces	52	47	49	45	41	37	19	21
Stone ... thousand short tons	28,640	46,556	29,802	46,955	26,951	43,734	27,589	47,256
Zinc (recoverable content of ores, etc.) ... short tons	43,464	9,997	66,364	17,122	54,763	12,595	53,654	12,340
Value of items that cannot be disclosed: Beryllium concentrate (1960–61), cement, abrasive garnet, lime, talc, titanium concentrate, and wollastonite	------------	76,904	------------	81,831	------------	[8] 75,867	------------	79,183
Total	------------	[8] 239,953	------------	[8] 260,922	------------	[8] 233,833	------------	241,892

NORTH CAROLINA

Abrasive stones ... short tons	[17] 191	[17] $5	([10])	[18] $2	([10])	[18] $3	([10])	[18] $2
Clays [3] ... thousand short tons	2,524	1,522	2,476	1,548	2,603	1,669	2,731	1,782
Feldspar ... long tons	([4])	([4])	270,761	2,781	251,858	2,477	244,708	2,373
Gem stones	([10])	9	([10])	4	([10])	6	([10])	2
Gold (recoverable content of ores, etc.) ... troy ounces	965	34	1,826	64	2,094	73	460	16
Iron ore (usable) ... thousand long tons	([4])	([4])	([4])	([4])	([4])	1	1	13
Lead (recoverable content of ores, etc.) ... short tons	-----	-----	424	99	318	66	219	40
Mica:								
Scrap ... do	47,736	1,212	47,281	1,100	53,615	1,010	61,983	1,384
Sheet ... pounds	505,623	1,755	[8] 436,579	1,539	390,870	2,237	320,305	867
Sand and gravel ... thousand short tons	8,580	7,426	8,801	7,453	9,779	8,467	12,516	11,457
Silver (recoverable content of ores, etc.) ... thousand troy ounces	16	15	212	192	170	157	100	109
Stone ... thousand short tons	12,859	20,302	14,721	23,296	15,921	25,262	19,308	29,533
Talc and pyrophyllite ... short tons	127,296	647	100,593	549	90,711	367	100,298	433
Value of items that cannot be disclosed: Abrasive stone (millstones 1959), asbestos, barite (1961), clay (kaolin), copper, lithium minerals, olivine, tungsten concentrate, and values indicated by footnote 4	-----	7,862	-----	6,469	-----	8,329	-----	6,586
Total	-----	40,789	-----	45,096	-----	50,124	-----	54,597

NORTH DAKOTA

Clays ... thousand short tons	[3] 61	[3] $79	[3] 102	[3] $129	([4])	([4])	98	$124
Coal (lignite) ... do	2,413	5,426	2,525	5,790	2,726	$6,141	2,733	6,135
Gem stones	([10])	1	([10])	1	([10])	1	([10])	1
Natural gas ... million cubic feet	17,915	1,774	19,483	2,221	20,100	2,533	25,155	3,446
Natural gas liquids:								
Natural gasoline ... thousand gallons	([4])	([4])	([4])	([4])	([4])	([4])	16,872	1,085
LP gases ... do	([4])	([4])	([4])	([4])	([4])	([4])	68,881	2,665
Petroleum (crude) ... thousand 42-gallon barrels	17,824	49,907	21,992	59,598	23,652	64,333	[6] 25,164	[6] 69,201
Sand and gravel ... thousand short tons	9,883	6,516	8,648	6,904	9,395	7,507	9,615	7,122
Stone ... do	48	84	28	44	40	40	19	19
Value of items that cannot be disclosed: Clays (bentonite 1959-60, fire clay 1960), salt (1960-62), uranium ore (1962), and values indicated by footnote 4	-----	3,555	-----	3,691	-----	4,370	-----	774
Total	-----	67,342	-----	78,378	-----	[8] 84,925	-----	90,572

See footnotes at end of table.

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

Mineral	1959 Quantity	1959 Value (thousands)	1960 Quantity	1960 Value (thousands)	1961 Quantity	1961 Value (thousands)	1962 Quantity	1962 Value (thousands)
OHIO								
Abrasive stones, grindstones and pulpstones……short tons	1,081	$101	(4)	(4)	(4)	(4)	(4)	(4)
Cement:								
Portland……thousand 376-pound barrels	18,994	63,935	17,480	$61,478	15,303	$53,251	15,353	$51,006
Masonry……thousand 280-pound barrels					846	2,604	946	2,793
Clays……thousand short tons	5,478	15,346	5,165	14,325	4,923	13,790	4,751	12,979
Coal (bituminous)……do	35,112	135,729	33,957	130,877	32,226	121,343	34,125	127,051
Gem stones	(10)	2	(10)	3	(10)	4	(10)	3
Lime……thousand short tons	3,190	45,121	3,117	44,403	[8] 3,048	[8] 41,266	3,102	43,792
Natural gas……million cubic feet	34,664	8,042	36,074	8,477	36,423	9,069	36,747	9,407
Peat……short tons	5,813	73	6,755	93	9,113	123	7,783	106
Petroleum (crude)……thousand 42-gallon barrels	5,978	17,157	5,405	16,053	5,639	17,425	[6] 5,066	[6] 15,705
Salt……thousand short tons	2,858	20,486	3,108	24,149	3,465	25,037	4,187	28,706
Sand and gravel……do	38,604	45,139	37,943	44,979	33,688	41,272	35,204	43,333
Stone……do	[7] 36,155	[7] 59,326	[7] 35,856	[7] 59,479	33,652	55,701	34,470	57,202
Value of items that cannot be disclosed: Gypsum, stone (dimension limestone 1960, calcareous marl 1959–60), and values indicated by footnote 4		2,027		1,826		1,566		1,588
Total		[8] 412,484		[8] 406,142		[8] 382,451		393,671

OKLAHOMA

Clays[3] ... thousand short tons	966	$970	734	$739	792	$801	737	$756
Coal (bituminous) ... do	1,525	10,272	1,342	9,113	1,032	6,784	1,048	6,978
Gypsum ... do	(4)	(4)	(4)	(4)	(4)	(4)	509	1,668
Helium ... thousand cubic feet	98,749	1,619	289,068	4,691	313,244	5,872	284,214	9,917
Lead (recoverable content of ores, etc.) ... short tons	601	138	936	219	980	202	2,710	499
Natural gas ... million cubic feet	811,508	81,151	824,266	98,088	892,697	108,016	1,060,717	135,772
Natural gas liquids:								
Natural gasoline and cycle products ... thousand gallons	448,353	29,443	531,995	33,074	521,237	33,358	552,795	35,764
LP gases ... do	675,869	27,070	762,258	32,409	817,082	30,141	838,903	25,223
Petroleum (crude) ... thousand 42-gallon barrels	198,090	578,423	192,913	563,306	193,081	561,866	[6] 198,616	[6] 579,959
Salt ... thousand short tons	(4)	(4)	3	16	3	19	5	25
Sand and gravel ... do	6,002	5,927	6,424	7,468	5,310	5,513	4,436	4,736
Stone ... do	12,683	14,980	[7] 14,054	[7] 16,098	14,981	16,561	14,666	18,819
Zinc (recoverable content of ores, etc.) ... short tons	1,049	241	2,332	602	3,148	724	10,013	2,303
Value of items that cnnot be disclosed: Native asphalt (1959–60), clay (bentonite), cement, gem stones, lime, pumice, stone (crushed granite 1960), tripoli, and values indicated by footnote 4	...	18,156	...	16,756	...	21,920	...	20,853
Total	...	[8] 768,390	...	[8] 782,579	...	[8] 791,777	...	843,272

OREGON

Clays ... thousand short tons	294	$308	318	$370	294	$357	249	$305
Copper (recoverable content of ores, etc.) ... short tons	...	...	6	4	(4)	(4)	(4)	(4)
Gold (recoverable content of ores, etc.) ... troy ounces	686	24	835	29	1,054	37	822	29
Lime ... thousand short tons	...	...	(4)	(4)	[8] 82	[8] 1,702	78	1,514
Mercury ... 76-pound flasks	1,224	278	513	108	138	27	(4)	(4)
Nickel (content of ore and concentrate) ... short tons	12,374	(4)	13,115	5,246	12,860	(4)	13,110	(4)
Perlite ... do	...	...	...	...	...	...	3	(5)
Pumice ... thousand short tons	(4)	(4)	(4)	(4)	203	461	(4)	(4)
Sand and gravel ... do	18,087	15,506	17,673	16,170	12,299	13,680	14,869	14,556
Silver (recoverable content of ores, etc.) ... thousand troy ounces	(19)	(5)	(19)	(5)	2	2	6	7
Stone ... thousand short tons	13,341	16,126	16,913	19,721	[8] 17,455	[8] 21,202	18,258	20,977
Uranium ore ... short tons	...	...	(4)	(4)	2,160	66	2,722	112
Zinc (recoverable content of ores, etc.) ... do	...	...	...	...	3	1	...	...
Value of items that cannot be disclosed: Asbestos (1959–61), carbon dioxide (1959–60), cement, diatomite, gem stones, iron ore (pigment material 1959, 1961), lead (1961), and values indicated by footnote 4	...	18,607	...	14,124	...	15,557	...	14,956
Total	...	[8] 50,849	...	[8] 55,772	...	[8] 53,092	...	52,458

See footnotes at end of table.

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

Mineral	1959		1960		1961		1962	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
PENNSYLVANIA								
Cement:								
Portland....thousand 376-pound barrels..	43,356	$150,918	38,320	$131,763	36,635	$124,506	38,463	$127,969
Masonry....thousand 280-pound barrels..					2,678	7,232	2,565	7,105
Clays....thousand short tons..	3,466	17,196	[3] 3,557	[3] 16,536	[3] 2,999	[3] 14,402	[3] 2,893	[3] 12,815
Coal:								
Anthracite....do....	20,649	172,320	18,817	147,116	17,446	140,338	16,894	134,094
Bituminous....do....	65,347	345,332	65,425	345,971	62,652	323,758	65,315	331,298
Cobalt (content of concentrate)....thousand pounds..	280	(4)	(4)	(4)	(4)	(4)	(4)	(4)
Gem stones....	(10)	3	(10)	4	(10)	5	(10)	4
Lime....thousand short tons..	1,263	18,261	1,120	16,277	[8] 1,093	[8] 16,428	1,104	16,647
Natural gas....million cubic feet..	99,366	29,015	113,928	36,229	100,427	29,526	90,053	24,494
Natural gas liquids:								
Natural gasoline....thousand gallons..	2,884	184	1,399	85	1,272	74	1,350	75
LP gases....do....	1,484	36	1,580	138	1,453	115	1,521	112
Peat....short tons..	26,948	262	30,837	325	27,993	291	32,936	369
Petroleum (crude)....thousand 42-gallon barrels..	6,160	25,872	6,009	27,341	5,643	26,579	[6] 5,225	[6] 23,878
Sand and gravel....thousand short tons..	14,257	23,233	13,011	21,204	12,594	19,766	14,419	23,587
Stone....do....	43,682	77,421	42,136	74,168	41,834	71,344	48,144	82,087
Zinc (recoverable content of ores, etc.)[15]....short tons..	16,718	3,828	13,746	3,559	23,428	5,408	24,308	5,652
Value of items that cannot be disclosed: Clays (kaolin 1960–62), copper, gold, graphite (1959–61), iron ore, scrap mica, pyrites, pyrophyllite and soapstone, silver, tripoli, and values indicated by footnote 4....	....	15,812	....	17,430	....	25,355	....	32,966
Total....	....	[8] 879,693	....	[8] 838,146	....	[9] 805,127	....	823,152
RHODE ISLAND								
Sand and gravel....thousand short tons..	1,740	$1,588	1,535	$1,355	1,726	$1,666	2,346	$1,890
Stone....do....	(4)	(4)	1,810	4,372	(4)	(4)	[7] 304	[7] 483
Value of items that cannot be disclosed: Nonmetals and values indicated by footnote 4....	....	745	....	....	....	1,413	....	621
Total....	....	2,333	....	5,727	....	3,079	....	2,994

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SOUTH CAROLINA

Clays ... thousand short tons	1,160	$5,920	1,297	$6,201	1,346	$6,169	1,518	$7,165
Mica (sheet) ... pounds	251	3	101	1	12	([5])	----	----
Peat ... short tons	4,194	([4])	([4])	([4])	([4])	([4])	([4])	([4])
Sand and gravel ... thousand short tons	3,104	3,077	3,029	3,048	2,904	3,067	3,318	3,670
Stone ... do	[7] 6,248	[7] 8,647	7,327	10,593	6,752	9,827	6,382	10,066
Value of items that cannot be disclosed: Barite, cement, feldspar, gem stones (1962), kyanite, scrap mica, pyrites (1960-62), stone (crushed limestone 1959, crushed sandstone 1959, calcareous marl 1959), vermiculite, and values indicated by footnote 4	----	13,640	----	11,144	----	12,311	----	13,000
Total	----	[8] 31,287	----	[8] 30,987	----	[8] 31,374	----	33,901

SOUTH DAKOTA

Beryllium concentrate ... short tons, gross weight	156	$84	167	$88	238	$130	144	$77
Cement:								
Portland ... thousand 376-pound barrels	([4])	([4])	([4])	([4])	([4])	([4])	2,316	7,369
Masonry ... thousand 280-pound barrels	([4])	([4])	([4])	([4])	([4])	([4])	60	197
Clays ... thousand short tons	[3] 227	[3] 227	[3] 202	[3] 202	[3] 249	[3] 249	249	690
Coal (lignite) ... do	22	88	20	83	18	75	18	77
Copper (recoverable content of ores, etc.) ... short tons	----	----	1	1	----	----	----	----
Feldspar ... long tons	30,825	196	45,588	292	29,354	186	29,697	191
Gem stones	([10])	20	([10])	20	([10])	18	([10])	20
Gold (recoverable content of ores, etc.) ... troy ounces	577,730	20,221	554,771	19,417	557,855	19,525	577,232	20,203
Gypsum ... thousand short tons	19	78	22	89	22	89	23	93
Iron ore (usable) ... thousand long tons	----	----	([4])	([4])	22	100	34	113
Lead (recoverable content of ores, etc.) ... short tons	----	----	----	----	----	----	3	1
Mica:								
Scrap ... short tons	158	5	205	10	1,054	32	210	6
Sheet ... pounds	38,775	158	30,887	145	18,086	37	2,085	12
Petroleum (crude) ... thousand 42-gallon barrels	151	([4])	281	([4])	233	([4])	[6] 170	([4])
Sand and gravel ... thousand short tons	17,775	11,058	13,548	9,359	11,324	7,336	15,371	9,207
Silver (recoverable content of ores, etc.) ... thousand troy ounces	124	113	108	98	127	118	113	123
Stone ... thousand short tons	2,721	7,243	3,149	7,909	2,806	6,642	2,852	6,533
Uranium ore ... short tons	45,734	606	41,104	586	43,588	495	29,452	370
Value of items that cannot be disclosed: Clays (bentonite), lime, lithium minerals (1959-60, 1962), vanadium (1960-62), and values indicated by footnote 4	----	9,401	----	9,376	----	[8] 8,975	----	507
Total	----	[8] 49,498	----	[8] 47,675	----	[8] 44,007	----	45,789

See footnotes at end of table.

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

Mineral	1959 Quantity	1959 Value (thousands)	1960 Quantity	1960 Value (thousands)	1961 Quantity	1961 Value (thousands)	1962 Quantity	1962 Value (thousands)
TENNESSEE								
Barite ... short tons	(4)	(4)	(4)	(4)	(4)	(4)	13,797	$229
Cement:								
Portland ... thousand 376-pound barrels	9,153	$28,934	8,246	$27,384	8,357	$26,964	8,509	27,741
Masonry ... thousand 280-pound barrels					1,018	2,753	1,089	2,931
Clays ... thousand short tons	1,146	4,952	1,270	4,537	[3] 1,040	[3] 4,190	[3] 1,037	[3] 4,597
Coal (bituminous) ... do	5,913	23,581	5,930	21,154	5,860	20,681	6,214	22,555
Copper (recoverable content of ores, etc.) ... short tons	11,490	7,055	12,723	8,168	12,272	7,363	14,298	8,808
Gem stones	(10)	(5)	(10)	1	(10)	1	(10)	1
Gold (recoverable content of ores, etc.) ... troy ounces	99	3	123	4	152	5	158	6
Iron ore (usable) ... thousand long tons, gross weight	21	111	(4)	(4)	(4)	(4)	(4)	(4)
Lead (recoverable content of ores, etc.) ... short tons	----------	----------	----------	----------	----------	----------	51	9
Manganese ore (35 percent or more Mn) ... short tons, gross weight	7,586	589	283	15	----------	----------	----------	----------
Manganiferous ore (5 to 35 percent Mn) ... do	56	1	(4)	(4)	----------	----------	----------	----------
Natural gas ... million cubic feet	52	9	63	11	71	13	75	14
Petroleum (crude) ... thousand 42-gallon barrels	6	(4)	20	(4)	17	(4)	[6] 18	(4)
Phosphate rock ... thousand long tons	1,755	13,255	1,939	15,424	2,235	18,675	2,418	19,868
Sand and gravel ... thousand short tons	6,221	7,570	6,293	7,655	6,232	8,046	6,075	8,018
Silver (recoverable content of ores, etc.) ... thousand troy ounces	60	54	65	58	83	77	112	122
Stone ... thousand short tons	18,767	29,094	20,074	29,942	23,940	35,906	24,398	35,614
Zinc (recoverable content of ores, etc.) ... short tons	89,932	20,684	91,394	23,579	81,734	18,799	71,548	16,456
Value of items that cannot be disclosed: Clay (fuller's earth 1961–62), lime, scrap mica (1959–60), pyrites, and values indicated by footnote 4	----------	7,392	----------	7,606	----------	[8] 7,238	----------	7,061
Total	----------	[8] 143,284	----------	[8] 145,538	----------	[8] 150,711	----------	154,030

Cement:								
Portland ... thousand 376-pound barrels	27,991	$88,067	23,365	$76,577	25,101	$80,808	26,204	$83,162
Masonry ... thousand 280-pound barrels					851	2,529	926	2,774
Clays [3] ... thousand short tons	3,870	5,703	3,302	5,058	3,786	5,737	3,744	5,634
Gem stones	([10])	100	([10])	100	([10])	150	([10])	150
Gypsum ... thousand short tons	1,351	4,770	1,131	3,960	1,074	[8] 3,832	1,120	3,956
Helium ... thousand cubic feet	238,113	3,918	120,921	2,044	173,066	3,196	245,623	8,552
Lime ... thousand short tons	809	8,530	821	9,087	[8] 790	[8] 8,703	1,047	11,999
Natural gas ... million cubic feet	5,718,993	617,651	5,892,704	665,876	5,963,605	733,523	6,080,210	747,866
Natural gas liquids:								
Natural gasoline and cycle products ... thousand gallons	2,790,155	209,238	2,880,906	207,583	3,111,427	214,279	3,205,517	233,345
LP gases ... do	4,353,368	181,148	4,476,142	200,478	4,768,222	185,558	5,012,291	189,382
Petroleum (crude) ... thousand 42-gallon barrels	971,978	2,893,146	927,479	2,748,735	939,191	2,791,377	[6] 936,508	[6] 2,796,136
Salt ... thousand short tons	4,519	17,498	4,756	18,222	4,695	17,682	5,553	19,485
Sand and gravel ... do	35,295	34,726	29,844	30,754	27,398	30,691	30,076	33,097
Stone ... do	42,172	47,787	39,029	45,088	38,316	45,874	38,067	48,988
Sulfur (Frasch process) ... thousand long tons	2,970	68,998	2,747	62,855	2,730	62,720	2,655	57,297
Talc and soapstone ... short tons	60,945	283	67,031	336	78,214	376	73,635	387
Value of items that cannot be disclosed: Abrasive stones (1959), native asphalt, barite (1961-62), bromine, clay (fuller's earth), coal (lignite), feldspar (1959-61), graphite, iron ore, magnesium chloride (for metal), magnesium compounds (except for metal), mercury (1959-60), pumice (1961-62), sodium sulfate, and uranium ore	----------	48,544	----------	49,666	----------	50,923	----------	58,774
Total	----------	[8] 4,230,107	----------	[8] 4,126,419	----------	[8] 4,237,958	----------	4,300,984

See footnotes at end of table.

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

Mineral	1959 Quantity	1959 Value (thousands)	1960 Quantity	1960 Value (thousands)	1961 Quantity	1961 Value (thousands)	1962 Quantity	1962 Value (thousands)
UTAH								
Asphalt and related bitumens, native: Gilsonite ......short tons..	379,362	$9,385	383,037	$10,020	(4)	(4)	(4)	(4)
Carbon dioxide, natural ......thousand cubic feet..	69,625	5	60,425	4	78,136	$5	81,920	$6
Clays ......thousand short tons..	[3] 185	[3] 484	[3] 143	[3] 416	143	1,080	174	1,403
Coal (bituminous) ......do....	4,545	27,982	4,955	31,458	5,159	31,126	4,297	23,209
Copper (recoverable content of ores, etc.) ......short tons..	144,715	88,855	218,049	139,987	213,534	128,120	218,018	134,269
Fluorspar ......do....	(4)	(4)	1,912	51	610	18	399	12
Gem stones	(10)	134	(10)	72	(10)	73	(10)	75
Gold (recoverable content of ores, etc.) ......troy ounces..	239,517	8,383	368,255	12,889	342,988	12,005	311,924	10,917
Iron ore (usable) ......thousand long tons, gross weight..	2,842	19,979	3,334	23,862	3,533	25,493	2,630	18,242
Lead (recoverable content of ores, etc.) ......short tons..	36,630	8,425	39,398	9,219	40,894	8,424	38,199	7,029
Lime ......thousand short tons..	90	1,773	127	2,672	142	2,626	163	2,759
Manganese ore (35 percent or more Mn) ......short tons, gross weight..	1,511	124	----------	----------	----------	----------	----------	----------
Natural gas ......million cubic feet..	38,921	5,527	51,040	9,187	57,175	8,976	74,128	12,454
Perlite ......short tons..	(4)	(4)	(4)	(4)	(4)	(4)	929	3
Petroleum (crude) ......thousand 42-gallon barrels..	39,959	114,283	37,594	103,008	33,118	91,075	[6] 30,964	[6] 84,841
Pumice ......thousand short tons..	39	81	60	134	60	95	28	46
Salt ......do....	209	2,453	231	3,092	249	3,187	311	3,349
Sand and gravel ......do....	8,843	6,436	6,848	6,182	[8] 18,325	[8] 16,979	19,941	20,954
Silver (recoverable content of ores, etc.) ......thousand troy ounces..	3,734	3,380	4,783	4,329	4,798	4,435	4,628	5,022
Stone ......thousand short tons..	3,338	4,048	1,837	3,087	1,808	3,219	2,118	3,865
Uranium ore ......short tons..	1,210,654	37,310	1,089,757	27,843	1,098,783	25,734	781,955	23,653
Vanadium (recoverable in ore and concentrate) ......do....	536	(4)	462	(4)	514	(4)	525	(4)
Zinc (recoverable content of ores, etc.) ......do....	35,223	8,101	35,476	9,153	37,239	8,565	34,313	7,892
Value of items that cannot be disclosed: Barite, cement, clay (kaolin 1959-60), gypsum, molybdenum, natural gas liquids, phosphate rock, potassium salts, pyrites (1959-60), and values indicated by footnote 4......	----------	27,396	----------	36,047	----------	45,554	----------	50,382
Total	----------	[8] 374,544	----------	[8] 432,712	----------	[8] 416,789	----------	410,412
VERMONT								
Gem stones	(10)	$1	(10)	$1	(10)	$2	(10)	$2
Sand and gravel ......thousand short tons..	2,320	1,590	1,809	1,218	2,232	1,567	1,430	1,076
Stone ......do....	944	17,372	2,114	17,444	2,731	18,715	1,715	19,815
Value of items that cannot be disclosed: Asbestos, clays, lime, and talc......	----------	4,420	----------	4,240	----------	4,012	----------	4,237
Total	----------	[8] 23,383	----------	[8] 22,903	----------	[8] 24,296	----------	25,130

VIRGINIA

Aplite ... long tons	(4)	(4)	(4)	(4)	97,465	$651	125,156	$912
Clays ... thousand short tons	1,346	$1,396	1,348	$1,395	1,406	1,332	1,464	1,444
Coal (bituminous) ... do	29,769	139,224	27,838	122,723	30,332	126,121	29,474	117,560
Gem stones	(10)	4	(10)	5	(10)	6	(10)	6
Lead (recoverable content of ores, etc.) ... short tons	2,770	637	2,152	504	3,733	769	4,059	747
Lime ... thousand short tons	765	8,168	711	8,028	[8] 657	[8] 7,375	615	7,668
Manganese ore (35 percent or more Mn) ... short tons, gross weight	6,232	499	----	----	----	----	----	----
Mica, sheet ... pounds	108	1	103	1	(4)	(4)	----	----
Natural gas ... million cubic feet	2,280	597	2,227	604	2,466	668	2,499	677
Petroleum (crude) ... thousand 42-gallon barrels	6	(4)	2	(4)	2	(4)	[6] 3	(4)
Sand and gravel ... thousand short tons	8,452	12,369	7,666	11,432	9,839	14,697	9,745	16,375
Silver (recoverable content of ores, etc.) ... thousand troy ounces	1	1	----	----	----	----	----	----
Stone ... thousand short tons	17,787	31,447	19,358	33,019	22,934	39,206	25,766	43,121
Zinc (recoverable content of ores, etc.)[18] ... short tons	20,334	4,662	19,885	5,142	29,163	6,726	26,479	6,141
Value of items that cannot be disclosed: Cement, feldspar, gypsum, iron ore (pigment materials 1960-62), kyanite, manganiferous ore (1959), pyrites, salt, talc and soapstone, titanium concentrate, and values indicated by footnote 4	----	28,848	----	26,027	----	[8] 27,747	----	27,843
Total	----	[8] 227,853	----	[8] 208,880	----	[8] 225,298	----	222,494

WASHINGTON

Barite ... short tons	(4)	(4)	(4)	(4)	5,100	$42	(4)	(4)
Clays[3] ... thousand short tons	180	$171	169	$162	145	138	103	$100
Coal (bituminous) ... do	242	1,841	228	1,721	191	1,381	235	1,630
Copper (recoverable content of ores, etc.) ... short tons	49	30	78	50	66	40	41	25
Iron ore (usable) ... thousand long tons	4	5	----	----	----	----	----	----
Lead (recoverable content of ores, etc.) ... short tons	10,310	2,371	7,725	1,808	8,053	1,659	6,033	1,110
Manganese ore (35 percent or more Mn) ... short tons, gross weight	83	(4)	----	----	----	----	----	----
Peat ... short tons	32,884	124	27,770	121	[8] 57,393	[8] 363	42,762	288
Petroleum (crude) ... thousand 42-gallon barrels	1	(4)	1	(4)	(20)	(5)	----	----
Pumice ... thousand short tons	9	112	(4)	(4)	(4)	(4)	10	130
Sand and gravel ... do	21,360	18,576	25,594	19.459	18,994	16,145	19,580	18,145
Stone ... do	12,278	13,587	13,897	15,796	11,464	14,758	12,749	18,180
Talc and soapstone ... short tons	4,073	23	2,406	12	2,927	23	2,835	11
Uranium ore ... do	152,336	(4)	171,255	3,223	175,327	3,582	110,948	2,050
Zinc (recoverable content of ores, etc.) ... do	17,111	3,936	21,317	5,500	20,217	4,650	21,644	4,978
Value of items that cannot be disclosed: Abrasive stone (grinding pebbles), carbon dioxide, cement, clays (fire clay, bentonite 1961), diatomite, epsom salts (1961-62), gem stones, gold, gypsum, magnesite, olivine, silver, strontium minerals (1959), tungsten (1961), and values indicated by footnote 4	----	25,054	----	24,552	----	23,667	----	21,827
Total	----	[8] 65,830	----	[8] 72,404	----	[8] 66,448	----	68,474

See footnotes at end of table.

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

Mineral	1959		1960		1961		1962	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
WEST VIRGINIA								
Clays ... thousand short tons..	596	$2,492	626	$2,639	475	$2,193	447	$2,086
Coal (bituminous) ... do....	119,692	621,003	118,944	597,222	113,070	558,525	118,499	578,293
Gem stones ...	(10)	1	(10)	1	(10)	(4)	(10)	(4)
Natural gas ... million cubic feet..	204,633	53,205	208,757	54,694	210,556	57,692	210,698	57,942
Natural gas liquids:								
Natural gasoline ... thousand gallons..	29,242	1,808	23,211	1,513	34,095	2,296	32,921	2,216
LP gases ... do....	308,316	15,534	329,874	16,527	342,646	17,826	344,969	17,475
Petroleum (crude) ... thousand 42-gallon barrels..	2,184	7,862	2,300	9,361	2,760	11,426	[6] 3,345	[6] 13,380
Salt ... thousand short tons..	811	3,305	920	3,673	899	3,510	1,042	4,635
Sand and gravel ... do....	4,854	10,513	4,506	9,802	4,882	10,152	5,202	10,942
Stone ... do....	[7] 5,923	[7] 10,482	[7] 8,001	[7] 14,001	7,628	13,244	[7] 7,506	[7] 13,242
Value of items that cannot be disclosed: Bromine (1959–60), calcium-magnesium chloride, cement, lime, stone (dimension sandstone 1959–60, 1961, calcareous marl 1959) and values indicated by footnote 4 ...	....	13,318	....	13,195	....	13,385	....	14,753
Total ...	....	[8] 739,523	....	[8] 722,628	....	[8] 690,250	....	714,964
WISCONSIN								
Abrasive stones ... short tons..	770	$27	397	$12	560	$17	569	$17
Clays ... thousand short tons..	178	192	144	156	126	130	137	156
Iron ore (usable) ... thousand long tons, gross weight..	701	(4)	1,502	(4)	1,122	(4)	1,045	(4)
Lead (recoverable content of ores, etc.) ... short tons..	745	171	1,165	273	680	140	1,394	256
Peat ... do....	7,500	(4)	8,500	(4)	(4)	(4)	(4)	(4)
Sand and gravel ... thousand short tons..	41,999	27,535	35,681	25,648	39,978	28,457	33,649	24,408
Stone ... do....	13,522	23,782	16,486	22,302	13,418	19,686	13,392	19,709
Zinc (recoverable content of ores, etc.) ... short tons..	11,635	2,676	18,410	4,750	13,865	3,189	13,292	3,057
Value of items that cannot be disclosed: Cement, gem stones, lime, and values indicated by footnote 4 ...	....	18,541	....	25,619	....	[8] 21,892	....	20,686
Total ...	....	[8] 72,924	....	[8] 78,760	....	[8] 73,511	....	68,289

Beryllium concentrate ... short tons, gross weight	1	(5)	5	$2	2	$1	1	(5)
Clays ... thousand short tons	[3] 764	[3] $9,449	[3] 788	[3] 9,571	[3] 859	[3] 10,301	1,141	$11,138
Coal (bituminous) ... do	1,977	6,669	2,024	6,992	2,529	8,573	2,569	8,198
Copper (recoverable content of ores, etc.) ... short tons	----------	----------	----------	----------	1	1	----------	----------
Gem stones ...	(10)	76	(10)	68	(10)	83	(10)	85
Gold (recoverable content of ores, etc.) ... troy ounces	----------	----------	40	1	1	(5)	----------	----------
Gypsum ... thousand short tons	9	31	13	46	(4)	(4)	(4)	(4)
Iron ore (usable) ... thousand long tons, gross weight	503	2,923	(4)	(4)	(4)	(4)	739	6,441
Natural gas ... million cubic feet	156,978	12,715	181,610	21,793	194,674	24,334	204,996	29,929
Natural gas liquids:								
Natural gasoline ... thousand gallons	64,586	4,003	72,195	4,535	76,349	4,705	78,780	4,935
LP gases ... do	90,314	3,951	120,693	5,279	132,831	5,451	149,438	5,762
Petroleum (crude) ... thousand 42-gallon barrels	126,050	315,125	133,910	336,114	141,937	354,843	[6] 145,167	[6] 361,466
Pumice ... thousand short tons	94	77	33	30	20	20	42	41
Sand and gravel ... do	4,692	3,982	5,928	5,356	6,669	5,356	7,769	8,104
Stone ... do	1,317	1,791	1,401	2,302	2,594	3,315	1,755	3,054
Uranium ore ... short tons	864,582	17,610	1,357,225	27,387	1,521,064	28,218	1,301,784	25,715
Vanadium (recoverable in ore and concentrate) ... do	----------	----------	(4)	(4)	(4)	(4)	(4)	442
Value of items that cannot be disclosed: Cement, clays (fire clay 1959, 1961, miscellaneous clay 1959–61), lime (1961–62), sheet mica (1959–61), phosphate rock, silver (1960–61), sodium carbonates and sulfates, vermiculite (1961–62), and values indicated by footnotes 4	----------	15,970	----------	19,780	----------	21,046	----------	20,467
Total	----------	[8] 394,372	----------	[8] 439,256	----------	[8] 466,247	----------	485,777

1 Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
2 Excludes certain cement, included with "Value of items that cannot be disclosed."
3 Excludes certain clays, included with "Value of items that cannot be disclosed."
4 Figure withheld to avoid disclosing individual company confidential data.
5 Less than $500.
6 Preliminary figure.
7 Excludes certain stone, included with "Value of items that cannot be disclosed."
8 Revised figure.
9 Less than 500 short tons.
10 Weight not recorded.
11 Less than 0.5 ton.
12 Includes 805 tons of low-grade beryllium ore in 1961 and 760 tons of 3.05 percent BeO concentrate in 1962.
13 Excludes salt in brine, included with "Value of items that cannot be disclosed."
14 Excludes quantity consumed by American Chrome Co.
15 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.
16 Less than 500 long tons.
17 Grinding pebbles and tube-mill liners.
18 Millstones only.
19 Less than 500 troy ounces.
20 Less than 500 barrels.

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

Area and mineral	1959		1960		1961		1962	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
American Samoa:								
Pumice .... thousand short tons							50	$108
Sand and gravel .... do							3	4
Stone .... do	178	$219	523	$261	362	$286	1,103	1,788
Total		219		261		286		1,900
Canal Zone:								
Sand and gravel .... thousand short tons	14	21	65	68	75	73	70	77
Stone (crushed) .... do	223	270	203	306	163	271	207	359
Total		291		374		344		436
Canton:								
Sand and gravel .... thousand short tons	(3)	(4)						
Stone (crushed) .... do	(3)	1					(3)	(4)
Guam:								
Sand and gravel .... thousand short tons	28	20	1	1	38	49		
Stone .... do	568	1,109	962	2,194	292	591	82	123
Total		1,129		2,195		640		123
Johnston:								
Sand and gravel .... thousand short tons			1	4	1	1		
Stone .... do			2	5	1	2		
Total				9		3		
Midway: Stone (crushed) .... thousand short tons					11	34		
Virgin Islands: Stone (crushed) .... do	14	51	15	51	20	75	21	82
Wake: Stone (crushed) .... do	32	34	36	49	24	62	5	41

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2] Production data for Canton and Wake furnished by U.S. Department of Commerce, Civil Aeronautics Administration; Midway and Johnston, by U.S Department of the Navy; Guam, by the Government of Guam; American Samoa, by the Government of American Samoa.
[3] Less than 500 short tons.
[4] Less than $500.

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

Mineral	1959		1960		1961		1962	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement .... thousand 376-pound barrels..	5,392	$16,982	5,441	$14,546	5,931	$16,946	6,347	$20,018
Clays .... thousand short tons..	167	83	160	102	184	112	219	131
Lime .... do....	10	321	1	15	1	15	1	14
Salt .... do....	3	38	(2)	(2)	....	....	....	....
Sand and gravel .... do....	530	888	8,996	8,669	11,370	10,385	7,378	9,793
Stone .... do....	2,063	2,878	4,219	7,661	5,049	7,284	5,589	8,551
Value of items that cannot be disclosed: Other nonmetals and values indicated by footnote 2	....	....	....	74	....	....	....	....
Total	....	[3] 21,190	....	[3] 31,067	....	[3] 34,742	....	38,507

[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] Revised figure.

TABLE 8.—U.S. imports for consumption of principal minerals and products

Mineral	1961 Quantity	1961 Value (thousands)	1962 Quantity	1962 Value (thousands)
Metals:				
Aluminum:				
Metal...short tons..	199,223	$91,187	307,521	$128,560
Scrap...do....	6,002	1,738	6,496	1,864
Plates, sheets, bars, etc...do....	49,310	33,062	59,188	37,147
Antimony:				
Ore (antimony content)...do....	6,713	1,389	8,602	2,168
Needle or liquated...do....	13	6	17	8
Metal...do....	4,912	2,347	4,720	2,300
Oxide...do....	1,980	935	2,910	1,391
Arsenic: White (As_2O_3 content)...do....	19,483	1,422	15,758	1,077
Bauxite: Crude...thousand long tons..	[1] 9,206	[2] 88,814	[1] 10,585	122,190
Beryllium ore...short tons..	8,516	2,786	8,552	2,897
Bismuth (general imports)...pounds..	798,518	1,498	816,190	1,478
Boron carbide...do....	11,992	37	9,124	34
Cadmium:				
Metal...thousand pounds..	1,079	1,473	1,117	1,640
Flue dust (cadmium content)...do....	239	112	1,570	850
Calcium:				
Metal...pounds..	17,266	23	43,962	52
Chloride...short tons..	3,022	103	1,896	60
Chromate:				
Ore and concentrate (Cr_2O_3 content)...do....	[2] 565,861	[2] 21,476	613,572	23,700
Ferrochrome (chromium content)...do....	18,698	7,611	24,802	10,023
Metal...do....	692	1,150	648	993
Cobalt:				
Metal...thousand pounds..	10,036	14,867	[1] 11,814	[1] 17,129
Oxide (gross weight)...do....	681	663	978	943
Salts and compounds (gross weight)...do....	159	59	120	47
Columbium ore [1]...pounds..	2,777,700	2,306	5,050,888	3,405
Copper: (copper content)				
Ore...short tons..	2,587	1,526	116	202
Concentrates...do....	21,914	12,516	2,206	1,212
Regulus, black, coarse...do....	95	57	22	12
Unrefined, black, blister...do....	5,929	3,508	1,119	669
Refined in ingots, etc...do....	87,206	51,852	130,525	77,189
Old and scrap...do....	1,643	870	3,846	2,242
Old brass and clippings...do....	390	173	1,289	738
Ferroalloys: Ferrosilicon (silicon content)...do....	2,307	803	2,573	976
Gold:				
Ore and base bullion...troy ounces..	456,139	15,938	382,468	13,281
Bullion...do....	1,159,320	40,273	3,929,718	137,652
Iron ore:				
Ore...thousand long tons..	25,805	250,226	33,431	324,702
Pyrites cinder...long tons..	3,504	18	4,248	26
Iron and steel:				
Pig iron...short tons..	377,180	20,511	500,010	24,682
Iron and steel products (major):				
Iron products...do....	31,157	5,794	54,132	10,634
Steel products...do....	[2] 3,277,325	418,268	4,236,605	514,115
Scrap...do....	235,350	8,315	[1] 189,035	[1] 5,726
Tinplate scrap...do....	33,039	770	21,092	341
Lead:				
Ore, flue dust, matte (lead content)...do....	[2] 136,780	[2] 24,332	133,867	21,137
Base bullion (lead content)...do....	236	[1] 51	[1] 2,083	710
Pigs and bars (lead content)...do....	[2] 247,427	[2] 45,881	257,866	41,570
Reclaimed, scrap, etc. (lead content)...do....	3,894	592	2,078	269
Sheets, pipe, and shot...do....	2,845	641	2,276	474
Babbitt metal and solder (lead content)...do....	1,409	14,207	1,030	3,443
Type metal and antimonial lead (lead content) short tons..	5,765	1,340	7,512	1,393
Manufactures...do....	2,319	807	2,021	978
Magnesium:				
Metallic and scrap...do....	1,005	483	[1] 2,359	[1] 1,080
Alloys (magnesium content)...do....	31	170	[1] 53	[1] 106
Sheets, tubing, ribbons, wire, and other forms (magnesium content)...short tons..	5	80	35	83
Manganese:				
Ore (35 percent or more manganese) (manganese content)...short tons..	1,031,062	78,144	943,659	66,149
Ferromanganese (manganese content)...do....	170,199	34,396	97,042	16,631
Mercury:				
Compounds...pounds..	90,724	228	46,368	105
Metal...76-pound flasks..	[2] 12,326	2,048	31,652	5,102
Minor metals: Selenium and salts...pounds..	127,482	738	160,389	866

See footnotes at end of table.

TABLE 8.—U.S. imports for consumption of principal minerals and products—Continued

Mineral	1961 Quantity	1961 Value (thousands)	1962 Quantity	1962 Value (thousands)
Metals—Continued				
Nickel:				
Ore and matte ---- short tons	(4)	(4)	14	$5
Pigs, ingots, shot, cathodes ---- do	115,985	$169,656	115,947	175,381
Scrap ---- do	278	175	601	545
Oxide ---- do	14,613	14,137	8,661	9,086
Platinum group:				
Unrefined materials:				
Ores and concentrates ---- troy ounces	568	39	----	----
Grains and nuggets, including crude, dust, and residues ---- troy ounces	[2] 31,614	[2] 2,288	23,366	1,610
Sponge and scrap ---- do	[2] 9,933	[2] 582	6,185	684
Osmiridium ---- do	2,601	66	24	1
Refined metal:				
Platinum ---- do	236,859	18,165	210,220	16,097
Palladium ---- do	571,693	12,672	431,872	9,370
Iridium ---- do	4,366	286	9,001	578
Osmium ---- do	466	26	1,062	55
Rhodium ---- do	17,394	2,328	30,123	3,965
Ruthenium ---- do	8,969	388	8,499	339
Radium:				
Radium salts ---- milligrams	12,947	185	46,962	700
Radioactive substitutes ----	(5)	1,509	(5)	1,732
Rare earths: Ferrocerium and other cerium alloys ---- pounds	22,955	63	20,608	60
Silver:				
Ore and base bullion ---- thousand troy ounces	34,559	30,832	37,168	35,814
Bullion ---- do	15,697	14,173	39,191	36,907
Tantalum: Ore [1] ---- pounds	1,004,151	2,002	1,211,757	3,527
Tin:				
Ore (tin content) ---- long tons	8,917	21,923	5,364	13,595
Blocks, pigs, grains, etc ---- do	[2] 39,893	[2] 96,896	[1] 41,408	[1] 103,124
Dross, skimmings, scrap, residues, and tin alloys, n.s.p.f ---- long tons	612	1,299	[1] 2,173	[1] 880
Tinfoil, powder, flitters, etc ----	(5)	676	(5)	819
Titanium:				
Ilmenite ---- short tons	[2] 207,151	[2] 5,018	166,434	4,470
Rutile ---- do	27,497	2,544	35,966	2,646
Metal ---- pounds	4,980,356	5,352	1,849,034	1,733
Ferrotitanium ---- do	364,721	93	240,326	88
Compounds and mixtures ---- do	18,044,423	3,536	11,758,373	2,334
Tungsten (tungsten content):				
Ore and concentrate ---- thousand pounds	2,123	1,983	3,977	2,870
Metal ---- pounds	55,613	139	497,054	938
Ferrotungsten ---- thousand pounds	340	422	534	531
Other alloys ---- pounds	9,955	15	41,807	47
Zinc:				
Ore (zinc content) ---- short tons	357,653	31,920	387,321	31,817
Blocks, pigs, and slabs ---- do	125,186	27,540	135,995	28,478
Sheets ---- do	1,183	354	1,315	367
Old, dross, and skimmings ---- do	1,410	178	2,768	406
Dust ---- do	86	28	909	207
Manufactures ----	(5)	787	(5)	1,139
Zirconium: Ore, including zirconium sand ---- short tons	33,805	873	30,872	845
Nonmetals:				
Abrasives: Diamonds (industrial) ---- carats	14,209,446	68,545	12,281,143	51,040
Asbestos ---- short tons	[2] 616,529	58,942	676,027	64,150
Barite:				
Crude and ground ---- do	615,128	5,690	736,867	6,012
Witherite (crude) ---- do	1,716	67	1,431	59
Chemicals ---- do	4,565	543	5,319	595
Bromine ---- pounds	300,491	196	461,108	245
Cement ---- 376-pound barrels	3,620,685	9,225	5,759,426	13,241
Clays:				
Raw ---- short tons	153,833	2,955	129,631	2,475
Manufactured ---- do	2,339	[2] 100	2,598	66
Cryolite ---- do	13,814	1,194	12,472	933
Feldspar: Crude ---- long tons	24	2	33	1
Fluorspar ---- short tons	505,759	13,644	595,695	15,596
Gem stones:				
Diamonds ---- carats	3,114,073	193,275	2,402,721	191,634
Emeralds ---- do	227,284	2,090	196,649	2,798
Other ----	(5)	27,350	(5)	30,074
Graphite ---- short tons	29,748	1,332	39,528	1,783

See footnotes at end of table.

TABLE 8.—U.S. imports for consumption of principal minerals and products—Continued

Mineral	1961		1962	
	Quantity	Value (thousands)	Quantity	Value (thousands)
Nonmetals—Continued				
Gypsum:				
Crude, ground, calcined .... short tons..	4,968,188	$9,094	5,422,656	$10,545
Manufactures	(5)	1,212	(5)	1,367
Iodine, crude .... thousand pounds..	3,017	2,852	3,026	2,841
Kyanite .... short tons..	5,415	244	5,281	234
Lime:				
Hydrated .... do....	950	22	1,141	19
Other .... do....	31,418	491	71,970	939
Dead-burned dolomite .... do....	4,256	233	4,456	245
Magnesium:				
Magnesite .... do....	56,521	3,839	107,169	5,939
Compounds .... do....	15,435	518	14,860	589
Mica:				
Uncut sheet and punch .... pounds..	852,648	1,841	1,107,929	1,789
Scrap .... short tons..	3,024	41	4,458	55
Manufactures .... do....	[2] 3,763	[2] 6,115	5,403	7,922
Mineral-earth pigments: Iron oxide pigments:				
Natural .... do....	2,248	114	2,937	128
Synthetic .... do....	4,806	777	6,206	960
Ocher, crude and refined .... do....	91	5	146	9
Siennas, crude and refined .... do....	546	57	879	84
Umber, crude and refined .... do....	2,685	93	2,663	94
Vandyke brown .... do....	168	13	256	21
Nitrogen compounds (major), including urea..do....	[2] 1,437,178	[2] 63,399	1,559,689	69,260
Phosphate, crude .... long tons..	134,004	3,629	133,628	3,551
Phosphatic fertilizers .... do....	32,467	2,453	83,894	4,630
Pigments and salts:				
Lead pigments and salts .... short tons..	18,155	3,498	18,986	3,027
Zinc pigments and salts .... do....	12,608	[2] 2,348	15,282	2,729
Potash [6] .... do....	[2] 465,007	[2] 17,315	620,236	21,864
Pumice:				
Crude and unmanufactured .... do....	6,907	69	7,136	70
Wholly or partly manufactured .... do....	4,063	116	3,184	89
Manufactures, n.s.p.f.	(5)	19	(5)	22
Quartz crystal (Brazilian pebble) .... pounds..	1,173,560	798	935,927	843
Salt .... short tons..	1,050,084	3,755	1,374,219	5,097
Sand and gravel:				
Glass sand .... do....	2	2	31,416	64
Other sand .... do....	335,005	441	307,637	415
Gravel .... do....	43,287	44	29,198	32
Sodium sulfate .... thousand short tons..	196	4,153	188	3,768
Stone, including slate and whiting	(5)	12,268	(5)	17,204
Strontium: Mineral .... short tons..	9,931	244	7,489	189
Sulfur and pyrites:				
Sulfur:				
Ore .... long tons..	94,181	1,934	448,132	8,618
Other forms, n.e.s .... do....	737,336	15,218	601,301	11,957
Pyrites .... do....	281,604	742	301,899	747
Talc: Unmanufactured .... short tons..	[2] 27,362	[2] 1,055	25,777	1,069
Fuels:				
Carbon black:				
Acetylene .... pounds..	8,073,544	1,482	7,883,462	1,384
Gas black and carbon black .... do....	557,327	111	284,296	49
Coal:				
Anthracite .... short tons..	792	10	7,583	63
Bituminous, slack, culm, and lignite .... do....	164,259	1,360	232,424	1,858
Briquets .... do....	7,338	370	8,396	410
Coke .... do....	126,518	1,543	141,883	1,855
Peat:				
Fertilizer grade .... do....	243,834	12,620	261,347	12,448
Poultry and stable grade .... do....	8,603	558	6,331	420
Petroleum:				
Crude [7] .... thousand barrels..	411,968	933,310	450,157	1,011,914
Gasoline [8] .... do....	[2] 17,354	[2] 57,089	33,369	102,455
Kerosine [9] .... do....	425	1,524	3	8
Distillate oil [10] .... do....	[2] 14,748	[2] 43,916	271,159 (distillate and residual combined)	575,463 (distillate and residual combined)
Residual oil [10] .... do....	[2] 240,106	[2] 521,744		
Unfinished oils [11] .... do....	25,802	69,978	21,527	57,224
Asphalt .... do....	6,728	15,646	6,698	15,845
Miscellaneous [7] .... do....	20	465	30	421

See footnotes on page 181.

[1] Adjusted by Bureau of Mines.
[2] Revised figure.
[3] Less than 1 ton.
[4] Less than $1,000.
[5] Weight not recorded.
[6] Data covers some quantities furnished by Potash Institute; values adjusted by Bureau of Mines.
[7] Includes some quantities imported free for supplies of vessels and aircraft.
[8] Includes naphtha, but excludes benzol: 1961—460,839 barrels ($5,476,518); 1962—547,537 barrels ($4,927,771).
[9] Includes quantities imported free for supplies of vessels and aircraft, assumed to be commercial jet fuel by Bureau of Mines.
[10] Effective July 1, 1962, distillate and residual fuel oil not separately classified.
[11] Due to changes in classification effective July 1, 1962, data not strictly comparable to earlier years.

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

TABLE 9.—U.S. exports of principal minerals and products

Mineral	1961		1962	
	Quantity	Value (thousands)	Quantity	Value (thousands)
Metals:				
Aluminum:				
Ingots, slabs, crude ... short tons	128,861	$57,638	151,250	$66,621
Scrap ... do	82,005	26,452	65,534	20,183
Plates, sheets, bars, etc ... do	25,241	23,975	40,069	32,931
Castings and forgings ... do	1,203	3,560	1,540	5,522
Antimony: Metals and alloys, crude ... do	34	21	35	15
Arsenic: Calcium arsenate ... pounds	669,932	58	942,399	104
Bauxite, including bauxite concentrates ... long tons	150,683	12,189	258,561	19,874
Aluminum sulfate ... short tons	14,213	535	17,776	608
Other aluminum compounds ... do	[1] 55,650	[1] 8,128	87,671	10,936
Beryllium ... pounds	123,349	645	63,975	352
Bismuth: Metals and alloys ... do	167,166	268	118,056	176
Cadmium ... thousand pounds	702	983	717	1,139
Calcium chloride ... short tons	22,047	1,091	43,830	1,687
Chrome:				
Ore and concentrate:				
Exports ... do	[1] 5,201	[1] 345	2,686	108
Reexports ... do	[1] 35,890	[1] 1,373	51,254	2,033
Chromic acid ... do	1,068	604	834	487
Ferrochrome ... do	7,844	2,838	3,075	1,182
Cobalt ... pounds	2,075,243	1,881	1,936,487	997
Columbium metals, alloys, and other forms short tons	69,863	151	38,157	277
Copper:				
Ore, concentrate, composition metal, and unfined copper (copper content) ... short tons	4,478	2,475	1,916	1,045
Refined copper and semimanufactures ... do	[1] 482,824	295,397	366,585	234,605
Other copper manufactures ... do	7,362	5,260	6,768	5,107
Copper sulfate or blue vitriol ... do	7,575	1,542	1,916	456
Copper-base alloys ... do	124,938	70,240	46,030	36,024
Ferroalloys:				
Ferrosilicon ... pounds	69,528,561	6,105	8,202,626	1,349
Ferrophosphorus ... do	[1] 65,720,159	[1] 1,426	28,260,782	595
Gold:				
Ore and base bullion ... troy ounces	13,717	480	22,724	809
Bullion, refined ... do	22,132,692	774,521	10,861,510	380,153
Iron ore ... thousand long tons	[1] 4,958	[1] 54,230	5,898	62,833
Iron and steel:				
Pig iron ... short tons	415,668	19,243	154,380	8,283
Iron and steel products (major):				
Semimanufactures ... do	[1] 1,428,369	[1] 274,343	1,505,740	282,536
Manufactured steel mill products ... do	[1] 792,788	[1] 252,406	761,045	262,220
Advanced products ... do	(2)	[1] 159,847	(2)	174,571
Iron and steel scrap: Ferrous scrap, including rerolling materials ... short tons	[1] 9,713,863	[1] 353,928	5,113,409	148,973
Lead:				
Ore, matte, base bullion (lead content) ... do	4,437	448	2,898	235
Pigs, bars, anodes ... do	2,133	518	2,108	528
Scrap ... do	5,163	940	2,461	457
Magnesium:				
Metal and alloys and semimanufactured forms, n.e.c ... short tons	6,648	4,519	7,020	4,659
Powder ... do	33	78	21	53
Manganese:				
Ore and concentrate ... do	7,528	1,054	8,643	1,012
Ferromanganese ... do	469	146	4,114	629
Mercury:				
Exports ... 76-pound flasks	285	71	224	64
Reexports ... do	180	33	257	43
Molybdenum:				
Ore and concentrate (molybdenum content) ... pounds	35,661,001	48,758	15,554,662	22,901
Metals and alloys, crude and scrap ... do	440,849	433	75,211	70
Wire ... do	12,488	376	12,088	374
Semifabricated forms, n.e.c ... do	7,362	135	8,961	135
Powder ... do	11,816	40	25,219	84
Ferromolybdenum ... do	358,523	501	189,823	305
Nickel:				
Ore ... short tons	1,766	495	45	16
Alloys and scrap (including Monel metal), ingots, bars, sheets, etc ... short tons	51,631	24,969	25,510	20,796
Catalysts ... do	805	1,456	1,093	1,963
Nickel-chrome electric resistance wire ... do	254	1,079	190	965
Semifabricated forms, n.e.c ... do	1,037	3,980	803	3,463

See footnotes at end of table.

TABLE 9.—U.S. exports of principal minerals and products—Continued

Mineral	1961 Quantity	1961 Value (thousands)	1962 Quantity	1962 Value (thousands)
Metals—Continued				
Platinum:				
Ore, concentrate, metal and alloys in ingots, bars, sheets, anodes, and other forms, including scrap____troy ounces__	41,385	$2,089	49,651	$1,514
Palladium, rhodium, iridium, osmiridium, ruthenium, and osmium (metal and alloys including scrap)____troy ounces__	20,460	820	10,940	459
Platinum-group manufactures, except jewelry__	(2)	2,983	(2)	4,106
Radium metal (radium content)____milligrams__	334	18	328	4
Rare earths:				
Cerium ore, metal, and alloys____pounds__	6,563	30	3,708	16
Lighter flints____do____	20,338	89	38,501	173
Silver:				
Ore and base bullion____thousand troy ounces__	654	597	770	789
Bullion, refined____do____	39,174	36,361	12,287	12,586
Tantalum:				
Ore, metal, and other forms____pounds__	[1] 135,321	[1] 990	[3] 54,256	[3] 716
Powder____do____	5,585	189	[3] 7,445	[3] 353
Tin:				
Ingots, pigs, bars, etc.:				
Exports____long tons__	543	1,264	335	840
Reexports____do____	257	626	100	267
Tin scrap and other tin-bearing material except tinplate scrap____long tons__	10,506	3,352	5,587	2,111
Tin cans, finished or unfinished____do____	30,929	15,093	25,531	13,927
Titanium:				
Ore and concentrate____short tons__	1,436	190	1,224	167
Sponge (including iodide titanium) and scrap____short tons__	886	927	818	925
Intermediate mill shapes____do____	336	1,929	453	2,609
Mill products, n.e.c____do____	48	773	108	1,493
Ferrotitanium____do____	212	93	130	95
Dioxide and pigments____do____	31,104	9,216	29,095	8,636
Tungsten: Ore and concentrate:				
Exports____short tons__	207	250	40	80
Reexports____do____	689	791	[3] 159	132
Vanadium ore and concentrate, pentoxide, etc. (vanadium content)____pounds__	4,161,978	[1] 7,660	2,018,957	2,961
Zinc:				
Ore and concentrate (zinc content)__short tons__	1,670	124	136	46
Slabs, pigs, or blocks____do____	50,055	11,196	36,102	8,050
Sheets, plates, strips, or other forms, n.e.c. short tons__	3,219	2,271	3,547	2,391
Scrap (zinc content)____do____	5,900	871	7,940	956
Dust____do____	717	224	676	240
Semifabricated forms, n.e.c____do____	3,036	1,317	1,613	1,254
Zirconium:				
Ore and concentrate____do____	1,277	278	1,666	365
Metals and alloys and other forms____pounds__	178,873	1,472	[4] 216,247	[4] 1,742
Nonmetals:				
Abrasives:				
Grindstones____short tons__	123	46	127	53
Diamond dust and powder____carats__	490,327	1,357	828,611	2,225
Diamond grinding wheels____do____	285,425	1,708	310,330	1,990
Other natural and artificial metallic abrasives and products____	(2)	[1] 26,098	(2)	28,489
Asbestos: Unmanufactured:				
Exports____short tons__	3,572	708	2,824	578
Reexports____do____	227	51	125	20
Boron: Boric acid, borates, crude and refined pounds__	538,542,810	23,212	584,528,807	24,736
Bromine, bromides, and bromates____do____	11,120,085	2,980	8,800,351	2,228
Cement____376-pound barrels__	285,816	1,387	380,383	1,853
Clays:				
Kaolin or china clay____short tons__	98,785	2,395	118,890	2,939
Fire clay____do____	155,166	3,391	188,282	3,462
Other clays____do____	304,858	8,499	309,776	10,454
Cryolite____do____	167	41	1,109	196
Fluorspar____do____	338	30	1,308	119
Graphite:				
Amorphous____do____	1,328	186	746	110
Crystalline flake, lump or chip____do____	91	34	127	42
Natural, n.e.c____do____	139	37	286	71

See footnotes at end of table.

TABLE 9.—U.S. exports of principal minerals and products—Continued

Mineral	1961		1962	
	Quantity	Value (thousands)	Quantity	Value (thousands)
Nonmetals—Continued				
Gypsum:				
Crude, crushed or calcined thousand short tons	20	$731	20	$736
Manufactures, n.e.c	(2)	568	(2)	566
Iodine, iodide, iodates thousand pounds	176	282	178	296
Kyanite and allied minerals short tons	4,000	318	3,568	287
Lime do	29,969	921	19,512	660
Mica:				
Unmanufactured pounds	334,221	142	430,856	166
Manufactured:				
Ground or pulverized do	7,074,850	396	7,427,420	432
Other do	190,320	689	197,441	765
Mineral-earth pigments: Iron oxide, natural and manufactured short tons	3,213	855	3,754	1,076
Nitrogen compounds (major) do	445,930	30,480	911,037	43,847
Phosphate rock long tons	4,122,732	36,910	4,239,120	38,833
Phosphatic fertilizers (superphosphates) do	469,197	23,695	558,188	27,690
Pigments and salts (lead and zinc):				
Lead pigments short tons	2,302	764	1,919	595
Zinc pigments do	2,791	759	2,411	658
Lead salts do	464	183	711	249
Potash:				
Fertilizer do	[1] 773,410	[1] 29,481	847,949	28,373
Chemical do	29,740	2,995	13,171	2,435
Quartz crystal (raw)	(2)	518	(2)	448
Radioactive isotopes, etc curies	202,769	1,741	226,824	1,895
Salt:				
Crude and refined short tons	641,966	3,876	665,202	3,616
Shipments to noncontiguous Territories do	10,164	793	11,347	823
Sodium and sodium compounds:				
Sodium sulfate do	32,259	992	50,914	1,486
Sodium carbonate thousand short tons	132	4,045	152	4,693
Stone:				
Limestone, crushed, ground, broken short tons	790,912	1,596	621,177	1,547
Marble and other building and monumental do	435,173	1,596	534,919	1,795
Stone, crushed, ground, broken do	128,149	3,027	114,744	2,166
Manufactures of stone	(2)	430	(2)	501
Sulfur:				
Crude long tons	1,585,531	35,370	1,537,419	35,496
Crushed, ground, flowers of do	10,512	1,254	16,567	1,799
Talc:				
Crude and ground short tons	47,912	1,721	46,939	2,133
Manufactures, n.e.c do	134	84	122	97
Powders—talcum (face and compact)	(2)	1,396	(2)	1,286
Fuels:				
Carbon black thousand pounds	522,331	48,166	442,437	41,801
Coal:				
Anthracite short tons	[1] 1,435,335	[1] 20,681	1,869,408	25,666
Bituminous do	34,969,825	319,034	38,413,424	351,320
Briquets do	12,731	176	18,596	233
Coke do	445,232	8,213	394,296	7,424
Petroleum:				
Crude thousand barrels	3,219	8,541	1,793	5,085
Gasoline [5] do	8,209	56,481	5,987	41,339
Kerosine do	210	1,462	312	1,817
Distillate oil do	6,838	23,594	8,918	30,071
Residual oil do	14,023	34,575	12,852	32,832
Lubricating oil do	[1] 16,605	218,388	17,165	225,480
Asphalt do	[1] 535	[1] 4,081	717	4,572
Liquefied petroleum gases do	3,549	13,322	3,875	11,250
Wax do	1,238	24,694	1,430	28,484
Coke do	7,271	29,234	7,456	29,357
Petrolatum do	246	6,098	238	6,151
Miscellaneous do	476	14,292	476	15,423

[1] Revised figure.
[2] Weight not recorded.
[3] Adjusted by Bureau of Mines.
[4] Final figure. Supersedes figure given in commodity chapter.
[5] Includes naphtha, but excludes benzol: 1961—1,106,390 barrels ($16,877,309); 1962—982,361 barrels ($12,027,669).

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

TABLE 10.—Comparison of world and U.S. production of principal metals and minerals

Mineral	1961 World	1961 United States		1962 World	1962 United States	
	Thousand short tons (unless otherwise stated)		Percent of world	Thousand short tons (unless otherwise stated)		Percent of world
Fuels:						
Coal:						
Bituminous	1,960,631	399,959	20	2,002,401	419,094	20
Lignite	729,510	3,018	(1)	758,936	3,055	(1)
Pennsylvania anthracite	189,900	17,446	9	191,900	16,894	9
Coke (excluding breeze):						
Gashouse [2]	49,430	(3)	(3)	49,540	(3)	(3)
Oven and beehive	304,470	51,711	17	301,474	51,910	17
Fuel briquets and packaged fuel	123,100	591	(1)	127,800	587	(1)
Natural gas (marketable) million cubic feet	(4)	13,254,025	(4)	(4)	13,876,622	(4)
Peat	166,200	531	(1)	169,700	572	(1)
Petroleum (crude) thousand barrels	8,186,246	2,621,758	32	8,878,881	2,676,185	30
Nonmetals:						
Asbestos	2,770	53	2	3,055	53	2
Barite	2,960	731	25	3,310	887	27
Cement [5] thousand barrels	1,967,606	397,003	20	2,095,654	414,582	20
China clay	(4)	2,740	(4)	(4)	2,998	(4)
Corundum	8	----------	-------	9	----------	-------
Diamonds thousand carats	34,250	----------	-------	32,876	----------	-------
Diatomite	1,450	482	33	1,440	482	33
Feldspar thousand long tons	1,490	497	33	1,500	492	33
Fluorspar	2,345	197	8	2,405	206	9
Graphite	440	(3)	(3)	570	(3)	(3)
Gypsum	48,320	9,500	20	49,965	9,969	20
Lime (sold or used by producers)	(4)	13,265	(4)	(4)	13,752	(4)
Magnesite	8,450	604	7	8,200	492	6
Mica (including scrap) thousand pounds	365,000	198,614	54	400,000	215,765	54
Nitrogen, agricultural [5 6]	11,900	2,739	23	12,790	2,936	23
Phosphate rock thousand long tons	43,670	18,559	42	46,040	19,382	42
Potash (K_2O equivalent)	10,700	2,732	26	10,700	2,452	23
Pumice [7]	13,300	2,463	19	13,600	2,297	17
Pyrites thousand long tons	19,800	987	5	20,100	916	5
Salt [5]	94,100	25,707	27	100,500	28,807	29
Strontium [7]	14	----------	-------	10	----------	-------
Sulfur, elemental thousand long tons	11,275	6,336	56	11,640	5,925	51
Talc, pyrophyllite, and soapstone	2,940	762	26	2,930	772	26
Vermiculite [7]	279	206	74	293	205	70
Metals, mine basis:						
Antimony (content of ore and concentrate) short tons	60,000	689	1	60,000	631	1
Arsenic, white [7]	54	(3)	(3)	56	(3)	(3)
Bauxite thousand long tons	28,805	1,228	4	29,940	1,369	5
Beryllium concentrate short tons	9,300	1,122	12	8,200	978	12
Bismuth thousand pounds	5,300	(3)	(3)	7,000	(3)	(3)
Cadmium do	26,400	10,115	38	25,600	10,641	42
Chromite	4,720	[8] 82	2	4,805	----------	-------
Cobalt (contained) [7] short tons	14,800	(3)	(3)	15,700	(3)	(3)
Columbium-tantalum concentrate [7] thousand pounds	7,480	----------	-------	8,250	----------	-------
Copper (content of ore and concentrate)	4,840	1,165	24	5,050	1,228	24
Gold thousand troy ounces	47,400	1,567	3	50,000	1,556	3
Iron ore thousand long tons	503,779	71,329	14	504,012	71,829	14
Lead (content of ore and concentrate)	2,625	262	10	2,765	237	9
Manganese ore (35 percent or more Mn)	15,073	46	(1)	15,590	25	(1)
Mercury thousand 76-pound flasks	240	32	13	244	26	11
Molybdenum (content of ore and concentrate) thousand pounds	87,900	66,563	76	75,000	51,244	68
Nickel (content of ore and concentrate)	394	11	3	401	11	3
Platinum group metals thousand troy ounces	1,205	43	4	1,190	29	2
Silver do	236,500	34,900	15	242,400	36,345	15
Tin (content of ore and concentrate) long tons	185,200	(3)	(3)	190,200	(3)	(3)
Titanium concentrates:						
Ilmenite [7]	2,327	782	34	2,295	808	35
Rutile [7]	129	9	7	151	10	7
Tungsten concentrate (60 percent WO_3) short tons	73,800	8,245	11	71,100	8,429	12

See footnotes at end of table.

TABLE 10.—Comparison of world and U.S. production of principal metals and minerals—Continued

Mineral	1961			1962		
	World	United States		World	United States	
	Thousand short tons (unless otherwise stated)		Percent of world	Thousand short tons (unless otherwise stated)		Percent of world
Metals, mine basis—Continued						
Vanadium (content of ore and concentrate)[7] ... short tons	8,871	5,343	60	8,350	5,233	63
Zinc (content of ore and concentrate)	3,770	464	12	3,870	505	13
Metals, smelter basis:						
Aluminum	5,210	1,904	37	5,555	2,118	38
Copper	5,090	1,207	24	5,300	1,322	25
Iron, pig (including ferroalloys)	287,350	66,717	23	294,200	67,636	23
Lead	2,665	449	17	2,665	376	14
Magnesium ... short tons	115,100	40,745	35	145,300	68,955	47
Selenium[7] ... thousand pounds	2,097	1,022	49	2,126	999	47
Steel ingots and castings	390,400	98,014	25	397,350	98,328	25
Tellurium[7] ... thousand pounds	366	205	56	398	264	66
Tin ... thousand long tons	189	[9] 9	5	196	[9] 5	3
Uranium oxide (U_3O_8)[7] ... short tons	36,080	17,399	48	33,550	17,010	51
Zinc	3,560	847	23	3,650	879	24

[1] Less than 1 percent.
[2] Includes low- and medium-temperature and gashouse coke.
[3] Bureau of Mines not at liberty to publish U.S. figure separately.
[4] Data not available.
[5] Including Puerto Rico.
[6] Year ended June 30 of year stated (United Nations).
[7] World total exclusive of U.S.S.R.
[8] Produced for Federal Government only; excludes quantity consumed by American Chrome Company U.S. imports of tin concentrates (tin content).

Compiled by Liela S. Price, Division of Foreign Activities.

Employment and Injuries in the Metal and Nonmetal Industries

By Forrest T. Moyer[1]

INJURY experience and employment data are presented in this chapter for metal and nonmetal mines, stone quarries, sand and gravel pits, iron blast-furnace slag plants, and metallurgical plants (including ore-dressing and nonferrous reduction plants and refineries) in the United States. Employment and injury experience data for all mineral industries are given in volume III. The 1962 figures are preliminary summations which are subject to revision. They were compiled from all reports from producers received by the Bureau of Mines through April 15, 1963. The data for metal, nonmetal (except well and brine operations), stone, and sand and gravel operations were collected by a mandatory reporting system under the provisions of the act of September 26, 1961, Public Law 87–300 (75 Stat. 649). The act authorized the Secretary of the Interior to study the various aspects of safety in metal and nonmetal mines (excluding coal mines) and report the findings 2 years subsequent to the enactment of the law. Data on nonmetal well and brine plants and nonferrous reduction plants and refineries were reported voluntarily by the operators.

METAL MINES

Preliminary data for the metal mining industry comprise reports on 1,871 mines and pits. The combined fatal and nonfatal injury-frequency rate was 31.95 per million manhours in 1962, a decrease of 8 percent from the similar rate of 34.54 in 1961. Metal operations reported a total of 61 fatal and 3,201 nonfatal injuries.

The mines and pits were active an average of 252 days in 1962 or 5 days more than in the preceding year. The average employee worked an 8-hour shift for a total of 2,025 hours during the year, an increase of 2 percent over that of 1961.

Copper.—Injury experience at reporting copper mines was an overall occurrence of 26.35 injuries (fatal plus nonfatal) per million man-hours of worktime, 4 percent less favorable than in 1961. There were 15 fatalities and 896 nonfatal injuries at the reporting mines.

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

Copper mines averaged 281 days of activity in 1962. The average employee had an 8-hour daily shift and worked 2,251 hours during the year.

Gold Placer.—No fatalities and only 34 nonfatal injuries were reported at gold placer operations. The overall injury-frequency rate fell to 34.86 or 31 percent below the corresponding rate in 1961. The average employee worked a total of 1,287 hours on an 8.3-hour daily shift in 1962.

Gold-Silver.—At gold-silver lode mining operations in 1962, the fatal and nonfatal combined injury-frequency rate of 36.86 declined 11 percent from the preceding year. The average employee worked an 8-hour daily shift for a total of 1,985 hours, an increase of 8 percent over that of 1961. Mines were active an average of 248 days during the year.

Iron.—Injury experience at reporting iron mines was not as favorable as in 1961. The fatal and nonfatal combined injury-frequency rate was 15.18, showing a 3-percent increase. The average shift was about 8 hours, and the average employee worked 1,897 hours, an increase of 98 hours over that of 1961. The mines were active 235 days, 11 more than in 1961.

Lead-Zinc.—At lead-zinc mines, the safety record was improved in 1962; the overall (fatal and nonfatal) injury-frequency rate was 69.35, a 14-percent decrease from the preceding year. The mines were active an average of 248 days, and the average employee worked 1,987 hours on an 8-hour daily shift.

Uranium.—Uranium mining had been included with miscellaneous metals prior to 1960 but owing to its size, separate data have been shown for the last 3 years. Injury experience at these mines has improved each year since 1960. The combined fatal and nonfatal injury-frequency rate of 38.37 was a 15-percent decrease from the rate in 1961. Employees averaged 241 workdays and worked 1,952 hours on 8-hour daily shifts during the year.

Miscellaneous Metals.—This group includes mines producing antimony, bauxite, beryl, chromite, cobalt, manganese, mercury, molybdenum, nickel, rare-earth metals, titanium, tungsten, and zircon. The safety record was less favorable and the combined fatal and nonfatal injury-frequency rate was 50.34, a 7-percent advance over that of 1961. The average employee worked a total of 2,001 hours on an 8-hour daily shift. Active mine days averaged 250, 6 days fewer than reported in 1961.

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

Industry and year	Men working daily	Average active mine days	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries: Fatal	Number of injuries: Nonfatal	Injury rate per million man-hours
Copper:							
1953-57 (average)	16,956	301	5,099	40,713	26	1,310	32.82
1958	14,972	261	3,912	31,295	20	911	29.75
1959	14,201	232	3,289	26,382	16	714	27.67
1960	16,077	275	4,421	35,388	17	828	23.88
1961	15,661	285	4,460	35,790	13	893	25.31
1962 [1]	15,360	281	4,322	34,578	15	896	26.35
Gold placer:							
1953-57 (average)	1,806	208	375	3,073	1	136	44.59
1958	1,793	172	309	2,549	1	120	47.48
1959	1,648	160	263	2,200	1	109	50.01
1960	1,224	165	202	1,688	2	68	41.47
1961	1,178	157	185	1,518	1	76	50.72
1962 [1]	758	154	117	975	----------	34	34.86
Gold-silver:							
1953-57 (average)	3,032	261	791	6,321	6	512	81.95
1958	3,687	248	914	7,306	2	304	41.88
1959	3,592	246	885	7,076	8	339	49.04
1960	3,669	236	865	6,928	4	221	32.48
1961	3,833	230	883	7,058	3	289	41.38
1962 [1]	3,213	248	796	6,376	8	227	36.86
Iron:							
1953-57 (average)	27,228	245	6,667	53,458	16	792	15.11
1958	21,382	206	4,411	35,374	14	432	12.61
1959	22,099	179	3,966	31,823	14	482	15.59
1960	21,170	242	5,131	41,158	16	610	15.21
1961	17,251	224	3,868	31,027	10	449	14.79
1962 [1]	16,010	235	3,763	30,375	9	452	15.18
Lead-zinc:							
1953-57 (average)	11,746	254	2,989	23,912	20	1,601	67.79
1958	8,298	244	2,023	16,160	19	834	52.79
1959	7,665	253	1,939	15,515	10	869	56.65
1960	8,137	227	1,845	14,750	12	959	65.83
1961	7,510	243	1,829	14,628	7	1,167	80.26
1962 [1]	6,661	248	1,655	13,237	9	909	69.35
Uranium: [2]							
1960	7,329	233	1,710	13,832	32	862	64.63
1961	5,965	245	1,461	11,811	11	525	45.38
1962 [1]	5,568	241	1,341	10,867	13	404	38.37
Miscellaneous:							
1953-57 (average)	7,434	246	1,827	14,649	14	1,054	72.90
1958	9,476	221	2,094	16,840	14	898	54.16
1959	9,352	231	2,161	17,580	24	768	45.05
1960	2,989	246	736	5,908	1	246	41.81
1961	2,853	256	730	5,846	5	270	47.04
1962 [1] [3]	2,839	250	709	5,681	7	279	50.34
Total: [4]							
1953-57 (average)	68,202	260	17,747	142,126	83	5,405	38.61
1958	59,608	229	13,665	109,523	70	3,499	32.59
1959	58,557	214	12,503	100,576	73	3,281	33.35
1960	60,595	246	14,910	119,653	84	3,794	32.41
1961	54,251	247	13,416	107,678	50	3,669	34.54
1962 [1]	50,409	252	12,704	102,090	61	3,201	31.95

[1] Preliminary figures.
[2] Uranium included with miscellaneous metals before 1960. Formerly classed as uranium-vanadium and included with miscellaneous metals. These plants are now classed as uranium.
[3] Includes antimony, bauxite, beryl, manganese, mercury, nickel, rate-earths and titanium.
[4] Data may not add to totals shown because of rounding.

NONMETAL MINES (EXCEPT STONE QUARRIES)

Nonmetal mines include those producing abrasives, asbestos, barite, boron minerals, clay, feldspar, fluorspar, gypsum, magnesite, mica, phosphate rock, potash, pumice, salt, sodium, sulfur, talc, soapstone, and pyrophyllite, and other miscellaneous nonmetals. The injury-frequency rate (fatal and nonfatal combined) increased 20 percent more than that of 1961 in the nonmetal mine group; the average days active were higher. The work shifts averaged 8.2 hours in both years. The 16,156 men employed in 1962 worked an average of 1,961 hours; 18,281 men worked an average of 1,943 hours in 1961.

These data include operations for extracting brines and other materials from wells, operations required for solar evaporation processes, Frasch sulfur operations, and operations in the salt and other saline mineral industries. These well and brine operations were excluded from the figures used in the report to Congress prepared under the provisions of the act of September 26, 1961, Public Law 87–300 (75 Stat. 649).

Nonmetal Mills.—Injury experience in mills processing nonmetallic minerals improved in 1962. The combined fatal and nonfatal injury-frequency rate was lower, 19.78 in 1962 compared with 20.09 in 1961. The mills were active 253 days and averaged an 8.2-hour shift.

The data on nonmetal mills, like those for the nonmetal mines, include operations processing materials from well and brine plants, which had not been included in the compilations for the aforementioned report to Congress.

Clay Mines and Mills.—The principal industrial clays are kaolin (china clay), bentonite, fuller's earth, ball clay, and fire clay.

As indicated in the accompanying table, the safety record at clay mines was less favorable than in 1961. Injuries occurred at clay mines at a frequency of 29.00 per million man-hours, or a 39-percent increase. However, at clay mills the safety record was improved, and the rate of occurrence of all injuries decreased 12 percent from 1961 to 23.93 per million man-hours in 1962.

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

Year	Men working daily	Average active mine days	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rate per million man-hours
					Fatal	Nonfatal	
1953-57 (average)	14,719	273	4,014	32,597	15	1,136	35.31
1958	17,820	239	4,258	34,648	15	955	28.00
1959	18,765	239	4,488	36,334	11	1,072	29.81
1960	18,653	242	4,515	36,805	19	1,056	29.21
1961	18,281	238	4,347	35,517	15	861	24.66
1962 [2]	16,156	240	3,879	31,681	14	924	29.61

[1] Includes abrasives, asbestos, barite, boron minerals, clay, feldspar, fluorspar, gypsum, magnesite, mica, phosphate rock, potash, pumice, salt, sodium, sulfur, talc, soapstone, and pyrophyllite, and other miscellaneous nonmetals.
[2] Preliminary figures.

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

Year	Men working daily	Average active mill days	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rate per million man-hours
					Fatal	Nonfatal	
1958	32,401	272	8,809	71,161	9	1,490	21.06
1959	40,800	274	11,195	90,706	11	2,156	23.89
1960	39,568	270	10,679	86,386	13	1,794	20.92
1961	39,031	268	10,471	83,925	6	1,680	20.09
1962 [1]	30,565	253	7,742	63,662	9	1,250	19.78

[1] Preliminary figures.

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

Year	Men working daily	Average active days	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rate per million man-hours
					Fatal	Nonfatal	
Mine:							
1958	5,890	193	1,134	9,277	6	322	35.36
1959	5,914	191	1,132	9,184	5	271	30.05
1960	6,209	192	1,193	9,638	5	272	28.73
1961	5,896	194	1,144	9,220	3	189	20.83
1962 [1]	5,222	186	970	7,829	1	226	29.00
Mill:							
1958	16,530	255	4,221	34,096	5	896	26.43
1959	20,142	252	5,084	41,170	7	1,267	30.94
1960	20,222	247	4,991	40,784	6	1,121	27.63
1961	20,532	247	5,068	40,593	2	1,107	27.32
1962 [1]	16,463	233	3,838	31,555	3	752	23.93

[1] Preliminary figures.

SAND AND GRAVEL PLANTS

The safety record of reporting sand and gravel operations retrogressed in 1962. The combined fatal and nonfatal injury-frequency rate of 21.87 per million man-hours of worktime increased 21 percent which was higher than any year since data were first compiled in 1958. The plants were active an average of 213 days, and each employee averaged 1,836 hours of work in 1962.

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

Year	Men working daily	Average active plant days	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rate per million man-hours
					Fatal	Nonfatal	
1958	51,122	211	10,763	92,456	25	1,698	18.64
1959	59,492	(1)	(1)	109,830	21	2,161	19.87
1960	52,352	(1)	(1)	95,749	25	1,919	20.30
1961	55,726	217	12,117	101,707	21	1,814	18.04
1962 [2]	39,700	213	8,456	72,890	52	1,542	21.87

[1] Data not available.
[2] Preliminary figures.

SLAG (IRON BLAST-FURNACE) PLANTS

Final data on slag plants shows declines from 1961 of 13 percent for both the number of men working and the number of man-hours worked. No fatal injuries have been reported in this industry for 3 consecutive years, and number of nonfatal injuries decreased by one. However, owing to the decreased worktime, the injury-frequency rate increased to 9.91 percent in 1962, from 8.93 in 1961. Each employee worked an average of 2,002 hours during the year.

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

Year	Men working daily	Average active plant days	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rate per million man-hours
					Fatal	Nonfatal	
1958	1,882	248	467	3,776	1	43	11.65
1959	1,789	254	455	3,681	1	43	11.95
1960	1,680	(1)	(1)	3,613	----------	34	9.41
1961	1,682	246	415	3,361	----------	30	8.93
1962	1,462	248	362	2,927	----------	29	9.91

1 Data not available.

METALLURGICAL PLANTS

Metallurgical plants (ore-dressing and primary nonferrous reduction and refinery plants) in 1962 reported an improved safety record. The overall injury-frequency rate of 11.51 was 5 percent lower than the rate reported for 1961. The average employee worked a 7.9-hour daily shift for a total of 2,495 hours, a decline of 1 percent from 1961.

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

Year	Men working daily	Average active plant days	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rate per million man-hours
					Fatal	Nonfatal	
1953–57 (average)	59,663	318	18,988	151,479	16	2,584	17.16
1958	52,109	302	15,733	125,773	12	1,698	13.60
1959	55,655	289	16,095	128,913	11	1,305	10.21
1960	58,689	309	18,149	145,210	12	1,482	10.29
1961	56,065	315	17,669	141,415	9	1,705	12.12
1962 1	47,319	314	14,855	118,073	23	1,336	11.51

1 Preliminary figures.

ORE-DRESSING PLANTS

Ore-dressing plants process metal-bearing ores by various methods such as crushing, screening, washing, jigging, magnetic separation, flotation, and other milling operations. A 13-percent increase was reported in the combined fatal and nonfatal injury-frequency rate over the rate of the preceding year. Gold-silver and lead-zinc plants had reported no fatalities when these data were compiled. The average employee worked a total of 2,390 hours on a daily 8-hour shift.

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

Industry and year	Men working daily	Average active mill days	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rate per million man-hours
					Fatal	Nonfatal	
Copper:							
1953-57 (average)	6,665	323	2,152	17,260	2	231	13.50
1958	6,468	283	1,828	14,618	1	140	9.65
1959	5,588	250	1,394	11,156		82	7.35
1960	5,255	314	1,648	13,188	3	111	8.64
1961	5,688	317	1,804	14,434		106	7.34
1962 [1]	6,134	326	1,997	15,980	7	127	8.39
Gold-silver:							
1953-57 (average)	424	289	123	981		32	32.63
1958	399	255	102	814		25	30.71
1959	410	270	111	888		18	20.26
1960	253	286	72	580		2	3.45
1961	343	241	83	659		12	18.22
1962 [1]	342	255	87	701		30	42.80
Iron:							
1953-57 (average)	4,596	247	1,133	9,124	2	83	9.32
1958	5,857	246	1,441	11,536	2	60	5.37
1959	6,324	196	1,240	10,035	1	56	5.68
1960	6,413	258	1,653	13,320		79	5.93
1961	5,515	266	1,468	11,777	3	65	5.77
1962 [1]	4,864	283	1,375	10,221	3	91	9.20
Lead-zinc:							
1953-57 (average)	3,531	250	883	7,086	1	139	19.76
1958	2,380	260	618	4,945		50	10.11
1959	1,659	259	430	3,435	1	51	15.14
1960	1,614	258	416	3,336		70	20.98
1961	1,322	241	319	2,554		76	29.76
1962 [1]	1,690	256	432	3,460		54	15.61
Uranium: [2]							
1960	2,578	321	826	6,610	1	138	21.03
1961	2,481	312	775	6,222		95	15.27
1962 [1]	2,186	303	661	5,340	2	87	16.67
Alumina (includes bauxite):							
1960	5,104	332	1,697	13,574		43	3.17
1961	3,749	353	1,322	10,583		54	5.10
1962	(5)	(5)	(5)	(5)	(5)	(5)	(5)
Miscellaneous metals:							
1953-57 (average)	4,245	305	1,293	10,350	2	290	28.21
1958	4,573	270	1,236	9,886		192	19.42
1959	5,442	300	1,632	13,107	3	146	11.37
1960	1,312	287	377	3,031	1	45	15.18
1961	1,420	292	415	3,324		50	15.04
1962 [1 3]	3,553	322	1,144	9,157	2	69	7.75
Total: [4]							
1953-57 (average)	19,462	287	5,584	44,801	7	775	17.45
1958	19,677	266	5,225	41,799	3	467	11.24
1959	19,423	248	4,808	38,621	5	353	9.27
1960	22,529	297	6,689	53,638	5	488	9.19
1961	20,518	301	6,186	49,552	3	458	9.30
1962 [1]	18,769	304	5,697	44,859	14	458	10.52

[1] Preliminary figures.
[2] Formerly classed as uranium-vanadium and included with miscellaneous metals. These plants are now classed as uranium.
[3] Includes antimony, beryl, manganese, mercury, molybdenum, nickel, rare-earths and titanium.
[4] Data may not add to total shown because of rounding.
[5] Included with miscellaneous metals.

NONFERROUS REDUCTION PLANTS AND REFINERIES

Nonferrous reduction plants and refineries are engaged in the primary extraction of nonferrous metals from ores and concentrates and the refining of crude primary nonferrous metals. There was an improvement in injury experience as measured by the combined fatal and nonfatal injury-frequency rate of 12.12 which was 11 percent below the 1961 rate. Workers averaged 2,564 hours of employment on an 8.0-hour daily shift.

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

Industry and year	Men working daily	Average active smelter days	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rate per million man-hours
					Fatal	Nonfatal	
Copper:							
1953-57 (average)	11,626	317	3,687	29,600	3	380	12.94
1958	10,801	312	3,370	26,966	4	426	15.95
1959	11,204	262	2,939	23,516	4	230	9.95
1960	11,805	313	3,693	29,445	3	370	12.67
1961	11,414	329	3,750	29,999	3	420	14.10
1962 [1]	11,075	328	3,634	29,051	5	358	12.50
Lead:							
1953-57 (average)	3,543	303	1,075	8,599	2	117	13.84
1958	2,999	297	890	7,120	2	118	16.85
1959	3,090	226	698	5,585	1	129	23.28
1960	2,782	267	742	5,939	1	103	17.51
1961	2,493	300	747	5,975	----------	116	19.41
1962 [1]	2,244	285	639	5,116	2	72	14.47
Zinc:							
1953-57 (average)	9,308	336	3,127	24,894	2	695	28.00
1958	7,323	322	2,361	18,891	2	379	20.17
1959	7,243	327	2,370	18,951	----------	361	19.05
1960	7,392	293	2,169	17,354	2	279	16.19
1961	6,518	328	2,138	17,107	2	360	21.16
1962 [1]	6,588	328	2,158	17,246	----------	277	16.06
Aluminum: [2]							
1960	12,630	346	4,365	34,920	1	214	6.16
1961	13,408	326	4,371	34,966	1	331	9.50
1962 [1]	7,203	318	2,292	18,325	2	150	8.29
Miscellaneous metals:							
1953-57 (average)	15,723	351	5,515	43,585	2	618	14.23
1958	11,309	344	3,886	30,998	1	308	9.97
1959	14,695	359	5,280	42,239	1	232	5.52
1960	1,551	315	489	3,913	----------	28	7.16
1961	1,714	278	477	3,816	----------	20	5.24
1962 [1] [3]	1,440	302	435	3,476	----------	21	6.04
Total: [4]							
1953-57 (average)	40,201	333	13,404	106,678	9	1,809	17.04
1958	32,432	324	10,508	83,974	9	1,231	14.77
1959	36,232	312	11,287	90,291	6	952	10.61
1960	36,160	317	11,459	91,572	7	994	10.93
1961	35,547	323	11,483	91,862	6	1,247	13.64
1962 [1]	28,550	321	9,158	73,213	9	878	12.12

[1] Preliminary figures.
[2] Aluminum included with miscellaneous metals group before 1960.
[3] Includes antimony, magnesium, tin, and titanium.
[4] Data may not add to total shown because of rounding.

STONE QUARRIES

The general safety record of the stone industries improved. The overall injury-frequency rate (fatal and nonfatal combined) per million man-hours of worktime decreased 24 percent, from 22.38 in 1961 to 17.06 in 1962. Employees averaged 2,133 hours of worktime during the year.

Cement.—The combined fatal and nonfatal injury-frequency rate in quarries and mills increased from 3.91 in 1961 to 4.15 in 1962. The average man worked 2,446 hours in 1962, and 2,469 hours in 1961.

Granite.—The overall injury-frequency rate (fatal and nonfatal) declined 18 percent from 1961; the average hours worked per man decreased 1 percent, from 1,944 in 1961 to 1,929 in 1962.

Lime.—The lime industry's injury-frequency rate (fatal and nonfatal) was 18.01 per million man-hours of worktime; the rate was 17.75 in 1961. Employees worked an average of 2,316 hours which was approximately the same as the 1961 average of 2,331 hours.

Limestone.—The limestone industry reported a 26-percent decline in the overall injury-frequency rate, from 31.08 in 1961 to 22.93 in 1962. The average number of man-hours per man was 1,992, an increase of 3 percent; the man-hours per man in 1961 was 1,933.

Marble.—The combined injury-frequency rate in the marble industry was 44.72, 4 percent lower than the rate of 46.51 in 1961. The hours worked per man averaged 2,049, compared with 2,006 in 1961.

Sandstone.—The sandstone industry reported a 39-percent decline in the overall injury-frequency rate from 44.44 in 1961 to 26.93 in 1962. The average employee worked 1,720 hours, an increase of 2 percent over the 1,694 hours worked in 1961.

Slate.—The injury-frequency rate (fatal and nonfatal combined) for the slate industry declined 44 percent from the 1961 rate. The average number of hours worked per man was 2,054, approximately the same as the 2,034 hours worked in 1961.

Traprock.—The combined injury-frequency rate (fatal and nonfatal) in the traprock industry was 22.90, a 49-percent decrease from the 45.27 reported in 1961. The hours worked per man averaged 1,799, approximately the same as the 1,823 in 1961.

Miscellaneous Stone.—The combined injury-frequency rates were 20.37 in 1961 and 22.79 in 1962, an increase of 12 percent. Employees worked an average of 1,570 hours in 1962, a 3-percent decrease from the 1,613 hours averaged in 1961.

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

Industry and year	Men working daily	Average active mine days	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries: Fatal	Number of injuries: Nonfatal	Injury rate per million man-hours
Cement: [1]							
1953–57 (average)	28,575	323	9,230	73,817	11	318	4.46
1958	29,908	296	8,864	70,910	9	297	4.32
1959	28,253	(2)	(2)	71,261	7	339	4.86
1960	28,837	(2)	(2)	70,846	5	334	4.79
1961	27,028	308	8,336	66,732	2	259	3.91
1962 [3]	25,293	306	7,732	61,866	8	249	4.15
Granite:							
1953–57 (average)	6,449	241	1,553	12,878	5	514	40.30
1958	7,522	242	1,824	14,590	4	708	48.80
1959	8,512	(2)	(2)	18,003	3	717	39.99
1960	8,532	(2)	(2)	16,563	2	551	33.39
1961	8,329	234	1,949	16,192	4	547	34.03
1962 [3]	7,138	228	1,627	13,769	7	376	27.82
Lime: [1]							
1953–57 (average)	8,565	291	2,489	20,004	5	454	22.95
1958	6,948	292	2,027	16,216	1	354	21.89
1959	7,800	(2)	(2)	18,686	7	354	19.32
1960	8,295	(2)	(2)	20,036	8	372	18.97
1961	8,485	291	2,466	19,775	3	348	17.75
1962 [3]	7,121	288	2,050	16,489	4	293	18.01
Limestone:							
1953–57 (average)	26,714	235	6,268	52,671	19	1,813	34.78
1958	29,649	245	7,266	58,128	23	2,026	35.25
1959	31,939	(2)	(2)	63,184	26	2,060	33.01
1960	33,453	(2)	(2)	66,250	13	2,072	31.47
1961	31,923	229	7,322	61,717	15	1,903	31.08
1962 [3]	28,795	232	6,679	57,356	33	1,282	22.93
Marble:							
1953–57 (average)	2,581	253	652	5,406	1	182	33.85
1958	3,126	246	771	6,164	1	219	35.69
1959	3,071	(2)	(2)	6,432	----------	269	41.82
1960	3,093	(2)	(2)	6,457	2	308	48.01
1961	3,119	245	765	6,257	2	289	46.51
1962 [3]	2,706	248	672	5,546	3	245	44.72
Sandstone:							
1953–57 (average)	3,510	231	811	6,623	1	317	48.02
1958	3,504	215	752	6,017	1	281	46.87
1959	3,788	(2)	(2)	6,692	2	286	43.04
1960	4,701	(2)	(2)	7,770	3	374	48.52
1961	4,370	206	900	7,404	2	327	44.44
1962 [3]	3,390	206	698	5,831	2	155	26.93
Slate:							
1953–57 (average)	1,508	257	388	3,222	1	164	51.21
1958	1,429	255	364	2,915	----------	128	43.91
1959	1,403	(2)	(2)	2,842	1	152	53.84
1960	1,273	(2)	(2)	2,451	----------	117	47.74
1961	1,160	251	292	2,359	----------	135	57.22
1962 [3]	1,222	244	298	2,510	3	77	31.88
Traprock:							
1953–57 (average)	2,970	222	659	5,726	3	241	42.61
1958	4,130	230	950	7,597	6	331	44.36
1959	4,808	(2)	(2)	8,746	3	443	50.99
1960	5,207	(2)	(2)	8,835	4	411	46.97
1961	4,979	220	1,097	9,079	4	407	45.27
1962 [3]	3,762	215	808	6,768	4	151	22.90
Miscellaneous stone: [4]							
1957–61 (average)	1,744	209	364	3,082	1	127	41.53
1962 [3]	1,258	193	243	1,974	1	44	22.79
Total: [5]							
1953–57 (average)	81,002	273	22,082	180,609	47	4,012	22.47
1958	88,448	264	23,353	186,821	45	4,572	24.71
1959	91,523	(2)	(2)	199,321	52	4,790	24.29
1960	95,304	(2)	(2)	202,366	39	4,668	23.26
1961	91,371	257	23,524	192,705	32	4,280	22.38
1962 [3]	80,685	258	20,807	172,109	65	2,872	17.06

[1] Includes burning or calcining and other mill operations.
[2] Data not available.
[3] Preliminary figures.
[4] Not compiled before 1957.
[5] Data may not add to total shown because of rounding.

Abrasive Materials

By James D. Cooper[1] and Gertrude E. Tucker[2]

Contents

COMBINED tonnage of natural abrasive materials sold or used in the United States in 1962 was 10 percent greater than that of 1961 and value was 9 percent higher. Production of crude artificial abrasives in the United States and Canada was up 14 percent in volume and 9 percent in value. Value of grinding-wheel sales increased 13 percent, and the value of coated-abrasives sales was up 10 percent. The value of imports and reexports declined, while the value of exports increased.

TABLE 1.—Salient abrasive statistics in the United States

Kind	1953–57 (average)	1958	1959	1960	1961	1962
Natural abrasives (domestic) sold or used by producers:						
Tripoli ... short tons	[1] 48,463	47,044	52,968	57,713	54,641	61,732
Value ... thousands	[1] $203	$183	$219	$247	$225	$244
Special silica-stone products [2] ... short tons	6,196	4,023	3,672	2,539	2,495	2,653
Value ... thousands	$396	$305	$315	$241	$238	$260
Garnet ... short tons	11,225	12,303	14,568	10,522	12,057	14,166
Value ... thousands	$1,061	$869	$1,211	$986	$1,036	$1,172
Emery ... short tons	11,020	7,687	8,555	8,169	6,180	4,316
Value ... thousands	$157	$126	$150	$142	$106	$71
Artificial abrasives [3] ... short tons	443,144	334,483	417,569	441,508	372,192	423,412
Value ... thousands	$53,385	$48,806	$62,928	$64,594	$54,937	$59,854
Foreign trade (natural and artificial abrasives):						
Imports for consumption (value) ... thousands	$84,913	$60,733	$91,560	$84,488	$96,219	$79,473
Exports (value) ... do	$23,721	$22,469	$23,100	$26,550	[4] $29,209	$32,757
Reexports (value) ... do	[5] $7,291	$12,964	$13,700	$10,409	$17,814	$11,454

[1] Average for 1955–57.
[2] See table 6 for kind of products.
[3] Production of silicon carbide and aluminum oxide (United States and Canada); shipments of metallic abrasives (United States).
[4] Revised figure.
[5] Average for 1954–57.

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

FOREIGN TRADE [3]

The value of imports declined 17 percent in 1962, owing to much lower deliveries of industrial diamond stones. Combined imports of crushing bort and diamond dust and powder increased substantially in quantity and value, as did imports of most other natural abrasive materials. Value for total imports of artificial abrasives remained at the 1961 level.

Exports of abrasive materials increased 12 percent in value compared with those of 1961. The largest increases were recorded for diamond, aluminum oxide, and coated paper and cloth made with artificial abrasives. Reexports declined 36 percent, owing almost entirely to much lower reexports of industrial diamond.

TABLE 2.—U.S. imports for consumption of abrasive materials (natural and artificial), by kinds

Kind	1961		1962	
	Quantity	Value	Quantity	Value
Burrstones: Bound up into millstones......short tons..			7	$943
Hones, oilstones, and whetstones..............number..	[1] 233,465	[1] $68,288	244,717	61,042
Corundum (including emery):				
Corundum ore..............................short tons..	2,396	54,856	2,430	57,326
Emery ore..do....	1,120	10,000	2,240	19,500
Grains, ground, pulverized, or refined..........do....	16	3,744	873	169,271
Paper and cloth coated with sand, emery, or corundum..............................	(2)	1,251,633	(2)	1,576,429
Wheels, files, and other manufactures of emery or garnet, and wheels of corundum or silicon carbide short tons..	185	232,539	(2)	304,520
Tripoli, rottenstone, diatomaceous earth, and burrstones, in blocks, unmanufactured........short tons..			8,145	10,025
Diamonds:				
Diamond dies, pierced or partially pierced, mounted or unmounted..................number..	10,422	178,247	21,111	161,452
Crushing bort (including all types of bort suitable for crushing)..............................carats..	5,065,021	13,010,244	2,644,408	6,995,489
Other industrial diamonds (including glaziers' and engravers' diamonds, unset, and miners') carats..	8,395,771	53,308,869	5,068,185	31,898,675
Carbonado and ballas...........................do....	1,947	30,195	12,601	77,171
Dust and powder..................................do....	746,707	2,195,799	4,555,949	12,069,050
Flint, flints, and flintstones, unground.......short tons..	[1] 12,148	[1] 287,441	12,619	271,403
Grit, shot, and sand, of iron and steel..............do....	1,353	576,996	1,579	730,691
Artificial abrasives:				
Crude, not separately provided for:				
Carbides of silicon (Carborundum, Crystalon, Carbolon, and Electrolon)........short tons..	73,727	10,826,925	57,766	7,761,545
Aluminous abrasives, Alundum, Aloxite, Exolon, and Lionite..............short tons..	124,143	13,549,098	150,154	15,452,298
Other..do....	128	16,700	16	173
Manufactures:				
Grains, ground, pulverized, refined, or manufactured..............................short tons..	2,181	545,322	7,807	1,764,967
Wheels, files, and other manufactures, not separately provided for............short tons..	76	72,565	(2)	91,221
Total..		[1] 96,219,461		79,473,191

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

Source: Bureau of the Census.

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

TABLE 3.—U.S. exports of abrasive materials, by kinds

Kind	1961		1962	
	Quantity	Value	Quantity	Value
Natural abrasives:				
Diamond grinding wheels, sticks, hones, and laps carats	285,425	$1,708,151	310,330	$1,990,352
Diamond dust and powder do	490,327	1,356,574	828,611	2,225,256
Diamond suitable only for industrial use do	475,211	1,822,383	715,042	2,268,859
Grindstones and pulpstones short tons	123	45,966	127	53,283
Emery powder, grains, and grits (natural) pounds	2,319,019	202,775	1,637,188	178,411
Corundum grains and grits (natural) do	191,870	50,923	218,792	55,124
Whetstones, sticks, etc. (natural) do	199,716	161,810	171,338	156,102
Natural abrasives not elsewhere classified do	22,712,491	1,297,121	21,421,364	1,177,537
Manufactured abrasives:				
Aluminum oxide, fused, crude, and grains do	23,576,230	3,441,468	27,053,672	4,419,868
Silicon carbide, fused, crude, and grains do	24,462,739	4,058,367	20,450,190	3,641,249
Alumina, unfused do	173,021	87,465	297,176	85,815
Manufactured abrasives, not elsewhere classified do	290,212	80,503	357,344	107,565
Abrasive pastes, compounds, and cake (except chemical) do	680,839	180,773	872,352	216,282
Grinding wheels, except diamond wheels do	[1] 3,567,852	[1] 4,389,759	3,324,180	4,379,086
Pulpstones of manufactured abrasives do	3,322,701	866,126	2,832,176	789,957
Whetstones, etc., of manufactured abrasives do	407,066	1,067,113	384,774	1,041,594
Abrasive paper and cloth (natural abrasives) reams	32,347	685,231	29,943	662,730
Abrasive paper and cloth (artificial abrasives) do	182,384	6,427,814	231,614	8,048,156
Metallic abrasives (except steel wool) pounds	15,478,787	1,278,764	15,823,291	1,260,075
Total		[1] 29,209,086		32,757,301

[1] Revised figure.

Source: Bureau of the Census.

TABLE 4.—U.S. reexports of abrasive materials, by kinds

Kind	1961		1962	
	Quantity	Value	Quantity	Value
Natural abrasives:				
Diamond grinding wheels, sticks, hones, and laps carats	1,077	$22,426	658	$8,429
Diamond dust and powder do	55,733	190,659	75,426	216,215
Diamond suitable only for industrial use do	2,601,349	17,582,881	1,965,021	11,213,091
Emery powder, grains, and grits (natural) pounds			8,400	754
Manufactured abrasives:				
Aluminum oxide, fused, crude, and grains do	37,182	6,891	5,102	884
Grinding wheels, except diamond wheels do	4,015	8,406	3,832	11,923
Abrasive paper and cloth (natural abrasives) reams	20	2,320		
Abrasive paper and cloth (artificial abrasives) do			8	326
Whetstones, etc., of manufactured abrasives pounds	58	562	139	1,897
Total		17,814,145		11,453,519

Source: Bureau of the Census

TRIPOLI [4]

For reporting purposes, the name *tripoli* is used as a general term to include tripoli from the Missouri-Oklahoma field, amorphous or soft silica from southern Illinois, and rottenstone from Pennsylvania. Although they differ in some respects, all are fine grained, porous silica materials with many similar properties and end uses. Production of crude domestic tripoli increased 13 percent in volume and 8 percent in value over that of 1961. Sales of processed tripoli increased 8 percent in quantity and 10 percent in value. Approximately 73 percent of the processed tripoli was sold for abrasive uses, compared with 71 percent in 1961.

In 1962, five companies mined and processed tripoli, amorphous silica, and rottenstone: Ozark Minerals Co., Elco, Ill. (amorphous silica); Tamms Industries Co., Tamms, Ill. (amorphous silica); American Tripoli Division, The Carborundum Co., Seneca, Mo., and Ottawa County, Okla. (tripoli); Penn Paint & Filler Co., Antes Fort, Pa. (rottenstone); and Keystone Filler & Manufacturing Co., Muncy, Pa. (rottenstone).

Prices for processed tripoli remained unchanged from 1961 according to quotations in E&MJ Metal and Mineral Markets. They were as follows (per pound, paper bags, minimum carlot 30 tons, f.o.b. Missouri): Once-ground through 40-mesh, rose- and cream-colored, 2.5 to 2.75 cents; double-ground through 110-mesh, rose- and cream-colored, 2.6 to 2.75 cents; and air-floated through 200-mesh, 2.75 to 3 cents.

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

Year	Abrasives		Filler		Other, including foundry facings		Total	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1953–57 (average)	30,656	$1,211	7,554	$176	[3] 4,271	[3] $149	42,481	$1,536
1958	29,994	1,257	7,385	178	4,778	159	42,157	1,594
1959	34,389	1,527	8,199	192	5,061	169	47,649	1,888
1960	37,050	1,589	9,590	206	5,258	167	51,898	1,962
1961	34,581	1,472	9,409	231	4,605	149	48,595	1,852
1962	38,241	1,641	9,578	252	4,863	152	52,682	2,045

[1] Includes amorphous silica and Pennsylvania rottenstone.
[2] Partly estimated.
[3] Includes some tripoli for filter block in 1955.

SPECIAL SILICA-STONE PRODUCTS

Grindstone sales were reported from Ohio; grinding pebbles from Minnesota, Washington, and Wisconsin; tube-mill liners from Minnesota; natural silica abrasive material for oilstones and other sharp-

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

ening stones from Arkansas and Indiana; and millstones from North Carolina.

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

Year	Grindstones		Grinding pebbles		Other products [1]		Total	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1953–57 (average)	2,330	$175	2,581	$81	1,285	$140	6,196	$396
1958	852	83	1,985	97	1,186	125	4,023	305
1959	1,081	101	1,695	82	896	132	3,672	315
1960	(2)	(2)	1,132	66	1,407	175	2,539	241
1961	(2)	(2)	(2)	(2)	2,495	238	2,495	238
1962	(2)	(2)	(2)	(2)	2,653	260	2,653	260

[1] Includes grindstones (1960–62), oilstones, and other sharpening stones (1953–62), value of millstones (1953–62), tube-mill liners (1953–62), and grinding pebbles (1961–62).
[2] Included with "Other products" to avoid disclosing individual company confidential data.

NATURAL SILICATE ABRASIVES

Garnet.—Sales of domestic garnet increased 17 percent in quantity and 13 percent in value over those of 1961. The principal use of the material from New York was as an abrasive grain for making coated abrasives. Idaho garnet was used in sandblasting. There were six producers in 1962: Idaho Garnet Abrasive Co. and Emerald Creek Garnet Milling Co., Fernwood, Idaho; Porter Brothers Corp., Valley County, Idaho; J. R. Simplot Co., Boise, Idaho; Barton Mines Corp., North Creek, N.Y.; and Cabot Corp., Willsboro, N.Y.

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

Year	Short tons	Value (thousands)	Year	Short tons	Value (thousands)
1953–57 (average)	11,225	$1,061	1960	10,522	$986
1958	12,303	869	1961	12,057	1,036
1959	14,568	1,211	1962	14,166	1,172

NATURAL ALUMINA ABRASIVES

Corundum.—There was no reported production of corundum in the United States or Canada in 1962. Imports were 1 percent greater in quantity and 5 percent greater in value than in 1961. The principal uses were as abrasive grains and powders for optical grinding and in lapping compounds.

The results of drilling, trenching, and evaluating the Monteagle deposit in Hastings County, Ontario, were reported. Commercial minerals amenable to concentration include nepheline, corundum, and mica.[5]

[5] Moyd, Louis, Pauline Moyd, and H. L. Noblitt. The Monteagle Nepheline-Corundum-Mica Deposit, Hastings County, Ontario. Canadian Min. and Met. Bull., v. 50, No. 604, August 1962, pp. 563–570.

TABLE 8.—World production of corundum by countries[1] [2]

(Short tons)

Country [1]	1953-57 (average)	1958	1959	1960	1961	1962
Argentina	30					
Australia	2					
India	410	435	236	276	363	332
Malaya, Federation of	[3] 21					
Mozambique	2					
Rhodesia and Nyasaland, Federation of:						
Nyasaland	8					
Southern Rhodesia	2,783	4,593	2,799	3,843	2,792	3,348
South Africa, Republic of	1,550	2,118	622	123	159	349
World total (estimate) [1] [2]	9,700	11,000	8,000	9,000	8,000	9,000

[1] Corundum is produced in the U.S.S.R., data on production are not available, and estimate is included in the total.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Exports.

Compiled by Liela S. Price, Division of Foreign Activities.

Emery.—Sales of domestic emery declined 30 percent in volume and 33 percent in value from sales in 1961. Principal uses were in coated abrasives and grinding wheels and in nonskid cements for surfacing floors, stairs, and pavements. Imports of emery doubled, and the value increased 95 percent.

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

Year	Short tons	Value (thousands)	Year	Short tons	Value (thousands)
1953-57 (average)	11 020	$157	1960	8,169	$142
1958	7,687	126	1961	6,180	106
1959	8,555	150	1962	4,316	71

INDUSTRIAL DIAMOND

Imports of crushing bort decreased 48 percent in 1962, but the decrease was more than offset by a fivefold increase in imports of diamond dust and powder. These materials are identical in most respects other than size and have similar end uses, and consequently, fluctuation of quantities imported is not significant. However, since the imports of dust and powder have become an important factor in recent years, table 10, showing U.S. imports for consumption of industrial diamonds, has been revised to include them. The only item of diamond imports now excluded from the table is diamond dies.

Production of manufactured diamond grit suitable for use in grinding wheels and saws was estimated to be in excess of 4 million carats in 1962. There were two firms producing this material on a commercial scale—General Electric Co., at Detroit, Mich., and Ultra High Pressure Units, Ltd., at Springs, near Johannesburg, Republic of South Africa. Commercial production was scheduled to start in Ireland and in the U.S.S.R. in 1963.

TABLE 10.—U.S. imports for consumption of industrial diamond[1] (excluding diamond dies)

(Thousand carats and thousand dollars)

Year	Quantity	Value	Year	Quantity	Value
1953–57 (average)	14, 324	$57, 771	1960	13, 146	$51, 836
1958	10, 069	39, 116	1961	14, 210	68, 545
1959	13, 094	62, 626	1962	12, 281	51, 040

[1] Revised to include imports of diamond dust and powder.

Source: Bureau of the Census.

TABLE 11.—U.S. imports for consumption of industrial diamond (including diamond dust), by countries

Year and country	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
1961:								
North America:								
Bahamas			200	$557				
Canada	124, 428	$354, 218	584, 257	3, 376, 771			8, 941	$18, 750
Mexico			201	5, 245				
Total	124, 428	354, 218	584, 658	3, 382, 573			8, 941	18, 750
South America:								
Brazil			115, 901	1, 933, 694	105	$2, 111		
British Guiana			1, 680	20, 452				
Venezuela			25, 231	473, 612				
Total			142, 812	2, 427, 758	105	2, 111		
Europe:								
Belgium-Luxembourg	6, 028	32, 339	2, 131, 579	13, 707, 995			38, 806	119, 151
France			46, 215	610, 507				
Germany, West			394, 382	4, 723, 563				
Ireland			99, 903	432, 439				
Netherlands	8, 026	28, 482	437, 196	3, 785, 096			36, 636	101, 310
Spain							100	320
Switzerland			11, 147	96, 320				
United Kingdom	2, 051, 819	5, 062, 335	3, 828, 067	20, 765, 228	1, 842	28, 084	31, 212	99, 797
Total	2, 065, 873	5, 123, 156	6, 948, 489	44, 121, 148	1, 842	28, 084	106, 754	320, 578
Asia:								
Israel			4, 654	33, 590			1, 880	5, 452
Japan			3, 448	41, 099				
Total			8, 102	74, 689			1, 880	5, 452
Africa:								
Congo, Republic of the, and Ruanda-Urundi	3, 100	9, 586	87, 150	424, 742			14, 150	43, 738
Ghana			56, 126	430, 191				
Union of South Africa	2, 871, 620	7, 523, 284	556, 178	2, 196, 816			614, 982	1, 807, 281
Western Africa, n.e.c.			7, 066	236, 890				
Total	2, 874, 720	7, 532, 870	706, 520	3, 288, 639			629, 132	1, 851, 019
Oceania: Australia			5, 190	14, 062				
Grand total	5, 065, 021	13, 010, 244	8, 395, 771	53, 308, 869	1, 947	30, 195	746, 707	2, 195, 799
1962:								
North America:								
Canada	56, 813	151, 460	158, 566	761, 090			4, 753	10, 410
Mexico			5, 917	474				
Total	56, 813	151, 460	164, 483	761, 564			4, 753	10, 410

TABLE 11.—U.S. imports for consumption of industrial diamond (including diamond dust), by countries—Continued

Year and country	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
1962—Continued								
South America:								
Brazil			86,340	$920,139	1,344	$14,656		
British Guiana			1,640	35,544				
Chile			500	2,000				
Venezuela	2,571	$7,099	38,630	341,123				
Total	2,571	7,099	127,110	1,298,806	1,344	14,656		
Europe:								
Belgium-Luxembourg	4,444	11,998	319,876	2,017,442			41,404	$115,161
France	40,460	77,683	7,694	54,039	49	198	300	690
Germany, West			40,553	281,285				
Ireland			309,739	1,584,323			400	1,031
Malta, Gozo			120	1,439				
Netherlands	3,000	7,950	55,904	471,381			32,538	89,703
Switzerland	227	851	12,782	116,941			4,739	12,960
United Kingdom	1,520,126	3,927,954	625,235	4,892,428	570	12,013	646,245	1,732,927
Total	1,568,257	4,026,436	1,371,903	9,419,278	619	12.211	725,626	1,952,472
Asia:								
Israel			8,388	142,271			3,315	9,614
Japan	1,363	19,645	4,515	73,888			100	470
Total	1,363	19,645	12,903	216,159			3,415	10,084
Africa:								
British East Africa and Tanganyika			1,106	7,753				
British West Africa and Sierra Leone	46,052	128,134	220,834	1,558,856				
Congo, Republic of the, and Ruanda-Urundi	175,980	460,957	497,823	2,132,674			294,918	801,852
Ghana	10,059	27,571	830,323	4,228,881			17,449	49,949
Liberia	17,397	48,171	181,715	1,456,574				
Nigeria, Federation of	834	3,000	1,044	31,000				
Portuguese West Africa, n.e.c			2,358	13,173				
South Africa, Republic of	694,194	1,893,884	1,191,785	7,616,098			3,508,608	9,237,624
Western Africa, n.e.c	59,190	183,955	387,201	2,343,729	2,905	13,245	55	490
Western Equatorial Africa, n.e.c	11,698	45,177	77,597	814,130	7,733	37,059	553,	5,069
Total	1,015,404	2,790,849	3,391,786	20,202,868	10,638	50,304	3,821,583	10,094.984
Oceania: Australia							572	1,100
Grand total	2,644,408	6,995,489	5,068,185	31,898,675	12,601	77,171	4,555,949	12,069,050

Source: Bureau of the Census.

World Review.—*Africa.*—Société Israelo-Centralafricaine de Diamants was established in the Central African Republic in May 1962 to purchase hand-mined raw diamonds for resale on the world market, with Israel having preference as a buyer. Capitalization of the new organization was approximtely US$40,000.[6]

Cessation of mining in the Tshikapa diamond field in southwest Kasai Province, Republic of the Congo, was announced by Société Internationale Forestiere et Miniere du Congo (Forminière) in February 1962. A buying agency was maintained in the area to purchase diamonds from native miners.[7]

[6] Bureau of Mines. Mineral Trade Notes. V. 55, No. 4, October 1962, p. 12.
[7] Bureau of Mines. Mineral Trade Notes. V. 54, No. 5, May 1962, p. 10.

TABLE 12.—World production of natural industrial diamond, by countries

(Thousand carats)

Country	1961	1962[1]
Africa:		
Angola	460	380
Central African Republic	70	185
Republic of the Congo	17,740	14,400
Congo (ex French)[2 3 4]	------	3,300
Republic of Ghana	[5] 2,560	2,580
Republic of Guinea[3]	730	210
Republic of Ivory Coast	330	182
Sierra Leone[3 6]	[5] 1,997	1,880
South-West Africa	90	227
Tanganyika	345	324
South Africa, Republic of:		
"Pipe" mines:		
Premier	1,200	1,260
De Beers Group	760	750
Others	80	84
"Alluvial" mines	160	190
Total Africa	[5] 26,522	25,952
Other areas:		
Brazil[3]	175	175
British Guiana	45	40
Venezuela	73	83
Australia, Borneo, India, and U.S.S.R.[3]	420	425
World total[3]	[5] 27,200	26,700

[1] Prepared jointly by the Bureau of Mines and Dr. George Switzer, Smithsonian Institution.
[2] Exports.
[3] Estimate.
[4] Probable origin, Republic of the Congo.
[5] Revised figure.
[6] Includes unofficial production of Liberia.

An aerial magnetic survey was made in the Makongonia diamond area of Gabon in 1961 by the French Bureau of Geological and Mineral Research, and geophysical ground surveying was scheduled for 1962. Mining operations in the area ceased in 1957 because of uneconomical operations.[8]

Changes in the Ghana diamond marketing regulations were announced near the end of 1962. Under the new executive instrument the Ghana Diamond Marketing Board was established to purchase all diamond produced. The board was given powers, subject to approval of the Minister of Finance and Trade, to control and fix prices paid to producers and to appoint and license buying agents to purchase diamonds from the board. Buyers in the Accra market were to be relicensed to purchase from the board.[9]

Exclusive prospecting rights were granted to the Government of Israel for two large areas of the Ivory Coast. Similar rights for several private companies were under consideration for other areas with the exception of Seguela, which was reserved for a new Government corporation created in January 1962.[10]

Expansion of the treatment plant at the Premier mine in Transvaal, Republic of South Africa, was completed at a total cost of US$7 million. The combined production from retreatment of old mine

[8] Bureau of Mines. Mineral Trade Notes. V. 55, No. 1, July 1962, p. 12.
[9] Bureau of Mines. Mineral Trade Notes. V. 56, No. 4, April 1963, pp. 14–15.
[10] Bureau of Mines. Mineral Trade Notes. V. 54, No. 6, June 1962, p. 37.

dumps and from blueground mined was expected to be 2.5 million carats per year.[11]

New diamond finds were reported in the Postmasburg area near Kimberley [12] and in Griqualand West.[13]

The first mining barge for recovery of diamond from the seabed off the South-West Africa coast was launched in April 1962. The barge (CCC77), is the first of five units planned for eventual treatment of 90,000 tons of gravel and recovery of about 75,000 carats of diamond per month.[14] Full-scale operation of the barge began in August 1962 60 miles north of the mouth of the Orange River, and according to reports, the first 5 days of round-the-clock operation produced 2,100 stones,[15] weighing 1,038 carats.[16]

Diamond prospecting in Namaqualand, South-West Africa, was spurred by the reopening of the Komaggas diamond fields, which were closed by the Government about 35 years ago. Over 200 applications had been received by the end of 1962 for prospecting in an area of 380,000 acres.[17]

At the end of 1962, Alamasi Ltd., a subsidiary of Tanganyika Diamonds, Ltd., was disposing of its mining assets, excluding the Mara mine claims, to Williamson Diamonds Ltd. for about US$225,000.[18]

Other Areas.—Brazil.—A new diamond occurrence was reported in the State of Mato Grosso at Chapada dos Guemarees.[19] Drilling and test pitting at two diamondiferous areas in Brazil was conducted by Pato Consolidated Gold Dredging Co., a Canadian firm.[20]

Canada.—Prospecting for diamond deposits was conducted in northern Ontario along the Ontario Northland Railway. The prospecting license was to run for 3 years and called for expenditure of a minimum of Can$65,000 in that period. The license was originally issued to a Canadian consulting firm, but it was later taken over by a subsidiary of De Beers Consolidated Mines, Ltd.[21]

U.S.S.R.—According to reports, development effort was diverted from the Mirny diamond field to a new area in the Sokhsolookh River Valley.[22] Diamond-gold placers of the Vishera River basin in Perm, northwest Urals, were being exploited with a floating dredge.[23]

Technology.—Complete and authoritative data on the diamond industry in 1960 and 1961 were published. In addition to detailed statistical data on diamond production, imports, and exports, the report

[11] Engineering and Mining Journal. Premier Diamond Mine Expanded To Recover Industrial Diamond From Tailings Dumps. V. 163, No. 11, November 1962, pp. 114, 116.
[12] Engineering and Mining Journal. V. 163, No. 1, January 1962, p. 155.
[13] Investor's Guardian (London). V. 199, No. 6228, June 22, 1962 (incorporating The Mining World and Engineering Record. V. 178, No. 4569, June 22, 1962, p. 1448).
[14] Bureau of Mines. Mineral Trade Notes. V. 55, No. 1, July 1962, pp. 13–16.
[15] California Mining Journal. Africa Has a Floating Diamond Mine Located Sixty Miles at Sea. V. 32, No. 4, December 1962, p. 7.
[16] Engineering and Mining Journal. V. 163, No. 10, October 1962, pp. 128, 130.
[17] Mining Journal (London). V. 259, No. 6645, Dec. 28, 1962, p. 617.
[18] South African Mining and Engineering Journal (Johannesburg). "Tanks" To Sell to Williamson's. V. 73, pt. 2, No. 3645, Dec. 14, 1962, p. 1407.
[19] Mining Journal (London). V. 259, No. 6624, Aug. 3, 1962, p. 110.
[20] Mining Journal (London). V. 258, No. 6601, Feb. 23, 1962, p. 195.
[21] Northern Miner (Toronto). Seek Diamonds in N. Ontario. V. 47, No. 52, Mar. 22, 1962, pp. 1, 12.
Northern Miner (Toronto). De Beers Comes to Canada Looking for Diamonds. V. 48, No. 11, June 7, 1962, p. 16.
[22] South African Mining and Engineering Journal (Johannesburg). New Russian Diamond Field. V. 73, pt. 1, No. 3597, Jan. 12, 1962, p. 81.
[23] Mining Journal (London). V. 258, No. 6598, Feb. 2, 1962, p. 121.

contains information on new developments in the producing, marketing, and consuming industries throughout the world.[24]

Natural Diamond.—Methods of prospecting for kimberlite occurrences in Siberia were described. Visual, photographic, and magnetic methods were used in prospecting from the air, followed by ground studies of anomalies.[25]

Optical separation of diamond from waste rock, a process originally developed to check the efficiency of other diamond concentration processes, was developed into a production line device for use in final recovery plants.[26]

Data were presented on a newly designed diamond-impregnated drill bit, which reportedly incorporates the drilling advantages of oriented surface-set diamond with the economy of crushing bort. Bit costs were reduced from $4.80 to $0.82 per foot on a typical drilling project when the new impregnated bits were used. Surface-set bits averaged 20 feet total penetration as opposed to 170 feet for impregnated bits.[27]

A new type of diamond-drilling stone, produced by rounding and smoothing rough, angular diamonds, was made available. The new stones reportedly cut down significantly on friction and heat, which tend to break up diamond. When the new stones were used, drilling footage increased 50 percent and diamond loss decreased 70 percent over conventional bits at a gold mine in Orange Free State, Republic of South Africa.[28]

Diamond saws were used for cutting 88 miles of contraction and longitudinal joints in concrete runways at the Dulles International Airport at Chantilly, Va. The joints were 2 or 3 inches deep, depending on the thickness of the concrete, and one-fourth inch wide. Blade costs were estimated to average approximately $0.09 per foot.

Improvements were made in the use of diamond for the automatic truing and dressing of abrasive wheels,[29] and in high-speed machining of nonferrous metals [30] and ceramics.[31]

Revised standards were announced for submicron diamond powders. The standards were expected to result in more uniform products and to expand the use of the powders for fine grinding, lapping, and polishing.[32]

The use of diamond saws in the dimension stone industries of the United Kingdom and Italy was reported. The replacement of conventional stonecutting equipment with diamond-set circular and blade

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[24] Moyar, A., and E. Buxant. (The Diamond Industry in 1960–1961.) Vlaams Economisch Verbond, Antwerp, January 1963, 112 pp.

[25] Barygin, V.M. Poiski kimberlitovykh trubok aèrometodami (Prospectng for Kimberlite Pipes From the Air). Min. Mag. (London), v. 107, No. 2, August 1962, pp. 73–78.

[26] Mining Magazine (London). Optical Sorting of Diamonds. V. 106, No. 4, April 1962, pp. 246–248.

[27] Barrett, James L. Drilling Research Develops Low-Cost Diamond Bit. Eng. and Min. J., v. 163, No. 5, May 1962, pp. 87–88, 90–92.

[28] Engineering and Mining Journal. A New Kind of Diamond—DRL Produces Smooth, Rounded Stones for Better Bits. V. 163, No. 10, October 1962, pp. 82, 83.

[29] South African Mining and Engineering Journal (Johannesburg). Automatic Diamond Dressers Speed Grinding of Rod Bores. V. 73, pt. 1, No. 3620, June 22, 1962, p. 1386.

[30] South African Mining and Engineering Journal (Johannesburg). Non-Ferrous Metals Machined at High Speeds With Diamonds. V. 73, pt. 1, No. 3620, June 22, 1962, p. 1362.

[31] Ceramic Age. Diamond Wheel Cuts Costs at Raytheon. V. 78, No. 9, September 1962, p. 67.

[32] Steel. New Diamond Powder Standards. V. 150, No. 24, June 11, 1962, p. 12.

saws resulted in greatly increased production and lower production costs.[33]

Manufactured Diamond.—Three methods of diamond synthesis were described—explosive pressure with resultant high temperature; static ultrahigh pressure with induced high temperature; and high-temperature gas-solid reaction at low pressure. Interpretations of the growth mechanisms for direct conversion and crystallization from solutions were discussed in considerable detail. Some correlation of laboratory synthesis and natural diamond growth was included but with due respect to limitations posed by major conditions of natural diamond formation that cannot be duplicated in the laboratory.[34]

Studies were made of diamond and other reaction products from high pressure-high temperature diamond synthesis. Some metals and minerals could be incorporated in the diamond lattice structure while others could not, apparently depending on the cell dimensions, crystal habit, and stability of the nondiamond products.[35]

Diamond synthesis from carbon was accomplished for the first time by pressure and temperature alone, without the use of a catalyst, at the General Electric Research Laboratory, Schenectady, N.Y. Pressures of about 3 million pounds per square inch (psi) and temperatures around 5,000° C were attained during the transition from graphite to diamond. The results were obtained by subjecting graphite, already under high pressure, to heat and additional pressure, both supplied by discharging an electrical capacitor through the graphite. Of perhaps equal or greater significance was the development of an extremely valuable research tool that can be used to study other materials at these pressures and temperatures.[36]

A process utilizing temperatures and pressures lower than those currently used in commercial production of manufactured diamond was announced by Tokyo Shibaura Electric Co., Tokyo, Japan. The diamond crystals produced were about 0.1 millimeter in diameter. According to the company, the process, which requires about 130,000 psi and 800° C, could result in lower production costs and consequently, lower prices for manufactured diamond.[37]

Patents were issued on methods for growing larger diamond crystals [38] and for growing diamond on seed crystals at moderate pressure by contacting with carbon-containing gases.[39]

Field testing of manufactured diamond from the Republic of South Africa was conducted by a number of U.S. grinding wheel manufac-

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33 Industrial Diamond Review. Automation and Diamonds Modernize an Old Craft. V. 22 No. 255, February 1962, pp. 52–58.
Industrial Diamond Review. Diamond Saws Revolutionize Italian Marble Industry. V. 22, No. 265, December 1962, pp. 334–335.
Wood, D. B. Green Slate Machining Techniques. Ind. Diamond Rev., v. 22, No. 257, April 1962, pp. 116–121.

34 Giardini, A. A., and J. E. Tydings. Diamond Synthesis: Observations on the Mechanism of Formation. Am. Miner., v. 47, Nos. 11–12, November–December 1962, pp. 1393–1421.

35 Kohn, J. A., and D. W. Eckart. X-Ray Study of Synthetic Diamond and Associated Minerals. Am. Miner., v. 47, Nos. 11–12, November–December 1962, pp. 1422–1430.

36 General Electric Research Laboratory (Schenectady). Press Release of Sept. 7, 1962, 4 pp.

37 New Scientist (London). Easier Way To Make Diamonds. V. 15, No. 294, July 5, 1962, p. 29.

38 Bovenkerk, P. (assigned to General Electric Co.). Method of Diamond Growth and Apparatus Therefor. U.S. Pat. 3,031,269, Apr. 24, 1962.

39 Eversole, William G. (assigned to Union Carbide Corp.). Synthesis of Diamond. U.S. Pats. 3,030,187 and 3,030,188, Apr. 17, 1962.

turers. Tests previously made by the distributor indicated that the manufactured diamond was 20 to 60 percent more efficient than natural diamond in grinding with resin-bond wheels.[40]

ARTIFICIAL ABRASIVES

Production of crude artificial abrasives in the United States and Canada increased 14 percent in volume and 9 percent in value in 1962. Most of the crude abrasives produced in Canada were sent to the United States for processing. None was processed in Canada, although some of the processed grain was returned for use in grinding wheels and other manufactured abrasive products. Aluminum oxide output included 19,805 tons of white, high-purity material, valued at $3,109,725. Silicon carbide production was at 80 percent of capacity; aluminum oxide, 61 percent; and metallic abrasives, 35 percent. Nonabrasive uses accounted for 5 percent of the aluminum oxide and 36 percent of the silicon carbide.

Sales of graded abrasive grain of all types to domestic users increased 14 percent and sales to foreign users increased 10 percent. The value of grinding wheels sold by domestic producers was $172.7 million, up 13 percent from that of 1961. Of the total sales, vitrified wheels accounted for 44 percent; resin- and shellac-bonded wheels, 38 percent; rubber-bonded wheels, 5 percent; and all others, including diamond grinding wheels, 13 percent. Sales of coated abrasives totaled 2,426,766 reams valued at $126,578,940, an increase of 10 percent in quantity and value compared with sales in 1961. Aluminum oxide accounted for 42 percent of total sales based on number of reams sold, followed by silicon carbide, with 32 percent; garnet, 13 percent; flint, 10 percent; and emery, 3 percent. Glue bond was used on 61 percent of the coated abrasives; waterproof bonds, on 20 percent; and resin bonds, on 19 percent.

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

Year	Silicon carbide [1]		Aluminum oxide [1] (abrasive grade)		Metallic abrasives [2]		Total	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1953–57 (average)	84,909	$12,419	216,601	$23,825	141,634	$17,141	443,144	$53,385
1958	110,456	17,597	122,868	16,870	101,159	14,339	334,483	48,806
1959	132,458	21,987	158,392	22,072	126,719	18,869	417,569	62,928
1960	133,219	20,636	195,906	27,111	112,383	16,847	441,508	64,594
1961	125,726	20,078	136,951	18,735	109,515	16,124	372,192	54,937
1962	115,716	17,728	181,924	23,458	125,772	18,668	423,412	59,854

[1] Figures include material used for refractories and other nonabrasive purposes.
[2] Shipments from U.S. plants only.

Technology.—The first year's results of an abrasive research program at Cornell Aeronautical Laboratory, Inc., sponsored by the Abrasive Grain Association, were reported. The program, scheduled to run for a minimum of 5 years, was designed to obtain scientific data on the

[40] Metalworking News. Synthetic Diamond Grit by Engelhard Gets Field Tests. V. 3, No. 80, Apr. 16, 1962, p. 13.

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

Year and product	Manufactured		Sold or used		Stocks Dec. 31 (short tons)	Annual capacity (short tons)
	Short tons	Value (thousands)	Short tons	Value (thousands)		
1961:						
Chilled iron shot and grit	36,841	$3,849	35,494	$3,773	9,604	162,684
Annealed iron shot and grit	28,827	3,667	29,056	3,698	1,469	[1] 68,802
Other [2]	45,211	7,840	44,965	8,653	7,478	102,735
Total	110,879	15,356	109,515	16,124	[3] 18,551	265,419
1962:						
Chilled iron shot and grit	43,016	4,764	41,771	4,689	10,849	237,458
Annealed iron shot and grit	27,572	3,348	27,738	3,521	1,303	[1] 89,774
Other [2]	57,953	9,843	56,263	10,458	9,168	126,410
Total	128,541	17,955	125,772	18,668	21,320	363,868

[1] Included in capacity of chilled iron shot and grit.
[2] Mostly steel shot and grit. Includes figures for cut wire shot and some other types of metallic abrasives that cannot be shown separately.
[3] Includes revisions in product detail.

properties of abrasives to replace or supplement empirical data commonly employed in the industry.[41]

A vacuum-molded, glass fiber, web-reinforced snagging wheel with improved metal removal rate was described. Special extruded alumina abrasive shapes used in the wheels were tailored to the job requirements.[42]

A rod-shaped abrasive made of calcined bauxite was tested in grinding wheels. Results indicated that the higher cost of the new material could be more than offset by longer wheel life and reduced power requirements.[43]

The extremely delicate control of abrasive cleaning with a fine air jet containing abrasive dust was demonstrated in exposing the details of a valuable fossilized skeleton of a prehistoric flying reptile. Specimens previously considered lost for study can now be rehabilitated.[44]

The concept of abrasive machining was described and its advantages over conventional machining methods were cited.[45]

The development and growth of the artificial abrasives industry in North America was reviewed, starting with the invention of silicon carbide and fused aluminum oxide, followed by establishment of production plants at Niagara Falls, N.Y., and then the subsequent migration to Canada to take advantage of lower power costs.[46]

Ceramographic and metallographic polishing techniques were discussed. Abrasives, methods, and time requirements were given for

[41] Bray, D. K. Why Does Abrasive Grain Cut. Grinding and Finishing. V. 8, No. 8, August 1962, p. 33.
[42] Steel. New Grinding Wheels Do More Work. V. 151, No. 1, July 2, 1962, pp. 62–63.
[43] Steel. Rodlike Abrasive Shapes Better Wheel Performance. V. 151, No. 18, Oct. 29, 1962, p. 39.
[44] Ingulli, Charles A. Abrasives Bare Bones of Flying Reptile. Grinding and Finishing, v. 8, No. 4, April 1962, pp. 42–44.
[45] Friedlander, Dan. Cutting Role of Abrasives Seen Rising. Metalworking News, v. 3, No. 82, Apr. 30, 1962, pp. 1, 12.
Mowry, W. W., and R. L. Smith. Abrasive Machining, A New Concept in Metalworking Economy. Grits and Grinds, v. 53, No. 3, April–May 1962, pp. 3–15.
[46] Anthes, L. B. The Synthetic Abrasives Industry in Canada. Canadian Min. and Met. Bull., v. 55, No. 601, May 1962, pp. 232–233.

grinding and polishing a number of polycrystalline ceramic materials, metals, and alloys for structure studies.[47]

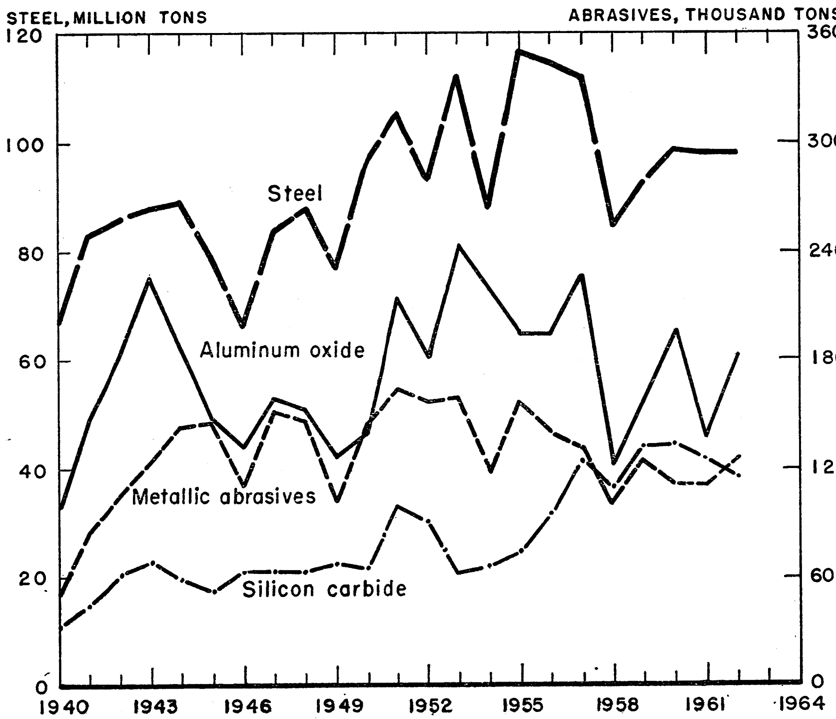

FIGURE 1.—Relationship between ingot steel and artificial abrasives production, 1940–62.

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

(Thousand short tons)

Year	Silicon carbide		Aluminum oxide		Metallic abrasives [1]	
	Stocks Dec. 31	Annual capacity	Stocks Dec. 31	Annual capacity	Stocks Dec. 31	Annual capacity
1953–57 (average)	16.3	120.1	34.0	283.6	14.8	249.3
1958	10.4	141.9	36.4	299.5	17.9	279.6
1959	10.6	142.0	29.2	299.5	16.2	265.3
1960	16.0	145.6	25.1	299.5	15.6	263.1
1961	14.7	145.7	23.2	299.5	[2] 18.6	265.4
1962	19.2	144.9	33.8	299.5	21.3	363.9

[1] United States only.
[2] Revised figure.

[47] Houle, M. C., and R. L. Coble. Ceramograpic Techniques: 1. Single Phase, Polycrystalline, Hard Materials. Am. Ceram. Soc. Bull., v. 41, No. 6, June 1962, pp. 378–381. Samuels, L. E. A Critical Comparison Between Mechanical and Electrolytic Methods of Metallographic Polishing. Metallurgia (Manchester, England), v. 66, No. 396, October 1962, pp. 187–199.

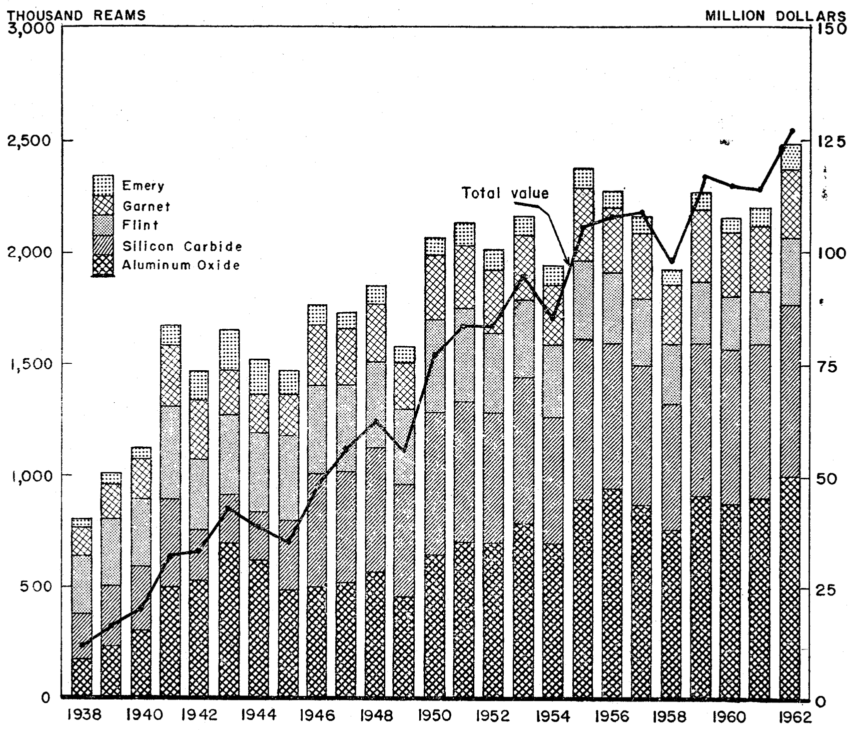

FIGURE 2.—Coated-abrasives industry in the United States, 1938–62.

MISCELLANEOUS MINERAL-ABRASIVE MATERIALS

In addition to the natural and artificial abrasive materials for which data are available, many other minerals were used for abrasive purposes. Oxides of tin, magnesium, iron, and cerium were used for polishing. Boron carbide and tungsten carbide were used as abrasives where extreme hardness was required. Finely ground and calcined clays, lime, talc, ground feldspar, river silt, slate flour, whiting, and other materials also were used as abrasives.

Aluminum

By Kenneth B. Higbie,[1] Clarke I. Wampler,[2] and Mary E. Trought[3]

DEMAND for aluminum rose steadily during 1962 throughout the industrialized countries of the world. More metal than ever before was produced and converted to a wider variety of shapes and forms for an ever-increasing number of commercial, scientific, and military applications.

Production of primary aluminum in the United States in 1962 reached a record high, 5 percent above the previous high in 1960. Shipments of U.S. metal exceeded production for the second year in a row; this resulted in yearend inventories equivalent to only a 24-day supply, based upon the rate of production for the month of December. Little change occurred in the domestic production capacity. U.S. firms were involved in constructing new production facilities abroad in conjunction with foreign investments. No changes in domestic capacity for production of superpure aluminum were announced during the year.

TABLE 1.—Salient aluminum statistics

(Thousand short tons and thousand dollars)

	1953-57 (average)	1958	1959	1960	1961	1962
United States:						
Primary production	1,521	1,566	1,954	2,014	1,904	2,118
Value	$683,183	$773,610	$955,190	$1,030,007	$949,768	$998,559
Price: Ingot, average cents per pound	24.0	26.9	26.9	26.0	25.5	23.9
Secondary recovery [1]	340	290	360	329	340	400
Imports for consumption (crude and semicrude)	273	293	302	196	255	373
Exports (crude and semicrude)	46	82	164	384	238	259
Consumption, apparent [2]	2,055	2,092	2,488	2,016	[3] 2,320	2,705
World: Production	3,355	3,865	4,480	4,985	[3] 5,210	5,555

[1] The 1953 data are recoverable aluminum-alloy content; data for subsequent years are recoverable aluminum content.
[2] Measured by quantity of primary sold or used plus secondary recovery and net imports.
[3] Revised figure.

LEGISLATION AND GOVERNMENT PROGRAMS

Harvey Aluminum, Inc., continued to ship aluminum ingot to the Government Defense Production Administration (DPA) inventory under a supply contract negotiated during 1950–52. Total metal

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.
[3] Commodity research assistant, Division of Minerals.

delivered was 20 percent less than that supplied during 1961. Quantities of aluminum metal in various Government stockpiles are given in the section on Stocks.

The Congress approved legislation to continue for 1 year the suspension of duties on imports of metal scrap, including principal types of scrap iron, steel, aluminum, magnesium, nickel, and nickel alloys. This suspension was to expire June 30, 1963. This duty had been suspended on an annual basis for each of the past 6 years.

The Justice Department charged that the Aluminum Company of America (Alcoa) violated the Clayton Antitrust Act in purchasing the Rome Cable Corp. Trial was held during February in the Federal Court in Utica, N.Y.; the court later ruled in favor of Alcoa. The Justice Department considered appealing the decision to the Supreme Court.[4]

TABLE 2.—Shipments of aluminum to the Government under aluminum supply contracts

(Short tons)

Year	Alcoa [1]	Kaiser [1]	Reynolds [2]	Harvey [3]	Total
1957	104,998	116,804	102,509		324,311
1958	97,497	95,272	130,359		323,128
1959			45,320	27,915	73,235
1960			[4] 34	36,968	37,002
1961				52,138	52,138
1962				41,544	41,544
Total	202,495	212,076	278,222	158,565	851,358

[1] Contract expired in 1958.
[2] Contract expired in 1959.
[3] Contract extended to expire in 1964.
[4] Shipment in December 1960 with respect to tenders made prior to 1960.

DOMESTIC PRODUCTION

PRIMARY

Domestic production of primary ingot reached an alltime high. The 2,118,000 short tons produced was 11 percent higher than the 1961 output and exceeded the previous record, set in 1960, by over 100,000 tons. Shipments, amounting to 2,185,000 tons, exceeded production for the second consecutive year. Inventories at yearend were only 68 percent of the stock figure at the beginning of the year and were equivalent to a 24-day supply, based on the rate of production for the month of December. During 1962, the industry operated at an average of 85 percent of installed capacity, with the highest quarterly rate, 87.4 percent, attained during the last quarter.

Consolidated Aluminum Corp., a subsidiary of Aluminium Industrie A.G., Zurich, Switzerland, announced plans to become the seventh producer of primary aluminum in the United States by constructing a $20 million reduction plant on a 240-acre tract on the Tennessee River, north of New Johnsonville, Tenn. Electric power for the new plant was to be supplied by the Tennessee Valley Authority,

[4] Iron Age. Court Rules Alcoa's Acquisition Is Legal. V. 191, No. 6, Feb. 7, 1963, p. 124.

and alumina was to be supplied by the Swiss parent company under a long-term contract. The initial capacity of 20,000 tons was to be expanded eventually to 250,000 tons. The smelter was scheduled for completion in 1963.

Early in 1962, Cerro Corp. and National Distillers & Chemical Corp. dropped plans to build a primary aluminum reduction plant in northwestern Oregon. Options on electrical power and land were allowed to expire. Overcapacity in the industry was cited as the reason for not completing the plans. However, Cerro Corp. formed a division, Cerro Aluminum Co., which initially expected to confine its activity to operating aluminum-sheet rolling mills and finishing facilities in Fairmont, W. Va. (formerly Fairmont Aluminum Co.) and in Los Angeles, Calif. (formerly United Pacific Aluminum Co.).

Alcoa announced modernization plans for its Badin, N.C., aluminum plant. Construction of a new potline to cost $20 million began in 1962. This potline would replace the facility built in 1949. The new facilities were to be completed in 12 to 18 months and would give the Badin plant a capacity of 51,000 tons of aluminum per year. Alcoa's Vancouver, Wash., reduction plant was scheduled for more ingot-casting equipment, alloying furnaces, and auxiliary finishing equipment. An additional unit for casting of direct-chill aluminum ingot was scheduled for Alcoa's Rockdale, Tex., works.

Alcoa also announced plans for the construction of a new plant at Warrick, Ind., that was intended to roll light-gage sheet for cans and other volume uses. The mill was to have an initial capacity of 60,000 tons and would be ready to operate in 19 to 24 months.

Ground was broken for Alcoa's new $30 million Technical Center. Construction of the campus-type project began with the headquarters building for the process development laboratories. Completion of the overall project was expected to take 10 years.

Kaiser Aluminum & Chemical Corp. announced a $6 million improvement program for its Mead reduction plant and Trentwood rolling mills, both near Spokane, Wash., early in the year. Projects for the Mead works included a new carbon-baking furnace and auxiliary equipment to enlarge capacity for the production of carbon anodes for the plant's reduction cells. Also to be expanded was the plant's capacity for casting special aluminum products. Later in 1962, Kaiser announced a $2 million expansion program at the Mead facility to provide additional carbon-anode-processing equipment and apparatus for preparing extrusion billets.

Kaiser began producing aluminum electrical transmission line cable at the former Dodge plant at San Leandro, Calif. The metals company bought the plant from Chrysler Corp. early in 1962.

In 1946, Kaiser began producing primary aluminum metal, and on June 25, 1962, it reached a total production of 5 million tons.

Kaiser began shipping molten aluminum from its Ravenswood, W. Va., reduction plant to the General Motors Corp. foundry at Defiance, Ohio, about 290 miles away. Each truck held 26,000 pounds of metal in two preheated crucibles. The temperature of the metal was 1,600°–1,700° F at the start and had dropped to around 1,400° F on arrival at the General Motors foundry.

The third and final potline at the newest Reynolds Metals plant in Massena, N.Y., was activated. The plant operated at 100,000-short-ton capacity for the first time since construction was completed 3 years ago.

Reynolds announced plans to build a $2 million plant at Torrance, Calif., to produce aluminum cans for tuna, oil, and beer. Other Reynolds projects included completion of new electrical wire and cable plant at Chester, Pa., construction of a foil printing plant at Torrance, Calif., and installation of foil rolling mills, 84 inches wide, in the Louisville and Richmond plants.

Reynolds concluded a 20-year lease with the Port of Longview, Wash., under which it was to install facilities to discharge alumina shipped from its Corpus Christi alumina plant.[5] Two tankers were being converted to handle alumina. Plans were announced to build a $2.5 million plant at Baton Rouge, La., to produce calcined coke for use in the firm's reduction plant.

Harvey Aluminum, Inc., announced plans to build a $50 million aluminum rolling mill near Lewisport, Ky. The 700,000-square-foot mill was expected to have a capacity of 60,000 tons of rolled products annually. New anodizing facilities capable of accommodating extrusions up to 32 feet long were added to the company's facilities at Torrance, Calif. The formerly Government-owned extrusion plant at Adrian, Mich., was purchased by Harvey in 1961, and placed in partial operation.

The $36 million aluminum rolling mill operated by Alroll Inc. at Oswego, N.Y., began operating during the last quarter. The mill, owned jointly by Scovill Manufacturing Co., Bridgeport Brass Co., Cerro Aluminum Co., and Aluminum Company of Canada, Ltd. (Alcan), had an initial capacity of 100,000 tons per year and converted aluminum ingot, purchased from Alcan into reroll stock.

Péchiney, Compagnie de Produits Chimiques et Electrométallurgiques, a French company rated as the largest primary aluminum producer in Western Europe, acquired approximately 40 percent of the outstanding stock of Howe Sound Co. This action provided Péchiney with an outlet for aluminum in the United States, because Howe Sound Co. owned Quaker State Metal Co., a fabricator of aluminum products in Lancaster, Pa.

A study of the primary aluminum industry of the Pacific Northwest was released by the Bureau of Mines.[6] The potential of the industry for expansion and increased stablilty of operation resulted from greater availability of power, lower freight rates on alumina and aluminum, good market prospects for the metal, and the possibility of developing bauxite deposits in the Pacific Northwest as well as other nearby mineral resources. This study was followed by a review of the aluminum fabrication industry in the Pacific Northwest.[7] The leading users of aluminum were manufacturers of building products (30 percent), airplanes and missiles (22 percent), and truck tractors,

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[5] Metal Bulletin. Reynolds Change to Seaborne Alumina. No. 4713, July 17, 1962, p. 25.

[6] Fulkerson, Frank B. Trends and Outlook in the Pacific Northwest Aluminum Industry. BuMines Inf. Circ. 8046, 1962, 42 pp.

[7] Fulkerson, Frank B. Aluminum Fabrication in the Pacific Northwest: An Economic Survey. BuMines Inf. Cir. 8123, 1962, 29 pp.

bodies, and trailers (17 percent). Foundries used 5 percent, and all others, 26 percent.

TABLE 3.—Production and shipments of primary aluminum in the United States[1]

(Short tons)

Quarter	1961		1962	
	Production	Shipments	Production	Shipments
First	452, 010	433, 601	505, 266	541, 585
Second	461, 271	491, 362	536, 992	575, 126
Third	491, 344	483, 406	528, 377	512, 711
Fourth	499, 086	547, 798	547, 294	555, 454
Total	1, 903, 711	1, 956, 167	2, 117, 929	2, 184, 876

[1] Quarterly production and shipments adjusted to final annual totals.

TABLE 4.—Actual and planned primary aluminum production capacity in the United States, by companies

(Short tons per year)

Company and plant	Capacity		
	Actual, end of 1962	Being built in 1962	Total, actual and planned
Aluminum Company of America:			
Alcoa, Tenn	157, 100		157, 100
Badin, N.C	47, 150		47, 150
Evansville, Ind	35, 000	140, 000	175, 000
Massena, N.Y	118, 000	32, 000	150, 000
Point Comfort, Tex	140, 000		140, 000
Rockdale, Tex	150, 000		150, 000
Vancouver, Wash	97, 500		97, 500
Wenatchee, Wash	108, 500		108, 500
Total	853, 250	172, 000	1, 025, 250
Reynolds Metals Co.:			
Arkadelphia, Ark	55, 000		55, 000
Jones Mills, Ark	109, 000		109, 000
Listerhill, Ala	190, 000		190, 000
Longview, Wash	60, 500		60, 500
Massena, N.Y	100, 000		100, 000
San Patricio, Tex	95, 000		95, 000
Troutdale, Oreg	91, 500		91, 500
Total	701, 000		701, 000
Kaiser Aluminum & Chemical Corp.:			
Chalmette, La	247, 500		247, 500
Mead, Wash	176, 000		176, 000
Ravenswood, W. Va	145, 000		145, 000
Tacoma, Wash	41, 000		41, 000
Total	609, 500		609, 500
Anaconda Aluminum Co.: Columbia Falls, Mont	65, 000		65, 000
Consolidated Aluminum Corp.: New Johnsonville, Tenn		20, 000	20, 000
Harvey Aluminum, Inc.: The Dalles, Oreg	75, 000		75, 000
Ormet Corp.: Hannibal, Ohio	180, 000		180, 000
Grand total	2, 483, 750	192, 000	2, 675, 750

SECONDARY

The secondary aluminum industry had its best year on record, recovering about 60,000 tons more metal than in 1961. According to reports received by the Bureau of Mines, domestic recovery of aluminum alloys (including all constituents) from 595,000 tons of nonferrous scrap totaled 495,000 tons. Recovery from new scrap was 352,000 tons, an increase of 25 percent. Recovery from old scrap and sweated pig increased to 143,000 tons, 8 percent more than in 1961. An additional 1,219 tons of aluminum was recovered from copper-base, zinc-base, and magnesium-base scrap. The value of 400,000 tons of aluminum recovered from processed scrap was $191 million, computed from the average price of primary aluminum ingot of 23.9 cents per pound.

Purchased aluminum-base scrap and sweated pig reported used by all consumers totaled 595,000 tons. Independent secondary smelters used 442,000 tons or 74 percent. Primary producers used 37,000 tons or 6 percent, fabricators used 86,000 tons or 15 percent, and foundries and other consumers used 30,000 tons or 5 percent.

The Bureau of Mines estimated that complete coverage of the industry would show a total scrap consumption of 700,000 tons and a secondary ingot production of 449,000 tons. Calculated aluminum recovery based on full coverage would total 469,000 tons, and the metallic aluminum-alloy recovery would total 582,000 tons.

Aluminum-alloy ingot production, as reported to the Bureau of Mines, totaled 384,000 tons, 30 percent more than in 1961. Data on remelt ingots excluded alloys produced from purchased scrap by the primary producers. Shipments of most casting alloys increased in 1962.

Data obtained through a Bureau of Mines canvass were combined with data made available to the Bureau by the Aluminum Smelters Research Institute, which covered the operations of its members. The combined coverage was estimated to represent about 85 percent of the secondary aluminum smelter industry.

Alloys & Chemical Corp. completed a plant for the production of master additive alloys containing titanium, titanium-boron, chromium, calcium, manganese, lithium, and the rare-earth elements. In preparing the master alloys, a very high purity aluminum was used to minimize the presence of other metal contaminents.

American Metal Climax, Inc. entered the aluminum industry through merger with Apex Smelting Co., and Kawneer Co. The latter two companies became divisions of American Metal Climax, Inc.

Wabash Smelting, Inc., completed a new 45,000-square-foot secondary aluminum smelting plant near Wabash, Ind. The facility had four large gas-fired reverberatory furnaces with capacity up to 60 tons. Productive capacity was approximately 4 million pounds per month.

A report covering the potential applications for the hydroelectric electric power to be produced by a dam on the Yukon River at Rampart, Alaska, was presented to Congress.[8] The aluminum industry was suggested as one of the possible consumers for the power. The Rampart Project would produce 31.1 billion kilowatt-hours per year upon reaching full capacity in 1990.

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[8] Chemical Engineering. Alaska Dam Would Spawn Power-Based Industries. V. 69, No. 20, Oct. 1, 1962, pp. 44–46.

TABLE 5.—Aluminum recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

Kind of scrap	1961	1962	Form of recovery	1961	1962
New scrap:			As metal	21,552	27,130
Aluminum-base	[1] 237,765	[2] 290,351	Aluminum alloys	316,396	370,059
Copper-base	55	42	In brass and bronze	142	131
Zinc-base	[3] 166	202	In zinc-base alloys	[3] 498	611
Magnesium-base	123	258	In magnesium alloys	330	292
			In chemical compounds	1,328	1,728
Total	[3] 238,109	290,853			
			Total	[3] 340,246	399,951
Old scrap:					
Aluminum-base	[1] 101,233	[2] 108,381			
Copper-base	87	89			
Zinc-base	[3] 442	443			
Magnesium-base	375	185			
Total	[3] 102,137	109,098			
Grand Total	[3] 340,246	399,951			

[1] Aluminum alloys recovered from aluminum-base scrap in 1961, including all constituents, amounted to 282,564 tons from new scrap and 133,400 tons from old scrap and sweated pig; total 415,964 tons.
[2] Aluminum alloys recovered from aluminum-base scrap in 1962, including all constituents, amounted to 351,869 tons from new scrap and 143,022 tons from old scrap and sweated pig; total 494,891 tons.
[3] Revised figure.

TABLE 6.—Stocks and consumption of new and old aluminum scrap and sweated pig in the United States in 1962 [1]

(Short tons, gross weight)

Class of consumer and type of scrap	Stocks, Jan. 1 [2]	Receipts	Consumption			Stocks, Dec. 31
			New scrap	Old scrap	Total	
Secondary smelters: [3]						
New scrap:						
Segregated 2S sheet and clips	538	7,289	7,316		7,316	511
Segregated 3S sheet and clips	657	9,681	9,757		9,757	581
Segregated 51S, 52S, 61S, etc., sheet and clips, less than 0.6 percent Cu	1,751	37,956	37,985		37,985	1,722
Segregated 14S, 17S, 24S, 25S, etc., sheet and clips, more than 0.6 percent Cu	191	8,429	8,097		8,097	523
Segregated 75S, 76S, 77S, 78S, 80S type sheet and clips, more than 0.6 percent Cu	1,163	6,338	7,034		7,034	467
Mixed low Cu clips, 0.6 percent maximum Cu	2,025	33,708	34,548		34,548	1,185
Mixed clips, more than 0.6 percent Cu	1,581	29,268	29,489		29,489	1,360
Cast scrap	342	6,384	6,460		6,460	266
Borings and turnings:						
Segregated 14S, 17S, 24S, 25S	202	12,058	12,084		12,084	176
Segregated 75S, 76S, 77S, 78S, 80S type	729	12,339	12,843		12,843	225
Segregated other	318	22,275	21,973		21,973	620
Mixed, Zn 1.0 percent maximum	1,260	30,469	30,464		30,464	1,265
Mixed, Zn over 1.0 percent	981	33,980	33,509		33,509	1,452
Dross and skimmings	5,306	62,562	62,893		62,893	4,975
Foil (includes both new and old)	332	1,899	1,941		1,941	290
Miscellaneous	576	6,921	7,195		7,195	302
Old scrap:						
Wire and cable	306	3,287		3,269	3,269	324
Pots and pans	672	18,980		19,114	19,114	538
Mixed alloy sheet	525	7,289		7,549	7,549	265
Aircraft	106	3,434		3,156	3,156	384
Castings and forgings	1,917	25,459		26,673	26,673	703
Pistons	432	4,218		4,507	4,507	143

See footnotes at end of table.

TABLE 6.—Stocks and consumption of new and old aluminum scrap and sweated pig in the United States in 1962—Continued

Class of consumer and type of scrap	Stocks, Jan. 1 [2]	Receipts	Consumption			Stocks, Dec. 31
			New scrap	Old scrap	Total	
Secondary smelters—Continued						
Old scrap—Continued						
Irony aluminum	630	10,937		10,955	10,955	612
Miscellaneous	1,054	8,329		8,555	8,555	828
Purchased pig	3,475	34,921		34,802	34,802	3,594
Total	27,069	438,410	323,588	118,580	442,168	23,311
Primary producers:						
New and old scrap:						
Segregated 2S sheet and clips	97	1,819	1,819		1,819	97
Segregated 3S sheet and clips	109	4,873	4,956		4,956	26
Segregated 51S, 52S, 61S, etc., sheet and clips, less than 0.6 percent Cu	247	12,739	12,800		12,800	186
Segregated 14S, 17S, 24S, 25S, etc., sheet and clips, more than 0.6 percent Cu	111	1,475	1,534		1,534	52
Segregated 75S, 76S, 77S, 78S, 80S type sheet and clips, more than 0.6 percent Cu	–16	1,808	1,759		1,759	33
Mixed low Cu clips—0.6 percent maximum Cu	61	1,471	1,491		1,491	41
Mixed clips, more than 0.6 percent Cu	0	16	16		16	0
Cast scrap	22	2,931	2,940		2,940	13
Borings and turnings:						
Segregated 14S, 17S, 24S, 25S	10	103	113		113	0
Segregated 75S, 76S, 77S, 78S, 80S type	7	39	46		46	0
Segregated other	43	231	262		262	12
Mixed, Zn 1.0 percent maximum	2	3	5		5	0
Mixed, Zn over 1.0 percent	12	–12	0		0	0
Dross and skimmings	0	25	0		0	25
Foil (includes both new and old)	163	3,305	3,422		3,422	46
Miscellaneous	67	4,545	4,443		4,443	169
Wire and cable	21	117		138	138	0
Miscellaneous	0	1		1	1	0
Purchased pig	0	775		775	775	0
Total	956	36,264	35,606	914	36,520	700
Foundries, fabricators, and chemical plants:						
New scrap:						
Segregated 2S sheet and clips	113	3,390	3,378		3,378	125
Segregated 3S sheet and clips	1,159	26,511	26,735		26,735	935
Segregated 51S, 52S, 61S, etc., sheet and clips, less than 0.6 percent Cu	80	8,788	8,537		8,537	331
Segregated 14S, 17S, 24S, 25S, etc., sheet and clips, more than 0.6 percent Cu	20	520	540		540	
Segregated 75S, 76S, 77S, 78S, 80S, type sheet and clips, more than 0.6 percent Cu	162	1,456	1,482		1,482	136
Mixed low Cu clips, 0.6 percent maximum Cu	660	8,318	8,671		8,671	307
Mixed clips, more than 0.6 percent Cu	571	1,377	1,664		1,664	284
Cast scrap	275	1,439	1,450		1,450	264
Borings and turnings:						
Segregated 14S, 17S, 24S 25S	0	45	45		45	0
Segregated other	0	301	222		222	79
Mixed, Zn 1.0 percent maximum	0	1,203	1,049		1,049	154
Mixed, Zn over 1.0 percent	0	3	3		3	0
Dross and skimmings	21	1,888	1,727		1,727	182
Foil (includes both new and old)	488	1,714	1,705		1,705	497
Miscellaneous	823	7,810	8,004		8,004	629

See footnotes at end of table.

TABLE 6.—Stocks and consumption of new and old aluminum scrap and sweated pig in the United States in 1962—Continued

Class of consumer and type of scrap	Stocks, Jan. 1[2]	Receipts	Consumption: New scrap	Consumption: Old scrap	Consumption: Total	Stocks, Dec. 31
Foundries, fabricators, and chemical plants—Continued						
Old scrap:						
Wire and cable	4	717	----------	716	716	5
Pots and pans	0	2	----------	2	2	0
Aircraft	0	5	----------	5	5	0
Castings and forgings	31	451	----------	448	448	34
Pistons	1	133	----------	133	133	1
Irony aluminum	1	509	----------	509	509	1
Miscellaneous	148	1,530	----------	1,256	1,256	422
Purchased pig	692	51,737	----------	47,904	47,904	4,525
Total	5,249	119.847	65.212	50,973	116,185	8,911
Grand total of all scrap consumed:						
New scrap:						
Segregated 2S sheet and clips	748	12,498	12,513	----------	12,513	733
Segregated 3S sheet and clips	1,925	41,065	41,448	----------	41,448	1,542
Segregated 51S, 52S, 61S, etc., sheet and clips, less than 0.6 percent Cu	2,078	59,483	59,322	----------	59,322	2,239
Segregated 14S, 17S, 24S, 25S, etc., sheet and clips, more than 0.6 percent Cu	322	10,424	10,171	----------	10,171	575
Segregated 75S, 76S, 77S, 78S, 80S type sheet and clips, more than 0.6 percent Cu	1,309	9,602	10,275	----------	10,275	636
Mixed low Cu clips, 0.6 percent maximum Cu	2,746	43,497	44,710	----------	44,710	1,533
Mixed clips, more than 0.6 percent Cu	2,152	30,661	31,169	----------	31,169	1,644
Cast scrap	639	10,754	10,850	----------	10,850	543
Borings and turnings:						
Segregated 14S, 17S, 24S, 25S	212	12,206	12,242	----------	12,242	176
Segregated 75S, 76S, 77S, 78S, 80S type	736	12,378	12,889	----------	12,889	225
Segregated other	361	22,807	22,457	----------	22,457	711
Mixed. Zn 1.0 percent maximum	1,262	31,675	31,518	----------	31,518	1,419
Mixed, Zn over 1.0 percent	993	33,971	33,512	----------	33,512	1,452
Dross and skimmings	5,327	64,475	64,620	----------	64,620	5,182
Foil (includes both new and old)	983	6,918	7,068	----------	7,068	833
Miscellaneous	1,466	19,276	19,642	----------	19,642	1,100
Old scrap:						
Wire and cable	331	4,121	----------	4,123	4,123	329
Pots and pans	672	18,982	----------	19,116	19,116	538
Mixed alloy sheet	525	7,289	----------	7,549	7,549	265
Aircraft	106	3,439	----------	3,161	3,161	384
Castings and forgings	1,948	25,910	----------	27,121	27,121	737
Pistons	433	4,351	----------	4,640	4,640	144
Irony aluminum	631	11,446	----------	11,464	11,464	613
Miscellaneous	1,202	9,860	----------	9,812	9,812	1,250
Purchased pig	4,167	87,433	----------	83,481	83,481	8,119
Total	33,274	594,521	424,406	170,467	594,873	32,922

[1] Includes imported scrap.
[2] Revised figure.
[3] Excludes secondary smelters owned by primary aluminum companies.

TABLE 7.—Production and shipments of secondary aluminum alloys, by independent smelters

(Short tons)[1]

Product	1961		1962	
	Production [2]	Shipments [3]	Production [2]	Shipments [3]
Pure aluminum (Al minimum, 97.0 percent)	21,552	21,188	27,130	26,868
Aluminum-silicon (maximum Cu, 0.6 percent):				
95/5 Al-Si, 356, etc. (0.6 percent Cu maximum)	11,130	10,364	16,211	15,885
13 percent Si, 360, etc. (0.6 percent Cu maximum)	23,006	23,573	32,112	31,629
Aluminum-silicon (Cu, 0.6 to 2 percent)	6,498	6,513	9,353	9,262
No. 12 and variations	4,033	4,136	4,061	4,130
Aluminum-copper (maximum Si, 1.5 percent)	1,404	1,379	1,327	1,402
No. 319 and variations	32,174	32,334	42,991	44,246
Nos. 122, 138	2,927	2,991	2,896	3,167
AXS-679 and variations	113,814	114,375	154,971	154,719
Aluminum-silicon-copper-nickel	16,106	16,146	19,719	19,446
Deoxidizing and other destructive uses:				
Grades 1 and 2	9,626	9,229	10,628	10,422
Grades 3 and 4	14,747	15,181	14,457	14,733
Aluminum-base hardeners	11,146	11,163	15,687	16,001
Aluminum-magnesium	1,441	1,556	1,812	1,624
Aluminum-zinc	5,093	4,614	5,065	5,292
Miscellaneous	20,279	20,901	25,225	24,461
Total	294,976	295,643	383,645	383,287

[1] Gross weight, including copper, silicon, and other alloying elements, at independent secondary smelters; total secondary aluminum and aluminum alloy ingot contained 10,294 tons primary aluminum in 1961 and 11,534 tons in 1962.
[2] No allowance was made for consumption by producing plants.
[3] No allowance was made for receipts by producing plants.

CONSUMPTION AND USES

An Aluminum Association survey compared overall shipments of aluminum and its products during the year. It was estimated that a total of 2,882,000 short tons of metal and products were shipped—compared with 2,464,500 tons in 1961.[9] For the entire year, 23 percent of the shipments went to the building products industry, 23 percent to transportation, 11 percent to consumer durables, 11 percent to electrical equipment, 7 percent to machinery and equipment, 7 percent to containers and packaging, and the remainder to other industries or exports. A review of the most important market applications for aluminum was released by the Aluminum Association.[10]

Aluminum played an increasingly important role in the plans of U.S. utility companies to reduce maintenance and erection costs of transmission line towers. A new $350 million high-voltage and power-plant project was announced by three companies of the Pennsylvania-New Jersey-Maryland interconnection, providing a pooling system for three large power producers.[11] The project involved 600 miles of new 500,000-volt transmission lines. The largest steel-reinforced aluminum conductor cable produced to date was fabricated to carry 2,820 amperes at 550,000 volts, direct-current.[12] The line had a diameter

[9] American Metal Market, Estimated End Use Distribution of Total Aluminum Industry Shipments. V. 70, No. 118, June 20, 1963, p. 13.
[10] The Aluminum Association. Expanding Markets for Aluminum. New York, 1962, 44 pp.
[11] American Metal Market. Huge Power Project Planned. V. 69, No. 222, Nov. 20, 1962, p. 12.
[12] Iron Age. Conductor Uses Two Metals. V. 190, No. 12, Sept. 20, 1962, p. 15.

of 2.375 inches and was composed of 5 layers of aluminum strands over 19 strands of steel core. Other transmission line construction projects employing aluminum metal were reviewed.[13]

The metal was useful in the following space applications: Satellite nose-cone containers; a single-wall 22-foot-diameter sphere for altitude simulation; nickel-coated aluminum mirrors utilized in a new lightweight all-metal telescope for missile and satellite tracking; an octagonally shaped Orbiting Astronomical Observatory; the 150 honeycomb doors on the Minuteman complex at the missile test center; the movable service enclosures for the stage IV Saturn bulkheads; and many other applications where lightweight, high-strength metal structures were required.

Missiles consumed large quantities of the lightweight metal. The Little Joe II launch vehicle was 85 percent aluminum with a gross deadweight of 10,000 pounds. Ultimate planned use of the Little Joe II was for suborbital testing of the Apollo spacecraft. Solid rocket propellent cases were made of aluminum combined with glass fiber resins. Use of the new case, combined with anticipated advances in rocket engine nozzle design, was expected to permit substitution of a single-stage rocket for the multistage configuration of certain types of missiles.

The skin for Project Echo's balloon satellite was aluminum foil only 0.00017 inch thick. The foil was laminated to both sides of a plastic film and constructed into 135-foot-diameter spheres, the total weight of which was 500 pounds.

The building and construction industry continued to be a major outlet for aluminum products. Aluminum metal pan forms mounted on rolling steel scaffolds were utilized as the basis for pouring concrete floors in multilevel buildings.[14] The portable forms enabled workmen to lay as much as 6,000 square feet of warehouse floor slab daily. Foil-backed gypsum board was developed as a lightweight wall material that would provide heat insulation characteristics and moisture vapor protection to structural elements of the wall.[15]

One of the most spectacular roofs ever built was an aluminum cover for the Coliseum at the Seattle World's Fair.[16] The roof was composed of 3,700 4- by 8-foot aluminum sandwich panels.

To accelerate the growth of aluminum in building, Alcoa formed an urban development company that planned to own five big-city housing projects. Among the applications of aluminum being tried in these projects was the use of aluminum in I-beams and girders, in frames for poured concrete, and in load-bearing curtain walls.[17]

Use of aluminum in the 1963 automobile models increased to slightly more than 70 pounds per vehicle, an average unit increase of about 3.5 pounds per unit.[18] Two car manufacturers, Chrysler Corp.,

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[13] Modern Metals. Aluminum's Popularity Growing in Transmission Line Program. V. 18, No. 2, March 1962, pp. 56, 58, 60, 61.

[14] Engineering News-Record. Aluminum Pans Aid Fast Casting. V. 168, No. 22, May 31, 1962, p. 70.

[15] Modern Metals. Foil Backed Gypsum New Vapor Barrier. V. 18, No. 2, March 1962, p. 89.

[16] Light Metal Age. World's Fair Roof. V. 19, Nos. 3–4, April 1962, p. 21.

[17] Chemical Engineering. Metal Makers Aim for New Uses. V. 70, No. 2, Jan. 21, 1963, p. 102.

[18] Light Metal Age. In 63—More Aluminum in Autos. V. 20, No. 9–10, December 1962, p. 17.

and General Motors Corp., Pontiac Division stopped casting aluminum motors for their compact models. The Chevrolet manufacturer saved 105 pounds per unit by converting from iron to aluminum for all automatic transmissions. All other General Motors Corp. passenger car divisions, except Buick, had turned to aluminum for their automatic transmission cases. About 80 percent of all grilles were made of aluminum. More than 50 percent of the U.S. automobiles in 1962 were finished with paints that contained aluminum pigments. It was estimated that aluminum-coated steel sheets were utilized to varying degrees in the exhaust systems of more than 90 percent of all 1962 model automobiles.[19] A survey of the use of mufflers made of this combination metal sheet indicated that failure was less than one-fourth that of plain steel units.

Perhaps the largest single application of aluminum in the industry's history was the 43 million pounds that was to be used in 1962 in the manufacture of U.S. Army M–113 armored personnel carriers.[20]

A 130–foot tower was fabricated from 200,000 pounds of aluminum for use at the joint Atomic Energy Commission-NASA Nuclear Rocket Development Station in the Jackass Flats Proving Grounds, Nev. The tower, constructed of 6061–T6 alloy up to 3 inches thick, was to be used in testing a new nuclear reactor rocket engine. Another type of tower, a 126-foot fractionation tower for an 800-ton-per-day oxygen plant, was made entirely of aluminum from plates claimed to be the largest ever rolled by the industry.[21] The plates were up to 10 feet wide by 46 feet long and up to 2 inches thick. The boiler section contained more than 60 miles of high-alloy aluminum tubing.

The 17.6-mile-long Chesapeake Bay Bridge-Tunnel was expected to contain 140,000 feet or 26.5 miles of aluminum bridge rail.[22] The railing system would utilize nearly 1.5 million pounds of aluminum castings, tube, and accessories.

Cooking utensils of teflon-coated aluminum became popular with housewives.[23] Another material, stainless steel clad aluminum sheet, was expected to have applications in the cooking utensil and small appliance field and in the automotive, aerospace, building, and chemical-processing industries.[24]

Aluminum barges were introduced to the water freight industry.[25] The barges, possessing the largest ship hulls ever constructed of aluminum, were to be used on the Mississippi River for transporting petrochemicals and solvents.

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[19] Steel. Aluminum Coated Sheets Gain as Heat, Dust Stoppers. V. 150, No. 18, April 30, 1962, pp. 123–125.

[20] Modern Metals. V. 18, No. 7, August 1962, p. 26.

[21] Chemical Engineering. Big Tower Readied for Huge Oxygen Plant. V. 69, No. 21, Oct. 15, 1962, p. 94.

[22] Modern Metals. Huge Bridge-Tunnel Span Will Have Aluminum Rail. V. 18, No. 3, April 1962, p. 92.

[23] Iron Age. Teflon Teams Up With Aluminum. V. 189, No. 16, Apr. 19, 1962, pp. 104–105.

[24] Steel. Stainless Clad Aluminum Shown for First Time. V. 150, No. 19, May 7, 1962, p. 25.

[25] Chemical and Engineering News. Aluminum Barge Enters Test Stage. V. 40, No. 5, Jan. 29, 1962, p. 55.

Aluminum captured more of the beer can market, with several brewing companies adopting aluminum ends on their beer cans. Other companies experimented with pull-tab tops and impact-extruded all-aluminum cans. As many as 30 breweries were reported to be using or planning to use aluminum at yearend. Reynolds predicted that 4 out of 10 beer cans would have aluminum tops by the end of 1962.

The lighter weight of aluminum pipe increased its use advantage over steel pipe in offshore drilling operations. The lightweight pipe increased the depth potential of a drilling rig.

A new type of foamed aluminum was developed that showed no significant damage when exposed to 2,700° F for 100 hours.[26] The foamed metal had from 3 to 50 percent of the theoretical density of aluminum and had pore sizes from 0.25 to 10 milliliters.

Aluminized plastic film was fabricated into a multilayer insulation that possessed a 2.4×10^{-5} of only thermal conductivity Btu per hour per square foot per degree F. per foot.[27] Although intended primarily for cryogenic applications, this type of material also was utilized for insulations at ordinary and high temperatures.

TABLE 8.—Apparent consumption of aluminum in the United States

(Short tons)

Year	Primary sold or used by producers [1]	Imports (net) [2]	Recovery from old scrap [3]	Recovery from new scrap [3]	Total apparent consumption
1953–57 (average)	1, 488, 219	226, 666	71, 887	267, 751	2, 054, 523
1958	1, 590, 978	211, 619	64, 127	225, 428	2, 092, 152
1959	1, 988, 560	139, 828	78, 006	281, 921	2, 488, 315
1960	1, 866, 251	−180, 057	62, 703	266, 747	2, 015, 644
1961	1, 956, 167	24, 004	[4] 102, 137	[4] 238, 109	[4] 2, 320, 417
1962	2, 184, 876	120, 402	109, 098	290, 853	2, 705, 229

[1] Includes shipments to the Government: 1957, 324,311 tons; 1958, 323, 128 tons; 1959, 73,235 tons; 1960 37,002 tons; 1961, 52,138 tons; 1962, 41,544 tons.
[2] Crude and semicrude. Includes ingot equivalent of scrap imports and exports (weight multiplied by 0.9). Includes some shipments to Government stockpiles: Figures not available.
[3] The 1953 data are recoverable aluminum-alloy content; data for subsequent years are recoverable aluminum content.
[4] Revised figure.

[26] Iron Age. Aluminum Foam at 2,700° F. V. 189, No. 16, Apr. 19, 1962, p. 91.
[27] Fabian, Robert J. Two New Super Insulations. Mat. in Design Eng., V. 55, No. 5, May 1962, pp. 101–105.

The following distribution for wrought products was obtained from the figures published by the Bureau of the Census:

	Percent 1961	Percent 1962
Plate, sheet, and foil:		
Non-heat-treatable	37.6	38.6
Heat-treatable	7.0	6.3
Foil	8.1	7.8
Rolled rod, bar, and wire:		
Rod, bar, etc	[1] 3.0	3.6
Bare wire, conductor and nonconductor	1.6	1.4
Bare cable (including steel-reinforced)	7.0	6.7
Wire and cable, insulated or covered	2.0	2.0
Extruded shapes:		
Alloys other than 2000 and 7000 series	26.4	[1] 25.7
Alloys in 2000 and 7000 series	1.5	1.6
Tubing:		
Drawn	1.9	2.0
Welded, non-heat-treatable [2]	1.1	1.1
Powder, flake, and paste:		
Atomized	.4	.6
Flaked	.2	.1
Paste	.5	.4
Forgings (including impact extrusions)	1.7	2.1
Total	100.0	100.0

[1] Includes a small amount of rolled structural shapes.
[2] Includes a small amount of heat-treatable welded tube.

TABLE 9.—Net shipments [1] of aluminum wrought and cast products by producers

(Short tons)

	1961	1962
Wrought products:		
Plate, sheet, and foil	881,968	1,004,146
Rolled structural shapes, rod, bar, and wire	227,418	260,721
Extruded shapes, rod, bar, tube blooms, and tubing	[2] 516,997	579,268
Powder, flake, and paste	17,942	21,841
Forgings	28,224	39,684
Total	[2] 1,672,549	1,905,660
Castings:		
Sand	62,311	73,366
Permanent mold	[2] 130,933	147,348
Die	[2] 187,948	240,717
Other	(3)	(3)
Total	380,910	463,414
Grand total	[2] 2,053,459	2,369,074

[1] Net shipments are total shipments less shipments to other metal mills for further fabrication.
[2] Revised figure.
[3] Figure withheld because estimates did not meet publication standards of the Bureau of the Census because of the associated standard error.

Source: Bureau of the Census.

STOCKS

The amount of aluminum metal in the national (strategic) stockpile on December 31, was 1,127,000 short tons. An additional 843,000 tons was in the DPA inventory. Thus, a total of 1,970,000 tons was available for governmental use—770,000 tons or 64 percent in excess of the estimated maximum objective required to meet essential needs in a limited war or in a general war of 3-year duration. There was an order at yearend for 49,000 tons of metal to be added to the DPA inventory.

Inventories of aluminum ingot at primary reduction plants declined from 207,100 tons on January 1 to 140,100 tons on December 31. Stocks decreased each month until September. Based on the December production rate, closing 1962 stocks were equal to 24 days of output. In addition to the primary aluminum stocks reported, reduction plants also had inventories of ingot and aluminum in process.

Secondary alloy inventories increased from a low of 22,400 tons to 26,400 tons on June 30, declined in July, reached a high of 27,500 tons on August 31, and then declined each succeeding month to a yearend total of 23,600 tons.

Aluminum-base-scrap inventories at the yearend totaled 32,900 tons, slightly below stocks at the beginning of 1962. Month-end stocks were high from February through November and the highest months were March, April, May, and October. Consumers' yearend inventories of scrap represented approximately a 21-day supply, based on the December consumption rate.

PRICES

The published domestic market price for unalloyed primary aluminum ingot remained unchanged through November at 24 cents per pound. The price was reduced to 22.5 cents per pound on December 3. The lower price was equal to the sales price of domestic and Canadian metal to European customers and prevailed since February.

The price of superpure (99.99 percent) aluminum was 43.50 cents per pound throughout most of the year. According to the American Metal Market, effective December 3, the price ranged from 42.00 cents to 43.50 cents per pound. On December 14, the price stabilized and was quoted at 42.00 cents for the remainder of the year.

Prices for aluminum scrap supplies and secondary alloys fluctuated slightly during the year. The major primary ingot producers announced a price reduction in February of 3 to 6 cents per pound for aluminum scrap generated and returned by their customers. The objective was to bring the price paid to customers for scrap more in agreement with the general market price of scrap.

The price of most secondary aluminum alloys increased 0.5 cent per pound in March. Reductions ranging from 0.25 cent and 1 cent per pound were quoted in October. The price differential between primary and secondary piston alloys during the year was approximately 2 to 3 cents per pound and for casting alloys, 4 to 5 cents per pound. Most secondary alloys increased 0.5 cent per pound on November 13. The exceptions were two grades of piston alloys, D 132 and No. 218, and the four grades of deoxidizing ingot, which remained unchanged. Alloy prices did not change throughout the remainder of the year.

FOREIGN TRADE[28]

Imports.—Total crude and semicrude aluminum imports amounted to 373,000 tons, 47 percent more than in 1961. The quantity exceeded total exports by 114,000 tons, continuing the trend begun in 1961. Value of imports of crude, semicrude, and manufactured aluminum products amounted to $188 million, 27 percent more than the 1961 value and $47 million greater than the value of comparable export products.

Approximately 61 percent of the imports of crude and semicrude aluminum came from Canada, Norway, France, and Belgium-Luxembourg supplied 13, 12, and 4 percent, respectively.

Exports.—Crude and semicrude aluminum exports increased 21,000 tons or 9 percent compared with those of 1961. Exports of manufactured products increased 51 percent. Total value of crude, semicrude, and manufactured aluminum exports was $141 million, approximately $16 million more than in 1961.

Principal destinations for crude and semicrude aluminum were the United Kingdom, West Germany, Italy, and India which received 19, 16, 10 and 8 percent of the exports, respectively.

Tariff.—The duty on aluminum in crude form, not including scrap, was 1.25 cents per pound. Aluminum and aluminum alloys in bars, blanks, circles, coils, disks, plates, rectangles, rods, sheets, squares, and strips were subject to a duty of 2.50 cents per pound. Suspension of the 1.50-cent-per-pound duty on scrap was extended through June 30, 1963. There was no quota for aluminum scrap.

TABLE 10.—U.S. imports for consumption of aluminum, by classes

Class	1961		1962	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Crude and semicrude:				
Metal and alloys, crude	199.223	$91,187	307,521	$128.560
Circles and disks	4.687	3,267	6.434	4,255
Plates, sheets, etc., n.e.s.	35.804	24.842	43.251	27,755
Rods and bars	8.819	4,953	9.503	5,137
Scrap	6.002	1.738	6.496	1,864
Toal	254.535	125.987	373,205	167,571
Manufactures:				
Foil less than 0.006 inch thick	4,952	6,283	5,060	6,395
Folding rules	(1)	1	(1)	6
Leaf (5.5 by 5.5 inches)	(2)	19	(2)	15
Powder and powdered foil (aluminum bronze)	90	100	112	120
Powder in leaf (5.5 by 5.5 inches)			(3)	(4)
Table, kitchen, hospital utensils, etc.	3,191	5.837	2,878	4,943
Other manufactures	(5)	10,048	(5)	9.255
Total	(5)	22.288	(5)	20,734
Grand total	(5)	148.275	(5)	188,305

1 1961, 3,566 rules; 1962, 5,202 rules; equivalent weight not recorded.
2 1961, 5,243,066 leaves; 1962, 4,107,090 leaves.
3 24,000 leaves.
4 Less than $1,000.
5 Quantity not recorded.

Source: Bureau of the Census.

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

TABLE 11.—U.S. imports for consumption of aluminum, by classes and countries

(Short tons)

Country	1961			1962		
	Metal and alloys, crude	Plates, sheets, bars, etc.[1]	Scrap	Metal and alloys, crude	Plates, sheets, bars, etc.[1]	Scrap
North America:						
Canada	119,004	9,924	5,930	209,892	11,396	6,260
Other			44			10
Total	119,004	9,924	5,974	209,892	11,396	6,270
Europe:						
Austria	885	1,188		2,157	1,331	
Belgium-Luxembourg	10	12,809		11	13,489	33
France	40,183	5,758		37,987	6,713	
Germany, West	2	1,333		1,097	3,745	
Italy		3,595		3	4,380	
Norway	37,820	166		46,907	56	13
Spain		1,168		4,329	1,469	
Sweden	90	1,313	6		510	119
United Kingdom	6	4,355	22	24	7,010	44
Yugoslavia	230	1,883		19	2,436	
Other	1	689		(2)	834	
Total	79,227	34,257	28	92,534	41,973	209
Asia:						
Japan		5,036		3,883	5,730	
Taiwan	992	71		1,102	39	
Other		20			17	17
Total	992	5,127		4,985	5,786	17
Africa				110		
Oceania		2			33	
Grand total:						
Short tons	199,223	49,310	6,002	307,521	59,188	6,496
Value, thousands	$91,187	$33,062	$1,738	$128,560	$37,147	$1,864

[1] Includes circles and disks, bars and rods, and plates, sheets, etc.
[2] Less than 1 ton.

Source: Bureau of the Census.

TABLE 12.—U.S. exports of aluminum, by classes

Class	1961		1962	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Crude and semicrude:				
Ingots, slabs, and crude	128,861	$57,638	151,250	$66,621
Scrap	82,005	26,452	65,534	20,183
Plates, sheets, bars, etc	25,241	23,975	40,069	32,931
Castings and forgings	1,203	3,560	1,540	5,522
Semifabricated forms, n.e.c	821	966	314	374
Total	238,131	112,591	258,707	125,631
Manufactures:				
Foil and leaf	1,697	2,130	2,487	3,052
Powders and pastes (aluminum and aluminum bronze) (aluminum content)	298	422	478	589
Cooking, kitchen, and hospital utensils	800	2,133	811	2,191
Sash sections, frames (door and window)	1,592	2,524	1,394	2,324
Venetian blinds and parts	1,230	1,437	749	943
Wire and cable	5,602	3,317	11,054	6,155
Total	11,219	11,963	16,973	15,254
Grand total	249,350	124,554	275,680	140,885

Source: Bureau of the Census.

TABLE 13.—U.S. exports of aluminum, by classes and countries

(Short tons)

Destination	1961			1962		
	Ingots, slabs, and crude	Plates, sheets, bars, etc.[1]	Scrap	Ingots, slabs, and crude	Plates, sheets, bars, etc.[1]	Scrap
North America:						
Canada	793	5,987	1,162	4,219	6,534	1,099
Mexico	4,855	337	4	7,680	2,000	113
Other	109	936	92	171	1,433	135
Total	5,757	7,260	1,258	12,070	9,967	1,347
South America:						
Argentina	11,470	127	----------	5,130	44	----------
Brazil	2,285	87	34	4,860	178	7
Colombia	3,274	459	----------	2,525	308	----------
Venezuela	879	663	31	1,453	587	38
Other	579	496	----------	729	313	14
Total	18,487	1,832	65	14,697	1,430	59
Europe:						
Belgium-Luxembourg	3,210	274	757	3,922	470	52
France	1,602	1,088	208	2,665	1,120	201
Germany, West	16,310	1,326	35,429	16,313	858	24,466
Greece	594	802	71	2,031	919	----------
Italy	3,875	713	12,889	6,461	1,391	19,135
Netherlands	8,089	435	701	2,818	1,351	2,600
Sweden	38	279	27	90	790	14
Switzerland	2,917	20	356	2,163	316	553
United Kingdom	25,207	9,810	4,475	37,517	7,251	4,331
Other	10,626	1,089	506	10,728	877	687
Total	72,468	15,836	55,419	84,708	15,343	52,039
Asia:						
India	937	202	67	9,836	11,074	----------
Israel	2,954	62	2	830	110	----------
Japan	13,243	367	24,837	2,385	221	11,024
Korea, Republic of	3,098	2	172	8,225	2	229
Philippines	3,458	182	39	1,505	83	----------
Other	1,740	240	34	2,198	704	146
Total	25,430	1,055	25,151	24,979	12,194	11,399
Africa	1,032	627	----------	663	1,066	----------
Oceania	5,687	655	112	14,133	1,923	690
Grand total:						
Short tons	128,861	27,265	82,005	151,250	41,923	65,534
Value, thousands	$57,638	$28,501	$26,452	$66,621	$38,827	$20,183

[1] Includes plates, sheets, bars, extrusions, castings, forgings, and unclassified "semifabricated forms."

Source: Bureau of the Census.

WORLD REVIEW

World production was estimated at 5.6 million short tons, 7 percent more than in 1961 and 89 percent of rated capacity. Countries with sizable increases included India, 49 percent; Australia, 49 percent; Brazil, 46 percent; Taiwan, 23 percent; Switzerland, 17 percent; Norway, 16 percent; the United States, 11 percent; Austria, 10 percent; and Japan, 10 percent.

New facilities during the year raised world aluminum capacity to 6.2 million short tons—an increase of nearly 197,000 tons. Hungary and Poland began producing superpure aluminum, raising the number of producing countries to 12.

Several books describing the world aluminum industry were published.[29]

TABLE 14.—World production of aluminum, by countries [1]

(Short tons)

Country	1953-57 (average)	1958	1959	1960	1961	1962
North America:						
Canada	579,180	634,102	593,630	762,012	663,173	640,000
United States	1,520,992	1,565,557	1,954,112	2,014,498	1,903,711	2,117,929
Total	2,100,172	2,199,659	2,547,742	2,776,510	2,566,884	2,757,929
South America: Brazil	4,297	13,102	19,950	20,034	22,078	32,300
Europe:						
Austria	58,302	62,716	72,271	74,924	74,578	81,668
Czechoslovakia	17,721	29,100	28,700	[2] 44,000	[2] 55,000	[2] 66,000
France	148,123	186,107	190,712	262,890	307,765	324,630
Germany:						
East [2]	27,800	37,500	38,600	44,000	60,600	66,000
West	148,685	150,759	166,631	186,221	190,212	196,018
Hungary	34,690	43,560	50,400	54,600	56,300	58,100
Italy	67,163	70,603	82,658	92,206	91,881	89,549
Norway	82,413	133,777	160,881	181,662	189,109	[2] 220,000
Poland	[3] 18,673	24,738	25,143	28,640	52,588	53,043
Spain	8,768	17,769	24,959	26,429	41,500	45,132
Sweden (includes alloys)	12,432	15,113	17,100	17,619	20,100	18,815
Switzerland	32,183	34,700	37,886	43,795	46,530	54,640
U.S.S.R.[2]	444,000	605,000	690,000	745,000	990,000	1,000,000
United Kingdom	32,245	29,517	27,462	32,390	36,169	38,113
Yugoslavia	11,152	23,899	21,214	27,635	30,211	30,840
Total [2]	1,145,000	1,465,000	1,635,000	1,860,000	2,245,000	2,345,000
Asia:						
China [2]	[3] 11,900	30,000	77,600	88,100	110,000	110,000
India	6,747	9,167	19,319	20,356	20,263	30,221
Japan [4]	63,954	93,231	110,385	146,864	169,424	187,093
Taiwan	7,949	9,455	8,251	9,106	9,938	12,254
Total [2]	90,600	141,900	215,600	264,400	309,600	339,600
Africa: Cameroon	8,300	35,121	46,644	48,436	52,446	57,400
Oceania: Australia	[5] 7,846	12,173	12,734	13,054	14,789	[2] 22,000
World total (estimate) [1]	3,355,000	3,865,000	4,480,000	4,985,000	5,210,000	5,555,000

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[2] Estimate.
[3] Average annual production 1954-57.
[4] Includes superpurity: 1953-57 (average), 330 tons; 1958, 514; 1959, 1,122; 1960, 2,187; 1961, 1,307 and 1962 1,898.
[5] Average annual production 1955-57.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

Per capita consumption of primary and secondary aluminum during 1961 for several nations was estimated as follows: United States, 25.3 pounds; Switzerland, 18.3 pounds; United Kingdom, 16.1 pounds; West Germany, 14.7 pounds; France, 10.3 pounds; and Italy, 6.2 pounds.[30] In developing these figures the following were considered: Production, imports, exports, inventory changes of primary and secondary metal, and direct imports and exports of semifabricated aluminum, aluminum foil, and finished goods. Indirect exports, such as vehicle and machine exports, were disregarded.

[29] Bracewell, Smith. Bauxite, Alumina and Aluminium. Overseas Geol. Survey Miner. Res. Div., London, 1962, 235 pp.
Ginsberg, Hans. Aluminium. Ferdinand Enkw Verlag, Stuttgart, West Germany, 1962, 135 pp. (in German).
[30] Aluminium (Duesseldorf, Germany). Die Entwicklung des Aluminiumverbrauchs pro Kopf der Bevölkerung. V. 38, No. 6, June 1962, pp. 427-428.

TABLE 15.—Changes in world aluminum productive capacity [1]

(Short tons)

Country, company, and plant location	Annual capacity 1962
South America:	
Brazil: Cia. Brasileira do Aluminio, São Paulo	22,000
Total South America	36,300
Europe:	
France: Société d'Électro-Chimie, d'Électro-Métallurgie et des Aciéries Électriques d'Ugine, Lannemezan	54,000
Germany, West: Vereinigte Aluminium Werke A.G.—Norf	44,000
Norway: A/S Aardal og Sunndal Verk—Aardal	146,700
Switzerland: Aluminium-Industrie A.G.—Steg	20,000
Total Europe	1,203,100
Asia:	
Japan:	
Showa Denko K.K., Goi	17,600
Nippon Keikinzoku K.K., Kambara	78,000
Sumitomo Kagaku K.K., Nagoya	23,000
Total	237,800
Taiwan: Taiwan Aluminium Corp., Takao	22,000
Total Asia	318,400
Oceania: Australia: Comalco Aluminium (Bell Bay) Ltd	39,200
Total free world	5,008,250
Total world	6,230,850

[1] Changes to up-date table 15 ("Producers of aluminum") in the Aluminum chapter of the 1961 Minerals Yearbook.

The worldwide aluminum industry was reviewed.[31] New metal markets, price and profit relationships, industrial capacity, expansion programs, and technology were discussed.

NORTH AMERICA

A resumé of the aluminum industry in North America, contained statistics from 1950 to 1961 on production, cost data, and trade, and a description of the producing companies.[32]

Canada.—Alcan operated at 76 percent of capacity, compared with 73 percent in 1961. All plants operated continuously during 1962. Output of primary aluminum by Alcan increased 5 percent in spite of a work stoppage late in 1962.

Alcan reduced the price of aluminum in world markets, except in Canada and the United States, from 23.25 cents (Canadian) per pound to 22.5 cents in February. The Canadian price remained 23.25 cents until June 18 when it was raised to 24 cents, reflecting the devaluation of the Canadian dollar. The price was reduced to 22.5 cents in December to conform with the U.S. price reduction from 24 to 22.5 cents; thus the world price was established at 22.5 cents.

Mexico.—A 22,000-short-ton aluminum plant, being built at Veracruz by Alumino, S.A. de C. V., was scheduled for completion by mid-1963. Mexican interests including Intercontinental S.A. had a 51-percent interest in the company. Alcoa had 35 percent, and a subsidiary of American & Foreign Power Co., Inc., had 14 percent. Alumina for the plant was to be shipped from the Alcoa Point Comfort, Tex., plant.

[31] Burke, Donald P. Aluminum. Chem. Week, V. 91, No. 11, Sept. 15, 1962, pp. 66–75, 78, 80, 84, 86, 90, 92, 94, 96.

[32] Dominick & Dominick. An Analysis of the Aluminum Industry in North America. New York, 1962, 50 pp.

No decision on the proposed Reynolds plant was reached during 1962.

SOUTH AMERICA

Argentina.—Reynolds International, Inc., was authorized to build an aluminum plant having an initial capacity of 25,000 short tons in Patagonia near Puerto Madryn or Comodoro Rivadavia. This was the second plant authorized by the Government. Kaiser was authorized to build a plant in Patagonia in 1961.[33]

EUROPE

Consumption of aluminum in the countries of the Organisation for European Economic Cooperation (OEEC) decreased 1 percent in 1961 from that of 1960. Regarding the four principal countries, Italy showed an increase of 7 percent and France, 1 percent, whereas United Kingdom consumption declined 11 percent and West German consumption, 3 percent. The use pattern varied slightly with transportation accounting for 28 percent of the total consumed, electrical engineering for 13 percent, building and construction for 11 percent, machinery and equipment and packaging for 10 percent each, home and office appliances for 9 percent, and other uses for 19 percent.

TABLE 16.—Europe: Aluminum consumption, by end uses, 1961 [1]

(Short tons)

	West Germany	France	Italy	United Kingdom	All other [2]	Total
Transportation	108,246	77,947	69,005	104,133	17,422	376,753
Machinery and equipment	49,604	24,720	11,023	25,395	22,356	133,098
Electrical engineering	66,249	29,784	11,795	37,229	29,305	174,362
Building and construction	27,778	18,082	17,417	34,799	50,985	149,061
Packaging	43,652	24,919	16,314	28,943	22,366	136,194
Home and office appliances	15,212	25,835	12,125	36,997	21,911	112,080
All other [3]	88,626	43,018	23,810	76,610	25,080	257,144
Total	399,367	244,305	161,489	344,106	189,425	1,338,692

[1] Organisation for European Economic Cooperation and Development. Non-Ferrous Metal Statistics. 1960/1961, pp. 134–135.
[2] Includes Austria, Belgium, Denmark, Netherlands, Norway, and Switzerland.
[3] Includes chemical, food, and agricultural appliances; powder; iron, steel, and other metal-producing industries; metal industries not elsewhere specified; and miscellaneous.

Germany, West.—Primary aluminum capacity in West Germany reached 224,800 short tons following completion of the Norf smelter. The European Economic Community (EEC) Council of Ministers granted an import quota of 88,000 tons of aluminum at the reduced duty rate of 5 percent for 1963. In 1962, the duty-favored import quota was 82,700 tons.[34]

Hungary.—The Hungarian Research Institute for Metallurgy announced that a pilot plant had been built for the extraction of both aluminum and iron from local bauxite. The production of gallium and superpure aluminum was announced for use in telecommunica-

[33] Light Metals. Second Smelter in Argentina. V. 25, No. 287, April 1962, p. 88.
[34] Metal Bulletin (London). German 1963 Import Quotas. No. 4758, Dec. 28, 1962, p. 15.

tions.[35] The capacity of the Inota plant was to be expanded to 30,000 tons.

The problem posed by the high cost of energy for the production of aluminum was solved by an agreement with the Soviet Union, whereby the Soviet Union would treat alumina produced in Hungary and return the metal. Shipments of alumina were to begin in 1967 and were scheduled to reach 364,000 tons per year by 1980.

Italy.—Montecatini, Soc. Generale per l'Industria Mineraria e Chimica, began installing a new unit using 100,000-ampere cells of the Soderberg-Montecatini type at the Bolzano plant. Completion of this unit was expected to raise capacity from 45,700 to 66,100 tons, although seasonally limited power would permit a production of only 60,600 tons. Modernization of the Mori plant, scheduled for completion in 1963, would raise plant capacity to 27,600 tons and company capacity to 93,700 tons in 1963. The Mori plant began producing superpure aluminium (99.999 percent). A new subsidiary, Alluminio Sardo, S.p.A., was organized to operate a proposed plant in Sardinia.

Production of aluminum totaled 89,000 tons, of which Montecatini accounted for 56,000 tons, Soc. Alluminio Veneto per Azioni (SAVA) for 29,000 tons, and Alcan Alluminio Italiano for 4,000 tons.

Netherlands.—Péchiney and N. V. Billiton Mattschappij considered the feasibility of establishing aluminum plants at Delfzijl. Each plant was to have an annual capacity of 66,000 tons.

Norway.—The Government approved plans for the 66,000-short-ton aluminum plant to be built at Husnes in the Kvinnherad district. A new company, Sør-Norge Aluminium A/S was organized in June by Aluminium-Industrie A.G., and Compagnie pour l'Etude et le Develloppement des Echanges Commerciaux S.A. (COMPADEC) to operate the plant, scheduled for completion in 1966. Each company had a 50-percent interest in the project. A/S Aardal og Sunndal Verk added 38,600 tons of capacity, bringing the total to 146,700 tons.

Poland.—Continuous production of superpure aluminum began in the white metal refinery at the zinc plant (Zoklady Cynkowe). In the past this material was imported. A 220,000-short-ton plant to produce aluminum from clay was scheduled for completion in 1965 by Skawina Aluminium Works.

Switzerland.—The first stage of the new plant under construction by Aluminium-Industrie, A.G., at Steg was completed. Exports of aluminum increased 41 percent in 1962 and totaled 9,439 tons. The principal markets were West Germany, 5,056 tons; Italy, 1,892 tons; Sweden, 1,211 tons; the United Kingdom, 773 tons; and Belgium-Luxembourg, 429 tons. Imports increased 6 percent to 12,250 tons.

Aluminium-Industrie, A.G., stated in its annual report that it had decided to change its name to Schweizerische Aluminium G.m.b.H. (Alusuisse).

[35] Engineering and Mining Journal. Hungary Expands Output of Pure Metals, Iron. V. 164, No. 3, March 1963, p. 141.

U.S.S.R.—Work on the Pavlodar and other plants, scheduled to begin operating in 1962, was delayed because of the lack of equipment.[36]

ASIA

India.—Hindustan Aluminium Corp., Ltd., began producing aluminum at its plant at Renukoot, near the Rihand Dam in Uttar Pradesh in June. The plant's capacity of 22,400 short tons was to be increased to 55,000 tons during the fourth 5-year plan.

Indian Aluminium Co., Ltd., planned to increase capacity of the Alwaye plant to 14,000 tons by mid-1964.

Tendulkar Industries planned to build a 22,400-ton plant at Koyna, Maharashta, in collaboration with Vereinigte Aluminium Werke, A.G.

Several articles were published on the Indian aluminum industry.[37]

Indonesia.—A survey of the Asahan River area was completed by Soviet experts. An integrated aluminum industry was planned for the area with financial and technical assistance from the Soviet Union. The project included a hydroelectric station with a capacity of 120 megawatts, a high-voltage transmission line, and an aluminum plant designed to produce about 20,000 tons per year. Raw material was to be obtained from the bauxite deposits on the islands of the Riau Archipelago. The plant was expected to produce 77,000 tons of alumina and 13,000 tons of rolled aluminum.[38]

Japan.—Aluminum production continued its upward trend and was 10 percent above that of 1961.

Showa Denko K.K. began partial operation of its new smelter at Goi, Chiba Prefecture, on November 1. About one-fourth of the plant was completed by the end of 1962. The plant was to have a capacity of 70,500 tons when finished.

Taiwan.—Taiwan Aluminium Corp. completed modernization of its Kaohsiung aluminum plant and thereby increased capacity from 15,400 to 22,000 tons.

AFRICA

Ghana.—Volta Aluminium Co. Ltd. (Valco) reached an agreement with the Government on plans for an aluminum plant to be built at Tema. The plant, with an initial capacity of 98,000 short tons, was to use imported alumina.

OCEANIA

Australia.—Comalco Industries Pty. Ltd., completed expanding capacity at its Bell Bay plant 5 months ahead of schedule. Eighty-four furnaces were added, raising capacity to 39,200 tons. Further expansion was expected to raise capacity to 58,200 tons by 1964. The name of the company operating the Bell Bay plant was changed to Comalco Aluminium (Bell Bay) Ltd.

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[36] Metal Bulletin (London). Russian Building Delays. No. 4756, Dec. 18, 1962, p. 31.
[37] Alluminio (Milan, Italy). Sviluppi e Prospettive per l'Industria dell'Alluminio in India (Development and Prospects of the Aluminum Industry in India). V. 31, No. 7–8, 1962, pp. 395–398.
Bhandari, S. R. The Indian Aluminium Industry. Eastern Metals Rev. (Calcutta, India). V. 16, No. 1, Feb. 4, 1963, pp. 55–57.
Modern Metals. India's Expanding Aluminum Industry. V. 18, No. 5, June 1962, pp. 52, 54.
[38] Light Metals. Indonesia. V. 25, No. 292, September 1962, p. 230.

A series of articles on the aluminum industry in Australia was published.[39]

New Zealand.—No decision was reached on plans to construct a 112,000 ton aluminum plant at Bluff, South Island.

TECHNOLOGY

The first international symposium devoted to all aspects of the extractive metallurgy of aluminum was held in New York City on February 18–22 in conjunction with the annual meeting of the American Institute of Mining, Metallurgical and Petroleum Engineers. The symposium was divided into four sections; Technology of Alumina Production (18 papers), Carbon Technology in Aluminum Production (13 papers), Technology of Aluminum Production (25 papers), and New Processes and Materials of Construction (11 papers). Reviews of the symposium contained summaries of the papers.[40]

Many organizations continued to investigate means by which the Hall cell operation might be improved. The voltage efficiency, approximately 40 percent, and the overall energy efficiency, about 35 percent, were two factors stated that could be improved. Modifications of existing reduction cells by using refractory-hard-metals (RHM) cathodes were explained.[41] The use of RHM cathodes reduced the average cathode voltage drop to less than 0.2 volt—from 0.5 to 0.7 volt in conventional cells. Properties of the carbide and boride materials, as well as several cell designs utilizing them, were released.[42] A patent covered the application of the RHM materials in both the conventional Hall-Heroult cell and the three-layer Hoopes cell.[43]

An electrolytic method for reducing alumina provided for a graphite anode and a cathode composed of mixed carbides and/or borides. It was claimed that such a cathode resisted the attack of molten cryolite and was more conductive than a graphite cathode. The possible composition of an electrolyte was given as 5 to 95 percent $3KF.AlF_3$, KCl, and/or KF and 95 to 5 percent cryolite, NaCl, NaF, $3LiF.AlF_3$, LiCl, and/or LiF. The total content of Li, Na, or Kal fluoride must be at least 50 percent.[44] Adding lithium to the electrolyte increased the productive capacity of conventional electrolytic cells without increasing the voltage drop across the cell. The lithium was added as

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[39] Barnett, F. R. Aluminium in Australia, Pt. 4, the Semifabrication of Aluminium. Australian Chem. Proc. V. 16, No. 1, January 1963, pp. 22–27.
Dickinson, S. B. Aluminium in Australia, Pt. 1, Australia's Bauxite Resources. Australian Chem. Proc. V. 15, No. 10, October 1962, pp. 8–15, Pt. 2, Alumina Production, No. 11, November 1962, pp. 16–19.
Nixon, J. C. Aluminium in Australia, Pt. 3, Commercial Production of Australian Aluminium. Australian Chem. Proc. V. 15, No. 12, December 1962, pp. 19–25.

[40] Engineering and Mining Journal. Aluminum Firms Continue Updating Standard Methods. V. 163, No. 4, April 1962, pp. 98, 100, 102. Journal of Metals. Extractive Metallurgy of Aluminum. V. 14, No. 6, June 1962, pp. 442–446.
Light Metals. Extraction of Aluminum—The International Symposium. V. 25, No. 287, April 1962, pp. 109–110; No. 288, May 1962, pp. 132–134.

[41] Metal Industry. Aluminum Reduction Cells. V. 100, No. 11, Mar. 16, 1962, p. 201.

[42] Mining Journal (London). Improved Aluminium Production. V. 258, No. 6609, Apr. 20, 1962, pp. 390–391.
Ransley, C. E. Refractory Carbides and Borides for Aluminum Reduction Cells. J. Metals, v. 14, No. 2, February 1962, pp. 129–135.

[43] Ransley, Charles Eric (assigned to British Aluminium Co. Ltd.). Producing or Refining Aluminum. U.S. Pat. 3,028,324, Apr. 3, 1962.

[44] Lewis, Robert A. (assigned to British Aluminium Co., Ltd.). German Pat. 1,130,607, May 30, 1962.

lithium fluoride and was equivalent to 3 to 8 percent of the solution contents.[45]

The operational characteristics of the Soderberg vertical-spike anode were discussed, stressing the importance of the flow properties of paste in the fluid zone, the thermal shrinkage in the carbonizing zone, and the surface distintegration in the consumption zone.[46] The requirements for paste recipe and binder quality were related to design and operation of a cell. A green electrode mix, for anodes used in the production of aluminum, was patented.[47] The mix consisted essentially of 80 to 85 percent carbon aggregate and 15 to 20 percent of a binder consisting of low-temperature tar pitch (25 to 90 weight-percent of the binder) and high-temperature tar pitch.

Developments in cell design affecting the power input and efficiency of the reduction of alumina to aluminum were reviewed.[48]

The evolution of cell development within Péchiney's aluminum plant from 3,000-ampere Heroult cells consuming 90,000 kilowatt-hours per metric ton of aluminum to 100,000-ampere cells requiring 15,000 kilowatt-hours was discussed. As a result of research, 12,500 kilowatt-hours per ton should be achieved in the near future.[49]

A review of power and fuel requirements at the Reynolds Metals Co. alumina plant at Hurricane Creek, Ark., and at the Jones Mills, Ark., and Arkadelphia, Ark., reduction plants was published.[50]

Péchiney's new carbothermic-process pilot plant continued in operation investigating a two-stage carbothermal method of reduction.[51] In the first stage corundum was prepared in an electric furnace by selective reduction of bauxite, separating the basic impurities from the alumina. The second stage involved the electric-furnace reduction of aluminum oxide to a spongy mixture of aluminum and aluminum carbide. At proper temperature and with the use of appropriate fluxes, the aluminum was exuded from the mass of carbide, which was recycled.

Aluminium Ltd. continued its pilot plant study of the monochloride reduction process,[52] in which impure metal comes into contact with aluminum trichloride in a reactor operating at 1,000° to 1,200° C at 1 atmosphere. Under these conditions, the volatile monochloride formed and flowed to a condenser, leaving impurities behind in the converter. The condenser was a refractory-lined vessel containing a large pool of molten aluminum at 700° to 800° C. A partly submerged impeller threw up a continuous shower of molten metal, which cooled the incoming monohalide. At the lower temperature, the first reaction was

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[45] Lewis, Robert A. (assigned to Kaiser Aluminum & Chemical Corp.). Electrolytic Production of Aluminum. U.S. Pat. 3,034,972, May 15, 1962.

[46] Bowitz, Olav, and Ove Sandberg. Soderberg Anode Carbon in Cells for Electrolytic Production of Aluminum. Trans. AIME, v. 224 (Met. Soc.), 1962, pp. 53–60.

[47] McNamara, James H., Mario J. Caprio, and Mike A. Miller (assigned to Aluminum Company of America). Electrode Binder Pitch. U.S. Pat. 3,035,932, May 22, 1962.

[48] Edgeworth, T. G. Some Developments in Aluminum Reduction. Canadian Min. and Met. Bull., v. 55, No. 604, August 1962, pp. 583–586.

[49] Grolee, Jean. Evolution of the Technique in the Construction of the Cells of the Péchiney Company. Revue de l'Aluminium (Paris), v. 39, No. 297, April 1962, pp. 507–514.

[50] Industrial Heating. The Use of Energy in Aluminum Production. V. 29, No. 12, December 1962, pp. 2338–2340, 2342, 2344, 2350.

[51] American Metal Market. Péchiney Reports Progress in Direct Reduction Work. V. 69, No. 197, Oct. 11, 1962, p. 12.

[52] Engineering and Mining Journal. Aluminum Nears Direct Reduction, Extraction From Clays. V. 163, No. 6, June 1962, p. 180.

reversed, forming metallic aluminum and aluminum trichloride, which were recycled.

The properties of 99.99999-percent-pure aluminum prepared by sublimation in a special high-vacuum installation were described.[53] Only a trace of magnesium was found in the spectrum. The metal was much softer and more plastic than standard-purity metal and at minus 271.4° C it had much lower residual magnetism. Its thermal and electrical conductivity, reflection capacity, and corrosion resistance were improved compared to 99.999-percent-pure aluminum. A pilot plant was designed for manufacturing this pure metal.

Aluminum containing less than 1 percent carbon was made by vacuum pyrolysis of aluminum carbide.[54] The process theoretically required only one-third of the energy needed for the electrolytic reduction of alumina. Aluminum vapor was obtained when the carbide was placed in a graphite crucible, evacuated to 10^{-8} atmospheres of pressure, and heated to 1,600° to 2,300° K in a vacuum induction furnace. The vapor condensed on a cooled surface, and the carbon remained in the crucible.

Methods of removing hydrogen, other gases, and oxide inclusions from aluminum, the effect of additions of various elements on grain refining, and the mechanism of their action were discussed.[55]

Techniques in vacuum-pressure diecasting of aluminum, magnesium, and zinc alloys for producing castings free from entrapped air and for allowing lower injection pressures, which reduce wear and tear on machines and dies, were explained.[56] Data were given for the control of surface finish, porosity, blistering, inclusions, dimensions, and tolerances. A method and equipment for the continuous casting of aluminum ingot in a horizontal mold was patented.[57] Molten metal was fed through an axially placed refractory nozzle and graphite mold. Water was sprayed upon the mold to control temperature, and continuous lengths of cast metal were produced. A description was published of the equipment and technology employed in continuous casting of aluminum for strip 11.5 inches wide and 0.5 inch thick for eventual rolling into aluminum siding.[58] Fundamental factors that influenced quality and uniformity were discussed. Several factors had to be evaluated before deciding how to make an aluminum casting,[59] and the fundamental factors that influence the quality and uniformity of the casting were considered.[60] The use of woven fiber glass fabrics to filter molten aluminum before casting was evaluated.[61]

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[53] Reichel, F. "Siebenneuner" Aluminium. (High Purity Aluminum.) Elektrotech. Maschinenbau (Vienna, Austria), v. 78, No. 8, April 1961, p. 295 (in German); Chem. Abs., v. 56, No. 3, Feb. 5, 1962, p. 2254.

[54] Search, Alan W., and David J. Meschi (assigned to U.S. Atomic Energy Commission). Aluminum From Aluminum Carbide. U.S. Pat 3,031,294, Apr. 24, 1962.

[55] Banerjee, P., and P. H. Dhar. Melting and Treating Aluminium and Its Alloys. J. Sci. Industr. Res., v. 20A, No. 11, November 1961, pp. 640–645. Abstr. in J. Appl. Chem., v. 12, No. 7, July 1962, p. ii–21.

[56] Addiscott, J. S. Progress in Pressure Die-Casting. Engineer and Foundryman, v. 28, No. 4, April 1962, pp. 11–13.

[57] Reynolds Metals Co. Continuous Casting of Metal. British Pat. 901,757, July 25, 1962.

[58] Steel. Continuous Casting Line Crops Aluminum Cost. V. 151, No. 22, Nov. 26, 1962, pp. 84–85.

[59] Lapin, John. Factors in Evaluating Casting Methods for Aluminum. Foundry, v. 90, No. 7, July 1962, pp. 50–54.

[60] Colwell, D. L. Melting Aluminum for Casting. Mod. Metals, v. 18, No. 4, May 1962, pp. 40, 42, 44, 46.

[61] Swanson, D. C. Glass Cloth Cleans Aluminum. Mod. Metals, v. 18, No. 4, May 1962, pp. 60, 62.

Difficulties in applying the inert-gas tungsten-arc spot-welding process for aluminum were overcome, and the process was utilized extensively in aluminum fabrication.[62] Developments in the production of aluminum pipes in larger sizes and with thinner walls were reviewed. The method of helically forming and welding tube continuously from strip was described.[63] Some of the basic rules to be observed in the methods of tool handling and maintenance of extrusion dies and tools utilized in processing aluminum were listed.[64]

A process of "blowing" aluminum cans in one step involved feeding special gases through the bottom of a vessel containing molten aluminum. A die was lowered to the surface of the molten aluminum, and the gas forced a bubble of metal inside the die to form the can. It was claimed that the cans were capable of resisting higher pressures than ordinary extruded or seamed cans and cost one-third less to manufacture.[65]

The resistance to chipping and to brittle failure of the internal surface of aluminum armorplate was increased by a patented process that provided for the softening of one side of the plate by heating it for several hours at 550° F while the other face, which was to be exposed, was left below 300° F by water cooling, and thus retained its hardness for resisting the penetration of bullets and other projectiles.[66]

A method, based upon electrophoresis, was developed for the coating of steel with aluminum powder suspended in methyl alcohol. The coated steel was compacted in a rolling mill by a light pass, coiled, and heattreated. The surface finish was controlled by the finish of the compacting rolls.[67]

A laboratory method of producing aluminum whiskers was announced. Fibers 300 microns long and up to 20 microns wide, were produced.[68] The metallic whiskers were made by a vapor-condensation method in which zone-refined aluminum was heated in a vacuum by high-frequency induction at 1,250° C for 1 hour. The metal condensed on the walls of a silica crucible and each whisker grew a ball at its tip.

Single-crystal aluminum wires less than 0.125 inch in diameter were produced.[69] All wires possessed exactly the same crystallographic orientation. Removal of the specimens from the molds without deformation after growth was accomplished by allowing the wire to pass, as is formed, into a tube of glycerine that supported the weight of the wire crystal. Composed of 99.9 percent aluminum wire crystals ranging from 0.015 to 0.125 inch in diameter and up to 3 feet in length were grown.

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[62] Light Metals. Arc-Spot Welding. V. 26, No. 295, December 1962, pp. 40–42.
[63] Metallurgia (Manchester, England). Developments in the Production and Joining of Aluminum Pipe. V. 66, No. 395, September 1962, pp. 123–127.
[64] Light Metal Age. Recommended Handling and Maintenance of Extrusion Dies and Tools. V. 20, Nos. 9–10, December 1962, pp. 9–11.
[65] Chemical Week. Blown Aluminum. V. 91, No. 16, Oct. 20, 1963, p. 41.
[66] George, Henry P., and Harold W. Euker (assigned to U.S. Department of the Army). Impact Resistance Aluminum Alloy Plate. U.S. Pat. 3,042,555, July 3, 1962.
[67] Bishop, Tom. New British Process for Coating Steel Strip With Aluminum. Metal Prog., v. 82, No. 1, July 1962, pp. 97–99.
[68] Barber, D. J. Growth of Aluminum Whiskers by Vapor Condensation. Nature, v. 194, No. 4825, Apr. 21, 1962, pp. 272–273.
[69] Green, Robert E., and Norman L. Newbern. Continuous Growth of Single Crystal Aluminum Wires from the Melt. Trans. AIME, v. 224 (Met. Soc.) 1962, pp. 398–399.

The current commercial and experimental aluminum powders that might be used in solid rocket propellants were surveyed.[70] It covered pure powders with alloy contents up to 50 percent and compared milled powders with powders produced by atomization. Milling in liquid components of solid propellants produced relatively uniform structures for some highly alloyed powders. A method for producing ultrafine aluminum powder (0.01 to 0.06 micron in diameter) was patented.[71] The untamped bulk specific gravity of the powder was 0.08; tamped specific gravity was 0.22. The basis of the process was to vaporize and condense the metal without impinging on any surface under pressures of 50 to 500 microns of mercury.

Research and technical progress on the metallurgy and uses of aluminum and its alloys in 1962 were reviewed.[72] Metallurgical aspects included production, melting and casting, working, joining, constitution, and properties. Reference was also made to interesting applications of these materials.

Cryogenic tests were carried out on alloy 5083 at Battelle Memorial Institute under sponsorship of The Aluminum Association.[73] The results showed that tensile strength, notch toughness, and ductility improved as the temperature was lowered to 452° F. A data table was developed showing the alloy strength at 75°, 320°, and 452° F.

Two specially designed oceangoing tankers for transporting liquid methane were being constructed in England. Each vessel was to utilize nine aluminum tanks requiring 3,000 tons of plate and extrusions to carry 170,000 barrels of liquified natural gas from North Africa to Great Britain.[74] The ability of aluminum to resist embrittlement and even to improve in structural qualities at very low temperatures made especially useful for cryogenic applications.

Low-temperature mechanical properties of the aluminum alloys in both bar and sheet form were obtained at temperatures ranging from room temperature to —452° F for tensile tests and from room temperature to —441° F for Charpy impact tests.[75] Both bar and sheet materials were from the same heat. Nearly all of the alloys investigated were found acceptable for application in a cryogenic environment. The mechanical properties of aluminum at low temperatures were reviewed.[76] The axial-stress fatigue properties of several aluminum-magnesium alloys at room temperatures and —320° F were reported.[77] Fatigue strengths at both plain and welded specimens were higher at —320° F than at room temperature. Welds

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[70] Lyle, J. P., Jr., R. J. Towner, and J. E. Vruggink. Aluminum Powders for Solid Propellants. Space Aeronautics, v. 38, No. 4, September 1962, pp. 70–74.

[71] Chemical Week. Metal Powders Out of the Clouds. V. 91, No. 22, Dec. 1, 1962, pp. 47–48; U.S. Pat. 3,065,958, Nov. 27, 1962.

[72] Elliott, E. Aluminum and Its Alloys in 1962. Metallurgia (Manchester, England), v. 67, No. 400, February 1963, pp. 63–72; v. 67, No. 401, March 1963, pp. 121–131.

[73] Modern Metals. Aluminum Shows Its Mettle in Cryogenic Tests. V. 18, No. 9, October 1962, p. 64.

[74] Light Metal Age. Aluminum To Play Big Role in Cryogenics Sea Transport, V. 20, Nos. 9 and 10, October 1962, p. 24.

[75] Hickey, Charles F., Jr. Mechanical Properties of Titanium and Aluminum Alloys at Cryogenic Temperatures. Watertown Arsenal Lab. Tech. Rept. WAL–TR–340.2/1, March 1962; ASTIA, AD275483.

[76] Fluornoy, R. W. Aluminum Alloys for Cryogenic Equipment. Light Metal Age, v. 19, Nos. 3–4, April 1962, pp. 10, 11, 28.

[77] Kaufman, J. G. and F. G. Nelson. Cryogenic Temperatures Up Fatigue Strength of Al-Mg Alloys. Space/Aeronautics, v. 38, No. 1, July 1962, pp. 91–93, 96.

proved less sensitive to notching under fatigue than at room temperature.

Hanford research studies showed that adding 1.8 percent iron and 1.2 percent nickel to high-purity aluminum imparted excellent reproducible corrosion-resistant characteristics to the aluminum.[78] Examination of the improved alloys suggested that fine, uniform, second-phase particle dispersal was essential to achieve the desired level of performance.

It was determined that the growth rate of oxide film on aluminum and aluminum alloys did not follow a simple parabolic time law.[79] It could be accelerated in pure aluminum by introducing traces of sodium. Base metal alloying additions were oxidized selectively, and noble metal additions tended to interfere with the formation of a compact protective film through vaporization.

A review of European metallurgy and U.S. patents of aluminum alloys containing cobalt was published.[80] Little commercial use was made of cobalt in aluminum alloys in the United States, although considerable research had been conducted.

The solid solubility of lithium in aluminum was determined at 200°, 300°, 400°, 500°, and 600° C and found to be 6.0, 7.1, 8.5, 10.8, and 13.7 atomic percent, respectively.[81] X-ray diffraction studies of the intermetallic compound LiAl indicated that its composition was almost independent of temperature when in equilibrium with the terminal solid solution of aluminum.

The corrosion rates of aluminum-clad elements measured within the reactor (inreactor) pressurized-water loops were found to be considerably greater than the rates measured in exreactor tests at the same temperature at the water-oxide surface.[82] Three factors found to be significant in aluminum corrosion that resulted in higher rates for fuel elements were dissolution, heat transfer, and radiation. Lowering the pH of the water by adding phosphoric acid reduced the corrosion of the aluminum deposit.

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[78] Dillion, R. L., and H. C. Bowen. A Basis for Design of Aluminum Alloys for High Temperature Water Service. Corrosion, v. 18, No. 11, November 1962, pp. 406–416.

[79] Thiele, W. (The Oxidation of Aluminum and Aluminum Alloy Melts). Aluminium (Duesseldorf, West Germany), v. 38, No. 11, November 1962, pp. 707–715.

[80] Morral, F. R. Cobalt in Aluminum Alloys. Light Metal Age, v. 20, Nos. 9–10, December 1962, pp. 13–16.

[81] Costas, P. F., and R. P. Marshall. The Solubility of Lithium in Aluminum. Trans. AIME, v. 224 (Met. Soc.), 1962, pp. 970–974.

[82] Dickinson, D. R., R. J. Lobsinger, and R. B. Richman. Corrosion of Aluminum-Clad Fuel Elements. Hanford Atomic Products Operation SA-2661, Aug. 24, 1962, 19 pp.; Nuclear Sci. Abs., v. 16, No. 24A, Dec. 31, 1962, p. 4427.

Antimony

By Richard N. Spencer [1] and Edith E. den Hartog [2]

MINE PRODUCTION of antimony decreased 8 percent to 631 tons, and secondary smelter production decreased slightly to 19,400 tons. Imports increased 21 percent to 16,800 tons, and primary smelter production increased 4 percent to 11,700 tons. Exports remained constant, and consumption increased appreciably. Industry stocks of antimony continued to decrease, but only slightly, remaining a little over 6,400 tons on December 31. All classes of stocks decreased except for ores and concentrates and residues. The largest stock reduction was in oxides.

Antimony continued to be eligible for acquisition by barter for the supplemental stockpile through the Commodity Credit Corporation (CCC), and 3,926 short tons was acquired.

DOMESTIC PRODUCTION

MINE PRODUCTION

Domestic mines produced 631 tons of antimony, recovered largely as impure cathode metal as a byproduct of processing silver-lead ores by Sunshine Mining Co., Shoshone County, Idaho. Some new domestic antimony mine production started in 1961 and continued during 1962. Antimony Gold Ores Co. started mining operations in the Yellow Pine district of Idaho and produced high-grade concentrate by flotation in a 50-ton-per-day concentrator at Yellow Pine.

SMELTER PRODUCTION

Primary.—Smelter production of antimony was 11,700 tons, an increase of 4 percent over that produced in 1961. Smelter output was recovered from source materials as follows: 5 percent from domestic mines, 17 percent as a byproduct from domestic lead ores, and 78 percent from foreign ores and concentrates. Byproduct antimony from foreign and domestic ores together accounted for 31 percent of total primary production.

Of the domestic smelter output, 2,600 tons, or 22 percent of production, was recovered from domestic ores. Companies reporting primary antimony production were American Smelting and Refining Company, Foote Mineral Co., Harshaw Chemical Co., Hummel Chemical Co.,

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M&T Chemicals, Inc., McGean Chemical Co., National Lead Co., and Sunshine Mining Co.

TABLE 1.—Salient antimony statistics

(Short tons)

	1953–57 (average)	1958	1959	1960	1961	1962
United States:						
Production:						
Primary:						
Mine	614	705	678	635	689	631
Smelter [1]	10,812	8,557	8,748	9,954	11,329	11,727
Secondary	23,018	19,515	20,043	20,104	19,466	19,362
Imports, general (antimony content)	13,133	9,878	13,273	14,519	13,942	16,833
Exports	83	86	174	906	44	45
Consumption [2]	15,522	11,880	13,317	13,271	12,697	15,452
Price: New York, average cents per pound	33.72	31.76	31.30	31.30	33.89	34.75
World: Production	53,000	51,000	59,000	61,000	60,000	60,000

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

TABLE 2.—Production and shipment of antimony (concentrates and metal) in the United States

(Short tons)

Year	Gross weight of antimony-bearing concentrate produced	Contained antimony (percent)	Antimony produced	Antimony shipped
1953–57 (average)	3,519	18.0	614	(1)
1958	4,309	16.4	705	382
1959	4,671	14.5	678	146
1960	4,256	14.9	635	1,086
1961	4,245	16.2	689	1,646
1962	3,941	16.0	631	732

[1] Data not available.

TABLE 3.—Primary antimony produced in the United States

(Short tons, antimony content)

Year	Class of material produced					Total
	Metal	Oxide	Sulfide	Residues	Byproduct antimonial lead	
1953–57 (average)	3,058	4,767	108	727	2,152	10,812
1958	2,833	3,825	84	319	1,496	8,557
1959	2,667	4,411	70	430	1,170	8,748
1960	3,665	5,188	60	385	656	9,954
1961	4,558	4,609	84	355	1,723	11,329
1962	4,407	4,788	53	366	2,113	11,727

Secondary.—The recovery of secondary antimony was 19,400 tons, a reduction of less than 1 percent from the 19,500 tons produced in 1961. All secondary antimony was recovered from antimony-containing lead and tin scrap, largely by secondary smelters. As far as known, no secondary metallic antimony was produced in the United States; all was recovered in alloys. Primary and secondary lead smelters recovered 18,600 tons of antimony from scrap, and manufacturers and foundries reclaimed the remaining 800 tons. Battery plate scrap supplied 11,500 tons; type metal, 3,400 tons; drosses, 2,200 tons; bearing metals, 1,100 tons; and antimonial lead scrap, 1,000 tons. Secondary smelters used 1,850 tons of primary antimony, in addition to antimony recovered from scrap, in making lead and tin alloys.

TABLE 4.—Secondary antimony produced in the United States, by kind of scrap and form of recovery

(Short tons, antimony content)

Kind of scrap	1961	1962	Form of recovery	1961	1962
New scrap:			In antimonial lead [1]	12,418	13,706
Lead-base	2,638	2,082	In other lead alloys	7,017	5,630
Tin-base	72	82	In tin-base alloys	31	26
Total	2,710	2,164	Total	19,466	19,362
			Value (millions)	$13.2	$13.5
Old scrap:					
Lead-base	16,715	17,158			
Tin-base	41	40			
Total	16,756	17,198			
Grand total	19,466	19,362			

[1] Includes 171 tons of antimony recovered in antimonial lead from secondary sources at primary plants in 1961 and 136 tons in 1962.

TABLE 5.—Byproduct antimonial lead produced at primary lead refineries in the United States

(Short tons)

Year	Gross weight	Antimony content				
		From domestic ores [1]	From foreign ores [2]	From scrap	Total	
					Quantity	Percent
1953-57 (average)	64,180	1,382	770	1,453	3,605	5.6
1958	50,246	811	685	1,307	2,803	5.6
1959	37,487	676	494	754	1,924	5.1
1960	30,230	456	200	919	1,575	5.2
1961	35,080	1,010	713	171	1,894	5.4
1962	33,325	1,361	752	136	2,249	6.7

[1] Includes primary residues and small quantity of antimony ore.
[2] Includes foreign base bullion and small quantities of foreign antimony ore.

CONSUMPTION AND USES

Industrial consumption of primary antimony was 15,500 tons, 22 percent higher than in 1961. Consumption in the first quarter, 3,400 tons, was equal to that in the fourth quarter of 1961; each successive quarter recorded a substantial gain in consumption, and more than 4,100 tons was consumed in the fourth quarter. Consumption increased in antimonial lead and in several nonmetal uses. Battery use of antimonial lead was the most significant item of both consumption and consumption gain. Bearings, type metal, and sheet and pipe used appreciable quantities of antimony, but all continued their consumption decline. Most of the nonmetal products took more antimony. Use in plastics, which previously had shown an upward trend, increased 3 percent; use of antimony oxide in flameproofing chemicals and compounds increased 7 percent; in rubber products the increase was 60 percent; and use in pigments rose 37 percent. Six percent less antimony was used in ceramics and glass.

TABLE 6.—Industrial consumption of primary antimony in the United States

(Short tons, antimony content)

Year	Class of material consumed						Total
	Ore and concentrate	Metal[1]	Oxide	Sulfide	Residues	Byproduct antimonial lead	
1953-57 (average)	1,037	5,358	6,141	107	727	2,152	15,522
1958	515	4,179	5,283	88	319	1,496	11,880
1959	270	5,420	5,948	79	430	1,170	13,317
1960	226	5,892	6,033	78	386	656	13,271
1961	106	4,994	5,450	69	355	1,723	12,697
1962	137	6,126	6,642	68	366	2,113	15,452

[1] Includes antimony in imported alloys.

TABLE 7.—Industrial consumption of primary antimony in the United States, by class of material produced

(Short tons, antimony content)

Product	1953-57 (average)	1958	1959	1960	196	1962
Metal products:						
Ammunition	8	(1)	(1)	(1)	(1)	(1)
Antimonial lead[2]	5,836	3,698	4,141	4,398	4,708	6,090
Bearing metal and bearings	934	644	886	803	737	682
Cable covering	147	208	157	146	141	114
Castings	76	82	84	72	53	64
Collapsible tubes and foil	32	37	33	17	24	112
Sheet and pipe	225	273	202	202	147	127
Solder	143	100	113	130	97	172
Type metal[2]	1,062	877	883	580	448	429
Other	139	147	130	148	152	271
Total[2]	8,602	6,066	6,629	6,496	6,507	8,061
Nonmetal products:						
Ammunition primers	20	10	11	11	15	14
Fireworks	37	33	28	33	20	23
Flameproofing chemicals and compounds	1,111	758	1,033	1,177	1,138	1,215
Ceramics and glass	1,803	1,570	1,727	1,640	1,223	1,146
Matches	19	18	19	17	(1)	9
Pigments	1,286	1,047	1,167	1,282	845	1,161
Plastics	734	841	1,034	1,013	1,228	1,269
Rubber products	117	265	217	238	287	460
Other	1,793	1,272	1,452	1,364	1,434	2,094
Total	6,920	5,814	6,688	6,775	6,190	7,391
Grand total	15,522	11,880	13,317	13,271	12,697	15,452

[1] Included with "Other" to avoid disclosing individual company confidential data.
[2] Includes antimony content of imported antimonial lead consumed.

STOCKS

Yearend industrial stocks of antimony totaled 6,436 tons, 10 tons less than at the close of 1961. Government stocks of antimony metal on December 31, 1962, in all stockpiles totaled 52,288 tons, of which 30,301 tons was in the strategic stockpile, 6,907 tons was in the CCC stockpile, and 15,080 tons was in the supplemental stockpile. Combined Government stockpile inventories amounted to 69 percent of maximum objectives. Barter contracts, as of December 31, called for the delivery of an additional 3,750 tons through CCC for the supplemental stockpile.

TABLE 8.—Industry stocks of primary antimony in the United States, Dec. 31

(Short tons, antimony content)

Stocks	1958	1959	1960	1961	1962
Ore and concentrate	3,052	2,884	2,356	850	1,450
Metal	1,232	1,422	1,346	1,680	1,599
Oxide	1,889	1,659	2,187	2,398	1,895
Sulfide	143	115	94	107	90
Residues and slags	565	685	938	873	999
Antimonial lead [1]	371	373	242	538	403
Total	7,252	7,138	7,163	6,446	6,436

[1] Inventories from primary sources at primary lead smelters only.

PRICES

The quoted price of RMM brand antimony metal, in cases, was 32.50–33.00 cents per pound throughout 1962. The last price change occurred on April 3, 1961. The New York equivalent price was 34.75 cents. Foreign antimony prices were mostly consistent with New York quoted prices, but some metal from China brought a substantially lower price. Antimony trioxide price varied considerably.

TABLE 9.—Antimony price ranges in 1962

Type of antimony:		Price
Domestic metal [1]	cents per pound	32.50 to 33.00
Foreign metal [2]	do	30.00 to 31.50
Antimony trioxide [3]	do	30.00 to 31.50
Antimony ore,[3] 50 to 55 percent	dollars per short-ton unit	3.00 to 3.50
Antimony ore, minimum 60 percent	do	4.00 to 4.50
Antimony ore, minimum 65 percent	do	4.25 to 4.75

[1] RMM brand, f.o.b., Laredo, Tex.
[2] Duty-paid delivery, New York.
[3] Quoted in E&MJ Metal and Mineral Markets.

FOREIGN TRADE [3]

Imports.—General imports of contained antimony were 16,833 tons, an increase of 21 percent. Imports of ore and concentrate, oxide, sulfide, and antimonial lead increased sharply, but imports of metal decreased slightly. Mexico supplied 47 percent of the ore and concentrates, the Republic of South Africa 43 percent, and Bolivia 10 percent. The major suppliers of metal were Belgium-Luxembourg, 32 percent; Yugoslavia, 25 percent; United Kingdom, 20 percent; and Peru, 11 percent. The antimony content of antimony oxide imports was 2,415 tons of which the United Kingdom supplied 55 percent, Belgium-Luxembourg 29 percent, and France 15 percent. Government barter acquisitions accounted for 23 percent of general imports.

Exports.—Exports of antimony were 45 tons, about the same as in 1961. Most of these exports were antimony metal, alloys, and needles. The United Kingdom and Venezuela were the largest purchasers.

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

TABLE 10.—U.S. imports[1] of antimony, by countries

Year and country	Antimony ore: Short tons (gross weight)	Antimony ore: Antimony content: Short tons	Antimony ore: Antimony content: Value (thousands)	Needle or liquated antimony: Short tons (gross weight)	Needle or liquated antimony: Value (thousands)	Antimony metal: Short tons	Antimony metal: Value (thousands)	Antimony oxide: Short tons (gross weight)	Antimony oxide: Value (thousands)
1953-57 (average)	17,043	6,957	$1,787	36	$17	3,774	$1,893	1,673	[2] $716
1958	8,203	3,427	643	136	58	4,355	1,900	1,634	643
1959	15,307	6,466	1,236	163	74	4,395	2,023	2,056	825
1960	16,406	6,455	1,214	24	11	5,437	2,495	2,368	972
1961:									
North America:									
Canada	-	-	-	-	-	50	52	(3)	(4)
Guatemala	113	71	18	-	-	-	-	-	-
Mexico	10,674	3,411	527	-	-	93	61	-	-
Total	10,787	3,482	545	-	-	143	113	(3)	(4)
South America:									
Bolivia[5]	585	362	87	-	-	22	9	-	-
Chile[5]	221	134	49	-	-	-	-	-	-
Peru[5]	109	65	19	-	-	272	104	-	-
Total	915	561	155	-	-	294	113	-	-
Europe:									
Belgium-Luxembourg	-	-	-	1	(4)	983	490	543	263
France	-	-	-	-	-	29	15	147	74
Germany, West	-	-	-	-	-	22	10	11	5
United Kingdom	-	-	-	12	6	1,286	580	1,279	593
Yugoslavia	-	-	-	-	-	2,155	1,026	-	-
Total	-	-	-	13	6	4,475	2,121	1,980	935
Africa: Union of South Africa	4,502	2,670	689	-	-	-	-	-	-
Grand total	16,204	6,713	1,389	13	6	4,912	2,347	1,980	935
1962:									
North America:									
Canada	-	-	-	-	-	(3)	10	-	-
Guatemala	51	32	11	-	-	-	-	-	-
Mexico	12,746	4,072	725	-	-	266	91	-	-
Total	12,797	4,104	736	-	-	266	101	-	-
South America:									
Bolivia	1,303	830	300	-	-	59	27	-	-
Peru	-	-	-	-	-	524	221	-	-
Total	1,303	830	300	-	-	583	248	-	-
Europe:									
Belgium-Luxembourg	-	-	-	11	5	1,515	791	849	426
Finland	-	-	-	-	-	40	22	-	-
France	1	(3)	(4)	-	-	-	-	427	213
Germany, West	-	-	-	-	-	28	15	11	5
Netherlands	-	-	-	-	-	-	-	22	11
Spain	-	-	-	-	-	165	67	-	-
United Kingdom	-	-	-	6	3	950	483	1,601	736
Yugoslavia	-	-	-	-	-	1,193	582	-	-
Total	1	(3)	(4)	17	8	3,891	1,960	2,910	1,391
Africa: South Africa, Republic of[6]	6,021	3,668	1,132	-	-	-	-	-	-
Grand total	20,122	8,602	2,168	17	8	4,740	2,309	2,910	1,391

[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] 1957 data known to be not comparable with other years.
[3] Less than 1 ton.
[4] Less than $1,000.
[5] Imports shown from Chile probably were mined in Bolivia or Peru and shipped from a port in Chile.
[6] Effective Jan. 1, 1962; formerly Union of South Africa.

Source: Bureau of the Census.

TABLE 11.—U.S. imports for consumption of antimony [1]

Year	Antimony ore: Short tons (gross weight)	Antimony ore: Antimony content: Short tons	Antimony ore: Antimony content: Value (thousands)	Needle or liquated antimony: Short tons (gross weight)	Needle or liquated antimony: Value (thousands)	Antimony metal: Short tons	Antimony metal: Value (thousands)	Type metal and antimonial lead [2] (short tons)	Antimony oxide: Short tons (gross weight)	Antimony oxide: Value (thousands)
1953–57 (average)	17,043	6,957	$1,787	36	$17	3,763	$1,889	990	1,671	[3] $715
1958	8,203	3,427	643	136	58	4,282	1,871	645	1,634	643
1959	15,307	6,466	1,236	177	79	4,422	2,039	592	2,056	825
1960	16,406	6,455	1,214	24	11	5,437	2,495	645	2,368	972
1961	16,204	6,713	1,389	13	6	4,912	2,347	665	1,980	935
1962	20,122	8,602	2,168	17	8	4,720	2,300	1,064	2,910	1,391

[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] 1957 data known to be not comparable with other years.

Source: Bureau of the Census.

WORLD REVIEW

Bolivia.—Antimony production, taken from export figures because nearly all production was exported, was 7,300 short tons, a decrease of 1 percent from that produced in 1961. Bolivia reported that 7,000 tons of antimony content in ores and concentrates was exported to the United States. This indicated a sharp change in marketing pattern because most Bolivian antimony in recent years had been sold in Europe. However, these reported antimony exports were in direct variance with U.S. imports as reported to the Bureau of Mines by the Bureau of the Census. On the basis of Bolivian reports, 96 percent of the production was sold in the United States. La Unificada, S.A., operating its privately owned mine, was the largest producer, and many small mines made up the remainder of production. Most Bolivian antimony ore was hand-sorted to a high-grade product that, because of grade and quality, merited a market premium. Ore reserve, because of mineralization characteristics and other factors, remained largely speculative; nevertheless, production potential was encouraging. Projects were considered for antimony concentration plants and for an antimony smelter. Czechoslovakia continued and improved its offer to build an antimony smelter for Bolivian Government operation. Several U.S. firms considered constructing concentration plants and an oxide plant or smelter, and negotiated for production rights. The U.S. Government sponsored antimony reserve studies to serve as a base for antimony industry planning. The concentration plant projects would probably increase output as a result of ability to treat lower grade ores. The proposed Czechoslovakian-built smelter for treating high-grade ore would not increase Bolivian antimony output but would tend to remove premium-quality ore from the existing oxide market and produce antimony metal at too high a cost to compete in the free world market at current prices.

TABLE 12.—World production of antimony (content of ore except as indicated), by countries [1]

(Short tons)

Country	1953–57 (average)	1958	1959	1960	1961	1962
North America:						
Canada [2]	831	430	829	826	666	910
Guatemala (U.S. imports)	[3] 13	47	97	119	71	32
Mexico [4]	4,728	3,029	3,622	4,664	3,977	5,254
United States	614	705	678	635	689	631
Total	6,186	4,211	5,226	6,244	5,403	6,827
South America:						
Argentina	17	11	—	—	—	—
Bolivia (exports) [4]	6,139	5,818	6,065	5,872	7,429	7,323
Peru [4]	989	964	793	901	790	441
Total	7,145	6,793	6,858	6,773	8,219	7,764
Europe:						
Austria	477	514	631	676	668	331
Czechoslovakia [5]	1,800	1,800	1,800	1,800	1,800	1,800
France	138	42	—	—	—	—
Greece	143	—	—	—	—	—
Italy	345	188	231	236	277	428
Portugal	4	7	7	—	—	—
Spain	212	220	180	243	190	176
U.S.S.R. [5]	5,500	6,600	6,600	6,600	6,600	6,600
Yugoslavia (metal)	1,750	1,835	2,514	2,657	2,715	2,966
Total [6]	10,400	11,200	12,000	12,200	12,300	12,300
Asia:						
Burma [4]	82	90	240	180	175	138
China [6]	13,200	16,500	16,500	19,000	18,500	18,500
Iran [7]	75	160	[6] 160	[6] 55	—	—
Japan	419	298	340	298	215	183
Ryukyu Islands	[8] 13	—	26	159	112	—
Thailand	40	—	10	—	36	49
Turkey	1,233	[9] 1,687	[9] 1,380	[9] 1,507	[9] 1,500	[9] 1,962
Total [6]	15,100	18,700	18,700	21,200	20,500	20,800
Africa:						
Algeria	2,099	1,106	1,135	785	720	150
Morocco	514	203	252	317	407	451
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	95	151	104	100	68	61
South Africa, Republic of	10,978	7,904	13,619	13,538	11,804	11,697
Total	13,686	9,364	15,110	14,740	12,999	12,359
Oceania: Australia	319	775	703	175	131	112
World total (estimate)	53,000	51,000	59,000	61,000	60,000	60,000

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[2] Antimony content of smelter products exclusively from mixed ores.
[3] One year only, as 1957 was the first year of commercial production.
[4] Includes antimony content of smelter products derived from mixed ores.
[5] Estimate according to the annual issues of Minerais et Metaux (France), except 1962.
[6] Estimate.
[7] Year ended March 20 of year following that stated.
[8] Average annual production, 1955–57.
[9] Exports.

Compiled by Catherine M. Judge, Division of Foreign Activities.

Canada.—Antimony production, 900 tons, was 37 percent greater than in 1961. All antimony output was recovered as a byproduct of processing lead and silver ores by Consolidated Mining & Smelting Co. of Canada, Ltd., at its smelter-refinery at Trail, British Columbia. Canadian consumption required imports to supplement domestic production.

China.—Considerable Chinese antimony was traded erratically and generally at a discount on the London Metal Exchange. The unknown factors of Chinese reserves and production potential contributed toward world market instability, because China continued to be the world's largest producer of antimony.

Mexico.—Antimony production was 32 percent more than in 1961. Most of this output was exported to the United States as ore and intermediate smelter products and, as such, was the source material for a large part of the U.S. domestic refined antimony. Mexican consumption increased slightly.

South Africa, Republic of.—Consolidated Murchison (Transvaal) Goldfields & Development Co., Ltd., was the only antimony producer. Production from the Transvaal mine decreased 1 percent. All output was exported, and the principal market continued to be the United Kingdom. Antimony reserves in the Transvaal gold-antimony mine were reported to be small, recent exploration added 2 to 3 years of mine life, and exploration was continued.[4]

TECHNOLOGY

Antimony technology was advanced by investigative studies and reports of research findings concerning new analytical methods,[5] flotation of antimonite,[6] liquid-liquid extraction,[7] ability to inhibit corrosion,[8] magnetic susceptibility of alloys,[9] electron resonances,[10] and fundamental studies of antimony and its alloys and compounds.[11]

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Arsenic

By F. L. Wideman [1] and Gertrude N. Greenspoon [2]

PRODUCTION of white arsenic in the United States rose 7 percent in 1962. Although shipments increased markedly they were lower than production, and stocks at yearend gained 16 percent, continuing the upward trend begun in 1959. Imports totaled 15,800 tons, a 19-percent decrease from 1961. World production was estimated at 55,500 tons, compared with 54,200 tons in 1961.

TABLE 1.—Salient white arsenic statistics

(Short tons)

	1953-57 (average)	1958	1959	1960	1961	1962
United States:						
Production	11,503	11,508	5,189	(1)	(1)	(1)
Shipments	13,234	10,931	7,239	(1)	(1)	(1)
Imports for consumption	6,669	9,524	19,386	12,825	19,483	15,758
Stocks Dec. 31: Producer	8,443	3,112	1,058	(1)	(1)	(1)
Consumption, apparent [2]	19,903	20,455	26,625	(1)	(1)	(1)
Price: Refined, carlots [3] cents per pound	5½	5½	4-5	4-5	4	4
World: Production	39,000	[4] 40,000	47,000	57,000	[4] 54,200	55,500

[1] Figure withheld to avoid disclosing individual company confidential data.
[2] Producers' shipments, plus imports, minus exports; no exports were reported by producers, 1953-62.
[3] E&MJ Metal and Mineral Markets.
[4] Revised figure.

DOMESTIC PRODUCTION

Domestic production of white arsenic increased 7 percent in 1962. The entire output was derived as a byproduct of smelting arsenic-containing copper ores by The Anaconda Company at Anaconda, Mont., and American Smelting and Refining Company at Tacoma, Wash. Arsenic metal was not produced in 1962.

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant. Division of Minerals.

TABLE 2.—Production and shipments of white arsenic in the United States

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
1953-57 (average)	10,836	12,550	$530,023	667	684	$53,940	11,503	13,234	$583,963
1958	11,121	10,544	421,777	387	387	37,884	11,508	10,931	459,661
1959	4,897	6,922	293,940	292	317	27,315	5,189	7,239	321,255
1960-62	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)

[1] Excludes crude consumed in making refined.
[2] Figure withheld to avoid disclosing individual company confidential data.

CONSUMPTION AND USES

In 1962 most of the white arsenic produced was consumed in manufacturing lead and calcium arsenate insecticides. Production of lead arsenate has ranged from 5,000 to 10,000 tons per year since 1951, compared with a peak of 45,000 tons in 1944. The downward trend has resulted from substitution of organic insecticides.

Arsenic compounds also were used in weedkillers, glass manufacture, cattle and sheepdips, dyestuffs, and wood preservatives. Apparent consumption of white arsenic decreased 2 percent from 1961.

TABLE 3.—Production of arsenical insecticides and consumption of arsenic wood preservatives in the United States

(Short tons)

Year	Production of insecticides[1]		Consumption of wood preservatives[2]		
	Lead arsenate (acid and basic)	Calcium arsenate (70 percent $Ca_3(AsO_4)_2$)	Wolman salts (25 percent sodium arsenate)	Other	Total
1953-57 (average)	6,827	6,037	1,015	591	1,606
1958	7,469	5,216	1,082	1,167	2,249
1959	6,452	3,212	1,357	1,274	2,631
1960	5,031	3,295	1,275	1,150	2,425
1961	5,223	4,019	1,344	1,329	2,673
1962	(3)	(3)	[4]1,233	[4]1,575	[4]2,808

[1] Bureau of the Census, U.S. Department of Commerce.
[2] Forest Service, U.S. Department of Agriculture.
[3] Data not available.
[4] Preliminary figure

STOCKS

Stocks rose 16 percent because production exceeded sales. Shipments of white arsenic increased 42 percent, but total new supply was only 3,000 tons less than in 1961.

PRICES

White arsenic was quoted at 4 cents per pound, in barrels, carlots, New York, throughout 1962. According to Oil, Paint and Drug Reporter, lead arsenate packed in 3- to 50-pound bags was quoted at 30½ cents per pound until late January when it was lowered to 26 cents; the price in 1-pound bags was 47 cents at the beginning of the year and dropped to 36 cents in late January. The price decline was attributed to competition from synthetic organic insecticides.

The London price for white arsenic in 1962 was £40 to £45 per long ton (equivalent to 5.00 to 5.63 cents per pound) for 98 percent minimum purity. Arsenic metal on the London market sold for £400 per long ton (50 cents per pound).

FOREIGN TRADE [3]

Imports.—Imports for consumption of white arsenic totaled 15,800 tons, 19 percent less than in 1961. Mexico continued to be the chief supplier with 69 percent of the total imports, followed by France with 25 percent and Sweden with 5 percent.

Nearly all of the 115 tons of arsenic metal imported came from Sweden. Canada, United Kingdom, and Ireland furnished small quantities. Belgium-Luxembourg supplied 33 tons of arsenic sulfide; United Kingdom and France supplied 83 and 45 tons, respectively, of sodium arsenate; and Australia supplied 7 tons of sheepdip.

Exports.—No exports of white arsenic were reported. Calcium arsenate shipments totaled 471 tons valued at $104,096, of which 369 tons went to Nicaragua, 82 to Israel, 17 to Canada, and 3 to Hong Kong.

Exports of lead arsenate totaled 711 tons valued at $248,894. Venezuela was the chief recipient with 350 tons, followed by Peru with 233, Guatemala 38, Costa Rica 21, and Colombia 20. The remainder, in lots of less than 15 tons each, went to 10 other countries.

Tariff.—White arsenic, arsenic sulfide, paris green, and sheepdip containing arsenic were duty free. Arsenic acid was subject to a duty of 3 cents per pound, and lead arsenate was subject to a duty of 1.5 cents per pound. The duty of 2.5 cents per pound on metallic arsenic, effective June 30, 1958, continued through 1962. Compounds of arsenic not specified in the Tariff Act of 1930 were subject to a duty of 12½ percent of their foreign market value.

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

TABLE 4.—U.S. imports for consumption of white arsenic (As_2O_3 content), by countries

Country	1953–57 (average)		1958		1959	
	Short tons	Value	Short tons	Value	Short tons	Value
North America:						
Canada	723	$57,314	800	$63,353	607	$49,116
Mexico	5,541	609,464	6,052	541,795	12,528	962,894
Total	6,264	666,778	6,852	605,148	13,135	1,012,010
Europe:						
France	232	9,756	1,201	49,532	3,504	153,336
Sweden	169	7,937	1,471	64,932	2,746	176,043
Other countries [1]	4	313	------	------	1	122
Total	405	18,006	2,672	114,464	6,251	329,501
Grand total	6,669	684,784	9,524	719,612	19,386	1,341,511

Country	1960		1961		1962	
	Short tons	Value	Short tons	Value	Short tons	Value
North America:						
Canada	503	$40,249	192	$12,022	------	------
Mexico	9,857	856,327	14,058	1,068,164	10,935	$799,097
Total	10,360	896,576	14,250	1,080,186	10,935	799,097
Europe:						
France	2,252	129,724	4,188	262,470	4,003	226,975
Sweden	213	19,357	1,042	74,406	804	49,666
Other countries [2]	([3])	382	3	4,654	16	783
Total	2,465	149,463	5,233	341,530	4,823	277,424
Grand total	12,825	1,046,039	19,483	1,421,716	15,758	1,076,521

[1] Includes Poland-Danzig and the United Kingdom.
[2] Includes Netherlands, United Kingdom, and Portugal.
[3] Negligible.

Source: Bureau of the Census.

TABLE 5.—U.S. imports and exports of arsenicals, by classes

(Pounds)

Class	1953–57 (average)	1958	1959	1960	1961	1962
Imports for consumption:						
White arsenic (As_2O_3 content)	13,337,529	19,048,920	38,771,199	25,649,095	38,966,394	31,515,599
Metallic arsenic	142,586	61,660	84,769	145,085	132,389	229,439
Sulfide	48,145	126,354	41,872	30,352	55,116	66,160
Sheepdip	57,456		116,785			14,765
Calcium arsenate	20,509	------	------	4,001	------	------
Sodium arsenate	196,585	173,337	152,769	209,956	211,034	255,466
Exports:						
Calcium arsenate	2,231,939	1,274,000	122,920	289,700	669,932	942,399
Lead arsenate	1,174,523	2,099,960	1,398,900	1,888,149	928,797	1,422,795

Source: Bureau of the Census.

WORLD REVIEW

World production of white arsenic was estimated at 55,500 tons, 2 percent more than in 1961. More than 1,200 tons came from Southern Rhodesia where arsenic is recovered as a byproduct of gold mining. Output in Mexico decreased 6 percent, but rose 7 percent in the United States.

TABLE 6.—Free world production of white arsenic, by countries [1] [2]

(Short tons)

Country [1]	1953-57 (average)	1958	1959	1960	1961	1962
North America:						
Canada	964	1,162	789	862	209	93
Mexico	3,223	3,411	11,536	13,372	13,537	[3] 12,700
United States	11,503	11,508	5,189	([4])	([4])	([4])
South America:						
Brazil	776	292	367	233	64	[3] 110
Peru	31	369	524	433	388	[3] 390
Europe:						
Belgium (exports)	2,299	543	3,161	([5])	([5])	([5])
France	6,096	8,354	8,842	9,200	10,500	[3] 11,000
Germany, West (exports)	420	205	180	110	154	[3] 80
Greece	33	13	11	[3] 11	[3] 3	[3] 3
Italy	1,139	688	1,254	654	979	[3] 880
Portugal	[6] 1,489	[6] 1,172	596	810	331	[3] 330
Spain	17	285	320	435	341	[3] 250
Sweden	9,040	10,213	12,300	12,950	12,153	[3] 12,000
Asia: Japan	1,719	1,429	1,186	1,247	1,047	[3] 1,100
Africa: Rhodesia and Nyasaland, Federation of: Southern Rhodesia	614	683	528	204	----------	1,207
World total (estimate) [1] [2]	39,000	40,000	47,000	57,000	54,200	55,500

[1] Arsenic may be produced in Argentina, Austria, China, Czechoslovakia, Finland, East Germany, Hungary, U.S.S.R., and United Kingdom, but there is too little information to estimate production.
[2] This table incorporates a number of revisions of data published in previous Arsenic chapters. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Estimate.
[4] Figure withheld to avoid disclosing individual company confidential data; included in world total.
[5] Data not available; estimate included in the world total.
[6] Exports.

Compiled by Catherine M. Judge, Division of Foreign Activities.

France.—The Arsenic Development Committee with headquarters at 26 Rue La Fayette, Paris, France, was formed in 1962 by principal producers in Europe. The organization was established to serve as an information center and to stimulate research and development for arsenic and its compounds. Members included Société Bolidens Gruvaktiebolag, Société Générale Métallurgique de Hoboken, Société Minierè et Metallurgique de Penarroya, S.P.A. Rumianca, and Société des Mines et Usines de Salsigne.[4]

South-West Africa.—Arsenic will be recovered [5] in the operation of both the copper and lead smelters of Tsumeb Corp., Ltd. The byproduct material will be volatilized as arsenic trioxide (white arsenic) in a separate plant using four single-hearth Godfrey-type roasters. The trioxide will be condensed to 95 percent AsO_3 which will be stockpiled or sold as the market permits.

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[4] American Metal Market. Arsenic Producers in Europe Set Up Information Center. V. 69, No. 157, Aug. 15, 1962, p. 16.
[5] South African Mining & Engineering Journal (Johannesburg). Tsumeb's R20 Million Smelter Projects. V. 73, pt. 2, No. 3641, Nov. 16, 1962, pp. 1129–1130, 1132.

Sweden.—The white arsenic refinery of Boliden Mining Co., which produced arsenic as a byproduct of smelting operations, was being replaced by a new larger plant.[6] The company accounted for all of Sweden's output at its Rönnskar plant, near Skelleftea, in northern Sweden. The new plant was expected to be in production by mid-1962.

TECHNOLOGY

Large arsenic crystals were grown from melts of fused arsenic in sealed, heavy wall, transparent fused quartz ampoules. Emission spectrographic analyses indicated that all detected impurities were deposited on the ends of the crystals.[7]

Ansul Chemical Co. conducted tests designed to evaluate cacodylic acid ($((CH_3)_2AsOOH)$) as a cotton plant defoliant and dessicator. The program reflected a growing emphasis on an enlarging role of arsenicals in farm chemical products.[8]

Arsenic-doped, melt-grown silicon crystals with level resistivity profiles were obtained by passing an arsenic trichloride-helium mixture into a silicon crystal grower.[9] The diffusion coefficient of arsenic in silicon was investigated over a temperature range of 1,100°–1,350° C using the formation of p–n junctions to determine diffusion depths and concentration.[10]

An article, translated from Russian, described results of experiments to produce spectrally pure arsenic.[11] Arsenic trioxide was purified by recrystallization from hydrochloric acid. The washed and dried precipitate of arsenic trioxide was reduced with charcoal to metallic arsenic.

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[6] Larsen Gustav E. (commercial attaché). Swedish Production of Arsenic. State Department Dispatch 805, Stockholm, Sweden, Mar. 30, 1962. 2 pp.

[7] Wiseberg, L. R., and P. R. Celmer. Arsenic Purification by Crystal Growth From the Melt. J. Electrochem. Soc., v. 110, No. 1, January 1963, pp. 56–59.

[8] Chemical Week. Arsenic Scores in New Organics. V. 91, No. 11, Sept. 15, 1962, pp. 13, 32, 134.

[9] Mehalchick, E. J., and P. J. Marshall. Vapor-Phase Doping of Silicon With Arsenic Trichloride J. Electrochem. Soc., v. 109. No. 3, March 1962, pp. 267–269.

[10] Armstrong, W. J. The Diffusity of Arsenic in Silicon. J. Electrochem. Soc., v. 109, No. 11, November 1962, pp. 1065–1067.

[11] Goryunova, N. A., L. V. Kradinova, V. I. Sokolova, and E. V. Sokolova. Method of Preparing High Purity Arsenic. J. Appl. Chem. U.S.S.R. (English transl. Zhurnal Prikladnoi Khimii), v. 33, No. 6, June 1960, pp. 1409–1410.

Asbestos

By J. M. West[1] and Victoria R. Schreck[2]

ALTHOUGH the United States consumed 24 percent of the world output of asbestos fiber, it supplied only 7 percent of its own requirements. The Nation ranked seventh among world producers and contributed 2 percent of the total output.

LEGISLATION AND GOVERNMENT PROGRAMS

A revised national stockpile purchase specification, P-4-R3, was issued on January 23, 1962, by the Office of Emergency Planning for Government procurement of amosite asbestos. The new specification superseded the one dated August 4, 1959.

Deliveries of Arizona No. 2 chrysotile for the stockpile were completed by one of three contracting operators. The Government continued to acquire amosite and crocidolite asbestos for stockpiling under barter agreements through the U.S. Department of Agriculture.

TABLE 1.—Salient asbestos statistics

	1953-57 (average)	1958	1959	1960	1961	1962
United States:						
Production (sales) ---------short tons--	46,322	43,979	45,459	45,223	52,814	53,190
Value ---------thousands--	$4,740	$5,127	$4,391	$4,231	$4,347	$4,677
Imports for consumption (unmanufactured) ---------short tons--	696,740	644,331	713,047	669,496	[1] 616,529	676,027
Value ---------thousands--	$59,722	$58,314	$65,006	$63,345	$58,942	$64,150
Exports (unmanufactured) [2] ---------short tons--	2,720	3,026	4,461	5,525	3,799	2,949
Value ---------thousands--	$375	$424	$793	$857	$759	$598
Exports of asbestos products (value) [2] ---------thousands--	$12,875	$13,233	$12,921	$13,703	$13,825	$14,274
Consumption, apparent [3] --short tons--	740,342	685,284	754,045	709,194	[1] 665,544	726,268
World: Production ---------do----	1,850,000	2,055,000	2,270,000	2,440,000	2,770,000	3,055,000

[1] Revised figure.
[2] Includes reexports.
[3] Measured by quantity produced, plus imports, minus exports.

DOMESTIC PRODUCTION

Asbestos production in the United States increased 1 percent in quantity and 8 percent in value compared with 1961. Most of the rise in value came from California and Vermont sales, although

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

the quantity of California fiber sold declined. An estimated 1.1 million tons of rock was mined to produce the 53,000 tons of fiber marketed.

Vermont Asbestos Mines Division of Ruberoid Co. operated its deposit at Belvidere Mountain near Hyde Park, Vt., and continued to be the largest U.S. producer. A small quantity of spinning-length fiber entered into electrolytic cell construction.

Shipments from mines in the Globe district, Arizona, were reported by four companies: Jaquays Mining Corp., Phillips Asbestos Mines, Metate Asbestos Corp., and Pan American Fiber Corp. Jaquays Mining Corp. continued to be the major producer in Arizona. Some fiber was sold for filter purposes. Asbestos Manufacturing Co. mill processed fiber from Phillips Asbestos Mines.

The following California companies reported production and shipments: Jefferson Lake Asbestos Corp., Calaveras County; Coalinga Asbestos Co., Inc., and Todd Industries, Inc., Fresno County; and Asbestos Bonding Co., Napa County. In addition, Union Carbide Nuclear Co. produced and shipped crude ore from its deposit near Coalinga, Fresno County, for experimental purposes in preparation for processing tests at the company's Kings City, Calif., pilot plant (under construction). Two companies discontinued mining operations, Rawhide Asbestos Corp. in Tuolumne County and Todd Industries, Inc., in Fresno County. Small quantities of chrysotile were produced and sold by the Coast Asbestos Co., from its Grant County, Oreg., mine. The Burnsville mine of Powhatan Mining Co., located in Yancy County, N.C., was the only domestic source of amphibole asbestos.

A number of articles were published about new mining and milling operations in California.[3]

The new plant of Jefferson Lake Asbestos Co., located near Copperopolis, went into production late in 1962 with capacity rated at 70,000 tons of fiber annually. Several shipments went to Japan, which was expected to be an important market, especially for grades 5R and 6D, used in the manufacture of asbestos cement sheet. The Coalinga Asbestos Co. mill, northwest of Coalinga, began operating at an initial capacity of 12,000 tons per year, and the first shipment of fiber was made in March to the Johns-Manville Corp. tile plant in Louisiana. Prices on two floor tile grades, a "Red" and a "Blue" brand, were quoted at $75 and $100 per ton, respectively. A "Green" brand was also produced. Hidden Splendor Mining Co., a subsidiary of Atlas Corporation, began work on a mill to have an initial capacity of 15,000 tons expandable to 25,000 tons of fiber per year at its property northwest of Coalinga in Fresno and San Benito Counties. Claims held by Asbestos Corporation, Ltd., were investigated.

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[3] Chemical and Engineering News. New Mills Set To Turn Out California Asbestos. V. 40, No. 22, May 28, 1962, pp. 36–37.
Huttl, John. Jefferson Lake—California's Premier Asbestos. Eng. and Min. J., v. 163, No. 10, October 1962, pp. 84–89.
Merritt, Paul C. California Asbestos Goes To Market. Min. Eng., v. 14, No. 9, September 1962, pp. 57–60.
Mining World. Asbestos Awakens Mother Lode. V. 24, No. 10, September 1962, pp. 22–27.
Munro, Robert C., and Kenneth M. Reim. Coalinga—Newcomer to the Asbestos Industry. Min. Eng., v. 14, No. 9, September 1962, pp. 60–62.
Utley, Harry F. Asbestos Boom in California. Pit and Quarry, v. 55, No. 6, December 1962, pp. 76–80, 85.

CONSUMPTION AND USES

Consumption of chrysotile asbestos increased from 666,000 tons in 1961 to 726,000 tons. Short-fiber asbestos, consumed largely in the manufacture of asbestos cement and asphalt building materials, comprised 97 percent of all fiber used. Domestic mines supplied 8 percent of all short-fiber chrysotile consumed. Crocidolite consumption, represented by imports, decreased from 18,000 tons in 1961 to 17,000 tons.

STOCKS

On December 31, national stockpile inventories were as follows: Amosite, 11,705 tons; chrysotile, 6,222 tons; and crocidolite (soft), 1,567 tons. Supplemental and Commodity Credit Corporation stockpiles, including asbestos obtained under barter, contained the following: Amosite, 20,597 tons; chrysotile, 5,532 tons; and crocidolite, 19,486 tons. Also, 2,348 tons of non-stockpile-grade chrysotile was held in the Defense Production Act stockpile. Maximum objectives remained at 45,000 tons for amosite and 11,000 tons for chrysotile. No objective was set for crocidolite. Government stocks of chrysotile were 230 tons higher on December 31, 1962, than on December 31, 1961.

PRICES

Canadian (Quebec) chrysotile asbestos prices, f.o.b. mine, were unchanged as follows:

Grade:	*Per short ton*
Crude No. 1	Can$1,410 to Can$1,475
Crude No. 2—Crude run of mine and sundry	610 to 875
No. 3—Spinning fiber	350 to 650
No. 4—Shingle fiber	180 to 245
No. 5—Paper fiber	120 to 150
No. 6—Waste, stucco, or plaster	86
No. 7—Refuse or shorts	40 to 80

Prices for British Columbia chrysotile asbestos, f.o.b. Vancouver, from Cassiar Asbestos Corp., Ltd., were as follows:

Grade:	*Per short ton*
No. 1 crude (C–1)	Can$1,522
AAA	787
AA	625
A	470
AC	325
AK	220
AS	181
AX	142
Talus	210

Vermont asbestos prices, f.o.b. Hyde Park or Morrisville, remained unchanged as follows:

Grade:	*Per short ton*
Group No. 3—Spinning and filtering	$345 to 402
Group No. 4—Shingle fiber	181 to 320
Group No. 5—Paper fiber	120 to 142
Group No. 6—Waste, stucco, or plaster	86
Group No. 7—Refuse or shorts	40 to 75

Asbestos magazine published Arizona asbestos prices, f.o.b. Globe, as follows:

Grade:	Per short ton 1961	Mar. 10, 1962
No. 1 soft	$1,650 to $1,800	$1,475 to $1,650
No. 2 soft	800 to 1,000	800 to 1,000
Group 3—Filtering and spinning	375 to 450	425 to 450
Group 4—Plastic and filtering	225 to 250	385 to 400
Group 5—Plastic and filtering	190 to 225	225 to 375
Group 7—Refuse and shorts	58 to 90	58 to 90

Market quotations were not available for African, Australian, and South American asbestos because sales were negotiated privately. The following average values were calculated from U.S. Department of Commerce import data:

Imports:	Per short ton 1961	1962
Amosite	$163	$164
Crocidolite:		
Bolivia	182	---
Australia	209	201
South Africa, Republic of	202	221

FOREIGN TRADE [4]

Imports of amosite and chrysotile increased 36 and 9 percent, respectively, and crocidolite decreased 4 percent, resulting in an overall increase of 9 percent in total asbestos imports in 1962.

Low-iron chrysotile imports of spinning-length fibers from British Columbia decreased from 5,374 tons in 1961 to 5,077 tons. Ninety-seven percent of all chrysotile imported was short fiber of less than spinning length.

The Republic of South Africa supplied crocidolite and chrysotile and was the only source of amosite. Imports from Australia consisted solely of crocidolite. The total of crocidolite imports from these two countries was 17,127 tons. An additional ton was imported from Bolivia. Finland supplied anthophyllite, and only chrysotile was imported from other countries.

Exports of unmanufactured asbestos decreased from 3,572 tons in 1961 to 2,824 tons.

Imports included 7,633 tons of amosite and 8,270 tons of crocidolite acquired for the Government's supplemental stockpile.

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

TABLE 2.—U.S. imports for consumption of asbestos (unmanufactured), by classes and countries [1]

Year and country	Crude (including blue fiber)		Textile fiber [2]		All other		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1961:								
North America: Canada	437	$60,097	16,903	$6,163,364	552,713	$44,713,557	570,053	$50,937,018
South America: Bolivia	50	9,090	-------	----------	-------	----------	50	9,090
Europe:								
Finland	-------	----------	-------	----------	[3] 165	14,500	[3] 165	14,500
Italy [2]	[3] 3	[3] 6,120	-------	----------	110	16,530	113	22,650
Portugal [2]	8	645	-------	----------	-------	----------	8	645
Yugoslavia	5,194	173,260	-------	----------	-------	----------	5,194	173,260
Africa:								
Rhodesia and Nyasaland, Federation of [2 4]	[3] 2,469	[3] 616,424	-------	----------	[3] 753	[3] 132,559	[3] 3,222	[3] 748,983
Union of South Africa [2]	[3] 33,335	[3] 6,182,426	18	5,349	[3] 2,057	[3] 365,388	[3] 35,410	[3] 6,553,163
Oceania: Australia	2,314	482,764	-------	----------	-------	----------	2,314	482,764
Total	[3] 43.810	[3] 7,530,826	16,921	6.168.713	[3] 555.798	[3] 45,242,534	[3] 616,529	58.942.073
1962:								
North America: Canada	232	55,411	14,816	5,875,484	608,757	49,003,906	623,805	54,934,801
South America: Bolivia [5]	1	300	-------	----------	-------	----------	1	300
Europe:								
Finland	-------	----------	-------	----------	440	18,150	440	18.150
Italy [2]	9	10,585	-------	----------	28	5,123	37	15,708
Portugal [2]	-------	----------	-------	----------	23	2,374	23	2,374
Yugoslavia	3,444	119,614	-------	----------	11	542	3,455	120,156
Africa:								
Rhodesia and Nyasaland, Federation of [2]	4,171	859,177	-------	----------	1,908	366,056	6,079	1,225,233
South Africa, Republic of [2 6]	30,250	5,514,426	-------	----------	4,412	803,274	34,662	6,317,700
Oceania: Australia	7,525	1,515,323	-------	----------	-------	----------	7,525	1,515,323
Total	45,632	8,074,836	14,816	5,875,484	615,579	50,199,425	676,027	64,149,745

[1] In Minerals Yearbook 1961, page 285, table 2, the 1960 total of short fibers should read 472,164 short tons instead of 5,472,164 short tons.
[2] Data reported by the Bureau of the Census have been adjusted by the Bureau of Mines.
[3] Revised figure.
[4] All believed to be from Southern Rhodesia.
[5] Reported by the Bureau of the Census as Chile.
[6] Effective Jan. 1, 1962; formerly Union of South Africa.

Source: Bureau of the Census.

TABLE 3.—U.S. imports for consumption of asbestos, from specified countries, by grades

(Short tons)

Grade	1961			1962		
	Canada	Southern Rhodesia [1]	Union of South Africa [2]	Canada	Southern Rhodesia [1]	Republic of South Africa [2] [3]
Chrysotile:						
Crudes	437	[4] 2,469	2,856	232	4,171	413
Spinning or textile	16,903		18	14,816		
All other	552,713	[4] 753	2,057	608,757	1,908	4,412
Crocidolite (blue)			[4] 15,501			9,602
Amosite			14,978	(5)		20,235
Total	570,053	[4] 3,222	[4] 35,410	623,805	6,079	34,662

[1] Reported by the Bureau of the Census as Federation of Rhodesia and Nyasaland. Believed to be from Southern Rhodesia. Excludes data adjusted by the Bureau of Mines.
[2] Includes data adjusted by the Bureau of Mines.
[3] Effective Jan. 1, 1962; formerly Union of South Africa.
[4] Revised figure.
[5] Excludes data adjusted by the Bureau of Mines.

TABLE 4.—U.S. exports [1] and reexports [2] of asbestos and asbestos products

Product	1961		1962	
	Quantity	Value	Quantity	Value
Exports:				
Unmanufactured:				
Crude and spinning fibers short tons	1,064	$281,444	655	$162,130
Nonspinning fibers do	1,084	256,261	968	204,797
Waste and refuse do	1,424	170,755	1,201	211,456
Total unmanufactured do	3,572	708,460	2,824	578,383
Products:				
Brake lining and blocks—molded, semimolded, and woven	(3)	4,192,908	(3)	4,645,844
Clutch facing and lining number	1,452,435	1,149,299	2,277,461	1,561,659
Construction materials, n.e.c. short tons	11,300	2,980,726	9,064	2,343,404
Pipe covering and cement do	2,627	1,485,640	2,890	1,242,752
Textiles, yarn, and packing do	1,288	3,106,542	1,453	3,311,355
Manufactures, n.e.c.	(4)	889,625	(4)	1,164,908
Total products		13,804,740		14,269,922
Reexports:				
Unmanufactured:				
Crude and spinning fibers short tons	108	24,175	95	14,193
Nonspinning fibers do	106	26,003		
Waste and refuse do	13	594	[5] 30	5,437
Total Unmanufactured do	227	50,772	125	19,630
Products:				
Brake lining and blocks—molded, semimolded, and woven	(3)	1,580	(3)	1,905
Construction materials, n.e.c. short tons	63	18,353	7	1,756
Textiles, yarn, and packing do	1	228		
Total products		20,161		3,661

[1] Materials of domestic origin, or foreign material that has been milled, blended, or otherwise processed in the United States.
[2] Material that has been imported and later exported without change.
[3] Values have been summarized; quantities not shown.
[4] Quantity not recorded.
[5] Adjusted by Bureau of Mines.

Source: Bureau of the Census.

WORLD REVIEW [5]

NORTH AMERICA

Canada.—Asbestos shipments in 1962 set a record of more than 1.2 million tons. More than 95 percent of 1961 shipments were exported.[6] Employment at Canadian asbestos mines and mills in 1961 totaled 6,875 workers.

Canadian Johns-Manville Co., Ltd., operated the Jeffrey mine, Asbestos, Quebec, close to capacity during 1962. The return of the mine to open-pit operation was essentially completed. An inclined skipway was installed for removing waste from the pit. Explorations for asbestos were conducted by the company between Amos and Barraute in northwestern Quebec. The company managed development operations at the Advocate Mines, Ltd. property, Baie Verte, northern Newfoundland, where stripping of waste continued in preparation for production to start in mid-1963. Output was expected to exceed 40,000 tons of fiber annually, mainly group 4 for use in asbestos-cement products.

Asbestos Corporation Ltd. exchanged shares equivalent to a 10-percent interest with Eternit S.A. of Belgium. A long-term contract for purchase of asbestos from the Canadian company was included in the agreement. Ore reserves at the end of 1962 were, in million tons: King-Beaver, 12.4; British Canadian, 46.9; Normandie, 20.3; and others, 14.2. A total of 4.6 million tons of ore was milled, and 10.9 million tons of barren rock excavated. More than 1 million tons of overlying waste was stripped from the ore body at the Normandie mine. A pilot plant for producing finely ground asbestos filler was installed at the mine.

An option was taken by Asbestos Corporation Ltd. on the Murray Mining Corp. Ltd., Asbestos Hill property, south of Deception Bay in the Ungava area, northern Quebec. Exploration and plans for development continued.

Production by Lake Asbestos of Quebec Ltd., a subsidiary of American Smelting and Refining Company, totaled 100,612 tons, compared with 95,042 tons in 1961. Ore reserves were increased at the company's Black Lake, Quebec, mine by continued development work on the open pit.

Several exploration holes were drilled by Bornite Copper Corp. on its prospect in Cleveland Township, near Asbestos, Quebec. A deposit 1,000 feet or more long and 140 feet wide was indicated. Assays were from 6.4 to 9.7 percent fiber and floats, mainly classified as shorts. A magnetometer survey was completed over the northeast part of the deposit.

National Gypsum Co. initiated an expansion program to increase capacity at its Thetford Mines, Quebec, property.

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[5] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.

[6] Dominion Bureau of Statistics, Industry and Merchandising Division (Ottawa, Canada). The Asbestos Industry, 1961. Annual Rept. No. 26–205, October 1962, 10 pp.

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TABLE 5.—World production of asbestos by countries [1] [2]

(Short tons)

Country [1]	1953–57 (average)	1958	1959	1960	1961	1962
North America:						
Canada (sales) [3]	991,896	925,331	1,050,429	1,118,456	1,173,695	1,223,509
United States (sold or used by producers)	46,322	43,979	45,459	45,223	52,814	53,190
Total	1,038,218	969,310	1,095,888	1,163,679	1,226,509	1,276,699
South America:						
Argentina	429	285	320	[4] 330	[4] 330	[4] 330
Bolivia (exports)	205		168	66	57	56
Brazil	2,738	3,816	12,325	14,590	[4] 18,700	[4] 18,750
Venezuela	3,223	9,152	5,095	4,333	650	
Total	6,595	13,253	17,908	19,319	[4] 19,750	[4] 19,150
Europe:						
Austria				215	564	503
Bulgaria	1,146	1,100	1,100	1,200	1,200	[4] 1,100
Finland [5]	11,567	7,932	9,579	10,534	10,339	10,869
France	13,641	20,742	23,360	28,662	30,746	27,558
Italy	33,059	42,500	49,778	56,672	62,816	61,233
Portugal	58	98	40	144	21	
Spain	35		19	4	11	
U.S.S.R [4]	425,000	550,000	600,000	660,000	880,000	1,100,000
Yugoslavia	4,465	5,960	4,748	5,970	6,709	7,401
Total [4]	490,000	630,000	690,000	765,000	990,000	1,210,000
Asia:						
China [4]	22,000	65,000	90,000	90,000	90,000	90,000
Cyprus	15,379	16,494	14,424	23,316	16,207	19,993
India	1,221	1,302	1,464	1,886	1,618	1,705
Japan	8,290	11,187	13,633	17,042	18,799	15,550
Korea, Republic of	90	22	88	740	341	1,333
Philippines			56	36	83	1,037
Taiwan	190	47	150	485	44	525
Turkey	208	839	411	238	496	709
Total [4]	47,000	95,000	120,000	135,000	128,000	130,000
Africa:						
Bechuanaland	1,185	2,265	1,410	1,282	1,924	2,375
Kenya	164	120	43	117	151	[4] 150
Morocco	467					
Mozambique	170	198	37	22	162	110
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	104,811	127,115	119,699	133,963	161,610	142,196
South Africa, Republic of	123,532	175,644	182,405	175,867	194,834	221,302
Swaziland	30,692	25,261	24,806	32,027	30,792	32,830
United Arab Republic (Egypt)	49	485	502	496	254	[4] 250
Total	261,070	331,088	328,902	343,774	389,727	399,213
Oceania:						
Australia	8,244	15,570	17,875	15,613	16,746	18,392
New Zealand	154	454	640	319	373	[4] 375
Total	8,398	16,024	18,515	15,932	17,119	18,767
World total (estimate) [1] [2]	1,850,000	2,055,000	2,270,000	2,440,000	2,770,000	3,055,000

[1] Asbestos also is produced in Czechoslovakia, Eritrea, North Korea, and Rumania. No estimates for these countries are included in the total, as production is believed to be negligible.
[2] This table incorporates some revisions. Data do not add to totals shown because of rounding where estimated figures are included in the detail.
[3] Exclusive of sand, gravel, and stone (waste rock only), production of which is reported as follows: 1953–57 (average) 27,042 tons; 1958, 18,449 tons; 1959, 29,532 tons; 1960, 51,624 tons; 1961, 41,696 tons; 1962, data not available.
[4] Estimate.
[5] Includes asbestos flour.

Compiled by Helen L. Hunt, Division of Foreign Activities.

TABLE 6.—Canada: Sales of asbestos by grades

Grade	1961			1962		
	Short tons	Value		Short tons	Value	
		Total (thousands)	Average per ton		Total (thousands)	Average per ton
Crude No. 1, 2, and other	163	$132	$810			
Milled group:						
3	29,296	10,619	362			
4	339,082	56,874	168	[1] 1,223,509	(2)	(2)
5	179,852	20,359	113			
6	193,467	14,461	75			
7	423,116	15,916	38			
8	8,719	164	19			
Total, all grades	1,173,695	118,525	101	[1] 1,223,509	(2)	(2)
Waste rock	41,696	35	1	(2)	(2)	(2)

[1] Breakdown by grades not available.
[2] Data not available.

Source: Dominion Bureau of Statistics

At Roberge Lake, northwestern Quebec, McAdam Mining Corp. drilled a 500-foot hole to explore a magnetic anomaly northeast of the main asbestos zone. The main zone was reported to contain 15 million tons of ore averaging about $5 per ton in fiber value. A third zone was indicated by a magnetometer survey. Central Asbestos Mines conducted magnetometer surveys of claims in the Thetford Mines area and Coleraine Township, Quebec. Recoveries from bulk tests in the pilot plant at the Hedman Mines Ltd. property in Warden and Munro Townships, 25 miles northeast of Matheson, Ontario, averaged about $25.50 per ton in value. Reserves available through open-pit mining to a depth of 300 feet were estimated at 8.5 million tons. Design of a large mill was nearly completed.

The main shaft at the Munro mine of Canadian Johns-Manville Co., Ltd., was deepened 300 feet below the 637-foot level in preparation for a second production level. Work continued on the westward extension of the 637-foot level. Two grades of fiber were produced.

Operations at the Cassiar Asbestos Corp. Ltd. mine in British Columbia continued through the winter months. During 1962 720,000 tons of ore was mined and 2,358,000 tons of waste rock stripped. Ore milled totaled 535,000 tons, consisting of 295,000 tons of concentrate from the rock-rejection circuit and 240,000 tons of mine-run ore. Plans were made to move the crushing plant to a lower level and to install a larger crusher. Recovery of AK and AX grades was to be improved. Ore reserves were sufficient for 30 years of production at the current rate. The parent company, Conwest Exploration Co., Ltd., leased waterfront property in North Vancouver, British Columbia, and planned a $1 million improvement in dock facilities. An option on an asbestos prospect southeast of Atlin on the Taku River, British Columbia, was dropped.

SOUTH AMERICA

Brazil.—The mine of Mineracão de Amianto, S.A., at Djalma Dutra (Pocões), Bahia, continued production. Sales of chrysotile to Brazilian ports totaled 1,279 tons in 1962. A pilot plant reportedly was constructed for processing fiber from newly discovered deposits in Batalha, Alagoes.

EUROPE

Greece.—Developmental work was continued on an extensive deposit of asbestos at Kozani by Kenbestos Corp., a subsidiary of Kennecott Copper Corp. A plant to produce asbestos-cement products was planned.

Ireland.—Exploratory drilling of a deposit near Sligo on the northwest coast was planned by Northern Canada Mines, Ltd.

United Kingdom.—A $3 million asbestos-cement-products plant, the largest in Europe, was opened at Widnes in northwest England.

Yugoslavia.—An established plant, Antisa Vucicic Salonite, began producing large-diameter asbestos-cement pipe partly for export. An asbestos-yarn plant began operating at Poloce on the Adriatic. Means for improving the mining and processing of asbestos were studied by an American, Dr. Arthur B. Cummins, under an International Cooperative Administration contract.

ASIA

Cyprus.—All production was exported, except for a few hundred tons that was used annually for domestic manufacture of asbestos-cement sheeting. Reserves at the Cyprus Asbestos Mines, Ltd., deposit below the summit of Mount Olympus near Amiandos were large, but the fiber content was generally less than 1 percent.

India.—Imports of asbestos totaled 21,679 tons valued at $4,935,000 in 1961, compared with 24,315 tons valued at $5,670,000 in 1960. Domestic asbestos was a suitable substitute for imported fiber in the manufacture asbestos-cement pipe in a process developed by Central Fuel Research Institute.[7]

Viet-Nam.—Plans were announced by Eternit Vietnam for an asbestos-cement plant at Saigon having an annual capacity of 10,000 tons.

AFRICA

Bechuanaland.—Exports totaled 1,852 tons valued at $450,527 in 1961. An aerial magnetometer survey was conducted, mainly over southern portions of the territory, in search of asbestos and other minerals.

Mozambique.—Long-fiber tremolite was produced from the Mavita mine of Sociedade Mineira de Mavita, Lda., south of Vila Manica near the Rhodesian border, and exported to several countries including the United States for asbestos-cement manufacture.

Rhodesia and Nyasaland, Federation of.—Crude asbestos exports, mostly from Turner and Newall, Ltd., mines at Shabani and Mashaba, totaled 133,516 tons valued at $23,637,000 in 1961. The tonnages were distributed as follows, in percent: United Kingdom, 57; Czechoslovakia, 8; Poland, 2; United States, 1; and other countries, 32. As-

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[7] Journal of Mines, Metals and Fuels (Calcutta, India). Asbestos Cement Pipes From Indian Asbestos. V. 10, No. 9, September 1962, pp. 29, 31.

bestos contributed $24.5 million, or 32 percent of the total value of Southern Rhodesia's mineral production in 1961. Turner and Newall, Ltd., mines produced 67 percent of the tonnage and 78 percent of the value of the fiber.

TABLE 7.—Southern Rhodesia: Asbestos production

Year	Short tons	Value (thousands)	Year	Short tons	Value (thousands)
1958	127,115	$24,147	1961	161,610	$24,453
1959	119,699	20,735	1962	142,196	20,467
1960	133,963	20,888			

Expansion of the Pangani Asbestos Mines (Pvt.), Ltd., operations near Filabusi, Southern Rhodesia, was announced. Three ore bodies containing reserves estimated to total 5.5 million tons of fiber were being prepared for open-pit mining. An output of 30,000 tons of fiber per year was anticipated. The fiber was expected to be sold mainly to asbestos manufacturers in Europe, and some to users in South America, South Africa, and the Far East.[8]

The Honeybird mine, a small producer at Shabani owned by Mashaba Rhodesian Asbestos Co., Ltd., was closed. The sinking of an 1,100-foot inclined shaft at the Ethel mine in the northern Umvukwes region was described.[9]

South Africa, Republic of.—Breakdowns of the 1960 and 1961 exports by varieties and countries were published.[10] A vertical shaft 1,356 feet deep was placed in operation at the Penge mine (the world's only important producer of amosite asbestos) operated by subsidiaries of Cape Asbestos S.A. (Pty.), Ltd. Reserves at levels below 500 feet exceeded previous estimates, and plans were made to increase production from 70,000 to 85,000 tons of fiber per year by 1963.

Cape Blue Mines (Pty.), Ltd., a subsidiary of Cape Asbestos S.A. (Pty.), Ltd., with the Koegas and Pomfret mines, was the world's largest producer of crocidolite. Griqualand Exploration and Finance Co., Ltd., was the second largest producer, with 30 percent of the total output coming from six small mines near Kuruman. The company developed several deposits in the same area in a joint venture with Federale Mynbou Beperk, and also acquired the Sterkspruit chrysotile mine in the eastern Transvaal. Kuruman Cape Blue Asbestos (Pty.), Ltd. was the third largest crocidolite producer; it operated three mines in the Kuruman area and was developing a fourth. The Msauli mine of Msauli Asbestos Mining and Exploration Co., Ltd., in the Barberton district, produced nearly half of the domestic chrysotile. Barberton Chrysotile Asbestos Ltd. and African Asbestos-Cement Corp., Ltd., were other important producers. The latter company recovered 4,003 tons of fiber from 81,106 tons of ore milled during the year ending June 30, 1962.

Swaziland.—Mineral Holdings Ltd. explored a chrysotile deposit near the Transvaal border.

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[8] Rhodesian Mining and Engineering (Salisbury, Southern Rhodesia). Top-Class Equipment for Use in Pangani Development. V. 27, No. 13, December 1962, pp. 34–35.

[9] Chambers, D. W. New Layout at Ethel Asbestos No. 3 Shaft. Rhodesian Min. and Eng. (Salisbury, Southern Rhodesia), v. 27, No. 1, January 1962, pp. 20–22.

[10] Bureau of Mines. Mineral Trade Notes. V. 55, No. 2, August 1962, pp. 7–9.

TABLE 8.—Republic of South Africa: Asbestos production, by varieties and sources

(Short tons)

Variety and source	1958	1959	1960	1961	1962
Amosite (Transvaal)	69,773	71,720	68,630	69,234	74,883
Chrysotile (Transvaal)	27,403	29,326	29,471	31,726	29,993
Blue (Transvaal)	16,670	13,113	11,185	11,176	14,296
Blue (Cape)	61,520	68,024	66,567	82,624	102,034
Tremolite (Transvaal)	278	222	14	74	96
Total	175,644	182,405	175,867	194,834	221,302

TABLE 9.—Republic of South Africa: Production and exports of asbestos

Year	Production (short tons)			Exports	
	Transvaal	Cape Province	Total	Short tons	Value (thousands)
1958	114,124	61,520	175,644	145,796	$25,420
1959	114,381	68,024	182,405	151,515	25,971
1960	109,300	66,567	175,867	174,810	28,965
1961	112,210	82,624	194,834	180,684	29,830
1962	119,268	102,034	221,302	184,170	30,787

OCEANIA

Australia.—The 1961 production consisted of 969 tons of chrysotile valued at $88,939 and 15,777 tons of crocidolite valued at $1,404,153.

TECHNOLOGY

Research on asbestos synthesis resulted in the description of properties of palygorskite, a potentially useful asbestiform mineral,[11] and of a synthetic magnesio-fluor-richterite that had some flexibility.[12]

The Jeffrey mine, Quebec Province, Canada, resumed open-pit operations using new skipways [13] and improved fragmentation with inclined drill holes.[14]

Papers given at the Industrial Minerals Division Joint Meeting of the Canadian Institute of Mining and Metallurgy and the American Institute of Mining, Metallurgical and Petroleum Engineers at Ottawa, Canada, in October 1961 covered geology of the asbestos belt in Southeastern Quebec,[15] mining and milling practices,[16] and testing and quality-control methods.[17] A short historical review of the development of the asbestos industry in Canada was published.[18]

[11] Huggins, Charles W., M. V. Denny, and H. R. Shell. Properties of Palygorskite, an Asbestiform Mineral. BuMines Rept. of Inv. 6071, 1962, 17 pp.

[12] Huggins, Charles W. Electron Micrographs of Some Unusual Inorganic Fibers. BuMines Rept. of Inv. 6020, 1962, 27 pp.

[13] Brigham, S. K. Conversion to Open Pit Skipway Operation at Jeffrey Mines. Canadian Min. and Met. Bull. (Montreal), v. 55, No. 599, March 1962, pp. 146–149.

[14] Milosevic, M. I. Inclined Drilling Proves Best. Eng. and Min. J., v. 163, No. 3, March 1962, pp. 86–90.

[15] Riordon, P. H. Geology of the Asbestos Belt in Southeastern Quebec. Canadian Min. and Met. Bull. (Montreal), v. 55, No. 601, May 1962, pp. 311–313; v. 55, No. 603, July 1962, p. 500.

[16] Gartshore, J. L. The Quebec Asbestos Industry: Mining and Milling. Canadian Min. and Met. Bull. (Montreal), v. 55, No. 602, June 1962, pp. 400–402.

[17] Wiser, J. P. The Quebec Asbestos Industry: Testing and Quality Control. Canadian Min. and Met. Bull. (Montreal), v. 55, No. 602, June 1962, pp. 403–405.

[18] Woodrooffe, H. M. One Hundred Years of Asbestos in Canada. Eng. J. (Montreal), v. 45, No. 6, June 1962, pp. 49–50.

Theories of the origin of serpentine and chrysotile in the Matheson area of northern Ontario were discussed. The host rocks resulted from local differential fusion of the peridotite substratum followed by multiple injection. Evidence indicated deposition of chrysotile in fissure veins from aqueous solutions, as replacements after picrolite, and as replacement veins in dunite and peridotite.[19]

Anthophyllite asbestos was found in Precambrian metasediments in Fremont County, Colo. Anthophyllite content ranged from trace amounts to 41 percent in some specimens. Dark silky green rocks having the highest content were characterized by radiating and sheaf-like clusters of anthophyllite.[20]

Open-pit mining and milling practices at the Vermont Asbestos Mines in Lamoille and New Orleans Counties, Vt., were described. Methods of exploration, sampling, and evaluation were outlined, and cost data were given for a recent year.[21]

Long-hole drilling was employed to advantage in an Eastern Transvaal asbestos mine. Exploration by percussion drill to depths of 80 feet and more revealed ore bodies that were missed in previous mining.[22]

Aromatic hydrocarbons and amino acids were detected in trace amounts of oil extracted from South African crocidolite and amosite samples and from the ironstone country rocks as well.[23]

Grading requirements were reported for anthophyllite from Finland; both descriptive and test data were supplied.[24]

Organic substances were extracted from asbestos products by a newly patented process using a heated aqueous solution containing acid salts of alkali silicates and phosphates.[25]

An improvement in the conventional fiber opening and cleaning apparatus was patented. Unopened fiber was retained by spikes spaced along the inner surface of a tube and beaten by fan blades or other means.[26]

In another design for fiberization, a pair of contrarotating beaters broke clumps of fiber by throwing them against a rotating cylindrical screen.[27] A Soviet patent was issued for a fiber-opening technique in which crude asbestos fiber bundles were saturated with heated acidulated water, pressurized at 30 to 32 atmospheres, and exploded into a chamber heated to 250° C.[28] To eliminate such impurities as magnetite and picrolite, especially from shingle and paper grades of fiber,

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[19] Grubb, P. L. C. Serpentinization and Chrysotile Formation in the Matheson Ultrabasic Belt, Northern Ontario. Econ. Geol., v. 57, No. 8, December 1962. pp. 1228–1246.

[20] Salotti, Charles A. Anthophyllite Within the Albite-Epidote Hornfels Facies, Fremont County, Colo. Am. Miner., v. 47, No. 9–10, September–October 1962, pp. 1055–1066.

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an aqueous suspension containing a colloidizing agent was strained through a screen.[29]

Asbestos in the form of a mat, woven fabric, or rovings was embedded in metal castings as reinforcement.[30] A method was patented for spraying roofs and walls of coal mines with a mixture of asbestos fibers or floats and limestone to reduce the danger of explosion and provide better illumination.[31]

Patents were also issued for the following: Filter paper capable of filtering particles 0.3 micron or less made from a mixture of ultrarefined- and intermediate-grade asbestos;[32] a process in which asbestos was ball-milled with an alkali-stabilized silica sol, and the resulting colloidally dispersed fiber used for a semitransparent, shiny, hard, and flameproof coating on paper,[33] a method of forming a brine-impervious asbestos diaphragm for electrolytic cells used in the production of alkali metals;[34] a plastic paving and surfacing mixture containing asbestos fibers and fines;[35] and fertilizer sticks with asbestos filler.[36]

New and improved products included fire-retardant plywood containing a lightweight asbestos foam core,[37] gasket material designed to swell without disintegrating,[38] asbestos-Teflon gasketing for cryogenic temperatures,[39] epoxy-lined asbestos-cement pipe,[40] and a polyester laminate for electrical insulation that was reported to be superior to glass-polyesters.[41]

Clotting during the blending of asbestos for paper-making was reduced when 7R fiber grade was used instead of 5R. The view was expressed that fiber longer than a few millimeters contributed nothing to paper strength.[42]

Asbestos-cement pipe was tested for sulfate resistance and found to be adversely affected by free lime. Autoclase formulation and curing using regular type I cement resulted in pipe with sulfate resistance about equal to that normally obtained with special type V cement.[43]

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Barite

By Milford L. Skow [1] and Victoria R. Schreck [2]

DOMESTIC output and imports of barite increased substantially to the largest totals since 1957.

LEGISLATION AND GOVERNMENT PROGRAMS

In an intial decision, a Federal Trade Commission examiner recommended dismissal of antitrust charges against National Lead Co. and Magnet Cove Barium Corp., a subsidiary of Dresser Industries, Inc. Hearings had been held intermittently on the complaints that were issued in March 1958 charging both firms with violation of section 5 of the Federal Trade Commission Act (15 U.S.C., sec. 45) and section 7 of the Clayton Act (15 U.S.C., sec. 18).

DOMESTIC PRODUCTION

Primary barite was produced in 13 States in 1962. Total output was 21 percent greater than in 1961.

Missouri displaced Arkansas as the leading producer and was followed in order by Arkansas, Nevada, and Georgia. Other producing States were California, Tennessee, Kentucky, Montana, South Carolina, Texas, Washington, Utah, and New Mexico. No production was reported from Idaho or North Carolina, but shipments were made from Idaho stocks. During 1962, total stocks of primary barite at domestic mines increased 18 percent.

Production of crushed and ground barite declined 8 percent from the 1961 total because requirements decreased. Inventories of this barite at processing plants increased 7 percent during 1962.

Output of most barium compounds increased. Changes were relatively small except for barium hydroxide, production of which was 19 percent larger than in 1961.

Pittsburgh Plate Glass Co. constructed a $1 million barium chemicals plant at Natrium, W. Va. Barite ore was the basic raw material to be used in producing barium carbonate, barium chloride, hydrogen sulfide, sodium sulfide, and sodium sulfhydrate.

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[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.

TABLE 1.—Salient barite and barium-chemical statistics

(Thousand short tons and thousand dollars)

	1953-57 (average)	1958	1959	1960	1961	1962
United States:						
Primary:						
Mine or plant production	1,123	486	867	771	731	887
Sold or used by producers	1,076	605	902	714	797	860
Value	$11,030	$7,507	$10,301	$8,574	[1] $9,300	$9,820
Imports for consumption	487	527	640	642	608	737
Value	$3,287	$3,733	$4,825	$5,006	$5,185	$6,009
Consumption [2]	1,506	1,196	1,396	1,190	1,391	1,210
Ground and crushed sold by producers	1,232	1,027	1,210	977	1,036	1,023
Value	$31,836	$28,352	$30,431	$24,219	$25,182	$24,285
Barium chemicals sold by producers	97	75	99	99	97	103
Value	$13,122	$10,685	$13,657	$14,152	$13,770	$14,554
World: Production	2,800	2,770	3,000	3,050	2,960	3,310

[1] Revised figure.
[2] Includes some witherite.

TABLE 2.—Domestic barite sold or used by producers in the United States, by States

(Thousand short tons and thousand dollars)

State	1953-57 (average)		1958		1959	
	Quantity	Value	Quantity	Value	Quantity	Value
Arkansas	436	$3,997	183	$1,668	339	$3,097
California	(1)	(1)	25	272	28	326
Georgia, South Carolina, Tennessee	127	1,977	108	2,285	90	1,809
Missouri	341	3,758	199	2,666	296	3,924
Nevada	117	726	59	403	91	623
Other States [2]	55	572	31	213	58	522
Total	1,076	11,030	605	7,507	902	10,301

State	1960		1961		1962	
	Quantity	Value	Quantity	Value	Quantity	Value
Arkansas	278	$2,578	278	$2,630	259	$2,232
California	16	181	21	295	7	133
Georgia, South Carolina, Tennessee	119	2,347	120	2,299	125	2,314
Missouri	181	2,588	227	3,052	304	3,994
Nevada	86	591	130	863	138	954
Other States [2]	34	289	21	[3] 161	27	193
Total	714	8,574	797	[3] 9,300	860	9,820

[1] Included with "Other States" to avoid disclosing individual company confidential data.
[2] Includes Arizona (1952-55), Idaho, Kentucky (1959-62), Montana, New Mexico (1959-62), North Carolina (1961 only), Texas (1961-62), Utah (1959-62), and Washington (1953-55, 1957-62).
[3] Revised figure.

CONSUMPTION AND USES

The domestic barite industry registered a modest improvement, despite a drop in demand for barite in oil- and gas-well drilling. The tonnage of primary barite sold or used by domestic producers was 8 percent more than in 1961.

The quantity of crude barite, both domestic and imported, used for producing crushed and ground barite, barium chemicals, and lithopone declined 13 percent from the 1961 tonnage. Sales of crushed and ground barite dropped 1 percent. Oil- and gas-well drillers used 91 percent of the crushed and ground material, the glass industry used 4 percent, and the remaining 5 percent was used chiefly as a filler for rubber and paint.

Manufacturers of barium chemicals consumed only slightly more barite than in 1961. Sales of the various barium chemicals increased in 1962, led by the growth in demand for carbonate and hydroxide.

TABLE 3.—Ground and crushed barite produced and sold by producers in the United States

(Thousand short tons and thousand dollars)

Year	Plants	Production (quantity)	Sales		Year	Plants	Production (quantity)	Sales	
			Quantity	Value				Quantity	Value
1953–57 (average)	30	1,277	1,232	$31,836	1960	36	973	977	$24,219
1958	34	1,014	1,027	28,352	1961	35	1,101	1,036	25,182
1959	33	1,199	1,210	30,431	1962	35	1,012	1,023	24,285

TABLE 4.—Crude barite (domestic and imported) used in the manufacture of ground barite and barium chemicals in the United States

(Thousand short tons)

Year	In manufacture of		Total	Year	In manufacture of		Total
	Ground barite [1]	Barium chemicals and lithopone [2]			Ground barite [1]	Barium chemicals and lithopone [2]	
1953-57 (average)	1,315	191	1,506	1960	1,005	185	1,190
1958	1,053	142	1,196	1961	1,224	167	1,391
1959	1,227	170	1,396	1962	1,043	167	1,210

[1] Includes some crushed barite.
[2] Includes some witherite.

TABLE 5.—Ground and crushed barite sold by producers, by consuming industries

Industry	1953-57 (average)		1958		1959	
	Short tons	Percent of total	Short tons	Percent of total	Short tons	Percent of total
Well drilling	1,149,643	93	977,255	95	1,153,560	95
Glass	27,411	2	9,890	1	12,165	1
Paint	21,683	2	14,641	1	17,046	1
Rubber	21,997	2	18,387	2	19,806	2
Undistributed	11,261	1	6,692	1	7,330	1
Total	1,231,995	100	1,026,865	100	1,209,907	100

Industry	1960		1961		1962	
	Short tons	Percent of total	Short tons	Percent of total	Short tons	Percent of total
Well drilling	920,283	94	941,539	91	934,007	91
Glass	15,012	1	30,713	3	39,017	4
Paint	18,273	2	16,128	2	19,786	2
Rubber	17,082	2	24,007	2	26,235	3
Undistributed	6,180	1	23,395	2	4,045	
Total	976,830	100	1,035,782	100	1,023,090	100

TABLE 6.—Barium chemicals produced and used or sold by producers in the United States

(Short tons)

Chemical and year	Plants	Produced	Used by producers[1] in other barium chemicals[2]	Sold by producers[3]	
				Short tons	Value
Black ash:[4]					
1953-57 (average)	10	126,747	125,147	2,306	$184,977
1958	8	93,539	81,861	1,351	126,050
1959	7	104,740	102,040	2,947	289,580
1960	9	116,995	113,466	3,136	298,741
1961	8	105,117	102,591	2,363	228,358
1962	9	107,023	104,767	3,393	365,904
Carbonate (synthetic):					
1953-57 (average)	5	74,918	28,155	47,381	4,469,824
1958	6	60,534	26,835	35,307	3,753,712
1959	6	77,048	29,398	47,137	5,099,366
1960	6	77,690	29,392	46,128	5,010,514
1961	7	78,665	28,599	47,401	5,119,826
1962	6	79,220	27,683	49,484	5,415,751
Chloride (100 percent $BaCl_2$):					
1953-57 (average)	3	11,605	496	10,979	1,622,590
1958	4	8,428		8,122	1,328,413
1959	4	(5)	(5)	(5)	(5)
1960	3	8,754		9,401	1,535,188
1961	3	10,891		10,290	1,697,606
1962	4	10,844		11,276	1,703,123
Hydroxide:					
1953-57 (average)	5	14,053	197	13,801	2,520,005
1958	4	9,892	68	10,093	1,853,900
1959	5	14,293	(5)	13,914	2,320,522
1960	5	17,579		14,971	2,336,402
1961	4	13,715		13,873	2,167,245
1962	4	16,328		15,123	2,643,019
Oxide:					
1953-57 (average)	3	17,310	7,261	9,665	2,043,268
1958	3	(5)	(5)	(5)	(5)
1959	3	(5)	(5)	(5)	(5)
1960	3	(5)	(5)	(5)	(5)
1961	3	(5)	(5)	(5)	(5)
1962	3	(5)	(5)	(5)	(5)

See footnotes at end of table.

TABLE 6.—Barium chemicals produced and used or sold by producers in the United States—Continued

(Short tons)

Chemical and year	Plants	Produced	Used by producers[1] in other barium chemicals[2]	Sold by producers[3]	
				Short tons	Value
Sulfate (synthetic):					
1953-57 (average)	6	10,942	112	10,382	$1,380,467
1958	3	6,581		6,628	844,940
1959	4	(5)		(5)	(5)
1960	4	(5)		(5)	(5)
1961	5	(5)		(5)	(5)
1962	4	(5)		(5)	(5)
Other barium chemicals:[6]					
1953-57 (average)	(7)	3,188	597	2,612	901,266
1958	(7)	18,549	3,213	13,871	2,778,377
1959	(7)	43,860	7,798	34,672	5,947,992
1960	(7)	30,690	(8)	25,464	4,971,000
1961	(7)	27,878	(5)	23,452	4,557,193
1962	(7)	27,850	(5)	23,864	4,425,798
Total:					
1953-57 (average)[9]				97,126	13,122,397
1958	13			75,372	10,685,392
1959	14			98,670	13,657,460
1960	14			99,100	14,151,845
1961	14			97,379	13,770,228
1962	14			103,140	14,553,595

[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] Included with other barium chemicals to avoid disclosing individual company confidential data.
[6] Includes barium acetate, oxide, peroxide, sulfate, and other unspecified compounds. Specific chemicals may not be revealed.
[7] Plants included in above figures.
[8] Figure withheld to avoid disclosing individual confidential data.
[9] A plant producing more than 1 product is counted only once in arriving at grand total.

PRICES

During 1962, E&MJ Metal and Mineral Markets quoted the following prices on barite, f.o.b. cars:

		Price
Georgia:		
Crude, jig and lump	short ton	$18.
Beneficiated, in bulk	do	$21.
Beneficiated, in bags	do	$23.50 to $25.
Missouri:		
Crude ore, minimum 94 percent $BaSO_4$ less than 1 percent Fe	short ton	$16 to $18.
Crude, oil well drilling, minimum 4.3 specific gravity, bulk	short ton	$18.
Some restricted sales	do	$11.50.
Ground, oil-well grade	do	$26.75.
Water ground, and floated, bleached, carload lots, f.o.b. mine or mill	short ton	$45 to $49.
Canada:		
Crude, in bulk, f.o.b. shipping point	long ton	$11.
Ground, in bags	short ton	$16.50.

Imported:

		Price
Crude, oil well drilling, minimum 4.25 specific gravity, bulk, c.i.f. Gulf Ports:		
Before May 10	short ton	$12.50 to $14.
Beginning May 10	do	$11 to $14.

The quotation on imported crude oil-well-drilling barite, the only category to vary in price since 1957, again was changed in May.

TABLE 7.—Price quotations for barium chemicals in 1962

	January	December
Barium carbonate, precipitated, bags, carlots, works — short ton	$111.50	Unchanged.
Smaller lots, works — do	126.50	(1).
Barium chlorate, drums, works — pound	.32 to .41	Unchanged.
Barium chloride, anhydrous, bags, carlots, works — short ton	176.00	Do.
Less carlots, works — do	196.00	(1).
Barium dioxide (peroxide), drums, freight equalized — pound	.20	Unchanged.
Barium hydrate, crystals, bags, carlots, truckloads, freight equalized — short ton	208.00	Do.
Less carlots, less truckloads, freight equalized — do	218.00	(1).
Barium nitrate, barrels, carlots, truckloads, delivered — pound	.16	Unchanged.
Less carlots, less truckloads, delivered — do	.17	Do.
Barium oxide, ground, drums, carlots, truckloads, freight equalized — short ton	275.00	Do.
Less carlots, less truckloads, freight equalized — do	285.00	(1).
Blanc fixe, direct process, bags, carlots, works — do	160.00	Unchanged.
Less carlots, works — do	170.00	(1).
New York warehouse — do	215.00	(1).
Lithopone, ordinary, bags, carlots, delivered — pound	[2].08 to ⅜ E	(3).
Less carlots, delivered — do	[2].09 to ⅛ E	(4).
Lithopone, titanated (high-strength), bags, carlots, delivered — do	.11	(4).
Less carlots, delivered — do	.12	(4).

[1] Last quoted Apr. 9, unchanged.
[2] E=East.
[3] Price changed Apr. 23 to $0.08½ E; last quoted Oct. 1 without further change.
[4] Last quoted Oct. 1, unchanged.

Source: Oil, Paint and Drug Reporter.

FOREIGN TRADE [3]

Imports.—Larger tonnages from both Mexico and Canada were largely responsible for a 21-percent increase in imports of crude barite over those in 1961. Mexico, Canada, and Peru, in descending order, supplied 77 percent of the total. Virtually all the imported crude barite entered the United States through four customs districts: New Orleans, La., 38 percent; Laredo, Tex., 35 percent; Sabine, Tex., 14 percent; and Galveston, Tex., 13 percent; 241 tons, less than 0.1 percent, entered through the El Paso and Arizona districts.

Imports of ground barite decreased more than 6,800 tons to the second lowest level since 1948.

The United Kingdom furnished all the crude witherite imported in 1962 and all the crushed or ground witherite except 6 tons, which came from Canada.

The total tonnage of imported barium chemicals was 17 percent greater than in 1961, resulting largely from increases in imports of blanc fixe and barium carbonate. West Germany, with 80 percent of the total tonnage, continued to be the source of most of the barium

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

chemicals entering the United States. France supplied 8 percent; the United Kingdom, 4 percent; Belgium-Luxembourg, 3 percent; and the Netherlands, Italy, Spain, U.S.S.R., Switzerland, Canada, and Sweden, 5 percent.

Exports.—Lithopone exports were 42 percent less than in 1961; the decrease in tonnage to Viet-Nam accounted for virtually all the loss. Of the total 1962 exports of lithopone, 54 percent was shipped to Viet-Nam, 45 percent to Canada, and 1 percent to Nicaragua.

TABLE 8.—U.S. imports for consumption of barite, by countries

	1961		1962	
	Short tons	Value	Short tons	Value
Crude barite:				
North America:				
Canada	145, 043	$1, 232, 892	221, 070	$1, 883, 119
Mexico	133, 733	1, 076, 905	243, 138	1, 716, 263
Total	278, 776	2, 309, 797	464, 208	3, 599, 382
South America:				
Brazil	19, 351	150, 490	10, 685	87, 240
Peru	109, 986	1, 039, 056	105, 560	978, 809
Total	129, 337	1, 189, 546	116, 245	1, 066, 049
Europe:				
Greece	63, 926	415, 219	34, 328	260, 525
Italy	7, 276	90, 940	5, 268	72, 028
Spain	10, 204	112, 542	18, 726	167, 330
United Kingdom			(1)	400
Yugoslavia	60, 401	537, 714	53, 019	424, 564
Total	141, 807	1, 156, 415	111, 341	924, 847
Africa: Morocco	58, 240	528. 989	44, 934	418, 402
Grand total	608, 160	5, 184, 747	736, 728	6, 008, 680
Ground barite:				
North America:				
Canada	6, 935	503, 262	18	690
Mexico			89	890
Total	6, 935	503, 262	107	1, 580
Europe: Germany, West	33	1, 653	32	1, 401
Grand total	6, 968	504, 915	139	2, 981

[1] Less than 1 ton.

Source: Bureau of the Census.

TABLE 9.—U.S. imports for consumption of barium chemicals

Year	Lithopone		Blanc fixe (precipitated barium sulfate)		Barium chloride		Barium hydroxide	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1953–57 (average)	65	$9, 019	1, 033	$86, 600	928	[1] $73, 173	45	$6, 955
1958	69	9, 307	1, 573	103, 865	1, 376	129, 159	161	25, 832
1959	73	8, 752	1, 757	122, 067	1, 510	134, 663	232	35, 104
1960	62	7, 973	1, 629	124, 093	1, 004	91, 843	39	16, 172
1961	74	8, 843	1, 378	122, 174	1, 019	93, 105	11	1, 880
1962	98	12, 538	1, 724	152, 267	1, 150	107, 214	11	1, 680

[1] Data known to be not comparable with other years.

TABLE 9.—U.S. imports for consumption of barium chemicals—Continued

Year	Barium nitrate		Barium carbonate precipitated		Other barium compounds	
	Short tons	Value	Short tons	Value	Short tons	Value
1953–57 (average)	373	$57,421	1,905	$132,945	579	$118,172
1958	701	107,724	322	23,350	38	26,415
1959	596	89,822	1,895	127,734	55	41,823
1960	736	106,818	1,406	104,674	172	132,294
1961	807	128,120	1,190	86,123	160	111,427
1962	807	125,253	1,501	112,406	126	95,931

Source: Bureau of the Census.

TABLE 10.—U.S. imports for consumption of crude, unground, crushed, or ground witherite

Year	Crude unground		Crushed or ground	
	Short tons	Value [1]	Short tons	Value [1]
1953–57 (average)	3,534	$131,677	(2)	(2)
1958	2,240	108,119	202	$15,610
1959	2,552	113,229	(3)	478
1960	1,344	59,257	50	3,246
1961	1,716	67,280	87	22,659
1962	1,431	58,766	71	4,726

[1] Value at port of shipment.
[2] Class established June 1, 1956; no transactions; 1957, 8 tons ($533).
[3] Less than 1 ton.

Source: Bureau of the Census.

TABLE 11.—U.S. exports of lithopone

Year	Short tons	Value		Year	Short tons	Value	
		Total	Average per ton			Total	Average per ton
1953–57 (average)	2,242	$351,497	$156.78	1960	190	$35,160	$185.05
1958	613	122,462	199.77	1961	608	87,905	144.58
1959	538	99,578	185.09	1962	350	68,317	195.19

Source: Bureau of the Census.

WORLD REVIEW [4]

Barite was produced in at least 39 countries in 1962. World output was estimated at 3.3 million tons, more than 10 percent higher than in 1961.

[4] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.

TABLE 12.—World production of barite, by countries [1] [2]

(Short tons)

Country [1]	1953-57 (average)	1958	1959	1960	1961	1962
North America:						
Canada	254,264	195,719	238,967	154,292	191,404	229,271
Cuba (exports)	5,540	11,931	----------	----------	----------	----------
Mexico	194,895	397,550	314,933	298,458	274,153	350,684
United States	1,123,327	486,287	867,201	771,318	731,381	886,964
Total	1,578,026	1,091,487	1,421,101	1,224,068	1,196,938	1,466,919
South America:						
Argentina	21,018	18,716	19,841	[3] 20,000	[3] 20,000	[3] 20,000
Brazil	20,953	68,630	56,009	43,826	68,834	[4] 56,220
Chile	1,396	[3] 880	[3] 880	1,054	1,551	[3] 1,540
Colombia	8,198	14,330	11,023	8,047	11,272	[3] 11,000
Peru	29,175	117,943	105,557	120,813	122,538	104,719
Total	80,740	220,500	193,310	193,740	224,195	193,480
Europe:						
Austria (marketable)	3,719	4,697	4,068	4,829	2,716	1,192
France	62,441	133,934	95,259	116,860	77,162	[3] 77,200
Germany, West (marketable)	427,023	409,105	428,304	517,657	448,640	[3] 470,000
Greece	49,550	169,629	143,014	112,203	82,673	[3] 88,000
Ireland	5,655	8,736	9,157	11,704	7,627	378
Italy	100,738	122,976	133,734	157,925	140,308	134,388
Poland	[5] 7,254	[3] 12,400	[3] 12,400	[3] 12,400	41,161	49,841
Portugal	457	1,351	3,760	4,310	2,285	[3] 2,300
Spain	14,018	31,408	28,186	28,596	37,449	[3] 37,500
U.S.S.R.[3]	110,000	130,000	130,000	140,000	140,000	200,000
United Kingdom [6]	84,800	66,139	68,408	67,431	91,677	84,763
Yugoslavia	109,846	103,801	118,267	120,691	126,766	143,300
Total [1] [3]	1,010,000	1,230,000	1,210,000	1,330,000	1,230,000	1,330,000
Asia:						
Burma	----------	907	1,120	1,792	2,248	4,462
China	(7)	[3] 55,000	[3] 55,000	[3] 65,000	[3] 90,000	[3] 90,000
India	12,329	17,536	14,939	14,976	16,794	26,980
Iran [8]	----------	1,124	1,904	14,330	20,944	16,535
Japan	21,727	16,510	21,331	25,184	32,243	38,634
Korea, Republic of	643	----------	----------	220	772	1,014
Pakistan	----------	342	569	709	489	3,164
Philippines	[9] 2,227	64	186	6,198	2,109	459
Turkey	[10] 2,111	6,035	2,513	1,653	----------	2,094
Total [1] [3]	60,000	98,000	98,000	130,000	166,000	183,000
Africa:						
Algeria	32,197	67,911	24,038	61,564	29,728	[3] 22,000
Morocco	17,273	47,060	40,574	92,945	90,591	98,980
Rhodesia and Nyasaland, Federation of:						
Southern Rhodesia	54	34	239	----------	----------	----------
South Africa, Republic of	2,482	2,721	2,355	1,878	1,962	1,873
Swaziland	427	480	461	200	454	68
United Arab Republic (Egypt)	104	2,282	2,017	2,866	[3] 3,000	[3] 3,000
Total	52,537	120,488	69,684	159,453	125,735	125,920
Oceania: Australia	7,750	7,618	6,960	12,787	21,523	[3] 11,000
World total (estimate) [1] [2]	2,800,000	2,770,000	3,000,000	3,050,000	2,960,000	3,310,000

[1] Barite is produced in Bulgaria, Czechoslovakia, East Germany, and North Korea, but data on production are not available. Estimates by author of chapter included in total.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Estimate.
[4] Exports.
[5] Average annual production 1955–57.
[6] Includes witherite.
[7] Data not available; estimate by senior author of chapter included in total.
[8] Year ended March 20, of year following that stated.
[9] Average annual production 1956–57.
[10] One year only, as 1957 was first year of commercial production.

Compiled by Liela S. Price, Division of Foreign Activities.

NORTH AMERICA

Canada.—Sheep Creek Mines, Ltd., recovered barite as a byproduct of its lead-zinc operations at the Mineral King mine near Invermere, British Columbia. Production during the fiscal year that ended May 31, 1962, increased to 5,300 tons of barite valued at Can$41,941.[5]

The mining history, geology, and mineralogy of the Magnet-Cove barite-sulfide deposit near Walton, Nova Scotia, the largest producer of Canadian barite, were discussed.[6]

Mexico.—The tonnage of barite exported in 1962 was 73 percent greater than in 1961. The most recent figures on quantity and value of barite exports were as follows:[7]

	Thousand short tons	*Value, thousands*
1960	190	$2, 280
1961	140	1, 648
1962	242	2, 461

SOUTH AMERICA

Brazil.—Crude barite was produced at Camamú, Bahia, by Pigmentos Minerais Industrial e Comercial Pigmina, S.A. Local consumption of barite in 1962 was 6,700 tons compared with 7,100 tons in 1961, but exports increased to 60,800 tons from 45,300 tons.

TABLE 13.—Brazil: Exports of crude barite from State of Bahia

Country of destination	1961		1962	
	Short tons	Value	Short tons	Value
Bolivia	500	$7, 258		
Trinidad	28. 891	235. 890	36. 989	$268, 448
United States	15. 903	129. 843	23. 833	182. 732
Total	45, 294	372, 991	60, 822	451, 180

Source: Bureau of Mines. Mineral Trade Notes. V. 56, April 1963, pp. 7-8.

Chile.—Cía. Minera Santa Ana, formerly Cía. Minera Indiana, held barite leases on 9 properties near Copiapó and 18 near Chañaral. The company reached a partnership agreement with a U.S. firm early in 1962.[8]

Peru.—Barite continued to be the only nonmetallic mineral exported in appreciable quantities. Exports of 93,341 tons valued at $842,980 were down 17 percent in quantity and 11 percent in value from the 1961 barite exports of 112,325 tons valued at $945,097.[9]

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[5] Canadian Mining and Metallurgical Bulletin (Montreal). V. 55, August 1962, p. 601.
[6] Boyle, R. W. Geology and Geochemistry of the Magnet Cove Barium-Lead-Zinc-Silver Deposit, Walton, Nova Scotia. Canadian Min. J. (Gardenvale, Canada), v. 83, April 1962, pp. 104–110.
[7] U.S. Embassy, Mexico City, Mexico. State Department Dispatch 1307, Apr. 23, 1962, encl. 1, p. 2; State Department Airgram A–1354, Apr. 23, 1963, encl. 1 and 2.
[8] Bureau of Mines. Mineral Trade Notes. V. 55, September 1962, p. 8.
[9] U.S Embassy, Lima, Peru. State Department Airgram A–659, Apr. 11, 1963, encl. 2, p. 2.

EUROPE

Greece.—Mycobar Mining Co., S.A., a Greek company controlled by Dresser Industries, Inc., began operating a barite grinding mill on Mykonos Island, which was also the location of the firm's barite deposits. Mycobar exports ground barite to Middle East countries and about 70,000 tons of crude barite annually to Magnet Cove Barium Corp., Houston, Tex.[10]

Ireland.—Magnet Cove Barium Corp., began stripping operations at its new barite pit in County Tipperary. The minimum production and export goal is 50,000 tons annually.[11]

United Kingdom.—The Gasswater mine at Cumnock, which produced over 600,000 tons since opening in 1919, was preparing to shut down by the end of 1963 because a sufficient supply of economically recoverable ore was not available.[12]

Laporte Chemicals, Ltd., decided to close the Silverband mine near Appleby because the barite was no longer needed to supply their Luton works.[13]

Yugoslavia.—After a study of barite occurrences near the Bulgaria-Yugoslavia border, it was reported that these deposits had not been explored sufficiently to provide definite conclusions as to their economic value. Available information indicated that the area should be examined further. Details of geology and mineralization provided a basis for selecting suitable methods of exploration.[14]

ASIA

India.—Exports of barite in 1961 declined sharply from 27,300 tons valued at $378,000 in 1960 to 8,100 tons valued at $126,000.[15]

Barium Chemicals, Ltd., New Delhi, which was organized early in 1962 with a capital of slightly over $1 million, was licensed to produce annually 2,250 tons of pigment-quality blanc fixe, 1,100 tons of barium nitrate, 600 tons of barium carbonate, 450 tons of technical barium chloride, 100 tons of barium hydroxide, and 25 tons each of high-purity barium chloride and barium sulfate. The plant at Kothagudam, Madras, was the first in India for producing barium chemicals.[16]

Iran.—Annual consumption of locally produced barite was said to be 40,000 tons in a report that outlined development of the Iranian barite industry. Two plants near Ghom, operated by Magcobar, Iran, S.A., were described. These plants had sufficient capacity to meet Middle East requirements but could not compete pricewise with barite from other sources in Middle East countries.[17]

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[10] U.S. Embassy, Athens, Greece. State Department Airgram A-69. Aug. 6, 1962, p. 4.

[11] Mining World. V. 25, Apr. 25, 1963, p. 126.

[12] Chemical Age (London). Largest U.K. Barytes Mine To Be Closed. V. 87, June 16, 1962, p. 986.

[13] Chemical Trade Journal and Chemical Engineer (London). V. 151, Aug. 31, 1962, p. 425.

[14] Jeremić, M. The Barite Occurrences Around the Jerma Colliery in Eastern Serbia. Rudarsko-metalurški Zbornik (Min. and Met. Quart.), No. 1, 1962, pp. 21–32; Trans. pub. by Nolit Pub House, Terazije 27/II, Belgrade, Yugoslavia, 1962.

[15] Bureau of Mines. Mineral Trade Notes. V. 55, December 1962, p. 4.

[16] U.S. Consulate, Bombay, India. State Department Dispatch 428, June 29, 1962, encl. 10, p. 2; Chem. Week, v. 91, Oct. 20, 1962, p. 53.

[17] Hooper, C. J. Barite Deposits of Iran. Pres. at CENTO Symp. on Ind. Rocks and Miner. Lahore, West Pakistan, Dec. 3–8, 1962; Central Treaty Organization Economic Committee. Rep. CENTO Symp. on Ind. Miner. CENTO Unclassified EC/11/M/D20, Ankara, Turkey, Jan. 16, 1963, p. 7.

Korea, Republic of.—Total exports of barite in 1961 were 1,048 tons valued at $17,000; Japan received 937 tons.[18]

Pakistan.—A report on barite deposits indicated that Pakistan was self-sufficient in this mineral and eventually could produce it for export. Total reserves were estimated at more than 1.5 million tons, subject to upward revision as exploration and development continued.[19]

Turkey.—The Mining Assistance Commission inspected a lead-zinc-barite occurrence near Canakkale and found that the mine must be dewatered to determine its operating potential. Also a deposit on the seacoast near Alanya was to be examined.[20]

Minor production was reported and barite deposits were described.[21]

AFRICA

Morocco.—Exports of barite increased from 66,630 tons in 1960 to 88,889 tons in 1961 and were shipped as follows:

Destination:	*Short tons*
Algeria	551
Belgium	6,398
Germany, West	4,700
Netherlands	6,337
United Kingdom	7,598
United States	59,800
Venezuela	3,505

Source: Bureau of Mines. Mineral Trade Notes. V. 56, January 1963, p. 3.

South Africa, Republic of.—Annual output of barite, 1,873 tons in 1962, changed little during the past 3 years. In 1962, local sales totaled 1,695 tons valued at $17,963; no exports were reported.[22]

Swaziland.—Reserves of 1.08 million tons of barite were estimated for a mine located on the Londosi River near the border of the Republic of South Africa. The mine was owned by Swaziland Barytes, Ltd., a wholly owned subsidiary of the Clyde Trading Co., Ltd., Johannesburg.[23]

Tanganyika.—Barite was found in a number of localities but never in economic quantities. It occurred as a gangue mineral in a number of gold and base metal veins of the Western Rift zone, as veinlets or nodules in sedimentary rocks, and as an accessory mineral in carbonatites.[24]

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[18] Bureau of Mines. Mineral Trade Notes. V. 55, October 1962, p. 5.

[19] Klinger, F. L., and S. H. Abbas. Barite Deposits of Pakistan. Pres. at CENTO Symp. on Ind. Rocks and Miner., Lahore, West Pakistan, Dec. 3–8, 1962; Central Treaty Organization Economic Committee. Rept. CENTO Symp. on Ind. Miner. CENTO Unclassified EC/11/M/D20, Ankara, Turkey, Jan. 16, 1963, p. 7.

[20] U.S. Embassy, Ankara, Turkey. State Department Dispatch 529. Apr. 25, 1962, encl. 1, p. 11.

[21] Kaaden, G. Barite Deposits of Turkey. Pres. at CENTO Symp. on Ind. Rocks and Miner., Lahore, West Pakistan, Dec. 3–8, 1962; Central Treaty Organization Economic Committee. Rept. CENTO Symp. on Ind. Miner. CENTO Unclassified EC/11/M/D20, Ankara, Turkey, Jan. 16, 1963, p. 7.

[22] U.S. Consulate, Johannesburg, Republic of South Africa. State Department Airgram A-362, Mar. 28, 1963, p. 1.

[23] U.S. Consulate, Johannesburg, Republic of South Africa. State Department Dispatch 410, Apr. 4, 1962, encl. 1, p. 1; State Department Dispatch 432, May 1, 1962, 2 pp.

[24] Harris, J. F. Summary of the Geology of Tanganyika. Tanganyika Geol. Survey Memori No. 1, pt. 4, Econ. Geol., 1961, p. 33.

TECHNOLOGY

Types of deposits and methods of ore recovery were discussed in a brief description of the U.S. barite industry.[25] The location, history, and geology were given for the Ritter Ranch deposit, the only known potentially commercial barite occurrence in Kern County, Calif.[26] A deposit of sanbornite, a rare barium silicate mineral, was reported to be large enough for consideration as a source of barium for the chemical industry.[27]

Barite was one of the minerals recovered by the application of heavy-medium separation to a mixed fed of newly mined ore and old material from the dumps of lead mines of two companies in England.[28] A flotation process increased both the purity and yield of barite recovered in processing an iron-manganese ore in East Germany.[29] Friction-head losses of barite slurries flowing in pipelines were determined and compared with losses that occurred in transporting limestone slurries.[30]

Water-soluble barium compounds were produced by sintering barite with the proper proportion of a silicate in a slightly reducing atmosphere.[31] Anhydrous barium chloride was formed by reacting gaseous chlorine with barite in the presence of carbon in a liquid consisting of one or more molten chlorides of the alkali or alkaline earth metals.[32] Barium oxide was produced from barium carbonate and carbon by heating the mixture to at least 1,800° C at atmospheric pressure and subjecting the resultant material to reduced pressure to increase the yield of oxide.[33] The mixture was pelletized after an alkali metal carbonate had been added, and the pellets were fluidized in an inert gas at 800° to 1,025° C.[34]

The separation of barium from strontium by a laboratory liquid-liquid extraction of the mixed chlorides was described.[35] A number of compounds in the ternary system $BaO\text{-}Fe_2O_3\text{-}MeO$, where Me was cobalt, nickel, copper, or zinc, were prepared, and their magnetic properties were determined.[36] Additional data were reported for the system barium oxide-silica.[37] Studies of aluminoborate glasses included determination of the effect of barium oxide concentration on resistiv-

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[25] Sackett, E. L. H. Barite. Min. Eng., v. 14, May 1962, pp. 46–49.

[26] Troxel, B. W., and P. K. Morton. Mines and Mineral Resources of Kern County, California. California Div. of Mines and Geol. County Rept. 1, 1962, p. 60.

[27] Matthews, R. A., and J. T. Alfors. Sanbornite from Rush Creek, Fresno County. California Division Mines and Geol., Miner. Inf. Service, v. 15, June 1962, pp. 1–3.

[28] Mining World. HMS Drum Makes Three-Product Separation. V. 24, April 1962, pp. 24–25.

[29] Mining Journal (London). New Barytes Process. V. 258, Feb. 23, 1962, p. 197.

[30] Bardill, J. D., D. R. Corson, and W. R. Wayment. Factors Influencing the Design of Hydraulic Backfill Systems (in Two Parts). 2. Friction-Head Losses of Barite and Limestone Slurries During Pipeline Transport. BuMines Rept. of Inv. 6066, 1962, 33 pp.

[31] Marcellus, M. C., and J. A. Scarlett (assigned to FMC Corp., New York). Process for Production of Barium Silicates Containing Water-Soluble Barium Values From Barite. U.S. Pat. 3,018,168, Jan. 23, 1962.

[32] Pitts, F. (assigned to Magnesium Elektron, Ltd., Clifton Junction, England). Production of Anhydrous Barium Chloride. U.S. Pat. 3,038,796, June 12, 1962.

[33] Scarlett, J. A. (assigned to FMC Corp, New York). Production of Barium Oxide. U.S. Pat. 3,031,266, Apr. 24, 1962.

[34] Unwin, J. T. (assigned to Laporte Chemicals, Ltd., Luton, England). Production of Barium Oxide. U.S. Pat. 3,059,999, Oct. 23, 1962.

[35] Wilhelm, H. A., and M. L. Andrews. Liquid-Liquid Extractor: Application to Separation of Strontium and Barium. Ind. and Eng. Chem., Process Design and Development, v. 1, October 1962, pp. 305–309.

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[37] Grebenshchikov, R. G., and N. A. Toropov. New Data on the Phase Diagram of the System Barium Oxide-Silica. Izvest. Akad. Nauk S.S.S.R., Otdel. Khim. Nauk, 1962, No. 4, pp. 545–553; Abs. in Ceram. Abs., v. 46, March 1963, pp. 87–88.

ities and dielectric constants.[38] Barium feldspar was formed by solid-state reaction of kaolin and barium sulfate.[39] Molten barium borate was a noncorrosive, nonvolatile, and otherwise desirable solvent for growing yttrium-iron garnets.[40] Higher concentrations and increased yields of glyoxal and erythrose resulted when barium sulfite was used in the hydrolysis of dialdehyde starch.[41]

Techniques studied for the chemical analysis of barium compounds included conductometric,[42] spectrographic,[43] radioactive tracer,[44] and complex formation.[45]

The effects of aggregate gradation, cement to aggregate ratio, and water content were observed for concrete with barite as the aggregate. The radiation-shielding properties of components made from this type of concrete were investigated.[46]

Barium aluminate-base refractory concrete was found to be superior to conventional calcium-aluminate base concrete in refractoriness, deformation under load, residual compressive strength, and radiation attenuation.[47] Changes in the structure and the mechanical properties of the barium aluminate component of refractory concrete were determined for the range 50° to 1,200° C.[48]

Barium compounds were used in producing ceramic materials that were dense, strong, and nonporous,[49] and in frits that were suitable for

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[38] Hirayama, C. Properties of Aluminoborate Glasses of Group II Metal Oxides: II, Electrical Properties. J. Am. Ceram. Soc., v. 45, June 1962, pp. 288–293.

[39] Sorrell, C. A. Solid State Formation of Barium, Strontium, and Lead Feldspars in Clay-Sulfate Mixtures. Am. Mineral., v. 47, March–April 1962, pp. 291–309.

[40] Linares, R. C. Growth of Yttrium-Iron Garnet From Molten Barium Borate. J. Am. Ceram. Soc., v. 45, July 1962, pp. 307–310.

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[42] Goldstein, G., D. L. Manning, and H. E. Zittel. Conductometric Determination of Sulfate by the Nonaqueous Barium Acetate Method. Anal. Chem., v. 34, August 1962, pp. 1169–1170.

[43] Cummins, R. A., and P. R. Mason. Investigation into Problems Relating to Spectrochemical Determination of Barium, Phosphorus, Calcium, and Zinc in Unused Lubricating Oil Blends. J. Inst. Petrol., v. 48, June 1962, pp. 237–245; August 1962, pp. 253–256.

Spreadborough, B. E. J. The Spectrographic Determination of Barium in Lead-Barium Temper Alloys. Admiralty Materials Laboratory Rept. A/60(M), August 1962, 3 pp, ASTIA, AD 290647.

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[45] Cartwright, P. F. S. Studies in Precipitation from Homogeneous Solution by Cation Release at Constant pH. The Analyst (Cambridge, England), v. 87, No. 1032, March 1962, pp. 163–168.

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[47] Budnikov, P. P., and V. G. Savel'yev. (Barium Aluminate Binder for Refractory Concrete). Ogneupory (U.S.S.R.), v. 27, No. 9, 1962, pp. 412–417; U.S. Dept. of Commerce, Office of Tech. Serv. Current Rev. of the Soviet Tech. Press, Nov. 9, 1962, p. 3 (828).

[48] Budnikov, P. P., and V. G. Savel'yev. (Dehydration of the Barium Aluminate Component of Refractory Concrete). Silikaty (U.S.S.R.), v. 4, No. 4, 1962, pp. 329–334; U.S. Dept. of Commerce, Office of Tech. Serv. Current Rev. of the Soviet Tech. Press, Dec. 28, 1962, p. 3 (860).

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Koch, W. J. (assigned to Radio Corp. of America, New York). Firing Process for Forsterite Ceramics. U.S. Pat. 3,020,619, Feb. 13, 1962.

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coating aluminum-clad steel.[50] A number of patented glass compositions contained barium in varying proportions.[51]

Studies resulted in a process for using a mixture of barium metaphosphate and catalytic nickelous oxide to enable high-carbon steels to be coated satisfactorily with various ceramic materials.[52] Processes were described for preparing a pigment from barium metaborate[53] and phosphors from barium silicate[54] and barium pyrophosphate.[55]

Barium oxide was a useful lubricant at elevated temperatures.[56] Methods of preparing a number of barium compounds, principally organic salts for use as oil additives, were patented.[57]

Compositions[58] and processes[59] for preparing barium ferrites were described, and some of their properties were reported.[60]

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[56] Johnson, R. L., and H. E. Sliney. Ceramic Surface Films for Lubrication at Temperatures to 2,000° F. Bull. Am. Ceram. Soc., v. 41, August 1962, pp. 504–508.

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Bauxite

By Kenneth B. Higbie,[1] Arden C. Sullivan,[2] and Mary E. Trought[3]

WORLD PRODUCTION of bauxite reached a new high, 30 million tons, exceeding 1961 by 8 percent. Over 50 percent of the world production was in the Western Hemisphere. Jamaica was the leading producer, followed by Surinam and British Guiana. Bauxite continued to be the main source of alumina required in the production of aluminum metal.

Production of bauxite in the United States increased 11 percent and was equivalent to 11 percent of the domestic supply of new bauxite. About 4.6 million short tons of alumina and aluminum oxide products was produced from bauxite. Aluminum production consumed 83 percent of the bauxite used. (Aluminum metal is discussed in the Aluminum chapter of this volume.)

TABLE 1.—Salient bauxite statistics

(Thousand long tons and thousand dollars)

	1953-57 (average)	1958	1959	1960	1961	1962
United States:						
Production, crude ore (dry equivalent)	1,705	1,311	1,700	1,998	1,228	1,369
Value	$14,473	$12,815	$17,725	$21,107	$13,937	$15,609
Imports for consumption [1]	5,374	7,915	8,149	8,739	9,206	10,585
Exports (as shipped)	27	12	17	29	151	259
Consumption (dry equivalent)	6,886	7,034	8,619	8,883	8,621	10,577
World: Production	17,400	[2] 21,075	[2] 22,710	[2] 27,015	28,805	29,940

[1] Includes bauxite imported for Government account. Import figures for Jamaican, Haitian, and Dominican Republic bauxite included were adjusted by Bureau of Mines to dry equivalent. Other imports, which are virtually all dried, are on an as-shipped basis.
[2] Revised figure.

DOMESTIC PRODUCTION

Output of crude bauxite in the United States was 1.4 million long tons, dry equivalent, valued at $15.6 million. Production increased 141,000 tons or 11 percent, and shipments to consumers from mines and processing plants increased 411,000 tons, or 37 percent from 1961.

Arkansas produced 93 percent of the total U.S. output. The two leading producers in Arkansas were Aluminum Company of America

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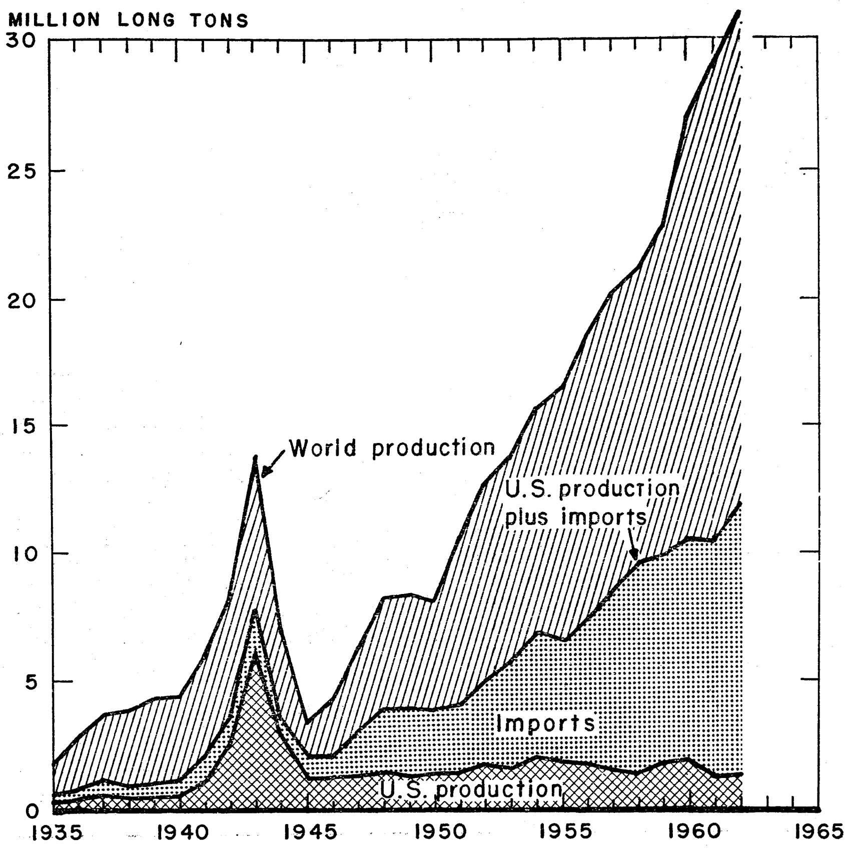

FIGURE 1.—U.S. supply and world production of bauxite, 1935–62.

(Alcoa) and Reynolds Metals Co., and each shipped crude ore to its own aluminum plant. Norton Co. shipped crude bauxite to consumers. Dried ore was produced by Campbell Bauxite Co. and Stauffer Chemical Co. Activated bauxite was produced by these same two companies and by Porocel Corp. Calcined bauxite was produced by American Cyanamid Co.

Harbison-Walker Refractories Co., R. E. Wilson Mining Co., and Wilson-Snead Mining Co. operated bauxite mines in Barbour and Henry Counties, Ala., and American Cyanamid Co. mined in Floyd and Sumter Counties, Ga. Together they produced 99,000 long dry tons of ore, a 100 percent increase over 1961. Crude ore was shipped to consumers by the Wilson-Snead Mining Co. and the American Cyanamid Co. American Cyanamid Co. and R. E. Wilson Mining Co. processed their crude ore and produced dried bauxite, and Harbison-Walker Refractories Co. produced calcined bauxite.

Kaiser Aluminum & Chemical Corp. completed a $750,000 expansion of its Baton Rouge, La., tabular-alumina products plant, that boosted the firm's aluminum oxide capacity by 500 percent.

Kaiser's new 15,000-ton-per-year hydrogen fluoride plant at Gramercy, La., which began production late in 1962, increased the U.S. annual hydrogen fluoride capacity to 225,000 tons. The plant was to supply requirements for aluminum fluoride for use in the companies metal reduction plants and provide hydrogen fluoride for the open market.

North American Coal Corp. began operating its aluminum sulfate production facility at Powhatan, Ohio. The plant, which extracted aluminum sulfate from alumina bearing waste coal shales, had an annual capacity of 40,000 tons. A second step was planned to convert part of the sulfate produced to a metallurgical grade of alumina.

Reynolds Metals Co. concluded a 20-year lease with the Port of Longview, Wash., under which it was to install facilities to discharge alumina that would be shipped by sea to the Pacific Northwest facilities from its Corpus Christi alumina plant. Two tankers were being converted to handle alumina cargos.

The annual capacity of domestic plants for producing metallurgical grade alumina increased almost 2 percent during 1962 as a result of the completion of process improvements and equipment changes by Reynolds at their Hurricane Creek, Ark., and La Quinta, Tex., plants. No other companies announced changes in their capacity ratings.

Annual capacity of domestic companies to produce dried bauxite was 111,000 long tons. The capacity of domestic firms to produce calcined and activated bauxite amounted to 225,600 long tons.

TABLE 2.—Mine production of bauxite and shipments from mines and processing plants to consumers in the United States

(Thousand long tons and thousand dollars)

State and year	Mine production			Shipments from mines and processing plants to consumers		
	Crude	Dry equivalent	Value[1]	As shipped	Dry equivalent	Value[1]
Alabama and Georgia:						
1953-57 (average)	76	59	$522	66	62	$680
1958	67	53	504	61	58	630
1959	89	69	677	63	61	678
1960	82	66	638	49	51	577
1961	60	49	475	40	43	498
1962	120	99	1,003	50	53	609
Arkansas:						
1953-57 (average)	1,948	1,646	13,951	1,926	1,665	15,249
1958	1,517	1,258	12,311	1,588	1,348	14,373
1959	1,940	1,631	17,048	1,827	1,580	17,960
1960	2,327	1,932	20,469	1,876	1,603	18,982
1961	1,419	1,179	13,462	1,244	1,080	13,220
1962	1,523	1,270	14,606	1,715	1,481	17,535
Total United States:						
1953-57 (average)	2,024	1,705	14,473	1,992	1,727	15,929
1958	1,584	1,311	12,815	1,649	1,406	15,003
1959	2,029	1,700	17,725	1,890	1,641	18,638
1960	2,409	1,998	21,107	1,925	1,654	19,559
1961	1,479	1,228	13,937	1,284	1,123	13,718
1962	1,643	1,369	15,609	1,765	1,534	18,144

[1] Computed from selling prices and values assigned by producers and estimates of the Bureau of Mines.

TABLE 3.—Recovery of dried, calcined, and activated bauxite in the United States
(Long tons)

Year	Crude ore treated	Processed bauxite recovered			
		Dried	Calcined or activated	Total	
				As recovered	Dry equivalent
1953-57 (average)	194,345	116,840	22,629	139,469	152,179
1958	192,921	92,111	44,394	136,505	151,072
1959	215,008	85,833	60,135	145,968	171,187
1960	186,094	46,015	58,373	104,388	147,079
1961	153,321	30,202	55,242	85,444	124,992
1962	172,262	37,776	57,232	95,008	141,969

CONSUMPTION AND USES

Domestic consumption of bauxite increased 23 percent. Of the total consumed, 85 percent came from foreign sources. Jamaican-type ore (from Jamaica, Haiti, and the Dominican Republic) provided 56 percent of the total consumption; Surinam-type ore (from Surinam and British Guiana) supplied 29 percent. Domestic sources supplied the remainder.

Shipments of domestic ore (an index of the grade of ore consumed) containing less than 8 percent silica were 12 percent of the total, an increase from the 7 percent shipped in 1961. The proportion of ore containing 8 to 15 percent silica remained the same, 58 percent of the total, and the proportion of the ore containing more than 15 percent silica decreased to 30 percent.

The eight domestic alumina plants operated by the aluminum companies produced 4,575,000 short tons of calcined alumina and aluminum oxide products calculated on the basis of the calcined equivalent. This represented an increase of 19 percent from 1961. The gross weight of the calcined alumina and aluminum oxide products was 4,649,000 tons, of which 4,389,000 tons was calcined alumina and 202,000 tons was trihydrate alumina. The remainder was activated or tabular alumina. Shipments of alumina and aluminum oxide products totaled 4,492,000 tons, of which 94 percent or 4,244,000 tons went to the aluminum industry. The remaining 248,000 tons, valued at $27 million, was shipped as commercial trihydrate or as activated, calcined, or tabular alumina for use chiefly by the chemical, abrasive, ceramic, and refractory industries.

Calcined alumina consumed at the 22 aluminum reduction plants in the United States totaled 4,044,000 short tons, 12 percent more than in 1961. An average of 2.159 long dry tons of bauxite was required to produce 1 short ton of alumina, and an average of 1.909 short tons of alumina was required to produce 1 short ton of aluminum metal. The overall ratio was 4.122 long dry tons of bauxite to 1 short ton of aluminum.

Alumina foams varying in densities between 20 and 60 pounds per cubic foot were developed.[4] Phosphoric acid acted both as a bonding

[4] Chemical & Engineering News. Honeycombs Bid for High Temperature Use. V. 40, No. 30, July 23, 1962, p. 44.

agent and a foaming agent for a starting mixture containing alumina, alumina hydrate, carbon, water, and phosphoric acid. The foam was cured for 32 hours under temperatures varying from 200° F. to 600° F.

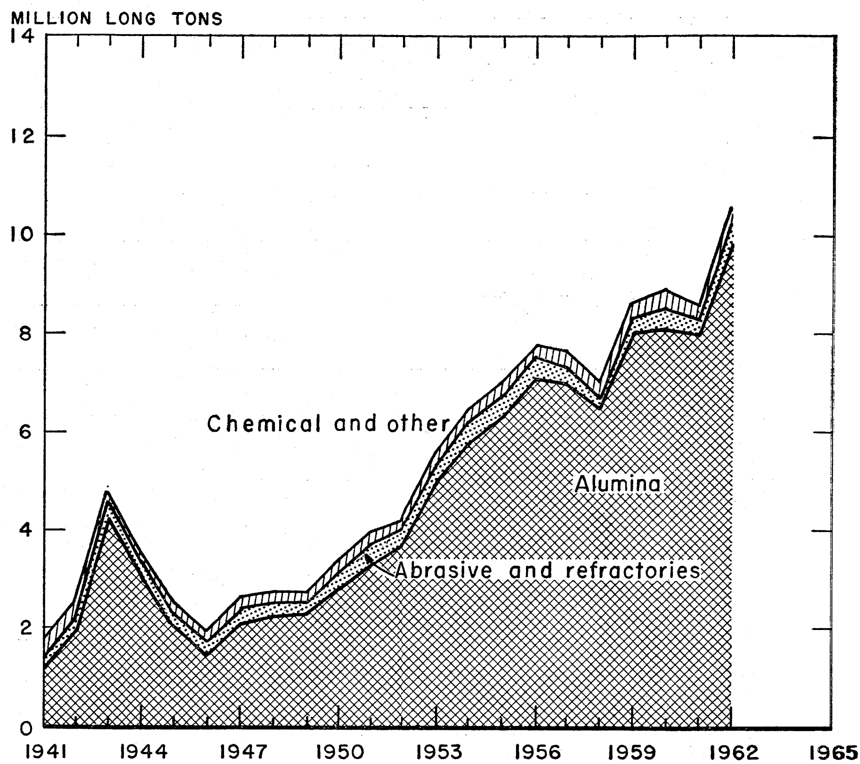

FIGURE 2.—Domestic consumption of bauxite, by uses, 1941–62.

TABLE 4.—Bauxite consumed in the United States, by industries

(Long tons, dry equivalent)

Year and industry	Domestic	Percent	Foreign	Percent	Total	Percent
1961:						
Alumina	907,824	88.2	7,126,218	93.9	8,034,042	93.2
Abrasive [1]			188,497	2.5	188,497	2.2
Chemical	85,844	8.3	148,046	1.9	233,890	2.7
Refractory	16,516	1.6	95,789	1.3	112,305	1.3
Other	19,194	1.9	33,398	.4	52,592	.6
Total [1]	1,029,378	100.0	7,591,948	100.0	8,621,326	100.0
Percent	11.9		88.1		100.0	
1962:						
Alumina	1,447,258	91.6	8,431,167	93.7	9,878,425	93.4
Abrasive [1]			260,657	2.9	260,657	2.5
Chemical	88,680	5.6	155,143	1.7	243,823	2.3
Refractory	20,150	1.3	117,454	1.3	137,604	1.3
Other	23,624	1.5	32,850	.4	56,474	.5
Total [1]	1,579,712	100.0	8,997,271	100.0	10,576,983	100.0
Percent	14.9		85.1		100.0	

[1] Includes consumption by Canadian abrasives industry.

TABLE 5.—Bauxite consumed in the United States in 1962, by grades

(Long tons, dry equivalent)

Grade	Domestic origin	Foreign origin	Total	Percent
Crude	1,466,683	1,281	1,467,964	13.9
Dried	25,458	8,623,330	8,648,788	81.8
Calcined	77,658	372,660	450,318	4.3
Activated	9,913		9,913	
Total	1,579,712	8,997,271	10,576,983	100.0
Percent	14.9	85.1	100.0	

TABLE 6.—Capacities of domestic alumina plants in operation and under construction

Company and plant	Capacity as of Dec. 31, 1962 (short tons per year)	
	Operating plants	Plants under construction
Aluminum Company of America:		
Mobile, Ala	985,500	
Bauxite, Ark	420,000	
Point Comfort, Tex	375,000	375,000
Total	1,780,500	375,000
Reynolds Metals Co.:		
Hurricane Creek, Ark	803,000	
La Quinta, Tex	876,000	
Total	1,679,000	
Kaiser Aluminum & Chemical Corp.:		
Baton Rouge, La	850,000	
Gramercy, La	430,000	
Total	1,280,000	
Ormet Corp.: Burnside, La	345,000	
Grand total	5,084,500	375,000

TABLE 7.—Production and shipments of selected aluminum salts in the United States in 1961

Type of salt	Number of plants producing	Production (short tons)	Total shipments including interplant transfers	
			Short tons	Value (thousands)
Aluminum sulfate:				
Commercial (17 percent Al_2O_3)	52	889,741	877,903	$31,692
Municipal (17 percent Al_2O_3)	5	4,001		
Iron-free (17 percent Al_2O_3)	16	55,006	26,992	1,805
Aluminum chloride:				
Liquid (32° Bé) } Crystal (32° Bé) }	10	22,976	13,016	1,073
Anhydrous (100 percent $AlCl_3$)	4	21,866	21,781	5,628
Aluminum fluoride, technical	6	60,973	59,078	14,906
Aluminum hydroxide, trihydrate (100 percent $Al_2O_3 \cdot 3H_2O$)	9	210,602	185,721	11,558
Other inorganic aluminum compounds [1]				12,016
Total				78,678

[1] Includes sodium aluminate, light aluminum hydroxide, cryolite, and alums.

Source: Data are based upon Bureau of the Census report Form MA[illegible]E.1, Annual Report on Shipments and Production of Inorganic Chemicals and Gases.

STOCKS

Bauxite stocks in the United States on December 31, 1962, had decreased 205,000 long dry tons from yearend 1961. On a dry basis, consumers inventories of crude and processed bauxite decreased 2 percent, and those at mines and processing plants decreased 14 percent. No withdrawals were made from the Government strategic or nonstrategic stockpile. Jamaican, Surinam, and refractory grades of bauxite remained on the Group I list of strategic materials for the national stockpile.

During the year, 1,063,444 long dry tons of Jamaican-type ore and 770,309 tons of Surinam-type ore were acquired by barter, bringing the total Government inventories to 7,558,000 tons of Jamaican-type ore and 7,755,000 tons of Surinam-type ore. Details of the quantities and various types of bauxite stored in the three Government inventory accounts are shown in tables 8 and 9.

Barter programs involving 1 million short tons of Jamaica-type bauxite were contracted for with domestic companies. No barter orders were placed for Surinam-type ore.

The Government maintained a stockpile of crude, fused aluminum oxide (alumina). Inventory at the end of the year equaled 200,000 short dry tons in the national (strategic) stockpile and 192,000 tons in the Commodity Credit Corporation (CCC) and supplemental stockpiles for a total of 392,000 tons, 96 percent in excess of the 200,000 ton maximum objective.

TABLE 8.—Stocks of bauxite in the United States [1]

(Long tons)

Year	Producers and processors		Consumers		Government	Total	
	Crude	Processed [2]	Crude	Processed [2]	Crude	Crude and processed [2]	Dry equivalent
1958	644, 051	6, 806	606, 643	2, 163, 120	2, 204, 674	5, 625, 294	5, 146, 918
1959	741. 228	7, 341	543, 074	1, 998, 475	2, 204, 674	5, 494. 792	5, 013, 995
1960	1, 225. 569	10, 242	530. 646	1, 974, 890	2, 204. 674	5, 946, 021	5, 388, 767
1961	1, 306. 419	9. 466	621. 729	1. 897. 635	2, 204, 674	6, 039, 923	5, 450, 930
1962	1, 121, 705	9, 960	542. 539	1, 920, 051	2, 204, 674	5, 798, 929	5, 246, 349

[1] Excludes strategic stockpile.
[2] Dried, calcined, and activated.

PRICES

No open-market price was in effect for bauxite mined in the United States, because the output was consumed mainly by the producing companies.

The average value of bauxite shipped and delivered to domestic alumina plants was estimated at $17.34 per long ton, dry equivalent, for imported ore.

Prices in E&MJ Metal and Mineral Markets for December 31, 1962, were listed for imported bauxite only and were noted as effective January 1, 1961. Abrasive-grade ore, crushed and calcined, 86 percent minimum Al_2O_3, f.o.b port, British Guiana, was quoted at $21.45 per long ton, and refractory-grade bauxite was quoted at $27.85 per long ton, the same as quotations of December 21, 1961.

TABLE 9.—Bauxite in Government inventories as of December 31, 1962

(Long tons)

	Metal grade, dried		Refractory grade, calcined
	Jamaican type	Surinam type	
Maximum objective	2,600,000	6,400,000	137,000
Government inventories:			
National (strategic) stockpile	880,000	4,963,000	299,000
DPA inventories	1,370,000		
CCC and supplemental stockpile	5,308,000	2,792,000	
Total	7,558,000	7,755,000	299,000
Surplus over maximum objective:			
Quantity	4,958,000	1,355,000	162,000
Percent	190.7	21.2	118.2

The average value of calcined alumina, as determined from producer reports, was $0.0336 per pound. The value of imported calcined alumina at the foreign port of shipment was $0.0266 per pound.

TABLE 10.—Average value of domestic bauxite in the United States [1]

(Per long ton)

Type	Shipments f.o.b. mines or plants		Type	Shipments f.o.b. mines or plants	
	1961	1962		1961	1962
Crude (undried)	$9.78	$9.53	Calcined	(2)	(2)
Dried	12.77	12.26	Activated	$68.89	$66.24

[1] Calculated from reports to the Bureau of Mines by bauxite producers.
[2] Figure withheld to avoid disclosing individual company confidential data.

TABLE 11.—Average value of U.S. imports and exports of bauxite

(Per long ton)

Type and country	Average value, port of shipment		Type and country	Average value, port of shipment	
	1961	1962		1961	1962
Imports:			Imports—Continued		
Crude and dried:			Calcined: [3]		
Brazil	$12.51		British Guiana	$23.30	$23.38
British Guiana	7.24	$9.16	Greece		4.83
Canada		29.87	Surinam	24.88	32.38
Dominican Republic [1]	13.21	12.38	Average	23.84	24.43
Greece	13.95	12.30			
Haiti [1]	9.41	9.39	Exports:		
Jamaica [1]	9.47	12.58	Bauxite and bauxite concentrate	80.89	76.86
Surinam [2]	9.32	9.86			
Average	9.65	11.54			

[1] Dry equivalent tons as adjusted by Bureau of Mines used in computation.
[2] Surinam has been adjusted by the Bureau of Mines to include: 1961, 26,960 long tons ($249,580); 1962, 2,033 long tons ($23,380) reported as Trinidad and Tobago by the Bureau of the Census.
[3] For refractory use.

Source: Bureau of the Census.

NOTE.—Bauxite is not subject to an ad valorem rate of duty and the average values reported may be arbitrary for accountancy between allied firms, etc. Consequently the data do not necessarily reflect market values in the country of origin.

TABLE 12.—Market quotations on alumina and aluminum compounds

Compound	Dec. 25, 1961	Dec. 31, 1962
Alumina, calcined, bags, carlots, works____pound__	$0.0530	$0.0530
Aluminum hydrate, heavy, bags, carlots, freight equalized____do____	.0370	.0370
Aluminum sulfate, commercial, ground, bulk, carlots, works, freight equalized__ton__	40.00	40.00
Aluminum sulfate, iron-free, bags, carlots, works, freight equalized______100 pounds__	3.80	3.80

Source: Oil, Paint and Drug Reporter.

FOREIGN TRADE [5]

Imports.—Imports of bauxite, including ores acquired by the U.S. Government, were 10.6 million long tons on a dry weight basis, 15 percent above that of 1961. Imports from Jamaica, the principal source in recent years, was the highest quantity in history, up 22 percent over 1961 and amounted to 57 percent of the total. Imports from Surinam decreased 2 percent and amounted to 27 percent of the total. The remainder came mostly from the Dominican Republic, British Guiana, and Haiti.

On a dry basis, 46 percent of the imports entered through the New Orleans, La., customs district; 33 percent through the Galveston, Tex., district; 18 percent through the Mobile, Ala., district; and 3 percent through other districts.

Imports of calcined alumina for producing aluminum were 174,201 short tons; 64 percent came from Japan and almost 36 percent came from Western Africa, probably Guinea. Other aluminum compounds imported into the United States, totaling 12,958 short tons, were chiefly from Canada, West Germany, France, the United Kingdom, and Italy.

Exports.—Exports of bauxite and bauxite concentrate increased 72 percent. The large increase resulted primarily from the domestic alumina producers capturing a larger part of the world's alumina requirements than in previous years. Canada received 62 percent of the exports; France, 20 percent; and India, 9 percent.

Of the 17,776 short tons of aluminum sulfate exported, about 83 percent was shipped to Venezuela, Canada, Iraq, Guatemala, and Peru. Of the 87,671 short tons of other aluminum compounds exported, 67 percent was shipped to Norway. Small quantities were shipped to 59 other countries.

Tariff.—The duties on crude bauxite, calcined bauxite, and alumina imported for making aluminum were suspended in 1962 until July 16, 1964. Duties on aluminum hydroxide and alumina not used for aluminum production were 0.25 cent per pound.

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

TABLE 13.—U.S. imports for consumption of bauxite (crude and dried)[1] by countries

(Thousand long tons and thousand dollars)

Country	1953–57 (average)	1958	1959	1960	1961	1962
North America:						
Canada						(2)
Dominican Republic			384	632	722	719
Haiti	64	317	307	341	289	436
Jamaica	2,221	4,950	4,220	4,175	[3] 4,933	6,010
Trinidad and Tobago					(4)	(4)
Total	2,285	5,267	4,911	5,148	[3] 5,944	7,165
South America:						
British Guiana	236	223	160	330	[3] 319	560
Surinam	2,845	2,425	3,078	3,256	[4] 2,912	[4] 2,853
Other	(2)				4	
Total	3,081	2,648	3,238	3,586	[3] 3,235	3,413
Europe	2	(2)		5	27	7
Africa	6					
Grand total:						
Quantity	5,374	7,915	8,149	8,739	9,206	10,585
Value	$41,575	$70,107	$73,549	$78,024	[3] $88,814	$122,190

[1] Import figures for Jamaican, Haitian, and Dominican Republic bauxite adjusted by Bureau of Mines to dry equivalent by deducting 13.6 percent free moisture for Jamaican, 14.6 percent for Haitian bauxite in 1957 and 13.6 percent in 1958 and later, and 17.7 percent for Dominican Republic. Other imports, which are virtually all dried, are on an as-shipped basis. Includes bauxite imported for Government account.
[2] Less than 1,000 tons.
[3] Revised figure.
[4] Surinam has been adjusted by the Bureau of Mines to include 26,960 long tons ($249,580) in 1961 and 2,033 long tons ($23,380) in 1962 reported by the Bureau of the Census as Trinidad and Tobago.

Source: Bureau of the Census.

TABLE 14.—U.S. exports of bauxite (including bauxite concentrate),[1] by countries

(Long tons)

Destination	1953–57 (average)	1958	1959	1960	1961	1962
North America:						
Canada	25,353	9,548	13,377	24,879	108,104	160,811
Mexico	619	1,177	1,614	2,781	562	826
Other	144	164	92	406	109	239
Total	26,116	10,889	15,083	28,066	108,775	161,876
South America	79	37	346	92	559	655
Europe	358	601	1,082	577	39,859	62,721
Asia	246	309	835	542	1,327	22,861
Africa	23	32	57	33	10	51
Oceania				7	153	10,397
Grand total as exported	26,822	11,868	17,403	29,317	150,683	258,561
Dried bauxite equivalent [2]	41,575	18,395	26,975	45,441	233,559	400,770
Value thousands	$1,552	$968	$1,825	$2,588	$12,189	$19,874

[1] Classified as "Aluminum ores and concentrates" by the Bureau of the Census.
[2] Calculated by Bureau of Mines.

Source: Bureau of the Census.

WORLD REVIEW [6]

An increase of 4 percent was registered in world bauxite production during the year. Jamaica, the principal producer, accounted for 25 percent of the total. Countries showing a considerable increase in output were Australia 92 percent; Haiti 66 percent; Ghana 44 percent; Rumania 31 percent; India 21 percent; and Indonesia 17 percent.

[6] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.

Table 17 shows international flow of bauxite in 1961. Total exports of bauxite in the world increased 1 percent in 1961. Principal producing countries beside Jamaica were Surinam, British Guiana, and the Dominican Republic in the Carribean area and the United States, France, Greece, Yugoslavia, and Republic of Guinea in the remainder of the free world.

World alumina capacity reported at 12,580,000 short tons in 1961 increased by approximately 300,000 tons to a total of 12,880,000 tons. France accounted for 220,000 tons of the increase, India 43,000 tons, and Japan 37,000 tons.

TABLE 15.—World production of bauxite by countries [1]
(Thousand long tons)

Country	1953-57 (average)	1958	1959	1960	1961	1962
North America (dried equivalent of crude ore):						
Dominican Republic	----------	----------	759	678	701	706
Haiti	[2] 263	280	255	268	263	[3] 436
Jamaica	2,726	5,722	5,125	5,745	6,663	7,435
United States	1,705	1,311	1,700	1,998	1,228	1,369
Total	4,694	7,313	7,839	8,689	8,855	9,946
South America:						
Brazil	44	69	95	119	96	[4] 100
British Guiana	2,341	1,586	1,674	2,471	2,374	[4] 2,69
Surinam	3,272	2,941	3,376	3,400	3,351	[5] 3,202
Total	5,657	4,596	5,145	5,990	5,821	5,992
Europe:						
Austria	19	23	24	26	18	17
France	1,395	1,801	1,729	2,035	2,155	2,127
Germany, West	5	4	4	4	4	[4] 4
Greece	534	843	904	870	1,100	[4] 985
Hungary	1,121	1,032	942	1,170	1,337	1,450
Italy	281	294	290	310	318	304
Rumania	38	72	70	87	68	89
Spain	6	8	8	3	6	6
U.S.S.R. [4]	1,820	2,750	3,000	3,500	4,000	4,000
Yugoslavia	733	721	802	1,009	1,213	1,311
Total [4]	5,952	7,548	7,773	9,014	10,219	10,293
Asia:						
China (diasporic) [4]	----------	150	300	350	400	400
India	83	166	215	377	468	564
Indonesia	223	338	381	389	413	484
Malaya	226	262	382	452	410	349
Pakistan	[6] 1	2	2	1	1	1
Sarawak	----------	136	207	285	253	225
Taiwan (Quemoy)	2	----------	----------	----------	----------	----------
Total	535	1,054	1,487	1,854	1,945	2,023
Africa:						
Ghana (exports)	144	207	148	224	196	282
Guinea, Republic of	407	343	296	1,171	1,739	1,348
Mozambique	3	5	4	5	5	5
Total	554	555	448	1,400	1,940	1,635
Oceania: Australia	7	7	15	69	26	50
World total (estimate)	17,400	21,075	22,710	27,015	28,805	29,940

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[2] One year only, as 1957 was the first year of commercial production.
[3] U.S. imports.
[4] Estimate.
[5] Exports.
[6] Average annual production 1955-57.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

TABLE 16.—Relationship of world production of bauxite and aluminum

(Million long tons)

Commodity	1953-57 (average)	1958	1959	1960	1961	1962
Bauxite	17.4	[1] 21.1	22.7	27.0	[1] 28.8	29.9
Aluminum	3.0	3.5	4.0	4.5	[1] 4.7	5.0
Tons of bauxite per ton of aluminum produced	5.8	6.0	5.7	6.0	[1] 6.1	6.0

[1] Revised figure.

World alumina production increased from 6.8 million short tons in 1955 to 10.2 million tons in 1960.[7] It also was stated that international trade in alumina was 1.4 million tons in 1960.

A book describing the world aluminum industry in detail was published.[8]

NORTH AMERICA

Jamaica.—The leading country in bauxite production accounted for 25 percent of the world output. Exports of 6 million tons were all to the United States. Production and export of alumina by Alcan Jamaica, Ltd., decreased to 702,962 short tons. Of the alumina exported, 425,537 tons went to Canada, 203,288 to Norway, 33,527 to Brazil, 21,594 to Sweden, 15,608 to the Netherlands, and 3,408 to other countries.

Alcoa Minerals of Jamaica, a subsidiary of the Aluminum Company of America, signed a 25-year agreement with the Jamaican Government for the mining of bauxite over a 50-square mile area in the Mocho Mountains in Clarenden parish.[9] The company expected to begin commercial production by May 1963 and to export at least 500,000 tons of bauxite a year. Alcoa planned to build a 18.8-mile railway to carry the ore to the port at Rocky Point where an ore drying plant and storage and port facilities were to be built.

Harvey Aluminum, Inc., which held a prospecting license since 1957, was granted a mining lease covering 47.8 square miles for 25 years.

An agreement between the United States and Jamaican Governments was signed in which the U.S. Agency for International Development guaranteed private U.S. investment against inconvertibility, expropriation, or loss from war, revolution, or insurrection. Jamaica exempted foreign investors from income tax for 7 years and permitted duty-free imports of machinery, equipment, and raw materials for manufacturing products for export.

Virgin Islands.—Harvey Aluminum, Inc., signed a contract to build a $25 million alumina plant having a capacity of 100,000 tons per year on the island of St. Croix.[10] Under the agreement with the subsidiary, Harvey Alumina Virgin Islands, Inc., the Territorial government was

[7] Bracewell, Smith. Bauxite, Alumina and Aluminium. Overseas Geol. Surveys, London, 1962, 235 pp.

[8] Ginsberg, Dr. Hans. Aluminium. Ferdinand Enke Verlag, Stuttgart (West Germany), 1962, 135 pp. (in German).

[9] Mining Engineering. Alcoa to Mine Jamaica Bauxite. V. 14, No. 5, May 1962, p. 20.

[10] Wall Street Journal. Harvey Aluminum Pact Signed for Alumina Plant in Virgin Islands. V. 69, No. 32, Feb. 14, 1962, p. 21.

TABLE 17.—Production and trade of bauxite in 1961, by major countries

(Thousand long tons)

Country	Production	Exports by country of destination: Total	North America: Canada	North America: United States	Europe: France	Europe: Germany, West	Europe: Italy	Europe: U.S.S.R.[1]	Europe: United Kingdom	Europe: Other Europe	Asia: Japan	Australia	All other countries
North America:													
Dominican Republic	701	856	------	856	------	------	------	------	------	------	------	------	------
Haiti	263	[2] 289	------	[2] 289	------	------	------	------	------	------	------	------	------
Jamaica	6,663	4,975	------	4,975	------	------	------	------	------	------	------	------	------
United States	1,223	151	108	------	18	(3)	(3)	21	1	(3)	(3)	------	3
South America:													
Brazil	96	2	------	------	------	------	------	------	------	------	------	------	2
British Guiana	2,374	1,606	875	506	17	25	18	------	44	49	20	------	52
Surinam	3,351	3,352	264	2,917	8	[4] 108	1	------	3	41	------	------	10
Europe:													
Austria	18	8	------	------	------	8	------	------	------	------	------	------	------
France	2,155	252	------	------	------	130	7	------	104	6	------	------	5
Germany, West	4	(3)	------	------	------	------	(3)	------	------	(3)	------	------	(3)
Greece	1,100	1,034	------	------	[4] 38	402	------	448	57	64	------	------	25
Hungary	1,337	699	------	------	------	[4] 87	------	612	------	------	------	------	------
Italy	318	------	------	------	------	------	------	------	------	------	------	------	------
Rumania	68	33	------	------	------	------	------	33	------	------	------	------	------
Spain	6	------	------	------	------	------	------	------	------	------	------	------	------
U.S.S.R.	[5] 4,000	(6)	------	------	------	------	------	------	------	------	------	------	------
Yugoslavia	1,213	915	------	------	39	650	182	40	------	4	------	------	------
Asia:													
China (diasporic)	[5] 400	(6)	------	------	------	------	------	------	------	------	------	------	------
India	468	99	------	------	------	9	[4] 18	------	(3)	------	62	9	1
Indonesia	413	423	------	------	------	------	------	------	------	------	423	------	------
Malaya, Federation of	410	284	------	------	------	------	------	------	------	4	260	10	10
Pakistan	1	------	------	------	------	------	------	------	------	------	------	------	------
Sarawak	253	256	------	------	------	------	------	------	------	------	220	------	36
Africa:													
Ghana	[7] 196	196	------	------	------	------	------	------	196	------	------	------	------
Guinea, Republic of	1,739	346	208	57	------	[4] 76	------	5	------	------	------	------	------
Mozambique	5	(6)	------	------	------	------	------	------	------	------	------	------	------
Oceania: Australia	26	30	------	------	------	------	------	------	------	------	30	------	------
World total	[8] 28,805	15,806	1,455	9,600	120	1,495	226	1,159	405	168	1,015	19	144

[1] U.S.S.R. and other Communist nations of East Europe.
[2] U.S. imports.
[3] Less than 500 tons.
[4] Imports.
[5] Estimate.
[6] Data not available.
[7] Exports.
[8] Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

Compiled by Corra A. Barry, Division of Foreign Activities.

to provide certain tax exemptions and several hundred acres of unused land on St. Croix. Bauxite was to be brought into the plant from Carribean or African mining areas, and the alumina was to be shipped to Harvey's aluminum reduction plant at The Dalles, Oreg., for processing into refined aluminum. Initial construction was begun.

SOUTH AMERICA

Brazil.—Mineração Geral do Brasil reported a new bauxite deposit near Caete, Minas Gerais, containing several million tons of low silica bauxite.

British Guiana.—Production of bauxite increased 13 percent. Reynolds Metals Co. increased its output of bauxite 21 percent, from 364,000 long tons in 1961 to 442,000 tons in 1962. Demarara Bauxite Co. shipped 1,398,000 long tons of bauxite and 253,000 short tons of alumina.

TABLE 18.—British Guiana: Bauxite exports

(Long tons)

Country of destination	1961		January–June 1962	
	Dried ore	Calcined ore	Dried ore	Calcined ore
Canada	772,660	102,602	301,858	45,570
France	2,066	14,470		18,313
Germany, West		25,130		14,046
Italy	20	18,178		9,562
Japan	600	19,746		15,601
United Kingdom	11,510	32,338	4,900	15,533
United States	415,155	90,830	282,607	71,352
Other countries	33,545	67,467	1,000	16,964
Total	1,235,556	370,761	590,365	206,941
Value, BWI$ [1]	14,197,888	14,277,089	6,491,360	7,859,915

[1] BWI$=US$0.59 in 1961 and US$0.58 in 1962.

Reynolds purchased an 8-inch dredge to deepen the ¾-mile canal and 12-mile channel leading to the Berbice River.[11] The dredging operation was expected to remove bottlenecks encountered in shipping bauxite from the mines to the drying plant at Everton.

Demarara began operating a drying kiln, capable of processing about 1.5 million tons of bauxite a year, at Mackenzie. The moisture content of the bauxite was reduced to 3.5 percent.

Surinam.—Despite the termination of the Suriname Aluminum Co. contract to ship ore to the U.S. stockpile at the end of April, the United States continued to be the principal market, receiving about 88 percent of the bauxite exported during 1962. The decline in exports of metal-grade ore to 2.9 million tons was partly offset by an increase in exports of abrasive-grade ore to 186,600 tons and chemical-grade ore to 70,300 tons. Total exports were 3.2 million tons, a decline of 3 percent from the 3.3 million tons exported in 1961. Surinam was accepted as an associate member of the European Common Market in August.

[11] Engineering and Mining Journal. New Eight-Inch Dredge Will Enable Reynolds To Increase British Guiana Bauxite Production. V. 163, No. 7, July 1962, pp. 76–77.

EUROPE

France.—Cie. Miniéré des Baux was formed by Union des Bauxites and Péchiney Compagnie de Produits Chimiques et Electrometallurgiques (Péchiney) to exploit the large lower grade bauxite deposits in the Les Baux region.

Alumina capacity was to be increased at the Salindres and Gardanne plants of Péchiney, and the Barasse plant of Société d'Électro-Chimie, d'Électro-Métallurgie et des Aciéries Électriques d'Ugine (Ugine). Total capacity was to be increased by 220,500 short tons by the end of 1962.

Société des Bauxites et Alumines de Provence; Ugine; Ste. de Recherches et d'Exploitation Minieres; Péchiney; and Union des Bauxites were granted permits to exploit bauxite mines in the Department of Var.

Germany, East.—VEB Leuchtstoffwerk Bad Liebenstein began production of alumina at Bad Liebenstein, for use by the tube industry. The plant was scheduled to be expanded during 1962 to meet the total demand of the industry.[12]

Greece.—Aluminium de Grèce, S.A., was granted exploration rights on land on the bay of Aspra Spitia, near Distomon, where alumina and aluminum plants were to be built. The company signed contracts with Barlos Bauxite Mining Co. for 246,000 long tons of bauxite a year and with Bauxite Parnassos Mining Co. for 221,000 tons to be supplied to the plant when completed. The alumina plant was scheduled to have an initial capacity of 110,000 short tons, but plans were underway to expand this to 220,000 tons. Half of the alumina produced was to be used for the production of aluminum, and the remainder was to be exported. The Government granted the companies permission to export 1,012,000 long tons of bauxite.

Bauxite Parnassos Mining Co., which holds 82 concessions from the State, retained the right to conduct free sales from the mines.

Hungary.—Although bauxite was considered plentiful, the high cost of power for producing aluminum prevented expansion of the industry, and about half of the bauxite and alumina produced was exported. A new agreement with the Soviet Union provided for the shipment of alumina on an increasing basis until 1980 when a rate of 364,000 short tons of alumina per year was to be attained. In return, the Soviet Union was to ship aluminum produced from this alumina to Hungary.

Italy.—Bauxite deposits were reportedly discovered near Salento, in the southern part of the country. Plans were being studied to build a processing plant at the site.[13]

Netherlands.—Aluminium Industrie, A.G., (AIAG) indicated its intention to build an alumina plant at Botlek near Rotterdam. The plant was expected to have a capacity of 220,500 short tons. Aluminium en Chemic Rotterdam, N.V., was formed to operate the plant.

Spain.—A new bauxite deposit was reported to have been discovered in Murcia near the village of Mula. Although numerous small deposits occurred in Spain, none was suitable for metallurgical use.

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[12] Mining Journal (London). Vol. 259, No. 6627, Aug. 24, 1962, p. 175.
[13] Engineering and Mining Journal. V. 163, No. 8, August 1962, p. 180.

Switzerland.—Aluminium Industrie, A.G., stated in its annual report that it had been decided to change its name to Schweizerische Aluminium G.m.b.H. (Alusuisse).

ASIA

A report on the bauxite resources and the aluminum industry of Asia and the Far East was published.[14]

India.—Bauxite production continued to increase and was 21 percent more than in 1961. Gujarat and Bihar States accounted for 90 percent of the output, and Madhya Pradesh, Maharashtra, and Mysore supplied the remaining 10 percent.[15]

Bauxite from Udgiri and Shrivardhan was tested and found to be amenable to the Bayer process. About 93 percent of the alumina could be leached by digesting with a solution containing 200 grams per liter of sodium hydroxide. The Al_2O_3 to NaOH ratio was 1:4 at 100° C and 1 atmosphere for less than 1 hour.[16]

Exports of 550,000 long tons of bauxite were authorized to be shipped from October 25, 1962 to October 24, 1964.

Madras Aluminium Co., Ltd., received an $8 million bank loan for the new alumina plant to be built in Coimbatore, Madras.

Indonesia.—During 1962, 413,000 long tons of bauxite was shipped to Japan as part of a contract signed in 1961. A 17-percent increase in bauxite production was reported in 1962.

Malaya.—Bauxite output continued to decline and was 15 percent less than in 1961. Aluminium, Ltd., completed the installation of a new washing plant early in 1962 to treat ore mined by South East Asia Bauxite Co. All bauxite was exported to Japan.

Japan.—Imports of bauxite declined 5 percent to 1,081,000 long tons. Alumina output was 3 percent more than in 1961 and totaled 478,000 short tons. Of this total Nippon Keikinzoku, K.K. (Japan Light Metals Co.) produced 223,000 tons; Sumitomo Kagaku, K.K. (Sumitomo Chemical Co., Ltd.) produced 145,000 tons; and Showa Denko, K.K. (Showa Electro-Chemical Industry Co., Ltd.) produced 110,000 tons.

AFRICA

Cameroon, Federal Republic of.—Compagnie Camerounaise d'Aluminium (ALUCAM) signed a new agreement with the Republic replacing the one signed in 1954 before the territory became independent. Under the new agreement the company planned to exploit Cameroon bauxite deposits and give preference to local ore in its plant. Also native labor was to be employed in increasing numbers.

Ghana.—Production of bauxite increased 44 percent and reached an alltime high of 282,000 long tons. The five bauxite mining concessions held by West African Aluminium Co., Ltd., were canceled by the Government.

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[14] United Nations. Bauxite Ore Resources and Aluminum Industry of Asia and the Far East. Min. Res. Development Series No. 17, 1962, 51 pp.

[15] Goel, H. G. A survey of Bauxite Industry. The Eastern Metals Rev. (Calcutta), v. 16, No. 1, Feb. 4, 1963, pp. 63–68.

[16] Altekar, V. A., and G. G. Mathad. J. Sci. Ind. Res. (India), v. 20D, 1961, pp. 404–407; Chem. Abs., v. 56, No. 8, Apr. 16, 1962, p. 8362.

Guinea, Republic of.—The bauxite mines on Kassa Island were operated by the Government since the take-over in August 1961. The production of 1,348,000 long tons was 22 percent less than in 1961. Alumina output at FRIA, Compagnie Internationale pour la Production d' Alumine was 505,000 short tons. Ninety-seven percent of the alumina was exported: France received 130,000 tons; Cameroon, 110,000 tons; Norway, 98,000 tons; the United States, 79,000 tons; the Netherlands, 43,000 tons; Poland, 17,000 tons; and Canada, 14,000 tons. The remainder was shipped to West Germany, Czechoslovakia, and Italy.

Sierra Leone.—Sierra Leone Ore & Metal Co., a subsidiary of Aluminium Industrie, A.G., signed a long-term contract with the Government for the mining and exporting of from 98,400 to 196,800 long tons of bauxite a year from deposits in the Banta and Dasse chiefdoms, Mokanji Hills, Moyamba district. Mining was to begin in 1963. A 350-kilometer road was expected to be built connecting the mines with the Sherbo River.

OCEANIA

Australia.—Commonwealth Aluminium Corp., Pty., Ltd. (Comalco) began shipping bauxite to the Bell Bay smelter in Tasmania from the Weipa deposits in Queensland in August, and by the second quarter of 1963 all requirements of the smelter were to be from this source. The company also contracted to ship 600,000 tons of bauxite to Japan over the 3-year period 1963-66. The conditions under which the Government granted the contract included the building of a 360,000-ton alumina plant to begin operating in 1966, and the expenditure of US$90 million at Weipa, including the building of the town.

The discovery of rich bauxite deposits was reported on leases held by the British Aluminium Co., Ltd., and Duval Holdings, Pty., in northeastern Arnhem Land.

Two prospecting licenses were granted Reynolds Pacific Co., Pty., Ltd., in the southeastern part of Western Australia.

Negotiations were in progress between Mitsubishi Chemical Industries, Ltd., of Japan and Alcoa of Australia, Pty., Ltd., for alumina to be shipped to Mitsubishi's aluminum smelter under construction in Japan.

A series of articles on the aluminum industry in Australia was published.[17]

Progress was made on the alumina plant being built at Kwinana, Western Australia, by Alcoa of Australia, Ltd., and the plant was expected to be operating by the fourth quarter of 1963. Capacity of the plant was expected to be 231,500 short tons a year.

New Zealand.—The results of the investigations of the bauxite deposits at Otoroa, in northern part of New Zealand, were published.[18] Ore reserves were estimated to be about 20 million tons containing over 30 percent alumina.

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[17] Barnett, F. R. Aluminium in Australia. Pt. 4. The Semifabrication of Aluminium. Australian Chem. Proc., v. 16, No. 1, January 1963, pp. 22–27.
Dickinson, S. B. Aluminium in Australia. Pt. 1, Australia's Bauxite Resources. Australian Chem. Proc., v. 15, No. 10, October 1962, pp. 8–15. Pt. 2, Alumina Production No. 11, November 1962, pp. 16–19.
Nixon, J. C. Aluminium in Australia. Pt. 3, Commercial Production of Australian Aluminium. Australian Chem. Proc., v. 15, No. 12, December 1962, pp. 19–25.

[18] Mining Journal (London). V. 258, No. 6604, Mar. 16, 1962, p. 264.

TECHNOLOGY

The first international symposium devoted to the extractive metallurgy of aluminum was held in New York City on February 18–22 in conjunction with the annual meeting of the American Institute of Mining, Metallurgical and Petroleum Engineers. The symposium was divided into four sections: Technology of Alumina Production, Carbon Technology in Aluminum Production, Technology of Aluminum Production, and New Processes and Materials of Construction. The sections contained 18, 13, 25, and 11 papers, respectively. Brief summaries of the papers were published.[19]

Results of metallurgical investigations by the Bureau of Mines on samples of bauxite obtained from the Hawaiian Islands of Kauai, Maui, and Hawaii, were published.[20] Extraction studies yielded recoveries up to 85.5 percent alumina by a modified Bayer process.

A Czechoslovakian patent described an improved method for extracting alumina from bauxite.[21] Utilizing a countercurrent flow of caustic soda, the crushed calcined bauxite was continuously reacted with fresh pure caustic at a bauxite-caustic ratio of 1:10 at 185° F. The process was claimed to be 25 percent more efficient than the conventional Bayer process.

The Commonwealth Scientific and Industrial Research Organization (CSIRO) of Australia announced a new two-stage sulfuric acid process for the recovery of alumina from low-grade ores that are high in silica and/or iron.[22] The process involved digesting the ore with acid, first at 265° F. and, then at 350° F. The leach liquor was treated with sulfur dioxide to reduce the iron, and basic aluminum sulfate crystals were recovered. Test studies showed that the alumina obtained was sufficiently pure to use as cell feed in the electrolytic production of aluminum. Several other acid-leach processes for extracting alumina from aluminum-bearing minerals were described and compared with the Bayer process.[23] The sulfuric acid system proposed by the North American Coal Corp. for processing coal shales, the hydrochloric acid system patented by Anaconda Aluminum Co., a German method developed by Kretz Schmar of Berlin-Charlottenberg, and a Canadian method proposed by the Canadian Department of Mines were reviewed.

The Bureau of Mines released the first two publications in a series which present cost evaluations of various extraction processes for the production of metallurgical-grade alumina from low-grade aluminous

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[19] Light Metals. Extraction of Aluminum—The International Symposium. V. 25, No. 287. April 1962, pp. 109–110; v. 25. No. 288. May 1962. pp. 132–134.
Journal of Metals. Extractive Metallurgy of Aluminum. V. 14, No. 6, June 1962, pp. 442–446.
Engineering and Mining Journal. V. 163, No. 4, April 1962, pp. 98, 100, 102.

[20] Calhoun, W. A., and T. E. Hill, Jr. Metallurgical Testing of Hawaiian Ferruginous Bauxite. BuMines Rept. of Inv. 6003, 1962, 43 pp.

[21] Chemical Week. Alumina Challenger. V. 90, No. 17, Apr. 28, 1962, p. 98. Czechoslovakian Patent 97,901. Jan. 15, 1961.

[22] Scott, T. R. Alumina by Acid Extraction. J. Metals, V. 14, No. 2, February 1962, pp. 121–125.

[23] Canadian Chem. Processing. Alumina From Shale to Shake Bauxite? V. 46, No. 4, April 1962, pp. 33–38.

materials.[24] Relative processing costs of the sulfurous acid and hydrochloric processes were based upon previously published pilot plant and laboratory studies. Costs were estimated from $65.09 to $119.65 per ton of alumina for plants producing 1,000 tons a day, using clay at $1 per ton.

A submerged-arc furnace process was proposed for the production of aluminum-rich alloys from bauxite.[25] Theoretical and engineering aspects of the process indicated production of a 65 percent aluminum alloy appeared feasible, but much experimental work had to be carried out to develop the process to the stage of designing a pilot plant.

Additional information was published relating to the desilication of solutions resulting from the leaching of lime-soda-sinters of Laramie, Wyo., anorthosite.[26] Preparation of commercial-grade aluminum fluoride by defluorinating low-grade siliceous fluorspars and reacting the off gas with alumina monohydrate was investigated.[27] Heats of formation of analcite, dehydrated analcite, lawsonite, anorthite, hexagonal anorthite, and leonhardite were determined by solution calorimetry with hydrofluoric acid as the reaction media.[28]

A detailed monograph was issued that presented information on production methods, uses, prices, specifications, etc., of bauxite, alumina, and aluminum.[29] Statistics were included on production and trade in British Commonwealth countries and other parts of the world.

A booklet was published describing analytical methods employed by the Geological Survey for rapid determination of alumina and other major constituents of silicate, carbonate, and phosphate rocks.[30]

Factors influencing the hydrolysis of aluminum sulfate solutions at elevated temperatures were investigated.[31] At temperatures above 100° C, the basic salt, $3Al_2O_3 \cdot 4SO_3 \cdot 9H_2O$, formed. In processing, rapid hydrolysis was achieved above 200° C and at SO_3 to Al_2O_3 ratios of 2.0 or less. Thirty minutes at 220° C yielded the satisfactory recovery of sulfate crystals.

Kinetic studies were made of the thermal decomposition of ferric sulfate and aluminum sulfate in order to obtain additional information concerning the possible selective separation of these two compounds.[32] The rate of decomposition of ferric sulfate was found to

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[24] Peters, F. A., P. W. Johnson, and R. C. Kirby. Methods for Producing Alumina from Clay. An Evaluation of the Sulfurous Acid-Caustic Purification Process. BuMines Rept. of Inv. 5997, 1962, 21 pp.

Peters, F. A., P. W. Johnson, and R. C. Kirby. Methods for Producing Alumina from Clay. An Evaluation of Five Hydrochloric Acid Processes. BuMines Rept. of Inv. 6133, 1962, 68 pp.

[25] Glasser, J., and W. E. Few. Submerged-Arc Furnaces for Smelting Aluminum Ores. A Substitute for the Electrolytic Process? J. Metals, v. 14, No. 2, February 1962, pp. 126–128.

[26] Lundquist, R. V., and N. Chardoul. The Desilication of Caustic Leach Liquors Containing Alumina. BuMines Rept. of Inv. 6100, 1962, 18 pp.

[27] Blake, Henry E., Jr., and Robert K. Koch. Defluorination of Fluorspar: Preparation of Aluminum Fluoride from Siliceous Fluorspar. BuMines Rept. of Inv. 6031, 1962, 17 pp.

[28] Barany, R. Heats and Free Energies of Formation of Some Hydrated and Anhydrous Sodium and Calcium-Aluminum Silicates. BuMines Rept. of Inv. 5900, 1962, 17 pp.

[29] Bracewell, Smith. Bauxite, Alumina, and Aluminum. Overseas Geol. Surveys. Min. Res. Div. London, 1962, 235 pp.

[30] Shapiro, Leonard, and W. W. Brannock. Rapid Analysis of Silicate, Carbonate, and Phosphate Rocks. Geol. Survey Bull. 1144–A, 1962, 56 pp.

[31] Davey, P. T., and T. R. Scott. The Hydrolysis of Aluminum Sulphate Solutions at Elevated Temperatures. Australian J. of Appl. Science, v. 13, No. 4, December 1962, pp. 229–241.

[32] Warner, N. A., and T. R. Ingraham. Kinetic Studies of the Thermal Decomposition of Ferric Sulfate and Aluminum Sulfate. Canadian J. Chem. Eng., v. 40, No. 6, December 1962, pp. 263–267.

be much more rapid than that of aluminum sulfate, the greatest difference occurring at lower temperatures.

Further investigations were reported on the determination of the specific conductivity of several molten salt mixtures including aluminum chloride—lithium chloride and aluminum chloride—potassium chloride.[33] The tests indicated that salts with small cations, which tend to dipole formation, and thus to develop complex ions, exerted the strongest influence on the reduction of the conductivity value.

A method for producing aluminum nitride and several applications of the material in industry were described.[34] Aluminum nitride having a strictly stoichiometric ratio of components was obtained by heating aluminum powder in pure nitrogen at 800° C for 1 hour followed by renitriding at 1,200° C for ½ to 1 hour. Suggested uses included refractories, abrasives, metalloceramics, semiconductors, and heat-resisting materials. Aluminum nitride refractory ware was produced for use as containers in the synthesis of the semiconductor gallium arsenide.[35] Use of these containers practically eliminated contamination of the gallium arsenide by silicon.

New data pertaining to the mineralogy of bonded refractories containing alumina were released.[36] Special emphasis was placed upon high temperature mineralogy, upon the development of the liquid under the influence of heat, and upon reactions occurring in the solid state, because these were all factors that determined the utility of a refractory material in service.

Properties essential to the satisfactory behavior of alumina when incorporated in a ceramic body were described.[37] Methods of producing fully recrystallized alumina on a laboratory scale and the effect of various alumina properties on the characteristics of a body were discussed. Various final ceramic properties were shown to be dependent upon the physical properties of the alumina powder. Physical characteristics of high alumina ceramics which make them especially suitable for pump parts, grinding media, catalyst carriers, refractories, heat exchangers, and other applications were described.[38]

Detailed studies were made of the hydrogen atmosphere sintering of alumina powder containing magnesia.[39] Empirical equations were derived for the effect of the major process variables on the sintered density and grain size. Densification rate was dependent upon both the initial density and the sintering temperatures. The rate of grain growth was independent of the initial density.

The Bureau of Mines experimented with the use of alumina and depleted uranium catalysts for the purification of automobile ex-

[33] Grothe, H. Study of the Conductivity of Fused Salt Mixtures. Aluminium, Dueseldorf (West Germany). V. 38, No. 5, May 1962, pp. 320–322.
[34] Samsonov, G. V., and T. V. Dubovik. (Production of Aluminum Nitride and Its Possible Uses in Industry.) Non-ferrous Metals (Moscow), v. 35, No. 3, March 1962, pp. 56–61; Abs. in Light Metals Bull., v. 24, No. 12, June 6, 1962, p. 616.
[35] Long, G., and L. M. Foster. Aluminum Nitride Containers for the Synthesis of Gas. J. Electrochem Soc., v. 109, No. 12, December 1962, pp. 1176–1178.
[36] McDowell, J. Spotts, Robert K. Scott, and C. Burton Clark. The Mineral Composition of Refractory Materials. The Refractories J., No. 12, December 1962, pp. 438–456.
[37] Forshaw, I. P. Alumina for the Ceramic Industry. J. Canadian Ceram. Soc., v. 30, 1961, p. 98; Light Metals Bull., v. 24, No. 17, Aug. 15, 1962, p. 833.
[38] Industrial and Engineering Chemistry. Alumina Ceramics. V. 54, No. 12, December 1962, pp. 18–23.
[39] Bruch, C. A. Sintering Kinetics for the High Density Alumina Process. Ceram. Bull., v. 41, No. 12, December 1962, pp. 799–806.

haust.[40] Activated alumina spheres coated with uranium oxide (U_3O_8) and other oxides were tested and showed promise as exhaust deoxidants. The best catalyst tested thus far consisted of 3.5 percent uranium oxide and 1.5 percent chromium oxide on gamma alumina.

Alumina was produced in powder form consisting of colloidal fibrils which swell in water and dissolve to form a colloidal solution containing positively charged particles.[41] Studies indicated the material was useful as a noncombustible binder for inorganic fibers and pigments; protective and decorative coatings on metals, ceramics, and other surfaces; a polymer reinforcing agent; a thickening, emulsifying, and suspending agent in water-based systems; and a textile surface modifier effecting reduction in pilling, static, and soiling propensity.

Conditions conducive to growth of alumina whiskers were investigated and the characteristics of the resulting growths reported. Evidence of several distinct types of growth forms was found.[42]

The concept of using the extremely high strength of filamentary crystals (whiskers) of alumina for reinforcing metals was reviewed.[43] Calculations showed that reinforcing a columbium alloy (F-48) with 50 percent alumina (sapphire) whiskers could improve the strength to density ratio more than fourfold over a 3,000° F temperature range. The crux of using the full reinforcing potential of whiskers lay in the careful orientation, wetting, and bonding of the whiskers in the metal phase.

An account was given of the chemistry of the aluminum soaps, of their solutions in organic solvents, and of their use in the manufacture of a variety of commercial products.[44]

The dangers associated with the handling of aluminum alkyls and the means by which they can be handled safely were outlined.[45] Cardinal rules to be followed included (1) preventing uncontrolled escape of alkyls and contact with reactive materials, (2) shielding operators and equipment from potential leaks, sprays, or splashes, and (3) requiring personnel to wear full protective equipment whenever there was a possibility of exposure.

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[40] U.S. Atomic Energy Commission. Development of Depleted-Uranium Catalysts for Destruction of Air Pollutants in Automobile Exhaust. TID-8213, January 1963. 44 pp.

[41] Industrial and Engineering Chemistry. A Novel Fine Alumina Powder, Fibrillar Boehmite. V. 1, No. 3, September 1962, pp. 157-161.

[42] Lynch, C. T., F. W. Vahldick, and L. B. Robinson. Growth and Analysis of Alumina "Whiskers." Wright-Patterson AFB, Ohio., Tech. Documentary Rept. ASD-TDR-62-272, May 1962, 34 pp.

[43] Sutton, Willard H. Development of Composite Structural Materials for Space Vehicle Applications. J. American Rocket Society, v. 32, No. 4, April 1962, pp. 593-600.

[44] Pilpel, N. Aluminum Soaps. Research Appl. in Industry, London, v. 15, No. 9, September 1962, pp. 385-392.

[45] Heck, W. B., Jr., and R. L. Johnson. Aluminum Alkyls Safe Handling. Ind. and Eng. Chem., v. 54, No. 12, December 1962, pp. 35-38.

Berylllium

By Donald E. Eilertsen [1]

INTEREST in beryllium continued in 1962. U.S. production of cobbed beryl was 218 short tons, and other figures for beryl were as follows: U.S. consumption, 7,758 tons; U.S. imports, 8,552 tons; and world production, 8,200 tons. Researchers delved deeper into the technology of beryllium for a better understanding of the metal for many more possible applications in high-speed flight, nuclear energy, and industry.

LEGISLATION AND GOVERNMENT PROGRAMS

A total of 246 tons of cobbed domestic beryl was bought in 1962 under the Domestic Beryl Purchase Program (authorized in 1953. Public Law 206, 83d Cong.), and the cumulative total under the program rose to 3,276 tons. This program terminated June 30, 1962.

No beryl or beryllium-copper master alloy was acquired in 1962 for stockpiling under the Strategic and Critical Materials Stockpiling Act of 1946 (Public Law 520, 79th Cong.).

Under the Agricultural Trade Development and Assistance Act of 1954 (Public Law 480, 83d Cong.), the Department of Agriculture through the Commodity Credit Corporation (CCC) bartered surplus agricultural commodities with certain countries in exchange for strategic materials such as beryl, beryllium-copper master alloy, and beryllium for the supplemental stockpile. A total of 69 tons of beryllium was acquired under this program during 1962, and 81 additional tons remained on order for delivery in 1963. An equivalent 169 tons of beryl, 115.5 tons of which was beryllium-copper master alloy, was transferred from CCC stocks to the supplemental stockpile.

The Office of Minerals Exploration, U.S. Department of the Interior, offered financial assistance up to 50 percent of approved costs to explore for all types of beryllium ore. No new contract for beryllium exploration was made in 1962.

The U.S. Tariff Commission conducted tariff studies on beryllium and prepared a report for the U.S. Senate.[2]

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[1] Commodity specialist, Division of Minerals.

[2] U.S. Tariff Commission. Beryllium. Report to the Congress on Investigation No. 332-41 Under Section 332 of the Tariff Act of 1930 Made Pursuant to Senate Resolution 206, 87th Congress, Sept. 23, 1961. TC Pub. 66, August 1962, 72 pp.

TABLE 1.—Salient beryl statistics

	1953-57 (average)	1958	1959	1960	1961	1962
United States:						
Beryl, approximately 11 percent BeO unless otherwise stated:						
Domestic beryl shipped from mines....short tons..	577	463	328	244	317	218
Value, delivered....	$286,509	$238,017	$170,523	$121,105	(1)	(1)
Other domestic low-grade beryllium ore....short tons..	----	42	97	265	805	760
Value, delivered....	----	$5,000	$8,622	$41,250	(1)	(1)
Imports....short tons..	7,902	4,599	8,038	8,943	8,516	8,552
Consumption....do....	3,424	6,002	8,173	9,692	9,392	7,758
Price, approximate, per unit BeO, domestic, cobbed beryl, delivered....	$45	$47	$48	$46	(1)	(1)
Price, approximate, per unit BeO, domestic, low-grade beryllium ore, delivered....	----	$42	$20	$31	(1)	(1)
Price, approximate, per unit BeO, imported, cobbed beryl at port of exportation....	$36	$31	$27	$29	$30	$31
World: Production....short tons..	10,000	7,700	6,600	9,600	9,300	8,200

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

DOMESTIC PRODUCTION

Mine Production.—Cobbed beryl production was the lowest since 1948. Domestic production (mine shipments) of concentrate was from 60 operations and totaled 978 tons. This consisted of 218 tons of hand-sorted beryl averaging 11 percent BeO, and 760 tons of bertrandite and beryl material from Colorado containing 3.05 percent BeO.

Mineral Concentrates and Chemical Co., Inc., Loveland Colo., reported that it upgraded beryl-bertrandite-euclase ore containing about 3 percent BeO to concentrate containing 11.5 to 13.5 percent BeO in its mill near Lake George, Park County, Colo. Shipments of beryllium mineral concentrate went to its processing plant in Loveland, Colo., and also to Japan.

Refinery Production.—The Beryllium Corp. of Reading and Hazleton, Pa., and The Brush Beryllium Co. of Elmore, Ohio, were the only

TABLE 2.—Beryllium concentrates shipped from mines in the United States, by States

State	1961				1962			
	Cobbed beryl		Lower grade beryllium ore		Cobbed beryl		Lower grade beryllium ore	
	Short tons	Units BeO	Short tons	Units BeO	Short ton	Units BeO	Short tons	Units BeO
Colorado....	14	155	805	2,715	22	277	760	2,320
New Hampshire....	23	272	----	----	7	79	----	----
New Mexico....	24	249	----	----	34	380	----	----
South Dakota....	238	2,613	----	----	144	1,557	----	----
Other States [1]....	18	181	----	----	11	110	----	----
Total....	317	3,470	805	2,715	218	2,403	760	2,320

[1] 1961—Arizona, Connecticut, Maine, Wyoming and New York; and 1962—Same as for 1961 except not New York.

firms in the United States that processed beryl to beryllium metal, alloys, and compounds. Most of the output was beryllium metal and beryllium-copper alloys. Production data were company confidential and not available for publication.

The U.S. Atomic Energy Commission (AEC) reported that deliveries under the 5-year contracts, previously awarded by AEC to The Beryllium Corp. and The Brush Beryllium Co. for annual delivery of 37,500 pounds of nuclear-grade beryllium, were completed.

A total of 69 tons of beryllium was delivered to the Government for stockpiling through the CCC barter program.

CONSUMPTION AND USES

Cobbed beryl consumption was 7,758 tons, and nearly all of the beryl was imported and processed into beryllium metal and its alloys and compounds.

Sales of The Beryllium Corp. were $27.1 million, compared with $23.6 million in 1961. The Brush Beryllium Co. sales were $22.6 million, compared with $26 million in 1961.

Five other consumers of cobbed beryl were as follows: Beryl Ores Co., Arvada, Colo., which produced specialized beryl materials for the ceramic industry; Lapp Insulator Co., LeRoy, N.Y., which used ground beryl in making high-voltage electrical porcelain; the Ceramic Division, Champion Spark Plug Co., Detroit, Mich., which used beryl as a minor constituent in special ceramic compositions (primarily spark plugs); Thomas Works, Delta Star Electric Division, H. K. Porter Co., Lisbon, Ohio, which used beryl in glass for high-voltage suspension insulators; and Glass Coating Materials Division, A. O. Smith Corp., Milwaukee, Wis., which produced ground-coat frit (glass) for ceramics, discontinued the use of beryl.

Mineral Concentrates and Chemical Co., Inc., Loveland, Colo., consumed a small quantity of beryllium mineral concentrate containing about 10 percent BeO for production of various beryllium compounds.

In addition to stockpile and AEC acquisitions, substantial beryllium was utilized in special applications for aircraft, missiles, space exploration vehicles, and nuclear energy, and in research and development in these fields. Some outstanding uses were the large heat shield of the *Friendship 7* capsule that carried Lt. Col. John H. Glenn, Jr., three orbits around the earth, shingles on the outside of space capsule *Aurora 7* that Lt. Comdr. M. Scott Carpenter flew for three orbiting trips around the earth, the gold-plated beryllium antenna of the satellite *Telstar I*, and inertial guidance systems for high-speed flight and marine navigation. The Advanced Test Reactor under construction in Idaho, the Systems for Nuclear Auxiliary Power 8 Reactor under development, and France's research reactor Triton and test reactor Siloe were reported to have neutron reflectors of beryllium. Some other uses developed for beryllium included intricate plates for the Gemini space capsule, large extruded tubing for the project Saturn rocket program, and application in aircraft and automobile brakes, mirrors in airborne instruments and optical systems, and disks

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and drums in computers. Beryllium was also under consideration for rocket fuels.

Heat-treatable beryllium-copper alloys, outstanding for their high strength and high thermal and electrical conductivity, were widely used in many industries. Some new uses for the alloy included housings to protect undersea telephone systems, automobile starter springs, bucket wheels used in instruments to measure the velocity of water, and antennas for space vehicles and satellites. Space capsule *Sigma 7* manned by Comdr. Walter M. Shirra in his six orbits around the earth contained an antenna consisting of tightly wound beryllium-copper ribbon that ejected to form a tubing 16 feet long. The *Lofti* and *Traac* satellites have this type of antenna. Other antennas were designed to eject as much as 1,000 feet of 0.5-inch-diameter tube from the ribbon. Beryllium-copper also had many other uses, such as in business machines, air conditioning, refrigeration, electrical and communication equipment, resistance welding, and electronic circuitry.

Heat-treatable and high-strength beryllium-nickel alloys had many applications in industry. Some new uses reported for this material were dies for forming aluminum channels for glass doors, necks of glass bottles, and stainless steel dinnerware. It also was used for clarinet keys.

Beryllium was used as an alloying constituent to give processing and property improvement to light metals. Beryllium oxide was used in nuclear, thermal, and electronic applications and in research and development of new applications.

STOCKS

Consumer stocks of beryl at the end of the year totaled 5,452 tons not including brokers stocks of beryl. Stocks of beryllium metal and beryllium-copper were smaller than in 1961.

As of December 31, 1962, the national (strategic) stockpile contained the equivalent of 23,233 tons of beryl, 1,085.5 tons of which was beryllium-copper master alloy, the same as on December 31, 1961.

Additional government stocks of beryllium-bearing materials on hand at yearend were as follows: Supplemental stockpile, the equivalent of 11,321 tons of beryl, 6,312 tons of which was beryllium-copper master alloy; CCC stocks, 69 tons of beryllium metal; and Defense Production Act stocks, 2,088 tons of domestically produced beryl.

PRICES AND SPECIFICATIONS

The price quoted for domestically produced cobbed beryl containing 10 to 12 percent BeO was \$46 to \$48 per short ton unit (20 pounds) of BeO, f.o.b. mine, only until July 5. The price of imported cobbed beryl per short ton unit of BeO, based on 10 to 12 percent BeO, c.i.f. U.S. ports, was \$34 to \$34.50 on term contracts and \$32 to \$33 on spot contracts until September 6. Thereafter spot contracts were quoted at \$30 to \$32.[3] The General Services Administration bought domestically produced cobbed beryl at depots in Custer, S. Dak., Franklin,

[3] E&MJ Metal and Mineral Markets. V. 33, Nos. 1–52, January–December 1962.

N.H., and Spruce Pine, N.C., only until June 30. Purchases were made on the basis of a short ton unit of contained BeO, and prices per unit were as follows: 8 to 8.9 percent BeO, $40; 9 to 9.9 percent BeO, $45; and 10 percent BeO and over, $50.

The price of beryllium metal, 97 percent pure, lump or beads, f.o.b. Reading, Pa., and Cleveland, Ohio, was quoted at $62 per pound in 1,000- to 2,000-pound quantities. A blend of beryllium powder, 200-grade, was quoted at $54 per pound in quantities of 20,000 pounds. Vacuum-cast beryllium ingot was quoted at $67 to $71 per pound. Beryllium-copper master alloy was quoted f.o.b. Reading, Pa., Detroit, Mich., and Elmore, Ohio, at $43 per pound of contained beryllium with copper paid for at the market price on date of shipment. Beryllium-copper strip, rod, bar, and wire were quoted at $1.98 per pound until October 3 and afterwards at $2.01 per pound. Beryllium-aluminum was quoted at $65 per pound of contained beryllium with aluminum paid for at the market price. Beryllium-magnesium-aluminum was quoted at $60 per pound of contained beryllium with magnesium and aluminum paid for at the market price.[4]

The Beryllium Corp. quoted the following prices per pound of beryllia: Grade I, smaller than 1-micron size, $12.50; grade II, chunks $15; grade III, 80-micron size, $18; and grade V, minus 20-mesh size, $20, minus 100-mesh size, $23, and minus 200-mesh size $26.

FOREIGN TRADE[5]

Imports.—Imports of cobbed beryl in 1961–62 are shown in table 3. Other imports in 1962 were 19 pounds of beryllium oxide or carbonate, valued at $357, and probably some beryllium metal not separately reported from other commodities.

Exports.—A total of 1,030 pounds of beryllium ores and concentrates valued at $2,131 was exported to Argentina, Canada, and France. Exports of other beryllium products are shown in table 4. Separate data on beryllium-copper alloy exports were not available.

Tariff.—Beryllium ore and concentrate entered the United States free of duty. Ad valorem duties on various other beryllium-bearing materials were as follows: Beryllium metal, 21 percent until June 30 and thereafter 19 percent; beryllium-copper master alloy, 10.5 percent; beryllium oxide and carbonate, 12.5 percent until June 30 and thereafter 11 percent; other beryllium compounds, 10.5 percent; and semifabricated beryllium-bearing materials such as beryllium alloy rod and wire, 22.5 percent.

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[4] American Metal Market. V. 69, Nos. 1–249, January–December 1962.
[5] Figures on imports and exports compiled by May B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 3.—U.S. imports for consumption of beryl, by countries

(Short tons)

Country	1961	1962
South America:		
Argentina	1,117	997
Brazil	2,661	3,715
Total	3,778	4,712
Europe:		
Portugal		48
Sweden		26
Total		74
Asia:		
India	885	150
Japan		(1)
Total	885	150
Africa:		
British East Africa and Tanganyika [2] (principally Uganda)	1,029	1,043
British West Africa, n.e.c.		37
Congo, Republic of the, and Ruanda-Urundi	220	485
Malagasy Republic	564	293
Mozambique	1,094	678
Rhodesia and Nyasaland, Federation of	188	322
South Africa, Republic of [3] (includes South-West Africa)	445	519
Total	3,540	3,377
Oceania: Australia	313	239
Grand total: Short tons	8,516	8,552
Value	$2,785,894	$2,897,495

[1] Less than 1 ton.
[2] Effective Jan. 1, 1962; formerly British East Africa.
[3] Effective Jan. 1, 1962; formerly Union of South Africa.

Source: Bureau of the Census.

TABLE 4.—U.S. exports of beryllium products, in 1962, by countries

Destination	Beryllium and beryllium alloy (except beryllium copper) metal powders		Beryllium metal and alloys (except beryllium copper) in crude form and scrap		Beryllium and beryllium alloys in semifabricated forms, n.e.c.	
	Pounds	Value	Pounds	Value	Pounds	Value
Argentina					1	$600
Australia					1,051	42,508
Austria			220	$792		
Belgium-Luxembourg			88	308	8	996
Canada	319	$1,256	6,242	17,333	85	34,388
Finland	4	298				
France	298	14,180	348	9,039		
Germany, West	25	2,185	25,413	83,471	30	7,351
India			595	2,107		
Israel					5	1,234
Italy			7,707	29,639	1	700
Japan	134	869	966	3,033		
Netherlands			580	2,303		
Netherlands Antilles					2	264
Spain			504	1,704		
Switzerland			1,160	4,138	5	2,158
United Kingdom	480	23,286	16,425	52,655	29	9,845
Yugoslavia			220	766		
Total	1,260	42,074	60,468	207,288	1,217	100,044

Source: Bureau of the Census.

WORLD REVIEW

World production of beryl, totaling 8,200 tons, consisting of 7,440 tons of hand-sorted beryl containing approximately 11 percent BeO, and 760 tons of bertrandite-beryl material containing 3.05 percent BeO.

Argentina.—Beryl was a byproduct in mining for minerals such as quartz and feldspar. Producers were free to sell their beryl to the Government through Comite para la Comercializaction de Minerales (COCOMINE) or to others. However, a permit from the State Secretariat of Commerce (National Foreign Trade Bureau) was required for the export of beryl, beryllium metal, beryllium-copper master alloy, and beryllium compounds.

Canada.—The occurrence of barylite ($Be_2BaSi_2O_7$), when pure containing about 15.5 percent BeO or 5.6 percent beryllium, near Seal Lake, Labrador, was described.[6]

Mexico.—The occurrence of bertrandite in the Aguachile Mountain fluorite deposit at Coahuila was reported.[7]

Mozambique.—Monteminas Lda. and Empresa Mineira do Alto Ligonha were by far the largest producers of beryl in Mozambique in 1961. Other producers of beryl included Sociedade Mineira de Mutala, Lda., Sociedade Mineira de Melela, Lda., and Sociedade Mineira da Zambezia Lda. The Monteminas firm also produced some bismuth concentrate and a little columbite and tantalite. The Monteminas concession was near exhaustion and was expected to close early in 1962. Empresa Mineira also produced substantial lepidolite, some columbite, tantalite, and pollucite, and a little mica. This firm employed about 1,000 people in its mining operations (stripping to cobbing), and sometimes crystals of beryl smaller than 0.25 inch in diameter were recovered. Melela finished operations at its concession area southwest of Gile in 1961. The immediate outlook for beryl was toward a reduction in production to approximately 500 to 700 tons per year.[8]

Uganda.—Beryl production in 1961 was almost as large as it was for the preceding 9 years. Almost twice as much beryl was produced in the Ankole district as in the Kigezi district. The immediate outlook for continued high production of beryl appeared to be good.[9]

TECHNOLOGY

The Bureau of Mines continued its extensive studies of widespread potential domestic beryllium resources. It also conducted research on milling methods to concentrate disseminated beryl and other beryllium minerals from low-grade ores, methods to recover beryllium salts from various concentrates and ore, and methods for extracting, purify-

[6] Heinrich, E. Wm., and R. W. Deane. An Occurrence of Barylite Near Seal Lake, Labrador. Am. Mineral., v. 47, Nos. 5–6, May–June 1962, pp. 758–763.
Nickel, E. H., and D. J. Charette. Additional Data on Barylite From Seal Lake, Labrador. Am. Mineral., v. 47, Nos. 5–6, May–June 1962, pp. 764–768.
[7] Levinson, A. A. Beryllium-Fluorine Mineralization at Aguachile Mountain, Coahuila, Mexico. Am. Mineral., v. 47, Nos. 1–2, January–February 1962, pp. 67–74.
[8] U.S. Consul General, Johannesburg, Republic of South Africa. Minerals—Mozambique Industry in 1961. State Department Dispatch 290, Jan. 26, 1961, 20 pp.
[9] Ware, S. F. (Commissioner of Mines). Annual Report of The Mines Department, Uganda Protectorate. Apr. 7, 1962, 19 pp.

TABLE 5.—World production of beryl, by countries [1]

(Short tons)

Country	1953-57 (average)	1958	1959	1960	1961	1962
North America:						
United States (mine shipments):						
Cobbed beryl	577	463	328	244	317	218
Other lower grade beryllium ore		42	97	265	805	760
Total	577	505	425	509	1,122	978
South America:						
Argentina	1,236	1,004	645	739	[2] 660	[2] 660
Brazil	1,887	1,314	1,127	1,870	1,684	[2] 1,650
Total	3,123	2,318	1,772	2,609	2,344	[2] 2,310
Europe:						
Norway [3]		3	4			
Portugal	311	52	41	32	39	21
Sweden		28	[3] 41			[3] 26
U.S.S.R. [2]	110	330	390	440	500	550
Total [2]	420	410	480	470	540	600
Asia:						
Afghanistan	23			11		
India [3]	1,210	600		1,000	885	150
Korea, Republic of	[3] 3				6	
Total	1,236	600		1,011	891	150
Africa:						
Congo, Republic of the (formerly Belgian)	[4] 935	1,063	280	369	184	[3] 485
Kenya	1	4	2	1	1	
Malagasy Republic	390	181	474	701	836	[2] 800
Morocco	11					
Mozambique	1,011	1,161	1,559	1,649	698	441
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia	10	13	2	2		
Southern Rhodesia	999	333	440	539	396	559
Ruanda-Urundi	72	51	187	310	[2] 330	([5])
Somali Republic	[6] 12					
South Africa, Republic of	343	464	203	325	192	360
South-West Africa	493	247	170	413	252	159
Swaziland			2	6	7	
Uganda	84	86	235	470	1,136	[3] 1,043
Total	4,361	3,603	3,554	4,785	4,032	3,847
Oceania: Australia	267	278	355	213	343	[2] 265
World total (estimate) [1]	10,000	7,700	6,600	9,600	9,300	8,200

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[2] Estimate.
[3] U.S. imports.
[4] Average annual production 1954-57.
[5] Ruanda-Urandi included in Republic of the Congo in 1962.
[6] Average annual production 1955-57.

Compiled by Liela S. Price, Division of Foreign Activities.

ing, and casting beryllium. Exploration of mineral deposits in California and Nevada revealed the presence of narrow stringers of low-grade beryl.[10]

The chemical, mineralogical, and physical properties of Spor Mountain, Utah, tuff containing a hydrated form of bertrandite and

[10] Benson, W. T. Inyo Beryl Deposit, Inyo County, Calif. BuMines Rept. of Inv. 6013, 1962, 8 pp.
Hall, Robert. Sampling of Lynch Creek Beryllium-Tungsten Prospect, Lander County, Nev. BuMines Rept. of Inv. 6118, 1962, 10 pp.

a berylliferous saponite were described.[11] Preferential staining techniques were developed for identifying particles of beryl in mineral samples.[12] Spectrochemical procedures were developed to determine 0.0015 to 4 percent beryllium in siliceous mineral beneficiation products.[13] Other spectrochemical methods were developed for determining 18 impurity elements in electrorefined beryllium and high-purity beryllium oxide.[14] The application of radioactive tracers in laboratory-scale beryllium research was described.[15] A flotation method to separate spodumene and beryl from the associated gangue minerals of pegmatites was patented.[16] Experiments on the extraction of beryllium from sulfate leach liquors were reported.[17] Direct fluorination and carbide chlorination methods appeared to be promising for extracting beryllium from low-grade concentrate.[18] Studies on beryllium chloride concentration, operating temperatures, and cathode current density were made in connection with fused-salt electrorefining of beryllium.[19] Thermal expansion and phase inversion measurements were made on oxides of beryllium, calcium, titanium, zirconium, hafnium, and thorium by high-temperature X-ray diffractometry.[20]

New Hampshire pegmatites were estimated to contain 1,800 tons of beryl, mostly in scattered zones in the pegmatites and recoverable only as a byproduct in mining feldspar and mica.[21] Sporadic occurrence of beryl in the Hugo pegmatite near Keystone, S. Dak., was reported.[22] A map showing most of the known occurrences of beryllium in the United States was published.[23]

AEC continued to support basic work on beryllium purification and single crystal deformation. Applied work on beryllium, including fabrication of tubing and irradiation testing, was brought to a close. Studies on beryllia continued at a relatively high level with emphasis on its performance under neutron irradiation. Beryllides of both columbium and zirconium were studied with particular attention to intermediate-temperature oxidation problems.

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[11] Montoya, J. W., R. Havens, and D. W. Bridges. Beryllium-Bearing Tuff From Spor Mountain, Utah: Its Chemical, Mineralogical, and Physical Properties. BuMines Rept. of Inv. 6084, 1962, 15 pp.

[12] Ampian, Sarkis G. A Preferential Stain for Beryl. BuMines Rept. of Inv. 6016, 1962, 4 pp.

[13] Peterson, M. J., and J. B. Zink. Spectrochemical Determination of Beryllium in Mineral Beneficiation Products. BuMines Rept. of Inv. 6132, 1962, 19 pp.

[14] Lewis, R. W., C. F. Earl, J. L. Potter, and R. Fehler. Spectrochemical Analysis of High-Purity Beryllium. BuMines Rept. of Inv. 6108, 1962, 15 pp.

[15] Poston, Jr., A. M., J. V. Batty, and H. L. Gibbs. Use of Radioactive Tracers in Beryllium Extractive Metallurgy Research. BuMines Rept. of Inv. 5980, 1962, 10 pp.

[16] Browning, James S., and Ballard H. Clemmons (assigned to the U.S. Department of the Interior). Separation of Spodumene and Beryl by Flotation. U.S. Pat. 3,028,008, Apr. 3, 1962.

[17] Dannenberg, R. O., D. W. Bridges, and J. B. Rosenbaum. Solvent Extraction of Beryllium From Sulfate Solutions by Alkylphosphoric Acids. BuMines Rept. of Inv. 5941, 1962, 16 pp.

Riley, J. M. Experiments in Purifying Solutions From Lime-Sintered Beryl Concentrates. BuMines Rept. of Inv. 5963, 1962, 10 pp.

[18] May, Joan T., and C. L. Hoatson. Studies of Anhydrous Methods for Extracting Beryllium From Low-Grade Ores. BuMines Rept. of Inv. 6037, 1962, 19 p.

[19] Wong, M. M., R. E. Campbell, and D. H. Baker, Jr. Electrorefining Beryllium. Studies of Operating Variables. BuMines Rept. of Inv. 5959, 1962, 14 pp.

[20] Grain, Clark F., and William J. Campbell. Thermal Expansion and Phase Inversion of Six Refractory Oxides. BuMines Rept. of Inv. 5982, 1962, 21 pp.

[21] Page, J. J., and David M. Larrabee. The Beryl Resource of New Hampshire. Geol. Survey Prof. Paper 353, 1962, 49 pp.

[22] Norton, J. J., L. R. Page, and D. A. Brobst. Geology of the Hugo Pegmatite, Keystone, S. Dak. Geol. Survey Prof. Paper 297B, 1962, 127 pp.

[23] Griffitts, W. R., D. M. Larrabee, and J. J. Norton. Beryllium in the United States, Exclusive of Alaska and Hawaii. Geol. Survey Miner. Inv. Res. Map MR-35, 1962, 4 pp.

The Armed Forces, particularly the Air Force, and industry sponsored numerous other research projects on beryllium to further develop the technology of the metal for applications that emphasize defense. Research reports on subjects such as beryllium refining, purification, alloy development, and fabrication for 1958–60 were summarized.[24] A report on the toxicity of beryllium was prepared as a review and guide for use in working with beryllium.[25]

A process for recovering beryllium from high-calcium-bearing acid leach solutions was patented.[26] Methods were patented for producing high-purity and very dense sintered beryllia by sintering a mixture of $Be(OH)_2$ and anions of mineral acid in the form of a beryllium salt.[27] Procedures for producing dense sintered compacts of beryllia by special heat treatment of cold compacted high-purity beryllia were patented.[28]

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[24] Hodge, Webster. Beryllium for Structural Applications, A Review of the Unclassified Literature 1958–1960. Office of Tech. Services, U.S. Dept. of Commerce, May 18, 1962, 204 pp.; ASTIA, AD 278723.

[25] The Kettering Laboratory (Univ. of Cincinnati, Cincinnati, Ohio). Toxicity of Beryllium. Final Tech. Eng. Rept. Sponsored by the U.S. Air Force. Office of Tech. Services, U.S. Dept. of Commerce, April 1962, 66 pp.; ASTIA, AD 276640.

[26] Mod, William A., and Charles W. Becker (assigned to The Dow Chemical Co., Midland, Mich.). Recovery of Beryllium From Acid Leach Solutions. U.S. Pat. 3,059,998, Oct. 23, 1962.

[27] Pruvot, Emile, Paul Baradez, and Roger Pointud (assigned to Commissariat a l'Energie Atomique, Paris). Methods of Obtaining Sintered Beryllium Oxide. U.S. Pat 3,057,684, Oct. 9, 1962.

[28] Murray, Peter, and David Thomas Livey (assigned to United Kingdom Atomic Energy Authority, London). Production of Sintered Compacts of Beryllia. U.S. Pat. 3,025,137, Mar. 13, 1962.

Bismuth

By Richard N. Spencer [1] and Edith E. den Hartog [2]

PRODUCTION, imports, industrial consumption, and stocks of refined bismuth all increased in 1962. Bismuth acquired by barter for the Government supplemental stockpile was 1,009,408 pounds, and 500,000 pounds was on order December 31.

World production during 1962 was estimated at 7 million pounds, 32 percent higher than that during 1961. Market price of bismuth, quoted in New York, remained unchanged throughout the year at $2.25 per pound, in ton lots.

TABLE 1.—Salient bismuth statistics

(Pounds)

	1953-57 (average)	1958	1959	1960	1961	1962
United States:						
Consumption	1,536,600	1,242,700	1,598,000	1,527,300	1,478,400	1,909,500
Imports, general	729,454	637,309	457,163	1,167,019	798,518	816,190
Exports	182,804	316,318	179,744	156,636	167,166	118,056
Price: New York, ton lots	$2.25	$2.25	$2.25	$2.25	$2.25	$2.25
Stocks Dec. 31: Consumer and dealer	251,620	546,100	472,000	362,800	323,000	447,800
World: Production	4,600,000	4,600,000	5,100,000	5,200,000	5,300,000	7,000,000

DOMESTIC PRODUCTION

Refined bismuth, derived from foreign and domestic ores, was almost entirely a metallurgical byproduct of lead refining. Output increased 53 percent over that of 1961. Companies reporting production to the Bureau of Mines were American Smelting and Refining Company, The Anaconda Company, United States Smelting Lead Refinery, Inc. (subsidiary of United States Smelting, Refining and Mining Co.), and United Refining and Smelting Company. Bismuth recovered from secondary sources decreased slightly from 1961.

CONSUMPTION AND USES

Consumption of refined bismuth was 1.9 million pounds, 29 percent greater than in 1961. Bismuth consumption in low-melting alloys increased 16 percent, in other alloys it increased almost 100 percent, and in pharmaceuticals and chemical compounds it increased 24 per-

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[2] Statistical assistant, Division of Minerals.

cent. Bismuth alloys, including low-melting (fusible) alloys, those used to improve machinability of aluminum alloys, and those used in malleable irons and steels, accounted for 65 percent of total industrial consumption. Pharmaceuticals and laboratory and industrial chemicals and compounds consumed 34 percent, and experimental and miscellaneous accounted for the remaining 1 percent.

TABLE 2.—Bismuth metal consumed in the United States, by uses

(Pounds)

Use	1961	1962	Use	1961	1962
Fusible alloys	683,804	[1] 795,588	Experimental uses	9,742	5,212
Other alloys	222,241	442,040	Other uses	41,913	21,559
Pharmaceuticals [2]	520,723	645,149	Total	1,478,423	1,909,548

[1] Includes 159,188 pounds of bismuth contained in bismuth-lead bullion used directly in the production of an end product.
[2] Includes industrial and laboratory chemicals.

STOCKS

Consumption was substantially higher and imports increased only slightly, but domestic refinery production was sufficiently higher to cause an increase in consumer and dealer stocks from 323,000 to 448,000 pounds.

Bismuth in all Government stockpiles on December 31, 1962, was 3,835,000 pounds—and comprised 1,306,000 pounds in the national (strategic) stockpile, 23,000 pounds in the Defense Production Act (DPA) stockpile, 504,000 pounds in the Commodity Credit Corporation (CCC) stockpile, and 2,002,000 pounds in the supplemental stockpile. Total Government stockpiles were 128 percent of stockpile objectives.

PRICES

E&MJ Metal and Mineral Markets continued to quote the New York price for refined bismuth metal at $2.25 per pound, in ton lots, throughout 1962. The last price change occurred September 5, 1950, when it advanced to $2.25 a pound from $2. The Metal Bulletin (London) quotation also remained unchanged at $2.24 per pound. No ore quotation was given on the domestic market; Metal Bulletin (London) quoted ore at $1.19 per pound of contained bismuth with a minimum of 65 percent bismuth and at $0.71 per pound with a minimum of 30 percent bismuth. Ore of lower grades was quoted at proportionate unchanged prices. Quoted prices of all common chemicals and compounds of bismuth remained unchanged throughout the year.

FOREIGN TRADE [3]

General imports of refined bismuth were 816,200 pounds, an increase of only 2 percent over the quantity imported in 1961. Metal imports

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

were augmented by bismuth base-bullion, impure bismuth bars, intermediate bismuth-rich smelter products, bismuth-containing base-metal ores and concentrates, and bismuth chemicals. Nearly all bismuth base-bullion was used as a master alloy in the production of specific alloy compositions. Bismuth in intermediate smelter products, in impure bismuth bars, and bismuth in ores and concentrates was processed in refineries and entered the market as refined bismuth. Consumption statistics for 1962 included 159,200 pounds of bismuth imported in bismuth base-bullion used directly in the manufacture of alloys. It was estimated that a very large import of impure bismuth bars from Mexico furnished source material for a large part of domestic refinery production.

Exports of bismuth metal and alloys totaled 118,100 pounds (gross weight), a decrease of 29 percent from exports during 1961. Bismuth metal exports reported to the Bureau of Mines were 42,000 pounds, compared with 73,900 pounds during 1961.

TABLE 3.—U.S. imports[1] of metallic bismuth, by countries

(Pounds)

Country	1961	1962	Country	1961	1962
North America:			Europe:		
Canada	106,291	35,239	Belgium-Luxembourg	2,000	----------
Mexico	203,539	180,166	France	501	----------
			Netherlands	11,805	175
Total	309,830	215,405	United Kingdom	(2)	----------
South America: Peru	434,701	573,651	Yugoslavia	39,681	26,456
			Total	53,987	26,631
			Asia: Korea, Republic of	----------	503
			Grand total	798,518	816,190

[1] Data are general imports; that is, they include bismuth imported for immediate consumption plus material entering country under bond.
[2] Less than 1 pound.

Source: Bureau of the Census.

TABLE 4.—U.S. exports of bismuth metal and alloys

Year	Gross weight (pounds)	Value	Year	Gross weight (pounds)	Value
1953–57 (average)	182,804	$324,381	1960	156,636	$275,540
1958	316,318	389,078	1961	167,166	267,775
1959	179,744	261,367	1962	118,056	176,163

Source: Bureau of the Census.

WORLD REVIEW

World production of bismuth, about 7 million pounds, showed a substantial gain of 32 percent. Peru, United States, Mexico, Bolivia, Japan, Canada, Republic of Korea, and Yugoslavia were the major producers, in the order named.

Bolivia.—Production of bismuth increased 40 percent, despite a decline in the output of tin, the major metal of Bolivian ores containing bismuth.

Canada.—Production of bismuth recovered as a byproduct in refining silver, copper, and molybdenum, decreased 22 percent.

Korea, Republic of.—Bismuth was recovered as a byproduct of tungsten ore processing. A new bismuth refinery, near the principal producing Sangdong mine of Korea Tungsten Mining Co., was the sole producer. The bismuth plant at Yongdongpo closed in August 1961.

TABLE 5.—World production of bismuth, by countries [1] [2]

(Pounds)

Country [1]	1953-57 (average)	1958	1959	1960	1961	1962
North America:						
Canada (metal)[3]	249,548	412,792	334,736	423,827	478,118	375,345
Mexico [3]	896,084	417,800	527,600	599,400	[4] 2,345,700	[5] 736,400
South America:						
Argentina (in ore)[5]	20,110	[6] 59,000	[6] 114,600	[6] 350		
Bolivia [7]	103,715	244,700	487,400	403,700	465,300	652,500
Peru [3]	699,581	851,560	737,617	908,438	1,031,795	[6] 1,638,000
Europe:						
France (in ore)	92,800	112,400	101,400	112,400	116,800	[5] 116,800
Spain (metal)	79,870	116,229	53,168	29,875	21,427	[5] 22,000
Sweden [5]	119,500	110,000	66,000	79,000	79,000	[5] 154,000
Yugoslavia (metal)	230,650	169,670	200,026	231,582	216,348	199,765
Asia:						
China (in ore)	[5] 251,000	(8)	(8)	(8)	(8)	(8)
Japan (metal)	134,562	168,751	223,187	261,089	422,326	[5] 420,000
Korea, Republic of (in ore)	341,300	198,000	227,000	317,000	333,000	[5] 350,000
Africa:						
Mozambique	4,173	2,436	22,900	30,000	38,800	[5] 38,800
South Africa, Republic of (in ore)	683	2,023	527	511	168	130
South-West Africa (in ore)	1,186	680	530	310	485	155
Uganda	1,596	15,030	18,984	3,750	1,430	[5] 1,430
Oceania: Australia (in ore)	2,308	2,352	925	265	900	[5] 220
World total (estimate)[1] [2]	4,600,000	4,600,000	5,100,000	5,200,000	[4] 5,300,000	7,000,000

[1] U.S. figure withheld to avoid disclosing individual company confidential data; included in world total. Bismuth is believed to be produced in Brazil, East and West Germany, and U.S.S.R. Production figures are not available for these countries, but estimates are included in the world total.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Bismuth content of refined metal and bullion plus recoverable content of concentrates exported.
[4] Includes approximately 2,000,000 pounds of bismuth in impure bars which is excluded from the world total to avoid duplication.
[5] Estimate.
[6] Exports.
[7] Content in ore and bullion exported, excluding that in tin concentrates.
[8] Data not available; estimate included in world total.

Compiled by Catherine M. Judge, Division of Foreign Activities.

Mexico.—Refined bismuth metal was produced by Metalurgica Mexicana Penoles, S.A. Most of the output was exported, and the United States received the major portion. Bismuth recovered at facilities of American Smelting and Refining Company was exported as smelter and refinery intermediate products and impure bars. Most of these unfinished products were further refined in U.S. refineries.

Peru.—Cerro de Pasco Corp. was the sole producer of refined bismuth and bismuth base-bullion. Peruvian production increased 59 percent. Peruvian exported ores and concentrates of base metals were additional sources of bismuth that was recovered in importing countries. The United States was a major importer of Peruvian bismuth production of all classes.

Yugoslavia.—Bismuth was recovered as a byproduct of lead-zinc mine production at The Zvecan Lead Smelter & Refinery. Production decreased 8 percent from that of 1961. Although Yugoslavia had one of the few mines in the world in which bismuth is the principal metal of value, the mine was not operating in 1962.

TECHNOLOGY

A highly efficient process to recover bismuth from waste products of tungsten concentration was described in detail.[4]

Fundamental properties of bismuth and its compounds were investigated.[5]

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A new method was developed to add controlled amounts of bismuth and other trace elements to molten iron and other alloys.[6]

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Findings of research concerning heat contents and entropies of bismuth chloride were published.[8]

A metallagenic map showing the location of domestic bismuth occurrences, with an accompanying description of each occurrence was published.[9]

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[6] Bremer, Edwin. Adding Trace Elements. Foundry, v. 90, No. 4, April 1962, p. 115.

[7] Mayer, Ludwig J., Robert J. Rickett, and Heinrich F. Stenemann. (Assigned to General Mills Inc.), U.S. Pat. 3,063,866, Nov. 13, 1962.

[8] Walden, G. E., and Donald F. Smith. High-Temperature Heat Contents and Entropies of Bismuth Chloride and Cerous Chloride. BuMines Rept. of Inv. 5859, 1961, 4 pp.

[9] Cooper, John R. Bismuth in the United States. U.S. Geol. Survey Miner. Inv. Res. Map MR–22, 1962, map and 19 pp.

Boron

By Henry E. Stipp[1] and Victoria R. Schreck[2]

WORLDWIDE consumption of boron materials increased as a result of a resumption of industrial expansion. Exports of boron compounds also increased significantly.

TABLE 1.—Salient boron minerals and compounds statistics in the United States

	1953–57 (average)	1958	1959	1960	1961	1962
Sold or used by producers:						
Short tons:						
Gross weight [1]	622,673	528,209	619,946	640,591	602,613	646,613
Boron oxide	245,428	265,613	314,286	323,955	313,104	339,060
Value ..... thousands	$29,193	$38,310	$46,150	$47,550	$46,936	$49,336
Imports for consumption:						
Short tons	[2] 1,039	133	91	74	15	15
Value ..... thousands	$117	$155	$174	$202	$52	$51
Exports:						
Short tons	205,148	235,584	253,674	300,606	269,271	292,264
Value ..... thousands	$13,796	$18,292	$21,047	$25,576	$23,212	$24,736
Consumption, apparent: Short tons	418,564	292,758	366,363	340,059	333,357	354,364

[1] In 1953–54 gross weight reported included a higher proportion of crude ore to finished products than in 1955–62.
[2] Imports for 1957 include a higher proportion of crude ore to refined products.

DOMESTIC PRODUCTION

Boron minerals and compounds production (as measured by sales) increased 7 percent in quantity and 5 percent in value compared with that of 1961. Demand for U.S. boron products in the United States and Canada was strong. In Europe consumption slackened in the spring, but U.S. exports to Europe exceeded those of 1961.

Boron minerals and compounds were produced from the brine of Searles Lake by American Potash & Chemical Corp., Trona, Calif., and West End Chemical Division of Stauffer Chemical Co., Westend, Calif. Kern County Land Co. mined colemanite in Sigma and Kern Counties, Calif. Pacific Coast Borax Division of United States Borax & Chemical Corp. mined borax and kernite from a deposit in the Kramer district near Boron, Calif., colemanite in Corkscrew Canyon, Inyo County, and ulexite from a deposit near Shoshone, Calif.

Production of alloy steel ingots (other than stainless steel ingots) that contained boron totaled 279,710 short tons, compared with 297,434 tons in 1960.[3]

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.
[3] American Iron and Steel Institute. Annual Statistical Report. New York, 1961, p. 56.

The expansion of plant facilities of American Potash & Chemical Corp. at Trona, Calif., was completed in 1962. Capacity to manufacture boron products was increased by about 35 percent. Kern County Land Co. reportedly started producing 40 to 60 tons per day of borate material from a deposit in Death Valley near Ryan, Calif. U.S. Borax & Chemical Corp. was scheduled to build facilities for loading ocean vessels at Wilmington, Calif. Facilities were expected to be completed by mid-1963. Metal Hydrides, Inc., and Hooker Chemical Corp. agreed to coordinate research and development of sodium borohydride and to exchange information on uses. Hooker became exclusive sales representative for borohydride products used in the pulp and paper industry. The U.S. Air Force planned to sell its boron hydride processing plant at Model City, N.Y.

CONSUMPTION AND USES

Although the largest quantity of boron compounds was consumed in the glass and ceramic industries, boron materials had numerous other uses. Borates were used in both herbicides and plant foods. They were employed in tanning leather, photographic chemicals, soaps and detergents, fungus control, starch and adhesives, antifreeze, hydraulic fluid, insulation, fire-resistant and firefighting materials, drugs and cosmetics, electrolytic condensers, nuclear control material, nonferrous metal refining, processing and plating, brazing, soldering and welding, building materials and structural products, paints, timber preservatives, and steel manufacturing.

Other applications for boron compounds included the use of sodium borohydride to improve the brightness and color stability of bleached paper pulp. A high-purity gold-boron alloy was employed for doping silicon semiconductor devices. Boron-silicon materials were offered for plasma sprays to protect carbon and metals. Boron trifluoride was used to catalyze the reaction between epoxidized soybean and linseed oils and polyoxyethylene glycols to yield a nonionic detergent. Alkylated ammonium borohydrides were suggested for use as detergents in motor fuels, lubricants, and fuel oil, as combustion control agents in fuels, for scavenging of carbonyls and peroxides from hydrocarbons, as antioxidants for ethers, plastics, elastomers, soaps, and unsaturated hydrocarbons. Boron heterocyclic compounds were being tested for diuretic activity in laboratory animals. Titanium boride electrodes were tested for use in aluminum production. A boron-tungsten epoxy resin was to be used in structures and reinforcements for missiles and in other aerospace applications. Styreneboronic acids were suggested for use as herbicides.

PRICES

Prices for borax and boric acid were steady throughout 1962. Shipping costs of borate materials decreased $9.30 per ton (boxcars of 50 tons or more and hopper cars of 60 tons or more) on October 25 for shipments to the Midwestern, Eastern, and Southeastern United States.

Compound:	January 1–December 31 (per ton)
Borax, technical:	
Anhydrous, 99.5 percent:	
Bags, carlots, works	$92.00
Bulk, carlots, works	83.00
Granular, decahydrate 99.5 percent:	
Bags, carlots, works	50.00
Bulk, carlots, works	43.50
Granular, pentahydrate 99.5 percent:	
Bags, carlots, works	64.50
Bulk, carlots, works	58.00
Powder, 99.5 percent: Bags, carlots, works	54.00
Boric acid, technical:	
Anhydrous, 99.9 percent; Bags, carlots, works	335.00
Crystals, 99.9 percent:	
Bags, carlots, works	163.50
Drums, carlots, works	188.50
Granular 99.9 percent:	
Bags, carlots, works	112.00
Drums, carlots, works	137.00
Bulk, carlots, works	106.00

Boric acid, U.S.P., in bags, $25 per ton higher than technical.

FOREIGN TRADE[4]

Imports of ferroboron from West Germany totaled 20,230 pounds valued at $16,032, compared with 17,239 pounds valued at $14,190 in 1961. Boron carbide, imported from Canada and West Germany, totaled 9,124 pounds valued at $33,601, compared with 11,992 pounds valued at $37,361 in 1961. Boric acid and anhydride imported from the United Kingdom amounted to 9 pounds valued at $1,495, compared with 7 pounds valued at $509 in 1961. Boron, barium, strontium, thorium, and vanadium metal imports were 7,787 pounds valued at $86,971 for the first 6 months of 1962. There were no imports of borate of soda or of lime or of other crude and unrefined borate material. No refined borate or borax was imported.

Boric acid, borates, and other boron compounds exported from the United States increased 9 percent in quantity and 7 percent in value over exports in 1961. Exports constituted approximately 45 percent of the U.S. production. A resumption in the trend of the industrial expansion, that was responsible for the high exports of 1960, was reported to be the reason for increased consumption of boron products.

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

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TABLE 2.—U.S. exports of boric acid, borates, and compounds,[1] by countries

Destination	1961		1962	
	Short tons	Value	Short tons	Value
North America:				
Canada	15,296	$1,764,152	16,344	$1,875,163
Costa Rica	373	33,136	361	30,705
Dominican Republic	26	3,094	122	13,557
Mexico	5,625	556,295	5,690	555,674
Nicaragua	22	6,040	14	4,792
Other	83	11,488	88	11,066
Total	21,425	2,374,205	22,619	2,490,957
South America:				
Argentina	273	22,153	10	1,182
Brazil	5,507	499,150	6,203	576,890
Colombia	723	69,451	849	86,070
Peru	479	40,360	324	27,561
Uruguay	185	20,840	255	27,614
Venezula	232	30,194	254	33,800
Other	93	7,842	22	2,461
Total	7,492	689,990	7,917	755,578
Europe:				
Austria	2,602	141,582	4,453	237,910
Belgium-Luxembourg	4,722	465,109	4,910	481,933
Denmark	1,095	84,707	733	64,465
Finland	2,064	175,394	1,688	154,869
France	29,470	2,407,901	34,975	2,797,882
Germany, West	52,092	3,731,511	56,363	4,053,173
Greece	133	8,389	253	14,613
Ireland	1,163	78,564	1,259	83,014
Italy	7,753	627,805	9,597	763,155
Netherlands	17,722	1,730,363	16,303	1,431,681
Norway	2,836	241,335	2,760	234,044
Portugal	556	48,413	756	60,312
Spain	2,886	128,442	6,502	297,951
Sweden	3,776	343,756	4,061	350,722
Switzerland	2,770	262,130	3,525	312,024
United Kingdom	46,358	3,912,046	46,227	3,908,502
Yugoslavia	1,134	114,721	3,082	308,882
Other	64	5,711	44	3,884
Total	179,196	14,507,879	197,491	15,559,016
Asia:				
Ceylon	576	$40,572	272	$18,749
Hong Kong	3,983	354,651	3,900	346,602
India	7,961	660,859	5,465	427,414
Indonesia	784	55,605	176	13,957
Iran	195	15,423	189	14,130
Israel	506	46,465	841	78,561
Japan	27,282	2,455,072	30,415	2,793,043
Korea, Republic of	345	29,584	1,062	85,512
Malaya, Federation of	96	7,354	162	14,505
Pakistan	612	65,896	942	73,166
Philippines	389	37,111	908	73,138
Singapore	143	12,446	159	11,359
Syrian Arab Republic	45	3,635	33	3,350
Taiwan	682	47,182	1,295	85,086
Thailand	660	65,372	805	74,879
Viet-Nam	855	57,643	296	31,088
Other	40	2,897	68	4,682
Total	45,154	3,957,767	46,988	4,149,221
Africa:				
Rhodesia and Nyasaland, Federation of	275	26,553	227	18,666
South Africa, Republic of[2]	2,227	238,456	2,688	293,325
Spanish Africa, n.e.c.	356	43,507	10	1,282
United Arab Republic (Egypt)	673	86,016	208	24,121
Other	137	12,828	345	36,262
Total	3,668	407,360	3,478	373,656
Oceania:				
Australia	8,146	806,176	9,598	953,883
New Zealand	4,190	468,883	4,173	453,900
Total	12,336	1,275,059	13,771	1,407,783
Grand total	269,271	23,212,260	292,264	24,736,211

[1] Classified by the Bureau of the Census as boric acid and borates, crude, refined, and compounds (including borate esters and other boron compounds) not elsewhere classified.

[2] Effective Jan. 1, 1962; formerly Union of South Africa.

Source: Bureau of the Census.

WORLD REVIEW

SOUTH AMERICA

Chile.—Borax Consolidated, Ltd., produced 6,345 short tons of ulexite (33 percent boron oxide, B_2O_3) in 1959 and lowered its output to 3,218 tons in 1960.[5] The mines were closed during 1961 owing to high stocks, but were to be reopened in 1962. Local sales totaled less than 3,307 tons, owing to a recession in the glass and ceramic industries. Anglo-Lautaro Nitrate Co. boric acid plant, which has a capacity of about 5,511 tons a year, was expected to produce 4,400 tons in 1962. Quimica Sud Americana and Cristalerias de Chile reportedly had an annual capacity of 2,646 tons of borax and 440 tons of boric acid, respectively. Empresa Nacional de Mineria (formerly Caja de Credito y Fomento Minero) had no output from its 110-ton-per-year boric acid plant at Antofagasta.

EUROPE

Austria.—Imports of boric acid were to be liberalized beginning January 1, 1963, under the General Agreement on Tariffs and Trade.[6]

France.—The new plant of Seurobor at Pierre Benite, Department of the Rhone, began producing in March.[7] Output was expected to total 12,000 tons of boric acid per year.

Germany, West.—Farbenfabriken Bayer A. G., Leverkusen, was completing an 80,000-pound-per-year plant to manufacture sodium borohydride.[8] The process consisted of reacting borax, quartz, and sodium at 3 atmospheres pressure and 450° to 500° C and extracting sodium borohydride with aqueous ammonia.

Italy.—The Larderello S.p.A. of Pisa, a state-controlled firm, was expected to complete plant expansion for doubling the firm's capacity to produce boron compounds, using domestic and imported Turkish ores.[9] Montecatini, Soc. Generale per l'Industria Mineraria e Chimica, and Philipp Brothers Corp. of the United States signed an agreement to establish a plant to produce boron products and market them.[10] The plant, which was scheduled to begin production in 1964, was being constructed at Ville Delle Nighere near Trieste. The plant reportedly will have an annual production capacity of 100,000 tons of boron compounds.

Netherlands.—A depot for unloading and storing boron materials from oceangoing vessels was being constructed near Rotterdam.[11] The facilities were expected to be completed by late 1963.

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[5] Bureau of Mines. Mineral Trade Notes. V. 55, No. 3, September 1962, p. 9.
[6] Chemical Age (London). V. 88, No. 2263, Nov. 24, 1962, p. 809.
[7] Chemical Age (London). New French Boric Acid Plant Comes on Stream. V. 87, No. 2233, Apr. 28, 1962, p. 686.
[8] Chemical Engineering. Inventory of New Processes and Technology. V. 69, No. 2, Jan. 22, 1962, pp. 131–138.
[9] Chemical Trade Journal and Chemical Engineer (London). Boron Compounds in Italy. V. 151, No. 3931, Oct. 5, 1962, p. 693.
[10] Mining Journal (London). V. 258, No. 6597, Jan. 26, 1962, p. 97.
Chemical Age (London). Boron Derivatives Plant for Montecatini. V. 88, No. 2261, Nov. 10, 1962, p. 728.
[11] Chemical Trade Journal and Chemical Engineer (London). V. 151, No. 3926, Aug. 31, 1962, p. 425.

Turkey.—Production of boron minerals increased to 125,596 tons compared with 71,678 tons (revised) in 1961.[12] Exports reached a new high of 97,531 tons valued at US$2,718,977 compared with 70,900 short tons (revised) in 1961.

United Kingdom.—Prices of technical and pharmaceutical grades of boric acid were reduced February 26.[13] Ton lots of technical-grade boric acid in paper bags were, granular—US$207.78, crystal—US$235.86, and powder—US$228.83. Prices for refined boron decahydrate and pentahydrate were also reduced.[14] Technical-grade borax in paper bags was priced as follows for ton lots: Granular—US$124.94 and powder—US$137.58. Purity requirements for technical-grade boric acid and boric oxide were published in British Standard 3476.[15]

ASIA

India.—Borax Ltd., Great Britain, and Dharamsi Mararji Chemicals, India, agreed to establish a factory near Bombay for the manufacture of boron products.[16]

TECHNOLOGY

Wightmanite, a new magnesium borate, was found at Crestmore, Calif.[17] It occurred as colorless, pseudohexagonal prisms in a dolomite-calcite rock. The mineral displayed two cleavages subtending an angle of 73° 30′. It contained 12.2 percent boron oxide (B_2O_3), and the formula was probably $9MgO \cdot B_2O_3 \cdot 8H_2O$.

The geography, geology, history, mining, and processing of boron minerals in southern California were described.[18]

The feasibility of well logging rocks containing elements with large cross sections for the capture of thermal neutrons was investigated.[19] The effect of disturbing elements on the determination of boron in rock strata containing water was also studied. The length of strata that contained boron and the sensitivity of the logging method were determined.

Boron compounds were recovered from calcium borate ore by leaching with a hot (83° C) aqueous solution of ammonia and carbon dioxide to form ammonium borate and calcium carbonate. The liquid was separated from solid calcium carbonate, and ammonium borate was separated from the liquor.[20]

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[12] Bureau of Mines. Mineral Trade Notes. V. 57, No. 2, August 1963, p. 10.
[13] Chemical Age (London). V. 87, No. 2225, Mar. 3, 1962, p. 354.
[14] Chemical Age (London). V. 87, No. 2226, Mar. 10, 1962, p. 396.
[15] Chemical Trade Journal and Chemical Engineer (London). V. 150, No. 3907, Apr. 20, 1962, p. 799.
[16] Chemical Trade Journal and Chemical Engineer (London). V. 151, No. 3940, Dec. 7, 1962, p. 1171.
[17] Murdoch, Joseph. Wightmanite, A New Borate Mineral From Crestmore, California. Am. Miner., v 47, Nos. 5–6, May–June 1962, pp. 718–722.
[18] Ver Planck, William E. Mines and Mineral Resources of Kern County, California—Borates. California Div. of Mines and Geol., County Rept. 1, 1962, pp. 39–41, 61–68.
[19] Ivanova, V. F., and V. K. Christianov. (Neutron Logging in Exploration of Commercial Sources of Boron.) Geokhimiya (U.S.S.R.), No. 2, 1956, pp. 68–73; abs. in Tech. Transl. U.S. Dept. of Commerce, Office of Tech. Serv., v. 8, No. 9, Nov. 15, 1962, p. 883.
[20] May, Frank H., and Vladimir V. Levasheff (assigned to American Potash & Chemical Corp.). Recovery of Borate Values From Calcium Borate Ores. U.S. Pat. 3,018,163, Jan. 23, 1962.

Single crystals of rare-earth, aluminum, and chromium borates were grown from a molten solution.[21] A general chemical formula for the crystals was given as $RX_3(BO_3)_4$, where R represented yttrium or a rare-earth element and X represented aluminum or chromium. All crystals in this series of compounds were found to be piezoelectric.

Sodium-calcium borate was used extensively in 1955–56 to fight fires, principally in the Southwestern United States.[22] It was an effective fire retardant when wet or dry. The borate had poor water-holding properties.

An X-ray study of the phase relationships in the system cadmium oxide-boron oxide was described.[23] Crystals of cadmium diborate ($CdO \cdot 2B_2O_3$) were orthorhombic and had a density of 3.52±0.08 grams per cubic centimeter. Crystals of dicadmium borate ($2CdO \cdot B_2O_3$) were triclinic and had a density of 5.24 grams per cubic centimeter.

Crystals of α and β forms of boron oxide were produced, using high-pressure techniques.[24] A phase diagram for liquid and crystalline boron oxide was prepared up to 1,100° C and 90,000 atmospheres. Infrared adsorption studies of boron oxide gave preliminary results. Viscosity, electric conductance, and density studies of liquid boron oxide were reported. Nuclear magnetic resonance absorption, infrared absorption, viscosity of binary borates, and single-crystal X-ray diffraction studies were also reviewed.

Synthesis of ternary compounds from calcium, carbon, and boron produced a compound of the composition calcium borocarbide (CaC_2B).[25] Polymeric substances containing CH_2 and CH groups were formed by acid treatment of the products from the calcium and boron oxide reduction with carbon. Barium or strontium borocarbide (BaC_2B, SrC_2B) was formed when barium or strontium was sintered with boron and carbon.

Data obtained on the alumina-boron oxide system enabled refinements to be made on a phase-equilibrium diagram.[26] Configuration of the liquidus was shown. Areas of flattening represented liquid immiscibility or compound formation. Phase compatibilities at 1,300° C in the silicon-boron-oxygen system were studied.

High-pressure forms of boron phosphate and boron arsenate were prepared and studied by powder X-ray crystallography.[27] Studies showed that the unit cells of these forms were analogous to quartz,

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[21] Ballman, A. A. A New Series of Synthetic Borates Isostructural With the Carbonate Mineral Huntite. Am. Miner., v. 47, Nos. 11–12, November–December 1962, pp. 1380–1383.

[22] Chemical & Engineering News. Fire-Fighting Chemicals List Grows. V. 40, No. 51, Dec. 17, 1962, pp. 57–58, 61.

[23] Hand, W. D., and J. Krogh-moe. New Data on the System CdO B_2O_3. J. Am. Ceram. Soc., v. 45, No. 4, April 1962, p. 197.

[24] MacKenzie, J. D. Structure of Vitreous and Liquid Boron Trioxide and Some Simple Borates. Gen. Elec. Res. Lab., Schenectady, N.Y., September 1962, 18 pp.; ASTIA, ARL 73.

[25] Markovskii, L. Ya., and N. V. Vekshina. (Ternary Compounds in the System Alkaline-Earth Metal-Boron-Carbon.) J. Appl. Chem. (U.S.S.R.), v. 34, No. 2, February 1961, pp. 242–248.

[26] Gielisse, P. J., T. J. Rockett, and W. R. Foster. Research on Phase Equilibria Between Boron Oxides and Refractory Oxides, Including Silicon and Aluminum Oxides. Ohio State Univ. Res. Foundation, Apr. 1–June 30, 1961, 11 pp.; ASTIA, AD 262575.

[27] Dachille, Frank, and L. S. Dent Glasser. High Pressure Forms of BPO_4 and $BAsO_4$; Quartz Analogues. Pennsylvania State Univ., contribution 58–86, June 28, 1961, pp. 1–4; ASTIA, AD 260917.

except that the length of the C-axis was doubled. The crystals were described as having trigonal symmetry and a threefold screw axis parallel to C.

Boron oxide properties indicated that it could be a useful boundary lubricant at temperatures of 70° to 1,800° F.[28] A plot of the friction-temperature curve of boron oxide indicated that a peak in the curve occurred near its softening point. Friction diminished rapidly with temperature as the oxide became less viscous. A point was reached at which boron oxide was not viscous enough to carry the load hydrodynamically. Then the boron oxide acted as a good boundary lubricant. Boron carbide also showed promise as a high-temperature lubricant.

Boron oxide was vaporized at 1,400° K and trapped in an inert gas matrix at 50° K.[29] Then the infrared spectrum was measured. Studies of the infrared spectrum resulted in a large change in the vibrational fundamentals and the thermodynamic properties of gaseous boron oxide.

The effect of boron on the physicomechanical properties of concrete and mortar prepared with alumina, magnesia, or portland cement binders was studied.[30] Addition of boron carbide up to 30 percent of the weight of the cement caused no deterioration in the strength of the concrete. To counteract the harmful effect of calcium diborate, up to 2 percent calcium chloride was added. It was considered inadvisable to use borax in concretes with silicate binders.

A method of preparing cements, which retain their strength up to 1,000° C, was developed.[31] From 0.5 to 3 percent of boron, in the form of boron oxide, was added to aluminous and portland clinkers during roasting, and 1 to 7 percent boron was mixed into the fire clay. The clinker and fire clay were milled together.

A number of papers on boron and boron compounds, given at two American Chemical Society symposia, were published.[32] The following topics were covered: Preparation and structure of elemental boron, isotopic exchange in boron hydrides, structure and analysis of boranes by mass spectrometry, kinetics and equilibria of boron hydride reactions, boron hydride oxidation, infrared spectroscopy techniques applied to structure of boron compounds, pyrolysis of diborane to decaborane, catalytic conversion of diborane to higher boron hydrides, formation and properties of sodium borohydrides, salts of boron hydrides, structures of ammoniated boron hydrogen compounds ($NH_3B_3H_7$) and [$(NH_3)_2BH_2Cl$], reactions of triphenylboroxine, tri-

[28] Rabinowicz, Ernest, and Imai Masaya. Friction and Wear at Elevated Temperatures. Wright-Patterson AFB, Ohio, WADC Tech. Rept. 59-603, pt. 11, May 1961, 26 pp.; ASTIA, AD 266717.

[29] Weltner, W., Jr., and J. R. W. Warn. Matrix Isolation of High Temperature Vapors: Boric Oxide and Carbon. Union Carbide Res. Inst., January 1962, 50 pp.; ASTIA, AD 272313.

[30] Arshinov, I. A. (The Influence of Chemical Additions on the Physicomechanical Properties of Heavy Concretes). Trudy Nauchno-Issledovatel'skogo Instituta Betona i Zhelezobetona Akademii Stroitel'stva i Arkhitecktury, No. 9, pp. 155–168; 1961. Abst. in: Referativnyy Zhurnal. Khimiya No. 9, 1962 (Abstracts resulting from the SOV/STEP Program under the sponsorships of the U.S. Air Force).

[31] Nekrasov, K. D. (New Developments in Research Into Heat-resistant Concrete and Its Uses). In: Stroitel'stvo Promyshchlennykh Pechei i Dymovykh Trub, pp. 16–24; Moskva, 1960; Abst. in: Referativnyy Zhurnal. Khimiya, No. 12, 1962 (Abstracts resulting from the SOV/STEP Program under the sponsorship of the U.S. Air Force).

[32] Wartik, Thomas. Borax to Boranes. Am. Chem. Soc., Advances In Chemistry Series No. 32, 1961, 244 pp.

o-chlorophenylboroxine, tri-o-tolylboroxine, and trimethoxryboroxine with chlorides, preparation of simple trialkylborane compounds, chemistry of borazine, and development of inorganic or semiinorganic polymers.

Several magnesium borides were studied in oxygen, nitrogen, and carbon atmospheres at high temperatures.[33] The magnesian boride MgB_{12} was the most resistant compound to oxidation in air, followed by MgB_6 and MgB_2. The role of MgB_{12} in preparing amorphous boron was investigated.

Platinum, ruthenium, and rhodium salts produced finely divided precipitates with aqueous sodium borohydride.[34] These precipitates in solution catalyzed the hydrolysis of the borohydride ion, rapidly yielding hydrogen. The materials were also active catalysts for olefin hydrogenations.

British Patent 905,204 was granted for preparing boric acid by reacting an aqueous solution of an alkali metal borate with a cation-exchange resin containing COOH groups.[35] The resin could be regenerated with an aqueous solution of a strong acid.

Boron suboxide (B_6O) was prepared in powder and solid forms.[36] A molecular mixture of boron oxide (B_2O_3) and boron was heated in a helium atmosphere for 1 hour at 1,500° C to yield B_6O and unreacted boron. The chemical and physical properties of the compound were reviewed.

Thermodynamic values of the molecules $(BOF)_3$ and BOF were reported.[37]

Two transparent curing agents that contained boron were developed for use with epoxy resins.[38] One agent, a mixture of tricresyl borates, reacted rapidly and exothermically with epoxidized cyclic polyolefins, epoxidized linear polyolefins, and epoxidized glycerides. The other compound, 2-(β-dimethylaminoethoxy)-4-methyl-1,3,2-dioxaborinane, was a slower acting, controllable, extended-life agent for use in castings, glass fiber cloth, and glass fiber windings. Several boron compounds were studied as curing agents for epoxy resins.[39] Some of the resins cured with boron compounds had useful physical properties. A boroxine-amine complex showed promise as a homogeneous, latent curing agent. Materials that had heat- and radiation-resistant properties were prepared by dispersing boron or lead compounds in epoxy, polyurethane, and silicone binders.[40]

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[33] Markovskii, L. Ya., and G. V. Kaputovskaya. (Certain Chemical Properties of Magnesium Borides and Their Role in the Production of Elemental Boron by Reduction With Magnesium.) J. Appl. Chem. (U.S.S.R.), v. 35, No. 4, April 1962, pp. 703–708.

[34] Chemical & Engineering News. Borohydrides Assume New Catalytic Role. V. 40, No. 22, May 28, 1962, pp. 49–50.

[35] Chemical Trade Journal and Chemical Engineer (London). Recent Patent Abstracts. V. 151, No. 3938, Nov. 23, 1962. p. 1085.

[36] Rizzo, H. F., W. C. Simmons, and H. O. Bielstein. The Existence and Formation of the Solid B_6O. J. Electrochem. Soc., v. 109, No. 11, November 1962, pp. 1079–1082.

[37] Rocket Power, Inc. Thermodynamics of Reactions Involving Light Metal Oxides and Propellant Gases. QR–1987–5, Pasadena, Calif., May 9–Aug. 9, 1961, 12 pp.; ASTIA, AD 263347.

[38] Chemical & Engineering News. New Epoxy Curing Agents Contain Boron. V. 40, No. 45, Nov. 5, 1962, pp. 46–47.

[39] Haworth, Daniel T., and Gilbert F. Pollnow. Boron Curing Agents for Epoxy Resins. Ind. and Eng. Chem., Proc. Res. and Devel., v. 1, No. 3, September 1962, pp. 185–187.

[40] Missiles and Rockets. Sprayable Material Resists Radiation. V. 11, No. 14, Oct. 1, 1962, p. 23.

The hydrolysis of manganese, iron, nickel, cobalt, and chromium borides in acids was investigated.[41] Hydrogen borides and hydrogen were evolved during hydrolysis of metal borides. The yield of hydrogen borides and the rate of boride decomposition decreased with an increase in the percentage of boron in the boride. The increase of the boron-to-boron bond strength was considered to be responsible.

Iron and cobalt borides and ternary alloys of boron with iron, cobalt, nickel, and manganese were prepared, and their magnetic properties studied.[42]

Tantalum crucibles coated with tantalum monoboride and ditantalum monoboride were examined as containers of molten uranium and calcium.[43] Boride coatings increased the life of the crucibles; however, the coatings were damaged by thermal cycling and chemical attack.

The chloride-diborohydride of gadolinium, terbium, dysprosium, erbium, and ytterbium was isolated by reacting rare-earth chlorides with lithium borohydride.[44]

A boron, titanium, and nitrogen material resisted the corrosive attack of molten aluminum.[45]

Thorium tetraboride and the diborides of zirconium, titanium, columbium, tantalum, and hafnium were reported to have properties that made them desirable as structural materials.[46] Mixed borides of ternary and higher systems had more promise in this field than binary borides. Borides appeared to be the only materials that could support substantial loads for extended periods under oxidizing conditions at 1,600° to 2,200° C. Zirconium diboride, modified by 10 percent molybdenum disilicide, had outstanding oxidation resistance in air at temperatures up to 3,600° F.[47] An adherent, self-healing film, composed of zirconium oxide and silica, provided refractoriness and self-healing properties. The material could be formed in many shapes by hot-pressing techniques. A zirconium diboride mixture with 5 to 15 molar percent molybdenum disilicide offered good resistance to oxidation in air at 1,950° C, good high-temperature strength and thermal shock resistance, and excellent electrical conductivity.[48] The mixture had promising potential as a coating for other materials.

A hydrocarbon compound that contained boron and phosphorus was patented.[49] The compound was used as an additive to tetraethyl lead for use in gasoline.

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[41] Markovskii, L. Ya., and E. T. Bezruk. (Chemical Stability of the Borides of Certain Transition Metals.) J. Appl. Chem. (U.S.S.R.), v. 35, No. 3, March 1962, pp. 491–498.

[42] Farrer, M. R. Laboratorie de ferromagnetisme. Institut de physique (Strasbourg, France), Final Tech. Rept. 3, Jan. 1, 1961 to Dec. 31, 1962, 12 pp.; ASTIA, AD 272635.

[43] Jenkins, I. L., and N. J. Keen. The Use of Tantalum Borides for the Containment of Molten Uranium and Calcium. J. Less-Common Metals (Amsterdam, Netherlands), v. 4, No. 4, August 1962, pp. 387–389.

[44] Battelle Technical Review. V. 11, No. 1, January 1962, p. 8a.

[45] Industrial Research Newsletter. October 1962, p. 2.

[46] Latva, John D. Selection and Fabrication of Ceramics and Intermetallics. Metal Prog., v. 82, No. 4, October 1962, pp. 139–144, 180, 186.

[47] The Carborundum Company (Niagara Falls, N.Y.). (Advanced Materials Technology. Winter 1963, p. 4.

[48] Shaffer, Peter T. B. An Oxidation Resistant Boride Composition. Am. Ceram. Soc. Bull., v. 41, No. 2, Feb. 15, 1962, p. 96–99.

[49] Fay, Philip S., Everett C. Hughes, and Chien-Wei Liao (assigned to The Standard Oil Co., Cleveland, Ohio). Novel Boron-Phosphorus Containing Compounds and Gasolines Containing the Same. U.S. Pat 3,031,280, Apr. 24, 1962.

The use of borides of the transition elements for cathodes in aluminum reduction cells was discussed.[50] The superior electrical properties of the borides made feasible new designs in cell construction. Methods were described for preparing these borides.

Zirconium boride was produced by reacting a mixture of zircon, carbon, and boric oxide in stoichiometric quantities and reacting in an arc furnace to form zirconium boride.[51]

Information was presented on the thermodynamic properties of tantalum and tungsten borides.[52] Ternary phase diagrams were prepared for the tantalum-zirconium-boron system and the tungsten-zirconium-boron system at 1,500° C.

The spalling resistance of nickel-chromium base alloys increased sharply when small amounts of boron were added. Alloys containing 0.01 to 0.5 percent boron had eutectic formations of boride phases situated along the grain boundaries.[53] A method was developed for electrolytic separation of boride phases from nickel-chromium base alloys. Some alloys revealed chromium boride with tetragonal structure corresponding to the formula $(Cr,Ni)_4B_3$ or $(Cr,Ni)_5B_4$. Borides with the approximate formula $(MO,Cr,W,Ni)_4B_5$ or $(MO,Cr,W,Ni)_5B_4$ were prepared.

Borides were reported to surpass carbides in hardness and corrosion resistance. They had comparatively low density and were good conductors of heat and electricity.[54] The systems TiB_2–CrB_2, TiB_2–W_2B_5, and ZrB_2–CrB_2 were studied for their properties and uses. The phase composition and structure of the diffusion products were investigated as well as the phase microhardness, corrosion resistance, and structure of various compositions. Combinations of TiB_2–CrB_2 and ZrB_2–CrB_2 had high corrosion resistance. Chromium diboride was the least expensive of the refractory hard borides. The TiB_2–W_2B_5 system was found to be analogous to the carbide system TiC–WC.

The phase composition of alloys in the nickel-chromium-boron system was studied.[55] The boride phase was separated electrochemically, and the precipitate was studied by chemical and X-ray analysis.

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[50] Ransley, C. E. Refractory Carbides and Borides for Aluminum Reduction Cells. J. Metals, v. 14, No. 2, February 1962, pp. 129–135.

[51] McMullen, John C., and William D. McKee, Jr. (assigned to The Carborundum Co., Niagara Falls, N.Y.). Method for Making Zirconium Boride. U.S. Pat. 3,069,238, Dec. 18, 1962.

[52] Leitnaker, James M., Melain G. Bowman, and Paul W. Gilles. Thermodynamic Properties of the Tantalum and Tungsten Borides. J. Electrochem. Soc., v. 109, No. 5, May 1962, pp. 441–443.

[53] Blok, N. I., M. N. Koslova, N. F. Lashko, and K. P. Sotokina. (Boride Phases in Nickel Chromium Base Alloys.) Zavodskaya Laboratoriya (Plant Laboratory), No. 9, 1959, pp. 1059–1064; ASTIA, AD 255387.

[54] Meyerson, G. A., G. V. Samsanov, R. B. Kotel'nikov, M. S. Voynova, I. P. Evteyeva, and S. D. Krasnenkova. (Certain Properties of Boride Alloys of Refractory Transition Metals.) Konferentsiya Po Khim. Bora I Yego Soyedinenii (U.S.S.R.), 1955, 26 pp.; ASTIA, AD 257671.

[55] Kolomytsev, P. T. Reaction of Boron and Chromium in Nickel-Base Ternary Alloys. Wright-Patterson AFB, Ohio, Tech. Documents Liaison Office, MCL–1020/1, Aug. 28, 1961, 9 pp.

Powder X-ray analysis showed that the boride phase consisted of nickel boride (Ni_3B). Chromium was virtually insoluble in Ni_3B. An increase in the boron content enriched the solid solution in chromium. When the chromium concentration in the solid solution was increased to 16 percent, boron reacted with the chromium so that the solid solution remained unchanged. In alloys enriched in boron, chromium boride crystallized before the solidification of the solid solution and the nickel borides. The formation of chromium boride was dependent upon the concentration of boron and chromium in the alloy and the maximum temperature of the melt.

A considerable decrease in corrosion rates was obtained by alloying boron with hafnium.[56] Desired boron content was not attained by arc melting; however, corrosion rates were superior to those of pure hafnium.

Lattice parameters of Cr_3B_4, obtained by X-ray single-crystal studies, were reported.[57] No parameter variations were observed within plus or minus 0.04 percent of the limit of experimental error. No abnormally short boron-to-boron distances were noted.

Metallographic studies on single-crystal and polycrystalline titanium diboride were reviewed.[58] Techniques of preparing specimens by sectioning, mounting, grinding, flattening, and polishing were described. Chemical and electrolytic etching was discussed. Widmanstatten patterns were found on single-crystal specimens, and polycrystalline samples displayed a needle pattern.

A refractory material composed of 82 to 83 percent boron nitride and 17 to 18 percent graphite was prepared by a special sintering process.[59] The material had good electrical resistivity up to 1,600° C, a low thermal coefficient of expansion, moderate evaporation in a vacuum, satisfactory strength and machinability, and excellent resistance to molten borates, chlorides, silicides, and cryolite-aluminum.

Graphite was sprayed with boron silicide to form a protective coating that retarded oxidation.[60] The bond between boron silicide and graphite was stable because of their similar coefficients of expansion.

A pyrolytic graphite alloy containing from 0.5 to 3 percent boron was reported to be superior in some respects to pure pyrolytic graphite.[61] Three specimens tested for tensile strength averaged 20,800 pounds per square inch. Compressive stresses of 7,600 to 9,300 pounds per square inch without failure were recorded.

Conditions for forming pyrolytic boron nitride were investigated.[62] Pyrolysis techniques and furnace designs were evaluated. Properties

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[56] Research Chemicals Division of Nuclear Corporation of America (Burbank, Calif.). Rare Earth Intermetallics. Jan. 15–Mar. 15, 1961, 10 pp.; ASTIA, AD 266150.

[57] Elfström, Mats. The Crystal Structure of Cr_3B_4. Inst. of Chem., Univ. of Uppsala, Uppsala, Sweden. Tech. Note 25, June 21, 1961, 5 pp.; ASTIA 262205.

[58] Lynch, C. T., F. W. Vahldiek, S. A. Mersol, and C. R. Underwood. Invetsigation of Single-Crystal and Polycrystalline Titanium Diboride. Metallographic Procedures and Findings. Wright-Patterson AFB, Ohio, Aeronautical Systems Div., ASD Tech. Rept. 61–350, November 1961, 47 pp.

[59] Samsonov, G. V., Yu. N. Semenov, and P. Ya. Borodlin. (A Refractory Based on Boron Nitride.) Ogenupary (Refractories), (Moscow), No. 7, 1962, pp. 332–336; U.S. Dept. of Commerce, Office of Tech. Serv., J.P.R.S. 16,158, Nov. 13, 1962, 6 pp.

[60] Colton, Ervin. How New Ceramic Materials Coat Graphite. Ceram. Ind., v. 78, No. 6, June 1962, pp. 62–64.

[61] High Temperature Materials, Inc. (Boston, Mass.). Development of Boron Pyralloy for Rocket Motor Hardware. Monthly Prog. Rept., February 1962, 4 pp.; June 1962, 3 pp.

[62] Francis, Rand, and E. P. Flint. Pyrolytic Refractory Materials for Solid-Fuel Rocket Motor Applications. Arthur D. Little, Inc., Aug. 10, 1961, 73 pp., abs. in U.S. Govt. Res. Repts. U.S. Dept. of Commerce, Office of Tech. Serv., v 37, No. 1, Jan. 5, 1962, p. 61.

of the material were studied and the principles derived were applied to forming shapes.

The results were presented of a number of oxidation tests with pyrolytic graphite and pyrolytic boron nitrite.[63] Oxidation resistance of boron pyralloy and pyrolytic graphite appeared to be about the same. Boron nitrite was considered to be a poor substitute for pyrolytic graphite in rocket nozzles.

Boron filaments possessed a modulus of elasticity roughly five times that of glass fiber at room temperature.[64] They also had high strength, low density, and excellent heat resistance. Fibers were produced with tensile strengths of 500,000 pounds per square inch and a modulus of 55 million pounds per square inch.

Elemental boron fibers, that were stronger than steel, were prepared by chemical vapor plating.[65] Boron was deposited on a core filament of other material in diameters ranging from 1 to 10 mils and in lengths up to 1,000 feet.

High-purity boron in 44-percent yields was obtained by passing boron tribromide and hydrogen over a silica tube heated to 1,100° C.[66] The boron contained 0.0016 percent iron, 0.008 percent copper, some silicon, and traces of magnesium.

Boron melted in the electron-beam furnace spattered excessively and attacked the tungsten cathode of the furnace.[67] About 50 percent of the boron was lost during the first melting. Considerable gas evolved when the boron button was held molten in the crucible for 45 minutes. The cooled boron button was brittle and cracked when removed from the furnace. Three boron-carbon alloys that were melted in the furnace broke into pieces when removed from the crucible. Double-melted buttons of boron-silicon alloys also were brittle and cracked when they were removed. Electron-beam melting reduced the nitrogen and hydrogen content, but did not reduce the oxygen content.

Elemental boron of semiconductor grade was prepared by hydrogen reduction of purified boron tribromide.[68] Impurities in the boron consisted of 0.007 to 0.019 percent carbon and a small quantity of silicon. Boron was grown into bars and rods and doped with silicon, germanium, tungsten, and molybdenum. Tungsten- and molybdenum-doped crystals had resistivities of 10^5 ohms per centimeter and p-type conduction. Bars with less than 5 percent silicon had p-type conduction, but after two passes through a float-zone furnace they showed a small area with n-type conduction.

The direct current resistivities and dielectric properties of several aluminoborate glasses were determined at temperatures of 100° to

[63] High Temperature Materials, Inc. (Boston, Mass.). Develpoment of Boron Pyralloy for Rocket Motor Hardware. Monthly Prog. Rept., May 1962, pp. 1–6; ASTIA, AD 277492.

[64] Materials in Design Engineering. Boron Fibers for Stronger Composites. V. 56, No. 4, October 1962, p. 11.

[65] Chemical & Engineering News. Boron Makes Strong Fibers. V. 40, No. 49, Dec. 3, 1962, pp. 55–56

[66] Hynek, Kristian. (The Preparation of Pure Boron.) Chemicky Prumysl, No. 5, 1962, pp. 248–249; abstract resulting from the SOV/STEP program, translated for Library of Congress.

[67] Seagle, S. R., R. L. Martin, and O. Bertea. Electron-Beam Melting. J. Metals, v. 14, No. 11, November 1962, pp. 812–820.

[68] Bean, K. E., J. T. Buford, R. J. Starks, and L. E. Stone. Research Investigations in the Physical Chemical and Metallurgy of Semiconducting Materials. Chem. & Metals Div., Eagle-Picher Co., Nov. 15, 1961–Feb. 15, 1962, 17 pp.; ASTIA, AD 274516.

500° C.[69] Resistivities of $10^{11.5}$ ohms per centimeter at 450° C and activation energies of 26 to 42 kilocalories per mole were determined.

A method of preparing a high-temperature ceramic article was patented.[70] Lithium borate, melted at 800° C but below 930° C, was deposited on the surface of an alumina ceramic. The borate penetrated and filled pores in the article, rendering it impermeable.

Thirsty glass, a silica type containing 2.95 percent boron oxide, was strong, chemically inert, and thermally stable.[71] It also provided rapid activation and high water adsorption. The glass could be fabricated into nondusting shapes.

An electron microscopic study of glasses in the sodium oxide-boron oxide (Na_2O–B_2O_3) system and the sodium oxide-boron oxide-silicon dioxide (Na_2O–B_2O_3–SiO_2) systems and alkali borosilicate glasses was reported.[72] All clear glasses showed phase separation. In the binary sodium borate system, phase separation was caused by the boric acid anomaly.

The effect of varying chemical composition and heat treatment on properties of a low carbon-titanium-boron steel was determined.[73] Differences in heat treatment had a greater effect on the properties of steel than the chemical composition and length of treatment time. Solution temperatures of at least 2,000° F were necessary for optimum strengths.

Boronized steel that had high surface hardness and good abrasive and corrosive resistance was prepared.[74] The boronizing process consisted of passing hydrogen and boron trichloride through a special furnace that contained steel specimens. At 850° C, active boron and hydrogen chloride were formed. Boron was adsorbed on the steel surface and diffused into it, forming a surface that varied in hardness. The hardness of the samples decreased with increasing carbon content.

The combustion rate of boron and chlorine trifluoride was studied at 1 to 0.1 atmosphere of pressure.[75] Consumption of boron per unit area was about proportional to the consumption of chlorine trifluoride at constant total pressure. The rate of reaction was constant over a tenfold pressure range with constant flow of chlorine trifluoride.

Olefinic polymers were hydrogenated with soluble trialkyl borane and similar borane catalyst systems.[76] Polybutadiene was reduced to a high-density, crystalline polyethylene, and polyisoprene to a tough polymer with borane catalysts.

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[69] Hirayama, Chikara. Properties of Aluminoborate Glasses of Group II Metal Oxides: 11, Electrical Properties. J. Am. Ceram. Soc., v. 45, No. 6, June 1962, pp. 288–292.

[70] Knapp, William John (assigned to General Dynamics Corp., of New York). Method of Treating an Alumina Ceramic Article With Lithium Borate. U.S. Pat. 3,049,447, Aug. 14, 1962, pp. 480, 481.

[71] Elmer, T. H., and M. E. Nordberg. Thirsty Glass. Mat. in Design Eng., v. 56, No. 7, December 1962, pp. 118–119.

[72] Skatulla, Walther, Werner Vogel, and Hans Wessel. (Phase Separation and Boric Acid Anomaly in Simple Sodium Borate and Technical Alkali Borosilicate Glasses.) Silikat Technik (East Germany), v. 9, No. 2, 1958, pp. 51–62; Tech. Transl. U.S. Dept. of Commerce, Office of Tech. Serv., v. 8, No. 9, Nov. 15, 1962, pp. 902–903.

[73] Salvaggi, John. Carbon-Titanium-Baron Steel Evaluation for High Temperature Service. Cornell Aeronautical Lab., Inc., Aug. 31, 1957, 34 pp.; abs. in U.S. Govt. Res. Repts. U.S. Dept. of Commerce, Office of Tech. Serv., v. 37, No. 17, Sept. 5, 1962, pp. 5–32.

[74] Pchelkina, M. A., and Yu. M. Lakhtin. (Boronizing in a Boron Trichloride Atmosphere.) Metallovedeniye i Term. Obrabotka Metallov, July 1960, No. 7, pp. 40–42: abs. in U.S. Dept. of Commerce, Office of Tech. Serv., Tech. Transl. No. 56, August 1962, pp. 270–271.

[75] Henderson, U. V., Jr., and Harry P. Woods. Combustion of Elemental Boron. Texaco Experiment, Inc., Aug. 1, 1961, 9 pp.; abs. in U.S. Govt. Res. Repts. U.S. Dept. of Commerce, Office of Tech. Serv., v. 37, No. 1, Jan. 5, 1962, p. 20.

[76] Chemical & Engineering News. V. 40, No. 19, May 7, 1962, p. 41.

Two alkylated ammonium borohydrides were prepared that have potential applications in the pharmaceutical, plastics, and petroleum industries.[77] Chemicals such as aldehydes, ketones, esters, acid halides, peroxides, and persulfates could be reduced in the presence of these borohydrides and solvents such as benzene, isopropanol, or water.

Linear polymers containing boron, nitrogen, and carbon were prepared by migration copolymerization of diaminoorganoborons with hexamethylene diisocyanate and toluylene diisocyanate.[78] Organoboron polymers with linear structure were obtained by copolymerizing β-substituted borazoles with hexamethylene diisocyanate.[79] Cross-linked copolymers were also formed.

Phenylborane derivatives were studied, and work started on the preparation and characterization of some substituted borazines.[80] Borazines were prepared by condensations between boron halides and amines. Further substitution was accomplished after formation of the borazine ring.

Organoboron compounds were prepared and evaluated for imparting permanent flame-resistant properties to cotton material.[81] About 50 compounds gave flame-resistant finishes to the material; however, none would withstand mild laundering.

Sodium borohydride was reported to be effective in improving the brightness and color stability of bleached paper pulps.[82] Borohydride, a powerful reducing agent, reduced carbonyl groups to hydroxyl groups. Carbonyl groups were thought to absorb certain light wavelengths, thereby causing yellowing of the pulp.

The selection, design, and fabrication of storage facilities for pentaborane were described.[83] Compatible construction materials, equipment design and selection, system fabrication, testing and cleaning procedures, inspection and maintenance, and reactivation of existing facilities were discussed.

A patent was issued for a fuel that consisted of 40 to 60 percent of a boron hydride, 30 to 35 percent of powdered boron, beryllium, and lithium, and 10 to 25 percent of a chlorate.[84]

Experiments on the combustion of elemental boron at 2,300° K and above in oxygen and in oxygen diluted with nitrogen and argon showed that the temperature of the boron was the most important single factor in determining burning behavior.[85] Other factors that af-

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[77] Chemical Engineering. V. 69, No. 13, June 25, 1962, pp. 80, 82.

[78] Korshak, V. V., N. I. Bekasova, V. A. Zamyatina, and G. I. Aristarkhova. (The Copolymerization of bis-(Alkylamino)Alkyl- or Arylboron With Organic Diisocyanates.) Vysokomolekulyarnyye Soyedineniya, v. 3, No. 4, 1961, pp. 521–524.

[79] Korshak, V. V., V. A. Zamvatina, N. I. Bekasova, and Ma Zhui-zhan'. (The Copolymerization of β-Substituted Borazoles With Hexamethylene Diisocyanate.) Vysokomolekulyarnyye Soyedineniya, v. 3, No. 4, 1961, pp. 525–529.

[80] Beachell, H. C., D. W. Beistel, and S. A. Butler. Boron Research. Univ. of Delaware, Dept. of Chem., 15th Quarterly Prog. Rept. Jan. 1–Mar. 31, 1961, 14 pp.; ASTIA, AD 254315.

[81] Liggett, R. Winston, and George Bosmajian. Development of a Permanently Fire-Resistant Cotton Fabric by Reaction With Organo-Boron Compounds. Southern Res. Inst., June 1961, 32 pp.; ASTIA, AD 268629.

[82] Chemical Week. Boronhydride Target: Pulp. V. 90, No .26, June 30, 1962, pp. 38–39.

[83] Rocketdyne Division of North American Aviation, Inc. Mechanical System Design—Criteria Manual for Pentaborane. September 1961, 80 pp.; ASTIA, AD 266118.

[84] Drummond, Folsom E. (assigned to the Commonwealth Engineering Co. of Ohio, Dayton, Ohio). Boron Containing Fuels. U.S. Pat. 3,070,472, Dec. 25, 1962.

[85] Talley, Claud P. Combustion of Elemental Boron. Texaco Experiment, Inc., TM-1269, Aug. 1, 1960, 13 pp.

fected the combustion rate were gasflow rate, shape and particle size of the boron, and the concentration of the gas used to dilute the oxygen. It was concluded that elemental boron could be burned self-propagatingly in air.

The combustion of boron rods in fluorine and chlorine trifluoride was studied.[86] Combustion was self-propagating at 1,600° K. Reaction products were volatile.

Flames of hydrazine diborane were tested at low pressures for characteristics such as quenching diameter, burning velocity, and light emission.[87]

A new boron hydride, icosaborane ($B_{20}H_{26}$), was prepared by irradiating decaborane 14 with deuterons.[88] Icosaborane appeared to form by coupling of two pentaborane 9 units.

Pentaborane was purified in a continuous chromatograph before being decomposed to high-purity boron.[89]

Acetonitrile and pyridine reacted with pentaborane to form adducts.[90] Pentaborane did not react with acetylenic compounds. Nuclear-substituted perhydrodecaborate salts and similarly substituted decaborane ($B_{10}H_{12}$) derivatives were prepared. The chemistry of chlorine-phosphorus-borohydride compounds was investigated. Some of these derivatives were polymerized. Polymers were also obtained by reacting diphosphines with decaborane.

Organic phosphites reacted with decaborane in benzene to produce the corresponding $B_{10}H_{12}$ compounds.[91] Higher yields were obtained with bis(acetonitrile)decaborane, and the best yields were obtained using bis(diethylsulfide)decaborane.

Persons exposed to borane fuels were tested by electroencephalographic tracings.[92] Results indicated little or no central nervous system damage by exposure to boron hydrides.

Decaborane and diphenylchorophosphine in ether or benzene reacted to form bis(chlorodiphenylphosphine)decaborane and hydrogen.[93] Bis(chlorodiphenylphosphine) decaborane $[B_{10}H_{12}(Ph_2PCl)]_2$ reacted with ammonia and primary aliphatic amines in alcohols to yield amino compounds. Secondary aliphatic amines used in the reaction resulted in the formation of esters or acids. An alcoholic suspension of bis(chlorodiphenylphosphine)decaborane and sodium azide yielded bis(chlorodiphenylphosphine)decaborane azide.

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86 Talley, Claud P., and Harry P. Woods. Combustion of Elemental Boron. Texaco Experiment, Inc., TM-1270, Nov. 1, 1960, 4 pp.

87 Vanpee, M., H. G. Wolfhard, and A. H. Clark. Flame Studies of High Energy Fuels and Oxidizers Hydrazine Diborane, Oxygen Diborane, Oxygen-Hydrazine and Hydrazine Decomposition Flames. Thiokol Chem. Corp., Reaction Motors Div., October 1961, 26 pp.; Abs. in U.S. Govt. Res. Repts., U.S. Dept. of Commerce, Office of Tech. Serv., v. 37, No. 2, Jan. 20, 1962, p. 40.

88 Chemical & Engineering News. Irradiated Decaborane-14 Yields $B_{20}H_{26}$. V. 40, No. 38, Sept. 17, 1962, p. 56.

89 Chemical & Engineering News. Prep Chromatograph Operates Continuously. V. 40, No. 37, Sept. 10, 1962, pp. 74–75.

90 Heying, T. L. Boron Polymers. Olin Mathieson Chemical Corp., Tech. Rept. 4, Aug. 11–Nov. 10, 1961, 16 pp.; ASTIA, AD 267820.

91 Polak, R. J., and T. L. Heying. The Preparation of Phosphite and Phosphinite Decaboranes. Olin Mathieson Chemical Corp., Nov. 2, 1961, 4 pp.; ASTIA, AD 265218. Office of Naval Research Tech. Rept. No. 1.

92 Schoettlin, C. E., G. M. Cianko, R. D. Walter, and T. Freedman. Toxicological Research on Central Nervous System Effects of Borane Fuels. North American Aviation, Inc., September 1961, 36 pp.; ASTIA, AD 268610.

93 Schroeder, Hansjuergen, Joseph R. Reiner, and Theodore L. Heying. Chemistry of Decaborane Phosphorus Compounds. Olin Mathieson Chemical Corp., Nov. 28, 1961, 12 pp.; ASTIA 266989, Office of Naval Research, Tech. Rept. 3.

Data on the vapor pressure of liquid pentaborane from 25° to 125° C and on thermal conductivity from 63° to 140° F were presented.[94]

Theoretical performance calculations for the pentaborane-fluorine and diborane-fluorine systems and results of performance tests of the pentaborane-fluorine system were presented.[95] At a chamber pressure of 110 pounds per square inch absolute and with an oxidizer-to-fuel ratio of 5, the pentaborane-fluorine system had a calculated specific impulse of 243 seconds. Tests indicated that results on the order of 90 percent of the theoretical value could be obtained.

Information, obtained from experience and evaluation of literature, was studied for the safe handling of pentaborane.[96] Properties, materials, hazard reduction and control, safety equipment, decontamination, transportation, storage, handling, venting, and disposal of pentaborane were reviewed.

Engineers at Edwards Air Force Base, Calif., reportedly obtained a specific impulse from boron fuels that was satisfactory for use in propelling space vehicles.[97]

Increased yields of 150 pounds of seed cotton per acre were obtained for 3 years by the use of 3 to 5 pounds of borax per acre.[98] Research was conducted at the Sand Mountain Substation of the Auburn University Agriculture Experiment Station and on farms in DeKalb and Marshall Counties, Ala.

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[94] Boynton, C. F. D. E. Terpho, and J. R. Ludwig. Physical Properties of Liquid Pentaborane. Callery Chemical Co., September 1961, 33 pp.; ASTIA, AD 267076.

[95] Grosse, A. V., T. R. Flint, S. Lipschutz, and C. S. Stokes. Explanatory Research on High Energy Propellant Systems. Res. Inst. of Temple Univ., January 1961, 59 pp.; ASTIA, AD 270941.

[96] Rocketdyne Division of North American Aviation, Inc. (Canoga Park, Calif.). Pentaborane Handling Manual. September 1961, 49 pp.; ASTIA, AD 2C6131.

[97] Chemical Week. V. 92, No. 14, Apr. 7, 1962, p. 64.

[98] Commercial Fertilizer. Is Boron Necessary for Cotton? V. 106, No. 1, January 1963, pp. 60, 65.

Bromine

By Henry E. Stipp [1] and Victoria R. Schreck [2]

BROMINE and bromine compound sales in 1962 increased for the second consecutive year. Exports declined from the record high of 1961.

DOMESTIC PRODUCTION

Bromine production rose 6 percent as sales of elemental bromine, ethylene dibromide, potassium, sodium and ammonium bromide, and ethyl bromide, increased. Sales of methyl bromide decreased slightly in quantity.

TABLE 1.—Sales of bromine and bromine compounds (bromine content) by primary producers in the United States

(Thousand pounds and thousand dollars)

Year	Quantity	Value	Year	Quantity	Value
1953-57 (average)	184,939	$42,402	1960	175,010	$44,637
1958	176,397	46,689	1961	180,798	44,517
1959	195,483	51,508	1962	190,747	46,617

Ethyl Dow Chemical Co. recovered bromine from sea water at Freeport, Tex., and FMC Corp., Mineral Products Division, extracted bromine from sea-water bittern at Newark, Calif. American Potash & Chemical Corp. extracted bromine from the brine of Searles Lake at Trona, Calif. Arkansas Chemicals, Inc., and Michigan Chemical Corp. extracted bromine from well brines near El Dorado, Ark. Plants of The Dow Chemical Co. at Midland and Ludington, Great Lakes Chemical Corp. at Manistee, Michigan Chemical Corp. at East Lake and St. Louis, and Morton Chemical Co. at Manistee recovered bromine from well brines in Michigan.

Expansion of The Dow Chemical Co. bromine production facilities at Midland, Mich., was completed.

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.

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TABLE 2.—Bromine and bromine compounds sold by primary producers in the United States

(Thousand pounds and thousand dollars)

Compound	Gross weight	Bromine content [1]	Value
1961:			
Elemental bromine	17,706	17,706	$3,510
Methyl bromide	10,260	8,636	4,277
Other, including ethylene dibromide, sodium bromide, ammonium bromide, and potassium bromide	184,531	154,456	36,730
Total	212,497	180,798	44,517
1962:			
Elemental bromine	23,106	23,106	4,267
Methyl bromide	9,963	8,386	4,316
Other, including ethylene dibromide, sodium bromide, ammonium bromide, and potassium bromide	190,903	159,255	38,034
Total	223,972	190,747	46,617

[1] Calculated as theoretical bromine content present in compound.

CONSUMPTION AND USES

Bromine was used principally to prepare ethylene dibromide and bromine compounds for medicinal, photographic, and industrial applications. It also was used as a laboratory reagent, bleaching and disinfecting agent, and in brominating dyes, swimming pool sanitizing, and water purifying. Ethylene dibromide, an additive to tetraethyl or tetramethyl lead gasoline antiknock fluid, accounted for the greatest percentage of total bromine consumption; sales increased for the second consecutive year. Ethylene dibromide also was used for fumigation of soil and seed, synthesis of dye and pharmaceutical intermediates, and several minor applications. Consumption of methyl bromide, used chiefly in fumigating and fire extinguishing, decreased 3 percent in quantity.

Elemental bromine consumption increased 30 percent in quantity in 1962 after declining somewhat in 1961.

Consumption of potassium, sodium, and ammonium bromides increased significantly. These compounds were used in preparing medicines, photographic plates, films, and emulsions. Potassium bromate, a laboratory oxidizing agent, was added to flour to improve the quality of bread.

Monobromotrifluoromethane and bromodichloromethane were used as fire-extinguishing agents. Bromochlorotrifluoroethane served as a nonflammable anesthetic. Bromine compounds such as p-bromochlorobenzine, pentabromophenol, tetrabromophtalic anhydride and tetrabromobisphenol-A, were offered for preparing flame-retardant resins, dyes and pharmaceuticals. Tris(2,3-dibromopropyl) phosphate was used as a flame-retardant additive. The compound 3,isopropyl-5-bromo-6-methyl uracil was used as an herbicide. Aluminum bromide was employed as a catalyst in the treatment of paraffinic hydrocarbons. Cuprous bromide single crystals were offered for laser-maser optical modulation studies.

PRICES

Prices for bromine and bromine compounds were virtually the same as in 1961. The following prices were quoted by Oil, Paint and Drug Reporter:

	Cents per pound
Bromine, purified, cases, carlots, ton lots, delivered east of Rocky Mountains	32
Drums, carlots, ton lots, delivered east of Rocky Mountains	31
Tanks, carlots, same basis	21.5
Ammonium bromide, National Formulary (N.F.) granular, drums, carlots, ton lots, freight equalized	44
Bromochloromethane, drums, carlots, freight equalized	48
Tanks, same basis	47
Ethylene dibromide, drums, carlots, freight equalized	30.5
Tanks, freight equalized	28.5
Potassium bromate, 200-pound drums, carlots, freight allowed	49
Potassium bromide, U.S.P., granular, barrels, kegs	39–40
Sodium bromide, U.S.P., granular, barrels, drums, works	40

FOREIGN TRADE [3]

Bromine and bromine compound imports totaled 461,108 pounds valued at $245,007, compared with 269,582 pounds valued at $184,708 in 1961. There were no imports of sodium or potassium bromide.

Exports of bromine, bromides, and bromates decreased 21 percent in quantity to 8,800,351 pounds valued at $2,227,945, compared with 11,120,085 pounds valued at $2,980,197 in 1961.

WORLD REVIEW [4]

France.—Bromine production in 1961 totaled 2,019 short tons valued at $751,558 compared with 2,216 short tons valued at $691,187 in 1960.[5]

Germany, West.—Bromine and bromine compound production in 1961 totaled 2,792 short tons valued at $1,284,000, compared with 2,317 short tons valued at $1.1 million in 1960.[6]

India.—A plant to produce 250 tons of bromine per year was scheduled to be built near Madras.[7]

Israel.—Production in the year ending March 31, 1962, totaled 4,850 short tons of elemental bromine and 3,638 short tons of ethylene dibromide valued at $2.6 million. Completion of a second unit of the Dead Sea Bromine Co. plant in 1961 increased annual capacity to 10,000 tons.[8] Reductions of 20 percent in U.S. duties on ethylene dibromide and potassium bromide were agreed to by the United States and Israel under the General Agreement for Tariffs and Trade.[9]

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

[4] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.

[5] U.S. Embassy, Paris, France. State Department Dispatch A–264. Aug. 3, 1962, encl. 1, p. 2.

[6] U.S. Embassy, Düsseldorf, West Germany. State Department Dispatch, Airgram 21. Sept. 7, 1962, encl. 1, p. 2.

[7] Chemical Engineering. V. 69, No. 21, Oct. 15, 1962, pp. 230, 232.

[8] Bureau of Mines. Mineral Trade Notes. V. 55, No. 4, October 1962, p. 7.

[9] Chemical Age (London). V. 87, No. 2,228, Mar. 24, 1962, p. 483.

TABLE 3.—U.S. exports of bromine, bromides, and bromates, by countries

Destination	1961		1962	
	Pounds	Value	Pounds	Value
North America:				
Canada	6,407,557	$1,127,375	6,656,806	$1,200,928
El Salvador	17,415	5,851	37,365	14,100
Guatemala	29,564	8,889	15,908	5,858
Mexico	459,273	240,645	363,358	194,473
Panama	2,200	822	21,851	6,429
Other	31,751	15,350	5,541	3,765
Total	6,947,760	1,398,932	7,100,829	1,425,553
South America:				
Argentina	19,849	9,265	15,640	8,963
Brazil	896,500	455,470	229,571	98,339
Colombia	27,189	6,473	12,200	6,938
Peru	3,980	2,410	4,132	2,842
Uruguay			5,450	3,698
Venezuela	52,184	21,533	66,664	25,172
Other	6,572	3,483	8,051	3,070
Total	1,006,274	498,634	341,708	149,022
Europe:				
Austria	4,800	2,730	6,400	3,552
Belgium-Luxembourg	15,616	8,459	10,173	8,607
Denmark	33,655	9,769	1,100	956
France	116,262	68,238	61,054	17,725
Germany, West	66,041	36,191	62,304	39,265
Italy	1,122,531	234,242	283,821	82,287
Netherlands	355,173	95,976	112,470	57,325
Spain	662	990	44,000	7,399
Sweden	11,239	4,841	6,098	1,967
Switzerland	125,570	260,380	186,790	181,989
U.S.S.R			132,400	74,000
United Kingdom	41,282	28,811	104,781	44,281
Other	4,748	3,517	1,980	697
Total	1,897,579	754,144	1,013,371	520,050
Asia:				
Burma			7,953	4,943
India	32,954	19,973	27,022	11,032
Iran	27,878	16,132	5,580	4,106
Japan	1,890	2,223	20,238	26,087
Korea, Republic of	150	250	2,732	2,097
Pakistan	2,800	1,554		
Philippines	11,838	5,559	7,636	3,498
Thailand	1,680	1,361	5,692	2,813
Viet-Nam	1,150	1,380	12,817	5,683
Other	4,150	3,114	7,409	2,968
Total	84,490	51,546	97,079	63,227
Africa:				
Canary Islands	34,995	8,679		
Rhodesia and Nyasaland, Federation of	953,701	191,217	69,984	30,156
South Africa, Republic of [1]	96,632	36,720	3,600	1,920
Other	1,600	888	1,200	642
Total	1,086,928	237,504	74,784	32,718
Oceania:				
Australia	97,054	39,437	165,240	33,294
New Zealand			7,340	4,081
Total	97,054	39,437	172,580	37,375
Grand total	11,120,085	2,980,197	8,800,351	2,227,945

[1] Effective Jan. 1, 1962; formerly Union of South Africa.

Source: Bureau of the Census.

Japan.—Elemental bromine production in 1961 totaled 3,056 short tons, compared with 2,151 short tons in 1960. Potassium bromide output totaled 379 short tons in 1961, compared with 390 short tons in 1960.[10]

Pakistan.—Bromine was discovered in the hot brines of an oil well near Dhariala by the West Regional Laboratories, Pakistan Council of Scientific and Industrial Research, Lahore.[11]

TECHNOLOGY

Bromine of 99.95 percent purity was produced by a new process installed early in 1962 by a major bromine producer.[12] The process reportedly combined physical and chemical treatments to remove all but 30 parts per million of organic materials. The use of higher purity bromine was expected to reduce corrosion and nonvolatile residues.

Another technique was developed for producing 99.98 percent pure bromine.[13] The preparation technique was not revealed, but the developer reported that a major difficulty in preparing high-purity bromine was identifying and analyzing for impurities.

Bromine was recovered from an anion-exchange resin by reducing the absorbed bromine to bromide with a sulfurous reducing agent in water and recovering the resulting bromide effluent.[14]

A new method for producing ethyl bromide was reported to be the first commercial chemical process to use gamma radiation as a catalyst.[15] Ethylene and anhydrous hydrogen bromide gases were reacted in a nickel vessel containing some ethyl bromide. The gamma radiation ionized the hydrogen bromide molecule, allowing it to react with ethylene. The product, a liquid, was drawn off at the top of the vessel. Yields were almost 100 percent, and the purity of the ethyl bromide was very high.

Metal whiskers that had high ductility were prepared by the hydrogen reduction of nickel bromide or cobalt bromide between 580° and 780° C.[16]

Boron was deposited on a tantalum filament which was held at a temperature of 1,200° C in a helium atmosphere. Hydrogen and boron tribromide vapor were introduced into a reduction chamber at 1,100° C, the ratio of boron tribromide was increased gradually, and the chamber temperature was raised to 1,175° C.[17]

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10 U.S. Embassy, Tokyo, Japan. State Department Dispatch 820. Apr. 4, 1962, encl. 1, p. 2.

11 Richards, Russell L. Evaporite Deposits in Pakistan. Cento Symposium on Industrial Rocks and Minerals, Lahore, West Pakistan, 1962, p. 4.

12 Chemical & Engineering News. Dow Uses New Bromine Purification Process. V. 40, No. 22, May 28, 1962, p. 62.

13 Chemical Week. A New Technique To Produce Ultra-High-Purity Bromine. V. 91, No. 22, Dec. 1, 1962, p. 61.

14 Hein, Rowland Frank (assigned to E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.). Process for Recovering Bromine Adsorbed on Anion-Exchange Resins. U.S. Pat. 3,037,845, June 5, 1962.

15 Chemical & Engineering News. Ethyl Bromide Process Uses Radiation. V. 40, No. 47, Nov. 19, 1962, pp. 52–53.

16 Bokshteyn, S. Z., S. T. Kishkin, and I. L. Svetlova. Fizika Tverdoga Tela. V. 4, No. 7, July 1962, pp. 1735–1742; U.S. Dept. of Commerce, Office Tech. Services, Current Review of the Soviet Technical Press. Oct. 5, 1962, p. 7(800).

17 Bean, Kenneth E., and William E. Medcalf (assigned to the Secretary of the Army). Boron Deposition Method. U.S. Pat. 3,053,636, Sept. 11, 1962.

Data on the purity of boron tribromide at formation temperatures ranging from 450° to 890° C were presented.[18] Thermodynamic calculations of the bromination of boron indicated that all impurities except carbon reacted completely. The activation energy of the reaction between bromine and impurities was considered to be the controlling factor. On this basis, a significant decrease in the carbon content of boron tribromide at lower temperatures was predicted.

Values for the enthalpy, entropy, and free energy of solid molybdenum dibromide were given.[19]

An improved method for preparing thiophosphoryl bromide by reacting phosphorus tribromide and sulfur between 90° and 140° C in the presence of a catalytic inorganic bromide was patented.[20]

A system of bromides and chlorides of potassium and thallium was studied.[21] The relative thermal effect of the exchange reaction was directed to the potassium chloride-thallium bromide side and equaled 2.36 kilo calories per equivalent. The exchange reaction had a greater shift in the direction of the potassium chloride-thallium bromide side.

A method of determining spectrophotometrically from 1 to 100 microgram-quantities of bromine in material was reported.[22] The test was more sensitive than the older bromine-fuchsin test and required no special equipment.

A rapid, accurate method for determining bromide and chloride quantitatively by gas chromatography methods was discovered.[23] The sample to be analyzed was added to sulfuric acid, which converted bromide to hydrogen bromide. This gas was collected in a liquid nitrogen trap after being carried from the acid by helium. The gases were analyzed by gas chromatography at minus 78° C with toluene and n-heptane on Teflon.

Factors affecting soil diffusion and pest control with methyl bromide were studied.[24] Best results for methyl bromide applied under a soil cover were obtained with warm, moist, compact soil that was low in organic matter.

A series of tests was conducted to outline the explosive limits of a methyl bromide and air mixture as a function of total pressure.[25] The explosive limits of this mixture at 1 atmosphere of pressure were found to be 10 percent to 15.4 percent methyl bromide in methyl bromide and air mixtures, compared to previous limits of 13.5 percent to

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[18] Armington, A. F., and G. F. Dillon. The Effect of Formation Temperature on the Purity of Boron Tribromide. Trans. of the Met. Soc. of AIME. V. 224, No. 3, June 1962, pp. 631–632.

[19] Shchkarev, S. A., I. V. Vasil'kova, D. V. Karol'kov, and S. S. Nikol'skiy. (Thermodynamic Study of Molybdenum Dibromide.) Vestnik Leningrad Universitet. Seriya Fiziki i Khim. No. 1, 1962, pp. 148–153.

[20] Olah, George A., and Stephen J. Kuhn (assigned to The Dow Chemical Co., Midland, Mich.). Preparation of Thio-Phosphoryl Bromide. U.S. Pat. 3,061,405, Oct. 30, 1962.

[21] Ilyasov, I. J., L. V. Rozhkovskaya, and A. G. Bergman. (Fusion Diagram for the System of Bromides and Chlorides of Potassium and Thallium.) J. Inorg. Chem. (U.S.S.R.), v. II, No. 8, 1957, pp. 1883–1887.

[22] Cogan, Edward. Determination of Trace Bromine. Anal. Chem., v. 34, May 1962, p. 716.

[23] Chemical & Engineering News. Gas Chromatography Determines Cl—, Br—. V. 40, No. 14, Apr. 2, 1962, pp. 54–55.

[24] Youngson, C. R., R. G. Baker, and C. A. I. Goring. Diffusion and Pest Control by Methyl Bromide and Chloropicrin Applied to Covered Soil. J. Agri. Food Chem., v. 10, No. 1, January–February 1962, pp. 21–25.

[25] Hill, Howard W. Methyl Bromide-Air Explosion. Chem. Eng. Prog., v. 58, No. 8, August 1962, pp. 46–49.

14.5 percent. Elevated pressure increased the explosive range of methyl bromide and air mixtures.

Boron tribromide was prepared by reacting elemental boron and bromine between 700° and 800° C and by an exchange reaction between either boron trifluoride or potassium fluoborate and aluminum bromide.[26] The chief impurity was silicon tetrabromide. Purification of the sample by distilling and rectifying it with the aid of a sieveplate column removed all but 0.01 percent silicon tetrabromide and other impurities of low volatility.

Lithium bromide and water were used in an experimental device designed to cool buildings.[27] Solar energy provided the power to operate the system. Commercial development of the system holds considerable promise, but the corrosiveness of lithium bromide presents a materials problem.

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[26] Ivanov-Emin, B. N., L. A. Nisel'son, and I. V. Petrusevich. (Synthesis and Purification of Boron Bromide and Iodide.) J. Appl. Chem. (U.S.S.R.), v. 34, No. 10, November 1961, pp. 2256–2260.

[27] South African Mining and Engineering Journal. Solar Cooling of Buildings. V. 73, pt. 2, No. 3645, Dec. 14, 1962, p. 1405.

Cadmium

By A. D. McMahon [1] and Esther B. Miller [2]

ALTHOUGH there was a rise in domestic production of cadmium for 1962, the supply was inadequate to meet the increasing demand. Inventories were drawn upon to relieve the shortage, lowering total stocks 45 percent. Producers and distributors were forced to allocate metal to many of their customers who, consequently, were unable to obtain their full requirements and initiated requests for release of surplus cadmium from the national strategic stockpile. There were only minor changes in imports and exports of cadmium metal but imports of flue dust, a substantial source of cadmium, were 30 percent lower than in 1961. The price of cadmium advanced 20 cents to $1.80 cents per pound in ton lots. However, there were reports of cadmium sales at $2.50 to $3.50 per pound.

TABLE 1.—Salient cadmium statistics

(Thousand pounds)

	1953-57 (average)	1958	1959	1960	1961	1962
United States:						
Production [1]	10,059	9,673	8,602	10,180	[2] 10,115	10,641
Imports for consumption, metal	1,517	1,002	1,638	942	1,079	1,117
Exports	887	580	900	2,448	702	717
Consumption, estimated	(3)	8,209	11,409	10,127	[2] 10,289	12,082
Price: Average [4] per pound	$1.76	$1.52	$1.36	$1.52	$1.68	$1.72
World: Production	19,100	[2] 21,600	[2] 22,100	[2] 24,800	[2] 26,400	25,600

[1] Primary and secondary cadmium metal.
[2] Revised figure.
[3] Estimated consumption of primary and secondary metal not available before 1956.
[4] Average quoted price for cadmium sticks and bars in lots of 1 to 5 tons.

LEGISLATION AND GOVERNMENT PROGRAMS

A bill, H.R. 11972, seeking Congressional approval to release 2 million pounds of cadmium from the national stockpile without waiting 6 months as prescribed in the Strategic and Critical Materials Stockpiling Act, was introduced in the House of Representatives on June 4, 1962. No action was taken on this bill and on October 16, 1962, the General Services Administration proposed, subject to ex-

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

press approval of the Congress, to offer 2 million pounds of stockpiled cadmium for sale beginning not earlier than 6 months after the date of publication of the notice in the Federal Register, which was October 20, 1962.

There were no contracts negotiated in 1962 by the U.S. Department of Agriculture, Commodity Credit Corporation (CCC) for acquisition of foreign-produced cadmium under the barter program; however, 293,000 pounds of cadmium was delivered during the year under earlier barter agreements. Late in 1962, cadmium was removed from the list of foreign-produced commodities to be considered for barter of surplus perishable agricultural products.

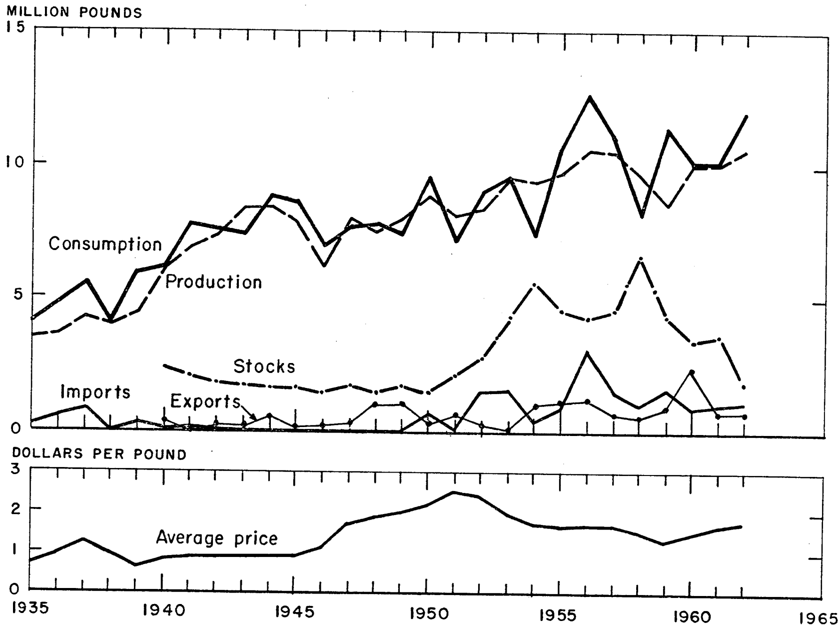

FIGURE 1.—Trends in production, consumption, yearend stocks, imports, exports, and average price of cadmium metal in United States, 1935–62.

DOMESTIC PRODUCTION

Despite the short supply situation that developed in 1962, production of cadmium from primary and secondary sources increased 5 percent to 10,641,000 pounds—an alltime high, slightly above the previous peak year of 1956. The increase apparently was related to a 13-percent rise in imports of zinc concentrate and a 9-percent rise in domestic zinc mine production that provided the source material from which most of the primary cadmium was produced.

It was estimated that 50 percent of the cadmium production was derived from foreign zinc ores and concentrates and other base-metal concentrates. Flue dust from Mexico provided 12 percent (18 percent in 1961) and, except for a small quantity of secondary cadmium recovered from scrap, the balance was obtained from processing domestically mined zinc ores. The principal suppliers of foreign zinc concentrates were Canada, Mexico, Peru, Australia, and the Republic of South Africa. Lower imports of flue dust from Mexico resulted from exhaustion of an inventory of cadmium-bearing dust early in 1962 that had contributed to the raw material intake of cadmium plants in prior years.

There was a shortage of cadmium-bearing scrap, consisting mainly of lead-bismuth-cadmium alloys, zinc-cadmium scrap, and electroplaters' scrap from which approximately 30 percent less secondary cadmium was recovered than in 1961.

TABLE 2.—Primary and secondary cadmium metal produced and shipped in the United States

(Thousand pounds)

	1953–57 (average)	1958	1959	1960	1961	1962
Production	10,059	9,673	8,602	10,180	[1] 10,115	10,641
Shipments by producers	9,738	7,921	11,273	12,151	10,165	11,561
Value ... thousands	$14,946	$10,067	$12,054	$14,924	$14,200	$17,688

[1] Revised figure.

Cadmium oxide production is not published to avoid revealing individual company data.

There was no change in the list of producers of primary and secondary cadmium shown in the 1960 Minerals Yearbook.

Production of cadmium sulfide, including cadmium lithopone and cadmium sulfoselenide, increased 19 percent to 1.3 million pounds.

TABLE 3.—Cadmium sulfide [1] produced in the United States

(Thousand pounds)

Year	Gross weight	Cadmium content	Year	Gross weight	Cadmium content
1953–57 (average)	3,743	1,184	1960	3,484	1,084
1958	2,884	983	1961	3,355	1,115
1959	3,701	1,243	1962	4,250	1,329

[1] Includes cadmium lithopone and cadmium sulfoselenide.

CONSUMPTION AND USES

Consumption of cadmium metal—estimated as production plus net imports and net stock changes of producers, compound manufacturers, and distributors—reached 12 million pounds and was 17 percent higher than that of 1961.

The greatest use of cadmium was in the electroplating industry for protective coatings on various parts of automobiles, appliances, aircraft, industrial machines, radio and television sets, electrical and electronic equipment, hardware, fittings, instruments, and numerous fastening items (nuts, bolts, screws, nails, tacks and rivets). Cadmium is particularly adaptable to plating complicated and intricate shapes because it can be deposited more uniformly in recesses.

Cadmium also was used in making solders, particularly the cadmium-silver type. Low-melting point fusible alloys of the cadmium-tin-lead-bismuth type have long been used in automatic sprinkler systems, fire-detection apparatus, and valve seats for high-pressure gas containers. Cadmium was alloyed with copper in the manufacture of trolley and telephone wires.

The second most important use was in pigments and chemicals. Cadmium sulfide and cadmium sulfoselenide were used for creating bright high-quality yellows and reds. Cadmium bromide and iodide were used in making photographic films and in photoengraving and photolithography. Cadmium stearate was used in vinyl plastics. Some organocadmium compounds were employed to provide heat and light stabilization in plastics.

Production of nickel-cadmium batteries was increasing. These batteries have a longer life than the standard lead-acid battery, are smaller, and are superior in performance. They were used in earth satellites, missiles, and ground equipment for polar regions. They are rechargeable and were in growing demand for flashlights and cordless power tools. The silver-cadmium rechargeable battery was being developed for similar uses.

STOCKS

Reported stocks of cadmium metal were 1.3 million pounds on December 31, 1962, down from 2.3 million pounds at the end of 1961. Cadmium contained in compounds increased to 775,000 pounds from 756,000 at yearend 1961.

At the end of 1962, 17.2 million pounds was in the Government stockpiles: 9.8 million pounds in the national (strategic) stockpile, 7.2 million pounds in the supplemental stockpile, and 215,000 in CCC stocks.

TABLE 4.—Industry stocks, December 31

(Thousand pounds)

	1961 [1]		1962	
	Cadmium metal	Cadmium in compounds	Cadmium metal	Cadmium in compounds
Metal producers	1,800	(2)	880	(2)
Compound manufacturers	117	710	234	700
Distributors	382	46	144	75
Total	2,299	756	1,258	775
Consumers	[3] 1,300	(4)	600	(4)

[1] Figures partly revised.
[2] Included with stocks of cadmium contained in compounds at compound manufacturers in order to avoid disclosing individual company confidential data.
[3] Estimate.
[4] Data not available.

PRICES

The quoted price for cadmium metal at the beginning of 1962 was $1.70 per pound for sticks, bars, and shapes in lots under 1 ton and $1.60 per pound in ton lots. Following a period of irregular pricing in mid-February, the quoted prices were established at $1.75 and $1.65 per pound, respectively. On April 2, prices again advanced to $1.75 to $1.85 per pound for less than ton lots and $1.70 to $1.80 per pound for ton lots. These quotations held for the remainder of the year.

Cadmium on the London market was quoted at the beginning of the year at 11s. 6d. ($1.61 on the basis of $2.80 per pound sterling). Early in March the quotation rose to 12s. 3d. ($1.72), and another increase to 12s. 9d. ($1.79) was announced in May. This quotation held until the middle of September when the price was raised to 13s. 6d. ($1.89). On December 14 the quotation was 14s. ($1.96), where it remained for the rest of the year.

In Italy the quoted price was 2,250 lire per kilogram at the beginning of the year, or about $1.64 per pound on the basis of $0.001611 per lira. By the end of March the quotation was 2,350 lire ($1.72), and by the middle of the year it was 2,550 lire ($1.86). Continued increases in the price were announced, and by the end of October it was 3,000 lire ($2.19), by November 30, 3,150 lire ($2.30), and at the end of the year 3,200 lire ($2.34).

The French quotation for metal began the year at 17.25 francs, or $1.60 per pound. Several increases brought the price to 20.00 francs ($1.86) by the middle of June. During the last half of the year two more increases brought the quotation to 22.00 francs ($2.05) by the end of the year.

FOREIGN TRADE [3]

Imports.—General imports of cadmium metal were slightly over 1.1 million pounds in 1962 as Canada, Peru and Japan increased their shipments to the United States. Imports from Belgium-Luxembourg, Italy, Angola, and the Republic of the Congo, however, declined. Imports of cadmium contained in flue dust, all from Mexico, decreased to 1.3 million pounds.

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

TABLE 5.—U.S. imports of cadmium metal and cadmium in flue dust, by countries

(Thousand pounds and thousand dollars)

Country	General imports [1]				Imports for consumption [2]			
	1961		1962		1961		1962	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
CADMIUM METAL								
North America: Canada	510	$695	812	$1,194	510	$695	812	$1,194
South America: Peru	104	140	130	176	104	140	130	176
Europe:								
Belgium-Luxembourg	48	67	33	57	48	67	33	57
Italy	44	64	24	37	44	64	23	35
Netherlands			1	2			1	2
Poland and Danzig			4	7			4	7
United Kingdom	(3)	1	(3)	(4)	(3)	1	(3)	(4)
Total	92	132	62	103	92	132	61	101
Asia: Japan	22	31	48	76	22	31	43	69
Africa:								
Angola	66	89	44	63	66	89	44	63
Congo, Republic of the and Ruanda-Urundi	318	430	22	29	285	386	22	29
Total	384	519	66	92	351	475	66	92
Oceania: Australia			5	8			5	8
Total cadmium metal	1,112	1,517	1,123	1,649	1,079	1,473	1,117	1,640
FLUE DUST (CADMIUM CONTENT)								
North America: Mexico	1,812	$948	1,273	$674	239	$112	1,570	$850
Total flue dust	1,812	948	1,273	674	239	112	1,570	850
Grand total	2,924	2,465	2,396	2,323	1,318	1,585	2,687	2,490

[1] Comprises cadmium imported for immediate consumption plus material entering bonded warehouses.
[2] Comprises cadmium imported for immediate consumption plus material withdrawn from bonded warehouses.
[3] Less than 1,000 pounds.
[4] Less than $1,000.

Source: Bureau of the Census.

Exports.—Exports of cadmium as metal and in alloys, dross, flue dust residues, and scrap were 717,000 pounds. The United Kingdom, France, West Germany, Netherlands and Italy received most of these exports.

TABLE 6.—U.S. exports of cadmium metal and cadmium in alloys, dross, flue dust, residues, and scrap

(Thousand pounds and thousand dollars)

Year	Quantity	Value	Year	Quantity	Value
1953-57 (average)	887	$1,283	1960	2,448	$3,014
1958	580	771	1961	702	983
1959	900	1,024	1962	717	1,139

Source: Bureau of the Census.

Tariff.—The import duty on cadmium metal remained at 3.75 cents per pound in 1962—the rate effective January 1, 1948, as established at the Geneva Trade Conference in 1947. Cadmium contained in flue dust remained duty free.

WORLD REVIEW

World production of cadmium metal decreased 3 percent to 25.6 million pounds. Larger output was reported for the United States, Japan, Norway, Poland and the United Kingdom. Production in Canada, Belgium, Republic of the Congo, Australia, West Germany, Italy and Peru declined.

TABLE 7.—World production of cadmium metal, by countries [1] [2]

(Thousand pounds)

Country	1953–57 (average)	1958	1959	1960	1961	1962
North America:						
Canada	1,766	1,756	2,160	2,357	[3] 2,399	2,153
Mexico, refined metal (exports) [4]		14	133	179	104	
United States (primary and secondary metal)	10,059	9,673	8,602	10,180	10,115	10,641
South America: Peru (refined metal) [4]	23	141	141	185	232	220
Europe:						
Austria	[5] 15	25	43	32	42	42
Belgium	[6] 1,276	[6] 1,488	[7] 1,512	[7] 1,583	[7] 1,988	[7] 1,521
France	324	386	539	560	551	551
Germany, West	562	703	926	902	952	560
Italy	445	413	552	638	765	545
Netherlands [6]	[8] 34	88	88	88	88	88
Norway	231	240	234	243	231	254
Poland [6]	528	573	595	620	640	661
Spain	21	14	14	26	76	77
U.S.S.R. [6] [9]	1,499	2,866	3,307	3,748	4,409	4,409
United Kingdom [10]	303	278	310	236	217	237
Yugoslavia	15	55	72	84	[6] 88	[6] 88
Asia: Japan	717	964	1,082	1,251	1,596	1,940
Africa:						
Congo, Republic of the (formerly Belgian)	419	1,080	1,047	1,113	1,168	[6] 992
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia	[5] 121	38		58	42	37
Oceania: Australia	697	791	763	672	685	607
World total (estimate) [1] [2]	19,100	21,600	22,100	24,800	26,400	25,600
The following data are not included in the above table: [4]						
Guatemala (exports) [4] [11]	[5] 95	52		123	94	90
Mexico (exports) [4]	1,930	1,992	2,074	1,201	2,557	[6] 1,389
Peru (exports) [4]	65	50	29	51	57	[6] 55
South West Africa (exports) [4]	1,876	2,688	1,294	1,732	1,747	1,219

[1] Data derived in part from bulletins of the World Non-Ferrous Metal Statistics and annual issues of Metal Statistics (Metallgesellschaft).
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Preliminary figure.
[4] To avoid duplicating figures, data on cadmium exported in zinc concentrates, flue dusts, etc., are not included in the world total, but are shown separately at end of table.
[5] Average for 1956–57.
[6] Estimate.
[7] Exports.
[8] Average for 1954–57.
[9] Data revised in accordance with more recent information.
[10] Including secondary.
[11] Recoverable.

Compiled by Catherine M. Judge, Division of Foreign Activities.

Australia.—The new Imperial process lead-zinc smelter operated by Sulphide Corp., Pty. Ltd., at Cockle Creek near Newcastle has a plant to recover cadmium from sinter-plant fume and a sludge-treatment plant to process residual liquors and sludges from the production units.

Mexico.—Construction of a new government-owned zinc smelter at Saltillo, Coahuila began in May 1962 and was scheduled for completion in late 1964. This plant will be equipped with cadmium recovery facilities.

United Kingdom.—Production of cadmium metal was 237,200 pounds compared with 217,000 pounds in 1961. Imports of metal were 2.6 million pounds. According to a bulletin of World Non-Ferrous Metal Statistics, published by The British Bureau of Non-Ferrous Metal Statistics, cadmium consumption was 2.8 million pounds and was used for the following purposes (in thousand pounds): Plating anodes, 1,256; plating salts, 298; cadmium-copper alloys, 110; other alloys, 76; alkaline batteries, 136; dry batteries, 10; solder, 175; colors, 701; and miscellaneous, 52.

TECHNOLOGY

The analysis for cadmium by titration with sodium selenite was reported to compare favorably with that of the classical gravimetric procedure.[4] A simple and accurate method was developed for the direct determination of cadmium in aluminum alloys by derivative-form polarography.[5]

The development of new brightening agents was reported,[6] which improve covering and throwing power of the plating bath. Embrittlement of high-strength steel induced by plating with tin and cadmium in separate layers was appreciably higher than by codeposition of tin and cadmium from a complex fluoborate bath.[7] Hydrogen embrittlement of steel bolts was reduced by vacuum cadmium plating.[8]

Tests of polycrystalline cadmium and binary solid-solution alloys of cadmium with silver and magnesium over the range from minus 196° to plus 200° C showed that the alloys exhibited plastic properties similar to those of cadmium but their yield and fracture stresses were higher at all temperatures.[9]

New inorganic pigments (maroons, reds, and oranges)—manufactured by adding a solution of mercury sulfide and sodium sulfide to a solution of cadmium sulfate—have greater hiding power and heat stability, are unaffected by alkalis, and show good resistance to or-

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[4] Analytical Abstracts (Cambridge, England). Amperometric Titration of Cadmium With Sodium Selenite. V. 9, No. 1, January 1962, pp. 44–50.

[5] Hine, R. A., F.R.I.C., and J. F. Bates. The Direct Polarographic Determination of Cadmium in Aluminum Alloys. Metallurgia (Manchester, England), v. 65, No. 388, February 1962, pp. 101–103.

[6] Materials in Design Engineering. Two New Brighteners for Cadmium Plating. V. 57, No. 1, January 1963, pp. 176–178.

[7] Beck, Walter, and E. J. Jankowsky. Effect of Binary Alloy Plating on Delayed Brittle Failure of Ultrahigh Strength Steel. Electrochem. Soc., v. 109, No. 6, June 1962, pp. 490–494.

[8] Hood, A. C. Bolts Tame Hydrogen Problem by Vacuum Cadmium Plating. Iron Age, v. 189, No. 4, Jan. 25, 1962, pp. 104–106.

[9] Tegart, W. J. McG. The Tensile Properties of Polycrystalline Cadmium and Some Cadmium Alloys in the Range —196 to 200° C. J. Inst. Metals (London), v. 91, pt. 3, November 1962, pp. 99–104.

ganic and mineral acids of low concentrations.[10] Processes were patented for producing complex cadmium salts, cadmium manganese ferrite,[11] and cadmium sulfoselenide.[12]

An improved process for impregnating nickel-cadmium battery plates makes them capable of achieving higher output per weight.[13] The underlying causes of thermal runaway condition in sealed nickel-cadmium cells with plastic electrodes were analyzed.[14] A long-life, high-capacity silver-cadmium battery well suited for cordless, electrically powered equipment was developed.[15] Pilot plant production was begun on a series of lightweight hermetically-sealed nickel-cadmium storage batteries destined for use in U.S. space ventures.[16] Solid reaction products of nickel-cadmium cells were studied by X-ray techniques and voltage decays were measured in cells stored at temperatures between minus 18° and plus 52° C.[17] The Telstar communications system was powered by a nickel-cadmium battery that was recharged by solar cells.[18] Nickel-cadmium batteries were to supply power for the electronic circuits of Relay, the world's most powerful active repeater, low-altitude communications satellite.[19] A new development in manufacturing silver-cadmium batteries increased available voltage for an extended period of time.[20] The sounding and telemetry transmitters of Canada's first satellite, the Alouette, were powered by 75 pounds of nickel-cadmium batteries.[21] An experimental cadmium-sulfide solar battery can be rolled up. Such batteries might be carried into orbit in a satellite and then unrolled to intercept maximum sunlight.[22]

Airborne reconnaissance capabilities can be improved by newly developed infrared detectors,[23] particularly where low-noise equivalent temperature is required. Cadmium-doped and mercury-doped germanium detectors were produced that provide an ideal combination of characteristics for these applications. Cadmium sulfide detectors were included in the dectector complements of U.S. satellites Injun I and Explorer II. These detectors added to the knowledge of the radiation environment of the earth and should have continued use.[24]

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[10] Chemical Engineering. Chemically Inert Cadmium-Mercury Pigments Offer Heat Stability. V. 69, No. 12, June 11, 1962, p. 112.

[11] Eichbaum, Barlane R. (assigned to International Business Machines Corp.). Cadmium Manganese Ferrospinel Composition. U.S. Pat. 3,028,336, Apr. 3, 1962.

[12] Kaspaul, Alfred F. (assigned to Minnesota Mining and Manufacturing Co.). Electrolytic Preparation of Cadmium Salts. U.S. Pat. 3,051,636, Aug. 28, 1962.

[13] Iron Age. Improved Ni-Cd Battery. .V 189, No. 22, May 31, 1962, p. 125.

[14] Salkind, Alvin J., and Joseph C. Duddy. The Thermal Runaway Condition in Nickel-Cadmium Cells and Performance Characteristics of Sealed Light Weight Cells. J. Electrochem. Soc., v. 109, No. 5, May 1962, pp. 360–364.

[15] Iron Age. Silver-Cadmium Module Offers Design Flexibility. V. 189, No. 25, June 21, 1962, p. 178.

[16] Getler, Michael. New Cells Due for Heavy Space Duty. Missiles and Rockets, v. 10, No. 24, June 11, 1962, pp. 34–35.

[17] Salkind, Alvin J., and Paul F. Bruins. Nickel-Cadmium Cells. J. Electrochem. Soc., v. 109, No. 5, May 1962, pp. 356–360.

[18] Chemical Trade Journal and Chemical Engineer (London). Nickel-Cadmium Batteries. V. 3924, No. 151, Aug. 17, 1962, p. 318.

[19] American Metal Market. Nickel-Cadmium and Silver-Zinc Batteries Play Vital Aerospace Roles. V. 69, No. 242, Dec. 19, 1962, p. 20.

[20] Chemical Week, v. 91, No. 6, Aug. 11, 1962, p. 51.

[21] Mining Journal (London). V. 259, No. 6636, Oct. 26, 1962, p. 393.

[22] Electronics. Cadmium-sulfide Solar Battery is Flexible. V. 35, No. 15, Apr. 13, 1962, p. 76.

[23] Whelen, F. G., and I. E. Distelhorst. Mercury and Cadmium Improve IR Detectors. Electronics, v. 35, No. 32, Aug. 10, 1962, p. 84.

[24] Freeman, John W. Energy Detector for Satellites. Electronics, v. 35, No. 15, Jan. 26, 1962, pp. 42–43.

Air Force research revealed that cadmium sulfide crystals were superior to other compounds for solar energy converters in photovoltaic cells.[25] Cadmium sulfide and cadmium selenide sintered polycrystalline layers were investigated with respect to the transient effects in their photoconductive rise and decay curves.[26] A patent was obtained for the development of a method of making a cadmium telluride semiconductor body containing a portion whose resistivity is at least 10^6 ohm-centimeters.[27] Cadmium sulfide crystals for the detection of gamma radiation were produced and made available for small detectors.[28]

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[25] Iron Age. Solar Cell Materials Rated. V. 190, No. 25, Dec. 20, 1962, p. 89.
[26] Weiss, Ronald D. Transient Effects in Cadmium Sulfide-Cadmium Selenide Type Photoconductors. J. Electrochem. Soc., v. 109, No. 8, August 1962, pp. 683–688.
[27] Dirk de Nobel, Eindhoven, and Ferdinand Anne Kroeger (assigned to North American Philips Co., Inc.). Method of Manufacturing High-Ohmic Cadmium Telluride for Use in Semiconductor Devices or Photo-Sensitive Devices. U.S. Patent 3,033,791, May 8, 1962.
[28] New Scientist (London). Crystal Detectors for Gamma-Rays. V. 14, No. 293, June 28, 1962, p. 707.

Calcium and Calcium Compounds

By C. Meade Patterson [1]

MORE calcium chloride was consumed than ever before as its capacities to melt ice and snow and lay dust won wider recognition in road construction and maintenance. Prospects for domestic calcium production became less favorable after a decline in uranium requirements was anticipated. The announcements of some new calcium-containing alloys were encouraging; perhaps some additional calcium would find its way into ferrous metallurgy.

DOMESTIC PRODUCTION

Nelco Metals, Inc., Canaan, Conn., the only producer of commercial calcium in the United States in 1962, completed its first year under the management of Chas. Pfizer & Co., Inc., New York, N.Y., having been acquired as part of a $13-million transaction completed October 18, 1961.

Shipment of calcium was controlled by Interstate Commerce Commission shipping regulations and came under Yellow Label restrictions. Calcium had always been barred from the U.S. mail because it was a flammable metal. Finely divided calcium ignites in air and burns violently with an orange-red flame; all calcium must be kept away from open fires, and must always be kept dry by storing in sealed containers. Though somewhat less reactive than sodium, calcium will release hydrogen from water on contact, or from adsorbed atmospheric moisture, and the heat of the reaction will ignite the hydrogen.[2]

Union Carbide Metals Co., Division of Union Carbide Corp., New York, N.Y., produced calcium-silicon, an alloy containing 30 to 33 percent calcium and 60 to 65 percent silicon.

Vanadium Corporation of America, New York, N.Y., introduced a calcium-bearing inoculant for the improvement of the mechanical properties of gray iron. The alloy contained calcium, 2 to 3 percent; silicon, 60 to 65 percent; manganese, 9 to 12 percent; barium, 4 to 6 percent; aluminum, 1 to 1.5 percent; and iron, the remainder. It had a bulk density of 115 pounds per cubic foot and a melting point between 2,000° and 2,200° F.[3]

Another calcium-silicon alloy was also introduced by Vanadium Corporation of America. It contained 12 to 16 percent calcium, 55 to

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[1] Commodity specialist, Division of Minerals.
[2] Chas. Pfizer & Co., Inc. Calcium Metal. Data Sheet 573, April 1962, 4 pp.
[3] Foundry. Graphitizing Inoculant. V. 90, No. 7, July 1962, p. 73.

60 percent silicon, 1 to 1.25 percent aluminum, 0.15 to 0.25 percent carbon, and the balance was iron. This alloy was recommended for deoxidizing regular and premium steels as a less expensive substitute for standard 30-percent calcium-silicon. The new alloy had a density 28 percent higher than that of standard calcium-silicon. Consequently, it sunk deeper into the molten steel within the ladle and, in this respect at least, was more effective as a deoxidizing agent and an inclusion-control additive. Its lower calcium content, compared to standard calcium-silicon, resulted in less violence and less fuming when it was added to the ladle during tapping at the rate of 3 to 4 pounds per ton of steel.[4]

Total production of natural and synthetic solid calcium chloride (73 to 75 percent $CaCl_2$) and flake calcium chloride (77 to 80 percent $CaCl_2$) was 558,000 short tons in 1961, and production of calcium chloride brine (40 percent $CaCl_2$) amounted to 227,000 tons, excluding all brine that went into the production of solid and flake calcium chloride. Shipments of natural and synthetic solid and flake, calcium chloride in 1961 were 557,000 tons valued at $15.8 million ($28.37 per ton) f.o.b. plant. Brine shipments amounted to 224,000 tons valued at $2.1 million ($9.38 per ton) f.o.b. plant.[5]

The reported domestic production of natural calcium chloride and calcium-magnesium chloride in all forms converted to the basis of 75 percent chloride and 25 percent water annually averaged 428,000 tons valued at $7.85 million ($18.34 per ton) during the period 1958–62. Production reached an alltime high in 1962. Tonnage increased 14 percent and value increased 12 percent over 1961.

Natural calcium chloride and natural calcium-magnesium chloride were produced by eight plants: Two in California, five in Michigan, and one in West Virginia. Michigan was by far the leading State with 96 percent of the reported domestic production, followed by California with less than 4 percent and West Virginia with less than 1 percent. Output was derived from Bristol Dry Lake in California and from underground saline formations in Michigan and West Virginia. Total domestic production of natural calcium chloride and natural calcium-magnesium chloride was reported as 80 percent flake, less than 20 percent brine, and less than 1 percent solid. Open-market synthetic calcium chloride was manufactured by Allied Chemical Corp., Solvay Process Division; by Pittsburgh Plate Glass Co., Chemical Division; and by Shell Chemical Co. Natural calcium chloride and natural calcium-magnesium chloride constituted 59 percent of the total solid and flake and 64 percent of the total brine produced in 1961.

CONSUMPTION AND USES

Average daily calcium requirements in human diet were set by the Food and Agricultural Organization and the World Health Organization: 400 to 500 milligrams for adults, somewhat more for children, especially those under 1 year and in the age range of 10 to 19 years, and 1,000 to 1,200 milligrams for pregnant and lactating women.

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[4] Blast Furnace and Steel Plant. Calcium-Silicon Alloy Announced. V. 50, No. 9, September 1962, pp. 910–911.

[5] U.S. Department of Commerce, Bureau of the Census, Industry Division. Inorganic Chemicals and Gases, 1961. Current Ind. Rept. Ser. M28A (61)—13, Dec. 7, 1962, p. 10.

Intake of calcium in excess of 1,000 milligrams per day was considered neither harmful nor useful.[6]

The addition of calcium to agricultural land by spreading lime and pulverized limestone was considered a safeguard for protecting growing crops against strontium 90 from fallout. These elements are so similar chemically that plants will absorb strontium whenever they are unable to obtain the necessary calcium from the soil.[7]

The U.S. Atomic Energy Commission used calcium and magnesium to reduce uranium and plutonium compounds to metals, but indications were that the quantity of these reductant metals needed would decline.[8] Wah Chang Corp., Albany, Oreg., used calcium to reduce molybdenum.[9]

The standard deoxidizer for steel was calcium-silicon alloy. It was an additive in ball-bearing steels and in steels of aircraft quality. When added to steel before it solidified, this alloy beneficially altered the shape of inclusions within the steel. Small quantities of calcium-silicon dropped into the ladle produced rounded inclusions that did not break up or string out during rolling. The resulting steel met critical specifications more readily, and most high-quality steels were treated with calcium-silicon.

Calcium-silicon or calcium-manganese-silicon improved iron and steel castings when added to the ladle before pouring. Three to five pounds of either calcium alloy per ton of molten metal provided an effective treatment and reduced sulfur content by 0.002 to 0.004 percent. Deoxidation was promoted, fluidity increased, and ductility of the finished casting improved. Greater fluidity resulted in improved soundness and surface of the casting.[10]

Calcium chloride was a major chemical in road construction and maintenance, being used as a soil stabilizer, a soil solidifier, a deicing compound, and a dust-control agent.[11] More calcium chloride was used on roads in 1962 than for all other uses combined. Highway consumption of calcium chloride was estimated at 534,000 tons. One-half of this total was used in ice and snow removal, and the other half was used in stabilizing unpaved roads and shoulders and in laying dust. The principal ice and snow control chemical continued to be rock salt (sodium chloride), and nearly 2 million tons was used in 1962.[12] It was reported that a carload of concentrated (high-test) flake calcium chloride (94 to 97 percent $CaCl_2$) would generate over 15 million Btu for melting ice and snow when spread on pavements.[13]

Plans were made to spread 1,100 tons of calcium chloride on the 81 miles of Chicago, Ill., expressways during the 1962–63 winter

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[6] New Scientist (London). Calcium Needs Reassessed. V. 15, No. 306, Sept. 27, 1962, p. 689.
[7] Rock Products. V. 65, No. 4, April 1962, p. 14.
[8] Chemical & Engineering News. AEC's Need for Chemicals Due to Decline. V. 40, No. 23, June 4, 1962, p. 14.
[9] Houck, J. A. Review of Recent Developments—Molybdenum and Molybdenum-Base Alloys. Defense Metals Inf. Center, Battelle Memorial Inst., July 6, 1962, p. 1.
[10] Foundry. Calcium Alloys Improve Castings. V. 90, No. 3, March 1962, p. 141.
Union Carbide Metals Review. Calcium Alloys Improve Castings. V. 5, No. 2, Spring-Summer 1962, p. 31.
[11] Chemical Week. Building a Road for Growth. V. 91, No. 22, Dec. 1, 1962, pp. 75, 77, 79, 81.
[12] Chemical & Engineering News. Chemicals Ride U.S. Highway Expansion. V. 40, No. 49, Dec. 3, 1962, pp. 25–26.
[13] Roads and Streets. Heat Melts Ice. V. 105, No. 12, December 1962, p. 26.

for rapid removal of snow and ice without hindering the speed and volume of the traffic.[14]

When calcium chloride was used as a stabilizing agent on gravel-base roads, the costs of road replacement were reduced by as much as $300 per mile.[15]

Heated concrete containing calcium chloride was poured during cold weather in erecting the twin, 588-foot, 60-story, circular towers of Marina City apartments, Chicago, Ill. They were the tallest concrete buildings in the world in 1962.[16]

PRICES AND SPECIFICATIONS

The New York price of calcium, 97 to 98 percent pure, cast in slabs and small pieces, in over 1-ton lots, was quoted at $2.05 per pound during 1962.[17] This nominal price had not changed at least since 1952. The following prices per pound were quoted for smaller quantities throughout 1962: 100 pounds to 1 ton—$2.40, and small lots, 99.9 percent pure—$4.55.[18] AEC raised the price of the radioactive isotope calcium 45.[19]

Chas. Pfizer & Co., Inc., New York, N.Y., offered two grades of calcium produced by its subsidiary, Nelco Metals, Inc., Canaan, Conn. Commercial-grade calcium (99 plus percent Ca) contained the following impurities: Magnesium, not more than 0.50 percent; aluminum, not more than 0.30 percent; nitrogen, not more than 0.08 percent; manganese, not more than 0.01 percent; and iron, not more than 0.008 percent. Redistilled-grade calcium (also designated 99 plus percent Ca) contained lower percentages of impurities than the Commercial-grade calcium: Magnesium, not more than 0.50 percent; nitrogen, less than 0.02 percent; manganese, less than 0.002 percent; aluminum, less than 0.001 percent; iron, less than 0.001 percent; cobalt, less than 0.0002 percent; and boron, less than 0.0001 percent. Commercial-grade calcium was supplied as full crowns, broken crowns (5 inches and smaller), 6-mesh nodules, turnings, ingots, and waffles, in 55-gallon sealed containers that held 200 to 300 pounds of calcium depending upon its physical form. Redistilled-grade calcium was supplied as broken crowns (8 inches and smaller), 6-mesh nodules, and ⅛-inch nodules, in 55-gallon sealed containers that held 200 to 300 pounds of calcium depending upon its physical form.

All calcium chloride prices increased in 1962 except USP granular calcium chloride which remained at $0.32 per pound in drums and purified granular calcium chloride at $0.27 per pound in drums. Prices of various commercial forms of calcium chloride were increased on July 1. The prices of flake, pellet, powdered, and solid calcium chloride were raised $2 per short ton; anhydrous calcium chloride was raised 0.5 cent to 7.5 cents per pound; 40-percent calcium chloride liquor, $1.50 per ton to $14; 30-percent calcium chloride liquor, 69

[14] Calcium Chloride Institute News. V. 12, No. 3, Third Quarter 1962, p. 9.
[15] Manufacturing Chemists' Association. Chemical Industry Facts Book. 1962, p. 21.
[16] Calcium Chloride Institute News. Spectacular Marina City. V. 12, No. 1, First Quarter 1962, p. 8.
[17] E&MJ Metal and Mineral Markets. V. 33, Nos. 1–52, Jan. 4–Dec. 31, 1962.
[18] American Metal Market. V. 69, Nos. 1–249, Jan. 2–Dec. 31, 1962.
[19] Chemical & Engineering News. AEC Has Posted New Prices on Radioisotopes. V. 40, No. 9, Feb. 26, 1962, p. 19.

cents to $5.75 per ton; and 38-percent calcium-magnesium chloride liquor, 75 cents to $6.25 per ton.[20]

Concentrated flake or pellet calcium chloride, 94 to 97 percent $CaCl_2$ (paper bags, carlots, at works, freight equalized), was $39.30 per ton from January 1 until July 1, when it was raised to $41.30 per ton. The price was raised again on October 1 to $41.70 per ton. Regular flake calcium chloride, 77 to 80 percent $CaCl_2$ (paper bags, carlots, at works, freight equalized), was $32 per ton until July 1, when it was raised to $34 per ton. Powdered calcium chloride, 77 percent minimum $CaCl_2$, was $38 per ton (paper bags, carlots, at works, freight equalized) at the beginning of 1962 but increased to $40 per ton on July 1. Solid calcium chloride, 73 to 75 percent $CaCl_2$ (drums, carlots, at works, freight equalized), was $30.50 per ton during the first half of the year but rose to $32.50 per ton July 1. Reporting of solid calcium chloride, 73 to 75 percent $CaCl_2$, in less than carlots (drums, at works, freight equalized), was discontinued after April 9, when the quoted price range was still $36 to $73 per ton, not having changed since February 25, 1957. Calcium chloride liquor or brine, about 40-percent $CaCl_2$, which was a supersaturated solution shipped in heated tank cars, had been $12.50 per ton (tank cars, at works, freight equalized) since February 25, 1957. It was raised to $14 per ton July 1.[21]

According to Chemical & Engineering News,[22] high-test calcium chloride (94 to 97 percent $CaCl_2$) in bulk sold for $34.40 per ton.

A U.S. Department of Justice report on identical bidding for Federal, State, and local Government contracts included calcium chloride among 22 different chemicals named.[23]

FOREIGN TRADE [24]

Imports.—All of the calcium imported in 1962 came from Canada. It amounted to 43,962 pounds valued at $51,669 ($1.18 per pound). Calcium-silicon alloy (also designated calcium silicide) was imported from France (81 percent) and West Germany (19 percent) at an average value of 14.6 cents per pound. Calcium chloride was imported from Belgium-Luxembourg, 38 percent; Canada, 35 percent; United Kingdom, 16 percent; and West Germany, 11 percent, at an average value of $31.52 per short ton.

Exports.—Again in 1962, there were no exports of calcium or calcium-silicon. Calcium chloride was exported mainly to Canada, 89 percent; Mexico, 4 percent; Venezuela, 2 percent; and Netherlands and Uruguay, 1 percent each. The remaining 3 percent was shipped to 37 countries in Asia, South America, Oceania, North America, Europe, and Africa, in order of descending quantities. The average value of exported calcium chloride was $38.49 per short ton.

[20] Oil, Paint and Drug Reporter. V. 181, No. 23, June 4, 1962, p. 28; v. 181, No. 25, June 18, 1962, p. 35.
[21] Oil, Paint and Drug Reporter. V. 181, Nos. 1–26; v. 182, Nos. 1–27; Jan. 1–Dec. 31, 1962.
[22] Chemical & Engineering News. V. 40, No. 44, Oct. 29, 1962, p. 62.
[23] Chemical & Engineering News. V. 40, No. 35, Aug. 27, 1962, p. 19.
[24] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 1.—U.S. imports for consumption of calcium, calcium-silicon, and calcium chloride and exports of calcium chloride

Year	Imports						Exports	
	Calcium		Calcium-silicon		Calcium chloride		Calcium chloride	
	Pounds	Value	Pounds	Value	Short tons	Value	Short tons	Value
1953–57 (average)	418,565	$524,513	312,171	$48,738	1,981	$66,083	24,758	$807,443
1958	15,694	24,084	130,866	25,111	1,234	45,977	37,632	1,325,460
1959	7,425	7,506	918,556	138,188	1,756	66,499	39,929	1,376,854
1960	12,618	15,276	352,765	50,899	1,570	61,938	26,792	1,067,909
1961	17,266	22,892	558,009	82,561	3,022	102,680	22,047	1,090,583
1962	43,962	51,669	1,370,048	200,163	1,896	59,753	43,830	1,686,819

Source: Bureau of the Census.

WORLD REVIEW

Canada.—Calcium production was 72,597 pounds valued at Can$76,359 (Can$1.05 per pound) in 1961, compared with 134,801 pounds, valued at Can$159,241 (Can$1.18 per pound) in 1960. The only producer was Dominion Magnesium, Ltd., Haley, Ontario. This company organized in 1941 had been the sole Canadian producer since 1945. Calcium was produced by the thermal reduction of quicklime (calcium oxide) with powdered aluminum in a vacuum. Virtually all of the output was exported. During the first 10 months of 1961, exports of calcium amounted to 71,700 pounds valued at Can$77,767 (Can$1.08 per pound). Belgium-Luxembourg received 37 percent; United States, 27 percent (19,600 pounds valued at Can$23,890 or Can$1.22 per pound); West Germany, 14 percent; India and the United Kingdom, 9 percent each; and all other countries, 4 percent. The prices quoted by Dominion Magnesium, Ltd., throughout 1961 ranged from 80 cents per pound for Commercial grade (98 percent Ca) to Can$1.40 per pound for Chemical Standard grade (nominally 99.9 percent Ca). The U.S. tariff on imported Canadian calcium was reduced from 17.5 percent ad valorem to 15.5 percent ad valorem on July 1, 1962. The Canadian most-favored-nation tariff on calcium was 15 percent ad valorem.[25]

Allied Chemical Canada Ltd., Montreal, Quebec (Canadian subsidiary of Allied Chemical Corp.), tried to eliminate the end-use qualification that permitted a special tariff for the most-favored nation on calcium chloride used in road treatment. Road use accounted for 75 percent of the sales of the company's Solvay plant at Amherstburg, Ontario. The regular tariff on calcium chloride was $3 per short ton, but 15 percent ad valorem if destined for road treatment. It was suggested that this end-use item be eliminated and that the tariff be raised to 20 percent ad valorem for all calcium chloride imported from the most-favored nation. The United States came under the most-favored-nation tariff, which was generally higher than the British preferential tariff. The total value of calcium chloride imported into Canada from the United States in 1961 was reported as Can$830,000.[26]

[25] Jackson, W. H. Calcium 1961. Canada Dept. Mines and Tech. Surveys, Min. Res. Div., Ottawa, April 1962, 3 pp.
[26] Chemical Week. Canadian Tariffs. V. 91, No. 12, Sept. 22, 1962, pp. 46, 54.

Western Chemicals Ltd., Edmonton, Alberta, built a calcium chloride plant near Two Hills, Alberta where its 67-ton-per-day caustic soda plant was located.[27]

India.—Three plants produced 754 short tons of calcium chloride in 1961.[28]

Israel.—Reserves of calcium chloride in the Dead Sea were estimated to be 6 billion tons.[29]

TECHNOLOGY

Calcium was produced by the electrolysis of a molten bath consisting of 40 to 60 percent calcium chloride and the remainder barium chloride. The temperature was maintained above the melting point of the bath and below the melting point of calcium, which accumulated as a solid deposit on a submerged cathode. Calcium was collected from the cathode.[30]

The United Kingdom Atomic Energy Authority and Elgar Trading Ltd., jointly developed a method of producing calcium electrolytically from a fused mixture of calcium sulfide and calcium chloride between a graphite anode and a molten cathode alloy of calcium and copper. As the calcium-copper alloy became enriched in calcium from the bath, it was continuously drawn up under vacuum to a heated still head where some of the calcium it contained was distilled off and collected on a condenser in the still head. After a quantity of calcium had been deposited on the condenser, the vacuum was broken, the calcium-depleted alloy flowed back into the cathode pool, and the calcium was removed from the cooled condenser. This was a continuous method of forming calcium-copper alloy from calcium sulfide and a semi-continuous method of extracting calcium from the alloy.[31]

Applying mixtures of calcium chloride and salt on Springfield, Mass., streets had reduced by 50 percent the amount of sand needed in winter maintenance. As a result, less sand had to be cleaned from streets, gutters, and catch basins in the spring.[32]

The Garden State Parkway in New Jersey employed two supplementary procedures for melting snow and ice: When the air temperature was 25° F or above and rising, 600 pounds of salt was spread per mile of 2-lane roadway; when the air temperature was below 25° F and falling, 600 to 800 pounds of a mixture of salt and calcium chloride was spread per mile of 2-lane roadway. The weight ratio of salt to calcium chloride in the mixture was 5:1.[33]

A major objection to using calcium chloride and sodium chloride for melting snow and ice on roads had been the corrosion of automobiles. This objection was refuted by the Detroit (Michigan) Engi-

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[27] Chemical Engineering. V. 69, No. 8, Apr. 16, 1962, p. 215.
[28] U.S. Consulate, Bombay, India. State Department Dispatch 428. June 29, 1962, encl. 1, p. 1.
[29] Chemical Engineering. Chemicals Loom Big in Israel's Economy. V. 70, No. 2, Jan. 21, 1963, pp. 50–52.
[30] Cobel, George B., and Paul R. Juckniess (assigned to The Dow Chemical Co., Midland, Mich.). Calcium Metal Production. U.S. Pat. 3,043,756, July 10, 1962.
[31] Chemical Trade Journal and Chemical Engineer (London). Pure Calcium Production. V. 150, No. 3914, June 8, 1962, p. 1145.
Chemical & Process Engineering (London). Pure Calcium. V. 43, No. 9, September 1962, p. 466.
[32] Calcium Chloride Institute News. New England Public Works Officials Confer on Winter Maintenance. V. 12, No. 2, Second Quarter 1962, p. 5.
[33] Calcium Chloride Institute News. Toll Road Engineers Confer on Winter Maintenance. V. 12, No. 1, First Quarter 1962, pp. 6–7.

neering Society whose studies revealed that 95 percent of automobile corrosion must be attributed to factors other than road salts. Regular periodic washing of automobiles following winter driving was recommended by the Calcium Chloride Institute, Washington, D.C., to prevent road-salt corrosion.[34]

The Iowa Highway Commission spread an average of 5.25 tons of calcium chloride per mile (1 pound per square yard of unpaved road surface) on 26 miles of institutional and park roads in 42 counties in 1961 to control dust. The cost of this first application amounted to $275 per mile for material and $75 per mile for labor. It was decided to treat these same roads every spring with calcium chloride.[35]

Field tests on a gravel road and on a limestone road indicated that a 1:1 mixture of calcium chloride and sodium chloride was essentially equivalent in dust-laying capacity to the same weight of calcium chloride. One pound per square yard of the mixture was spread on some sections of the roads, and 1 pound per square yard of calcium chloride was spread on other sections of the roads. Flake calcium chloride, pelletized calcium chloride, evaporated salt, and rock salt were used in the experiments. Substituting salt for one-half of the calcium chloride resulted in a saving without any apparent reduction in the effectiveness of the dust control.[36]

Another substitute for calcium chloride on unpaved roads appeared in some areas. Some paper mills in Wisconsin had started collecting waste sulfite pulping liquor, instead of dumping it into streams, and selling it as a binder for unpaved roads. Maine paper mills followed this example, and nearly 6 million gallons of waste liquor was spread on gravel roads in Maine in 1961. Thus, waste liquor was being used beneficially, no longer were streams being polluted, and a serious disposal problem had been solved. Waste liquor was less expensive than calcium chloride, and some considered it superior to calcium chloride as a binder on unpaved roads.[37]

Algin gel, a fire-retardant chemical, was prepared by adding a small quantity of an aqueous calcium chloride solution to algin-thickened water. Varying the calcium chloride content slightly had a pronounced effect on the viscosity of the resulting gel. Algin-thickened water was one of three firefighting chemicals employed by the U.S. Forest Service, and the use of algin gel was under consideration. Calcium chloride-thickened algin solutions clogged firefighting equipment, however, unless flushed out following use.[38]

Calcium chloride brine was one of the refrigerants that International Minerals & Chemical Corp. employed underground to freeze unstable strata to enable sinking a shaft through them to reach the large potash deposit more than 3,000 feet deep at Esterhazy, Saskatchewan, Canada.[39]

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[34] Calcium Chloride Institute News. V. 12, No. 3, Third Quarter 1962, p. 2.

[35] Calcium Chloride Institute News. Iowa State Parks Solve Dust Problem. V. 12, No. 1, First Quarter 1962, p. 9.

[36] Fiedelman, H. W., R. E. Erikson, and W. R. Geisz. Using a Sodium Chloride-Calcium Chloride Mixture for Dust Control. American Road Builder, v. 39, No. 11, November 1962, pp. 6–7.

[37] Chemical Engineering. Highways, Not Rivers, Absorb Paper Mill Waste. V. 69, No. 11, Apr. 28, 1962, p. 84.

[38] Chemical & Engineering News. Fire-Fighting Chemicals List Grows. V. 40, No. 51, Dec. 17, 1962, pp. 57–58, 61.

[39] Thut, A. B. International Minerals Conquers High-Pressure Water and Quickstand to Sink Canadian Potash Shaft. Min. World, v. 24, No. 12, November 1962, pp. 20–24.

Cement

By J. M. West [1] and Ardell H. Lindquist [2]

CONSTRUCTION sent cement production and shipments above the 1961 figures and 1962 became the second highest year exceeded only by 1959. A new monthly high in portland cement shipments of 40.4 million barrels was attained in August.

TABLE 1.—Salient cement statistics [1]

	1953–57 (average)	1958	1959	1960	1961	1962
United States:						
Production____thousand barrels__	[2] 302,142	321,490	350,419	328,715	332,558	345,567
Capacity used at portland cement mills____________percent__	88.6	77.3	80.5	73.5	73.1	71.5
Shipments from mills thousand barrels__	[2] 297,628	317,263	346,675	321,646	329,443	340,770
Value [3]__________thousands__	[2] $878,569	$1,038,672	$1,144,867	$1,089,134	$1,105,537	$1,129,387
Average value____per barrel__	$2.95	$3.27	$3.30	$3.39	$3.36	$3.31
Stocks Dec. 31: At mills thousand barrels__	20,900	30,664	31,437	35,660	[4] 36,415	38,435
Imports for consumption__do____	2,988	3,390	5,265	4,108	3,621	5,759
Exports__________________do____	1,903	641	277	187	286	380
Consumption, apparent [5]__do____	298,713	320,012	351,663	325,567	332,778	346,149
World: Production___________do____	1,260,407	[4] 1,555,541	[4] 1,725,407	[4] 1,853,533	[4] 1,967,606	2,095,654

[1] Barrel as used in this chapter, unless otherwise stated, refers to a 376-pound barrel.
[2] Portland cement, 1953–57; and masonry and natural cement 1955–57.
[3] Value received f.o.b. mill, excluding cost of containers.
[4] Revised figure.
[5] Quantity shipped plus imports minus exports.

Plans were made for approximately 25 million barrels of new annual cement capacity, including construction of six plants and expansion of eight existing plants. At least 25 distribution centers were completed or under construction and 15 others were planned.

Changes in cement distribution patterns and customer services were viewed with mixed concern.[3] Generally the customer benefited from improved supply services.

Three classes of hydraulic cement were produced domestically—portland, natural, and slag. Many plants also produced prepared masonry cements.

LEGISLATION AND GOVERNMENT PROGRAMS

Following investigations by the U.S. Treasury Department, charges were brought against importation of cement from the Dominican

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.
[3] Bell, Joseph N. Revolution in Cement Distribution. Rock Products, v. 65, No. 5, May 1962, pp. 104–109.
Chemical Week. Bold New Bid for Cement Sales. V. 91, No. 19, Nov. 10, 1962, pp. 89–92, 95.
MacDougall, A. Kent. Cement Producers Offer Better Service in Struggle for Sales. Wall Street J., v. 160, No. 38, Aug. 23, 1962, pp. 1, 6.

Republic under the Anti-Dumping Act; but in April the U.S. Tariff Commission ruled the sales were not injurious to the domestic cement industry. The Treasury dropped charges of Belgian cement dumping. Action on charges against cement imports from Poland were pending at yearend.

PORTLAND CEMENT

PRODUCTION AND SHIPMENTS

Production of portland cement rose 4 percent above the 324 million barrels produced in 1961 and was only 2.6 million barrels below the record high in 1959. In 1962, 99 of the 175 plants producing in 1961 had greater outputs. Four new portland cement plants reported production during 1962. These were at Redding, Calif. (Calaveras Cement Co., Division of The Flintkote Co.), Houston, Tex. (Gulf Coast Portland Cement Co., Division of McDonough Co.), Logansport, Ind. (Louisville Cement Co., Inc.), and Ravena, N.Y. (Atlantic Cement Co.). New plants were under construction at Atlanta, Ga., Joppa, Ill., Helena, Mont., Castle Hayne, N.C., and Amarillo, Tex. Plans were announced to build plants at New Orleans, La., and at an undesignated site in central Florida.

Descriptions were published of equipment installed as part of expansion plans or in new cement plants at Redding, Calif.,[4] Dixon, Ill.,[5] Mitchell, Ind.,[6] Wyandotte, Mich.,[7] Ravena, N.Y.,[8] Dallas Tex.,[9] South Norfolk, Va.,[10] Bellingham, Wash.,[11] and Laramie, Wyo.[12]

The California cement industry was described.[13]

Number of portland cement plants in the United States (including Puerto Rico) in 1962, by size groups

Estimated annual capacity, Dec. 31, million barrels:	*Number of plants*	*Percent of total capacity*
Less than 1	7	1.1
1 to 2	58	18.7
2 to 3	64	32.9
3 to 4	28	19.5
4 to 5	11	10.0
5 to 11	11	17.8
Total	[1]179	100.0

[1] Includes one nonproducing plant in standby condition.

[4] Torgerson, Ralph S. Automation Guarantees Quality. Rock Products, v. 65, No. 5, May 1962, pp. 111–117.
[5] Herod, Buren C. Medusa Modernized Centralized Control and Kiln Feed Handling. Pit and Quarry, v. 55, No. 1, July 1962, pp. 108–120, 172.
Levine, Sidney. Medusa's Largest Plant Adds Processing Flexibility. Nonmet. Min. Proc., v. 3, No. 8, August 1962, pp. 14–19.
Rock Products. Medusa's Modernization Matures. V. 65, No. 9, September 1962, pp. 89–96.
[6] Herod, Buren C. Lehigh's Third-Generation Indiana Mill. Pit and Quarry, v. 55, No. 4, October 1962, pp. 94–103.
[7] Perry, Wesley, Jr. Revamped Wet Process is Boosting Cement Yield. Chem. Eng., v. 70, No. 16, Aug. 6, 1962, pp. 100–102.
[8] Pit and Quarry. On Schedule-Construction Progress at Atlantic's Ravena Plant. V. 55, No. 1, July 1962, pp. 125, 126.
[9] Trauffer, Walter E. Texas Industries Cement Plant. Pit and Quarry, v. 54, No. 9, March 1962, pp. 94–100.
[10] Trauffer, Walter E. Lone Star Builds New Plant Beside Old Operation at Norfolk. Pit and Quarry, v. 55, No. 1, July 1962, pp. 128–151.
[11] Utley, Harry F. Pipelines for Permanente. Pit and Quarry, v. 54, No. 7, January 1962, pp. 159–161, 170.
[12] Wyoming Natural Resource Board, Cheyenne. Monolith Cement in Wyoming. Wyoming Progress Reports, v. 2, No. 6, September 1962, 4 pp.
[13] Bowen, Oliver E., and Cliffton H. Gray, Jr. The Portland Cement Industry in California—1962. Calif. Div. of Mines and Geol., Min. Inf. Service, pt. I, v. 15, No. 7, July 1962, pp. 1–7; pt. II, v. 15, No. 8, August 1962, pp. 1–11.

TABLE 2.—Finished portland cement produced, shipped, and in stock in the United States,[1] by districts

District	Active plants		Production			Shipments from mills								Stocks at mills Dec. 31		
			Thousand barrels		Change from 1961 (percent)	1961			1962					Thousand barrels		Change from 1961 (percent)
						Thousand barrels	Value		Thousand barrels	Value		Change from 1961 (percent) in—				
	1961	1962	1961	1962			Total	Average per barrel		Total	Average per barrel	Barrels	Average value	1961[2]	1962	
New York, Maine	12	13	18,061	20,133	+11	18,189	$61,982	$3.41	19,083	$63,344	$3.32	+5	−3	2,728	3,708	+36
Eastern Pennsylvania	17	17	29,027	31,778	+9	29,236	99,230	3.39	30,974	103,083	3.33	+6	−2	3,879	4,545	+17
Western Pennsylvania	5	5	7,564	7,777	+3	7,399	25,276	3.42	7,489	24,886	3.32	+1	−3	1,475	1,632	+11
Maryland, West Virginia	4	4	8,703	9,825	+13	8,588	28,727	3.34	9,611	32,002	3.33	+12	--------	896	909	+1
Ohio	10	10	15,059	15,465	+3	15,303	53,251	3.48	15,353	51,006	3.32	--------	−5	1,695	1,780	+5
Michigan	9	9	21,661	23,070	+7	21,948	75,172	3.43	22,682	73,267	3.23	+3	−6	2,773	3,161	+14
Indiana, Kentucky, Wisconsin	7	8	20,052	18,596	−7	18,692	63,410	3.39	17,905	59,219	3.31	−4	−2	2,573	2,378	−8
Illinois	4	4	8,757	9,081	+4	8,595	28,301	3.29	9,145	30,205	3.30	+6	--------	1,240	1,053	−15
Tennessee	6	6	8,729	8,845	+1	8,357	26,964	3.23	8,509	27,741	3.26	+2	+1	802	850	+6
Virginia, South Carolina	4	4	8,063	8,320	+3	8,064	27,261	3.38	8,271	27,461	3.32	+3	−2	716	765	+7
Georgia, Florida	6	6	10,928	10,842	−1	10,841	36,497	3.37	10,526	36,152	3.43	−3	+2	913	1,179	+29
Alabama	8	8	12,837	12,914	+1	12,445	39,027	3.13	12,482	40,164	3.22	--------	+3	1,162	1,191	+2
Louisiana, Mississippi	5	5	6,615	7,875	+19	6,536	20,693	3.17	7,751	24,535	3.17	+19	--------	736	802	+9
Minnesota, South Dakota, Nebraska	4	4	8,740	8,440	−3	8,650	28,382	3.28	8,430	28,643	3.40	−3	+4	1,097	1,077	−2
Iowa	5	5	12,786	11,869	−7	12,108	41,718	3.45	12,261	42,417	3.46	+1	--------	1,890	1,367	−28
Missouri	5	5	11,940	12,239	+3	11,839	41,142	3.48	12,739	44,004	3.45	+8	−1	1,900	1,344	−29
Kansas	6	6	8,329	8,235	−1	8,028	25,605	3.19	8,058	25,134	3.12	--------	−2	1,358	1,504	+11
Oklahoma, Arkansas	6	6	9,094	9,589	+5	8,940	27,825	3.11	9,311	27,071	2.91	+4	−6	975	1,222	+25
Texas	16	17	24,889	26,443	+6	25,101	80,808	3.22	26,204	83,162	3.17	+4	−2	2,241	2,473	+10
Wyoming, Montana, Idaho	3	3	2,787	3,062	+10	2,803	10,191	3.64	3,054	11,003	3.60	+9	−1	295	303	+3
Colorado, Arizona, Utah, New Mexico	7	7	13,730	13,565	−1	13,605	46,128	3.39	13,762	45,695	3.32	+1	−2	1,127	930	−17
Oregon, Washington	9	9	7,413	7,191	−3	7,386	25,832	3.50	7,081	24,971	3.53	−4	+1	974	1,080	+11
Northern California	5	6	16,911	17,340	+3	16,944	54,698	3.23	17,345	57,297	3.30	+2	+2	1,223	1,218	--------
Southern California	8	7	24,254	26,489	+9	24,146	75,138	3.11	26,322	81,854	3.11	+9	--------	1,516	1,683	+11
Hawaii	2	2	1,115	1,140	+2	1,077	5,574	5.18	1,128	6,055	5.37	+5	+4	191	203	+6
Puerto Rico	2	2	6,070	6,365	+5	5,931	16,946	2.86	6,347	20,018	3.15	+7	+10	204	222	+9
Total	175	178	324,114	336,488	+4	[3] 320,751	1,065,778	3.32	[3] 331,823	1,090,389	3.29	+3	−1	36,579	38,579	+5

[1] Includes Puerto Rico.
[2] Incorporates some revisions.
[3] Does not include finished cement used in manufacturing prepared masonry cement as follows: 1961, 2,642,000; 1962, 2,665,000 barrels.

TABLE 3.—Production, shipments from mills, and stocks at mills of finished portland cement in the United States [1] in 1962, by months [2] and districts

(Thousand barrels)

District	January	February	March	April	May	June	July	August	September	October	November	December
Production:												
New York, Maine	1,157	926	983	1,337	1,907	2,040	2,077	2,323	2,063	2,110	1,689	1,599
Eastern Pennsylvania	1,923	1,666	1,863	2,699	3,201	3,085	3,136	3,200	2,824	2,928	2,731	2,547
Western Pennsylvania	342	49	515	697	723	853	812	935	937	930	749	228
Maryland, West Virginia	642	187	529	894	1,055	1,111	1,057	943	997	1,039	844	537
Ohio	545	515	623	1,160	1,605	1,849	1,702	1,881	1,935	1,552	1,441	660
Michigan	606	491	636	1,871	2,625	2,433	2,777	3,100	2,727	2,506	2,100	1,255
Indiana, Kentucky, Wisconsin	486	467	790	1,563	2,049	2,109	2,238	2,325	1,944	2,132	1,510	974
Illinois	461	224	417	690	930	920	845	1,095	981	920	942	643
Tennessee	439	466	630	759	845	825	807	908	859	911	749	621
Virginia, South Carolina	453	446	516	602	824	856	768	902	889	825	728	511
Georgia, Florida	814	787	833	961	1,119	818	864	995	1,018	1,032	891	711
Alabama	723	874	1,053	1,107	1,263	1,107	1,037	1,252	1,239	1,149	1,118	920
Louisiana, Mississippi	280	366	483	734	744	764	747	804	803	776	726	641
Minnesota, South Dakota, Nebraska	215	138	315	523	918	830	1,014	1,159	1,057	1,028	687	521
Iowa	693	485	172	715	1,167	1,282	1,278	1,321	1,408	1,469	1,029	840
Missouri	255	504	689	967	1,230	1,258	1,406	1,294	1,339	1,384	1,083	820
Kansas	311	197	536	872	927	677	687	945	854	836	758	617
Oklahoma, Arkansas	411	665	786	704	871	927	794	930	885	972	964	671
Texas	1,540	1,999	2,397	2,300	2,550	2,205	2,401	2,439	2,128	2,449	2,181	1,743
Wyoming, Montana, Idaho	78	102	110	267	334	330	331	376	374	340	228	190
Colorado, Arizona, Utah, New Mexico	747	690	924	1,320	1,439	1,275	1,231	1,252	1,178	1,283	1,159	1,067
Oregon, Washington	390	328	562	641	604	611	705	768	718	745	686	428
Northern California	1,235	896	1,233	1,534	1,673	1,248	1,671	1,898	1,696	1,496	1,411	1,331
Southern California	1,785	1,228	2,227	2,493	2,417	2,313	2,430	2,437	2,192	2,472	2,236	2,268
Hawaii	41	100	115	141	150	59	54	98	98	88	130	66
Puerto Rico	479	513	517	538	549	519	519	552	526	554	569	531
Total:												
1962	17,051	15,309	20,454	28,089	33,719	32,304	33,388	36,132	33,669	33,926	29,339	22,940
1961	16,744	15,038	21,851	26,463	31,102	31,594	32,511	33,262	31,474	32,348	27,625	23,393
Shipments:												
New York, Maine	735	635	946	1,545	2,009	2,087	2,261	2,450	2,013	2,076	1,509	1,045
Eastern Pennsylvania	1,335	1,148	1,981	2,844	3,295	3,212	3,348	3,592	3,014	3,301	2,606	1,289
Western Pennsylvania	205	197	351	541	841	855	898	1,065	809	903	616	209
Maryland, West Virginia	429	335	603	799	1,086	1,029	985	1,079	855	1,167	823	420
Ohio	314	362	620	1,183	1,607	1,825	1,654	1,996	1,750	1,865	1,267	417
Michigan	484	487	775	1,587	2,326	2,877	2,954	3,433	2,734	2,926	1,910	746
Indiana, Kentucky, Wisconsin	404	533	829	1,401	1,779	2,120	2,109	2,581	2,057	2,079	1,394	618
Illinois	122	175	341	639	966	1,092	1,089	1,504	1,120	964	790	322
Tennessee	327	469	643	739	899	783	860	1,014	817	948	624	372
Virginia, South Carolina	366	465	604	726	881	770	858	941	774	847	658	381
Georgia, Florida	745	811	902	948	1,014	884	919	966	795	1,054	825	662
Alabama	637	881	1,047	1,049	1,218	1,076	1,178	1,314	1,075	1,289	926	724

Louisiana, Mississippi	372	464	599	573	729	761	836	870	773	759	567	449
Minnesota, South Dakota, Nebraska	112	130	215	638	760	928	1, 143	1, 404	1, 160	1, 155	589	196
Iowa	161	191	303	766	1, 261	1, 606	1, 486	1, 959	1, 705	1, 595	874	354
Missouri	189	378	579	982	1, 287	1, 335	1, 601	1, 698	1, 392	1, 562	1, 217	519
Kansas	177	330	520	839	849	766	783	959	738	957	714	425
Oklahoma, Arkansas	355	600	781	764	896	813	886	1, 027	771	1, 041	810	567
Texas	1, 438	2, 122	2, 497	2, 132	2, 789	2, 087	2, 309	2, 538	2, 010	2, 450	2, 041	1, 769
Wyoming, Montana, Idaho	68	91	138	291	313	313	344	410	386	369	213	119
Colorado, Arizona, Utah, New Mexico	616	739	1, 043	1, 328	1, 415	1, 322	1, 324	1, 432	1, 223	1, 367	1, 086	867
Oregon, Washington	409	414	532	689	656	600	619	836	657	679	545	442
Northern California	1, 135	673	1, 255	1, 590	1, 343	1, 244	1, 883	2, 144	1, 599	1, 750	1, 616	1, 111
Southern California	1, 801	1, 118	2, 297	2, 485	2, 525	2, 341	2, 384	2, 518	2, 132	2, 482	2, 195	2, 044
Hawaii	89	88	97	95	105	110	98	98	80	99	93	77
Puerto Rico	500	503	579	506	549	513	534	569	460	571	599	465
Total:												
1962	13, 525	14, 339	21, 077	27, 679	33, 398	33, 349	35, 343	40, 397	32, 899	36, 255	27, 107	16, 609
1961	14, 174	14, 351	21, 884	24, 531	31, 030	33, 739	31, 753	37, 106	33, 204	35, 410	25, 446	17, 323
Stocks (end of month):												
New York, Maine	2, 909	3, 187	3, 218	3, 002	2, 890	2, 747	2, 551	2, 413	2, 477	2, 477	3, 073	3, 620
Eastern Pennsylvania	4, 458	4, 969	4, 844	4, 677	4, 571	4, 429	4, 194	3, 771	3, 555	3, 160	3, 275	4, 529
Western Pennsylvania	1, 608	1, 460	1, 614	1, 756	1, 622	1, 605	1, 504	1, 359	1, 476	1, 489	1, 614	1, 632
Maryland, West Virginia	1, 098	946	853	927	875	939	990	831	950	803	808	909
Ohio	1, 927	2, 081	2, 063	1, 990	1, 932	1, 907	1, 867	1, 684	1, 757	1, 360	1, 517	1, 760
Michigan	2, 859	2, 863	2, 739	3, 120	3, 493	3, 092	2, 993	2, 726	2, 837	2, 463	2, 678	3, 187
Indiana, Kentucky, Wisconsin	2, 628	2, 515	2, 432	2, 494	2, 664	2, 571	2, 608	2, 246	2, 058	2, 028	2, 070	2, 375
Illinois	1, 571	1, 614	1, 677	1, 716	1, 662	1, 478	1, 230	813	666	608	745	1, 062
Tennessee	905	890	851	841	756	776	688	560	577	509	609	840
Virginia, South Carolina	803	784	697	573	516	601	511	471	586	564	635	765
Georgia, Florida	981	953	877	885	987	913	854	882	1, 101	1, 074	1, 136	1, 179
Alabama	1, 224	1, 191	1, 160	1, 174	1, 181	1, 171	992	894	1, 026	853	1, 016	1, 192
Louisiana, Mississippi	643	543	420	574	586	580	485	419	448	447	617	803
Minnesota, South Dakota, Nebraska	1, 206	1, 213	1, 313	1, 176	1, 334	1, 236	1, 107	891	794	666	758	1, 078
Iowa	2, 443	2, 729	2, 590	2, 524	2, 406	2, 067	1, 845	1, 202	878	742	884	1, 367
Missouri	1, 964	2, 088	2, 195	2, 175	2, 112	2, 026	1, 830	1, 429	1, 372	1, 187	1, 045	1, 344
Kansas	1, 480	1, 346	1, 362	1, 395	1, 473	1, 373	1, 276	1, 253	1, 386	1, 267	1, 312	1, 504
Oklahoma, Arkansas	1, 041	1, 102	1, 107	1, 044	1, 016	1, 128	1, 032	930	1, 042	972	1, 118	1, 222
Texas	2, 361	2, 237	2, 137	2, 302	2, 129	2, 262	2, 366	2, 286	2, 386	2, 419	2, 530	2, 503
Wyoming, Montana, Idaho	305	316	289	265	286	304	291	257	245	216	231	302
Colorado, Arizona, Utah, New Mexico	1, 257	1, 208	1, 096	1, 082	1, 105	1, 059	966	786	741	657	730	929
Oregon, Washington	956	870	900	852	799	808	894	825	887	954	1, 094	1, 080
Northern California	1, 339	1, 563	1, 540	1, 484	1, 814	1, 818	1, 607	1, 361	1, 458	1, 205	1, 000	1, 219
Southern California	1, 500	1, 609	1, 538	1, 547	1, 439	1, 411	1, 448	1, 367	1, 427	1, 417	1, 459	1, 683
Hawaii	143	156	174	220	265	214	170	170	188	177	214	203
Puerto Rico	183	193	131	163	163	169	154	138	204	187	156	222
Total:												
1962	39, 792	40, 626	39, 817	39, 958	40, 076	38, 684	36, 453	31, 964	32, 522	29, 901	32, 324	38, 509
1961	37, 939	38, 531	38, 237	39, 999	39, 789	37, 346	37, 889	33, 768	31, 785	28, 437	30, 382	[3] 36, 343

[1] Includes Puerto Rico.
[2] Difference between monthly and annual reports not adjusted.
[3] Revised figure.

TABLE 4.—Portland cement produced and shipped in the United States,[1] by types

Type and year	Active plants	Production (thousand barrels)	Shipments: Thousand barrels	Value: Total (thousands)	Value: Average per barrel
General-use and moderate-heat (types I and II):					
1953–57 (average)	159	263,608	260,037	$749,486	$2.88
1958	167	[2] 291,688	287,377	922,921	3.21
1959	171	[2] 316,600	312,970	1,012,836	3.24
1960	175	[2] 297,279	290,968	962,453	3.31
1961	174	[2] 302,107	298,616	980,371	3.28
1962	177	[2] 313,888	309,784	1,004,793	3.24
High-early-strength (type III):					
1953–57 (average)	104	10,971	10,620	35,799	3.37
1958	120	[3] 12,161	12,274	45,107	3.67
1959	129	[3] 14,439	14,363	53,484	3.72
1960	135	[3] 13,961	13,772	51,731	3.76
1961	135	[3] 13,530	14,305	53,000	3.71
1962	141	[3] 14,958	14,597	53,576	3.67
Low-heat (type IV):					
1953–57 (average)	1	62	46	145	3.15
1958	2	7	9	35	3.90
1959	3	10	10	46	4.44
1960	3	7	8	32	4.07
1961	2	18	14	60	4.23
1962	2	----------	9	37	4.45
Sulfate-resisting (type V):					
1953–57 (average)	6	114	112	415	3.71
1958	9	244	205	767	3.75
1959	11	189	192	743	3.86
1960	14	445	435	1,664	3.83
1961	13	931	416	1,608	3.87
1962	11	236	244	1,048	4.29
Oil-well:					
1953–57 (average)	16	1,713	1,705	5,560	3.26
1958	15	983	1,058	3,739	3.54
1959	16	1,288	1,182	4,121	3.49
1960	14	1,055	1,059	3,669	3.46
1961	14	1,015	1,235	4,181	3.39
1962	13	1,281	1,215	4,140	3.41
White:					
1953–57 (average)	4	1,135	1,121	6,540	5.83
1958	4	[4] 1,377	1,237	8,001	6.47
1959	4	[4] 1,525	1,515	9,819	6.48
1960	4	[4] 1,504	1,384	9,274	6.70
1961	5	[4] 1,647	1,532	10,387	6.78
1962	5	[4] 1,726	1,668	11,690	7.01
Portland-slag and portland pozzolan:					
1953–57 (average)	9	4,376	4,292	12,782	2.98
1958	11	[5] 4,096	3,977	13,632	3.43
1959	8	[5] 3,653	3,806	12,864	3.38
1960	7	[5] 3,630	3,525	12,057	3.42
1961	8	[5] 3,586	3,316	11,179	3.37
1962	7	[5] 2,848	2,868	9,524	3.32
Miscellaneous:[6]					
1953–57 (average)	23	1,364	1,151	4,080	3.54
1958	21	[4] 915	931	3,499	3.76
1959	22	[4] 1,387	1,414	5,331	3.77
1960	20	[4] 1,128	1,141	4,366	3.83
1961	19	[4] 1,280	1,317	4,992	3.79
1962	19	[4] 1,551	1,438	5,581	3.88
Grand total:					
1953–57 (average)	159	289,770	285,378	831,326	2.91
1958	[7] 168	311,471	307,068	997,701	3.25
1959	[7] 172	339,091	335,452	1,099,244	3.28
1960	[7] 176	319,009	312,292	1,045,246	3.35
1961	[7] 175	324,114	320,751	1,065,778	3.32
1962	[7] 178	336,488	331,823	1,090,389	3.29

[1] Includes Puerto Rico.
[2] Includes air-entrained portland cement as follows (in thousand barrels): 1958, 31,470; 1959, 38,961; 1960, 35,473; 1961, 36,373; 1962, 38,096.
[3] Includes air-entrained portland cement as follows (in thousand barrels): 1958, 4,382; 1959, 5,126; 1960, 4,645; 1961, 4,140; 1962, 5,078.
[4] Includes a small amount of air-entrained portland cement.
[5] Includes air-entrained portland cement as follows (in thousand barrels): 1958, 2,164; 1959, 1,969; 1960, 1,400; 1961, 1,996; 1962, 1,617.
[6] Includes hydroplastic, plastic, and waterproofed cements.
[7] Includes number of plants making air-entrained portland cement as follows: 1958, 113; 1959, 119; 1960, 120; 1961, 120; 1962, 121.

TABLE 5.—Portland-cement-manufacturing capacity of the United States,[1] by districts

District	Capacity Dec. 31 (thousand barrels)		Percent utilized	
	1961	1962	1961	1962
New York, Maine	27,006	36,956	66.9	54.5
Eastern Pennsylvania	44,278	41,908	65.6	75.8
Western Pennsylvania	11,708	11,708	64.6	66.4
Maryland, West Virginia	11,210	11,950	77.6	82.2
Ohio	22,370	22,400	67.3	69.0
Michigan	31,154	34,154	69.5	67.5
Indiana, Kentucky, Wisconsin	25,249	26,461	79.4	70.3
Illinois	10,725	10,930	81.7	83.1
Tennessee	9,843	9,974	88.7	88.7
Virginia, South Carolina	10,390	10,590	77.6	78.6
Georgia, Florida	16,061	19,261	68.0	56.3
Alabama	16,340	16,290	78.6	79.3
Louisiana, Mississippi	9,366	9,500	70.6	82.9
Minnesota, South Dakota, Nebraska	9,232	9,322	94.7	90.5
Iowa	15,424	15,190	82.9	78.1
Missouri	16,277	16,277	73.4	75.2
Kansas	12,490	12,490	66.7	65.9
Oklahoma, Arkansas	12,785	16,100	71.1	59.6
Texas	38,809	41,733	64.1	63.4
Wyoming, Montana, Idaho	3,350	3,300	83.2	92.8
Colorado, Arizona, Utah, New Mexico	15,850	17,670	86.6	76.8
Oregon, Washington	11,025	11,190	67.2	64.3
Northern California	19,360	20,900	87.4	83.0
Southern California	32,520	32,520	74.6	81.5
Hawaii	[2] 2,700	2,700	[2] 41.3	42.2
Puerto Rico	7,500	7,500	80.9	84.9
Total	443,022	468,974	73.2	71.8

[1] Includes Puerto Rico.
[2] Revised figure.

TABLE 6.—Capacity of portland cement plants in the United States,[1] by processes

Process	Capacity, Dec. 31						Percent of capacity utilized			Percent of total finished cement produced		
	Thousand barrels			Percent of total								
	1960	1961	1962	1960	1961	1962	1960	1961	1962	1960	1961	1962
Wet	252,288	[2] 259,167	275,933	58.3	58.5	58.8	74.0	[2] 72.7	70.9	58.5	58.1	58.2
Dry	180,653	183,855	193,041	41.7	41.5	41.2	73.3	73.8	72.9	41.5	41.9	41.8
Total	432,941	[2] 443,022	468,974	100.0	100.0	100.0	73.7	73.2	71.8	100.0	100.0	100.0

[1] Includes Puerto Rico.
[2] Revised figure.

Alpha Portland Cement Co. acquired the Orange, Tex., plant of Texas Portland Cement Co. Aetna Portland Cement Co., with one plant at Bay City, Mich., was acquired by Martin Marietta Corp. Plans to merge Ponce Cement Corp. and Puerto Rico Cement Corp. were announced, with the latter to be the surviving company.

The Sandt's Eddy, Pa., plant of Lehigh Portland Cement Co. was closed in late summer.

TYPES OF PORTLAND CEMENT

General-use and moderate-heat cements (types I and II) were produced at 177 of 178 operating plants and comprised 93 percent of all portlant cement made. High-early-strength cement (type III) was produced at 141 plants, 6 more than in 1961. Seven plants reported production of portland-slag cement, three of the plants accounting for 79 percent of the 2.8 million barrel output. These plants also produced other types of portland cement.

CAPACITY OF PLANTS

Estimated annual capacity of all portland cement plants on December 31, as reported to the Bureau of Mines by producers, was 6 percent greater than on December 31, 1961. The capacity increase of 26 million barrels resulted mainly from 4 new plants and expansions at 10 of the 175 plants in operation in 1961.

CLINKER PRODUCTION

Production of clinker was 4 percent higher than in 1961. Output reached a high of 31.7 million barrels in August. Yearend stocks of clinker were 8 percent lower than those of 1961.

RAW MATERIALS

About 71 percent of the domestic production of portland cement was made from limestone, clay, and shale. Argillaceous limestone (cement rock) or a mixture of cement rock and limestone was used for 22 percent of the portland cement produced. Two plants used marl instead of limestone; one used a combination of marl and limestone; another used marl, limestone, and shell; and 11 plants used shell exclusively.

Blast-furnace and other slags were used as raw material in producing portland cement at 23 plants, 7 of these used approximately 249,000 tons of slag to produce portland-slag cement.

FUEL AND POWER

More coal, oil, and natural gas were used in producing cement than in 1961. Coal and oil supplied 53 percent of the heat requirements, compared with 54 percent in 1961. Consumption of natural gas increased 4 percent compared with that in 1961. The 178 active plants used an average of 1.2 million B.t.u. per barrel of cement produced.

TABLE 7.—Portland cement clinker produced and in stock at mills in the United States,[1] by process [2]

Clinker	Plants		Production		Stocks Dec. 31—	
	1961	1962	1961 (thousand barrels)	1962 (thousand barrels)	1961 [3] (thousand barrels)	1962 [4] (thousand barrels)
Wet	104	106	188,751	193,742	8,563	8,147
Dry	69	70	134,659	142,962	10,953	9,783
Total	173	176	323,410	336,704	19,516	17,930

[1] Includes Puerto Rico.
[2] Compiled from monthly estimates of producers.
[3] Revised figures.
[4] Preliminary figures.

TABLE 8.—Production of portland cement clinker at mills in the United States[1] in 1962, by months and districts

(Thousand barrels)

District	January	February	March	April	May	June	July	August	September	October	November	December
New York, Maine	1,277	1,211	1,250	1,560	1,817	1,885	2,170	2,182	2,171	2,147	1,839	1,736
Eastern Pennsylvania	2,100	1,938	2,095	2,664	3,036	3,093	3,103	3,066	2,795	2,865	2,710	2,586
Western Pennsylvania	449	112	611	877	726	869	591	905	885	870	695	303
Maryland, West Virginia	779	327	633	869	1,016	959	1,001	861	984	1,033	779	745
Ohio	929	891	1,088	1,220	1,258	1,524	1,573	1,538	1,572	1,241	1,297	922
Michigan	1,320	1,142	1,584	1,847	2,114	1,944	2,003	1,901	1,927	2,014	1,891	1,804
Indiana, Kentucky, Wisconsin	1,224	1,070	1,470	1,554	1,736	1,882	1,583	1,772	1,805	1,639	1,513	1,131
Illinois	550	358	766	811	895	818	806	941	796	828	917	816
Tennessee	649	430	702	753	787	802	832	782	808	887	820	765
Virginia, South Carolina	568	615	618	650	798	796	861	816	856	872	723	774
Georgia, Florida	949	934	885	843	1,106	879	859	983	1,084	1,147	936	821
Alabama	785	791	1,115	1,112	1,240	1,183	1,051	1,167	1,249	1,205	1,163	1,006
Louisiana, Mississippi	339	299	508	703	698	705	762	762	779	755	733	717
Minnesota, South Dakota, Nebraska	673	607	679	708	751	749	770	778	741	734	660	527
Iowa	817	398	166	681	1,144	1,326	1,235	1,276	1,282	1,358	1,142	1,101
Missouri	551	746	954	1,047	1,198	1,141	1,181	1,215	1,233	1,274	884	877
Kansas	451	289	545	843	918	704	729	783	763	806	853	684
Oklahoma, Arkansas	596	701	977	758	877	822	846	850	857	974	959	727
Texas	1,908	1,883	2,282	2,437	2,530	2,206	2,535	2,555	2,368	2,456	2,253	1,779
Wyoming, Montana, Idaho	124	70	94	268	309	320	259	308	322	251	261	229
Colorado, Arizona, Utah, New Mexico	1,041	790	983	1,158	1,277	1,167	1,187	1,291	1,122	1,172	1,163	1,208
Oregon, Washington	343	386	542	579	634	677	658	672	755	734	684	453
Northern California	1,267	1,093	1,455	1,509	1,539	1,474	1,525	1,603	1,491	1,469	1,346	1,430
Southern California	2,108	1,840	1,977	2,139	2,271	2,012	2,009	2,095	2,110	2,187	2,088	2,176
Hawaii	--------	88	120	150	139	138	6	54	91	89	148	92
Puerto Rico	563	514	492	524	473	464	567	534	536	563	522	458
Total:												
1962	22,360	19,523	24,591	28,264	31,287	30,539	30,702	31,690	31,382	31,570	28,979	25,817
1961	21,767	18,823	24,386	26,812	29,916	29,790	30,121	28,801	28,296	29,992	28,539	26,167

[1] Includes Puerto Rico.

TABLE 9.—Production and percentage of total output of portland cement in the United States,[1] by raw materials used

Year	Cement rock and pure limestone		Limestone and clay or shale [2] [3]		Blast-furnace slag and limestone	
	Thousand barrels	Percent	Thousand barrels	Percent	Thousand barrels	Percent
1953–57 (average)	64,093	22.1	205,085	70.8	20,592	7.1
1958	71,681	23.0	225,495	72.4	14,295	4.6
1959	79,895	23.5	239,336	70.6	19,860	5.9
1960	85,924	26.9	215,625	67.6	17,460	5.5
1961	70,824	21.9	230,376	71.1	22,914	7.0
1962	75,042	22.3	238,160	70.7	23,286	7.0

[1] Includes Puerto Rico.
[2] Includes output of 4 plants using marl and clay in 1953–57 (average); 4 plants in 1958–60; 3 plants in 1961; and 2 plants in 1962.
[3] Includes output of 8 plants using oystershells and clay in 1953–57 (average); 9 plants in 1958–61; and 10 plants in 1962.

TABLE 10.—Raw materials used in producing portland cement in the United States [1]

Raw materials	1960	1961	1962
Cement rock thousand short tons	19,917	18,482	20,829
Limestone (including oystershell) do	66,823	68,139	69,456
Marl do	1,224	549	1,689
Clay and shale [2] do	9,657	10,105	9,943
Blast-furnace slag do	1,269	1,295	1,119
Gypsum do	1,146	2,754	2,826
Sand and sandstone (including silica and quartz) do	2,690	1,386	1,423
Iron materials [3] do	774	623	659
Miscellaneous [4] do	66	137	105
Total	103,566	103,470	108,049
Average total weight required per barrel (376 pound) of finished cement pounds	649	638	642

[1] Includes Puerto Rico.
[2] Includes fuller's earth, diaspore, and kaolin.
[3] Includes iron ore, pyrite cinders and ore, and mill scale.
[4] Includes fluorspar, pumicite, calcium chloride, soda ash, borax, air-entraining compounds, and grinding aids.

TABLE 11.—Finished portland cement produced and fuel consumed by the portland-cement industry in the United States,[1] by processes

Year and process	Finished cement produced			Fuel consumed		
	Plants	Thousand barrels	Percent of total	Coal (thousand short tons)	Oil (thousand 42-gallon barrels)	Natural gas (thousand cubic feet)
1961:						
Wet	105	188,346	58.1	3,960	3,329	124,497,379
Dry	70	135,768	41.9	3,808	581	55,856,216
Total	175	324,114	100.0	[2] 7,768	3,910	180,353,595
1962:						
Wet	108	195,745	58.2	3,998	3,383	128,352,699
Dry	70	140,743	41.8	3,909	635	59,394,641
Total	178	336,488	100.0	[3] 7,907	4,018	187,747,340

[1] Includes Puerto Rico.
[2] Comprises 152,644 tons of anthracite and 7,615,153 tons of bituminous coal.
[3] Comprises 188,049 tons of anthracite and 7,719,179 tons of bituminous coal.

TABLE 12.—Portland cement produced in the United States,[1] by kinds of fuel

Year and fuel	Finished cement produced: Plants	Finished cement produced: Thousand barrels	Finished cement produced: Percent of total	Fuel consumed: Coal (thousand short tons)	Fuel consumed: Oil (thousand 42-gallon barrels)	Fuel consumed: Natural gas (thousand cubic feet)
1961:						
Coal	58	[2] 100,656	31.0	5,234		
Oil	9	[2] 14,803	4.6		2,783	
Natural gas	33	[2] 51,297	15.8			61,794,992
Coal and oil	22	46,235	14.3	1,813	707	
Coal and natural gas	22	40,216	12.4	596		36,751,068
Oil and natural gas	23	56,010	17.3		397	65,787,274
Coal, oil, and natural gas	8	14,897	4.6	125	23	16,020,261
Total	175	324,114	100.0	[3] 7,768	3,910	180,353,595
1962:						
Coal	59	[2] 103,912	30.9	5,192		
Oil	9	[2] 14,842	4.4		2,820	
Natural gas	37	[2] 58,604	17.4			69,113,189
Coal and oil	21	48,068	14.3	1,951	683	
Coal and natural gas	19	33,884	10.1	519		31,256,068
Oil and natural gas	21	56,073	16.7		425	65,951,842
Coal, oil, and natural gas	12	21,105	6.2	245	90	21,426,241
Total	178	336,488	100.0	[4] 7,907	4,018	187,747,340

[1] Includes Puerto Rico.
[2] Average consumption of fuel per barrel of cement produced as follows: 1961—coal, 104.0 pounds; oil, 0.1880 barrel; natural gas, 1,205 cubic feet, 1962—coal, 99.9 pounds; oil, 0.1900 barrel; natural gas, 1,179 cubic feet.
[3] Comprises 152,644 tons of anthracite and 7,615,153 tons of bituminous coal.
[4] Comprises 188,049 tons of anthracite and 7,719,179 tons of bituminous coal.

TABLE 13.—Electric energy used at portland cement plants in the United States,[1] by processes

Year and process	Generated at portland cement plants: Active plants	Generated at portland cement plants: Million kilowatt-hours	Purchased: Active plants	Purchased: Million kilowatt-hours	Total: Million kilowatt-hours	Total: Percent	Finished cement produced (thousand barrels)	Average electric energy used per barrel of cement produced (kilowatt-hours)
1961:								
Wet	20	510	101	3,741	4,251	56.6	188,346	22.6
Dry	26	1,105	68	2,161	3,266	43.4	135,768	24.1
Total	46	1,615	169	5,902	7,517	100.0	324,114	23.2
Percent of total electric energy used		21.5		78.5	100.0			
1962:								
Wet	21	484	106	3,801	4,285	54.8	195,745	22.0
Dry	25	1,142	69	2,393	3,535	45.2	140,743	25.3
Total	46	1,626	175	6,194	7,820	100.0	336,488	23.2
Percent of total electric energy used		20.8		78.2	100.0			

[1] Includes Puerto Rico.

TRANSPORTATION

Shipments of cement in bulk increased to a record high of 85 percent of total shipments. The balance was shipped in paper bags except for a small quantity shipped in cloth bags from two Texas plants. Shipments by truck increased 5 percent compared with those in 1961. The following districts had the greatest increases: Iowa 15 percent, Missouri 15 percent, Georgia-Florida 14 percent, Oregon-Washington 14 percent, Alabama 12 percent, Oklahoma-Arkansas 10 percent, Illinois 10 percent, and Kansas 9 percent. Shipments by boat were highest from plants in New York, Kentucky, Louisiana, Texas, and Puerto Rico. Other States reporting boat shipments included Pennsylvania, Virginia, Alabama, Missouri, Washington, Oregon, and California. Two new ocean-going cement transports were placed in service—one, the S.S. *Keva Ideal*, with 80,000-barrel capacity, and the other, the barge *Angela*, with 90,000-barrel capacity. The tabulations in this chapter represent only shipments from producing companies to consumers and do not include shipments between producing plants or to distribution centers.

TABLE 14.—Shipments of portland cement from mills in the United States,[1] in bulk and in containers by types of carriers

Year and type of carrier	In bulk		In paper bags [2]		Total shipments	
	Thousand barrels	Percent	Thousand barrels	Percent	Thousand barrels	Percent
1961:						
Truck	150,533	56.0	31,588	61.0	182,121	56.8
Railroad	111,154	41.3	20,024	38.6	131,178	40.9
Boat	7,013	2.6	146	.3	7,159	2.2
Used at the plant	232	.1	61	.1	293	.1
Total	268,932	100.0	51,819	100.0	320,751	100.0
Percent of total	83.8		16.2		100.0	
1962:						
Truck	171,472	60.8	32,711	65.6	204,183	61.5
Railroad	103,660	36.8	16,856	33.8	120,516	36.3
Boat	6,514	2.3	156	.3	6,670	2.0
Used at the plant	335	.1	119	.3	454	.2
Total	281,981	100.0	49,842	100.0	331,823	100.0
Percent of total	85.0		15.0		100.0	

[1] Includes Puerto Rico.
[2] Cloth bags and other containers included with paper bags to avoid disclosing individual company confidential data.

CONSUMPTION

Shipments of cement into the various States are considered to be an index of consumption. Shipments into 30 of the States were higher than in 1961. The trend in consumption for the years 1900 to 1962 is shown in figure 1.

Shipments to ready-mixed concrete producers increased 9.7 million barrels from those in 1961, and shipments to building material dealers rose 1.2 million barrels. Nearly all companies supplied breakdowns of shipments by types of customers, as in 1961.

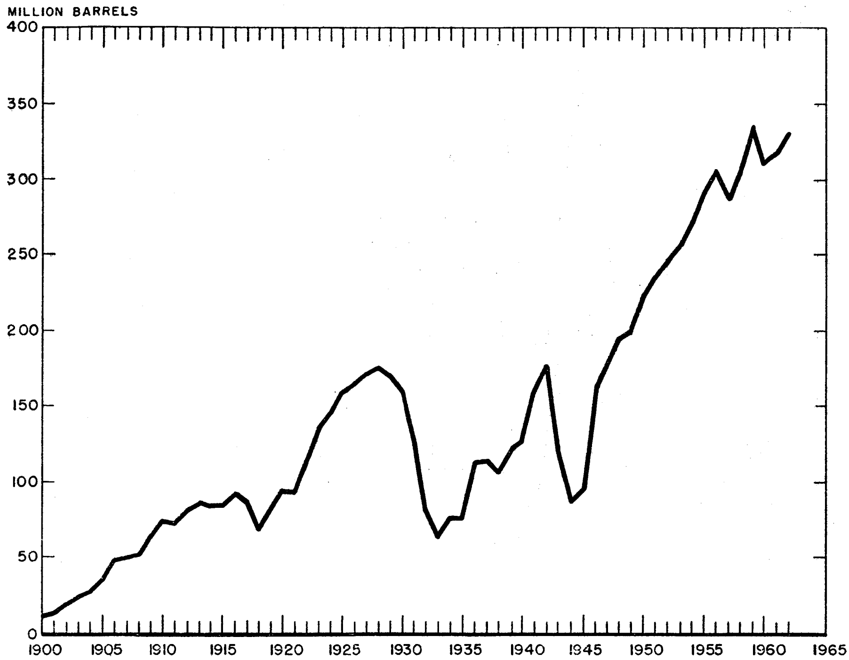

FIGURE 1.—Apparent consumption of finished portland cement in the United States, 1900–1962.

STOCKS

Stocks of finished portland cement and clinker at portland cement plants on December 31 were 5 percent higher and 8 percent lower, respectively, than those on hand December 31, 1961. Changes in stocks from 1952 to 1962 are shown in figure 2.

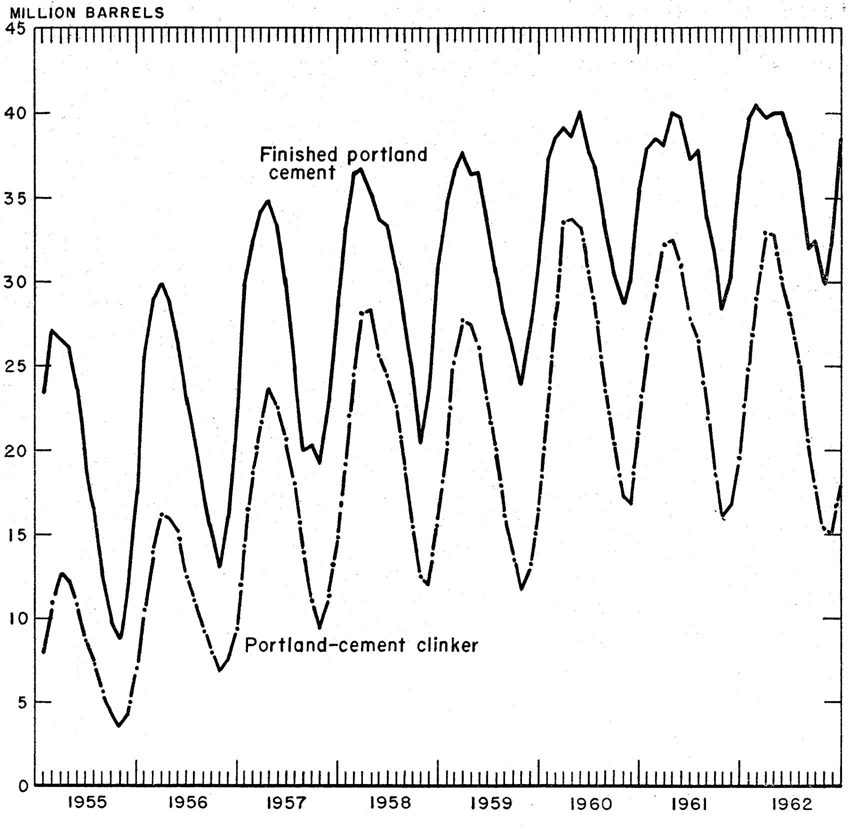

FIGURE 2.—End-of-month stocks of finished portland cement and portland-cement clinker, 1955–62.

PREPARED MASONRY CEMENTS

Prepared masonry cements were produced at 130 portland cement plants, 2 natural cement plants, and 2 slag-cement plants. Production was 5 percent higher than in 1961. Ohio and North Carolina received the greatest total shipments.

Producers reported shipments of masonry cements in 280-pound barrels, although such cements actually varied considerably in composition and bulk density.

TABLE 15.—Destination of shipments of all types of finished portland and high-early-strength cement from mills in the United States, by States

(Thousand barrels)

Destination	Finished portland		High-early strength	
	1961	1962	1961	1962
Alabama	4,992	4,764	154	84
Alaska [1]	(2)	(2)	(2)	(2)
Arizona	5,409	5,058	24	----------
Arkansas	2,968	3,053	30	26
Northern California	14,401	14,520	27	80
Southern California	23,409	25,347	166	171
Colorado	4,725	4,775	16	17
Connecticut [1]	3,617	3,609	355	358
Delaware [1]	665	896	66	97
District of Columbia [1]	1,632	1,559	81	88
Florida	[3] 11,743	[3] 11,143	907	922
Georgia	6,261	7,066	165	96
Hawaii	1,242	1,129	----------	----------
Idaho	1,125	1,091	----------	2
Illinois	17,791	17,582	595	674
Indiana	8,476	8,179	443	461
Iowa	6,746	6,460	247	221
Kansas	5,770	5,331	73	71
Kentucky	4,179	4,599	153	146
Louisiana	7,865	8,875	94	102
Maine	866	811	91	88
Maryland	5,538	6,246	296	349
Massachusetts [1]	4,605	4,878	481	500
Michigan	13,828	14,671	821	764
Minnesota	6,838	6,600	395	407
Mississippi	3,603	3,704	44	29
Missouri	8,066	8,814	250	278
Montana	1,085	1,291	48	58
Nebraska	4,168	4,620	192	199
Nevada [1]	981	1,598	10	14
New Hampshire [1]	771	755	80	92
New Jersey [1]	8,769	8,862	1,440	1,538
New Mexico	2,607	2,345	123	172
New York	17,646	18,599	1,316	1,600
North Carolina [1]	5,630	5,432	199	199
North Dakota [1]	1,271	1,397	17	27
Ohio	15,828	15,771	433	436
Oklahoma	5,573	5,941	15	25
Oregon	2,987	3,045	8	45
Eastern Pennsylvania	9,837	9,003	1,123	1,048
Western Pennsylvania	3,401	5,763	138	216
Rhode Island [1]	688	820	71	65
South Carolina	2,312	2,578	54	41
South Dakota	2,250	2,023	60	94
Tennessee	5,929	6,270	286	152
Texas	21,566	22,900	1,362	1,180
Utah	2,527	2,857	71	65
Vermont [1]	358	380	33	37
Virginia	6,459	7,266	504	453
Washington	5,462	4,984	508	487
West Virginia	2,473	1,848	33	37
Wisconsin	7,754	7,937	149	259
Wyoming	1,023	1,101	38	6
Total United States	315,715	326,146	14,285	14,576
Other countries	[4] 5,036	[4] 5,677	[5] 20	[5] 20
Total shipped from cement plants	320,751	331,823	14,305	14,596

[1] Noncement producer.
[2] Included with "Other countries" to avoid disclosing individual company confidential data.
[3] Includes shipments from Puerto Rican mills.
[4] Direct shipments by producers to foreign countries, the State of Alaska, and to Puerto Rico, including distribution from Puerto Rican mills.
[5] Direct shipments by producers to other countries and the State of Alaska.

TABLE 16.—Apparent consumption of finished portland cement in the United States, 1900–1962 [1]

Year	Thousand barrels	Year	Thousand barrels	Year	Thousand barrels	Year	Thousand barrels
1900	10,758	1916	91,681	1932	80,487	1948	196,476
1901	13,205	1917	87,768	1933	63,625	1949	200,330
1902	18,791	1918	68,483	1934	75,077	1950	223,995
1903	24,289	1919	82,474	1935	74,786	1951	235,961
1904	26,675	1920	94,072	1936	113,339	1952	245,653
1905	35,217	1921	94,313	1937	114,065	1953	255,635
1906	48,118	1922	116,554	1938	106,838	1954	270,274
1907	49,875	1923	136,150	1939	122,902	1955	291,841
1908	51,039	1924	146,525	1940	126,938	1956	307,353
1909	64,356	1925	159,269	1941	160,337	1957	288,197
1910	74,367	1926	163,794	1942	177,386	1958	305,256
1911	72,559	1927	172,445	1943	120,659	1959	336,174
1912	80,847	1928	176,621	1944	87,309	1960	311,248
1913	85,792	1929	170,221	1945	96,457	1961	318,821
1914	84,000	1930	158,789	1946	163,097	1962	330,945
1915	84,247	1931	126,688	1947	179,258		

[1] Shipments to consumers in the various States plus imports. Includes Hawaii after 1958 but excludes all Alaska and Puerto Rico shipments. To avoid duplication cement clinker imports were subtracted as follows, in thousand barrels: 1953, 3; 1955, 467; 1956, 483; 1957, 122; 1958, 12; 1959, 6; and 1962, 429. Data on clinker imports prior to 1953 not available. Small quantities of imported cement other than portland may be included.

TABLE 17.—Cement shipments by types of customers in 1962

District	Number of plants in district	Building materials dealers		Concrete product manufacturers		Ready-mixed concrete		Highway contractors		Other contractors		Federal, State and other Government agencies		Miscellaneous, including own use		Total
		Percent	Thousand barrels	Percent	Thousand barrels	Percent	Thousand barrels	Percent	Thousand barrels	Percent	Thousand barrels	Percent	Thousand barrels	Percent	Thousand barrels	Thousand barrels
New York, Maine	13	11.4	2,169	11.0	2,098	63.1	12,063	11.3	2,158	2.9	549	0.2	36	0.1	10	19,083
Eastern Pennsylvania	17	17.3	5,371	20.7	6,404	54.1	16,769	4.7	1,452	1.9	576	------	13	1.3	389	30,974
Western Pennsylvania	5	9.0	678	14.3	1,069	55.7	4,171	19.2	1,439	1.4	103	------	2	0.4	27	7,489
Maryland, West Virginia	4	7.7	744	18.1	1,738	60.6	5,822	11.5	1,106	1.8	176	0.2	19	0.1	6	9,611
Ohio	10	9.3	1,427	13.8	2,128	59.3	9,102	16.9	2,590	0.2	31	0.1	14	0.4	61	15,353
Michigan	9	8.5	1,923	15.4	3,492	54.1	12.275	14.1	3,189	7.2	1,645	0.1	23	0.6	135	22,682
Indiana, Kentucky, Wisconsin	8	9.5	1,695	12.3	2,201	62.6	11,213	12.8	2,296	2.0	364	0.2	40	0.6	96	17.905
Illinois	4	4.7	427	10.3	938	68.3	6,248	15.4	1,410	1.3	122	------	------	------	------	9.145
Tennessee	6	6.8	580	18.1	1,541	59.1	5,032	12.0	1,022	2.2	186	1.3	108	0.5	40	8,509
Virginia, South Carolina	4	7.3	608	14.9	1,230	63.1	5,218	3.3	274	10.3	849	0.4	35	0.7	57	8,271
Georgia, Florida	6	12.0	1,262	18.9	1,992	54.8	5,766	10.1	1,063	1.0	105	0.9	94	2.3	244	10,526
Alabama	8	9.2	1,144	19.4	2,419	51.7	6,460	11.5	1,433	4.8	604	3.0	379	0.4	43	12,482
Louisiana, Mississippi	5	4.9	379	11.5	889	44.7	3,466	23.9	1,855	2.1	163	12.0	926	0.9	73	7,751
Minnesota, South Dakota, Nebraska	4	16.4	1,383	7.8	662	40.3	3,397	30.1	2,534	5.3	449	------	1	0.1	4	8,430
Iowa	5	13.7	1,680	16.5	2,029	52.8	6,469	14.9	1,828	1.9	229	0.2	23	------	3	12,261
Missouri	5	8.9	1,135	11.2	1,424	57.2	7,291	15.2	1,939	6.2	790	0.2	22	1.1	138	12,739
Kansas	6	13.3	1,073	6.1	493	54.5	4,389	14.5	1,164	7.3	585	------	5	4.3	349	8,058
Oklahoma, Arkansas	6	10.6	987	8.0	749	46.6	4,336	18.4	1,711	12.6	1,173	0.7	66	3.1	289	9,311
Texas	17	9.7	2,531	9.4	2,474	57.2	14,982	10.9	2,857	2.0	529	2.8	733	8.0	2,098	26,204
Wyoming, Montana, Idaho	3	10.7	326	10.6	322	54.3	1,660	7.7	237	7.4	226	0.2	6	9.1	277	3,054
Colorado, Arizona, Utah, New Mexico	7	11.5	1,577	7.5	1,026	53.9	7,420	9.3	1,283	7.5	1,029	8.2	1,130	2.1	297	13,762
Oregon, Washington	9	5.4	384	11.9	846	69.4	4,913	3.5	244	8.2	583	1.1	77	0.5	34	7,081
Northern California	6	9.1	1,578	8.7	1,501	64.7	11,225	6.0	1,044	9.8	1,698	1.4	250	0.3	49	17,345
Southern California	7	12.6	3,318	9.5	2,512	69.5	18,283	5.0	1,315	2.4	641	0.3	73	0.7	180	26,322
Hawaii	2	17.9	202	21.8	246	56.3	635	0.9	10	0.9	10	1.5	17	0.7	8	1,128
Puerto Rico	2	38.3	2,431	3.9	251	30.7	1,950	0.5	29	0.3	20	3.7	233	22.6	1,433	6,347
Total	178	11.2	37,012	12.9	42,674	57.4	190,555	11.3	37,482	4.0	13,435	1.3	4,825	1.9	6,340	331,823

TABLE 18.—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

(Thousand barrels)

Year		Dec. 31, quantity	Range			
			Low		High	
			End of month	Quantity	End of month	Quantity
1958	Cement	30,718	October	20,415	March	36,734
	Clinker	15,505	November	12,124	April	28,409
1959	Cement	31,465	October	23,913	March	37,711
	Clinker	16,506	do	11,681	do	27,709
1960	Cement	35,640	do	28,841	May	40,101
	Clinker	20,958	November	16,838	April	33,616
1961	Cement	[2] 36,579	October	28,437	do	39,999
	Clinker	[2] 19,516	do	16,215	do	32,432
1962	Cement	38,579	do	29,901	February	40,626
	Clinker	17,930	November	15,051	March	32,950

[1] Includes Puerto Rico.
[2] Revised figure.

TABLE 19.—Shipments of prepared masonry cement from mills in the United States, by States

(Thousand barrels) [1]

Destination	1961	1962
Alabama	509	570
Alaska [2]	(3)	(3)
Arizona	(3)	(3)
Arkansas	239	272
California	1	----------
Colorado	279	289
Connecticut [2]	110	129
Delaware [2]	38	42
District of Columbia [2]	257	289
Florida	1,146	1,159
Georgia	888	1,030
Idaho	14	13
Illinois	774	722
Indiana	659	675
Iowa	201	191
Kansas	218	199
Kentucky	455	487
Louisiana	287	314
Maine	76	75
Maryland	480	493
Massachusetts [2]	258	266
Michigan	1,063	1,058
Minnesota	382	399
Mississippi	304	329
Missouri	196	204
Montana	23	20
Nebraska	93	94
New Hampshire [2]	66	66
New Jersey [2]	550	555
New Mexico	117	125
New York	1,068	1,079
North Carolina [2]	1,326	1,341
North Dakota [2]	61	58
Ohio	1,334	1,360
Oklahoma	249	313
Oregon	2	1
Eastern Pennsylvania	590	536
Western Pennsylvania	572	572
Rhode Island [2]	28	27
South Carolina	612	686
South Dakota	57	52
Tennessee	884	942
Texas	816	919
Utah	14	14
Vermont [2]	37	34
Virginia	1,057	1,120
Washington	45	44
West Virginia	206	202
Wisconsin	501	487
Wyoming	30	22
Total United States	19,172	19,874
Other countries [4]	103	124
Total shipped from cement plants	19,275	19,998

[1] 280-pound barrels.
[2] Noncement producer.
[3] Included with "Other countries" to avoid disclosing individual company confidential data.
[4] Direct shipments by producers to other countries and to Alaska and Arizona.

TABLE 20.—Prepared masonry cement produced and shipped in the United States, by districts

District	Active plants		Production (thousand barrels) [1]		Shipments from mills					
					1961			1962		
	1961	1962	1961	1962	Thousand barrels [1]	Value (thousands)	Average per barrel	Thousand barrels [1]	Value (thousands)	Average per barrel
New York, Maine	12	12	1,036	1,145	1,056	$2,769	$2.62	1,076	$2,856	$2.65
Eastern Pennsylvania	16	15	1,624	1,715	1,743	4,593	2.63	1,694	4,617	2.73
Western Pennsylvania	5	5	933	870	935	2,639	2.82	871	2,488	2.86
Maryland, West Virginia	4	4	840	920	847	2,242	2.65	869	2,336	2.69
Ohio	8	8	871	937	846	2,604	3.08	946	2,793	2.95
Michigan	6	6	1,584	1,574	1,515	4,467	2.95	1,517	4,335	2.86
Indiana, Kentucky, Wisconsin	6	7	2,720	2,664	2,674	7,463	2.79	2,703	7,268	2.69
Illinois	4	4	423	435	461	1,420	3.08	440	1,320	3.00
Tennessee	5	5	997	1,096	1,018	2,753	2.70	1,089	2,931	2.69
Virginia, South Carolina	4	4	1,288	1,461	1,288	3,512	2.73	1,448	4,216	2.91
Georgia, Florida	5	5	1,111	1,145	1,094	3,312	3.03	1,105	3,237	2.93
Alabama	8	9	1,976	2,200	2,006	6,156	3.07	2,187	6,521	2.98
Louisiana, Mississippi	5	4	341	368	272	714	2.63	340	887	2.61
Minnesota, South Dakota, Nebraska	4	4	279	272	300	959	3.20	280	903	3.23
Iowa	4	4	522	593	557	1,843	3.31	568	1,786	3.15
Missouri	5	5	368	434	437	1,398	3.20	455	1,457	3.20
Kansas	7	7	412	375	379	1,156	3.05	392	1,156	2.95
Oklahoma, Arkansas	6	6	427	436	417	1,268	3.04	488	1,453	2.98
Texas	13	14	852	877	851	2,529	2.97	926	2,774	2.99
Wyoming, Montana, Idaho	3	3	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Colorado, Arizona, Utah, New Mexico	5	6	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Oregon, Washington	6	6	56	65	61	186	3.04	56	173	3.11
Northern California	1	1	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Southern California	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Hawaii	1	-----	(2)	-----	(2)	(2)	(2)	-----	-----	-----
Undistributed	-----	-----	528	566	518	1,754	3.37	548	1,898	3.46
Total	143	144	19,188	20,148	19,275	55,737	2.89	19,998	57,405	2.87

[1] Barrels of 280 pounds.
[2] Included with "Undistributed" to avoid disclosing individual company confidential data.

NATURAL AND SLAG CEMENTS

Natural cement was produced at two plants, and slag cement at two others. All four producers also made large quantities of prepared masonry cement. Annual capacity of the four plants totaled about 1 million barrels. Producers reported use of about 90,000 tons of cement rock, 14,000 tons of limestone, 14,000 tons of slag, 8,000 tons of coal, and 43 million cubic feet of natural gas in processing these cements.

Because masonry cements made at these plants contained some portland cement, they are included in the tabulations of masonry cement prepared at portland cement plants (tables 19 and 20). Production figures for natural and slag cements from 1957 to 1962 are not strictly comparable with those for earlier years because of changes in the method of reporting by several producers.

TABLE 21.—Natural, slag, and hydraulic-lime cements produced, shipped, and in stock at mills in the United States

Year	Production		Shipments		Stocks Dec. 31, thousand barrels
	Active plants	Thousand barrels	Thousand barrels	Value (thousands)	
1955–57 (average)	6	900	897	$2,878	87
1958	5	520	492	1,633	107
1959	4	438	441	1,450	64
1960	4	568	548	1,949	85
1961	4	225	269	968	[1] 40
1962	4	440	402	1,611	78

[1] Revised figure.

PRICES

Average net value of shipments from all cement plants was $3.31 per barrel, compared with $3.35 in 1961.

Portland cement prices at plant increased from $3.27 per barrel in the last quarter of 1961 to $3.29 in the first quarter of 1962, continued steady at $3.29 through the second and third quarters, and declined to $3.27 in the final quarter of 1962. Average prices of types I and II portland cement (93 percent of all portland cement produced) increased from $3.23 in the first quarter to $3.25 and $3.26 in the second and third quarters, respectively, and then fell to $3.22 in the fourth quarter.

The average price of type III high-early strength cement increased from $3.69 in the first quarter to $3.74 in the second quarter, declined to $3.70 in the third quarter, and jumped to $3.86 in the fourth quarter.

The average price of prepared masonry cement increased from $2.82 per barrel (280 pounds) in the first quarter to $2.88 in the second quarter, declined to $2.83 in the third quarter, and increased to $2.84 in the last quarter.

The composite average annual wholesale price index for portland cement, f.o.b. destination, according to the Bureau of Labor Statistics index (1957–59=100) was 103.1 in 1962 compared with 103.3 in 1961. Previous indices (based on 1947–49=100) were convertible to the 1957–59 basis by multiplying by the factor of 0.6671609.

TABLE 22.—Average mill value in bulk, of cement in the United States [1]

(Per barrel)

Year	Portland cement	Natural, slag, and hydraulic-lime cements	Prepared masonry cement [2] [3]	All classes of cement [4]
1953-57 (average)	$2.91	$3.14	$2.64	$2.94
1958	3.25	3.32	2.81	3.27
1959	3.28	3.28	2.82	3.30
1960	3.35	3.56	2.95	3.37
1961	3.32	3.60	2.89	3.35
1962	3.29	4.01	2.87	3.31

[1] Includes Puerto Rico.
[2] Includes masonry cements made at portland, natural, and slag cement plants.
[3] 280 pound barrels.
[4] Includes masonry cement converted to 376 pound barrels.

FOREIGN TRADE [14]

Imports.—Imports of hydraulic cement increased from 3.6 million barrels in 1961 to 5.8 million barrels. The 1962 imports included 429,000 barrels of hydraulic cement clinker shipped into New York State from Canada late in 1962. Total imports into New England States and New York were 4.5 million barrels, nearly double the 2.4 million barrels in 1961, and represented 78 percent of all cement imports, compared with 67 percent in 1961. Canada, Belgium-Luxembourg, Colombia, Israel, and West Germany supplied 63 percent of the cement imported. Imports from Israel jumped from none in 1961 to 480,000 barrels in 1962.

Sixty-one percent of the white cement imported entered the Florida customs district. Belgium-Luxembourg and France supplied 58 percent of the white cement imports, and 19 percent was imported from Japan.

Exports.—Exports of hydraulic cement were 33 percent greater than in 1961.

TABLE 23.—U.S. imports for consumption of cement

(Thousand barrels and thousand dollars)

Year	Roman, portland, and other hydraulic cement		Hydraulic cement clinker		White nonstaining portland cement		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1953-57 (average)	2,560	[1] $7,655	215	$380	213	[1] $1,243	2,988	[1] $9,278
1958	3,111	8,060	11	91	268	1,531	3,390	9,682
1959	4,979	12,268	6	47	280	1,458	5,265	13,773
1960	3,826	8,736	----------	----------	282	1,570	4,108	10,306
1961	[2] 3,359	[2] 7,858	----------	----------	[2] 262	[2] 1,367	3,621	9,225
1962	5,013	10,845	429	892	317	1,504	5,759	13,241

[1] Data from 1954-57 not comparable with earlier years.
[2] Revised figure.

Source: Bureau of the Census.

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

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TABLE 24.—U.S.[1] imports for consumption of hydraulic cement in 1962,[2] by countries and customs districts

(Barrels)

Customs district	Belgium-Luxembourg	Canada	Colombia	Denmark	France	West Germany	Japan	Mexico	Norway	Poland-Danzig	Sweden	United Kingdom	Other [3]	Total
Alaska		106					591							697
Arizona								364						364
Buffalo		51,517				275								51,792
Chicago	100	15,957												16,057
Connecticut									1,079,482					1,079,482
Dakota		48,848												48,848
El Paso								176						176
Florida	223,782		95,393		5,609	1,408	29,294			18,317	47,372	12,307	299	433,781
Galveston												60		60
Georgia	599										70,167	5,498		76,264
Hawaii	377			111			1,500							1,988
Laredo								22,690						22,690
Los Angeles							11,512					1,749		13,261
Maine and New Hampshire		5,128												5,128
Massachusetts										126,572				126,572
Michigan						13,426								13,426
Minnesota								351						351
Mobile	401													401
Montana and Idaho		18,873												18,873
New Orleans	4,314											1,377		5,691
New York	364,316		41,760	20,223		294,067	13		83,234			2,791	960,518	1,766,922
North Carolina	7,935													7,935
Oregon		17,180					69							17,249
Philadelphia						6,226						506	16,443	23,175
Puerto Rico	11,803		464,318	997	11,979	126	16,744						23,998	529,965
Rochester		1,208,277												1,208,277
St. Lawrence		27,460				625								28,085
San Diego		361					250	53,486						54,097
San Francisco		398										453		851
Vermont		205,660												205,660
Washington		136					1,172							1,308
Total: Barrels	613,627	1,599,901	601,471	21,331	17,588	316,153	61,145	77,067	1,162,716	144,889	117,539	24,741	1,001,258	5,759,426
Value	$1,745,442	$3,907,512	$1,254,480	$94,537	$76,603	$786,260	$286,390	$269,332	$2,278,573	$279,761	$185,063	$130,342	$1,947,016	$13,241,311

[1] Includes Puerto Rico.

[2] Changes in Minerals Yearbook 1961, p. 412, should read as follows: Belgium-Luxembourg $808,455; United Kingdom (Florida customs district) 10,325 barrels. Total barrels 3,621,283, value $9,224,613.

[3] Includes Dominican Republic (Florida customs district) 299 barrels, (New York) 269,883 barrels, (Puerto Rico) 22,123 barrels; Haiti (New York) 21,779 barrels; Israel (New York) 480,000 barrels; Italy (New York) 188,856 barrels; Venezuela (Puerto Rico) 1,875 barrels; Yugoslavia (Philadelphia) 16,443 barrels.

Source: Bureau of the Census.

TABLE 25.—U.S. exports of hydraulic cement, by countries

Destination	1960 Barrels	1960 Value	1961 Barrels	1961 Value	1962 Barrels	1962 Value
North America:						
Bermuda	1,363	$7,913	745	$4,128	3,197	$5,850
Canada	55,440	364,976	54,802	376,575	29,867	222,012
Central America:						
British Honduras	382	1,717	590	2,377	452	3,345
Canal Zone	140	1,227	32,675	126,962		
Costa Rica	4,557	16,432	24,083	74,624	16,763	57,080
El Salvador	26	560	323	1,520	124	2,412
Guatemala	1,026	5,775	48	522		
Honduras	9	198	12	260		
Nicaragua	7,776	33,915	4,813	21,515	3,676	17,714
Panama			124	1,382		
Mexico	7,344	60,324	13,696	61,410	13,177	95,516
West Indies:						
British:						
Bahamas	14,403	65,265	34,236	108,490	25,122	110,403
Barbados	2,024	6,240			25	200
Jamaica	537	1,803	202	870		
Leeward and Windward Islands	12,241	43,162	16,773	52,965	20,832	63,956
Trinidad and Tobago	398	2,042	5,048	26,579	798	3,130
Cuba	1,157	7,239				
Dominican Republic	94	1,364	74	374	34	210
French West Indies	6,455	18,244	615	2,164	3,687	10,138
Haiti					1,000	2,800
Netherlands Antilles	640	6,048	419	1,310	55	232
Total	116,012	644,444	189,278	864,027	118,809	594,998
South America:						
Argentina	10,928	57,747	8,310	40,501	385	1,961
Bolivia	2,891	21,093	4,650	29,251	2,551	21,392
Brazil	2,004	22,074	22	484	3,425	73,563
Chile	10,353	64,153	1,381	17,360	1,604	21,888
Colombia	219	3,840	1,203	8,855	380	2,577
Peru	815	8,967	2,505	15,115	2,918	16,540
Venezuela	287	4,694	66	1,144		
Other			306	2,529	54	338
Total	27,497	182,568	18,443	115,239	11,317	138,259
Europe:						
Belgium-Luxembourg	264	2,582	1,321	2,135	596	8,984
Germany, West	191	2,960	120	600	187	2,300
Netherlands	88	1,654			1,425	8,042
Switzerland	135	6,173	1,320	6,446	4,165	12,355
Other	144	5,425	1,191	10,506	273	2,974
Total	822	18,794	3,952	19,687	6,646	34,655
Asia:						
India	55	1,238	562	4,355	818	4,605
Indonesia	750	3,735	19,159	86,278	20,329	98,099
Iraq	8,250	70,010	1,250	7,791		
Japan	1,112	28,567	8,762	72,041	5,133	49,203
Korea, Republic of			36	970	201,649	846,635
Kuwait	1,500	6,533	804	3,660	372	3,548
Pakistan	1,366	9,501	206	1,140	128	520
Philippines	751	5,991	1,506	7,721	48	900
Saudi Arabia	54	936	1,067	3,316	166	1,304
Turkey	187	2,900			3,543	20,978
Other	3,536	22,934	1,163	7,932	3,316	14,842
Total	17,561	152,345	34,515	195,204	235,502	1,040,634
Africa:						
Liberia	5,500	29,688	3,250	2,326	2,913	13,501
Libya	1,025	8,900	400	4,968	3,038	20,135
South Africa, Republic of[1]	4	264	136	658	974	4,405
Other	2,325	11,701	6,113	28,397	572	1,773
Total	8,854	50,553	9,899	36,349	7,497	39,814
Oceania	16,558	85,971	29,729	156,340	612	4,616
Grand total	187,304	1,134,675	285,816	1,386,846	380,383	1,852,976

[1] Effective Jan. 1, 1962, formerly Union of South Africa.

Source: Bureau of the Census.

WORLD REVIEW [15]

NORTH AMERICA

Canada.—Apparent consumption of cement in 1961 was 31,696,000 barrels compared with 29,944,000 barrels in 1960.[16] Capacity of 20 plants operating at the end of 1961 totaled 50,010,000 barrels. Canada Cement Co., Ltd. opened a distribution plant at Regina, Saskatchewan. Minor expansions were underway in several plants.

TABLE 26.—World production of hydraulic cement by countries [1]

(Thousand barrels)

Country	1953-57 (average)	1958	1959	1960	1961	1962
North America:						
Canada (sold or used by producers)	24,778	32,729	33,427	30,782	33,010	35,907
Cuba	2,938	4,192	3,670	[2] 2,345	[2] 1,759	[2] 1,759
Dominican Republic	1,231	1,583	1,114	997	1,390	1,507
Guatemala	457	692	680	657	733	686
Haiti	[3] 117	211	223	281	258	[2] 258
Honduras	----------	----------	64	199	246	328
Jamaica	686	1,044	1,155	1,243	1,266	1,173
Mexico	12,155	14,887	15,884	18,112	17,801	19,654
Nicaragua	188	235	205	188	229	270
Panama	446	393	569	639	668	633
Salvador	346	510	487	504	440	375
Trinidad	[4] 616	879	1,055	1,038	575	100
United States (including Puerto Rico)	301,133	326,352	355,734	334,130	338,628	351,932
Total	345,091	383,707	414,267	391,115	397,003	414,582
South America:						
Argentina	11,328	14,488	13,884	15,485	16,675	17,021
Bolivia	188	170	170	223	264	293
Brazil	16,382	22,222	22,521	26,232	27,610	29,739
Chile	4,503	4,257	4,902	4,855	5,101	6,725
Colombia	6,250	7,200	7,951	8,590	9,217	10,061
Eucador	751	938	921	1,179	1,284	1,137
Paraguay	59	41	76	82	94	100
Peru	3,020	3,547	3,412	3,524	3,835	3,870
Uruguay	1,894	2,539	2,474	2,433	2,281	2,193
Venezuela	7,828	9,475	10,976	8,719	8,871	8,854
Total	52,203	64,877	67,287	71,322	75,232	79,993
Europe:						
Albania	240	457	434	428	704	[2] 704
Austria	10,484	12,630	14,172	16,593	18,082	17,924
Belgium	27,042	23,787	26,027	25,728	27,862	28,126
Bulgaria	4,726	5,476	8,402	9,293	10,255	11,099
Czechoslovakia	17,115	24,098	27,558	29,616	31,328	34,300
Denmark	7,141	6,262	8,150	8,455	9,287	9,545
Finland	5,775	5,424	6,860	7,347	7,863	7,956
France	63,001	78,650	82,080	83,101	91,057	97,917
Germany:						
East	17,338	20,862	24,655	29,504	30,929	31,849
West	99,535	115,407	135,817	146,025	159,153	167,667
Greece	6,104	7,857	8,467	9,598	10,771	[2] 10,876
Hungary	6,057	7,634	8,402	9,211	9,393	10,132
Iceland	----------	193	457	428	440	569
Ireland	3,489	3,055	3,102	3,342	4,538	5,312
Italy	65,124	75,185	84,443	93,895	105,721	118,187
Luxembourg	950	1,149	1,126	1,231	1,354	[2] 1,349
Netherlands	6,461	8,009	9,381	10,542	11,158	11,815
Norway	4,966	6,045	6,631	6,749	7,200	8,279
Poland	22,327	29,657	31,175	38,651	43,177	44,233
Portugal	5,083	6,004	6,045	7,024	7,300	8,226
Rumania	11,510	15,080	16,716	17,907	19,396	20,457
Spain	24,731	31,193	33,591	33,614	38,862	37,783

See footnotes at end of table.

[15] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.

[16] Dominion Bureau of Statistics, Industry and Merchandising Division (Ottawa, Canada). Cement Manufacturers, 1961. Annual, No. 44-204, December 1962, 10 pp.

TABLE 26.—World production of hydraulic cement by countries [1]—Continued

(Thousand barrels)

Country	1953–57 (average)	1958	1959	1960	1961	1962
Europe—Continued						
Sweden	14,435	14,717	16,535	16,452	17,660	17,907
Switzerland	12,202	12,811	15,731	17,801	21,114	21,847
U.S.S.R	130,388	195,283	227,402	266,897	299,028	335,967
United Kingdom	72,001	69,486	74,992	79,137	84,291	83,587
Yugoslavia	9,135	11,533	13,017	14,060	13,691	14,764
Total	647,360	787,944	891,368	982,629	1,081,614	1,158,377
Asia:						
Afghanistan [5]	----------	----------	199	217	240	[2] 410
Burma	276	211	211	264	235	[2] 235
Ceylon	422	469	557	498	481	498
China	30,794	54,529	71,943	79,155	[2] 58,633	[2] 52,770
Cyprus	[6] 311	487	487	516	545	557
Hong Kong	592	891	833	879	1,079	1,243
India	27,634	36,270	40,668	45,939	48,337	50,424
Indonesia	985	1,753	2,017	2,269	2,609	2,996
Iran [5]	921	2,404	3,395	4,673	4,368	[2] 4,368
Iraq	2,093	3,923	3,876	3,624	5,494	5,400
Israel	3,547	4,181	4,579	4,726	4,960	5,594
Japan	68,255	87,862	101,247	132,147	144,448	168,787
Jordan	[4] 493	668	645	967	1,308	1,378
Korea:						
North	2,474	7,177	11,293	13,398	13,263	13,931
Republic of	352	1,736	2,099	2,527	3,067	4,632
Lebanon	2,498	2,973	4,356	5,007	5,125	[2] 5,048
Malaya	522	645	1,132	1,677	1,941	1,865
Pakistan	4,526	6,391	5,875	6,796	7,288	8,179
Philippines	2,287	3,764	4,263	4,661	5,975	5,635
Saudi Arabia	----------	16,019	(7)	(7)	616	891
Syrian Arab Republic	1,618	2,269	2,621	2,867	3,166	3,512
Taiwan	3,330	5,951	6,256	6,936	8,824	10,906
Thailand	2,181	2,674	2,990	3,084	4,673	5,646
Turkey	5,031	8,895	10,167	11,949	11,891	13,597
Viet-Nam, North	1,179	1,771	2,228	2,380	2,656	[2] 2,756
Total	162,321	253,913	283,937	337,156	341,222	371,258
Africa:						
Algeria	3,770	4,937	5,611	6,227	6,285	[2] 3,811
Angola	416	973	909	944	921	956
Cameroon, Republic of	[3] 59	64	[2] 64	----------	----------	----------
Canary Islands	----------	35	293	405	(8)	(8)
Congo, Republic of the (formerly Belgian)	2,252	2,287	2,035	[2] 1,173	[2] 680	[2] 950
Ethiopia	141	188	147	164	176	240
Kenya	739	1,272	1,841	2,070	1,935	2,029
Morocco	3,682	2,392	2,943	3,401	3,694	4,093
Mozambique	756	1,055	1,249	1,302	1,243	1,085
Nigeria	----------	663	721	909	2,680	[2] 2,814
Rhodesia and Nyasaland, Federation of	2,902	4,667	3,489	[2] 3,518	2,568	[2] 2,345
Senegal	674	874	1,020	985	1,067	1,073
South Africa, Republic of	13,632	15,960	15,520	15,860	15,233	15,591
Sudan	[3] 375	522	586	709	487	498
Tunisia	1,941	2,023	2,592	2,375	2,105	2,128
Uganda	299	610	481	422	369	328
United Arab Republic (Egypt)	7,763	8,871	10,419	10,859	12,524	12,606
Total	39,401	47,393	49,920	51,323	51,967	50,547
Oceania:						
Australia	11,680	14,418	15,333	16,370	16,751	17,197
New Zealand	2,351	3,289	3,295	3,618	3,817	3,700
Total	14,031	17,707	18,628	19,988	20,568	20,897
World total (estimate) [1]	1,260,407	1,555,541	1,725,407	1,853,533	1,967,606	2,095,654

[1] This table incorporates some revisions.
[2] Estimate.
[3] Average annual production 1955–57.
[4] Average annual production 1954–57.
[5] Year ended March 20 of year following that stated.
[6] Average annual production 1956–57.
[7] Data not available; no estimate included in total.
[8] Included with Spain.

Compiled by Helen L. Hunt, Division of Foreign Activities.

Costa Rica.—A loan of $2.8 million from the Inter-American Development Bank was approved for construction of a $5 million 500,000-barrel plant (the country's first cement plant) by Industria Nacional de Cemento, S.A., at Cartago in Cartago Province, 20 miles southeast of San Jose.[17]

Dominican Republic.—Exports of cement totaled 831,000 barrels in 1961 and 173,000 barrels in the first quarter of 1962. Capacity of the country's only cement plant at Santo Domingo was rated at 1,760,000 barrels.

El Salvador.—Production was valued at $1,276,680, equal to $3.41 per barrel.

Grand Bahama.—Bahama Cement Co., a subsidiary of Universal Atlas Cement Co., began construction of a $40 million cement plant equipped with two 575-foot kilns. The plant was to be completed in 1964. A large part of the production was to be exported.

Honduras.—Since completion of the Western Highway Extension in El Salvador opened new cement markets, Cementos de Honduras made plans to double its capacity to 600,000 barrels.

Jamaica.—Operations at the Caribbean Cement Co., Ltd., plant and quarry were described.[18] Capacity was scheduled for doubling by the installation of a third kiln.

Netherlands Antilles.—Clay and limestone suitable for use in cement were found in a survey by E. J. Longyear Co. (Minneapolis, Minn.) at Sabana Basora, Barcadera, and Bubali on the island of Aruba. Financing was sought for a $10 million, 1-million-barrel plant possibly located at Barcadera, the site of new harbor construction.

SOUTH AMERICA

Bolivia.—Corporació Boliviana de Fomento planned an $800,000 expansion of its Sucre cement plant.

Brazil.—Cement processing was described at the plant of Companhia Cimento Portland Caue, Belo Horizonte, State of Minas Gerais.[19] The company doubled capacity to 1 million barrels during 1962. Cia. Cimento Brasileiro, at Esteio near Pôrto Alegre, imported Norwegian equipment to increase capacity from 750,000 to 1 million barrels per year.

Chile.—The new plant of Cementos Bio-Bio, S.A., began operating in late 1961. Cia. de Acero del Pacifico supplied high-grade limestone and blast furnace slag to the plant.

Colombia.—Controls were relaxed on imports of portland cement. Cementos del Caribe, S.A., and Cementos Nare planned to erect a 200,000- to 300,000-barrel plant at Cartagena.

Peru.—With funds provided by the Inter-American Development Bank, Compania Peruana de Cemento Portland began the modernization and expansion of its Atacongo plant near Lima. Capacity was to rise from 3 million to 4 million barrels annually. Increased public construction and the Mantaro hydroelectric project contributed to the expansion.

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[17] Bureau of Mines. Mineral Trade Notes. V. 54, No. 3, March 1962, pp. 9, 10.

[18] Moorhead, G. A. Rock Ripping at Long Mountain, Jamaica. Mine and Quarry Eng. (London), v. 28, No. 4, April 1962, pp. 146–151.

[19] Moller, Ole. Brazilian Cement Firm Doubles Plant Capacity. Nonmet. Min. Proc., v. 3, No. 2, February 1962, pp. 15–18.

EUROPE

The European cement industry in 1961 was evaluated in a statistical report published by the Organization for Economic Co-Operation and Development.[20] Production capacity of the member countries totaled 694,392,000 barrels at the end of 1961 and was expected to rise to 742,790,000 barrels in 1962.

Bulgaria.—Scheduled completion of the Devnya cement plant expansion from 3- to 6-million-barrel capacity was advanced from 1964 to late 1963.

France.—The Fourth Modernization Plan included a 108-million-barrel cement capacity by 1965. Domestic consumption increased 9.6 percent in 1961 from the 1960 figure and reached 84,680,000 barrels. Exports of 6,157,000 barrels, including 938,000 barrels to the Saar, and imports of 88,000 barrels were reported in 1961.

Greece.—The first of two 1.2-million-barrel kilns was installed in the Titan Cement Co. plant at Thesaloniki and the second was expected to be in operation by late 1964. When complete, expansions would bring capacity to 5 million barrels. The feasibility of using Ptolemais lignite for fuel was studied. General Cement Co. planned a $1 million expansion of its Piraeus plant and a total plant expansion of 2-million-barrels capacity. Chalkis Cement Co. planned a $5 million expansion with a German-made kiln which would increase capacity from 700,000 to 2 millon barrels by 1964. The Greek Government authorized construction of a $5 million plant with about 1.5 million-barrel capacity by an American company, European Growth, Inc.

Hungary. Operation of the new 6-million-barrel plant of the Danube Cement and Lime Works at Vac, north of Budapest, was scheduled to begin in early 1963. Output of the Belapatfalva Cement and Lime Works was to be tripled to 3 million barrels by 1967. The Hejocsaba Cement and Lime Works was remodeled, adding 800,000 barrels of capacity.

Iceland.—The State-owned cement plant at Arkranes supplied all production, 105,000 barrels of which was exported to the United Kingdom. Domestic consumption totaled 364,000 barrels. First exports of cement were reported in 1961 when 111,000 barrels were sold in the United Kingdom at $2.67 per barrel, c.i.f. A distribution and shipping terminal was to be constructed at Reykjavik. Cement consumption increased because of building construction and harbor improvements.

Italy.—In all, 113 cement plants with 114-million-barrel capacity were in operation.

Norway.—Cement consumption in 1961 was 6,709,000 barrels, compared with 6,357,000 barrels in 1960. Exports, mainly to the United States, increased to a record 710,000 barrels in 1961 from 334,000 barrels in 1960. Production of A/S Dalen Portland Cementfabrik at Brevik totaled 3,577,000 barrels in 1961, and the plant was the source of exported cement.

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[20] Organization for Economic Co-Operation and Development (Paris). The Cement Industry of Europe, 1961. July 1962, 38 pp.

Poland.—The cement industry and its productivity were discussed.[21] Sixteen plants were active in 1962. Output of 60 million barrels of cement from 19 plants was scheduled for 1965. White cement production was scheduled at the Wejherowo plant.

Sweden.—Exports totaled 1,120,000 barrels in 1961, and were mostly to other European countries. Skanska Cement, A.B. produced 13.5 million barrels of cement in 1961. About 64 percent of all shipments were in bulk.

Switzerland.—Capacity was doubled to 3.5 million barrels at the Jura Cement Works, Aarau-Wildegg, with the installation of a new Lepol kiln.

U.S.S.R.—A breakdown of production by types of cement was published for the years 1928 to 1958.[22] The Russian cement industry was described.[23] The U.S.S.R. planned to add 50 million barrels of cement capacity in 1963.

United Kingdom.—The new 1.2-million-barrel plant of Associated Portland Cement Manufacturers, Ltd. at Plymstock, Devon, began production in October 1961. Operations at the Ribblesdale Cement Ltd. plant, near Chitheroe, Lancs, were described.[24]

ASIA

Afghanistan.—A 350,000-barrel cement plant built with technical assistance from Czechoslovakia was formally opened at Ghori near Pul-i-Khumri, northern Afghanistan, in May. The plant production was to be expanded to 700,000 barrels during the Second Five-Year Plan.

Ceylon.—The State-owned Kankesan Cement Works at Kankesanturai, managed by Ceylon Cement Corp., was to have its production capacity expanded from 0.5 to 1.5 million barrels by 1964.[25] A terminal and clinker grinding plant with a 600,000-barrel capacity were to be established at Galle. The facility would use imported clinker until clinker was available from Kankesanturai. A second plant, with an initial capacity of 1 million barrels, was to be constructed at Puttalam.

India.—A license was granted by the Indian Government to Tendulkar Industries to build a plant in the Yeotmal district, Maharashtra State. An initial capacity of 1.5 million barrels, expandable to 6 million barrels, was planned. The new 600,000-barrel plant of Mysore Cements, Ltd., a joint venture of Mudalier Associates and Kaiser Engineers Overseas Corp., began operation in November. Expansion was already underway to double capacity. The 1961 imports, mainly from West Pakistan, totaled 169,000 barrels valued at $707,000 and exports, mostly to East Pakistan and Ceylon, were 587,000 barrels valued at $1,987,000.[26]

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[21] Kuklinski, Antoni, and Antonina Rosakowdka. (Production and Employment in Polish Cement Industry in 1946–1965.) Cement Wapno Gips (Warsaw, Poland), v. 17, No. 7–8, July–August 1962, pp. 236–271.

[22] Rock Products. Soviet Cement Figures Demonstrate Rapid Growth. V. 65, No. 8, August 1962, p. 51.

[23] Revue des Materiaux de Construction et de Travaux Publics (Paris, France). (Cement Industry in the U.S.S.R.) No. 552, 1961, pp. 379–392; No. 553, 1961, pp. 415–433; J. Am. Ceram. Soc., Ceram., Abs., v. 45, No. 6, June 1962, p. 134.

[24] Mine and Quarry Engineering (London). Institute of Quarrying Annual Conference. V. 28, No. 12, December 1962, p. 538.

[25] Bureau of Mines. Mineral Trade Notes. V. 55, No. 5, November 1962, pp. 7–9.

[26] Bureau of Mines. Mineral Trade Notes. V. 55, No. 6, December 1962, p. 6.

Indonesia.—Machinery for the Tonasa cement plant was shipped to Makassar.

Iraq.—The Government signed a contract with Ingra, a Yugoslav organization, to establish a supply of raw materials and place in operation the idle $7 million Government-owned Hamman-al Alil plant near Mosul. The unsuccessful plant was designed for a capacity of 700,000 barrels per year.

Israel.—Exports of cement remained high as a result of trade commitments with the United States, whereas Eastern European cement was imported for domestic consumption. Exports totaled 987,000 barrels valued at $1.86 million, compared with 1,063,000 barrels valued at $2.03 million in 1961. Expansion of the Ramle plant of Nesher Cement Co. was underway with the installation of two kilns.

Japan.—The cement industry and the Japanese role as the world leading cement exporting country were discussed.[27] About 12 million barrels of cement was exported in 1961. A total of 49 plants were in operation.

Jordan.—A third kiln was added to the Jordan Cement Factory Co., Ltd., plant which increased capacity to 2 million barrels. About 20 percent of the plant production contained pozzolana. The company, in which the Government had one-half interest, imported 66,000 barrels of cement in 1961.[28]

Korea, Republic of.—A West German company, Polysius, G.m.b.H., supplied equipment for a new 2.2-million-barrel plant under construction by Hamil Cement Manufacturing Co. in Tanyang County, North Chungchong Province. New kilns were added in 1961 at Korea's two existing plants of Tongyang Cement Co. at Samchok and United Nations Korean Reconstruction Agency at Mungyong, increasing the combined capacity by 1.7 million barrels. The Ministry of Commerce and Industry announced plans for a 1.7-million-barrel plant to be constructed in the Kangwon-do area on the Korean east coast.

Lebanon.—Two companies, Cimenterie Nationale, a Lebanese corporation, and Swiss controlled Société des Ciments Libanais, operated plants several miles apart south of Chekka.[29] Ground was broken for a white cement plant at Chekka.

Malaya, Federation of.—Consumption of cement increased from 1,886,000 barrels in 1960 to 2,455,000 barrels in 1961. Imports in 1961 totaled 552,000 barrels, and exports totaled 29,000 barrels. A one-third increase in capacity was planned by Malayan, Cement Ltd., and a new plant was to be built near Ipoh.

Pakistan.—Construction of a $6.8 million cement plant at Takerghat, East Pakistan, was recommended following studies by the Technical Consulting Institute of Japan. A plant with initial capacity of 900,000 barrels and using Sylhet natural gas for fuel was being considered by Shoaīb Enterprise. Limestone at Takerghat was in lowlands that were flooded during the monsoon, and further studies of the deposits were planned.[30] New kilns were planned for the Wah

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[27] Cole, Kenneth J. The Japanese Cement Industry. Cement, Lime and Gravel (London), v. 37, No. 2, February 1962, pp. 55–56.
[28] Bureau of Mines. Mineral Trade Notes. V. 55, No. 5, November 1962, p. 9.
[29] Bureau of Mines. Mineral Trade Notes. V. 55, No. 3, September 1962, pp. 10–12.
[30] Bureau of Mines. Mineral Trade Notes. V. 56, No. 3, March 1963, pp. 8, 9.

and Rohri plants of Associated Cement Co., Ltd., increasing capacity of the two plants to 3 million barrels, following purchase of the Indian-owned company by a Pakistan-U.S. consortium. Zeal-Pak Cement Co. planned to add a fourth 700,000 barrel kiln to its Hyderabad plant. Total capacity of the six West Pakistan plants was 7,480,000 barrels.[31]

Philippines.—The new $10 million Filipinas Cement Corp. plant at Teresa, Rizal, neared completion. The Republic Cement Co. plant at Norzogarey was to be expanded to a 2.5-million-barrel capacity.

Ryukyu.—Cement totaling 1,484,000 barrels was imported, compared with 1,202,000 barrels in 1961.

Taiwan.—Taiwan Cement Corp. completed a 300,000-barrel plant at Hwalien, eastern Taiwan, and the company increased the capacity at its Kaohsiung plant to 3.5 million barrels.

Thailand.—Exports increased to 798,000 barrels valued at $1.9 million in 1961, compared with 142,000 barrels valued at $520,000 in 1960. Most of the cement went to the U.S. Operations Mission in South Viet-Nam. Thai Cement Co., with plants at Bangsue, Bangkok, and Tha Larn, Ayudhya, having total capacity of 4 million barrels, received promotional privileges from the Government to establish a third plant with about a 1.5-million-barrel capacity in southern Thailand.

Turkey.—The State-owned cement plant at Söke, with a capacity of 600,000 barrels, was opened in November, and was expected to relieve local shortage in the Aegean area.

Viet-Nam.—A 350,000-barrel plant was under construction in Thua Thien Province.

AFRICA

Gabon.—Limestone deposits at Achouka on the Ogooue River were to be investigated by the French Bureau of Geological and Mineral Research in the expectation of establishing supplies for a cement plant to be constructed at Port Gentil.

Ghana.—An agreement was signed between Ghana and the Polish trade organization, CEKOP, to construct a 1-million-barrel plant at Nauli, in western Ghana for initial operation in 1964. This would be the first cement plant in Ghana.

Kenya.—British Standard Portland Cement Co., Ltd., planned to increase capacity by 300,000 barrels to 2.3-million-barrels capacity at its Bamburi plant.

Liberia.—A proposed cement plant to be established jointly by the Liberian Government and an Italian firm would use limestone transported from Italy to Liberia as ballast on ore ships.

Senegal.—Value of cement production was $3,672,000. Exports in 1961 totaled 1,066,000 barrels.

South Africa, Republic of.—Expansion to a 3.5-million-barrel capacity was completed at the Pretoria Portland Cement Co. Ltd. plant at Slurry in the Transvaal. Construction plans for a $2.8 million blast-furnace slag cement plant at Coedmore, near Durban, were announced. The plant which is to be completed in 1963, was to use slag from the Newcastle works of African Metals Corp., Ltd. Durban Cement

[31] Bureau of Mines. Mineral Trade Notes. V. 55, No. 3, September 1962, pp. 12, 13.

Products, Ltd. was formed to operate the plant by the combine of Pretoria Portland Cement Co., Ltd., White's South Africa Portland Cement Co., Ltd., Anglo-Alpha Cement, Ltd., and Cape Lime Holdings.

Tanganyika.—Tanganyika Portland Cement Co., which handled cement imported from the Bamburi, Kenya, plant of British Standard Portland Cement Co., Ltd., completed negotiations with the Government to construct a cement plant at Wazo Hill, north of Dar es Salaam.

OCEANIA

Australia.—Fourteen cement plants were in operation—five in New South Wales, two in Victoria, two in Queensland, two in South Australia, two in Western Australia, and one in Tasmania. The new 1.5-million-barrel Geelong plant of Australian Portland Cement Pty., Ltd., was to start operating in 1963.[32]

New Zealand.—Wilsons Portland Cement, Ltd., of Auckland, placed in service a 1,750-ton bulk cement carrier, the *John Wilson*.[33] The ship featured fast airslide unloading.

TECHNOLOGY

A digital computer was used successfully for closed loop control of kiln operations in a west coast cement plant.[34] The same computer was in use for several years for raw mix and clinker composition control. Variables at 20 points were scanned every 8 seconds, and control set points for feed, fuel, air, and cooler were adjusted according to programmed calculations cycled every 5 minutes. An emergency program corrected for unusual happenings. A number of advantages were cited, including better control of free lime in the cement. A recently-built Japanese wet-process cement plant was being redesigned around a similar computer installation.[35] Processing controls covered raw material blending of slurry, calcination, and product blending to make production of four 2-million-barrel kilns as efficient as possible.

Various other automatic control devices were described and discussed. Analog computer control at a northern California plant was the subject of one article.[36] A number of writers reported on cement plant automation.[37] Cement manufacture was monitored by tele-

[32] Cement, Lime and Gravel (London). Production and Use of Cement in Australia. V. 37, No. 5, May 1962, pp. 151 and 152.
[33] Rock Products. "Down Under" Cement Ship. V. 65, No. 5, May 1962, pp. 180–182.
[34] Chemical & Engineering News. V. 40, No. 25, June 18, 1962, pp. 62, 64–65.
[35] Chemical Engineering. Computer System Tightens Cement-Kiln Control. V. 69, No. 22, Oct. 29, 1962, pp. 62–64.
[36] Rock Products. New Control Concept at Calaveras. V. 65, No. 5, May 1962, pp. 118–121.
[37] Adams, G. E., W. M. Gaines, J. H. Herz, and J. R. Romig. Use of Process Control Computers in the Cement Industry. Nonmet. Min. Proc., v. 3, No. 9, September 1962, pp. 45–50.
Aiken, W. S. Digital Process Control Computers: Capabilities and Types. Nonmet. Min. Proc., v. 3, No. 9, September 1962, pp. 25–32.
Gunsaulus, R. K. New Trends and Concepts in Cement Plant Central Control Centers. Nonmet. Min. Proc., v. 3, No. 6, June 1962, pp. 31–37.
Krueger, Robert W. Interesting Process and Operational Features of the St. Louis Plant of Missouri Portland Cement Co. Nonmet. Min. Proc., v. 3, No. 6, June 1962, pp. 39–43.
Levine, Sidney. Process Instrumentation and Control Computers in the Cement Industry. Nonmet. Min. Proc., v. 3, No. 9, September 1962, p. 55.
Markle, H. A., Jr. Cement Plant Arrangements Most Suitable for Automation. Nonmet. Min. Proc., v. 3, No. 9, September 1962, pp. 21–23.
Rock Products. Does a Robot Cement Plant Lie Around the Corner? V. 65, No. 6, June 1962, pp. 142, 144, 147–148.

vision.[38] Operational data were given for a Michigan plant.[39] Included in the plant was an extensive closed circuit television system.

Sessions were held on electrical maintenance and safety, power distribution, drive mechanisms, and automation at the Fourth Annual Cement Industry Technical Conference of the American Institute of Electrical Engineers in April at St. Louis, Mo. The program presented 20 papers, and included reports on the vacuum X-ray spectrometer, X-ray raw mix control, instrument maintenance, plant lighting, electrical grounding insulation and distribution, and automatic process control equipment.[40] Changes in capacities and plant ownership patterns in recent years were discussed at the meeting.[41]

Effectiveness of maintenance in cement plants was measured by charting four major functions: planning, work load, cost, and productivity. Rating zones from excellent to poor were drawn, and by superimposing the four functional charts an overall evaluation was possible.[42]

Recommended solutions were given for electrical distribution problems in cement plants, and power costs were compared for various operating voltages and substation capacities.[43]

Electrical service to cement plants in the Lehigh Valley, Pa., was discussed.[44] Annual power consumption by 11 plants was in excess of 264 million kilowatt hours. Characteristics of geared drives and ratings to be considered in their use in cement plants were discussed.[45]

Cement production methods and efficiencies in America were compared with those in Europe.[46] Vertical shaft kilns were used in more than 20 plants in Europe but in only 1 plant in the United States.

Proceedings of the Fourth International Symposium on Chemistry of Cement held in October 1960 at Washington, D.C., were published.[47] Reviews were given of transactions of the Fourteenth General Meeting of the Japan Cement Engineering Association in 1960.[48] Papers on air classifier efficiency, sampling of kiln exhaust gases, over-grinding of cement clinker, and control of water in slurries by radioisotope measurement were among those discussed. Exceptional research enterprise was shown by a Japanese cement company.[49] Central facilities

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[38] Rock Products. Television Keeps an Eye on Cement. V. 65, No. 3, March 1962, pp. 80–81.

[39] Nonmetallic Minerals Processing. Pointers for Cement Plant Design. V. 3, No. 1, January 1962, pp. 26–28.

[40] Nonmetallic Minerals Processing. Highlights from Technical Reports Delivered at the AIEE Conference. V. 3, No. 6, June 1962, pp. 45–55.

[41] Young, W. J. Growth of the American Cement Industry: 1950–1960 and the Next Decade. Nonmet. Min. Proc., v. 3, No. 6, June 1962, pp. 26, 27.

Trauffer, Walter E. AIEE Cement Industry Technical Conference at St. Louis Features Automation, Maintenance. Pit and Quarry, v. 54, No. 12, June 1962, pp. 86–90, 92.

[42] Kolb, Elmer R. Can More Be Expected of Maintenance? Rock Products, v. 65, No. 3, March 1962, pp. 114–132.

[43] Nonmetallic Minerals Processing. How to Plan Power Distribution for Cement Plants. V. 3, No. 1, January 1962, pp. 20–25; pt. II, v. 3, No. 2, February 1962, pp. 25–28.

[44] Baum, W. U., P. J. Britt, and C. L. Pollard. The PP&L: How it Serves the Lehigh Valley Cement Industry. Nonmet. Min. Proc., v. 3, No. 12, December 1962, pp. 26–30.

[45] Lordi, A. C. Selecting Geared Drives for Cement Plants. Nonmet. Min. Proc., v. 3, No. 7, July 1962, pp. 16–20.

[46] Voldbaek, Erik. Developments in Cement Production—European Versus American. Min. Cong. J., v. 48, No. 8, August 1962, pp. 84–88, 92.

[47] National Bureau of Standards. Chemistry of Cement, Proceedings of the Fourth International Symposium. NBS Monograph 43, v. 1–2, 1962, 1125 pp.

[48] Effects of Calcium Sulphates on Various Portland Cements. Rock Products, v. 65, No. 12, December 1962, pp. 18, 90, 92.

Rockwood, Nathan C. More Japanese Research on Cements. Rock Products, v. 65, No. 11, November 1962, pp. 20, 96–100.

[49] Marsh, C. W. Onoda Cement Company of Japan. Pit and Quarry, v. 54, No. 8, February 1962, pp. 86–89.

were provided for quality control and testing, product development, and analysis by electronic data processing of reports from the company's 11 plants.

Standard samples of portland cement were made available by the National Bureau of Standards for calibration of laboratory instruments and checking accuracy of analytical methods.[50] The samples were of special value for calibrating X-ray fluorescence equipment.

X-rays came into increasing use in cement plants, but standardization of X-ray analytical equipment was a problem.[51] Reproducible results were obtained with a 2½ minute X-ray scan of cement and raw mix samples making simultaneous analyses of five elements.[52] Importance of correct sampling technique for X-ray analysis was stressed.[53]

Errors in X-ray analysis of clinker for various mineralogical components were reduced by use of a counting rate computer.[54] Calculations of mineralogical content from chemical analyses were in good agreement with the content observed under the microscope.[55] The latter report included photomicrographs showing crystalline changes during clinker calcination from 900° to 1,450°C and gave results of a study on ash pickup from fuel in which free calcium oxide disappeared when ash content was increased from 6 to 9 percent.

Thin sections of hydrated cement were cut by an ultra-microtome and examined under the electron microscope. Apparent factors involved in strength development of hardening cement were summarized as follows: Formation of a three-dimensional network of calcium hydroxide; bonding of fibers and layers of calcium silicate hydrates by van der Waals and electrostatic forces; and interlocking of calcium silicate hydrates and calcium hydroxide by coalescence of similarly oriented lattices with chemical cross-connections.[56]

Cement hydration studies were conducted on the following subjects: Effect of lime and gypsum on hydration of a tetracalcium aluminoferrite (C_4AF) paste;[57] internal and capillary forces affecting the hardening of cement;[58] importance of silica gel in blocking corrosive attack;[59] reaction of cement with water indicating

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[50] U.S. Department of Commerce. Portland Cement Standard Samples. Technical News Bulletin, v. 46, No. 11, November 1962, pp. 174, 175.

[51] Hoffman, William S., and James W. Pastorius. X-Ray Analysis and Control of a Cement Raw Mix. Pit and Quarry, v. 55, No. 3, September 1962, pp. 113–116, 144.

[52] Palmer, Kenneth E. Applications of the Vacuum X-Ray Spectrometer to Cement Plant Operations. Pit and Quarry, v. 55, No. 1, July 1962, pp. 102–107, 179.

[53] Cook, Paul E. Continuous Sampling for X-Ray Analysis. Nonmet. Min. Proc., v. 3, No. 3, March 1962, pp. 19–22.

[54] Smolczyk, H. G. (The X-Ray Determination of the Crystalline Phases of Portland Cement Clinker.) Zement-Kalk-Gips (Wiesbaden, Germany), v. 50, No. 12, December 1961, pp. 558–566; Bldg. Sci. Abs. (London), v. 35, No. 4, April 1962, p. 110.

[55] Nitzsche, Hans G. (Microscopic Investigations of Commercial and Laboratory Cement Clinkers.) Tonindustrie-Zeitung und Keramische Rundschau (Goslar, Germany), v. 86, No. 2, 1962, pp. 25–30; J. Am. Ceram. Soc., Ceram. Abs., v. 45, No. 8, August 1962, p. 184.

[56] Uchikawa, H., and S. Takagi. (Electron Microscope Studies of Completely Hydrated Clinker Components.) Zement-Kalk-Gips (Wiesbaden, Germany), v. 14, No. 4, 1961, pp. 153–158; Tech. Transl. (Office of Tech. Services, U.S. Dept. of Commerce), v. 8, No. 9, Nov. 15, 1962, p. 888.

[57] Chatterji, S., and J. W. Jeffery. Studies of Early Stages of Paste Hydration of Cement Compounds, I. J. Am. Ceram. Soc., v. 45, No. 11, November 1962, pp. 536–543.

[58] Grün, W., and H. R. Grün. (The Problem of Physico-Chemical Behaviour of Hydrating Cement in Concrete.) Zement-Kalk-Gips (Wiesbaden, Germany), v. 14, No. 11, 1961, pp. 514–520; Bldg. Sci. Abs. (London), v. 35, No. 4, April 1962, p. 99.

[59] Steopoe, A., and L. Vaicum. (On the Diffusion of Ions Through the Gels Formed from Corroded Hardened Cement Paste.) Zement-Kalk-Gips (Wiesbaden, Germany), v. 50, No. 8, 1961, pp. 348–351; Building Sci. Abs. (London), v. 35, No. 1, January 1962, p. 4.

formation of a solid without initially going into solution;[60] and improved methods for calculating heat of hydration.[61] Rate and extent of the reaction of hardened cement paste with atmospheric carbon dioxide, a factor in deterioration, was shown to vary according to evaporable water content of the paste.[62] A study of the effect of thermal shock on hardened cement paste indicated that spalling was unrelated to the rate of heating.[63]

Measurements were made of the heats of solution of zinc oxides from various sources in nitric and hydrofluoric acids for use in determining heats of solution of cements and their pastes.[64] Ethylenediamine was used for rapid volumetric determination of aluminum, iron, and titanium in cements.[65] Alkali content of cement was determined after trapping iron, aluminum, calcium, and magnesium in ion exchange columns.[66]

Requirements and test methods for cement particle-size analysis were discussed.[67] The Coulter Counter method of size analysis was successfully applied to cement. In this method, particles passing through a tiny aperture between two electrodes caused resistance changes related to amount of displaced electrolyte. An electronic count was made from the amplified signal.[68] Specific surface area of cement was investigated.[69]

Procedures by which one company maintained uniform qualities of its cement were described.[70] A method was devised for processing low-grade siliceous fluorspar and clay in a cement kiln in the presence of steam to produce both portland cement clinker and hydrofluoric acid.[71] White cement and byproduct potassium sulfate were manufactured from potash, feldspar, limestone, and gypsum in a process developed by the Regional Research Laboratory at Hyderabad, India.

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[60] Hansen, W. C. Solid-Liquid Reaction in Portland Cement Pastes. Mat. Res. & Standards, v. 2, No. 6, June 1962, pp. 490–493.

[61] Jong, Ken, and Kung Jen Hsia. Estimation of Heat of Hydration of Portland Cement. Proc. Am. Conc. Inst., v. 58, No. 4, April 1961, pp. 459–470.

von Gronow, H. Elsner. (The Heat of Hardening of Portland Cement, With Particular Reference to the Physico-Chemical Nature of the Water Bound in the Hardened Cement Mortar.) Tonindustrie-Zeitung und Keramische Rundschau (Goslar, Germany), v. 86, No. 10, 1962, pp. 219–222; Building Sci. Abs. (London), v. 35, No. 9, September 1962, p. 261.

[62] Hunt, Charles M., and Lewis A. Tomes. Reaction of Hardened Portland Cement Paste With Carbon Dioxide. NBS J. Res., v. 66A (Phys. and Chem.), No. 6, November–December 1962, pp. 473–481).

[63] Tomita, H., and D. E. Well. Effect of Temperature Rise on Compressive Strength of Hardened Cement Paste. U.S. Naval Civil Engineering Laboratory, Port Hueneme, Calif., Tech. Rept. 169, November 1961, 45 pp.

[64] Newman, Edwin S. Zinc Oxide as a Standard Substance in the Solution Calorimetry of Portland Cement. NBS J. Res., v. 66A (Phys. and Chem.), No. 5, September–October 1962, pp. 381–388.

[65] Wallraf, M. (Volumetric Determination of Aluminum, Iron, and Titanium in Cements With the Aid of Ethylenediamine.) Zement-Kalk-Gips (Wiesbaden, Germany), v. 14, No. 11, 1961, pp. 504–507; Building Sci. Abs., v. 35, No. 9, September 1962, p. 261.

[66] Pucher, S. (Alkali Determination in Cements By Means of Ion Exchanges.) Zement-Kalk-Gips (Wiesbaden, Germany), v. 14, No. 8, 1961, pp. 346–348; J. Am. Ceram. Soc., Ceram. Abs., v. 45, No. 6, June 1962, p. 134.

[67] Porter, E. S. Particle-Size Analysis in Portland Cement Manufacturing. Min. Eng., v. 14, No. 6, June 1962, pp. 64–67.

[68] Brown, O. E. Use of the Coulter Counter for Particle Size Anlysis of Cement and Related Material. Cement, Lime, and Gravel (London), v. 37, No. 4, April 1962, pp. 99–104.

[69] Guerrero, D. Guinea. (A New Definition of Specific Surface of Cement). Instituto Eduardo Torroja de la Construccion y del Cemento (Madrid, Spain), Mono. No. 223, 1962, 27 pp.; Building Sci. Abs. (London), v. 35, No. 10, October 1962, p. 291.

[70] Nonmetallic Minerals Processing. Lone Star's Plant Chemists Assure Uniformity of Cement. V. 3, No. 4, April 1962, pp. 20–23.

[71] Kamlet, J. Process for the Joint Manufacture of Hydrofluoric Acid and Portland Cement Clinker. U.S. Pat. 3,017,246, Jan. 16, 1962.

Kiln Feed.—A newly developed photoelectric sorter was installed to remove off-color, high-dolomite limestone from mill feed.[72] Descriptions were given of a crushing and screening plant;[73] a system of interlocking controls for cement processing equipment;[74] lowered peak power by use of air-actuated clutches on mill drives;[75] an unusual preparation system utilizing fluidized bed drying;[76] and use of spring roll-type mills with grinding capacities up to 90 tons per hour.[77] An improved low-height vertical preheater was developed for dry process rotary type kiln,[78] and a high-capacity pelletizer was designed.[79]

Slurries.—Potential gains in production rates of about 8 percent were estimated through the use of phosphate deflocculants to thin slurries.[80] Carbonation and aging lowered viscosity and allowed several percent reduction in moisture, resulting in a 4 percent increase in production rate.[81] Properly sized slurry was obtained by directing the slurry flow against an inclined screen.[82]

Calcination.—Complex transient reactions in a wet process cement kiln were studied by mathematical models. Equations were given for expressing various material and energy balances, heat transfer, rates, and processing times.[83] Charts of several kiln variables showed advantages of computer over manual control. Benefits of computer control including increased fuel economy and production and decreased lining cost and downtime for a typical 1 million-barrel kiln were valued greater than $165,000 per year.[84]

Kiln speed was increased in properly incremented steps on startup by means of a motor-driven cam built into the kiln speed recorder. Such control resulted in smoother operation than was possible with a manually operated variable speed control.[85]

Results of a survey of 577 kilns operated in 133 plants in the United States and Canada were reported. Historical kiln data were given and comparisons were made of various features of equipment and processing.[86] A new furnace capacity formula was based on fuel

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[72] Chemical Week. Electric Eye on Feedstock. V. 92, No. 16, Apr. 21, 1962, p. 88.

[73] Nonmetallic Minerals Processing. Allentown Portland Installs New Crushing and Screening Plant. V. 3, No. 12, December 1962, pp. 17–18.

[74] Herz, J. H. Process Sequence Interlocking Including Motion Switching and Bin Level Detection. Nonmet. Min. Proc., v. 3, No. 9, September 1962, pp. 41–44.

[75] Nonmetallic Minerals Processing. Air-Actuated Clutches Reduce Peak Power Demand. V. 3. No. 7, July 1962, pp. 28–29.

[76] Rock Products. Novel System Keys Crushing. V. 65, No. 6, June 1962, pp. 112, 115–119.

[77] Kaminsky, W. A. (The Development of Large Spring Roll-Mills for Cement Works.) Zement-Kalk-Gips (Wiesbaden, Germany), v. 14, No. 11, 1961, pp. 489–496; Building Sci. Abs. (London) v. 35, No. 4, April 1962, pp. 98–99.

[78] Zacpal, Z. (assigned to Prerovske Strojirny, Czechoslovakia). Apparatus for Preheating Finely Divided Material. U.S. Pat. 3,067,990, Dec. 11, 1962.

[79] McDowell, R. C., and E. A. Gambon (assigned to McDowell Co., Inc., Cleveland). Apparatus for Making Nodules or Pellets. U.S. Pat. 3,060,496, Oct. 30, 1962.

[80] Schumacher, Carl P. Thinning Slurries for Fatter Profits. Nonmet. Min. Proc., v. 3, No. 12, December 1962, pp. 22–24.

[81] Diehl, Kent. B. Effectiveness of CO_2 Gas on Portland Cement Slurry. Nonmet. Min. Proc., v. 3, No. 12, December 1962, pp. 19–21.

[82] Hukki, R. T. (assigned to Insinooritoimisto-Engineering Bureau, Helsingers, Finland). Apparatus for Wet Sizing of Solid Materials. U.S. Pat. 3,064,806, Nov. 20, 1962.

[83] Min, H. S., P. E. Parisot, J. F. Paul, and J. W. Lyons. Computer Simulation of Wet-Process Cement Kiln Operation. Nonmet. Min. Proc., v. 3, No. 9, September 1962, pp. 35–39.

[84] Puckett, J. P. Instrumentation and Automatic Control Techniques as Applied to Rotary Kilns. Nonmet. Min. Proc., v. 3, No. 9, September 1962, pp. 51–54.

[85] Bendy, W. R. Programmed Control of Kiln Speed. Nonmet. Min. Proc., v. 3, No. 4, April 1962, pp. 18–19.

[86] Kannewurf, A. S., and C. F. Clausen. What Do You Know About Cement Kilns? Rock Products, v. 65, No. 5, May 1962, pp. 128–144.

burning capacity and effective use of heat.[87] Tests were made of oxygen enrichment in gas-fired kilns. It was said to be possible to boost clinker production by as much as 30 percent with oxygen.[88] Refractory problems in cement kilns were discussed in several articles.[89]

Patents were issued for the following: A device for the measurement and control of bed depth in a rotary kiln;[90] an improvement in fluidized bed cement manufacture preventing formation of clinker balls in the reaction zone;[91] a process for removing alkalies from off-gases by condensation on a cool surface;[92] a compact vertical water-cooled clinker heat exchanger;[93] and measurement and control of clinker cooler bed depth by nuclear radiation beam.[94]

A continuous grate method of manufacturing cement clinker was developed. It was said to permit efficient removal of alkalies and other volatiles and recovery of certain valuable hydrocarbons.[95] Cement clinker was cooled in an apparatus designed to admit large volumes of air.[96]

White portland cement was improved by adding fluorspar to the raw mix to lower the clinkering temperature and 2 to 10 percent of charcoal or petroleum coke to reduce iron and other oxides.[97]

Reducing and cooling liquids were sprayed into adjacent areas against the sloping side of the kiln in the manufacture of white portland cement.[98]

Vertical Kilns.—An 18-foot coal-fired vertical kiln was scheduled to be installed for research studies at a Colorado cement plant. Potential advantages of vertical kilns were weighed, and a new Austrian plant utilizing the latest technical developments was described.[99] Cement was produced by vertical kiln in Australia.[1]

Clinker Grinding.—Steps taken to improve grinding efficiencies in finish cement mills were discussed. Hammer-mills and rod mills

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[87] Coulson, Donald C. How to Figure Rotary Kiln Capacity. Rock Products, v. 65, No. 4, April 1962, pp. 114–116, 119.

[88] Chemical Week. Technology Newsletter. V. 70, No. 21, May 26, 1962, p. 81.

[89] Brick and Clay Record. The Cement & Lime Industries. V. 140, No. 1, January 1962, pp. 59, 79–80.

Mehta, P. K. Slagging Failure of Refractories in Cement Rotary Kilns. Nonmet. Min. Proc., v. 3, No. 7, July 1962, pp. 21–24.

Parnham, H. A New Approach to Solve Cement and Lime Kiln Hot Zone Problems. Nonmet. Min. Proc., v. 3, No. 8, August 1962, pp. 21–24.

[90] Moklebust, O., and J. R. Walker (assigned to R-N Corp., New York, N.Y.). Bed Depth Gauge for Rotary Kiln. U.S. Pat. 3,026,728, Mar. 27, 1962.

[91] Pyzel, R. (assigned to Union Commerce Bank, Cleveland, Ohio). Hydraulic Cement Process. U.S. Pat. 3,022,989, Feb. 27, 1962.

[92] Schlauch, R. G. (assigned to Fuller Co., Catasauqua, Pa.). Method for the Production of Hydraulic Cement. U.S. Pat. 3,043,703, July 10, 1962.

[93] Smith, A. R. (assigned to United States Steel Corp., Pittsburgh, Pa.). Heat Exchanger for Pulverulent Material. U.S. Pat. 3,026,626, Mar. 27, 1962.

[94] Butters, R. B. (assigned to Industrial Nucleonics Corp., Columbus, Ohio). Conveyor Speed Control by Measuring Material Level. U.S. Pat. 3,064,357, Nov. 20, 1962.

[95] Grebe, J. J., and J. F. Miller (assigned to The Dow Chemical Co., Midland, Mich.). Production of Cement. U.S. Pat. 3,044,756, July 17, 1962.

[96] Knaust, H. Apparatus for Cooling Ore Sinter and Sinter Material. U.S. Pat. 3,052,988, Sept. 11, 1962.

[97] Coiffu, P. (assigned to Soc. des Ciments Francais). French Pat. 1,279,468, Dec. 22, 1961.

[98] Dano, T. H., and H. E. O. Pedersen. (assigned to F. L. Smidth & Co. A/S). British Pat. 891,451, Mar. 14, 1962.

[99] Ironman, Ralph. The Automatic Vertical Cement Kiln—50 Years Later. Rock Products, v. 65, No. 8, August 1962, pp. 81–83.

[1] Cement and Lime Manufacture (London). Vertical Kiln Operation in Australia. V. 34, No. 6, 1961, pp. 83–92; Building Sci. Abs. (London), v. 35, No. 3, March 1962, p. 67.

ahead of finish grinding improved power efficiency and capacity.[2]

Patents were issued for an improved shaft type cooler;[3] a method to increase grinding efficiency in a drum mill by using eccentrically rotated hammers to retard the tumbling load;[4] an improved ball mill liner to limit load separation above the cascade slope;[5] and use of 0.01 to 0.25 percent of phenol or related compounds as a grinding aid.[6]

Dust Control.—Developments in various control methods were reviewed.[7] Glass fiber bag collectors found increasing use in the cement industry.[8] Collection systems were compared.[9]

Additives.—Values of 7-day compressive strength 5 percent higher than average for type III cements were obtained by adding 0.3 percent fluorspar to the raw mix. Amount of fluorspar needed for optimum benefit was related to the tricalcium silicate content.[10] Adding 1 pound of a lignin byproduct from the manufacture of paper pulp per cubic yard of concrete at Glen Canyon Dam, Arizona, reduced water requirements and was claimed to result in a 10-percent increase in compressive strength.

Water-reducing admixtures were tested.[11] All compounds caused increased air entrainment and retarded hardening. Effects of additives on hydration reactions were studied.[12] Anionic air-entraining agents changed the heat of hydration, but nonanionic agents did not. Adsorption isotherms were determined by spectrophotometer for cement admixtures—calcium ligninsulfonate and salicylic acid.[13] An improved automatic proportioning control for additives to clinker was patented.[14] Gluconic compounds were added to cements to improve workability.[15]

High-Alumina Cements.—Calcium aluminate cement and fused silica aggregate mixtures were tested for thermal shock resistance in the exhaust of a small oxyhydrogen rocket motor. The cement provided a source of water for transpiration cooling; the amount of cooling

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[2] Rowland, C. A. Preparing Cement Clinker for Finish Grinding. Pit and Quarry, v. 55, No. 1, July 1962, pp. 168–170, 179.

[3] Lellep, O. G. (assign d to Allis-Chalmers Mfg. Co., Milwaukee, Wis.). Apparatus for Grinding and Cooling Solids. U.S. Pat. 3,063,647, Nov. 13, 1962.

[4] Hukki, R. T. (assigned to Insinooritoimisto-Enginering Bureau, Helsingfors, Finland). Method and Apparatus for Grinding Material to a Fine Degree. U.S. Pat. 3,056,561, Oct. 2, 1962.

[5] Hall, N. L. Lifter-Liner Lining for Rotary Ball Mills. U.S. Pat. 3,042,323, July 3, 1962.

[6] Fagerholt, G. R. (assigned to F. L. Smidth & Co., Copenhagen, Denmark). Method of Grinding Portland Cement Using a Phenolic Compound as a Grinding Aid. U.S. Pat. 3,068,110, Dec. 11, 1962.

[7] Pilpel, N. Recent Progress in Dust Arrestment in the Cement Industry. Cement, Lime and Gravel (London), v. 37, No. 3, March 1962, pp. 67–72.

[8] Ballard, W. E. Glass Bags—From Batch to Baghouse. Rock Products, v. 65, No. 10, October 1962, pp. 61–68, 104.

[9] Wheeler, D. H. Engineering Evaluates Dust Control. Rock Products, v. 65, No. 5, May 1962, pp. 157–169.

[10] Waanders, J. Fluorspar Admixes Strengthen Cement. Rock Products, v. 65, No. 12, December 1962, pp. 80–82.

[11] Gaynor, R. D. Tests of Water-Reducing Retarders. National Sand and Gravel Assn. and National Ready Mixed Concrete Assn. Joint Res. Lab. No. 12, August 1962, 14 pp.

[12] Stein, H. N. Influence of Some Additives on the Hydration Reactions of Portland Cement. I. Non-ionic Organic Additives, II. Electrolytes. J. Appl. Chem. (London), v. 11, No. 2, 1961, pp. 474–492; Building Sci. Abs., (London), v. 35, No. 4, April 1962, pp. 99–100.

[13] Blank, B., D. R. Rossington, and L. A. Weinland. Adsorption of Admixtures on Portland Cement. Bull. Am. Ceram. Soc., v 41, No 4, April 1962, p. 221.

[14] Ludwig, N. C. (assigned to United States Steel Corp., Pittsburgh, Pa.). Proportioning Control System. U.S. Pat. 3,027,099, Mar. 27, 1962.

[15] Liberthson, Leo. and Milton H. Zara (assigned to Sonneborn Chemical and Refining Corp., New York, N.Y.). Portland Cement Adjuvant. U.S. Pat. 3,053,674, Sept. 11, 1962.
Walker, Wayne A. (assigned to Halliburton Company, Duncan, Okla.). Oil Well Cement Compositions. U.S. Pat. 3,053,673, Sept. 11, 1962.

was found to be related to water content as determined by differential thermal analysis. A stainless steel honeycomb filled with a cement and fused silica mixture provided strength reinforcement.[16]

Slag suitable for grinding directly into alumina cement was obtained from a blast furnace in a method in which bauxite and low-silica flux were added to the iron ore mixture before agglomeration and charging of the furnace.[17] Oxygen converters in the steel industry provided a new type of high-alumina cement with a high content of iron oxides. Different varieties of clinker were obtained by adding bauxite and titanium-aluminum slag to the converter melt.[18]

Special Concretes.—A lightweight concrete containing wood shavings was tested at the University of Washington, Seattle, Wash. The concrete was claimed to have one-third the weight and three-quarters of the strength of the woodless product. Cementitious properties of finely ground coal ash were discussed.[19] Research indicated that materials have pozzolanic properties only if they are semiconductors of electricity. Reactivity of pozzolana to lime in cement was believed to be related to semiconductor surface reactions.[20] Favorable strengths were found for mixtures of special low-lime slags, pozzolana, and anhydrite. Montmorillonitic clays made especially good pozzolana.[21]

Epoxy resin plastic surfacing cements came into increasing use on highways,[22] and cracks in concrete were effectively healed with epoxy glues.[23] A water- and acid-resisting cement developed in Poland was composed of 2 parts portland cement, 1 part fly ash, and small amounts of chalk, sodium chloride, aluminum acetate, and aluminum sulfate.[24]

Soil-Cement.—Cement-treated soil subbases for highways significantly reduced stresses on overlying concrete slabs. Improved stability of roads with such treatment resulted in smoother pavement. Construction procedures were given.[25]

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[16] Poulos, N. E., J. D. Walton, Jr., and S. R. Elkins. Fused Silica-Hydrated Cements for Thermal Protection Systems. Bull. Am. Ceram. Soc., v. 41, No. 12, December 1962, pp. 812–815.

[17] Bosley, J. J., and R. L. Stephenson (assigned to United States Steel Corp., Pittsburgh, Pa.). Method for Producing High-Temperature Cement in the Blast Furnace. U.S. Pat. 3,052,534, Sept. 4, 1962.

[18] Butt, Yu. M., S. M. Royak, V. F. Krylov, and G. A. Fedorov. (Investigation of Ferruginous High-Alumina Cement Obtained in an Oxidizing Medium.) Tsement (Moscow), v. 28, No. 1, 1962, pp. 13–16; Building Sci. Abs. (London), v. 35, No. 9, September 1962, p. 261.

[19] Meixner, Alex. (Coal Ash—A Valuable Hydraulic Cement). Tonindustrie Zeitung und Keramische Rundschau (Goslar, Germany), v. 86, No. 2, 1962, pp. 30–35; J. Am. Ceram. Soc., Ceram. Abs., v. 45, No. 8, August 1962, p. 184.

[20] Chatterji, A. K. Pozzolanic Activity and Semi-Conductivity of Fired Kaolin and Kaolinitic Clay. Nature (London), v. 192, 1961, pp. 1180–1181; Building Sci. Abs. (London), v. 35, No. 4, April 1962, p. 102.

[21] Ferrari, F. Low-Lime Cements. Revue des Materiaux de Construction et de Travaux Publics (Paris), No. 544, 1961, pp. 20–22; Building Sci. Abs. (London), v. 35, No. 3, March 1962, p. 66.

[22] Materials Research and Standards. Use of Epoxy Surfacing on Highways Seen Growing. V. 2, No. 2, February 1962, p. 110.

[23] Wakeman, C. M., H. E. Stover, and E. N. Blye. Glue for Concrete Repair. Mat. Res. and Standards, v. 2, No. 2, February 1962, pp. 93–97.

[24] New Scientist (London). Water-Resisting Cement. V. 14, No. 282, 1962, p. 36; Building Sci. Abs. (London), v. 35, No. 8, August 1962, p. 226.

[25] Kawala, E. L. Cement Treated Subbase for Concrete Pavements. Roads and Streets, v. 105, No. 12, December 1962, pp. 50–53, 83–85.

Chromium

By Andrew S. Prokopovitsh [1] and Hilda V. Heidrich [2]

FOR THE FIRST time since 1899 there were no reports of chromite production in the United States.

Chromite production also declined in most other countries because of intense world competition, declining prices, and excess stocks. Significant increases in chromite output during 1962 were virtually limited to the Republic of South Africa, Turkey, and the U.S.S.R., all large producers.

TABLE 1.—Salient chromite statistics

(Thousand short tons and thousand dollars)

	1953–57 (average)	1958	1959	1960	1961	1962
United States:						
Production (shipments)	150	144	[1] 105	[1] 107	[1] 82	----------
Value	$6,754	$6,187	[2] $3,765	[2] $3,813	[2] $2,939	----------
Imports for consumption	1,997	1,263	1,554	1,387	[3] 1,329	1,446
Exports	1	1	11	5	[3] 5	2
Consumption	1,488	1,221	1,337	1,220	1,200	1,131
Stocks Dec. 31: Consumer	1,248	1,537	1,800	1,707	1,633	1,700
World: Production	4,340	[3] 4,225	[3] 4,345	[3] 4,870	[3] 4,720	4,805

[1] Produced for Federal Government only.
[2] Estimate by Bureau of Mines.
[3] Revised figure.

LEGISLATION AND GOVERNMENT PROGRAMS

The General Services Administration (GSA) announced the availability for purchase by sealed bids of approximately 35,864 long dry tons of metallurgical chromite in the form of domestic concentrates. Bids were received in Washington, D.C., until April 4, but none was accepted. GSA later considered offers to purchase all or parts of the total tonnage on a negotiated basis. The material was stored in one pile at the Letterkenny Ordnance Depot, Chambersburg, Pa.

Another announcement by GSA revealed that sealed bids to buy 1,890 long tons of metallurgical chromite would be received on August 15. The chromite in the form of mixed lumps and fines was stored at Calvert City, Ky.

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[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

Approximately 19,577 long tons of chrome-bearing materials and 22,500 pounds of intermediate ferrochromium alloy products were also available for purchase by sealed bid in July, according to an announcement by GSA. The materials were stored in Nevada, Oregon, California, and Alaska, and were offered on an "as is", "where is" basis, but no bids acceptable to GSA were received. They were reoffered for sale by negotiation. However, 4,800 pounds of electrolytic chromium metal offered by sealed bid was sold to Metallurg, Inc., New York.

Chromite was eligible for acquisition under the agricultural barter program administered by the U.S. Department of Agriculture, Commodity Credit Corporation. Government financial assistance was available for exploring for domestic chromite deposits upon approval by the Office of Minerals Exploration.

DOMESTIC PRODUCTION

No domestic production of chromite was reported in 1962.

Chromium chemicals were produced by Pittsburgh Plate Glass Co. in its new plant at Corpus Christi, Tex. The plant processed chrome ore imported from Africa into chromium chemicals and pigments.

Ohio Fire Brick Co., Oak Hill, Ohio, started producing basic refractory brick. General Refractories Co. discontinued its plant at Morrisville, Pa.

Pacific Northwest Alloys, Inc., a U.S. subsidiary of Chromium Mining and Smelting Corp., Ltd., Sault Ste. Marie, Ontario, Canada, closed its plant at Mead, Wash. Ferroalloy production was transferred to its expanded subsidiary plant at Woodstock, Tenn.

TABLE 2.—Chromite production (mine shipments) in the United States, by States

(Short tons, gross weight)

State	1958	1959	1960	1961		1962
				Shipments	Value	
California	20,588	(1)				
Montana	119,057	[2] 105,000	[2] 107,000	[2] 82,000	[3] $2,939,000	
Oregon	4,133					
Washington	17					
Total	143,795	[2] 105,000	[2] 107,000	[2] 82,000	[3] $2,939,000	

[1] Small quantity produced; Bureau of Mines not at liberty to publish.
[2] Dry weight; excludes quantity consumed by American Chrome Co.
[3] Estimate.

CONSUMPTION AND USES

Domestic consumption of 1,131,000 short tons of chromite ores and concentrate, containing about 331,000 tons of chromium, was approximately 7 percent less than 1961 consumption. The metallurgical industry consumed 52 percent of the total; the refractory industry, 32 percent; and the chemical industry, the remaining 16 percent.

The metallurgical industry consumed 579,000 tons of chromite (containing 185,000 tons of chromium) in producing 265,000 tons of chromium ferralloys and chromium metal, containing 157,000 tons of chromium. In addition, 11,000 tons (containing 4,000 tons of chromium) was used directly in alloying steel. Of the 579,000 tons of chromite consumed in producing ferroalloys, 453,000 tons (47.9 percent chromium oxide, Cr_2O_3) was metallurgical-grade, 93,000 tons (44.7 percent chromium oxide) chemical grade, and 32,000 tons (32.8 percent chromium oxide) refactory-grade chromite. Seventy-four percent of the metallurgical-grade chromite had a chromium to iron ratio of 3:1 and above; 21 percent, a ratio between 2:1 and 3:1; and 5 percent, a ratio of less than 2:1.

Producers of chromite-bearing refractories consumed 354,000 tons of chromite, containing 84,000 tons of chromium; an additional 11,000 tons (containing 3,000 tons of chromium) was used directly in repairing furnace linings.

Producers of chemicals consumed 176,000 tons of chromite (containing 55,000 tons of chromium) in producing 128,000 short tons of chemicals (sodium bichromate equivalent).

Total production of chromium ferroalloys and chromium was 6 percent below 1961. Low-carbon ferrochromium fell 19 percent, high-carbon ferrochromium gained 4 percent, and both ferrochrome-silicon and chromium metal decreased approximately 10 percent.

Consumption of chromium ferroalloys and chromium was 3 percent higher; low-carbon ferrochromium was about the same as in 1961; high-carbon ferrochromium and ferrochrome-silicon showed a gain of 9 and 8 percent, respectively. Consumption of chromium metal increased 11 percent; exothermic low- and high-carbon ferrochromium consumption was the same as in 1961, but exothermic ferrochrome-silicon decreased 10 percent.

TABLE 3.—Consumption of chromite and tenor of ore used by primary consumer groups in the United States

(Thousand short tons)

Year	Metallurgical industry		Refractory industry		Chemical industry		Total	
	Gross weight	Average Cr_2O_3 (percent)	Gross weight	Average Cr_2O_3 (percent)	Gross weight	Average Cr_2O_3 (percent)	Gross weight	Average Cr_2O_3 (percent)
1953–57 (average)	926	46.6	412	34.3	150	44.9	1,488	43.1
1958	778	46.9	312	35.2	131	45.6	1,221	43.8
1959	796	46.7	379	35.0	162	45.4	1,337	43.2
1960	665	46.4	391	34.9	164	45.3	1,220	42.6
1961	662	46.5	375	34.6	163	45.2	1,200	42.6
1962	590	46.6	365	35.0	176	45.3	1,131	42.7

TABLE 4.—Production, shipments, and stocks of chromium ferroalloys and chromium metal in 1962

(Short tons, gross weight)

Alloy	Net production	Chromium contained	Shipments	Producer stocks Dec. 31
Low-carbon ferrochromium	88,135	61,180	81,585	22,441
High-carbon ferrochromium	99,361	63,120	90,014	32,921
Ferrochromium silicon	52,849	20,799	52,482	13,553
Other [1]	24,646	12,029	23,699	3,881
Total	264,991	157,128	247,780	72,796

[1] Includes chromium briquets, chromium metal, exothermic chromium additives, and other miscellaneous chromium alloys.

TABLE 5.—Consumption of chromium ferroalloys and chromium metal in the United States in 1962, by major end uses, and consumer stocks Dec. 31

(Short tons)

	Low-carbon ferrochromium	High-carbon ferrochromium	Ferrochromium silicon	Exothermic ferrochromium silicon	Chromium briquets	Other [1]	Total
Stainless steels	53,148	32,285	21,505	3	[2] 4,498	97	111,536
High-speed steels	372	664	38			3	1,077
Other tool steels	477	931	25		1	5	1,439
Other alloy steels [3]	8,042	22,347	2,957	1,472	241	5,520	40,579
Gray and malleable iron	282	2,664	205	25	196	187	3,559
High-temperature alloys	3,516	509	86		3	1,246	5,360
Nickel-base alloys	166	18				76	260
Other nonferrous alloys [4]	239	858			6	533	1,636
Total (contained chromium)	66,242	60,276	24,816	1,500	4,945	7,667	165,446
Total (gross weight)	96,579	95,128	57,729	3,677	8,433	14,513	276,059
Stocks on hand (gross weight)	5,531	5,684	2,119	729	409	1,330	15,802

[1] Includes exothermic high- and low-carbon ferrochromium, chromium metal, and other chromium alloys.
[2] Believed to be low-carbon ferrochromium.
[3] Includes quantities that were believed used in producing high-speed and other tool steels and stainless steels because some firms failed to specify individual uses.
[4] Includes cutting and wear-resistance alloys, hard-facing alloys, welding rods electrical-resistance alloys, and other nonferrous alloys.

TABLE 6.—End use of individual chromium ferroalloys and chromium metal in the United States in 1962

(Percent in contained weight)

Alloy	Stainless steels	High-speed steels	Other tool steels	Other alloy steels	Gray and malleable castings	High-temperature alloys	Nickel-base alloys	Other nonferrous alloys
Low-carbon ferrochromium	80.2	0.6	0.7	12.1	0.4	5.3	0.3	0.4
High-carbon ferrochromium	53.6	1.1	1.6	37.1	4.4	.8		1.4
Ferrochromium-silicon	86.7	.2	.1	11.9	.8	.3		
Chromium briquets	[1] 91.0			4.9	4.0			.1
Exothermic ferrochrome-silicon	.2			98.1	1.7			
Low-carbon exothermic ferrochromium				84.4	4.7	10.9		
High-carbon exothermic ferrochromium	.1			96.7	2.0			1.2
Chromium metal	4.1	.1	.2	15.7	.4	55.3	3.4	20.8
Other chromium alloys				1.3	87.0			11.7

[1] Believed to be low-carbon ferrochromium.

STOCKS

Industry stocks of chromite ore at all locations are given in table 7. Chromium materials in Government inventories on December 31, 1962 are presented in table 8.

Stocks of chromium ferroalloys and chromium metal at producer plants increased 26 percent, compared with 1961, while consumer stocks decreased 44 percent.

Stocks of chromium chemicals at producer plants totaled 13,000 tons (sodium bichromate equivalent) at yearend.

TABLE 7.—Stocks of chromite at consumer plants, Dec. 31

(Thousand short tons)

Industry	1958	1959	1960	1961	1962
Metallurgical	749	[1] 955	[1] 863	[1] 773	[1] 771
Refractory	612	730	719	728	764
Chemical	176	115	125	132	165
Total	1,537	[1] 1,800	[1] 1,707	[1] 1,633	[1] 1,700

[1] Includes stocks at locations other than consumer plants.

TABLE 8.—Chromium materials in Government inventories on Dec. 31, 1962

	National (strategic stockpile) [1]	DPA inventory [2]	CCC and supplemental stockpile [3]	Total
Chromite:				
Chemical grade thousand short dry tons	559		609	1,168
Metallurgical grade do	3,799	986	1,543	6,328
Refractory grade do	1,047		190	1,237

[1] Acquired through the Strategic and Critical Materials Stockpiling Act.
[2] Acquired through the Defense Production Act (DPA).
[3] Acquired through the Commodity Credit Corp. (CCC) and by barter for agricultural commodities.

PRICES

Prices for chromite ores quoted during 1962 by E&MJ Metal and Mineral Markets were unchanged and indicated a reasonable steady market despite persistent concern by many chromite producers for their established commerce. Some producers of ferroalloys announced significant price reductions at midyear.

TABLE 9.—Price quotations for various grades of foreign chromite in 1962

Source	Cr_2O_3 (percent)	Cr/Fe ratio	Price per long ton[1]	
			Jan. 1	Dec. 31
Rhodesia[2]	48	3:1	$35.75–36.25	$35.75–36.25
Do	48	2.8:1	32.00–33.50	32.00–33.50
Do	48		27.00–28.00	27.00–28.00
South Africa, Republic of	48		25.50–27.00	25.50–27.00
Do	44		19.75–20.50	19.75–20.50
Turkey	48	3:1	36.00–38.00	36.00–38.00
Do	46	3:1	33.50–34.00	33.50–34 00

[1] Quotations are on a dry basis, subject to penalties if guarantees are not met, f.o.b. cars, east coast ports.
[2] Term contract.

Source: E&MJ Metal and Mineral Markets.

FOREIGN TRADE[3]

Imports.—Imports of chromite ores and concentrates increased approximately 9 percent, compared with 1961. Metallurgical-grade ore (46.6 percent chromium oxide) comprised 40 percent of the total imports, refractory-grade (33.7 percent chromium oxide) 26 percent, and chemical-grade (44.2 percent chromium oxide) 34 percent. Of the 1.4 million tons imported, 44 percent came from the Republic of South Africa, 22 percent from the Philippines, 17 percent from the Federation of Rhodesia and Nyasaland, 13 percent from Turkey, 3 percent from U.S.S.R., and the remaining 1 percent from Pakistan, Sweden (believed to be reexports), Iran, and Guatemala. Approximately half of the chromite ore imported from Turkey was in connection with a multilateral barter agreement between Turkey, Israel, and the United States.

Imports for consumption of chrome or chromium metal totaled 648 tons valued at $992,655; 302 tons came from Japan, 169 tons from United Kingdom, 163 tons from France, and 14 tons from West Germany.

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

TABLE 10.—U.S. imports for consumption of chromite, by grades and countries

Year and country	Metallurgical grade			Refractory grade			Total		
	Short tons		Value	Short tons		Value	Short tons		Value
	Gross weight	Cr_2O_3		Gross weight	Cr_2O_3		Gross weight	Cr_2O_3	
1961:									
North America: Cuba				8,526	2,642	$170,539	8,526	2,642	$170,539
Europe: U.S.S.R.	19,686	9,720	$502,439				19,686	9,720	502,439
Asia:									
Philippines	10,080	4,458	189,000	272,429	85,911	5,052,500	282,509	90,369	5,241,500
Turkey	[1] 149,691	[1] 70,775	[1] 3,818,872	[1] 6,720	[1] 3,226	[1] 60,000	[1] 156,411	[1] 74,001	[1] 3,878,872
Total	[1] 159,771	[1] 75,233	[1] 4,007,872	[1] 279,149	[1] 89,137	[1] 5,112,500	[1] 438,920	[1] 164,370	[1] 9,120,372
Africa:									
Rhodesia and Nyasaland, Federation of	217,639	97,861	5,186,392				217,639	97,861	5,186,392
Union of South Africa	54,038	24,002	500,601	37,265	16,152	364,621	[2] 644,360	[2] 291,268	[2] 6,496,008
Total	271,677	121,863	5,686,993	37,265	16,152	364,621	[2] 861,999	[2] 389,129	[2] 11,682,400
Grand total	[1] 451,134	[1] 206,816	[1] 10,197,304	[1] 324,940	[1] 107,931	[1] 5,647,660	[1,2] 1,329,131	[1,2] 565,861	[1,2] 21,475,750
1962:									
North America: Guatemala	354	156	14,167				354	156	14,167
Europe:									
Sweden	7,280	3,495	162,180				7,280	3,495	162,180
U.S.S.R.	35,862	17,405	901,123				[2] 37,038	[2] 18,051	[2] 915,933
Total	43,142	20,900	1,063,303				[2] 44,318	[2] 21,546	[2] 1,078,113
Asia:									
Iran	3,360	1,613	66,000				3,360	1,613	66,000
Pakistan	11,591	5,563	243,198				11,591	5,563	243,198
Philippines	11,829	4,175	264,429	306,768	97,245	5,652,498	318,597	101,420	5,916,927
Turkey	171,432	80,661	4,024,460	1,120	381	19,430	[2] 183,752	[2] 86,418	[2] 4,303,890
Total	198,212	92,012	4,598,087	307,888	97,626	5,671,928	[2] 517,300	[2] 195,014	[2] 10,530,015

See footnotes at end of table.

TABLE 10.—U.S. imports for consumption of chromite, by grades and countries—Continued

Year and country	Metallurgical grade			Refractory grade			Total		
	Short tons		Value	Short tons		Value	Short tons		Value
	Gross weight	Cr_2O_3		Gross weight	Cr_2O_3		Gross weight	Cr_2O_3	
1962—Continued									
Africa:									
Rhodesia and Nyasaland, Federation of	233,974	108,184	$5,339,628	8,388	3,655	$134,497	[2] 248,531	[2] 114,666	[2] $5,611,428
South Africa, Republic of	100,877	47,191	1,588,940	[3] 54,889	[3] 23,779	[3] 537,537	[2,3] 635,072	[2,3] 282,190	[2,3] 6,465,854
Total	334,851	155,375	6,928,568	63,277	27,434	672,034	[2] 883,603	[2] 396,856	[2] 12,077,282
Grand total	576,559	268,443	12,604,125	371,165	125,060	6,343,962	[2] 1,445,575	[2] 613,572	[2] 23,699,577

[1] Revised figure.

[2] Includes chemical grade—1961: Union of South Africa 553,057 short tons, gross weight; 251,114 short tons, Cr_2O_3, valued at $5,630,786. 1962: Federation of Rhodesia and Nyasaland 6,169 short tons, gross weight; 2,827 short tons, Cr_2O_3, valued at $137,303. Republic of South Africa 479,306 short tons, gross weight; 211,220 short tons, Cr_2O_3, valued at $4,339,377. Turkey 11,200 short tons, gross weight; 5,376 short tons, Cr_2O_3, valued at $260,000. U.S.S.R. 1,176 short tons, gross weight; 646 short tons, Cr_2O_3 valued at $14,810.

[3] Adjusted by the Bureau of Mines to include 12,130 short tons, gross weight; 5,225 short tons, Cr_2O_3, valued at $123,768, reported by the Bureau of the Census as Mozambique.

Source: Bureau of the Census.

TABLE 11.—U.S. imports for consumption of ferrochromium, by countries

Year and country	Low-carbon ferrochromium (less than 3 percent carbon)			High-carbon ferrochromium (3 percent or more carbon)		
	Short tons		Value	Short tons		Value
	Gross weight	Chromium content		Gross weight	Chromium content	
1961:						
North America: Canada				1,227	655	$258,375
Europe:						
France	554	409	$212,817	870	604	215,522
Germany, West	1,520	1,096	522,043	972	692	248,814
Italy	2,732	1,776	587,049	8,041	5,335	1,824,460
Norway	3,893	2,612	1,554,373	528	364	129,147
Sweden	2,643	1,934	920,792	28	18	5,033
Yugoslavia	574	406	201,592			
Total	11,916	8,233	3,998,666	10,439	7,013	2,422,976
Asia: Japan	1,058	719	353,593	1,526	1,030	295,884
Africa:						
Rhodesia and Nyasaland, Federation of	434	313	134,154			
Union of South Africa				1,214	735	147,979
Total	434	313	134,154	1,214	735	147,979
Grand total	13,408	9,265	4,486,413	14,406	9,433	3,125,214
1962:						
North America: Canada				6,111	3,582	1,134,738
Europe:						
France	4,048	2,921	1,249,761	39	27	10,098
Germany, West	5,183	3,792	1,764,768	1,357	851	178,219
Greece	109	79	39,417			
Italy	60	45	20,528	94	66	19,373
Norway	2,730	1,898	878,461	926	644	186,111
Sweden	6,820	5,024	2,301,618	53	37	10,705
United Kingdom	166	118	52,754			
Yugoslavia	264	187	94,913			
Total	19,380	14,064	6,402,220	2,469	1,625	404,506
Asia: Japan	4,239	2,845	1,348,836	2,327	1,557	404,918
Africa:						
Rhodesia and Nyasaland, Federation of	509	370	157,563			
South Africa, Republic of	162	86	39,928	1,122	673	130,083
Total	671	456	197,491	1,122	673	130,083
Grand total	24,290	17,365	7,948,547	12,029	7,437	2,074,245

Source: Bureau of the Census.

Imports for consumption of chromium-nickel was 3 tons valued at $3,352; chromium carbide, 30 tons valued at $58,614; chromium yellow, green chromic oxide, and other chromium colors, 776 tons valued at $355,407; potassium chromate and dichromate, 5 tons valued at $1,727; sodium chromate and dichromate, 253 tons valued at $387,625; chrome brick and shapes, 1,200 pounds valued at $724.

Imports of ferrochromium increased 31 percent above 1961. Low-carbon ferrochromium imports accounted for all the increase, whereas high-carbon ferrochromium imports decreased 17 percent. Sweden, West Germany, Japan, France, and Norway accounted for 95 percent of the low-carbon ferrochromium imports; Federation of Rhodesia and Nyasaland, Yugoslavia, United Kingdom, Greece, Italy, and Republic of South Africa supplied the remainder.

Exports.—Exports of chromium products included 834 tons of chromic acid and anhydrides, industrial (chromium oxide content), valued at $487,355; sodium bichromate and chromate, 4,997 tons valued at $1,162,027; chromium and chromium-bearing alloys in crude form and scrap, 12 tons valued at $51,826; chromium and chromium alloys in semifabricated forms, 5 tons valued at $34,318; ferrochrome, 3,075 tons valued at $1,182,382. Reexports of ferrochrome totaled 219 tons valued at $77,864.

TABLE 12.—U.S. exports of chromite ore and concentrates

Year	Exports [1]		Reexports [2]	
	Short tons	Value	Short tons	Value
1953–57 (average)	1,187	$66,834	5,462	$208,321
1958	717	48,829	52,303	2,157,966
1959	11,080	530,714	[3] 26,591	1,064,612
1960	5,184	320,179	19,927	720,575
1961 [4]	5,201	344,907	35,890	1,373,083
1962	2,686	108,112	51,254	2,032,941

[1] Material of domestic origin or foreign material that has been ground, blended, or otherwise processed in the United States.
[2] Material that has been imported and later exported without change of form.
[3] Adjusted by the Bureau of Mines.
[4] Revised figures.

Tariff.—There were no import duties on chromite ores and concentrates. Duties on chromium products, under various trade agreements to the Tariff Act of 1930, from all countries except U.S.S.R. and other designated Communist countries and areas were unchanged from 1960.

WORLD REVIEW

In 1962 world chromite production increased slightly, principally because of larger output by three chromite producing countries, Republic of South Africa, Turkey, and U.S.S.R., but the increase did not indicate a vigorous mining climate because many producers accumulated large stocks of unsold ore. At yearend there was concern about prospects for contracting for future production as substantial quantities of high-grade chromite became available at low prices. Intense competition resulted, and there developed a persistent tendency toward lower prices not only for chromite but also for chromium alloys.

TABLE 13.—World production of chromite by countries [12]

(Short tons)

Country [1]	1953-57 (average)	1958	1959	1960	1961	1962
North America:						
Cuba	84,418	[3] 82,800	[4] 43,732	[4] 32,774	[3] 27,600	[3] 22,000
Guatemala	591	1,168	452	200	110	22
United States	[5] 149,851	143,795	[6] 105,000	[6] 107,000	[6] 82,000	----------
Total	234,860	227,763	149,184	139,974	109,710	22,022
South America:						
Brazil	4,740	5,832	6,861	6,245	17,035	10,050
Colombia	----------	----------	55	77	200	[3] 330
Total	4,740	5,832	6,916	6,322	17,235	10,380
Europe:						
Albania	130,577	221,800	272,300	315,300	[3] 330,000	[3] 330,000
Greece	52,975	72,217	71,973	50,366	[3] 44,000	88,200
U.S.S.R. [3 7]	756,000	880,000	940,000	1,010,000	1,015,000	1,265,000
Yugoslavia	135,953	125,188	117,965	110,873	119,188	106,974
Total [1 3]	1,100,000	1,320,000	1,420,000	1,520,000	1,540,000	1,820,000
Asia:						
Cyprus (exports)	8,066	13,260	13,637	15,702	21,078	10,669
India	74,112	70,500	105,376	110,354	50,625	64,390
Iran [8]	32,854	[3] 38,600	60,600	75,000	81,300	121,000
Japan	40,397	46,155	63,578	74,394	77,350	64,145
Pakistan	25,225	26,619	17,946	20,265	28,116	[3] 27,600
Philippines	658,706	458,903	720,345	809,579	705,811	583,891
Turkey	857,739	631,403	427,324	530,676	443,932	517,148
Total [7]	1,697,099	1,285,440	1,408,806	1,635,970	1,408,212	1,388,843
Africa:						
Malagasy Republic	----------	----------	----------	----------	11,574	[9] 19,800
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	491,554	618,841	543,104	668,401	590,888	507,685
Sierra Leone	22,210	15,944	19,974	6,023	[9] 10,080	[9] 10,530
South Africa, Republic of	705,465	696,057	749,873	850,916	989,718	1,006,167
United Arab Republic (Egypt)	428	----------	275	330	1,530	[3] 550
Total	1,219,657	1,330,842	1,313,226	1,525,670	1,603,790	1,544,732
Oceania:						
Australia	3,770	869	134	592	----------	----------
New Caledonia	80,633	52,300	48,463	43,166	40,413	17,036
Total	84,403	53,169	48,597	43,758	40,413	17,036
World total (estimate) [1]	4,340,000	4,225,000	4,345,000	4,870,000	4,720,000	4,805,000

[1] 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 some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Estimate.
[4] United States imports.
[5] Includes 45,710 tons of concentrates from low-grade ores and concentrates stockpiled near Coquille, Oreg. during World War II.
[6] Produced for Federal Government only; excludes quantity consumed by American Chrome Co.
[7] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.
[8] Year ended March 20 of year following that stated.
[9] Exports.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

NORTH AMERICA

Canada.—Strategic-Udy Metallurgy, Ltd., at Niagara Falls operated its commercial smelting division during 1962 to produce ferrochromium from chrome-ore fines. The plant produced high-carbon ferrochromium and used a bottom-blow oxygen converter for refining. Chromium ferroalloys were also produced by Union Carbide Canada, Ltd., Metals and Carbon Division, Welland, Ontario, and Chromium Mining and Smelting Corp., Ltd., Sault Ste. Marie, Ontario. Other consumers of chrome ore included Canadian Refractories, Ltd., Marelan, Quebec, and General Refractories Company of Canada, Ltd., Smithville, Ontario.

Imports of chrome ore totaled 71,268 short tons in 1961 from Cyprus, Philippines, Republic of South Africa, Federation of Rhodesia and Nyasaland, and the United States.

SOUTH AMERICA

Brazil.—Chromita do Brazil, S/A, which owned and operated a chromite mine at Campo Formoso, leased its mine to Companhia Ferro Ligas da Bahia, S.A.

EUROPE

U.S.S.R.—Continuing as the leading world producer of chromite, ore exports totaled 483,000 tons in 1962 compared with 471,000 tons in 1961, an increase of 3 percent. Many countries received Soviet ore; two-thirds of it was shipped to western European countries. West Germany, Japan, Sweden, France, United Kingdom, Italy, Poland, Czechoslovakia, China, and East Germany accounted for virtually all of the chromite exported. Exports of chromite to the United States was 30,000 tons.

ASIA

India.—Most requirements for low-carbon ferro-chromium were met through imports, since the Mysore Iron and Steel Works at Bhadravati, the only producer, manufactured a small quantity of the alloy. Another ferrochromium plant was being established, however, at Bhadrak in Orissa in the private sector to produce 8,000 tons of low-carbon ferrochromium and 2,000 tons of high-carbon ferrochromium.

Production of chromite was expected to increase from 80,000 tons in 1960–61 to 120,000 tons in 1965–66 and to 250,000 tons by 1970–71.[4]

Iran.—Faryab Mining Co., which had mined chromite from small lenses for about 7 years, was developing the Shahriar mine, where reserves were about 500,000 tons of hard lumpy chromite, averaging better than 48 percent chromium oxide. This was the first large scale attempt at exploiting Iranian chromite. A good road linked the mines in the Faryab area to the loading facilities at Bandur Abass.

Japan.—Interest was shown in buying chromite from Iran following a trial shipment of 10,000 tons and the visit of a trade mission in 1962.

Japan was scheduled to import about 75,000 tons of chromite from the U.S.S.R. in 1962, under a protocol signed by the two countries, which would nearly double the quantities provided for in the 1961 trade plan.

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[4] Rao, A. Achutha. Future Prospects of Refractory Industry in India. J. Mines, Metals, and Fuels (Calcutta, India), v. 10, No. 2, February 1962, pp. 12–15, 18.

Pakistan.—A promising chromite deposit was discovered a few miles from Khanozai in the Hindubagh area. The deposit was found by tracing two intersecting fault lines, each of which ran through an operating mine. Exports of chromite to the United Kingdom and Japan totaled 13,000 tons in 1961, but chromite accumulated on the Karachi docks and at Hindubagh mine heads in 1962, and production at the major mines was curtailed.

Philippines.—Metallurgical–and refractory–grade chromite was exported to Australia, Canada, Italy, Japan, the Netherlands, the United Kingdom, and the United States. Unshipped stocks of chromite at the end of 1962 totaled more than 100,000 tons.

Turkey.—Antalya Ferrochrome and Carbide Plant, officially opened October 12 was scheduled to produce 8,000 tons of ferrochromium annually. The plant, the first of its kind in Turkey, was built by the Electrometallurgical Industry Corp. Ownership of the new plant was divided between the State-owned Mining and Industrial Bank, and a French combine consisting of Pechiney Compagnie de Produits Chimiques et Electrometallurgiques and Compagnie pour l'Etude de Developpement des Eschanges Commerciaux. Chromite was to be supplied from mines in the Antalya, Mugla, and Burdur areas.

The accumulation of large stocks of chromite at mines and ports resulted in suspensions of mining operations by some private producers.

Exports of chromite totaled 378,000 tons in 1962 compared with 434,000 tons in 1961, a decline of 13 percent. The exports included about 90,000 tons under a triangular barter agreement concluded with Israel and the United States.

AFRICA

Rhodesia and Nyasaland, Federation of.—The new ferrochromium plant at Que–Que in Southern Rhodesia had a capacity of 12,000 tons of ferrochromium per year and was expected to employ more than 1,000 people at the smelter and the associated chromite mines. The plant produced high–carbon ferrochromium, in contrast to the low-carbon smelter that operated at Gwelo.

Some small chromite mines were closed as a result of decreased demand during 1962.

South Africa, Republic of.—Anglo-American Corporation of South Africa, Ltd., and Avesta Jernverks Aktiebolag of Sweden, planned a new company, Transalloys (Pty.), Ltd., to produce ferrochromium near Witbank from South African chromite. The new plant was expected to use a new process patented by Avesta that would permit the use of low-grade ore to produce low-carbon alloy having a high-chromium content. It was anticipated that most of the ferrochromium would be exported.

TECHNOLOGY

The Bureau of Mines published its studies on improving the chromium to iron ratio of offgrade chromite by selective reduction in an electric-arc furnace.[5] The bureau also published its studies on determining the properties of arc-melted alloys ranging in chromium content from 12 to 50 weight-percent.[6] Another Bureau report described the ferroalloy industry of the Pacific Northwest, its magnitude, raw materials, and some of the factors controlling industry growth.[7] High-carbon ferrochromium production from offgrade chromite ores, fines, and concentrates by selective reduction with carbon in an electric furnace was described.[8]

Among the new or improved alloys that contained appreciable quantities of chromium were the following: A family of stainless steels, containing 14 percent chromium to meet current needs for materials with better corrosion resistance and better high-temperature hardness;[9] a spring material chromium alloy, reported to have a zero thermoelastic coefficient of expansion over the temperature range from minus 50° to 150° F; a new 15-percent-chromium alloy, reported to combine toughness with resistance to grinding abrasion in clay and concrete materials;[10] and new ferritic steel containing 17 percent chromium, reported to give increased corrosion resistance without affecting physical properties.[11]

Another development in the field of chromium alloys was the beginning of an integrated chromium alloy program, consisting of a group of coordinated research projects, directed toward better knowledge of the effects of alloying chromium with rhenium and other metals. The program was to be conducted at Battelle Memorial Institute with both industry and Government support.

Composites of chromium and fine particles of metal-oxide, consolidated by standard powder metallurgy techniques and then extruded or forged into a variety of shapes, were reported to exhibit good mechanical properties, oxidation resistance above 2,000° F, and fabricability.[12]

New experimental evidence and a critical literature review confirmed that the chromium–nickel system was a simple eutectic type with extensive terminal solid solutions.[13] The electrical resistivity parallel to an axis of a single chromium crystal was measured from 4 to 330° K.[14] Recent technological developments in the use of chromite and chromite agglomerates for basic brick manufacture were summarized.[15] Internal oxidation in chromium alloys and its relation

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[5] Hunter, W. L., and L. H. Banning. Pyrometallurgical Benefication of Offgrade Chromite and Production of Ferrochromium. BuMines Rept. of Inv. 6010, 1962, 16 pp.

[6] Asai, G., and H. Kato. Properties of Arc-Melted Iron-Chromium Alloys. BuMines Rept. of Inv. 5936, 1962, 14 pp.

[7] Kingston, G. A. The Pacific Northwest Ferroalloy Industry. BuMines Inf. Circ. 8050, 1962, 26 pp.

[8] Douglas, W. S., and J. W. Donaldson. High Carbon Ferrochrome by the Strategic-Udy Process. J. of Metals, December 1962, pp. 897–901.

[9] Parker, T. D. New Stainless Steel with Better Hot Hardness. Mat. in Design Eng., November 1962, pp. 14–15.

[10] Newer Metals. American Metal Market. April 1962, p. 14.

[11] Metallurgia (Manchester, England). Recent Developments. February 1962, p. 94.

[12] Scruggs, D. M. Chromium Composites are Ductile. Mat. in Design Eng., December 1962, pp. 115–117.

[13] Smart, R. F., and F. G. Haynes. Some Observations on the Chromium-Nickel System. J. Inst. Metals (London), December 1962, pp. 153–157.

[14] Arajs, S., R. V. Colvin, and M. J. Marcinkowski. Electrical Resistivity of a Chromium Single Crystal. Less-Common Metals, February 1962, pp. 46–51.

[15] Eusner, G. R. Status of Basic Refractory Technology. J. Metals, March 1962, pp. 218–224.

to spalling were discussed.[16] By utilizing a precise sectioning technique with the radioisotope, chromium 51, self-diffusion measurements in large grains of 99.9-percent chromium were extended from 1,200° to 1,600° C.[17]

Electrochemical developments included a report of pilot-plant electrodeposition of high-purity chromium from a fluoride-type bath[18] and the introduction of a palladium anode to avoid contamination in the electrowinning of chromium.[19] Chromium-plated, thin strip steel to be used as can and container material was made by electrolytically plating from a chromic anhydride solution.

[16] Felter, E. J. Internal Oxidation in Iron-Chromium-Yttrium Alloys. Trans. AIME Met. Soc., February 1962, pp. 202-203.

[17] Hagel, W. C. Self-Diffusion in Solid Chromium. Trans. AIME Met. Soc., June 1962, pp. 430-434.

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Clays

By Taber de Polo [1] and Betty Ann Brett [2]

Contents

PRODUCTION of total clays sold or used in 1962 increased 1 percent in tonnage and 4 percent in value. Only fire clay and fuller's earth decreased from the 1961 tonnage figures. Exports increased 10 percent, and imports decreased 15 percent.

Trends in the clay industry continued along the lines evidenced during the past few years, toward plant mergers, expansion and automation, research on product improvements, more varied color and texture lines, increased unit sizes, improved packaging, and bulk handling.

TABLE 1.—Salient clay and clay products statistics in the United States

(Thousand short tons and thousand dollars)

	1953–57 (average)	1958	1959	1960	1961	1962
Domestic clays sold or used by producers	[1] 45,887	43,750	49,383	49,069	47,389	47,797
Value	[1] $141,362	$143,487	$159,659	$162,411	$156,829	$163,012
Imports for consumption	169	162	176	160	156	132
Value	$2,706	$2,900	$3,288	$3,103	[2] $3,055	$2,540
Exports	406	450	489	530	559	617
Value	$10,478	$12,129	$13,490	$13,714	$14,285	$16,855
Clay refractories, shipments (value)	[3] $177,215	$162,887	$178,632	$178,836	[2] $166.628	$166,095
Clay construction products,[4] shipments (value)	[5] $457,800	$459,700	[2] $522,700	[2] $488,500	[2] $480,300	$510,500

[1] Includes Puerto Rico 1953–54.
[2] Revised figure.
[3] Does not include value of shipments of ground crude fire clay, high-alumina, and silica fire clay for 1954.
[4] Principal products only.
[5] Average for 1954–57 only.

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

TABLE 2.—Value of clays produced in the United States, by States

(Thousand dollars)

State	1961	1962	Kinds of clay produced in 1962
Alabama	[1] $2,068	[1] $1,947	Kaolin, fire clay, miscellaneous clay.
Arizona	[2,3] 240	[2,3] 184	Fire clay, bentonite, miscellaneous clay.
Arkansas	1,758	1,693	Fire clay, miscellaneous clay.
California	6,405	7,349	Kaolin, ball clay, fire clay, bentonite, fuller's earth, miscellaneous clay.
Colorado	1,241	1,573	Fire clay, bentonite, miscellaneous clay.
Connecticut	[1] 260	[1] 287	Kaolin, miscellaneous clay.
Florida	7,202	6,741	Kaolin, fuller's earth, miscellaneous clay.
Georgia	42,024	47,462	Do.
Idaho	[1,2,3] 20	70	Kaolin, fire clay, bentonite, miscellaneous clay.
Illinois	4,166	4,151	Fire clay, miscellaneous clay.
Indiana	2,446	2,255	Do.
Iowa	1,426	1,427	Do.
Kansas	1,225	1,091	Do.
Kentucky	[4] 2,406	[4] 2,158	Ball clay, fire clay, miscellaneous clay.
Louisiana	645	641	Miscellaneous clay.
Maine	51	63	Fire clay, miscellaneous clay.
Maryland	997	899	Ball clay, fire clay, miscellaneous clay.
Massachusetts	85	96	Miscellaneous clay.
Michigan	1,975	1,917	Do.
Minnesota	[3] 241	291	Fire clay, miscellaneous clay.
Mississippi	5,034	5,742	Ball clay, fire clay, bentonite, fuller's earth, miscellaneous clay.
Missouri	5,040	5,033	Fire clay, miscellaneous clay.
Montana	[3] 76	[3] 77	Do.
Nebraska	148	142	Miscellaneous clay.
New Hampshire	30	37	Do.
New Jersey	1,681	1,476	Fire clay, miscellaneous clay.
New Mexico	[3] 165	156	Do.
New York	1,373	1,618	Miscellaneous clay.
North Carolina	[1] 1,669	[1] 1,782	Kaolin, miscellaneous clay.
North Dakota	([5])	[3] 124	Fire clay, bentonite, miscellaneous clay.
Ohio	13,790	12,979	Fire clay, miscellaneous clay.
Oklahoma	[2] 801	[2] 756	Fire clay, bentonite, miscellaneous clay.
Oregon	357	305	Bentonite, miscellaneous clay.
Pennsylvania	[1] 14,402	[1] 12,815	Kaolin, fire clay, miscellaneous clay.
South Carolina	6,169	7,165	Kaolin, miscellaneous clay.
South Dakota	[2] 249	690	Bentonite, miscellaneous clay.
Tennessee	[6] 4,190	[6] 4,597	Ball clay, fuller's earth, miscellaneous clay.
Texas	[6] 5,737	[6] 5,634	Fire clay, bentonite, fuller's earth, miscellaneous clay.
Utah	1,080	1,403	Kaolin, fire clay, bentonite, fuller's earth, miscellaneous clay.
Virginia	1,332	1,444	Miscellaneous clay.
Washington	[3] 138	[2,3] 100	Fire clay, bentonite, miscellaneous clay.
West Virginia	2,193	2,086	Fire clay, miscellaneous clay.
Wisconsin	130	156	Miscellaneous clay.
Wyoming	[3,7] 10,301	11,138	Fire clay, bentonite, miscellaneous clay.
Other [8]	3,863	3,262	
Total	156,829	163,012	
Puerto Rico	112	131	Miscellaneous clay.

[1] Value of kaolin included with "Other" to avoid disclosing individual company confidential data.
[2] Value of bentonite included with "Other" to avoid disclosing individual company confidential data.
[3] Value of fire clay included with "Other" to avoid disclosing individual company confidential data.
[4] Value of ball clay included with "Other" to avoid disclosing individual company confidential data.
[5] Included with "Other".
[6] Value of fuller's earth included with "Other" to avoid disclosing individual company confidential data.
[7] Value of miscellaneous clay included with "Other" to avoid disclosing individual company confidential data.
[8] Includes Delaware, District of Columbia, Hawaii (1962), Nevada, and Vermont, and values indicated by footnotes 1 through 7.

REVIEW OF DOMESTIC PRODUCTION, PRICES, AND FOREIGN TRADE BY TYPE OF CLAY

CHINA CLAY OR KAOLIN

The quantity of domestic kaolin sold or used increased 9 percent, and the value increased 14 percent. These were new highs for the industry. The paper, rubber, refractories, and pottery industries consumed 80 percent of the kaolin, and the remainder was used for a variety of purposes, including floor and wall tile, fertilizers, chemicals, insecticides, and paint filler or extender. Use in paper coating continued to increase substantially, rising 10 percent in 1962.

Georgia continued to be the major producer, with 76 percent of the tonnage and 83 percent of the value.

In December, Oil, Paint and Drug Reporter quoted prices for kaolin as follows: Domestic, dry-ground, calcined, air-floated, bags, carlots, works, $43 to $68 per short ton; domestic, dry-ground, uncalcined, air-floated, 99 percent through 325-mesh, Georgia, bags, carlots, f.o.b. plant, $11 to $17 per ton water-ground, washed, bags, carlots, f.o.b. plant, $21.50 to $50 per ton.

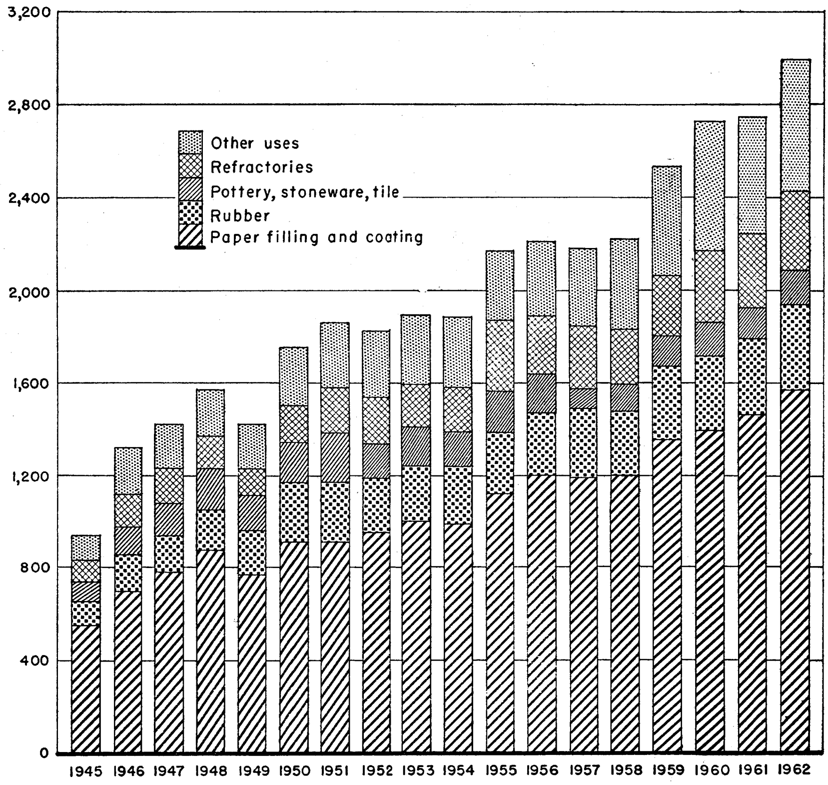

FIGURE 1.—Kaolin sold or used by domestic producers for specified uses, 1945–62.

Prices for imported china clay in December were quoted by Oil, Paint and Drug Reporter as follows: White, lump, bulk, carlots, ex dock (Philadelphia, Pa., and Portland, Maine), $23 to $35 per long ton; white, powdered, bags, carlots, ex dock, $43.50 to $45 per long ton.

In 1962 the average value per short ton for kaolin used, as reported by producers, was $8.29 per short ton and for kaolin sold, $18.89 per ton.

Imports of kaolin were 111,948 tons, down 16 percent from 1961. Virtually all the imports came from the United Kingdom; small quantities came from Mexico, Netherlands, and West Germany.

Exports of kaolin or china clay increased 20 percent over 1961; 61 percent went to Canada, 8 percent to Mexico, 5 percent to Italy, 4 percent each to Venezuela and Argentina, and 3 percent to Japan. Small tonnages also went to other countries in Central and South America, Europe, Africa, and Asia.

Georgia Kaolin Co., Elizabeth, N.J., announced affiliation with Benton Clay Co., Casper, Wyo.

TABLE 3.—Kaolin sold or used by producers in the United States, by States

Year and State	Sold by producers		Used by producers		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1953–57 (average)	1,876,146	$29,590,507	195,250	$1,828,671	2,071,396	$31,419,178
1958	2,003,526	33,991,313	218,659	2,429,884	2,222,185	36,421,197
1959	2,305,134	39,267,837	230,340	2,414,117	2,535,474	41,681,954
1960	2,432,918	43,417,589	297,533	2,259,506	2,730,451	45,677,095
1961:						
California	(1)	(1)	(1)	(1)	18,620	215,859
Florida and North Carolina	29,319	637,699	----------	----------	29,319	637,699
Georgia	1,989,410	38,589,830	157,768	967,292	2,147,178	39,557,122
South Carolina	(1)	(1)	(1)	(1)	433,748	5,300,509
Other States[2]	452,789	5,650,442	110,530	1,087,607	110,951	1,221,681
Total	2,471,518	44,877,971	268,298	2,054,899	2,739,816	46,932,870
1962:						
California	17,196	294,202	----------	----------	17,196	294,202
Florida and North Carolina	32,326	704,145	----------	----------	32,326	704,145
Georgia	2,161,471	43,820,582	116,813	834,687	2,278,284	44,655,269
South Carolina	(1)	(1)	(1)	(1)	527,993	6,279,131
Other States[2]	491,927	6,227,670	178,424	1,613,501	142,358	1,562,040
Total	2,702,920	51,046,599	295,237	2,448,188	2,998,157	53,494,787

[1] Included with "Other States."
[2] Includes States indicated by footnote 1, and Alabama, Connecticut, Idaho, Pennsylvania, Utah, and Vermont.

TABLE 4.—Georgia kaolin sold or used by producers, by uses

(Thousand short tons and thousand dollars)

Year	China clay, paper clay, etc.	Refractory uses	Total kaolin		
	Quantity	Quantity	Quantity	Value: Total	Value: Average per ton
1953–57 (average)	1,312	181	1,493	$23,675	$15.86
1958	1,510	187	1,697	29,348	17.30
1959	1,751	189	1,940	33,965	17.51
1960	1,861	260	2,121	37,822	17.83
1961	1,925	222	2,147	39,557	18.42
1962	2,094	184	2,278	44,655	19.60

BALL CLAY

The tonnage of ball clay sold or used by producers increased 10 percent and the value increased 12 percent over that of 1961. Tennessee continued to be the major producer, accounting for 64 percent of the U.S. total tonnage and 61 percent of the value; Kentucky ranked second.

Demand in the pottery and floor and wall tile industries increased, and in 1962 they consumed 54 percent and 20 percent, respectively, of the total.

Quotations on domestic ball clay in Oil, Paint and Drug Reporter for December were as follows: Crushed, shed-moisture, bulk, carlots, f.o.b. plant (Tennessee), $8 to $11.25 per short ton; air-floated, in bags, carlots, f.o.b. plant (Tennessee), $17.50 to $21.50 per ton. The average value per short ton for ball clay, as reported by producers, was $13.99 compared with $13.70 in 1961.

Prices for imported ball clay in December were quoted by Oil, Paint and Drug Reporter as follows: Air-floated, in bags, carlots, Atlantic ports, $43 to $47 per short ton; lump, bulk, Atlantic ports, $31.50 to $37.50 per ton.

TABLE 5.—Ball clay sold or used by producers in the United States

Year	Short tons	Value	Year	Short tons	Value
1953–57 (average)	381,479	$4,909,305	1960	444,369	$5,977,963
1958	396,949	5,502,986	1961	444,593	6,090,091
1959	475,235	6,459,902	1962	486,936	6,810,441

Imports of common blue and ball clay decreased 16 percent in tonnage and 11 percent in value compared with that of 1961. Unmanufactured blue and ball clays represented the major share of the imports; the United Kingdom supplied 99 percent of this classification and all of the imports of manufactured blue and ball clay. The remainder of the unmanufactured blue and ball clays came from Canada. Imports of Gross Almerode clays, including fuller's earth, totaled 889 short tons. Mexico accounted for 47 percent, West Germany 40 percent, and Argentina, Canada, and the United Kingdom for the remainder.

FIRE CLAY

The tonnage and value of fire clay sold or used by producers in the United States decreased 7 and 8 percent, respectively, from the 1961 figures. Most of this loss was due to a lower demand for firebrick and block and heavy clay products. The decrease in refractory uses accounted for 58 percent of the decline. Some individual categories that showed substantial gains were foundry and steelworks and chemicals.

The three States producing the largest quantities—Ohio, Pennsylvania, and Missouri—all reported decreases representing 45 percent of the loss in 1962. Together these three States accounted for 57 percent of the total U.S. fire-clay production, and 62 percent of the value. Only Colorado, Illinois, Indiana, and Iowa reported increases.

The principal uses of fire clay were for the manufacture of refractories, which consumed 49 percent of the total output (49 percent in 1961), and heavy clay products, including terra cotta, which consumed 47 percent (48 percent in 1961). Floor and wall tile and chemicals accounted for 2 percent and 1 percent, respectively, and 1 percent was used for a variety of applications.

TABLE 6.—Fire clay, including stoneware clay,[1] sold or used by producers in the United States, by States

Year and State	Sold by producers		Used by producers		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1953–57 (average)	3,044,976	$9,322,502	7,457,504	$34,469,085	10,502,480	$43,791,587
1958	2,276,745	7,369,379	6,531,430	33,050,861	8,808,175	40,420,240
1959	2,272,451	7,877,026	7,589,235	37,313,810	9,861,686	45,190,836
1960	2,489,945	8,840,604	7,425,427	36,390,257	9,915,372	45,230,861
1961:						
Alabama	(2)	(2)	(2)	(2)	270,313	699,963
Arkansas			339,604	1,330,008	339,604	1,330,008
California	121,497	380,818	423,180	1,340,174	544,677	1,720,992
Colorado	125,371	383,046	70,166	306,277	195,537	689,323
Illinois	(2)	(2)	(2)	(2)	262,959	1,763,508
Indiana	(2)	(2)	(2)	(2)	333,986	587,798
Iowa	(2)	(2)	(2)	(2)	16,791	44,373
Kansas			228,935	499,692	228,935	499,692
Kentucky	55,635	237,944	192,399	1,320,682	248,034	1,558,626
Maine			27	79	27	79
Mississippi			168,803	361,956	168,803	361,956
Missouri	190,418	381,524	921,674	3,638,202	1,112,092	4,019,726
New Jersey	(2)	(2)	(2)	(2)	126,043	1,011,007
Ohio	534,971	1,745,095	1,740,841	8,875,100	2,275,812	10,620,195
Oklahoma			411	4,110	411	4,110
Pennsylvania	(2)	(2)	(2)	(2)	1,464,620	9,803,316
Texas	(2)	(2)	(2)	(2)	676,217	1,660,497
West Virginia	(2)	(2)	(2)	(2)	259,340	1,964,265
Other States[3]	1,039,941	3,956,572	2,535,844	14,040,520	165,516	462,365
Total	2,067,833	7,084,999	6,621,884	31,716,800	8,689,717	38,801,799
1962:						
Alabama	(2)	(2)	(2)	(2)	222,646	683,705
Arkansas			286,080	1,328,478	286,080	1,328,478
California	80,962	254,498	373,716	1,499,802	454,678	1,754,300
Colorado	119,122	364,170	98,172	413,139	217,294	777,309
Illinois	(2)	(2)	(2)	(2)	316,609	1,737,172
Indiana	(2)	(2)	(2)	(2)	347,121	568,847
Iowa	(2)	(2)	(2)	(2)	41,155	82,767
Kansas			159,689	355,834	159,689	355,834
Kentucky	39,123	181,404	156,714	1,014,836	195,837	1,196,240
Maine			27	79	27	79
Missouri	86,138	241,319	994,373	3,819,259	1,080,511	4,060,578
New Jersey	(2)	(2)	(2)	(2)	114,645	880,760
North Dakota			6,000	12,000	6,000	12,000
Ohio	610,067	1,915,440	1,606,500	8,091,226	2,216,567	10,006,666
Oklahoma			425	4,250	425	4,250
Pennsylvania	(2)	(2)	(2)	(2)	1,276,145	8,267,676
Texas	(2)	(2)	(2)	(2)	615,110	1,557,669
Other States[3]	1,098,920	3,916,858	2,349,020	12,395,323	514,509	2,533,585
Total	2,034,332	6,873,689	6,030,716	28,934,226	8,065,048	35,807,915

[1] Includes stoneware clay as follows: 1953–57 (average), 53,802; 1958, 26,429; 1959, 27,418; 1960, 27,470; 1961, 24,554; 1962, 57,860 tons.
[2] Included with "Other States."
[3] Includes States indicated by footnote 2 and Arizona, Idaho, Maryland, Minnesota, Mississippi (1962), Montana, Nevada, New Mexico, North Dakota (1961), Utah, Washington, West Virginia (1962), and Wyoming.

The average value per ton of fire clay sold by producers (as reported to the Bureau of Mines) was $3.38, compared with $3.43 in 1961, and $3.55 in 1960. The average value of all fire clay, including both sales and captive tonnage, was $4.44, compared with $4.47 in 1961. Captive tonnage amounted to 75 percent of the fire clay produced.

Generally, quoted prices on firebrick were as follows: Superduty, $185 per thousand; high duty, $140; low duty, $103. According to statistics published by the Bureau of the Census, the average selling value of 1,000 9-inch equivalents of fire-clay brick, including special shapes, was $156 in 1962. For superduty fire-clay brick and shapes the value was $284.

Exports of fire clay increased 21 percent in quantity to 188,282 tons, and 2 percent in value compared with 1961. The average value was $20.59 per ton, compared with $21.85 in 1961. Canada received 47 percent; Mexico, 20 percent; Japan, 8 percent; Italy, 7 percent; France, 4 percent; Belgium-Luxembourg, United Kingdom, and West Germany, 2 percent each.

BENTONITE

The quantity of bentonite sold or used by producers increased 10 percent, and the value increased 7 percent, principally because of increased use in foundries and steelworks, absorbent uses, and iron ore pelletizing.

The use of bentonite for pelletizing taconite (iron ore) had increased rapidly in recent years. According to figures reported to the Bureau of Mines, the tonnage for this use amounted to 163,201 tons, an increase of 26 percent over that of 1961.

Wyoming, the largest producer of bentonite, accounted for 66 percent of the total production and 67 percent of the total value; Mississippi and Texas had substantial production with 19 percent and 8 percent, respectively. Wyoming output increased 11 percent, and Mississippi output increased 21 percent.

The price of bentonite was given in Oil, Paint and Drug Reporter for December, as follows: 200-mesh, in bags, carlots, f.o.b. mines (Wyoming), $14 a short ton; imported, Italian, white, high-gel, in bags, 5-ton lots, ex warehouse, $98.20 a ton; and Italian, low-gel, in bags, 5-ton lots, ex warehouse, $97 a ton.

The average value per short ton, as reported to the Bureau of Mines, was $11.26, compared with $11.65 in 1961.

Exports of bentonite increased 38 percent, from 43,813 short tons in 1961 to 60,315 tons in 1962, according to reports received by the Bureau of Mines.

Benton Clay Co. of Casper, Wyo., expanded its bentonite facilities in the Mountain View area by a $500,000 plant.[3]

The dust-free pneumatic-conveying system of Filtrol Corp., Jackson, Miss. plant was described.[4]

The Black Hills Bentonite Co. announced a new plant near Casper, Wyo.[5]

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[3] Mining World. V. 24, No. 3, March 1962, p. 56.
[4] Ceramic Age. Pneumatic Conveying System Solves Filtrol's Clay Handling Problems. V. 78, No. 5, May 1962, pp. 37–39.
[5] Chemical Week. National Roundup. V. 90, No. 23, June 9, 1962, p. 28.

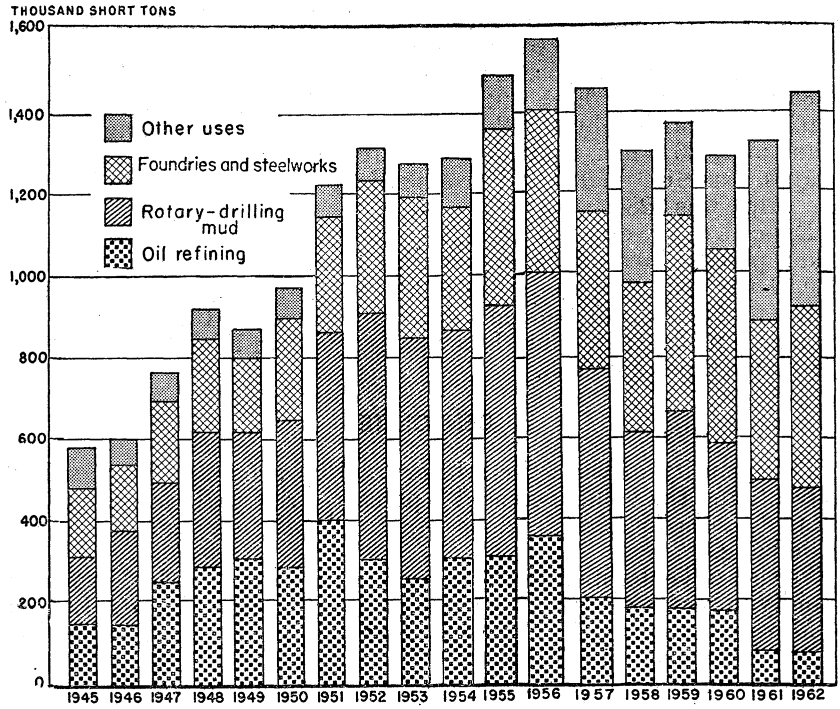

FIGURE 2.—Bentonite sold or used by domestic producers for specified uses, 1945–62.

TABLE 7.—Bentonite sold or used by producers in the United States, by States

Year and State	Short tons	Value
1953-57 (average)	1,410,009	$16,868,695
1958	1,291,414	15,317,250
1959	1,372,286	15,841,455
1960	1,268,800	15,004,757
1961:		
California	12,873	347,127
Colorado	700	4,500
Mississippi	228,020	2,836,181
Oregon	1,309	15,711
Texas	122,456	900,426
Utah	2,790	38,868
Washington	27	258
Wyoming	859,476	10,300,990
Other States [1]	79,540	780,286
Total	1,307,191	15,224,347
1962:		
California	14,444	$282,928
Colorado	1,200	7,800
Mississippi	276,380	3,428,894
Oregon	702	8,430
Texas	117,677	872,899
Utah	2,359	31,938
Wyoming	957,231	10,889,866
Other States [1]	74,142	731,460
Total	1,444,135	16,254,215

[1] Includes Arizona, Idaho, Nevada, North Dakota, Oklahoma, South Dakota, and Washington (1962).

FULLER'S EARTH

Fuller's earth sold or used by producers decreased 3 percent in tonnage and 2 percent in value compared with 1961. Florida continued to be the leading producer and with Georgia supplied 85 percent of the total U.S. tonnage and accounted for 88 percent of the value. The largest single use was as an absorbent, which accounted for 50 percent of the national consumption. Other uses were insecticides and fungicides, 22 percent; rotary-drilling mud, 12 percent; and filtering, decolorizing, and clarifying, 8 percent.

The average value per short ton of fuller's earth, reported sold or used in the United States was $22.87, compared with $22.55 in 1961.

The latest quotation on fuller's earth, published in Oil, Paint and Drug Reporter in February 1960, were as follows: Insecticide-grade, dried, powdered, in bags, carlots, Georgia or Florida mines, $17.50 per ton; oil-bleaching grade, 100-mesh, in bags, carlots, f.o.b. Georgia and Florida mines, $16.30 to $17 per ton; and 200-mesh, same basis, $17.50 to $18.

Effective January 1, 1955, fuller's earth import statistics were not classified separately but were included under "Other clay." Exports were not given separately in official foreign trade statistics. According to reports made by producers to the Bureau of Mines, exports were a negligible 240 tons, compared with 280 tons in 1961.

TABLE 8.—Fuller's earth sold or used by producers in the United States, by States

Year and State	Short tons	Value	Year and State	Short tons	Value
1953-57 (average)	393,139	$7,806,569	1962:		
1958	357,883	7,609,049	Florida and Georgia	349,465	$8,264,850
1959	409,622	9,027,059	Utah	3,942	53,774
1960	408,325	9,161,658	Other States [1]	56,582	1,058,731
1961:			Total	409,989	9,377,355
Florida and Georgia	363,233	8,477,603			
Utah	3,068	41,770			
Other States [1]	55,880	998,865			
Total	422,181	9,518,238			

[1] Includes California, Mississippi, Nevada, Tennessee, and Texas.

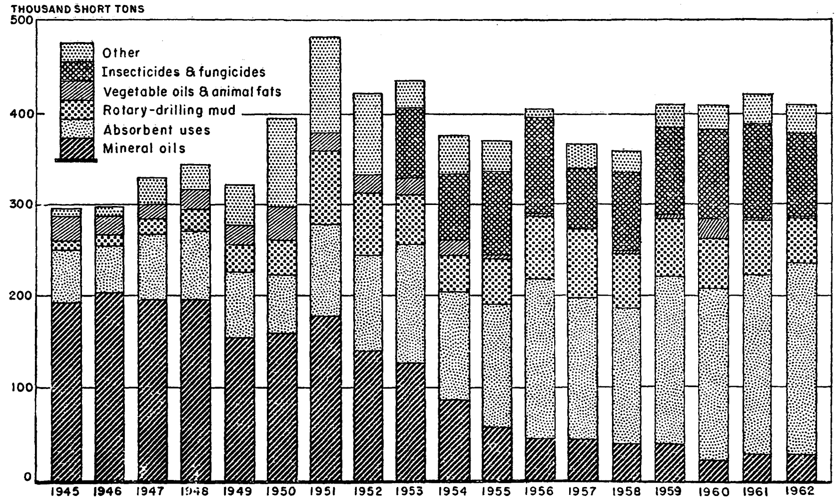

FIGURE 3.—Fuller's earth sold or used by producers for specified uses, 1945–62.

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 2 percent in tonnage and 2 percent in value compared with 1961. A substantial increase of 12 percent was recorded for use in lightweight aggregate, and miscellaneous clay used for cement decreased 1 percent. Captive tonnage—clay produced by mine operators for their own use in manufacturing brick, tile, cement, lightweight aggregate, and other products and marketed for the first time as such—was 97 percent of the miscellaneous clay sold or used in 1962. Texas, North Carolina, California, and Ohio reported tonnages exceeding 2 million tons. About half the States showed increases and half decreases in production. The decreased production in Ohio and Illinois was more than offset by the increased production in New York and Pennsylvania. Of the States producing over 1 million tons, New York made the largest gain, with a 35-percent increase.

The average reported value of miscellaneous clay sold as crude or prepared clay was $1.05 per ton, compared with $1.13 in 1961. There was a 4-percent quantity increase in this clay classification. Some special types of clay included under the miscellaneous-clay classification, however, sold at much higher prices. The value of captive tonnage, computed from individual estimates, averaged $1.20 per ton.

According to figures compiled by the Bureau of the Census, exports of clay not elsewhere classified were 309,776 tons valued at $10,454,496, an increase of 2 percent in tonnage and 23 percent in value from that of 1961. Some countries of destination with percentages received were Canada, 35 percent; Australia and United Kingdom, 7 percent each; France, Japan, the Netherlands, Venezuela, and West Germany, 4 percent each; Brazil and Italy, 3 percent each; and Colombia and Belgium-Luxembourg, 2 percent each. Smaller quantities were shipped to other countries in Central and South America, Europe, Asia, and Africa.

TABLE 9.—Miscellaneous clay, including shale and slip clay, sold or used by producers in the United States, by States

Year and State	Sold by producers		Used by producers		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1953-57 (average) [1]	1,538,467	$2,462,386	29,589,820	$34,104,539	31,128,287	$36,566,925
1958	979,565	1,687,185	29,693,948	36,529,282	30,673,513	38,216,467
1959	851,006	1,562,552	33,879,888	39,893,102	34,730,894	41,455,654
1960	1,457,387	2,101,850	32,842,407	39,263,112	34,299,794	41,364,962
1961:						
Alabama			1,516,939	1,367,874	1,516,939	1,367,874
Arizona			165,379	239,785	165,379	239,785
Arkansas			432,683	427,923	432,683	427,923
California	106,786	141,442	2,333,452	3,834,327	2,440,238	3,975,769
Colorado	90,303	167,500	269,537	379,723	359,840	547,223
Connecticut			149,101	259,679	149,101	259,679
Georgia			1,320,681	581,142	1,320,681	581,142
Idaho			26,975	19,360	26,975	19,360
Illinois	(2)	(2)	(2)	(2)	1,719,308	2,401,648
Indiana	97,443	121,799	930,331	1,736,147	1,027,774	1,857,946
Iowa	(2)	(2)	(2)	(2)	1,026,756	1,381,966
Kansas			725,012	725,012	725,012	725,012
Kentucky			657,844	847,475	657,844	847,475
Louisiana			645,114	645,114	645,114	645,114
Maine			42,737	51,042	42,737	51,042
Massachusetts			104,084	85,292	104,084	85,292
Michigan	1,650	3,300	1,815,361	1,971,909	1,817,011	1,975,209
Minnesota			175,998	241,287	175,998	241,287
Mississippi			649,955	651,080	649,955	651,080
Missouri			1,019,937	1,020,113	1,019,937	1,020,113
Montana	(2)	(2)	(2)	(2)	55,192	76,689
Nebraska			145,970	147,670	145,970	147,670
New Hampshire			29,810	29,810	29,810	29,810
New Jersey	(2)	(2)	(2)	(2)	530,477	669,988
New Mexico	(2)	(2)	(2)	(2)	67,433	165,198
New York	(2)	(2)	(2)	(2)	1,037,128	1,373,317
North Carolina			2,602,873	1,668,915	2,602,873	1,668,915
Ohio	157,221	198,741	2,490,255	2,971,086	2,647,476	3,169,827
Oklahoma			791,843	797,072	791,843	797,072
Oregon	60,000	90,000	232,529	250,912	292,529	340,912
Pennsylvania	(2)	(2)	(2)	(2)	1,534,840	4,598,562
South Carolina			912,247	867,627	912,247	867,627
South Dakota			248,921	248,921	248,921	248,921
Tennessee	(2)	(2)	(2)	(2)	749,809	280,406
Texas	(2)	(2)	(2)	(2)	2,987,622	3,177,313
Virginia			1,406,201	1,332,165	1,406,201	1,332,165
Washington	(2)	(2)	(2)	(2)	145,465	137,614
West Virginia			215,497	228,531	215,497	228,531
Wisconsin			125,632	130,245	125,632	130,245
Undistributed [3]	403,369	313,042	10,688,259	15,469,936	1,237,598	1,520,277
Total	916,772	1,035,824	32,871,157	39,227,174	33,787,929	40,262,998
1962:						
Alabama			1,408,969	1,262,567	1,408,969	1,262,567
Arizona			138,492	184,098	138,492	184,098
Arkansas			368,175	364,974	368,175	364,974
California	97,801	137,188	2,523,586	4,695,537	2,621,387	4,832,725
Colorado	(2)	(2)	(2)	(2)	583,380	787,611
Connecticut			178,942	286,513	178,942	286,513
Georgia			1,415,540	639,529	1,415,540	639,529
Illinois	(2)	(2)	(2)	(2)	1,612,455	2,413,871
Indiana	(2)	(2)	(2)	(2)	1,103,257	1,686,472
Iowa	(2)	(2)	(2)	(2)	998,068	1,343,780
Kansas			734,611	734,611	734,611	734,611
Kentucky			739,690	961,620	739,690	961,620
Louisiana			637,883	640,723	637,883	640,723
Maine			47,885	63,145	47,885	63,145
Massachusetts			125,470	95,547	125,470	95,547
Michigan	(2)	(2)	(2)	(2)	1,751,317	1,916,828
Mississippi			645,847	647,347	645,847	647,347
Missouri			972,626	972,802	972,626	972,802
Montana			55,806	76,592	55,806	76,592
Nebraska			142,445	142,445	142,445	142,445
New Hampshire			37,115	37,115	37,115	37,115
New Jersey			469,199	594,947	469,199	594,947
New York	(2)	(2)	(2)	(2)	1,396,579	1,617,733

See footnotes at end of table.

TABLE 9.—Miscellaneous clay, including shale and slip clay, sold or used by producers in the United States, by States—Continued

Year and State	Sold by producers		Used by producers		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1962—Continued						
North Carolina			2,730,690	$1,782,305	2,730,690	$1,782,305
North Dakota			91,935	111,935	91,935	111,935
Ohio	163,552	$169,798	2,370,620	2,802,099	2,534,172	2,971,897
Oklahoma			736,954	752,477	736,954	752,477
Oregon	39,000	58,500	208,925	237,913	247,925	296,413
Pennsylvania	(2)	(2)	(2)	(2)	1,617,317	4,547,197
South Carolina			989,733	885,796	989,733	885,796
Tennessee	37,350	14,000	689,238	422,843	726,588	436,843
Texas	(2)	(2)	(2)	(2)	3,011,173	3,203,023
Virginia			1,464,417	1,443,927	1,464,417	1,443,927
Washington			102,881	100,136	102,881	100,136
Wisconsin	(2)	(2)	(2)	(2)	136,616	155,850
Undistributed [3]	619,498	623,575	13,407,186	19,322,973	1,816,522	2,274,183
Total	957,201	1,003,061	33,434,860	40,262,516	34,392,061	41,265,577

[1] Includes Puerto Rico 1953–54.
[2] Included with "Undistributed."
[3] Includes States indicated by footnote 2 and Delaware, District of Columbia, Florida, Hawaii (1962), Idaho (1962), Maryland, Minnesota (1962), Nevada, New Mexico (1962), North Dakota (1961), South Dakota (1962), Utah, Vermont, West Virginia (1962), and Wyoming.

CONSUMPTION AND USES—ALL CLAYS

Of the total clay consumed in 1962, heavy clay products (building brick, structural tile, and sewer tile) accounted for 45 percent. The total tonnage and value of clays consumed increased 1 percent and 4 percent respectively.

Some decreases for individual classifications were filtering, decolorizing, and clarifying, 10 percent; fertilizers, 9 percent; paint, 7 percent; rotary-drilling mud, 6 percent; and total refractories, 5 percent. Some increases in consumption were stoneware, art pottery, flowerpots, and glaze slip, 31 percent; exports, 26 percent; chemicals, 23 percent; floor and wall tile, 14 percent; lightweight aggregates and rubber, 12 percent each; and paper coating and absorbent uses, 10 percent each.

Refractories.—The value of clay-refractories shipments was $166.1 million, nearly the same as for 1961. Shipments of nonclay refractories decreased 3 percent in value to $223.6 million.

Trends in the refractories industry were toward an increase in the manufacture of specialty products with a diversificiation of products to meet specific demands of customers; increase use of monolithic linings to offset the high installation cost and shortage of masons; continued increase in nonclay refractories with more interest in chrome, magnesite, silicon carbide, etc.; greater use of rotary kilns in burning grog to high temperature with resultant higher firing temperature of brick; use of basic refractories in the open-hearth main roof; and increased quality control procedures including more control of grain sizing of raw materials and control of analysis of materials.

Plastics and castables replaced many fired shapes and accounted for 30 percent of the industries production of all refractories. As a result of the need for products that withstand increasingly severe service conditions and higher temperatures, and the demand for very pure

TABLE 10.—Clay sold or used by producers in the United States in 1962, by kinds and uses

(Short tons)

Use	Kaolin	Ball clay	Fire clay and stoneware clay	Bentonite	Fuller's earth	Miscellaneous clay including slip clay	Total
Pottery and stoneware:							
Whiteware, etc.	126,393	251,385	—	—	—	—	377,778
Stoneware, art pottery, flowerpots, and glaze slip	5,327	12,050	57,820	—	—	60,553	135,750
Total	131,720	263,435	57,820	—	—	60,553	513,528
Floor and wall tile	15,688	95,254	137,143	—	—	114,259	362,344
Refractories:							
Firebrick and block	261,611	—	3,059,958	—	—	—	3,321,569
Bauxite, high-alumina brick	—	—	44,055	—	—	—	44,055
Fire-clay mortar	—	—	92,185	—	—	—	92,185
Zinc retorts and condensers	—	—	58,469	—	—	—	58,469
Foundries and steelworks	—	—	523,311	436,311	—	55,633	1,015,255
Saggers, pins, stilts, and wads	—	—	30,640	—	—	—	30,640
Other refractories	80,161	73,987	118,313	—	—	—	272,461
Total	341,772	73,987	3,926,931	436,311	—	55,633	4,834,634
Heavy clay products: Building brick, paving brick, draintile, sewer pipe, and kindred products	—	—	3,829,010	—	—	17,711,699	21,540,709
Architectural terra cotta	2,840	—	3,848	—	—	—	6,688
Lightweight aggregates	—	—	—	—	—	6,769,912	6,769,912
Filler:							
Paper filling	594,378	—	—	—	—	—	594,378
Paper coating	967,491	—	—	—	—	—	967,491
Rubber	367,642	—	—	—	—	—	367,642
Paint	50,715	—	—	—	—	—	50,715
Fertilizers	22,367	—	—	—	—	—	22,367
Insecticides and fungicides	33,939	—	—	—	89,435	—	123,374
Other fillers	120,009	4,100	8,119	52,476	4,547	6,943	196,194
Total	2,156,541	4,100	8,119	52,476	93,982	6,943	2,322,161
Portland and other hydraulic cements	—	—	7,211	—	—	9,578,096	9,585,307
Miscellaneous:							
Filtering, decolorizing and clarifying	—	—	—	72,462	31,129	—	103,591
Rotary-drilling mud	—	—	1,473	394,009	49,958	8,643	454,083
Chemicals	30,586	—	86,813	—	—	—	117,399
Absorbent uses	—	—	—	123,576	206,978	—	330,554
Exports	113,171	—	—	60,315	240	—	173,726
Other uses	205,839	50,160	6,680	304,986	27,702	86,323	681,690
Total	349,596	50,160	94,966	955,348	316,007	94,966	1,861,043
Grand total:							
1962	2,998,157	486,936	8,065,048	1,444,135	409,989	34,392,061	47,796,326
1961	2,739,816	444,593	8,689,717	1,307,191	422,181	33,787,929	47,391,427

refractories for jet-propulsion engines, refractories companies were increasing both basic and applied research.

A detailed account of H. K. Porter Co.'s new $2.25 million refractory plant at Bessemer, Ala., was published.[6] The construction was unique in that the new plant was built over the site of the existing one without interruption of customer service.

[6] Tatnall, R. F. New Plant Built Over Old. Ceram. Age, v. 78, No. 12, December 1962, pp. 24–27.

The developments and improvements in refractories for byproduct coke ovens, blast furnaces, blast-furnace stoves, oxygen vessels, and open hearths were summarized.[7]

A description of the installation of bottom-lift kilns, and how they reduced costs and shortened time in firing special refractory shapes was presented.[8]

The timesaving vibratory feeders of A. P. Green Fire Brick Co., Mexico, Mo.,[9] and of Harbison-Walker Refractories Co., Fulton, Mo.,[10] were described.

A new plant to furnish refractory block, brick, and cements was completed in Belgium by a new subsidiary of National Lead Co., parent company of The Chas. Taylor Sons Co.

A. P. Green Fire Brick Co., announced the beginning of a new clay calcining plant near Sweet Home, Ark.

The new basic brick plant of North American Refractories Co. at Womelsdorf, Pa., commenced operations early in 1962.

TABLE 11.—Shipments of refractories in the United States, by kinds

Product	Unit of quantity	Shipments			
		1961		1962	
		Quantity	Value (thousands)	Quantity	Value (thousands)
Clay refractories:					
Fire-clay brick, standard and special shapes, except superduty.	1,000 9-inch equivalent.	279,315	$44,966	277,878	$43,336
Superduty fire-clay brick and shapes	do	61,885	17,553	63,349	18,020
High-alumina brick and shapes (50 percent Al_2O_3 and over) made substantially of calcined diaspore or bauxite. [1]	do	23,346	10,851	28,539	12,998
Insulating firebrick and shapes	do	39,412	9,834	42,852	10,823
Ladle brick	do	187,404	20,925	177,827	19,379
Sleeves, nozzles, runner brick and tuyeres	do	32,563	6,814	38,365	8,174
Glasshouse pots, tank blocks, feeder parts and upper structure shapes used only for glass tanks. [1]	Short ton	15,681	4,943	13,402	4,151
Hot-top refractories	do	[2] 73,684	[2] 5,142	61,164	4,171
Clay-kiln furniture, radiant-heater elements, potters' supplies, and other miscellaneous shaped refractory items.			[2] 6,135		6,505
Refractory bonding mortars, air-setting (wet and dry types). [3]	Short ton	[2] 48,544	[2] 5,662	50,213	5,629
Refractory bonding mortars, except air-setting types. [3]	do	9,658	987	8,945	955
Ground crude fire clay, high-alumina clay and silica fire clay. [4]	do	428,270	4,103	379,742	3,545
Plastic refractories and ramming mixes [1]	do	138,373	11,407	143,750	11,977
Castable refractories (hydraulic-setting)	do	99,090	10,259	98,117	9,921
Insulating castable refractories (hydraulic-setting).	do	27,312	2,951	21,554	2,499
Other clay refractory materials sold in lump or ground form. [4 5]	do	176,339	4,096	170,567	4,012
Total clay refractories			[2] 166,628		166,095

See footnotes at end of table.

[7] Brashares, C.A. Refractories Material-Research, Development, Application. Iron and Steel Eng., v. 39, No. 9, September 1962, pp. 133–141.

[8] Ceramic Age. Bottom-Lift Kilns Reduce Cost, Speed Firing of Special Refractory Shapes. V. 78, No. 3, March 1962, pp. 34–35.

[9] Ceramic Age. Vibratory Equipment Cuts Costs at A. P. Green Fire Brick. V. 78, No. 11, November 1962, p. 47.

[10] Brick and Clay Record. Down Time Reduced by 25%. V. 141, No. 3, September 1962, p. 65.

TABLE 11.—Shipments of refractories in the United States, by kinds—Continued

Product	Unit of quantity	Shipments 1961 Quantity	Shipments 1961 Value (thousands)	Shipments 1962 Quantity	Shipments 1962 Value (thousands)
Nonclay refractories:					
Silica brick and shapes	1,000 9-inch equivalent.	145,027	$29,643	119,161	$23,497
Magnesite and magnesite-chrome (magnesite predominating) brick and shapes (excluding molten-cast).	do	61,659	52,090	65,485	56,187
Chrome and chrome-magnesite (chrome ore predominating) brick and shapes (excluding molten-cast).	do	41,248	32,367	33,775	26,387
Graphite crucibles, retorts, stopper heads, and other shaped refractories, excluding those containing natural graphite.	Short ton	11,939	8,865	12,493	9,851
Mullite brick and shapes made predominantly of kyanite, sillimanite, andalusite or synthetic mullite (excluding molten-cast).	1,000 9-inch equivalent.	4,634	5,768	4,944	6,042
Extra-high alumina brick and shapes made predominantly of fused bauxite, fused or dense-sintered alumina (excluding molten-cast).	do	3,230	5,580	3,089	4,942
Silicon carbide brick and shapes made substantially of silicon carbide.	do	3,780	8,781	3,999	9,552
Zircon and zirconia brick and shapes made predominantly of either of these materials.	do	844	3,386	781	2,623
Forsterite, pyrophyllite, molten-cast, and other nonclay brick and shapes.			21,685		23,444
Nonclay refractory bonding mortars, air-setting (wet and dry types).	Short ton	146,744	14,634	142,966	13,969
Nonclay refractory bonding mortars, except air-setting types.	do	13,311	1,157	13,825	1,320
Nonclay refractory castables (hydraulic-setting).	do	12,362	1,752	27,824	2,654
Nonclay plastic refractories and ramming mixes (wet and dry types).	do	[2] 198,665	[2] 22,463	164,453	19,302
Dead-burned magnesia or magnesite. [4]	do	155,307	9,615	173,420	10,548
Carbon refractories; brick, block, and shapes, excluding those containing natural graphite.	do				
Other nonclay gunning mixes	do	158,264	12,816	166,146	13,304
Other nonclay refractory materials sold in lump or ground form. [4]	do				
Total nonclay refractories			[2] 230,602		223,622
Grand total refractories			[2] 397,230		389,717

[1] Excludes data for mullite or extra-high alumina refractories. These products are included with mullite and extra-high alumina brick and shapes in the nonclay refractories section.
[2] Revised figure.
[3] Includes data for bonding mortars which contain up to 60 percent Al_2O_3, dry basis. Bonding mortars which contain more than 60 percent Al_2O_3 dry basis are included in the nonclay refractories section.
[4] Represents only shipments by establishments classified in "manufacturing" industries, and excludes shipments to refractory producers for the manufacture of brick and other refractories.
[5] Includes data for calcined clay, ground brick, and siliceous and other gunning mixes.

Source: Bureau of the Census.

Heavy Clay Products.—Increased construction activity and economic gains in other industries enabled the clay-industry market to register a 1-percent increase over that of 1961 in the total quantity of all clays consumed. The combined use of clays in heavy clay products, lightweight aggregate, and cement gained slightly in 1962. The large increase recorded for lightweight aggregate, amounting to 12 percent, more than offset the slight declines in heavy clay products and cement. Production of unglazed building brick (common and face) increased 3 percent.

A number of new heavy clay product and lightweight aggregate plants were completed or under construction during 1962.

The consolidation of clay product plants continued, and expansion and automation were in evidence in all sections of the country.

Emphasis continued to be on larger unit sizes of brick, block, and panels. The application of a 4 by 4 by 12-inch brick in construction of cavity walls met with success. There was an increase in the variety of glazed and textured surfaces of building units offered. Until recently the principal outlet for lightweight aggregate was the block market but the trend in 1962 was toward increased use in structural concrete. The Expanded Shale, Clay, and Slate Institute conducted studies in creep and shrinkage and on fire resistance of structural and prestressed lightweight products. The Clay Pipe Institute increased research efforts on combining greater strength with lighter weight. The Institute also established a technical aid reference library where significant testing data for sewer pipe were kept up to date for the use of member firms.

The results of experimental loading of brick on flat cars were increased capacity and lower freight rates in some instances.[11]

Ideal conditions were attained in the drying of heavy clay products by electronic techniques using radiation absorption and heat transfer methods to obtain equal surface and interior heating.[12]

The building of shell houses using a 4 by 6 by 12-inch brick lowered costs and increased the competitive position of the industry.[13]

The new plant of Boren Clay Products Co., Pleasant Garden, N.C., was described in detail. The plant featured an extra-wide kiln with a capacity of 80,000 brick per day.[14]

The new operation of the Buildex, Inc., plant at Marquette, Kans., was described. A unique feature was a concrete-lined pit for cooling expanded shale clinker. The plant's capacity was 1,000 cubic yards per day.[15]

The $2.5 million lightweight aggregate plant of Nytralite Aggregates, Inc., a subsidiary of New York Trap Rock Corp., was described including a detailed flow sheet.[16] The plant had the largest operating kiln in the production of lightweight aggregate.

The operating flexibility of the Stiles & Hart Co. new thin-walled kiln at South Bridgewater, Mass., was described. The kiln, lined with lightweight insulating firebrick, effected savings in fuel and labor, and resulted in a smaller percentage of low quality brick.[17]

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[11] Brick and Clay Record. New Methods for Shipping Brick in Flat Cars. V. 140, No. 4, April 1962, p. 71.

[12] Moody, W. F. Electronic Drying for Heavy Clay Products. Brick and Clay Record, v. 140, No. 4. April 1962, pp. 69–61, 96.

[13] Brick and Clay Record. Shell Houses Help Market Clay Products. V. 140, No. 6, June 1962, pp. 62–63.

[14] Brick and Clay Record. Extra-Wide Kiln Built for Product Versatility. V. 141, No. 1, July 1962, pp. 42–43.

[15] Levine, Sidney. Second Aggregate Plant Increases Buildex Production. Nonmetallic Miner. Processing, v. 3, No. 1, January 1962, pp. 11–13.

[16] Bergstrom, John H. Nytralite Is Newest Contender in Lightweight Scramble. Rock Products, v. 65, No. 12, December 1962, pp. 58–62.

[17] Brick and Clay Record. How New Concept in Kilns Saves $35,000. V. 141, No. 1, July 1962, pp. 46–48.

The new brick and tile plants of The Eastern Brick & Tile Co. at Sumter, S.C.,[18] and of Higgins Brick & Tile Co. at Chino, Calif.,[19] were described.

The completion of a modernizing expansion program by Elgin Standard Brick Manufacturing Co., raised the daily capacity to 310,000 brick equivalents.[20]

Installations of automated and modernized equipment were described in a number of articles: The new grinding plant of Globe Brick Co., Newell, W. Va., enabled one man to control automatically the operation that provided raw material for three plants;[21] The Ludowici Celadon Co., New Lexington, Ohio,[22] and the Straitsville Brick Co., New Straitsville, Ohio,[23] installed automatic control systems for their periodic kilns, resulting in reproducible firing curves and substantial fuel and labor savings; Java Brick Works,[24] Roseton, N.Y., and Toronto Brick Co., Ltd.,[25] Toronto, Canada, instituted modern automatic packaging methods, realized substantial savings, and increased output.

Chandler Materials Co. purchased the Hagdite lightweight aggregate plant at Choctaw, Okla., from Texas Industries, Inc., Sanford Brick & Tile Co. and its affiliated companies were purchased by G. L. Ohrstrom & Co.

Construction was started on a number of new heavy clay products plants: The Fisher Tile Co. planned to produce roofing tile, chimney tile, and bathroom tile at Tampa, Fla.; the new plant of Acme Brick Co. at Denton, Tex., was to have an annual capacity of 25 million brick; Dorchester Ceramics, Inc., a new corporation, expected to produce brick in 1963 at a new plant near Summerville, S.C.; the Texas Clay Tile Co. was planning structural clay tile and brick production in its new plant at Molakoff, Tex.; and Waco Brick Manufacturing Co. planned to produce 10 million, soft mud antique brick annually at a new Waco, Tex., plant.

Among the many companies that started or announced plans for substantial expansion programs were: Hawaii Clay Products, Honolulu, Hawaii, announced the installation of a $200,000 tunnel kiln with a 25,000-brick-per-day capacity; Slidell Brick & Tile, Inc., Slidell, La., planned a $500,000 modernization and expansion program; two new gas-fired tunnel kilns were under construction at the Logan, Ohio plant of General Hocking Brick Co.; Athens Brick Co., Inc., Athens, Tex., announced a $700,000 expansion program that would double its capacity to produce solar, drain, and structural tile; and

[18] Brick and Clay Record. New South Carolina Plant To Help Fill State Demands. V. 141, No. 6, December 1962, pp. 42–44.
[19] Brick and Clay Record. Higgin's New Tunnel Kiln Plant. V. 141, No. 5, November 1962, pp. 82–85, 95.
[20] Brick and Clay Record. Expansion Sparks Elgin Standard's Progress. V. 140, No. 3, March 1962, pp. 26–29.
[21] Brick and Clay Record. How One Man Grinds Clay for Three Plants. V. 141, No. 3, September 1962, pp. 72–73.
[22] Brick and Clay Record. Automatic Kiln Firing Provides Economy. V. 141, No. 3, September 1962, pp. 62–64.
[23] Tatnall, R. F. Automatic Control for Periodic Kilns from 100° to 2000° F. Ceram. Age, v. 78, No. 7, July 1962, pp. 23–25.
[24] Brick and Clay Record. Packaging Machine Ups Output by 50 Percent. V. 141, No. 3, September 1962, p. 74.
[25] Brick and Clay Record. New Packaging Method Saves Shipping Cost. V. 141, No. 3, September 1962, p. 76.

Herford Tile and Brick Co., Herford, Tex., was modernizing and expanding its facilities.

Two of the largest producers of clay pipe and brick in North Carolina, Pomona Terra-Cotta Co., Greensboro, and Pine Hall Brick and Pipe Co., Winston-Salem, merged to become Pine Hall-Pomona Corp. Some other mergers were Vitri Neer Corp., Denver, Colo., with Robinson Brick and Tile Co. also of Denver; Kendrick Brick and Tile Co., Charlotte, N.C., Brood River Brick Co. and Rockingham Block and Ready Mix Co., both of Pleasant Garden, N.C., into the Boren Clay Products Co., Pleasant Garden.

According to the U.S. Department of Commerce, the value of clay construction products was $510.5 million, a 6-percent increase above the 1961 value of $480.3 million. Shipments of the principal clay product, unglazed brick, were approximately 6.9 billion brick with a value of $246.5 million, compared with 6.4 billion brick valued at $225.3 million in 1961. Other increases were registered for structural facing tile and for clay floor and wall tile.

TABLE 12.—Shipments of principal structural clay products in the United States

Product	Unit of quantity	Shipments 1961 Quantity	Shipments 1961 Value (thousands)	Shipments 1962 Quantity	Shipments 1962 Value (thousands)
Unglazed brick (building)	1,000 standard brick	6,427,600	$225,300	6,913,100	$246,500
Unglazed structural tile	Short tons	476,000	7,400	422,900	6,600
Vitrified clay sewer pipe and fittings	do	1,749,000	89,600	1,714,000	88,600
Facing tile, ceramic glazed, including glazed brick.	1,000-brick equivalent	388,000	[1] 31,600	370,300	31,100
Facing tile, unglazed and salt glazed	1,000-tile, 8- by 5- by 12-inch, equivalent.	11,900	2,100	14,100	2,200
Clay floor and wall tile and accessories, including quarry tile.	1,000 square feet	228,400	124,300	253,100	135,500
Total			[1] 480,300		510,500

[1] Revised figure.

Source: Bureau of the Census, U.S. Department of Commerce.

WORLD REVIEW [26]

NORTH AMERICA

Canada.—Reviews of bentonite,[27] clays and clay products,[28] and lightweight aggregates [29] in Canada in 1961 were published. The occurrences, uses, export-import data, and price information were reported for bentonite, miscellaneous clay and shale, stoneware clay, fire clay, ball clay, and kaolin. A list of lightweight aggregate producers was also provided.

[26] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.

[27] Ross, S. J. Bentonite, 1961. Canada Dept. Mines and Tech. Surveys, Ottawa, Canada, June 1962, 4 pp.

[28] Brady, J. G. Clay and Clay Products, 1961. Canada Dept. Mines and Tech. Surveys, Ottawa, Canada, August 1962, 8 pp.

[29] Wilson, H. S. Lightweight Aggregates, 1961. Canada Dept. Mines and Tech. Surveys, Ottawa, Canada, May 1962, 6 pp.

TABLE 13.—World production of china clay by countries [1]

(Thousand short tons)

Country [1]	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962
North America: United States	1,884	1,873	2,166	2,250	2,184	2,222	2,535	2,730	2,740	2,998
South America:										
Argentina	20	31	35	42	25	21	31	(2)	(2)	(2)
Chile	5	6	7	3	(2)	(2)	(2)	9	16	33
Colombia	(2)	2	2	3	7	4	17	22	22	(2)
Ecuador	(3)	(3)	(3)	1	(3)	(3)	1	(3)	1	(3)
Peru	(3)	(3)	(3)	(3)	(3)	(3)	(3)	1	1	(3)
Europe:										
Austria	217	266	287	300	322	331	328	356	379	371
Belgium	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	285	230
Bulgaria	(2)	(2)	(2)	(2)	(2)	33	33	(2)	(2)	(2)
Czechoslovakia	(2)	206	247	255	281	285	288	301	(2)	(2)
Denmark:										
Crude	12	7	7	7	4	7	7	7	9	[4] 9
Washed and pressed	7	7	7	5	4	6	5	5	13	[4] 13
France	106	122	125	129	143	152	159	150	160	(2)
Germany, West (marketable)	299	326	351	351	365	362	338	342	460	497
Greece	14	12	11	22	6	19	3	29	[4] 33	[4] 28
Hungary:										
Crude	(2)	28	(2)	(2)	(2)	36	(2)	(2)	(2)	(2)
Enriched	(2)	6	(2)	(2)	(2)	8	(2)	(2)	(2)	(2)
Italy:										
Crude	70	72	57	60	67	67	101	96	50	(2)
Kaolinic earth	21	30	45	53	52	61	26	51	87	(2)
Portugal:										
Crude	27	26	21	27	23	38	19	20	22	(2)
Washed	14	17	26	27	30	28	30	32	33	(2)
Spain (crude)	72	57	73	62	94	100	128	124	140	(2)
Sweden	[5] 1	[5] 2	[5] 2	[5] 2	[5] 1	[5] 1	22	30	30	(2)
U.S.S.R.	(2)	(2)	(2)	(2)	(2)	(2)	[5] 650	(2)	(2)	(2)
United Kingdom	906	1,089	1,282	1,340	1,371	1,359	1,470	1,835	1,814	(2)
Yugoslavia	11	11	14	(2)	(2)	(2)	18	(2)	(2)	5
Asia:										
Hong Kong	7	7	6	6	8	9	8	7	9	7
India	106	164	132	173	202	204	287	386	409	423
Indonesia (kaolin powder)	(2)	(2)	(2)	1	1	1	1	1	(2)	(2)
Iran [6]	(2)	(2)	(2)	(2)	(2)	1	2	5	3	(2)
Japan	17	14	14	16	18	24	23	23	30	65
Korea, Republic of	8	10	16	10	7	24	47	56	56	42
Malaya, Federation of	1	2	2	1	2	1	1	1	2	4
Pakistan	-----	-----	-----	-----	-----	-----	-----	(3)	1	-----
Taiwan	(2)	(2)	(2)	4	4	6	6	(2)	(2)	(2)
Viet-Nam, Republic of	(2)	4	4	7	1	1	1	2	(2)	4
Africa:										
Algeria	(3)	(3)	1	-----	-----	-----	-----	-----	-----	-----
Eritrea	(3)	(3)	(3)	(3)	1	1	6	2	4	1
Kenya	-----	-----	1	2	1	1	1	1	1	1
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	-----	-----	-----	-----	-----	-----	-----	7	20	-----
South Africa, Republic of	9	14	11	11	16	27	20	29	26	31
Swaziland	-----	-----	-----	-----	-----	-----	-----	-----	(3)	3
Tanganyika	1	(3)	(3)	(3)	-----	(3)	(3)	(3)	(3)	(3)
United Arab Republic (Egypt)	(3)	1	3	3	8	10	13	22	30	(2)
Oceania: Australia [7]	44	46	50	46	49	42	41	54	53	(2)

[1] China clay is also produced in Brazil, China, East Germany, Israel, Mexico, Rumania, and Thailand, but data on production are not available; a negligible quantity is produced in Malagasy, Morocco, Mozambique, Nigeria, and Paraguay.
[2] Data not available.
[3] Less than 500 tons.
[4] Estimate.
[5] Washed.
[6] Year ended March 20 of year following that stated.
[7] Includes ball clay.

Compiled by Helen L. Hunt, Division of Foreign Activities.

The value of clay products made in Canada from domestic and imported clays during 1961 was Can$63.9 million, up Can$4.2 million from the revised 1960 figure. Production from domestic clays was valued at Can$38 million, about the same as in 1960, although production from imported clays showed a substantial increase. The value of imports of clay and clay products was Can$47.1 million, a slight increase, and of exports, Can$5.8 million, a slight increase also. The value of all lightweight aggregate production in Canada was 3 percent higher in 1961 than in 1960. Expanded clay and shale aggregates were 9 percent higher in quantity and 7 percent higher in value than in 1960. Two new plants—at Regina, Saskatchewan, and St. Boniface, Manitoba—began operations.

A revised list of ceramic plants in Canada was published giving location, management, kind and source of raw material, process, number and types of kilns, fuel, products, and plant capacity. Information included data received by July 1, 1962.[30]

SOUTH AMERICA

Brazil.—Bentonite Union began installing a plant at Sacramento in Minas Geraes to mine montmorillonite for use in foundries.[31]

Guatemala.—Estimated production of clay in 1962 was 15,000 tons with a value of $1,667.[32]

Peru.—Production of clay for building brick in 1961 totaled 266,345 tons and for refractories, 3,645 tons.[33]

Uruguay.—In 1962, production of common clay amounted to 10,233 tons, and of refractory clay, 1,853 tons.[34]

EUROPE

Belgium.—In 1962, production of kaolin and other clays was 230,000 tons.[35]

Denmark.—The amount of common clay produced was indicated for the following product quantities (1962 values not available):

Use:	1961 Short tons (thousands)	1961 Value in $1,000	1962 Short tons (thousands)[1]
Common brick	732, 809	15, 871	740, 000
Moler	45, 728	902	50, 000
Roofing tile	10, 707	694	12, 000
Drain tile	38, 740	1, 585	40, 000

[1] Estimated.

Greece.—Bentonite production in 1962 was 33,060 tons valued at $866,667.[36]

Ireland.—Fire clay production in 1962 was 19,947 tons,[37] and common clay and shale for structural products and cement was 300,854 tons.[38]

Italy.—In 1962 production of bentonite was 122,715 tons valued at $997,759.[39]

[30] Canada Department of Mines and Technical Surveys. Ceramic Plants in Canada. Min. Res. Div., Operators List 6, July 1962, 37 pp.
[31] Mining Journal (London). Bentonite in Brazil. V. 258, No. 6603, Mar. 9, 1962, p. 244.
[32] U.S. Embassy, Guatemala. State Department Airgram A–642. May 2, 1963, p. 1.
[33] Bureau of Mines. Mineral Trade Notes. V. 55, No. 2, August 1962, p. 14.
[34] U.S. Embassy, Montevideo, Uruguay. State Department Airgram A–761, May 10, 1963, p. 1.
[35] U.S. Embassy, Brussels, Belgium. State Department Airgram A–1365. May 22, 1963, p. 1.
[36] U.S. Embassy, Athens, Greece. State Department Airgram A–1029. May 8, 1963, pp. 1–2.
[37] U.S. Embassy, Dublin, Ireland. State Department Airgram A–282. May 3, 1963, p. 1.
[38] U.S. Embassy, Dublin, Ireland. State Department Dispatch 42. Apr. 23, 1963. p. 1.
[39] U.S. Embassy, Rome, Italy. State Department Airgram A–1648. May 14, 1963, p. 4.

Poland.—Encouraged by the Petroleum Institute, a bentonite processing plant was completed in Chmielnik, Busko Powiat, Kielce Wojewodztwo. It was the first of its kind in Poland and was reported to have an annual capacity of 20,000 tons.[40]

Sweden.—Output of fire clay in 1961 was 173,675 tons, an increase from 162,655; and of clinker clay, 109,539 tons, an increase from 54,769 tons.[41]

Yugoslavia.—Production of fire clay in 1962 was 148,587 tons valued at $2,252,000; bentonite production was 23,000 tons (estimated), valued at $630,000.[42]

ASIA

Burma.—A $600,000 government-owned tile and brick plant was being constructed.[43]

Ceylon.—The Ceylon Government planned to erect a kaolin beneficiation plant with a 1,500-ton-per-year capacity near the Boralesgamuwa kaolin reserves.[44]

India.—Proven bentonite reserves in the Akli-Thumbli-Giral area were reported to be 9 million tons with an inferred reserve of 46 million tons.[45] Production of fire clay in 1962 was 372,000 tons, valued at $606,060.[46]

Israel.—The tariff rates of some clay products were lowered. New rates were for unglazed paving and wall tiles, white, 15 percent plus $1.33 per square meter; other, 15 percent plus $1.67 per square meter. For glazed paving and wall tile, white, 15 percent plus $1.33 per square meter; other, 15 percent plus $1.67 per square meter.[47] Production of ball and fire clays totaled 42,614 tons in 1961 compared with 27,308 tons in 1960.[48]

Japan.—Ceramic production was valued at $186,916,361 in 1962. Exports of ceramic products to all countries amounted to $107,460,717, of which $56,000,808 went to the United States. Exports of pottery products alone totaled $72,079,844 in 1962, and $41,405,856 represented sales to the U.S. market. Tile production in 1962 was the highest in history. Export value amounted to $23,113,555; of which the United States received $13,757,656.[49]

Pakistan.—In 1962 production of fire clay was 10,034 tons, of fuller's earth, 9,949 tons; and of bentonite, 440 tons.[50]

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[40] Nafta (Katowice). New Clay Processing Plant in Chmielnik. No. 6, June 1962, p. 177.
[41] U.S. Embassy, Stockholm, Sweden. State Department Airgram A–501. Dec. 14, 1962, p. 1.
[42] U.S. Embassy, Belgrade, Yugoslavia. State Department Airgram A–1045. Apr. 13, 1963, pp. 1–2.
[43] International Commerce. Burma. V. 68, No. 7, July 30, 1962, p. 2.
[44] Mining Journal (London). Kaolin Project for Ceylon. V. 258, No. 6600, February 1962, p. 171.
[45] Bureau of Mines. Mineral Trade Notes. V. 55, No. 6, December 1962, p. 7.
[46] U.S. Embassy, New Delhi, India. State Department Airgram A–1309. Apr. 29, 1963, p. 1.
[47] U.S. Embassy, Tel Aviv, Israel. State Department Airgram A–653. Apr. 23, 1963, p. 3.
[48] Bureau of Mines. Mineral Trade Notes. V. 55, No. 4, October 1962, p. 9.
[49] U.S. Consulate, Nagoya, Japan. State Department Airgram A–120. Apr. 26, 1963, pp. 3–8.
[50] U.S. Embassy, Karachi, Pakistan. State Department Airgram A–1239. May 30, 1963, p. 1.

A detailed account of some of the bentonite deposits in West Pakistan was presented. Some development work and production had been accomplished.[51]

Although the clay resources of West Pakistan had not been thoroughly examined, it was known that commercial deposits of fire clays occur in the Salt Range and in the Jhempir-Jungshahi area. Commercial deposits of kaolin had been found near Ahl in Hazara District and in the Nagar Parkar. Bentonite occurs in the Bhimber area in Azad Keshmir. Extensive deposits of fuller's earth occur in Khairpur. Pottery and common clay occurrences are widespread.[52]

In the Mymensengh district of East Pakistan, a deposit of kaolin occurs that possibly could be upgraded for use as a china clay. Common clay deposits are abundant.[53]

Taiwan.—Production of clay was 1,024,800 tons with a value of $5 million. A breakdown by use was as follows: Ceramic and pottery industry, 44,800 tons; paper industry, 3,360 tons; cement industry, 416,640 tons; and brick and tile industry, 560,000 tons.[54]

Viet-Nam.—Production of common clay almost doubled in 1962 to an estimated 40,000 tons.[55]

AFRICA

Algeria.—In 1962 fuller's earth production decreased to 42,358 tons, about one-third of the 1961 total.[56]

Morocco.—Production of fuller's earth increased to 42,540 tons in 1961. Ghassoul output amounted to 2,528 tons. Over half the production was exported to France, Spain, and Algeria.[57] The location of a promising deposit of porcelain-grade clay, which could eliminate the need for substantial imports was reported.[58]

Mozambique.—Production of bentonite totaling 40 tons was reported for the first time in 1960.

Rhodesia and Nyasaland, Federation of.—Output of fire clay in 1962 was 15,333 tons valued at $18,116.[59]

South Africa, Republic of.—Reported local sales of clay in 1962 were as follows: Fuller's earth, 736 tons valued at $3,091;[60] flint clay, 61,484 tons valued at $144,096; fire clay, 201,770 tons valued at $378,058; and bentonite, 6,333 tons valued at $88,662. In addition, 81,199 tons of flint clay valued at $1,217,725 was exported.

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[51] Bogue, R. G., and R. G. Schmidt. Bentonite Deposits Near Padhaar, Rawalpindi Division, West Pakistan. Geol. Survey of Pakistan, Min. Inf. Circ. No. 3, April 1961, 24 pp.

[52] Kazmi, Ali H., and M. Safdar. Clay Resources of West Pakistan. Centro Symp. on Ind. Rocks and Miner., Lahore, West Pakistan, Geol. Survey of Pakistan, 1962, 10 pp.

[53] Khan, F. H. Clay Deposits of East Pakistan. Centro Symp. on Ind. Rocks and Miner., Lahore, West Pakistan, Geol. Survey of Pakistan, 1962, 8 pp.

[54] U.S. Embassy, Taipei, Taiwan. State Department Airgram A-860. Apr. 27, 1963, pp. 1–2.

[55] U.S. Embassy, Saigon, Viet-Nam. State Department Airgram A-766, June 6, 1963, p. 1.

[56] U.S. Embassy, Algiers, Algeria. State Department Airgram A-505, May 4, 1963, p. 2.

[57] Bureau of Mines. Mineral Trade Notes. V. 56, No. 1, January 1963, p. 5.

[58] U.S. Embassy, Rabat, Morocco. State Department Airgram A-430. Feb. 20, 1963, p. 1.

[59] U.S. Consulate, Johannesburg, Republic of South Africa. State Department Airgram A-402. May 9, 1963, p. 1.

[60] U.S. Consulate, Johannesburg, Republic of South Africa. State Department Airgram A-362. Mar. 28, 1963, pp. 2–5.

OCEANIA

Australia.—A plant with an annual capacity of 25 million brick was to be constructed at Campbellfield, 10 miles north of Melbourne.[61]

TECHNOLOGY

A comprehensive book on clay mineralogy appeared. The more important structural and chemical properties of clay minerals were presented, and the utilization of clay minerals was discussed from the consideration of their basic structure. Clay in ceramic products and in the petroleum industry was covered in detail and more than 30 miscellaneous uses of clays were correlated with their mineralogy.[62]

A completely revised and up-to-date list of clay modifiers was published. The list included a concise summary of materials used to control firing, drying, forming, texture, color, porosity, weight, strength, and size.[63]

The proceedings of the Eighth National Conference on Clays and Clay Minerals, held in Norman, Okla., in 1959, and sponsored by the Committee on Clay Minerals of the National Academy of Sciences—National Research Council, were published in 1960. Selected papers in this volume were of special interest to the clay industry.[64]

Clay Science, a new journal sponsored by the Clay Research Group of Japan, began publication in English.[65]

Investigation and ceramic testing of some Philippine clay deposits indicated the suitability of local clay materials for making such structural clay products as building bricks and tile, roofing tile, draintile, and sewer pipe.[66]

The clay minerals of the Colorado plateau were studied in detail to determine if they could be used as guides to uranium deposits.[67] X-ray analyses of 50 clay samples mineralogically related the clays to parent material.[68]

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[61] Jobson's Investment Digest (Sydney). Melbourne Brickworks. V. 43, No. 9, May 11, 1962, p. 307.

[62] Grim, Ralph E. Applied Clay Mineralogy. McGraw-Hill Book Co., Inc., New York, 1962, 422 pp.

[63] Brick and Clay Record. Clay Modifiers. V. 141, No. 4, October 1962, pp. 51–63, 75–76, 78.

[64] Eighth National Conference on Clays and Clay Minerals, Nat. Acad. Sci.-Nat. Res. Council, Norman, Okla. Pergamon Press, Inc., 1960, 292 pp.
Specifically the following papers:
Barshad, Isaac. Thermodynamics of Water Adsorption and Desorption on Montmorillonite, pp. 84–101.
Grandquist, W. T., and S. S. Pollack. A Study of the Synthesis of Hectorite, pp. 150–169.
Grim, R. E., John B. Droste, and W. F. Bradley. A Mixed-Layer Clay Mineral Associated With an Evaporite, pp. 228–236.
Hinckley, David N., and Thomas F. Bates. Evaluation of the Amount and Distribution of Montmorillonite in Some Georgia and South Carolina Kaolins, pp. 18–21.
Low, Philip F. Viscosity of Water in Clay Systems, pp. 170–182.
Murray, Haydn H., and Sanford C. Lyons. Further Correlations of Kaolinite Crystallinity With Chemical and Physical Properties, pp. 11–17.
Oakes, D. T. Solids Concentration Effects in Bentonite Drilling Fluids, pp. 252–273.
Ponder, Herman, and W. D. Keller. Geology, Mineralogy, and Genesis of Selected Fireclays From Latah County, Idaho, pp. 44–62.
van Olphen H. Ion Adsorption on Clays: A Review, p. 115.

[65] Clay Science. Secretary-General, Tomoji Egawa, National Institute of Agricultural Sciences. Nishigahara-machi, Kiti-Ku, Tokyo, Japan.

[66] Boutesta, E. N., E. V. Pasiliao, R. M. Lozano, and C. R. Sison. Preliminary Ceramic Tests on Clay From Bondolan, San Dionisio, Iloilo. Philippine Bureau of Mines, Rept. of Inv., No. 37, Manila, June 1962, 19 pp.

[67] Keller, W. D. Clay Minerals in the Morrison Formation of the Colorado Plateau. U.S. Geol. Survey Bull. 1150, 1962, 90 pp.

[68] Tank, R. W. Clay Mineralogy of Selected Clays From the English Wealden. Geol. Mag., v. 99, No. 2, February 1962, pp. 128–136.

A study of the exchange adsorption of cesium on kaolinite, halloysite, montmorillonite, and illite was part of an investigation of some physicochemical reactions that might have significant effects upon the transport and dispersal of radioactivity by water.[69] It was observed that the relatively high cation-exchange capacity of poorly ordered kaolins was more directly a result of high surface area than of crystallinity which played a minor role.[70] The cation exchange capacity of montmorillonite was investigated.[71]

Studies on the kinetics of volume-strain behavior during the drying of clayware established a guide to minimize the development of cracks during drying.[72] The friction and cohesion of saturated clays were studied experimentally to determine the influence of clay structure and method of loading.[73] A study was made to develop a reliable means for predicting the potential expansion of clays from classification test data.[74]

Much interest had been shown in high-alumina clays as sources of alumina. Methods of utilizing aluminous clays were concisely outlined.[75]

A description was published of the kaolin spray-drying process to produce a superior clay at the Georgia plant of J. M. Huber Corp.[76] Laboratory techniques were developed for separating ultrafine contaminating minerals from kaolin.[77]

A detailed study was undertaken of the morphological changes that take place when well-crystallized kaolinite is acid treated.[78] Experiments were also conducted on electronoscopic observations of kaolinite at elevated temperatures in a vacuum.[79] Other experiments were conducted to determine quantitatively the role of crystal structure in determining the high-temperature reactions of clays containing kaolinite, boehmite, and diaspore.[80]

The rheological properties of aqueous suspensions of flocculated kaolin were investigated. Data on shear stress versus shear rate were obtained.[81] Settling rates and sediment volumes as functions of kaolin concentration, container dimensions, and chemical composition of the aqueous phase were determined for aqueous, flocculated kaolin sus-

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69 Wahlberg, J. S., and M. J. Fishman. Adsorption of Cesium on Clay Minerals. Federal Geol. Survey Bull. 1140–A, 1962, 30 pp.

70 Ormsley, W. C., J. M. Shartsis, and K. H. Woodside. Exchange Behavior of Kaolins of Varying Degrees of Crystallinity. J. Am. Ceram. Soc., v. 45, No. 8, August 1962, pp. 361–366.

71 Tettenhorst, Rodney. Cation Migration in Montmorillonites. Am. Mineral., v. 47, Nos. 5–6, May–June 1962, pp. 769–773.

72 Belopol'skii, M. S. Quantitative Evaluation of the Sensitivity of Clays to Drying. Glass and Ceram., U.S.S.R., v. 18, No. 12, December 1962, pp. 611–617 (English).

73 Wu, T. H., A. G. Douglas, and R. D. Goughnour. Friction and Cohesion of Saturated Clays. Proc. Am. Soc. Civil Engineers, v. 88, pt. 1, 1962, pp. 1–32.

74 Seed, H. B., R. J. Woodward, and R. Lundgren. Prediction of Swelling Potential for Compacted Clays. Proc. Am. Soc. Civil Engineers, v. 88, pt. 1, 1962, pp. 53–87.

75 Mining Journal (London). Alumina From Low Grade Bauxites and Clay. V. 258, No. 6632, Sept. 28, 1962, pp. 280–281, 283.

76 Ceramic Age. Huber Spray Dries Clays. V. 78, No. 9, September 1962, pp. 52–53.

77 Greene, E. W., and J. B. Duke. Selective Froth Flotation of Ultrafine Minerals or Slimes. Min. Eng., v. 14, No. 10, October 1962, pp. 50–55.

78 Towe, K. M. Electronoscopic Studies of Acid-Treated Kaolinite. Am. Mineral., v. 47, Nos. 11–12, November–December 1962, pp. 1446–1453.

79 Borasky, R., and C. A. Sorrell. Vacuum-Firing and High-Temperature Replication of Kaolinite. Am. Mineral., v. 47, Nos. 9–10, September–October 1962, pp. 1184–1187.

80 Bratton, R. J., and G. W. Brindley. Structure-Controlled Reactions in Kaolinite-Diaspore-Boehmite Clays. J. Am. Ceram. Soc., v. 45, No. 11, pp. 513–516.

81 Michaels, A. S., and J. C. Bolger. The Plastic Flow Behavior of Flocculated Kaolin Suspensions. Ind. Eng. Chem. (Fundamentals), v. 1, No. 3, March 1962, pp. 153–162.

pensions, and equations correlating the experimental data were derived.[82]

Investigations were also conducted on the reproducibility of particle-size analyses using different deflocculents on elutriated kaolin samples.[83]

An extensive report on the geology of some refractory clay deposits in northeast Kentucky appeared. It was reported that reserves in Haldeman and Wrigley quadrangles amount to 30 million tons of clay with better than the minimum requirements for use in refractories. Only a fraction of this tonnage was considered suitable for superheat-duty products.[84]

A program for testing refractory clay prospect samples, included a burning test, a pyrometric cone equivalent determination, ignition loss and iron content, and a temperature gradient furnace test.[85]

The advantages and disadvantages of various firefighting chemicals, including bentonite, were discussed.[86]

A detailed description of Canadian bentonite production included a flowsheet and specifications for various uses.[87] The bentonite industry in Africa was discussed, including information on properties, occurrences, mining and beneficiation, specifications, uses and prices.[88]

An examination of 174 brands of fire-clay brick was conducted to develop a more realistic method of rating. Tests included apparent porosity, bulk density, 2,640° F load deformation, modulus of rupture, and panel-spalling loss.[89] Data were presented on production of high-density firebrick by particle-size grading and high-firing temperature to obtain a product with no open pores and less than 5 percent shrinkage.[90] Techniques for the best results in firing face brick in a tunnel kiln were described.[91] Data on the interpretation of thermal properties of processed clay and chemical, dilatometric, differential thermal analysis (DTA), and shock-resistance tests were included.

The mechanism of slagging failure was described in terms of chemical corrosion, vitrification, and spalling. The physicochemical factors influencing slagging are chemical interaction, chemical reaction rates, surface tension, viscosity, porosity, and gas diffusion.[92] The reasons for using fire-clay brick for ladle lining requirements were presented. Data were included on present and future developments, including

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[82] Michaels, A. S., and J. C. Bolger. Settling Rates and Sediment Volumes of Flocculated Kaolin Suspensions. Ind. Eng. Chem., v. 1, No. 1, February 1962, pp. 24–33.

[83] Koster, H. M. Particle-Size Analysis of Kaolins by the Pipette Method. Ber. dtsch. keram. Ges., v. 39, No. 8, August 1962, pp. 432–438 (English summary).

[84] Patterson, S. H., and J. W. Hosterman. Geology and Refractory Clay Deposits of the Haldemen and Wrigley Quadrangles, Kentucky. U.S. Geol. Survey Bull. 1122-F, 1962, 113 pp.

[85] Hess, R. L. Testing Refractory Clay Prospect Samples. Ceram. Age, v. 78, No. 7, July 1962, pp. 30–31, 34.

[86] Chemical and Engineering News. Fire-Fighting Chemicals List Grows. V. 40, No. 51, Dec. 17, 1962, pp. 57–58, 61.

[87] Wolke, R., A. Zrimseh, and G. Vingar. Development of Canadian Bentonite for Canadian Industry. Canadian Min. and Met. Bull., v. 55, No. 602, June 1962, pp. 406–408.

[88] Timmermans, O. E. B. Bentonites, Their Properties, Treatment, and Application. South African Min. and Eng. J. (Johannesburg), v. 73, pt. 2, No. 3642, Nov. 23, 1962, pp. 1191–1194, 1196.

[89] Eusner, G. R., and K. K. Kappmeyer. Ratings of Fireclay Brick. Am. Ceram. Soc. Bull., v. 41, No. 1, January 1962, pp. 1–7.

[90] Gugel, E., and F. H. Norton. High-Density Firebrick. Am. Ceram. Soc. Bull., v. 41, No. 1, January 1962, pp. 8–11.

[91] Groskaufmanis, E. Firing Face Brick in a Tunnel Kiln. Am. Ceram. Soc. Bull., v. 41, No. 3, Mar. 15, 1962, pp. 151–155.

[92] Mehta, P. K. Slagging Failure of Refractories in Cement Rotary Kilns. Nonmet. Miner. Proc., v. 3, No. 7, July 1962, pp. 21–24.

high-alumina brick, basic bricks, and plumbago (clay graphite) bricks.[93]

The advantages of using lamination techniques in making thinner, lighter refractories for kiln furniture for high-temperature firing, and other applications were discussed.[94]

The results of experimental work by the Bureau of Mines on testing procedures for evaluating clays, shales, and slates for lightweight aggregates using the rotary-kiln method of production were published. Details covered preliminary testing, pilot plant rotary testing, and the evaluation of properties of concrete made from lightweight aggregate.[95] Shales from 65 deposits and 11 sources of coal mine waste in western Oregon and Washington were tested in a rotary kiln for suitability as raw material for expanded aggregate.[96] Some Alaskan clays were tested and reported to be suitable for making expanded lightweight aggregate for concrete. Details of testing were included in a report.[97]

The 1,000-ton-per-day lightweight aggregate plant of Masslite, Inc., Plaineville, Mass., was described. This plant, completed in 1962, employed an 8- by 64-foot sintering grate which was reported to be the largest in U.S. lightweight aggregate production. Flowsheets and specifications for use in concrete and blocks were given.[98] The new lightweight aggregate plant near San Clemente, Calif., built and operated by Susquehanna-Western, Inc., Denver, Colo., was described. The $1.8 million plant had a capacity of 1,000 cubic yards per day. A detailed flowsheet was included.[99] Recent research at Ohio State University on the production of expanded clay and shale aggregate was described.[1]

A new rotary kiln was specifically designed for making lightweight aggregates. The kiln was fired from both ends and the temperature was kept constant throughout the length of the zone. It was claimed that better temperature control and heat distribution would enable many marginal clays and shales to be bloated.[2]

A detailed study was made on the physical properties of concrete containing a sintered expanded clay product and the results compared with heavy aggregate concrete.[3] A résumé of the economical and technical aspects of lightweight aggregate for concrete was presented.[4]

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[93] Workman, G. M. Steel Plant Ladle Refractories. Steel and Coal (London), v. 185, No. 4921, Nov. 9, 1962, pp. 888–892.

[94] Saunders, A. C. Refractory Laminates—A Step Forward in Refractory Technology and Engineering. Ceram. Age, v. 78, No. 4, April 1962, pp. 51–53.

[95] Hamlin, H. P., and George Templin. Evaluating Raw Materials for Rotary-Kiln Production of Lightweight Aggregate. BuMines Inf. Circ. 8122, 1962, 23 pp.

[96] Harris, H. M., K. G. Strandberg, and H. J. Kelly. Resources for Making Expanded Aggregate in Western Washington and Oregon. BuMines Rept. of Inv. 6061, 1962, 41 pp.

[97] Warfield, R. S. Some Nonmetallic Mineral Resources for Alaska's Construction Industry. BuMines Rept. of Inv. 6002, 1962, 25 pp.

[98] Herod, Buren C. Lightweight Aggregate Operation With Heavyweight Capabilities. Pit and Quarry, v. 55, No. 4, October 1962, pp. 78–83, 115–116.

[99] Torgerson, Ralph S. Creslite Enters Lightweight Aggregate Field. Rock Products, v. 65, No. 8, August 1962, pp. 72–75.

[1] Shook, W. B. New Horizons in Lightweight Aggregate. News in Eng., v. 34, No. 2, 1962, pp. 23–25.

[2] Brick and Clay Record. A New Rotary Kiln Makes LW Aggregate News. V. 140, No. 5, May 1962, pp. 48–49.

[3] Evans, R. H., C. O. D. Arrand, and C. O. Orangun. Research Experience With Aglite and Lytag. Cement, Lime and Gravel (London), v. 37, No. 10, October 1962, pp. 273–302.

[4] Protze, H. G., and Sidney Levine. Lightweight Aggregate for Structural Concrete and Products. Nonmetallic Miner. Processing, v. 3, No. 10, October 1962, pp. 26–27.

Investigations to determine the reasons for dissimilar behavior of glazes on apparently similar underclays included grain-size analyses, microscopic study of sand fraction, X-ray investigation of silt and clay fractions, and quantitative and qualitative analyses for soluble salts, and chemical analyses.[5] Experiments were conducted on the preparation of slip and the mechanics of slip casting with special attention to consistency, casting rates, and particle size as they affect casting properties.[6] An improved method was described for attaining uniformity in clay and additive mixes. The objective was to realize consistency in reproducing colored brick.[7]

The advantages and disadvantages of air balance in kiln firing to control scumming were presented. Possible methods of preventing scumming were given.[8]

An article described the use and effectiveness of silicone resins (dissolved in an organic solvent) to improve the water repellency of brick and tile.[9]

Successful experiments were conducted using inflatable rubber bulkheads in brick shipment with a saving of $10 per car.[10]

A patent was issued on an apparatus for the continuous dewatering of undiluted kaolin and other clay slip using a combination of orbital vibrations and rocking movements.[11]

Other patents were obtained on an apparatus for, or methods of, kaolin beneficiation involving deairing,[12] bleaching,[13] fractionization,[14] and delamination.[15]

Two similar patents were issued for producing acid-activated kaolin involving sulfuric acid addition, slurry aging, and calcining.[16]

A method of producing a paper-coating grade of kaolin of minus 2-micron size by sonic energy was patented.[17]

Other patents were obtained on methods of preparing petroleum-cracking catalysts from kaolin.[18]

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[5] De Rudder, R. D., and C. W. Beck. Glaze Peeling of Selected Indiana Underclays. Am. Ceram. Soc. Bull., v. 41, No. 5, May 15, 1962, pp. 326–331.

[6] van Wunnick, John. Practical Control of Slip Properties. Ceram. Age, v. 78, No. 12, December 1962, pp. 45–52.

[7] Edgar, Leo K. Screw Feeders Regulate Additives and Clay for Colored Brick. Brick and Clay Record, v. 140, No. 4, April 1962. pp. 72–73.

[8] Bishop, G. J. Balance Your Kiln to Control Scumming. Brick and Clay Record, v. 140, No. 1, January 1962, pp. 72–73, 91–93.

[9] Bebbington, G. Silicones in the Clay Industry. Claycraft (London), v. 35, No. 9, September 1962, pp. 309–314.

[10] Brick and Clay Record. Inflatable Dunnage Lowers Rail Shipping Cost. V. 140, No. 4, April 1962, p. 58.

[11] Hurst, J. (assigned to Russell Construction, Ltd., London). Straining and Sifting Process and Apparatus. U.S. Pat. 3,047,151, July 31, 1962.

[12] Johnson, W. E. Apparatus for Inducing the Flow of Pulverized Material. U.S. Pat. 3,036,745, May 29, 1962.

[13] Urfer, A. D., and L. E. Jackson (assigned to Stauffer Chemical Co., New York). Method of Bleaching Clay and Improved Clay Products. U.S. Pat. 3,043,707, July 10, 1962.

[14] Billue, R. F. (assigned to Thiele Kaolin Co., Sandersville, Ga.). Fractured Clay. U.S. Pat. 3,058,671, Oct. 16, 1962.

[15] Gunn, F. A., and H. H. Morris (assigned to Southern Clays, Inc., New York). Delaminated English Clay Products, Etc. U.S. Pat. 3,034,859, May 15, 1962.

[16] Pedler, A. H. (assigned to Minerals & Chemicals Philipp Corp., Menlo Park, N.J.). Activation of Clay by Acid Treatment, Aging in Conditioned Oil and Calcination. U.S. Pat. 3,024,205, Mar. 6, 1962.

Weir, J. V., and A. J. Robinson (assigned to Minerals & Chemicals Philipp Corp., Menlo Park, N.J.). Activation of Clay by Acid Treatment, Oil Aging, and Calcination. U.S. Pat. 3,033,798, May 8, 1962.

[17] Burgess, M. S. (assigned to Burgess Pigment Co., Sandersville, Ga.). Treatment of Mineral Substances. U.S. Pat. 3,042,320, July 3, 1962.

[18] Braithwaite, D. C., E. H. McGrew, W. P. Hettinger, Jr., and J. S. D'Amico (assigned to Nalco Chemical Co., Chicago, Ill.). Catalysts and Process for the Preparation Thereby. U.S. Pats. 3,034,994, and 3,034,995, May 15, 1962.

Robinson, A. J., and W. L. Heden, Jr. (assigned to Minerals & Chemicals Philipp Corp., Menlo Park, N.J.). Spherical Contact Masses. U.S. Pat. 3,039,973, June 19, 1962.

Patents on the use of acid-activated kaolin for treatment of engine exhaust [19] and shredded tobacco [20] were issued.

Patents were granted on the use of kaolin in recovering fresh water from sea water,[21] in the manufacture of gel metal oxide catalysts,[22] as an extender in open-celled plastics,[23] and in the production of synthetic crystalline zeolites.[24]

A process for improving the flocculation and sedimentation of finely divided bentonite or other clays was patented.[25] Two patents were issued covering the use of bentonite and hectorite in producing water-resistant grease compounds.[26] Other patents involving the use of bentonite in processes for removing oleaginous materials from aqueous solutions,[27] and in the preparation of weather-resistant pellets of sulfidic concentrates [28] were issued. Several patents involved the use of bentonite and attapulgite in drilling muds.[29] Bentonite was involved in new patents on slurry viscosity,[30] pelletizing iron ores,[31] and foundry-sand bonding.[32]

A method for producing activated attapulgite to be used in liquid internal therapeutic formulations,[33] and another method for producing low bulk-density adsorbents [34] were patented.

Many other patents were obtained for a variety of uses of bentonite, kaolin, hectorite, and attapulgite. Some of these included use in

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[19] Robinson, A. J., C. A. Specht, and C. G. Albert (assigned to Minerals & Chemicals Philipp Corp., Menlo Park, N.J.). Method of Treating Exhaust From an Internal Combustion Engine Operated on Leaded Fuel. U.S. Pat. 3,025.133, Mar. 13, 1962.

[20] Gary, W. W. (assigned to Minerals & Chemicals Philipp Corp., Menlo Park, N.J.), Process for Affixing Particulated Mineral-Type Materials to Tobacco. U.S. Pat. 3,046,996, July 31, 1962.

[21] Toulmin, H. A., Jr. (assigned to Commonwealth Engineering Co. of Ohio, Dayton, Ohio). Recovery of Fresh Water From Sea Water. U.S. Pat. 3,019,611, Feb. 6, 1962.

[22] Reitmeier, R. E. (assigned to Catalysts & Chemicals Inc., Louisville, Ky.). Preparation of Gel Extrudates. U.S. Pat. 3,020,243, Feb. 6, 1962.

[23] Ferrigno, T. H. (assigned to Minerals & Chemicals Philipp Corp., Menlo Park, N.J.). Mineral Filled Polyurethane Foams. U.S. Pat. 3,015,634, Jan. 2, 1962.

Ferrigno, T. H. Polyurethane Foams With Organophilic Kaolin Clay and Method for Making Same. U.S. Pat. 3,029,209, Apr. 10, 1962.

[24] Haden, W. L., Jr., and F. J. Dzierzanowski (assigned to Minerals & Chemicals Philipp Corp., Menlo Park, N.J.). Synthetic Crystalline Zeolite Produced From Dehydrated Aluminum Silicate. U.S. Pat. 3,065,054, Nov. 20, 1962.

[25] Wiley, R. M. (assigned to The Dow Chemical Co., Midland, Mich.). Canadian Pat. 637,703, Mar. 6, 1962.

[26] Loeffler, D. E. (assigned to Shell Oil Co., New York). Preparation of Clay Thickened Grease. U.S. Pat. 3,036,001, May 22, 1962.

Peterson, W. H. (assigned to Shell Oil Co., New York). Clay Grease Composition. U.S. Pat. 3,050,463, Aug. 21, 1962.

[27] Levy, E. (assigned to Midland-Ross Corp., Cleveland, Ohio). Treatment of Aqueous Suspensions. U.S. Pat. 3,046,233, July 24, 1962.

[28] Schaefer, B., R. Michels, K. Meyer, and H. Rausch (assigned to Metallgesellschaft A.G., Frankfurt on the Main, Germany). Method of Processing Sulphidic Concentrates. U.S. Pat. 3,027,251, Mar. 27, 1962.

[29] Dod, C. G. (assigned to The Pure Oil Co., Chicago, Ill.). Thermally Stable Attapulgite-Base Drilling Mud. U.S. Pat. 3,046,211, July 24, 1962.

Klaas, N. P., G. M. Ide, and K. E. Heidelberg (assigned to Minnesota Mining & Manufacturing Co., St. Paul, Minn.). Canadian Pat. 634,602, Jan. 16, 1962.

Mayhew, E. J. (assigned to Halliburton Co., Dallas, Tex.). Oil and Gas Well Cementing Compositions. U.S. Pat, 3,036,633, May 29, 1962.

[30] Kyte, J. R. (assigned to Jersey Production Research Co., subsidiary of Standard Oil of N.J., New York). Oil Displacement by Water Containing Suspended Clay. U.S. Pat. 3,051,234, Aug. 28, 1962.

[31] Larpenteur, B. J. (assigned to Bethlehem Steel Corp., Bethlehem). Agglomeration of Iron Ores. U.S. Pat. 3,053,647, Sept. 11, 1962.

[32] Barlow, T. E. (assigned to International Minerals & Chemical Corp., Chicago, Ill.). Foundry Sand Composition. U.S. Pat. 3,023,113, Feb. 27, 1962.

[33] Allegrini, A. P. (assigned to Minerals & Chemicals Philipp Corp., Menlo Park, N.J.). Method of Preparing Activated Attapulgite. U.S. Pat. 3,041,238, June 26, 1962.

[34] Allegrini, A. P. Method of Drying Attapulgite Clay Dispersions. U.S. Pat. 3,050,863, Aug. 28, 1962.

asphalt emulsions for fiber pipe,[35] for tar adsorbents in cigarettes,[36] for preparation of magnetic particles,[37] for water sealing slurries,[38] for gelling agents,[39] and for binding agents.[40]

Patents were obtained on an improved flexible-backed assembly of mosaic tile,[41] and on an improved sound-insulating clay tile.[42]

A number of improvements in equipment for forming and firing brick and other heavy clay products were patented.[43]

Processes for producing vitreous clay products,[44] and new bricks having the appearance of aged brick [45] were patented.

Some patents were issued for methods and apparatus for producing lightweight aggregate from clays and shales.[46]

A method of producing a load-bearing panel from expanded clay was patented.[47]

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[35] Drukker, J. J. (assigned to The Patent & Licensing Corp., New York). Coated Bituminized Fiber Pipe. U.S. Pat. 3,039,495, June 19, 1962.

[36] Allegrini, A. P. (assigned to Minerals & Chemicals Philipp Corp., Menlo Park, N.J.). Lightweight Adsorbent Clay Product and Method of Making Same. U.S. Pat. 3,049,449, Aug. 14, 1962.

[37] Schuele, W. J. (assigned to The Franklin Institute of the State of Pennsylvania, Philadelphia). Magnetic Particles and Method of Making Same. U.S. Pat. 3,042,543, July 3, 1962.

[38] Deming, J. M. (assigned to Monsanto Chemical Co., St. Louis, Mo.). Method of Treating Soil With Aqueous Slurry of Lattice Clay and Anionic Polyelectrolyte. U.S. Pat. 3,016,713, Jan. 16, 1963.

[39] Koenecke, D. F., and W. L. Van Nostrand, Jr. (assigned to Esso Research & Engineering Co., Delaware). Coating Compositions With Gelatin Agents Therein. U.S. Pat. 3,030,233, Apr. 17, 1962.

Sawyer, E. W., Jr. (assigned to Minerals & Chemicals Philipp Corp., Menlo Park, N.J.). Agent for Gelling Organic Liquids and Organic Liquids Gelled Therewith. U.S. Pat. 3,049,498, Aug. 18, 1962.

[40] Miericke, K. A. (assigned to National Lead Co., New York). Molding Sand. U.S. Pat. 3,027,265, Mar. 27, 1962.

[41] MacDonald, D. J., D. J. Barbour, and K. M. Claus (assigned to the Mosaic Tile Co., Zanesville, Ohio). Multiple Unit Ceramic Tile Assembly. U.S. Pat. 3,041,785, July 3, 1962.

[42] Toulmin, H. A., Jr. (assigned to Commonwealth Engineering Co. of Ohio, Dayton, Ohio). Sound Deadening Tile. U.S. Pat. 3,022,607, Feb. 27, 1962.

[43] Boyles, A. G. Gas-Fired Kiln. U.S. Pat. 3,023,478, Mar. 6, 1962.

Davis, E. E., and C. W. Taylor. Shuttle Car Kiln. U.S. Pat. 3,024,514, Mar. 13, 1962.

Donini, D. C. Apparatus for the Intermittent and Adjustable Feeding of Fuel Oil Burners for Brick Kilns. U.S. Pat. 3,021,890, Feb. 20, 1962.

Hanley, W. L. Cooling Section for Tunnel Kiln. U.S. Pat. 3,024,515, Mar. 13, 1962.

Schmunk, J. D., and H. E. Gilliland (assigned to The Hancock Brick & Tile Co., Findlay, Ohio). Tile Cutting Machine. U.S. Pat. 3,035,469, May 22, 1962.

[44] Felder, J. L. Method of Producing Vitreous Clay Products. U.S. Pat. 3,050,812, Aug. 28, 1962.

[45] Silva, T. C. Method of Manufacturing New Bricks Into Bricks Which Simulate Aged Brick. U.S. Pat. 3,043,040, July 10, 1962.

[46] Johnson, A. S., Jr. (assigned to Carolina Tuff-Lite Corp., Salisbury, N.C.). Methods and Apparatus for Heating Solid Particles. U.S. Pats. 3,030,089, and 3,030,090, Apr. 17, 1962.

Old, A. F. (assigned to Solite Corp., Richmond, Va.). Method and Apparatus for Production of Lightweight Aggregate From Dust. U.S. Pat. 3,039,165, June 19, 1962.

Pixley, F. V., G. W. Pixley, and H. Lopinot (assigned to Pelm Research & Development Corp., Newburg, N.Y.). Method for Forming Lightweight Aggregates. U.S. Pat. 3,037,940, June 5, 1962.

Sainty, C. L. (assigned to Structural Concrete Components Ltd., Hassocks, England). Manufacture of Pellets of Discrete Bodies Formed From Extruded Clay and Similar Materials. U.S. Pat. 3,036,333, June 29, 1962.

Sainty, C. L. Manufacture of Aggregate Suitable for Use in Concrete and Like Composite Materials. U.S. Pat. 3,042,388, July 3, 1962.

[47] Blaha, E. (assigned to Selas Corp., Dresher, Pa.). Manufacture of Uniform Cellular Ceramic Articles. U.S. Pat. 3,056,184, Oct. 2, 1962.

Cobalt

By Joseph H. Bilbrey, Jr.,[1] and Violet M. Clarke[2]

COBALT consumption of 11.3 million pounds by U.S. industry in 1962 set a new record, 5 percent higher than the previous record of 10.8 million pounds in 1952. Cobalt consumption was 17 percent greater than in 1961 because of increased demand for cobalt in high-temperature, high-strength alloys, permanent-magnet alloys, cemented carbides, and other products. Bethlehem Cornwall Corp. was the only domestic producer mining cobalt. Imports of cobalt increased from 10.5 to 12.4 million pounds. The Republic of the Congo, the largest supplier of cobalt to the United States, increased its production 16 percent.

TABLE 1.—Salient cobalt statistics

(Thousand pounds of contained cobalt)

	1953–57 (average)	1958	1959	1960	1961	1962
United States:						
Domestic mine production of ore or concentrate	2,711	4,844	2,994	(1)	(1)	(1)
Recoverable cobalt	2,004	4,023	2,331	(1)	(1)	(1)
Imports for consumption	17,158	15,149	21,245	12,170	10,495	12,433
Stocks, Dec. 31: Consumer	1,181	874	1,403	1,856	1,807	1,479
Consumption	9,310	7,542	9,899	8,930	9,596	11,268
Price: Metal per pound	$2.40–$2.00	$2.00	$2.00–$1.75	$1.75–$1.50	$1.50	$1.50
Free world: Production	[2] 28,400	[2] 27,800	[2] 32,600	[2] 31,600	[2] 30,000	32,000

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

DOMESTIC PRODUCTION

Bethlehem Cornwall Corp. was the only producer of cobalt concentrate. Production, from the corporation's magnetic iron ores at Cornwall and Morgantown, Pa., was slightly more than in 1961. Pyrites Co., Inc., Wilmington, Del., processed the concentrate into metal, oxide, and hydrate.

The Bunker Hill Co. recovered 118 tons of residues containing 8,590 pounds of cobalt at its Kellogg, Idaho, zinc plant. No shipments were made.

[1] Commodity specialist, assisted technically by Isaac E. Weber, Division of Minerals.
[2] Statistical clerk, Division of Minerals.

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Freeport Nickel Co. did not operate the refinery at Port Nickel, La., because suitable concentrate was not available.

Based on cobalt content, domestic production of cobalt oxide increased 5 percent over that of 1961. Hydrate production increased 43 percent, and salts, 31 percent.

TABLE 2.—Cobalt materials consumed by refiners or processors in the United States

(Thousand pounds of contained cobalt)

Form[1]	1953-57 (average)	1958	1959	1960	1961	1962
Alloy and concentrate	5,016	4,645	3,342	2,062	1,121	721
Metal	808	999	1,098	961	1,101	1,255
Hydrate	77	57	24	18	16	17
Carbonate			3	2		
Purchased scrap	117	250				
Other	57	56	55	28	33	52

[1] Total consumption is not shown because the metal, hydrate, and carbonate originated from alloy and concentrate.

TABLE 3.—Cobalt products[1] produced and shipped by refiners and processors in the United States

(Thousand pounds)

Product	1961				1962			
	Production		Shipments		Production		Shipments	
	Gross weight	Cobalt content	Gross weight	Cobalt content	Gross weight	Cobalt content	Gross weight	Cobalt content
Oxide	437	306	459	322	457	320	440	308
Hydrate	225	103	244	113	277	147	270	144
Salts:								
Acetate	284	59	309	65	301	72	241	58
Carbonate	282	129	311	142	381	177	336	157
Sulfate	383	88	399	91	502	112	361	82
Other	260	54	238	49	321	71	168	39
Driers	10,362	608	10,231	593	8,717	545	8,412	525
Total	12,233	1,347	12,191	1,375	10,956	1,444	10,228	1,313

[1] Figures on metal withheld to avoid disclosing individual company confidential data.

CONSUMPTION AND USES

Industrial demand for cobalt increased to 11.3 million pounds, 17 percent more than in 1961. Cobalt consumed for metallic uses rose 21 percent and for nonmetallic uses (exclusive of salts and driers), 14 percent. Consumption of cobalt for salts and other nonmetallic uses dropped 7 percent.

The largest single use of cobalt, 27 percent of the total and 28 percent more than in 1961, was for high-temperature, high-strength alloys. Permanent magnet alloys occupied second place with 25 percent of the total cobalt consumed, 17 percent more than in 1961.

TABLE 4.—Cobalt consumed in the United States, by uses

(Thousand pounds of contained cobalt)

Use	1953-57 (average)	1958	1959	1960	1961	1962
Metallic:						
High-speed steel	218	88	214	155	220	343
Other tool steel	131	100	619	53	44	64
Other alloy steel				574	540	546
Permanent magnet alloys	2,599	2,340	2,979	2,387	2,457	2,867
Cutting and wear-resisting materials	223	161	139	263	257	316
High-temperature, high-strength alloys	3,337	2,193	2,423	2,024	2,354	3,015
Alloy hard-facing rods and materials	537	361	404	447	550	650
Cemented carbides	267	148	339	320	298	610
Nonferrous alloys	250	252	654	107	145	128
Other				495	659	582
Total	7,562	5,643	7,771	6,825	7,524	9,121
Nonmetallic (exclusive of salts and driers):						
Ground-coat frit	469	457	543	465	526	533
Pigments	184	251	200	190	192	168
Other	115	161	254	278	314	474
Total	768	869	997	933	1,032	1,175
Salts and driers: Lacquers, varnishes, paints, inks, pigments, enamels, glazes, feed, electroplating, etc. (estimate)	980	1,030	1,131	1,172	1,040	972
Grand total	9,310	7,542	9,899	8,930	9,596	11,268

TABLE 5.—Cobalt consumed in the United States, by forms

(Thousand pounds of contained cobalt)

Form	1953-57 (average)	1958	1959	1960	1961	1962
Metal	6,884	5,403	7,630	6,761	7,478	9,091
Oxide	726	754	877	757	900	998
Purchased scrap	720	355	261	240	178	207
Salts and driers	980	1,030	1,131	1,172	1,040	972
Total	[1] 9,310	7,542	9,899	8,930	9,596	11,268

[1] Includes a small quantity of ore and alloy.

STOCKS

In addition to consumer stocks reported in table 1, 96,908,000 pounds of specification-grade cobalt was held in Government inventories of strategic materials as of December 31, 1962. This included 76,848,000 pounds in the national (strategic) stockpile, 18,983,000 pounds in Defense Production Act (DPA) inventory, and 1,077,000 pounds in the supplemental stockpile. Of the total, 77,908,000 pounds was declared surplus to the maximum objective of 19,000,000 pounds. An additional 6,211,000 pounds of cobalt in the DPA inventory did not meet stockpile specifications.

PRICES

The price of cobalt metal granules and regular fines, $1.50 per pound, f.o.b. carrier, port of New York, packed in 500-pound drums, remained unchanged through 1962. This also applied to the prices of ceramic-grade oxide (70 to 71 percent cobalt) at $1.12 a pound and ceramic-grade oxide (72.5 to 73.5 percent cobalt) at $1.15 a pound, east of the Mississippi River, f.o.b. shipping point, packed in 250-pound kegs, freight allowed. The prices of both grades of oxide were subject to a 1-percent discount.

FOREIGN TRADE [3]

Imports.—Cobalt imports of 12.4 million pounds exceeded consumption by 10 percent and exceeded 1961 imports by 18 percent. The Republic of the Congo continued to be the main supplier of cobalt, providing 40 percent of all imports. Belgium supplied 21 percent. The Belgian metal and oxide originated in the Republic of the Congo; therefore, 61 percent of U.S. imports came from the Congo. West Germany supplied 13 percent of the total; Norway, 10 percent; France, 6 percent; the Federation of Rhodesia and Nyasaland, 6 percent; and Canada, 4 percent.

TABLE 6.—U.S. imports for consumption of cobalt, by classes

(Thousand pounds and thousand dollars)

Year	White alloy [1]		Ores and concentrates [2]		Metal	
	Gross weight	Cobalt content	Gross weight	Cobalt content	Gross weight	Value
1953–57 (average)	4,590	2,013	138	15	[3,4] 14,668	[3,4] $34,504
1958	----------	----------	----------	----------	14,538	28,664
1959	----------	----------	[3] 772	[3] 35	20,087	35,926
1960	----------	----------	[3] 6,462	[3] 314	10,801	17,093
1961	----------	----------	----------	----------	10,036	14,867
1962	----------	----------	([3,5])	([3,5])	[3] 11,814	[3] 17,129

Year	Oxide		Salts and compounds		Total	
	Gross weight	Value	Gross weight	Value	Gross weight	Cobalt content (estimated)
1953–57 (average)	718	$1,152	350	$212	20,464	17,158
1958	837	1,116	234	145	15,609	15,149
1959	1,557	1,851	278	134	22,694	21,245
1960	1,459	1,520	230	104	18,952	12,170
1961	681	663	159	59	10,876	10,495
1962	978	943	120	47	12,912	12,433

[1] Reported by importer to Bureau of Mines, which adjusted the figures for "Ores and concentrates" for 1953–57, as reported by the Bureau of the Census, to exclude "white alloy" from the Republic of the Congo (Belgian Congo).
[2] Figures exclude receipts of "white alloy" from the Republic of the Congo (Belgian Congo).
[3] Adjusted by the Bureau of Mines.
[4] Includes scrap.
[5] Less than 1,000 pounds.

Source: Bureau of the Census.

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

TABLE 7.—U.S. imports for consumption of cobalt metal and oxide, by countries

(Thousand pounds)

Country	Metal		Oxide (gross weight)	
	1961	1962	1961	1962
North America: Canada	897	[1] 441		19
Europe:				
Belgium-Luxembourg	[2] 1,632	[1] 1,970	681	959
France	295	[1] 729		
Germany, West	1,394	1,586		
Netherlands	5	20		
Norway	547	1,237		
United Kingdom	27	69	(3)	(3)
Total	[2] 3,900	5,611	681	959
Asia: Japan		22		
Africa:				
Congo, Republic of the, and Ruanda-Urundi	[2] 5,039	[1] 5,014		
Rhodesia and Nyasaland, Federation of	200	[1] 726		
Total	[2] 5,239	5,740		
Grand total	10,036	[1] 11,814	681	978

[1] Adjusted by the Bureau of Mines.
[2] Revised figure
[3] Less than 1,000 pounds.

Source: Bureau of the Census.

Exports.—Exports of cobalt-bearing materials totaled 2,134,000 pounds, 4 percent less than in 1961. Scrap (5 percent or more cobalt) was the main cobalt-bearing item, and 197,800 pounds was in fabricated forms. The remainder was ore, concentrate, metal, and alloys in crude form. Shipments to Japan were 39 percent of the total; to the Republic of South Africa, 20 percent; to West Germany, 11 percent; to Italy, 6 percent; and to France and the United Kingdom, 5 percent each. No substantive change was made in the Positive List of cobalt commodities requiring validated export licenses, except that "Cobalt melting base materials" was added under Schedule B, No. 66429 on June 7, 1962.

Tariff.—Cobalt metal and ore entered the United States duty free, and the duty of 5 cents per pound on cobalt linoleate remained unchanged. Effective July 1, 1962, the duty was reduced on cobalt oxide to 2.7 cents per pound, and on sulfate, to 2 cents per pound; the duty on other salts and compounds was reduced to 13.5 percent ad valorem.

In response to Senate Resolution 206, 87th Congress, the U.S. Tariff Commission convened on May 15, 1962, to hold a public hearing to investigate conditions in the cobalt industry. No interested party appeared. The Commission made a report to the Congress on the cobalt industry; the report was based on information obtained from the Commission's files, from other Government agencies, from field work by members of the Commission's staff, and from questionnaires.[4]

[4] U.S. Tariff Commission. Cobalt. Report to the Congress on Investigation No. 332–42 (under Sec. 332 of the Tariff Act of 1930). Made pursuant to Senate Resolution 206, 87th Cong., adopted Sept. 23, 1961. TC Pub. 64, August 1962, 54 pp.

WORLD REVIEW

Free world production of cobalt increased 6 percent. The Republic of the Congo produced 68 percent of the total, 16 percent more than in 1961. Canada ranked second, producing 11 percent of the total, and Morocco produced 10 percent.

TABLE 8.—Free world production of cobalt, by countries [1] [2]

(Short tons of contained cobalt)

Country [1]	1953-57 (average)	1958	1959	1960	1961	1962
North America:						
Canada [3]	1,461	1,355	1,575	1,784	1,591	1,721
United States (recoverable cobalt)	1,002	2,012	1,165	(4)	(4)	(4)
Total	2,463	3,367	2,740	(4)	(4)	(4)
Africa:						
Congo, Republic of the (formerly Belgian) (recoverable cobalt)	9,404	7,166	9,294	9,063	9,178	10,615
Morocco: Southern zone (content of concentrate)	703	1,021	1,330	1,401	1,422	1,583
Rhodesia and Nyasaland, Federation of: Northern Rhodesia (content of white alloy, cathode metal, and other products)	1,134	1,792	2,270	2,036	1,701	948
Total	11,241	9,979	12,894	12,500	12,301	13,146
Oceania:						
Australia (recoverable cobalt in zinc concentrate)	13	17	16	15	15	[5] 13
New Caledonia (content of concentrate)		44	93			
Total	13	61	109	15	15	[5] 13
Free world total (estimate) [1] [2]	14,200	13,900	16,200	15,600	14,800	15,700

[1] Cobalt is also recovered, principally in West Germany, from pyrites produced in Finland, and estimates are included in the world total. Cobalt concentrates are being stockpiled in Uganda, but exact figures are not available.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Cobalt in all forms. Excludes the cobalt content of nickel oxide sinter shipped to the United Kingdom by International Nickel Co., Inc. (estimate for which is included in the world total), but includes the cobalt content of Falconbridge Nickel Mines, Ltd., shipments of nickel-copper matte to Norway.
[4] Figure withheld to avoid disclosing individual company confidential data; U.S. figure included in world total.
[5] Estimate.

Compiled by Catherine M. Judge, Division of Foreign Activities.

NORTH AMERICA

Canada.—Cobalt was obtained mainly as a byproduct of refining nickel-copper ores from the Sudbury district, Ontario, and Lynn Lake and Thompson, Manitoba. Canada produced 1,721 tons of cobalt, 8 percent more than in 1961. It was expected that Cobalt Refinery, Ltd., Cobalt, Ontario, would process concentrate from the silver-cobalt ores of the Cobalt-Gowganda area. Shipments of concentrate from this area through Temiskaming Testing Laboratories during 1962 were about 2 million pounds containing 143,000 pounds of cobalt.

The International Nickel Company of Canada, Ltd. (Inco), recovered electrolytic cobalt at its nickel refinery at Port Colborne, Ontario. Impure cobalt oxide was shipped from the refinery to Inco's Clydach, Wales, plant for conversion to high-grade oxide, metal, and salts. A new plant was constructed at Clydach for the recovery of cobalt from plant residues. Inco delivered 2.28 million pounds of cobalt, 9 percent less than in 1961.[5]

Falconbridge Nickel Mines Ltd., delivered 1,226,000 pounds of cobalt, 16 percent less than in 1961. The cobalt was recovered from Sudbury nickel-cobalt matte exported to the Falconbridge Nikkelverk, A/S, refinery at Kristiansand S., Norway.[6]

Sherritt Gordon Mines Ltd. produced a record 608,580 pounds of cobalt from Lynn Lake ore and purchased feed; this was about three times the 1961 production and almost double the previous high in 1959. The expanded cobalt circuit was in operation early in the year. Sherritt Gordon sold 352,568 pounds of cobalt, 62 percent more than in 1961.[7]

EUROPE

Germany, West.—The Duisburger Kupferhütte refinery at Duisburg, the major producer, recovered cobalt mainly from pyrite sinter imported from Finland and other European countries. The refinery of Gebrüder Borchers A. G. at Goslar treated cobalt-bearing alloy scrap and spent catalyst material and residues; it produced cobalt oxides, salts, and metal powder.

AFRICA

Congo, Republic of the (formerly Belgian).—Union Minière du Haut-Katanga produced 10,615 tons of cobalt, 68 percent of free world production and 16 percent more than in 1961. The company operated its plants most of the year in spite of difficult political conditions that existed in Katanga during 1962.

Morocco.—Société Minière de Bou-Azzer et du Graara produced about 15,800 tons of concentrate containing 1,583 tons of cobalt, 11 percent more than in 1961.

Rhodesia and Nyasaland, Federation of.—In the fiscal year ending June 30, 1962, Rhokana Corporation, Ltd., milled 5,323,000 tons of ore averaging 0.11 percent cobalt, 7 percent less than in fiscal year 1961. Cobalt concentrate produced from ores of the Mindola and Nkana mines was 36,239 tons containing 3.34 percent cobalt. Recovery was 955 tons, compared with 837 tons in fiscal year 1961. The efficiency of recovery increased from 54.4 percent in 1961 to 75.8 percent, owing to improvements in the circuit, more experience in operation, and higher grade concentrate feed. Nevertheless, for the greater part of the year, it was necessary to purchase metal from other sources to meet contractual commitments.[8]

During the fiscal year ending June 30, 1962, Chibuluma Mines Ltd. milled 501,140 tons of ore averaging 0.16 percent cobalt and produced 21,251 tons of copper-cobalt concentrate, which was converted to cobalt matte at the Ndola refinery. The matte was refined in

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[5] The International Nickel Company of Canada, Ltd. 1962 Annual Report. Pp. 9, 14.
[6] Falconbridge Nickel Mines, Ltd. 1962 Annual Report. P. 8.
[7] Sherritt Gordon Mines Ltd. Annual Report 1962. Pp. 3, 5.
[8] Rhokana Corporation, Ltd. Annual Report. June 30, 1962, pp. 8–15.

Belgium, and 738 tons of cobalt was returned, compared with 464 tons in fiscal year 1961. Production of cobalt matte at Ndola for refining overseas stopped in February 1962 so that a new improved process, scheduled to start in 1963, could be initiated. Consequently, Chibuluma did not expect to sell cobalt from mine production during fiscal year 1963. Combined ore reserves from Chibuluma and Chibuluma West ore bodies were estimated, as of June 30, 1962, at 10.2 million tons averaging 4.67 percent copper and 0.15 percent cobalt. During fiscal year 1962, Chibuluma Mines Ltd. repaid the final installment of £0.4 million on the loan made by the U.S. Government.[9]

TECHNOLOGY

Federal Bureau of Mines research dealt with the separation of nickel and cobalt and the recovery of these metals from lateritic ores. The separation processes included solvent extraction and molten-salt electrolysis. Electrochemical and chlorination methods for recovering nickel-cobalt alloys from high-temperature alloy scrap and rapid analytical methods to help in this development were being sought. The effect on physical properties and corrosion of substituting cobalt for nickel in some stainless steels was under investigation. Work proceeded on the vapor deposition of cobalt-tungsten alloys.

Published reports included a study of the feasibility of establishing a nickel industry in the Philippines and the recovery of cobalt from upgraded ferronickel;[10] information on the origin, collection, movement, and consumption of high-temperature alloy scrap in California and Nevada in 1959–60;[11] and a report of the chemistry and catalytic properties of cobalt carbonyls.[12]

A material survey on cobalt was published that included chapters on forms and uses, history, resources, world reserves, secondary resources, technology, supply and distribution, structure of the industry, research and development, and legislation and government programs.[13] A comprehensive account of the mineralogy of the nickel-copper ores of the Sudbury, Ontario, district was published. It included a number of tables on the nickel-cobalt content of the pyrrhotite and pentlandite deposits.[14] A field method for determining cobalt in soil and sediment samples, based on extracting a thiocyanate complex of cobalt with amyl alcohol, was described.[15]

Bethlehem Steel Co. announced that it would build a new plant to leach calcined pyrite ore from the sulfuric acid plant at Sparrows

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[9] Rhodesian Selection Trust, Ltd. Annual Report 1962. Pp. 26–28.

[10] Banning, L. H., W. E. Anable, R. B. Quicho, H. D. Hess, and P. C. Good. Metallurgical Investigations of Philippine Nickeliferous Ores. BuMines Rept. of Inv. 6063, 1962, 71 pp.

[11] Branner, G. C., and J. W. Padan. High-Temperature Alloy Scrap in California and Nevada. BuMines Open-File Report, 1962, 24 pp.

[12] Wender, I., H. W. Sternberg, R. A. Friedel, S. J. Metlin, and R. E. Markby. The Chemistry and Catalytic Properties of Cobalt and Iron Carbonyls. BuMines Bull. 600, 1962, 83 pp.

[13] Bilbrey, J. H., Jr. Cobalt. A Materials Survey. BuMines Inf. Circ. 8103, 1962, 140 pp.

[14] Hawley, J. E. The Sudbury Ores: Their Mineralogy and Origin. Mineralogical Association of Canada (Kingston, Ontario, Canada), 1962, 207 pp.

[15] Stanton, R. E., and A. J. McDonald. Field Determination of Cobalt in Soil and Sediment Samples. Bull. Inst. Min. and Met. (England), v. 71, No. 667, June 1962, pp. 511–516.

Point, Baltimore, Md., to produce a cobalt and copper solution and insoluble iron oxides. The liquid concentrate, containing an estimated 700,000 pounds of cobalt and 900,000 pounds of copper a year, will be shipped by tank truck to Pyrites Co., Inc., Wilmington, Del., for further processing.[16]

Sherritt Gordon Mines Ltd. planned to make pilot-plant studies on a process for recovering nickel and cobalt from lateritic ores and a process for recovering nickel and cobalt from high-temperature alloy scrap in 1963.[17]

Annual cobalt capacity reached 1 million pounds at the Norwegian Kristiansand nickel refinery of Falconbridge Nikkelverk, A/S, a subsidiary of Falconbridge Nickel Mines Ltd., Canada. Canadian converter matte containing 0.8 percent cobalt as well as nickel, copper, sulfur, and other elements was used as raw material. The process for the production of nickel and cobalt was described.[18]

Mining and metallurgical operations of Union Minière du Haut-Katanga in the Kolwezi area of Katanga Province were outlined. The Luilu electrolytic operations for the production of 4,000 tons per year of high-purity cobalt were described.[19]

The Defense Metals Information Center (DMIC), Battelle Memorial Institute, Columbus, Ohio, published a detailed report on the physical and chemical phenomena that affect the behavior of cobalt-base superalloys.[20] DMIC studies also included a compilation of tensile properties of high-strength alloys including cobalt-base superalloys.[21]

Martin Metals Co. (formerly Sierra Metals Corp.) began commercial production of SM302, a high-temperature, vacuum-melted, cast cobalt-base alloy that contains relatively high percentages of chromium, tungsten, and tantalum. It is used in the first turbine stage of modern turbojet engines. SM322, an improved cobalt-base alloy, was introduced for use as a turbine-blade and turbine-vane material. It contains less tungsten and tantalum than SM302, but more zirconium and titanium, and has greater high-temperature strength.[22]

Interest continued in 18-percent maraging alloy steels, developed by The International Nickel Co., Inc. The alloy with a yield strength of 250,000 pounds per square inch contains 7 percent cobalt, and the alloy with a yield strength of 300,000 pounds per square inch, 9 percent cobalt. The alloys showed great promise for aerospace and cryo-

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[16] Journal of Metals. Bethlehem Cobalt Concentrate. V. 14, No. 10, October 1962, p. 738.

[17] Sherritt Gordon Mines, Ltd. Annual Report 1962. P. 6.

[18] Archibald, F. R. The Kristiansand Nickel Refinery. J. Metals, v. 14, No. 9, September 1962. pp. 648–652.

[19] Saquet, J. J., V. Apraxine, J. Lakaye, and P. Troch. Kolwezi Mining and Metallurgical Operations of Union Minière du Haut Katanga. Min. Eng., v. 14, No. 12, December 1962, pp. 71–81.

[20] Wagner, H. J., and A. M. Hall. The Physical Metallurgy of Cobalt-Base Superalloys. DMIC Rept. 171, July 6, 1962, 84 pp.

[21] Campbell, J. E. Compilation of Tensile Properties of High-Strength Alloys. DMIC Memo 150, Apr. 23, 1962, table 12, pp. 29–33.

[22] Martin Metals Co. (a subsidiary of Martin Marietta Corp., Wheeling, Ill.). Brochure SM302, High Temperature Cobalt Base Superalloy, 11 pp.; Brochure SM322, High Temperature Cobalt Base Superalloy, Preliminary Technical Information, 11 pp.

genic applications, aircraft structural parts, and for pressure vessels. Commercial maraging steels were offered by many steel companies.[23]

Alloy AM-367, a new high-strength, precipitation-hardening stainless steel with good notch toughness was developed by Allegheny Ludlum Steel Corp. The nominal composition that gave the best combination of strength and toughness was 15.5 percent cobalt, 14 percent chromium, 3.5 percent nickel, 2.0 percent molybdenum, 0.5 percent titanium, and 0.03 percent carbon maximum.[24]

The Centre d'Information du Cobalt (Cobalt Information Center), Brussels, Belgium, published papers on the following: Production, uses, and properties of cobalt oxides and salts;[25] the improvement in strength and ductility of commercial Ti-6Al-4V alloy by additions of up to 4 percent cobalt;[26] and the development of permanent magnets in Japan, including research on various types of magnets.[27]

A new wrought, highly ductile, improved magnetic alloy, that contains 52 percent cobalt, 10 percent vanadium, and 38 percent iron was introduced by Westinghouse Electric Corp. under the name of Vicalloy. It can be fabricated into tape, wire, bar, and very thin sheet.[28]

Changes in hardness of various cobalt-base Stellite-type alloys were measured at increasing temperatures by a tungsten carbide indenter technique in a vacuum of 0.001 millimeter of mercury.[29]

A new radioactivity standard sample in solution form, cobalt-57 chloride, was announced for distribution by the National Bureau of Standards, Washington, D.C. Chemical-grade cobalt-57 chloride was offered by Abbott Laboratories, North Chicago, Ill. Gamma radiation emitted by cobalt 57 can be used for calibrating gamma-detecting systems. Cobalt 57 was used as a tracer in vitamin B-12 studies.[30]

Cobalt-platinum alloy magnets (23.2 percent cobalt and 76.8 percent platinum) were used in wristwatches.[31]

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[23] Decker, R. F., J. T. Eash, and A. J. Goldman. 18 Percent Nickel Maraging Steel. Trans. ASM, v. 55, No. 1, March 1962, pp. 58–76.
Drennen, D. C., and D. B. Roach. Properties of Maraging Steels. DMIC Memo 156, July 2, 1962, 51 pp.

[24] Hammond, C. M. AM-367—A New Precipitation-Hardening Stainless Steel. Metal Prog., v. 82, No. 6, December 1962, pp. 92–95.

[25] De Bie, E., and P. Doyen. Cobalt Oxides and Salts. Cobalt, No. 15, June 1962, pp. 3–13; No. 16, September 1962, pp. 3–15.

[26] Diderrich, E., and L. Habraken. Properties of Ti-6Al-4V Alloys With Additions of 2 and 4 Per Cent Cobalt. Cobalt, No. 16, September 1962, pp. 16–27.

[27] Makino, N. The Development of Permanent Magnets in Japan. Cobalt, No. 17, December 1962, pp. 3–10.

[28] Iron Age. Magnetic Alloy Shapes Easily. V. 190, No. 4, July 26, 1962, p. 74.

[29] Phelps, R. E. Hot Hardness Properties of Cobalt-Base Stellite Alloys. Metallurgia (England), v. 65, No. 391, May 1962, pp. 229–231.

[30] Chemical & Engineering News. Chemical Grade Cobalt-57 Is Now Being Produced and Marketed. V. 40, No. 3, Jan. 15, 1962, p. 43.
Technical News Bulletin, National Bureau of Standards. New and Reissued Radioactivity Standard Materials. V. 46, No. 6, June 1962, pp. 71–72.

[31] Walmer, M. S. Cobalt-Platinum—A Permanent Magnet Alloy. Englehard Industries, Inc., Tech. Bull., v. 2, No. 4, March 1962, pp. 117–121.

Patents were issued on the recovery of cobalt from ores,[32] on the separation of cobalt and nickel,[33] on various alloys,[34] on cobalt catalyst,[35] and on the use of a water-soluble cobalt salt to stabilize antibiotic bacitracin in storage.[36]

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[32] Illis, A. (assigned to The International Nickel Co., Inc., New York). Treatment of Lateritic Cobalt-Nickel Ores. U.S. Pat. 3,058,824, Oct. 16, 1962.

Kruse, J. M. (assigned to E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.). Treatment of Ore. U.S. Pat. 3,057,716, Oct. 9, 1962.

Sheer, C., and S. Korman (assigned to Sheer Korman Associates, Inc., New York). Beneficiation of Ores. U.S. Pat. 3,060,109, Oct. 23, 1962.

[33] Corbiau, P. (assigned to Société Générale Metallurgique de Hoboken, Hobokenlez-Anvers, Belgium). Separation of Nickel From Cobalt-Containing Solutions. U.S. Pat. 3,041,138, June 26, 1962.

Hard, R. A., and H. F. Kummerle (assigned to Union Carbide Corp.). Method of Separating Nickel and Cobalt Compounds and Producing Salts Therefrom. U.S. Pat. 3,069,231, Dec. 18, 1962.

[34] Burket, R. E., W. C. Coy, and L. E. Peterman (assigned to Allegheny Ludlum Steel Corp., Brackenbridge, Pa.). Processing Magnetic Material. U.S. Pat. 3,024,141, Mar. 6, 1962.

Cape, A. T. (assigned to Coast Metals, Inc., Little Ferry, N.J.). Hard Facing Alloys. U.S. Pat. 3,060,017, Oct. 23, 1962.

Hoppin, G. S., III (assigned to General Electric Co.). Cobalt Base Brazing Alloy. U.S. Pat. 3,028,235, Apr. 3, 1962.

Malerich, J. B., and R. F. Wilde (assigned to General Electric Co.). Nickel-Cobalt Base Alloys. U.S. Pat. 3,027,254, Mar. 27, 1962.

Simons, H. J. H. (assigned to Stamicarbon N.V., Heerlen, Netherlands). Process of Preparing Nickel-Aluminum or Cobalt-Aluminum Alloys Starting From Raney Catalysts. U.S. Pat. 3,036,909, May 29, 1962.

Wawrousek, H. W., and P. W. Neurath (assigned to General Electric Co.). Treatment of Iron-Cobalt Alloys. U.S. Pat. 3,065,118, Nov. 20, 1962.

[35] Dienes, E. K. (assigned to Catalysts and Chemicals, Inc., Louisville, Ky.). Preparation of Homogeneous Catalysts Containing Cobalt Oxide and Aluminum Oxide. U.S. Pat. 3,020,244, Feb. 6, 1962.

Melchiore, J. J. (assigned to Sun Oil Co., Philadelphia, Pa.). Cobalt Oxidation Catalyst. U.S. Pat. 3,055,839, Sept. 25, 1962.

Natta, G., L. Porri, and L. Fiore (assigned to Montecatini Societa Generale per L'Industria Mineraria e Chimica). Homogeneous Polymerization Catalysts Based on Cobalt, and Polymerization of Diolefins Therewith. U.S. Pat. 3,016,371, Jan. 9, 1962.

Reitmeier, R. E. (assigned to Catalysts and Chemicals, Inc., Louisville, Ky.). Preparation of Catalysts Containing Cobalt and Molybdenum Oxides. U.S. Pat. 3,020,245, Feb. 6, 1962.

[36] Zorn, R. A. (assigned to Grain Processing Corp., Muscatine, Iowa). Bacitracin Product and Processes Utilizing Cobalt Compounds. U.S. Pat. 3,021,217, Feb. 13, 1962.

Columbium and Tantalum

By F. W. Wessel[1] and Robert A. Whitman[2]

RESURGENCE of interest in research on both columbium and tantalum was notable in 1962. Research ranged from constructing a superconducting magnetic coil at minus 269° C to testing hot-strength of new alloys at 1,100° C.

The price of columbium remained firm in spite of a cutback in production.

LEGISLATION AND GOVERNMENT PROGRAMS

The sale of 18,900 tons of Malayan tin slag (containing 4.0 to 4.5 percent columbium oxide and 2.5 to 3.5 percent tantalum oxide) by the General Services Administration was completed in July, and the storage sites were vacated.

DOMESTIC PRODUCTION

There was no domestic mine production of columbium or tantalum ore in 1962.

Although interest was renewed in both metals, the production of columbium dropped to 64 tons, about 50 percent of the 1961 total. E. I. du Pont de Nemours & Co., Inc., Newport, Del., was the principal producer; others included Wah Chang Corp., Albany, Oreg.; Union Carbide Metals Co., Niagara Falls, N.Y.; Kawecki Chemical Co., Boyertown, Pa.; Stauffer Chemical Co., Richmond, Calif.; Fansteel Metallurgical Corp., North Chicago, Ill.; and Kennametal, Inc., Latrobe, Pa.

Production of tantalum metal was up from 1961 to 257 tons. Kawecki Chemical Co.; Fansteel Metallurgical Corp., Muskogee, Okla.; and National Research Corp., Newton, Mass., were the principal producers—others included Union Carbide Metals Co., Kennametal, Inc., and Wah Chang Corp.

New production facilities for columbium and tantalum were announced by Haynes Stellite Co., a division of Union Carbide Corp. These included melting and forging equipment to produce existing commercial forms and shapes. The Metals Division of Stauffer

[1] Project coordinator, Bureau of Mines, Pittsburgh, Pa.
[2] Commodity specialist, Division of Minerals.

TABLE 1.—Salient columbium-tantalum statistics

	1953–57 (Average)	1958	1959	1960	1961	1962
United States:						
Columbium-tantalum concentrate shipped from mines [1] ....pounds..	129,548	428,347	189,263	----------	----------	----------
Imports for consumption:						
Columbium-mineral concentrate...do....	5,930,198	2,555,942	3,395,816	[2] 5,051,800	[2] 2,777,700	5,050,888
Tantalum-mineral concentrate...do....	1,158,019	1,035,588	652,839	[2] 709,936	[2] 1,004,151	1,211,757
Industrial consumption:[3]						
Contained metal short tons..	[4] 623	593	828	1,058	1,283	1,895
World: Production of columbium-tantalum concentrates...pounds..	8,170,000	[2] 4,880,000	[2] 6,040,000	[2] 7,020,000	[2] 7,480,000	8,250,000

[1] 1956–59 data are for columbite-tantalite concentrate plus columbium-tantalum oxide content of euxenite concentrate.
[2] Revised figure.
[3] Includes metal content of all raw materials consumed, including columbium-tantalum bearing tin slag.
[4] Average for 1954–57.

Chemical Co. announced expansion of its capacity for production of high-purity ingots of columbium, tantalum, molybdenum, tungsten, and specialty alloys. Materials Research Corp., Orangeburg, N.J., produced ultrapure metals, including columbium and tantalum, by zone refining and formation of single crystals. Temescal Metallurgical Corp., Berkeley, Calif., announced availability of equipment not used before for primary production of columbium.

The Chemical and Metallurgical division of Fansteel Metallurgical Corp. established a warehouse offering off-the-shelf deliveries of tantalum, columbium, tungsten, molybdenum, and columbium alloy mill products.

Union Carbide Corp. announced plans to boost output of solid tantalum capacitors by 50 percent in its Kemet plant in Cleveland, Ohio.

Production of ferrocolumbium accounted for over 85 percent of the consumption of columbium. Its use increased over that of 1961. Vanadium Corporation of America, Cambridge, Ohio; Molybdenum Corporation of America, Pittsburgh, Pa.; Union Carbide Metals Co., Niagara Falls, N.Y.; and Shieldalloy Corp., Newfield, N.J., were the principal producers of ferrocolumbium. The production of ferro-tantalum-columbium increased slightly over 1961.

CONSUMPTION AND USES

Domestic consumption of columbium and tantalum raw materials in terms of metal content was 1,422 and 473 tons, respectively, distributed in percent as follows:

	Columbium	Tantalum
Source:		
Tantalite	5. 75	26. 70
Columbite	60. 61	40. 20
Pyrochlore	14. 96	0. 37
Tin Slag	13. 34	26. 01
Oxide Residue	5. 34	6. 72
	100. 00	100. 00
Use:		
Powder	6. 13	15. 83
Ingot	4. 44	37. 31
Ferroalloy	85. 55	4. 66
Carbide	1. 81	6. 43
Other	2. 07	35. 77
	100. 00	100. 00

Columbium continued to be used in various ways in the generation of nuclear energy. The Nuclear Division, The Martin Co., conducted extensive tests to obtain engineering data on the use of a columbium-based alloy, possibly columbium-1-percent zirconium as a construction material to contain liquid lithium. This loop will permit operation of the reactor at 1,000 to 1,165° C. The SNAP–50 (Systems for Nuclear Auxiliary Power) reactors will utilize these materials. Columbium-based alloys were also developed to clad uranium carbide fuel elements. Tube hollows from columbium and columbium alloys, which may be converted to finished tubes of various sizes, were commercially available.

Research and pilot development of superconducting magnets continued; columbium-zirconium alloy wire for this purpose became commercially available. Westinghouse Electric Corp. marketed a cryogenic magnet consisting of a coil of this alloy capable of developing a field of 50 kilogauss at minus 269° C. Columbium-containing steel spring wire that resists attack by sulfuric acid and other corrosive liquids also was available.

Columbium continued to be considered for use in high-quality capacitors; the high-leakage rate may be due to trace impurities, thus ultrapure columbium may have electrical properties equal to those of tantalum. Capacitor-grade tantalum wire was marketed in standard diameters of 0.010 inch to 0.100 inch.

The first year of trouble-free service was completed for a 15-mile natural-gas pipeline laid in Oklahoma in 1961. Its success was attributed to its being constructed of light-walled columbium steel. Panhandle Eastern Pipeline Co., having completed similar in-use testing, announced plans to build a 406-mile gasline in the Midwest. Such steels had been used principally in pipe, tanks, and pressure vessels. During 1962, however, they became of interest also for structural members of heavy machinery.

With developmental assistance from Fansteel Metallurgical Corp., R. S. Corcoran Co. marketed an all-tantalum pump of 100 gallons per minute capacity for corrosive fluids. Tantalum also was used in bayonet heaters.

The National Bureau of Standards developed a tube furnace to operate at temperatures as high as 2,200° C. The heating element of the furnace is a 1-inch tantalum tube with a wall thickness of 0.020 inch.

Further expansion in the use of tantalum in capacitors was reported during 1962.

Westinghouse scientists announced the start of production of a new tantalum-based alloy, T–111, with excellent cold workability and hot-temperature strength.

Columbium pentachloride and tantalum pentachloride became available in commercial quantities at an increase in purity up to 99.95 percent.

STOCKS

The national (strategic) stockpile at yearend comprised 14,624,121 pounds of columbium contained in ore of specification grade and 1,476,412 pounds in nonspecification-grade ore. There was 3,011,776 pounds of tantalum in specification-grade ore, and 1,950,505 pounds of tantalum in nonspecification-grade ore. There also was 588,798 pounds of columbium and tantalum in ferroalloys.

Consumers and dealers at yearend held the following inventories (in short tons): Columbite, 1,164; tantalite, 1,057; tin slag, 6,291; and pyrochlore, 315.

There were also the following columbium inventories: Primary metal, 54,384 pounds; ingot, 48,996 pounds; scrap, 99,079 pounds; and oxide, 245,874 pounds. Tantalum inventories included: Primary metal, 27,565 pounds; ingot, 34,428 pounds; scrap, 105,761 pounds; oxide, 64,759 pounds; and potassium tantalum fluoride, 210,239 pounds.

PRICES AND SPECIFICATIONS

Columbite prices at yearend ranged from $0.90 to $1.00 per pound of contained pentoxides for the 10:1 ratio material and $0.85 to $0.90 for the 8.5:1 ratio concentrate, c.i.f., U.S. ports. Pyrochlore sold during most of the year at $0.95 per pound of contained columbium pentoxide. The price of tantalite declined steadily to the $5 to $6 range, where it remained during the last half.

Similar prices were quoted in London: At the yearend, 65-percent, 10:1 ratio columbite was quoted at 135s. to 145s. per long ton unit, and 60-percent tantalite at 880s. to 1,040s. The high for the year, 1,600s. to 1,750s., was quoted early in April.

Ferrocolumbium and ferrotantalum-columbium prices closed at $3.40 and $3.00, respectively, per pound of contained columbium.

In January, the price of commercial grade tantalum powder rose to $31.65 per pound; the price of oxide, to $18; and the price of carbide, to $22. Foil and sheet prices also increased according to the following schedule:

Thickness, inch:	Price, dollars per pound	Increase, dollars per pound
0.0005	55.60	1.30
.010	52.90	1.84
.050	50.40	2.87
.125	48.30	3.42

TABLE 2.—Average grade of concentrate received by U.S. consumers and dealers in 1962, by country of origin

(Percent of contained pentoxides)

Country	Columbite			Tantalite	
	Cb_2O_5	Ta_2O_5	Ratio	Ta_2O_5	Cb_2O_5
Brazil	40	30	1.33:1	42	25
Canada [1]	53	0.37			
Congo, Republic of the	49	22	2.2:1	35	34
Malaya, Federation of	54	15	3.6:1	40	27
Mozambique	35	28	1.25:1	48	21
Nigeria	65	6	10.8:1	31	43
Norway [1]	59	0.42			
Portugal and Spain	36	35	1:1	31	33
Rhodesia and Nyasaland, Federation of	38	33	1.2:1	48	15

[1] Pyrochlore concentrate.

Electronic grade foil prices declined slightly at this time; foil with maximum direct-current leakage of 0.5, 1.25, and 3.0 microamperes per square inch sold at $128.70, $91.90, and $89.60 per pound, respectively.

Factors causing upward pressure on metal prices included increased demand for electronic, electrical, and alloy-base forms, and ore price increases since early 1961.

FOREIGN TRADE[3]

Imports.—In addition to raw material imports shown in tables 3 and 4, 2,875 pounds of columbium metal, valued at $47,233, was imported, principally from West Germany.

Imports of tin slag during 1962 were reported at 4,367 short tons, exclusive of the national stockpile material referred to previously. Of this total, 2,095 tons came from Malaya; 1,936 tons, from Nigeria; 320 tons, from the United Kingdom (presumably from Nigerian ores); and 16 tons, from Portugal.

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

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TABLE 3.—U.S. imports for consumption of columbium-mineral concentrates by countries

(Pounds)

Country	1953-57 (average)	1958	1959	1960	1961	1962
North America: Canada	-----	-----	14,000	-----	35,575	1,509,928
South America:						
Argentina	4,365	2,262	3,591	-----	-----	-----
Bolivia	3,976	-----	-----	-----	-----	-----
Brazil	121,365	101,992	137,648	126,374	73,363	95,767
British Guiana	1,871	-----	-----	-----	-----	-----
Total	131,577	104,254	141,239	126,374	73,363	95,767
Europe:						
Belgium-Luxembourg	-----	-----	-----	-----	-----	32,549
Germany, West	223,784	46,628	11,578	6,283	-----	2,204
Netherlands	-----	-----	13,000	35,554	-----	28,926
Norway	340,632	310,858	454,535	164,486	-----	662,498
Portugal	97,838	65,461	38,083	35,383	22,457	42,565
Spain	1,387	-----	-----	976	-----	-----
Sweden	3,342	-----	-----	-----	-----	-----
United Kingdom	8,164	-----	-----	22,400	-----	56,002
Total	675,147	422,947	517,196	265,082	22,457	824,744
Asia:						
Aden	270	-----	-----	-----	-----	-----
Korea, Republic of	400	-----	-----	-----	-----	-----
Malaya, Federation of } Singapore, Colony of }	289,429					
Malaya, Federation of		709,077	151,881	249,946	221,161	119,882
Singapore, Colony of		-----	-----	-----	7,298	-----
Thailand	-----	-----	13,546	-----	-----	-----
Total	290,099	709,077	165,427	249,946	228,459	119,882
Africa:						
British East Africa	13,503	5,771	2,205	11,670	29,971	-----
British West Africa	2,904	-----	-----	-----	-----	-----
Congo, Republic of the, and Ruanda-Urundi [1]	893,975	507,725	519,712	227,724	113,085	55,846
Malagasy Republic [2]	12,234	9,920	11,939	17,412	6,524	7,536
Mozambique	55,719	171,164	85,249	75,851	60,613	25,453
Nigeria, Federation of [3]	3,776,053	543,925	1,936,296	4,071,115	2,181,318	2,388,377
Rhodesia and Nyasaland, Federation of	10,486	-----	-----	1,983	20,700	7,137
South Africa, Republic of [4]	43,138	81,159	-----	4,643	2,240	4,974
Western Equatorial Africa, not elsewhere classified [5]	940	-----	-----	-----	-----	11,244
Total	4,808,952	1,319,664	2,555,401	4,410,398	2,414,451	2,500,567
Oceania: Australia	24,423	-----	2,553	-----	3,395	-----
Grand total:						
Pounds	5,930,198	2,555,942	3,395,816	5,051,800	2,777,700	5,050,888
Value	$10,483,760	$2,345,890	$2,651,783	$3,686,549	$2,305,941	$3,404,858

[1] Effective July 1, 1960; formerly Belgian Congo.
[2] Effective July 1, 1960; formerly Madagascar and Dependencies.
[3] Effective Jan. 1, 1962; formerly Nigeria.
[4] Effective Jan. 1, 1962; formerly Union of South Africa.
[5] Effective July 1, 1960; formerly French Equatorial Africa.

Source: Bureau of the Census.

TABLE 4.—U.S. imports for consumption of tantalum-mineral concentrates by countries

(Pounds)

Country	1953-57 (average)	1958	1959	1960	1961	1962
South America:						
Argentina	2,205	11,635	1,611	-----------	4,444	3,637
Brazil	172,551	159,015	205,898	182,118	159,925	194,955
French Guiana	15,297	-----------	-----------	-----------	-----------	-----------
Total	190,053	170,650	207,509	182,118	164,369	198,592
Europe:						
Belgium-Luxembourg	1,278	10,681	21,871	2,426	47,993	31,896
Germany, West	131,379	135,431	-----------	-----------	-----------	11,276
Netherlands	-----------	-----------	-----------	8,012	26,495	-----------
Norway	2,346	-----------	-----------	-----------	-----------	-----------
Portugal	52,047	32,513	27,227	34,062	29,793	95,692
Spain	2,255	-----------	-----------	3,157	11,148	2,645
Sweden	4,699	992	-----------	-----------	-----------	-----------
United Kingdom [1]	5,707	-----------	-----------	-----------	-----------	-----------
Total	199,711	179,617	49,098	47,657	115,429	141,509
Asia:						
Japan	-----------	-----------	-----------	-----------	-----------	4,401
Malaya, Federation of } Singapore, Colony of }	2,194	6,000	-----------	14,714	82,807	57,437
Singapore, Colony of			-----------	-----------	-----------	-----------
Thailand	-----------	-----------	4,515	-----------	-----------	5,941
Total	2,194	6,000	4,515	14,714	82,807	67,779
Africa:						
British East Africa	2,543	2,034	2,690	-----------	36,182	9,911
Congo, Republic of the, and Ruanda-Urundi [2]	582,255	370,120	166,317	332,424	164,277	228,185
Malagasy Republic [3]	8,773	7,716	9,375	30,738	11,953	12,126
Mozambique	19,306	149,777	68,343	87,801	219,847	351,087
Nigeria, Federation of [4]	80,340	34,537	50,902	7,698	121,110	48,551
Rhodesia and Nyasaland, Federation of	18,515	77,667	44,720	-----------	53,098	98,716
South Africa, Republic of [5]	6,873	27,368	24,805	2,239	31,677	8,733
Western Equatorial Africa not elsewhere classified [6]	-----------	-----------	-----------	-----------	-----------	26,455
Western Portuguese Africa, not elsewhere classified	-----------	-----------	-----------	-----------	-----------	3,490
Total	718,605	669,219	367,152	460,900	638,144	787,254
Oceania: Australia	47,456	10,102	24,565	4,547	3,402	16,623
Grand total:						
Pounds	1,158,019	1,035,588	652,839	709,936	1,004,151	1,211,757
Value	$2,030,213	$1,838,338	$1,165,536	$1,136,868	$2,001,944	$3,526,948

[1] Presumably country of transshipment rather than original source.
[2] Effective July 1, 1960; formerly Belgian Congo.
[3] Effective July 1, 1960; formerly Madagascar and Dependencies.
[4] Effective Jan. 1, 1962; formerly Nigeria.
[5] Effective Jan. 1, 1962; formerly Union of South Africa.
[6] Effective July 1, 1960; formerly French Equatorial Africa.

Source: Bureau of the Census.

TABLE 5.—U.S. exports of columbium and tantalum, by classes, in 1962

Class	Pounds	Value
Columbium ores and concentrates	21,330	$13,196
Tantalum ores and concentrates	[1] 36,322	[1] 139,503
Metals and alloys in crude form, and scrap	[1] 23,673	[1] 236,413
Metals and alloys in semifabricated forms	11,088	603,458
Tantalum metal powder	[1] 7,445	[1] 352,562

[1] Adjusted by Bureau of Mines.

Source: Bureau of the Census.

Exports.—Columbium ore was shipped to Japan and the United Kingdom; tantalum ore went mostly to Japan. Tantalum powder was exported principally to Japan, various countries in western Europe, and Canada. Most of the crude and semifabricated metal was shipped to the United Kingdom, West Germany, Japan, and Canada.

WORLD REVIEW

NORTH AMERICA

Canada.—About 80 percent of the pyrochlore concentrate produced at the St. Lawrence Columbium and Metals Corp. plant at Oka, Quebec, was marketed in the United States, presumably for ferrocolumbium production. In October a second pit was opened, and production was increased to about 1,000 tons of ore per day, containing 0.44 percent columbium pentoxide (Cb_2O_5). Mill capacity was expanded accordingly.

During the first half of 1962, Columbium Mining Products, Ltd., obtained assurance of additional financing. Construction of a 500-ton-per-day capacity mill was planned that would permit production of 1.4 million pounds of columbium pentoxide annually.

SOUTH AMERICA

Brazil.—The Comissao Nacional de Energia Nuclear (CNEN) suspended the exportation of pyrochlore concentrate made by Distribuidora e Exportadora de Mineiros e Adubos, S.A. (DEMA) at Araxá, Minas Gerais. Negotiations were underway between DEMA, a Brazilian corporation in which Wah Chang Corp. and Molybdenum Corporation of America had a joint interest, and CNEN; meanwhile, 1,600 tons of 50-plus percent columbium pentoxide concentrate was stockpiled ready for export.

EUROPE

Belgium.—Construction of a fabricating facility at Hoboken by Refractory Metals Fansteel-Hoboken, S.A., a joint venture of Société Générale Metallurgique de Hoboken and Fansteel Metallurgical Corp., was scheduled to initiate production of tantalum and columbium in the various forms required by the European market by mid-1963. The new company was to sell Fansteel products in Europe until the fabricating plant was in operation.

Netherlands.—N. V. Kawecki-Billiton Metaalindustrie was formed as a joint enterprise of N. V. Billiton Maatschappij and Kawecki Chemical Co. to build a plant at Arnhem for the manufacture of tantalum and columbium sheet and foil and tantalum anodes. The new company also planned to sell other rare metals produced by the parent companies.

Norway.—Pyrochlore operations at the Government-owned mines at Søve, Telemark, were conducted at a financial loss, owing to the price decline of columbium ores over the past 2 years. A mine closure, which is probable, will affect U.S. supply.

TABLE 6.—Free world production of columbium and tantalum concentrates[1] by countries[2]

(Pounds)

<table>
<tr><th rowspan="2">Country</th><th colspan="2">1953-57 (average)</th><th colspan="2">1958</th><th colspan="2">1959</th><th colspan="2">1960</th><th colspan="2">1961</th><th colspan="2">1962</th></tr>
<tr><th>Columbium</th><th>Tantalum</th><th>Columbium</th><th>Tantalum</th><th>Columbium</th><th>Tantalum</th><th>Columbium</th><th>Tantalum</th><th>Columbium</th><th>Tantalum</th><th>Columbium</th><th>Tantalum</th></tr>
<tr><td>North America:</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Canada</td><td colspan="2">[3] 86</td><td>----</td><td>----</td><td>[4] 14,000</td><td>----</td><td>----</td><td>----</td><td>62,229</td><td>----</td><td>967,000</td><td>----</td></tr>
<tr><td>United States (mine shipments)</td><td colspan="2">129,548</td><td colspan="2">428,347</td><td colspan="2">189,263</td><td>----</td><td>----</td><td>----</td><td>----</td><td>----</td><td>----</td></tr>
<tr><td>South America:</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Argentina</td><td colspan="2">1,300</td><td>[4] 2,262</td><td>[4] 11,635</td><td>[4] 3,591</td><td>[4] 1,611</td><td>----</td><td>----</td><td>----</td><td>[4] 4,444</td><td>----</td><td>[4] 3,637</td></tr>
<tr><td>Brazil (exports)</td><td>163,231</td><td>137,576</td><td>158,513</td><td>213,114</td><td>33,459</td><td>207,232</td><td>26,460</td><td>257,951</td><td>38,477</td><td>264,519</td><td>37,500</td><td>321,900</td></tr>
<tr><td>French Guiana</td><td colspan="2">16,490</td><td>----</td><td>----</td><td>----</td><td>----</td><td>----</td><td>----</td><td>----</td><td>----</td><td>----</td><td>----</td></tr>
<tr><td>Europe:</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Norway</td><td>421,480</td><td>----</td><td>629.634</td><td>----</td><td>639,114</td><td>----</td><td>762,792</td><td>----</td><td>708,118</td><td>----</td><td>[4] 662,498</td><td>----</td></tr>
<tr><td>Portugal (U.S. imports)</td><td>97,838</td><td>52,047</td><td>65,461</td><td>32,513</td><td>38,083</td><td>27,227</td><td>35,383</td><td>34,062</td><td>22,457</td><td>29,793</td><td>33,818</td><td>104,439</td></tr>
<tr><td>Spain (U.S. imports)</td><td>1,387</td><td>2,255</td><td>----</td><td>----</td><td>----</td><td>----</td><td>976</td><td>3,157</td><td>----</td><td>11,148</td><td>----</td><td>2,645</td></tr>
<tr><td>Sweden (U.S. imports)</td><td>3,343</td><td>4,699</td><td>----</td><td>992</td><td>----</td><td>----</td><td>----</td><td>----</td><td>----</td><td>----</td><td>----</td><td>----</td></tr>
<tr><td>Asia: Malaya, Federation of</td><td>366,195</td><td>----</td><td>356,160</td><td>----</td><td>268,800</td><td>----</td><td>208,320</td><td>----</td><td>212,800</td><td>----</td><td>246,400</td><td>----</td></tr>
<tr><td>Africa:</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Congo, Republic of the (formerly Belgian) and Ruanda-Urundi [5]</td><td colspan="2">803,356</td><td colspan="2">553,355</td><td colspan="2">522,490</td><td>[4] 227,724</td><td>[4] 332,424</td><td>[4] 113,085</td><td>[4] 164,277</td><td>[4] 97,294</td><td>[4] 186,737</td></tr>
<tr><td>Malagasy Republic</td><td colspan="2">24,471</td><td colspan="2">28,880</td><td colspan="2">22,100</td><td colspan="2">22,300</td><td colspan="2">46,750</td><td>[4] 7,586</td><td>[4] 12,126</td></tr>
<tr><td>Mozambique</td><td colspan="2">116,026</td><td colspan="2">378,916</td><td colspan="2">320,004</td><td colspan="2">335,487</td><td colspan="2">303,166</td><td colspan="2">220,460</td></tr>
<tr><td>Nigeria, Federation of</td><td>5,620,608</td><td>26,432</td><td>1,803,200</td><td>49,930</td><td>3,559,875</td><td>31,114</td><td>4,587,520</td><td>24,640</td><td>5,257,280</td><td>26,230</td><td>5,066,880</td><td>38,013</td></tr>
<tr><td>Rhodesia and Nyasaland, Federation of</td><td>8,248</td><td>30,710</td><td>----</td><td>96,260</td><td>----</td><td>116,820</td><td>----</td><td>108,080</td><td>----</td><td>138,380</td><td>----</td><td>159,820</td></tr>
<tr><td>Sierra Leone</td><td>[6] 8,960</td><td>----</td><td>----</td><td>----</td><td>----</td><td>----</td><td>----</td><td>----</td><td>----</td><td>----</td><td>----</td><td>----</td></tr>
<tr><td>South Africa, Republic of</td><td>----</td><td>22,576</td><td>----</td><td>37,920</td><td>----</td><td>11,500</td><td>----</td><td>14,000</td><td>----</td><td>20,000</td><td>----</td><td>8,000</td></tr>
<tr><td>South-West Africa</td><td colspan="2">18,503</td><td>4,152</td><td>6,574</td><td>2,610</td><td>1,539</td><td>2,899</td><td>7,491</td><td>670</td><td>5,790</td><td>1,116</td><td>10,444</td></tr>
<tr><td>Uganda [7]</td><td colspan="2">17,642</td><td colspan="2">6,384</td><td colspan="2">5,264</td><td colspan="2">5,226</td><td colspan="2">16,240</td><td colspan="2">28,851</td></tr>
<tr><td>Oceania: Australia</td><td colspan="2">74,545</td><td colspan="2">13,507</td><td colspan="2">18,950</td><td colspan="2">23,677</td><td colspan="2">31,808</td><td colspan="2">[8] 35,000</td></tr>
<tr><td>Free world total (estimate)[2]</td><td colspan="2">8,170,000</td><td colspan="2">4,880,000</td><td colspan="2">6,040,000</td><td colspan="2">7,020,000</td><td colspan="2">7,480,000</td><td colspan="2">8,250,000</td></tr>
</table>

[1] Frequently composition (Cb_2O_5-Ta_2O_5) of this concentrate is intermediate, neither Cb_2O_5 nor Ta_2O_5 being strongly predominant. In such cases production figure has been centered.

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

[3] Average annual production, 1955–57.

[4] U.S. imports.

[5] In addition, tin-columbium-tantalum concentrate was produced as follows: 1953–57 (average), 5,172,873 pounds; 1958, 3,196,670 pounds; 1959, 2,773,387 pounds; 1960, estimated 1,500,000 pounds; 1961 and 1962 not available; 1962, columbium-tantalum content averaging about 10 percent.

[6] Average annual production, 1954–57.

[7] In addition, tin-columbium-tantalum concentrate was produced as follows: 1953–55 (average), 3,905 pounds; no further production recorded.

[8] Estimate.

Compiled by Kathleen W. McNulty and Berenice B. Mitchell.

Portugal.—Some decline in production of tantalite concentrate was attributed to a water shortage. Ore was stockpiled as mined pending more favorable conditions.

Accumulations of tin slag from several hundred years of small smelting operations were relocated, and exploitation begun. The slags reportedly contained up to 20 percent tantalum pentoxide.

ASIA

Japan.—Imports of tantalum for the Japanese electronics industry were resumed in 1962. Japanese producers were believed to be capable of producing electronic-grade tantalum; consequently, for several months during 1961, imports of the metal did not receive official sanction. Import of the metal was to continue until local producers could meet quality specifications.

AFRICA

Mozambique.—A new operation of Metallium Corp. produced columbite of about 3:1 ratio at the rate of 120,000 pounds annually.

Nigeria.—In October the Nigerian Government liberalized the requirements for licensing columbite and tantalite exports.[4] One condition removed was a requirement designed to prevent reshipment by the declared country of destination to a third country unacceptable to Nigerian authorities.

The Nigerian Embel tin smelter, which began operating in April 1961, was shut down during most of 1962. Smelting continued at the Makeri plant.

Rhodesia and Nyasaland, Federation of.—Tantalite, cassiterite, and beryl were recovered from detrital material along the Gwaai River above Kamativi.

Tanganyika.—Development of the pyrochlore deposit at Mbeya continued. The work included pilot plant beneficiation studies that proved more difficult than expected.

Uganda.—Construction of a mine and mill to produce 150,000 pounds of pyrochlore concentrate annually began at Sukulu Mines; apatite was to be a coproduct.

OCEANIA

Australia.—Tantalite was shipped from mines in Western Australia and New South Wales during 1962 at an increased rate. Producing districts included Yalgoo, Pilbarra, West Pilbarra, Gascoyne, and Greenbushes.

TECHNOLOGY

An excellent summary of the geology, mining, and marketing of tantalite in Rhodesia was published.[5] At Oka, Quebec, the columbium

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[4] Bureau of Mines. Mineral Trade Notes. V. 56, No. 2, February 1963, pp. 7–8.

[5] Lunzer, J. L. Tantalum on the Market. Chamber of Mines J. (Salisbury), v. 4, No. 2, February 1962, pp. 32–33.

Martin, H. J. Tantalum and Niobium in Southern Rhodesia. Chamber of Mines J. (Salisbury), v. 4, No. 2, February 1962, pp. 29–31.

Southern Rhodesia Chamber of Mines. Tantalite/Microlite Mining Operations. Chamber of Mines J. (Salisbury), v. 4, No. 2, February 1962, pp. 34–36.

content of pyrochlore was found to vary inversely with the radioactivity.[6]

A summary of progress in the application of refractory metals compared the properties of columbium, tungsten, and molybdenum for various uses and briefly described the more promising new alloys.[7]

Research teams in the United Kingdom produced complex salts of columbium and tantalum using both benzine derivatives and aliphatic amines.[8] A study of the separation of columbium and tantalum pentachlorides by distillation showed the necessity of complete oxygen removal, and described methods for accomplishing it.[9]

Addition of calcium fluoride to chlorination charges permitted low-temperature (500° C) chlorination of such materials as tin slags, and also was useful in separating columbium and tantalum chlorides.[10] Columbium and tantalum were reduced from their chlorides by sodium or magnesium.[11]

Many research results in the field of physical metallurgy were published. Of particular importance were studies of the tantalum-zirconium alloy system,[12] the columbium-molybdenum-vanadium system,[13] and of the tantalum-hydrogen and tantalum-sulfur systems. The effect of grain size on the properties of tantalum and the tantalum-10-percent tungsten alloy were studied and elongation curves prepared.[14] Some properties of Cb-752, a columbium-10-percent tungsten-2.5-percent zirconium alloy, were determined at elevated temperatures.[15]

The use[16] of various columbium-based alloys with hafnium and with vanadium was evaluated at elevated temperatures.

The preparation and fabrication of superconductive alloys was an important field of study. Publications showed the columbium-tin phase diagram, determined the useful temperature range for the favored columbium-tin and columbium-zirconium compounds, and discussed the many columbium-tin compounds which appear in the

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[6] Nickel, E. H. Compositional Variations in Pyrochlore and Niobian Perovskite From a Niobium Deposit in the Oka District of Quebec. Dept. Mines & Tech. Surveys (Ottawa) Tech. Bull. 31, February 1962, 35 pp.

[7] Peckner, D. Refractory Metals Roundup. Mat. in Design Eng., v. 56, No. 4, October 1962, pp. 131–146.

[8] Carnell, P. J. H., and G. W. A. Fowles. The Reaction of Niobium and Tantalum Halides With Aliphatic Amines. J. Less-Common Metals, v. 4, No. 1, February 1962, pp. 40–45.

Fairbrother, F., N. Ahmed, K. Edgar, and A. Thompson. Complexes of Niobium and Tantalum Hydroxides With Di-ols. J. Less-Common Metals, v. 4, No. 5, October 1962, pp. 466–475.

[9] Niselson, L. A. (Separation and Purification of Tantalum and Niobium by Distillation of Their Pentachlorides.) J. Inorg. Chem. (USSR), v. 3, No. 12, 1958, pp. 2603–2617.

[10] Henderson, A. W., and F. E. Block. Calcium Fluoride Additions to Chlorination Reactions. BuMines Rept. of Inv. 5919, 1962, 19 pp.

[11] Campbell, T. F., F. E. Block, G. B. Robidart, and J. L. Schaller. Preparation of Columbium and Tantalum by Metallic Reduction of Their Chlorides. BuMines Rept. of Inv. 6080, 1962, 20 pp.

[12] Williams, D. E., R. J. Jackson, and W. L. Larsen. The Tantalum-Zirconium Alloy System. AIME Met. Soc. Trans., v. 224, No. 4, August 1962, pp. 751–756.

[13] Baron, V. V., K. N. Ivanova, and E. M. Savitsky. (Structure Diagram and Some Properties of Alloys of the System Niobium-Molybdenum-Vanadium.) Izvest. Akad. Nauk (SSSR), No. 4, 1960, pp. 143–149.

[14] Tedmon, C. S., and D. P. Ferriss. The Dependence of Yield Stress on Grain Size for Tantalum and a 10 Pct W–90 Pct Ta Alloy. AIME Met. Soc. Trans., v. 224, No. 5, October 1962, pp. 1079–1080.

[15] Iron Age. Columbium Alloy Resists Heat. V. 190, No. 19, Nov. 8, 1962, pp. 108–109.

[16] Babitzke, H. R., G. Asai, and H. Kato. Columbium-Vanadium Binary Alloys for High-Temperature Service. BuMines Rept. of Inv. 5987, 1962, 19 pp.

Babitzke, H. R., G. Asai, and H. Kato. Columbium-Hafnium Binary Alloys for Elevated Temperature Service. BuMines Rept. of Inv. 6101, 1962, 17 pp.

preparation of columbium-tin (Nb_3Sn).[17] A general discussion of cryogenic electromagnets summarized the state of superconductivity from its inception in 1911.[18]

Tests on columbium capacitors, previously demonstrated to be satisfactory at loads up to 20 volts, showed that at 35 volts initial capacitance depends upon the particle-size distribution of the columbium powder, whereas leakage depends upon the purity of the powder.[19] The cause and effect of voltages generated within tantalum capacitors were measured and discussed.[20] Wet units generate an electromagnetic force as a wet cell, whereas in dry units the electromagnetic force is thermally generated.

Nickel-chromium alloys may be hardened with a few percent columbium, in place of titanium or aluminum, to avoid formation of oxide films.[21]

Recalculation of the tolerance level of tantalum in reactor-grade stainless steel resulted in the conclusion that the maximum of 10 parts per million could be safely increased to 100 or possibly 1,000 parts per million.

By adding columbium costing 1 or 2 cents per pound of hot-rolled sheet, the effective thickness of low-carbon steels could be decreased for a net cost reduction of 20 to 30 percent.[22] Maximum thickness was limited to three-eighths-inch by transition temperatures.

Small columbium additions to type 410 stainless steel increased the tensile strength and greatly increased the impact properties.[23]

Studies of high-temperature corrosion of columbium and tantalum were in progress, and the effects of oxygen, nitrogen, and hydrogen were reported.[24]

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[17] Babiskin, J., and P. G. Siebenmann. Critical Transition Properties of Nb_3Sn and Nb-25% Zr. Rept. of NRL Progress PB 181071, April 1962, pp. 1–4.
Metal Industry (London). Niobium-Tin Alloys. V. 101, No. 21, Nov. 22, 1962, p. 339.
Wyman, L. L., J. R. Cuthill, G. A. Moore, J. J. Park, and H. Yakowitz. Intermediate Phases in Superconducting Niobium-Tin Alloys. J. Res., (U.S. Dept. Commerce), v. 66A No. 4, July–August 1962, pp. 351–358.

[18] Kunzler, J. E., and M. Tanenbaum. Superconducting Magnets. Sci. Am., v. 206, No. 6, June 1962, pp. 60–67.

[19] Ling, H. W., and T. L. Kolski. Niobium Solid Electrolyte Capacitors. J. Electrochem. Soc., v. 109, No. 1, January 1962, pp. 69–70.

[20] Law, J. M., and W. C. Richards. Cell and Thermoelectric Effects of Tantalum Electrolytic Capacitors. J. Electrochem. Soc., v. 109, No. 3, March 1962, pp. 215–221.

[21] Haynes, F. G. The Use of Niobium in the Development of Air-Cast Nickel-Chromium Alloys for High-Temperature Service. J. Inst. Metals (London), v. 90, pt. 8, April 1962, pp. 311–320.

[22] Peckner, D. Stronger Carbon Steels. Mat. in Design Eng. v. 55, No. 6, June 1952, pp. 99–102.
VanVoris, F. E. What Columbium Does to Carbon Steel. Metal Prog., v. 82, No. 2, August 1962, pp. 84–87.

[23] Steel. Stainless Steel Properties Bettered With Columbium. V. 151, No. 10, Sept. 3, 1962, pp. 90, 92.

[24] Evans, P. R. V. The Effect of Nitrogen on the Yield Strength of Niobium. J. Less-Common Metals, v. 4, No. 1, February 1962, pp. 78–91.
Kofstad, Per. Oxidation of Tantalum in the Temperature Range 500–700° C. J. Inst. Metals (London), v. 90, pt. 7, March 1962, pp. 253–264.
Mallett, M. W., and B. G. Koehl. Kinetics of the Tantalum-Hydrogen Reaction. J. Electrochem. Soc., v. 109, No. 10, October 1962, pp. 968–972.
Norman, N. Metallic Oxide Phases of Niobium and Tantalum: I. X-Ray Investigations. J. Less-Common Metals, v. 4, No. 1, February 1962, pp. 52–61.
Norman, N., P. Kofstad, and J. O. Krudtaa. Metallic Oxide Phases of Niobium and Tantalum: II. Metallographic Studies. J. Less-Common Metals, v. 4, No. 2, April 1962, pp. 124–137.
Ong, J. N., Jr. Oxidation of Refractory Metals as a Function of Pressure, Temperature, and Time: Tantalum in Oxygen. AIME Met. Soc. Trans., v. 224, No. 5, October 1962, pp. 991–998.

Sputtered tantalum films were found to be less subject to oxidation than bulk tantalum,[25] and could be stabilized by minor nitriding.[26] The U.S. Naval Research Laboratory continued its study of zinc as a protective coating for columbium.[27] The coating was self-repairing. Small additions of nickel and aluminum to the zinc protective coating for columbium doubled the life of the coating. Intermetallic compounds (aluminum- or silicon-based) also were tested as protective coatings for columbium and columbium-based alloys D14, D31, F48, FS82, and FS85. Tantalum and tantalum-based alloys were similarly protected from oxidation by spray coating with a tin-aluminum alloy.

Alloys for high-temperature service developed during 1962 are listed in table 7.

TABLE 7.—Columbium and tantalum alloys developed in 1962

Developed by	Designation	Composition, percent						
		Cb	Ta	Zr	Hf	W	Mo	V
Battelle Memorial Institute			85					15
Do			90				10	
Do			80		20			
E. I. du Pont de Nemours and Co., Inc	X110	89		1		10		
General Electric Co	AS55	94		1		5		
Stauffer Chemical Co	SM278	X	X				X	
Wah Chang Corp	C129	80			10	10		

Ceramic research on columbium oxide as a constituent of dielectric bodies was conducted.[28] The value of tantalum boride as a refractory material also was reported.[29]

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[25] Basseches, H. The oxidation of Sputtered Tantalum Films. J. Electrochem. Soc., v. 109. No. 6, June 1962, pp. 475–479.

[26] Bell Laboratories Record. Tantalum-Sputtered Resistors Improved by Adding Nitrogen. V. 40, No. 6, June 1962, p. 219.

[27] Brown, B. F., R. A. Meussner, R. J. Goode, A. J. Pollard, G. Sandoz, T. C. Lupton, R. L. Newbegin, R. J. Hicks, J. A. Smith, S. W. Strauss, and J. Stoop. Protection of Refractory Metals for High-Temperature Service. NRL Rept. 5550, Nov. 28, 1960, 37 pp; rept. of NRL Progress. PB 181072, July 1962, pp. 36–38.

[28] Ibrahim, M., and N. F. H. Bright. The Binary System $Nb_2O_5SiO_2$. J. Am. Ceram. Soc., v. 45, No. 5, May 1962. pp. 221–222.

Ibrahim, M., N. F. H. Bright, and J. F. Rowland. The Binary System CaO-Nb_2O_5. J. Am. Ceram. Soc., v. 45, No. 7, July 1962, pp. 329–334.

Jaeger, R. E., and L. Egerton. Hot Pressing of Potassium-Sodium Niobates. J. Am. Ceram. Soc., v. 45, No. 5, May 1962, pp. 209–213.

Müller, E. K., and B. J. Nicholoson. Concerning the Phase Diagram and Dielectric Behavior of the Oxide System Al_2O_5-Nb_2O_5. J. Am. Ceram. Soc., v. 45, No. 5, May 1962, pp. 250–251.

Subbarao, E. C., and J. Hrizo. Solid Solutions Based on Ferroelectric $PbNb_2O_6$. J. Am. Ceram. Soc., v. 45, No. 11, November 1962, pp. 528–531.

[29] Jankins, I. L., and N. J. Keen. The Use of Tantalum Borides for the Containment of Molten Uranium and Calcium. J. Less-Common Metals, v. 4, No. 4, August 1962, pp. 387–389.

Leitnaker, J. M., and M. G. Bowman. Thermodynamic Properties of the Tantalum and Tungsten Borides. J. Electrochem. Soc., v. 109, No. 5, May 1962, pp. 441–442.

Copper

By F. L. Wideman,[1] Gertrude N. Greenspoon,[2] and Wilma F. Washington [2]

Contents

RATES of copper production, which began to accelerate in late 1961, continued to rise through the first 6 months of 1962. Supplies began to exceed requirements, and in mid-July producers here and abroad inaugurated curtailments in output or sales. Nevertheless, record highs were established in U.S. and world mine production and in domestic smelter and refinery outputs from primary materials. The price of electrolytic copper in the United States, established at 31 cents per pound on May 19, 1961, was unchanged throughout 1962, and the price on the London Metal Exchange was fairly stable at 29.25 cents.

U.S. consumption of refined copper rose from a monthly average of 133,300 tons in 1961 to 145,300 tons in March 1962. Use of copper averaged 134,000 tons per month in January to June, but dropped to 93,100 tons in July, with the result that fabricators consumed an average of 125,600 tons per month in the last 6 months. Consumption during 1962 rose 9 percent to the highest on record. Despite the record consumption and production curtailments, producers' inventories of refined copper turned upward from July through December except for September, and at the yearend were 45 percent more than at the end of 1961.

Imports of unmanufactured copper rose 5 percent because a 48-percent increase in the refined-copper class more than offset decreases of 2 percent in receipts of blister copper and 8 percent in the other unrefined classes. Exports of refined copper, the chief export class, decreased 22 percent.

Despite work stoppages and production cutbacks, world mine production rose to the highest ever achieved. Increases of 5 percent in the United States, 6 percent in Canada, and 6 percent in Chile enabled those countries to establish new records. Output declined 16 percent in Peru and 2 percent in Northern Rhodesia.

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LEGISLATION AND GOVERNMENT PROGRAMS

Through the Office of Minerals Exploration, the Government participated with private industry to the extent of taking 50 percent of the financial risk in exploratory ventures judged capable of increasing the Nation's resources for selected mineral commodities. Until July 1, 1962, when copper was removed from the list of materials eligible for such assistance, three contracts were executed:

Name:	*Total cost*
R. V. Lloyd, Custer County, Idaho	$64,350
Henry Clay Mines, Hidalgo County, N. Mex.	30,570
Paymaster Mines, Inc., Okanogan County, Wash.	64,910

The 1.7-cent-per-pound excise tax on copper imports effective July 1, 1958, was unchanged.

TABLE 1.—Salient copper statistics

	1953–57 (average)	1958	1959	1960	1961	1962
United States:						
Ore produced [1] thousand short tons	113,752	114,824	103,716	134,994	142,722	150,217
Average yield of copper percent	0.81	0.79	0.74	0.73	0.75	0.75
Primary (new) copper produced						
From domestic ores, as reported by—						
Mines short tons	990,301	979,329	824,846	1,080,169	1,165,155	1,228,421
Value thousands	$672,493	$515,127	$506,455	$693,468	$699,093	$756,707
Smelters short tons	996,744	992,918	799,329	1,142,848	1,162,480	1,282,126
Percent of world total	27	25	19	23	23	24
Refineries short tons	980,430	1,001,645	796,452	1,121,286	1,181,015	1,214,146
From foreign ores, matte, etc., refinery reports short tons	368,431	350,875	301,795	397,641	369,124	397,584
Total new refined, domestic and foreign short tons	1,348,861	1,352,520	1,098,247	1,518,927	1,550,139	1,611,730
Secondary copper recovered from old scrap only short tons	452,804	411,367	471,007	429,365	411,110	415,674
Imports, general:						
Unmanufactured [2] do	610,964	496,301	570,891	524,344	457,669	478,851
Refined do	209,113	128,464	214,058	142,709	66,855	98,820
Exports:						
Metallic copper [3] do	290,379	[4] 428,015	[4] 196,012	[4] 510,494	[4] [5] 482,824	[4] 366,585
Refined do	218,896	384,868	158,938	433,762	[5] 428,718	336,525
Stocks Dec. 31: Producers:						
Refined short tons	59,000	48,000	18,000	98,000	49,000	71,000
Blister and materials in solution short tons	230,000	257,000	253,000	261,000	236,000	246,000
Total do	289,000	305,000	271,000	359,000	285,000	317,000
Withdrawals (apparent) from total supply on domestic account:						
Primary copper short tons	1,322,000	1,157,000	1,183,000	1,148,000	[5] 1,237,000	1,352,000
Primary and old copper (old scrap only) short tons	1,775,000	1,568,000	1,654,000	1,577,000	[5] 1,648,000	1,768,000
Price: Average cents per pound [6]	33.6	26.3	30.7	32.1	30.0	30.8
World:						
Production:						
Mine short tons	3,460,000	3,780,000	4,030,000	4,640,000	[5] 4,840,000	5,050,000
Smelter do	3,650,000	[5] 3,970,000	4,190,000	[5] 4,990,000	[5] 5,090,000	5,300,000
Price: London, average cents per pound	[7] 28.68	24.79	29.80	30.81	28.73	29.33

[1] Includes old tailings smelted or retreated. 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] Total exports of copper, exclusive of ore, concentrates, composition metal, and unrefined copper. Exclusive also of "Other manufactures of copper."
[4] Beginning Jan. 1, 1958, copper rods not separately classified; included in "Other copper manufactures."
[5] Revised figure.
[6] Exclusive of copper produced abroad and delivered in the United States.
[7] Average for 1954–57.

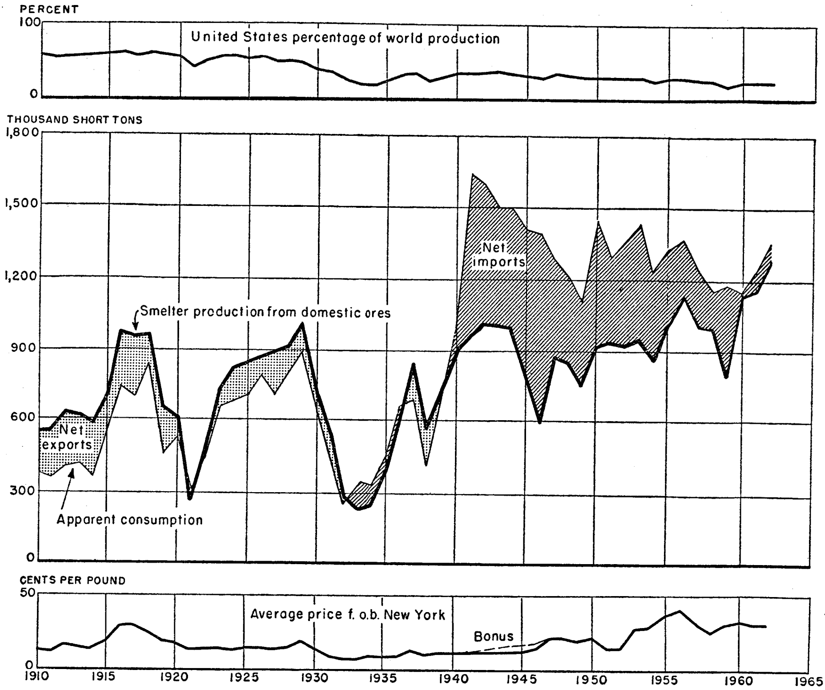

Figure 1.—Production, consumption, and price of copper in the United States, 1910–62.

DOMESTIC PRODUCTION

PRIMARY COPPER

By midyear, supplies of copper began to exceed requirements and a number of producers moved to curtail production. On July 11, Phelps Dodge Corp. announced a 6-percent reduction and on September 7 a further cutback was reported; both cutbacks were equivalent to a 10-percent reduction below pre-July levels. The Anaconda Company began a 5-percent curtailment on July 12 at U.S. and Chilean properties, and on July 16 a 9-percent cut was introduced by Inspiration Consolidated Copper Co. Kennecott Copper Corp. announced 10-percent reductions effective September 9 at its Nevada and New Mexico properties, September 10 at the Utah mine, and September 16 at the Arizona mine. Curtailment also went into effect at the company's Chilean properties.

Mine Production.—Production of copper at U.S. mines increased 5 percent to 1,228,400 tons, a new record. The upward trend, which had begun in the fourth quarter of 1961, continued through the second half of 1962. Output averaged 106,700 tons monthly from January to June but fell to 91,700 tons in the next 3 months; the decline was largely the result of vacations at many of the principal producing properties and of the closure of The Anaconda Company Montana open-pit and underground mines on July 16 and 23, respectively. Operations were resumed at the Butte mines on August 2 and at the Berkeley pit on September 21. In the last quarter, U.S. output averaged 104,200 tons monthly.

Arizona supplied 52 percent of the U.S. total and continued to lead all States by a wide margin. Production rose 10 percent over that in 1961 to a new record. The Mission project, 15 miles southwest of Tucson, completed its first full year of operation, and the Christmas mine, Gila County, began production in August. A description of operations of the Christmas mine was published.[3]

Utah maintained its rank as the second largest copper producing State; output rose 2 percent, and the State accounted for 18 percent of the total U.S. production. Montana ranked third with 8 percent of the U.S. total but produced 10 percent less than in 1961. New Mexico and Nevada were in fourth and fifth places, respectively, and each supplied 7 percent of the total U.S. output. New Mexico output, increasing 4 percent over 1961 production, exceeded the previous record of 1942 by 3 percent. Output in Nevada rose 6 percent. Michigan, ranking sixth, produced 6 percent of the total, and 5 percent more than in 1961. Output in Tennessee rose 17 percent to establish a new record.

Classification of production by method showed that approximately 75 percent of the recoverable copper and 81 percent of the copper ores came from open pits. Most domestic ore was treated by flotation at or near the mine, and the resulting concentrate was shipped for smelting. Some copper ores were direct-smelted either because of their high grade or because of their fluxing qualities.

For many decades copper had been produced domestically from mine waters and leach liquors by precipitation with iron. The first total domestic production was reported in 1921 when 8,200 tons of copper was produced by this method. Production by the cementation process gradually grew to 10,200 tons in 1928, thereafter it declined to 3,600 tons in 1934. From 1938 to 1957, production by precipitation rose steadily from 23,000 tons to 85,100 tons and then accelerated to 109,200 tons in 1962. This was 13 percent more than in 1961 and 6 percent above the former peak of 103,300 tons in 1960. Copper produced by precipitation in 1962 was 9 percent of the mine production, a slight increase over the average of the previous 5 years.

In 1962, 159,600 short tons of iron was consumed by precipitating copper. Iron used in the process was detinned tinplate scrap, tin cans, scrap and sponge iron.

The first 5 mines in table 6 produced 48 percent of the total U.S. copper production, the first 10 produced 74 percent, and the entire 25 furnished 97 percent.

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[3] Knoerr, Al, and Mike Eigo. Arizona's Newest Copper Producer—The Christmas Mine. Eng. and Min. J., v. 164, No. 1, January 1963, pp. 55–67.

TABLE 2.—Copper produced from domestic ores, by sources

(Short tons)

Year	Mine	Smelter	Refinery	Year	Mine	Smelter	Refinery
1958	979,329	992,918	1,001,645	1961	1,165,155	1,162,480	1,181,015
1959	824,846	799,329	796,452	1962	1,228,421	1,282,126	1,214,146
1960	1,080,169	1,142,848	1,121,286				

TABLE 3.—Copper ore and recoverable copper produced, by mining methods

(Percent)

Year	Open pit		Underground		Year	Open pit		Underground	
	Ore	Copper	Ore	Copper		Ore	Copper	Ore	Copper
1945	68	61	32	39	1954	83	79	17	21
1946	66	58	34	42	1955	83	77	17	23
1947	73	68	27	32	1956	78	73	22	27
1948	76	68	24	32	1957	77	72	23	28
1949	78	70	22	30	1958	76	71	24	29
1950	81	74	19	26	1959	79	74	21	26
1951	84	74	16	26	1960	80	75	20	25
1952	85	77	15	23	1961	80	74	20	26
1953	83	75	17	25	1962	81	75	19	25

TABLE 4.—Mine production of recoverable copper in the United States in 1962, by months[1]

Month	Short tons	Month	Short tons
January	103,789	August	93,702
February	101,296	September	90,098
March	109,478	October	106,150
April	109,406	November	104,955
May	113,782	December	101,629
June	102,725		
July	91,411	Total	1,228,421

[1] Monthly figures adjusted to final annual mine-production total.

TABLE 5.—Mine production of recoverable copper in the United States, with production of maximum year, and cumulative production from earliest record to end of 1962, by States

(Short tons)

State	Maximum production [1]		Production by years						Total production from earliest record through 1962
	Year	Quantity	1953–57 (average)	1958	1959	1960	1961	1962	
Alabama	1907	42							64
Alaska	1916	59,927	1	5	36	41	92		686,084
Arizona	1962	644,242	449,464	485,839	430,297	538,605	587,053	644,242	18,426,686
California	1909	28,644	632	749	663	1,087	1,382	1,162	639,932
Colorado	1938	14,171	4,226	4,193	2,940	3,247	4,141	4,534	307,706
Georgia	1917	465							1,117
Idaho	1958	9,846	5,630	9,846	8,713	4,208	4,328	3,861	179,075
Maine	1918	383							(2)
Maryland	1917	146							(2)
Massachusetts	1906	5							(2)
Michigan	1916	136,846	43,537	58,005	55,300	56,385	70,245	74,099	5,494,959
Missouri	1949	3,670	1,903	1,429	1,065	1,087	1,479	2,752	[3] 52,785
Montana	1916	176,464	81,289	90,683	65,911	91,972	104,000	94,021	7,777,981
Nevada	1942	83,663	73,913	66,137	57,375	77,485	78,022	82,602	2,813,338
New Hampshire	1908	[4] 94							(2)
New Mexico	1962	82,683	68,254	55,540	39,688	67,288	79,606	82,683	2,422,523
North Carolina	1930	6,695		(5)	(5)	(5)	(5)	(5)	61,561
Oregon	1916	1,791	10	10		6	(5)	(5)	(6)
Pennsylvania [7]	1942	6,410	4,405	8,073	6,604	7,907	8,934	6,108	(2)
South Carolina	1938	4							10
South Dakota	1918	32				1			107
Tennessee	1962	14,298	9,413	9,109	11,490	12,723	12,272	14,298	533,378
Texas	1928	224							1,384
Utah	1943	323,989	240,548	189,184	144,715	218,049	213,534	218,018	8,610,077
Vermont	1954	4,352	3,882	475					(2)
Virginia	1944	291							(2)
Washington	1940	9,612	3,192	52	49	78	66	41	121,855
Wisconsin	1914	5							(2)
Wyoming	1900	2,102	2	(8)			1		16,336
Total	1962	1,228,421	990,301	979,329	824,846	1,080,169	1,165,155	1,228,421	[9] 48,404,846

1 For Missouri and States east of the Mississippi River, maximum since 1905.
2 Data not available.
3 Small quantity for Wisconsin included with Missouri.
4 The 1908 volume of Mineral Resources credits this figure to Massachusetts and New Hampshire; the 1909 volume credits it to New Hampshire alone.
5 Included with Pennsylvania to avoid disclosing operations of individual companies.
6 Figure withheld to avoid disclosing individual company confidential data.
7 Includes North Carolina for 1956–62 and Oregon for 1961–62 to avoid disclosing operations of individual companies.
8 Less than 1 ton.
9 Largely smelter production for States east of the Mississippi River except Michigan; includes 257,888 tons for States indicated by footnote 2.

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TABLE 6.—Twenty-five leading copper-producing mines in the United States in 1962, in order of output

Rank	Mine	District or region	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 Company	Copper, silver-zinc ores.
4	San Manuel	Old Hat	Arizona	Magma Copper Co.	Copper ore.
5	Chino	Central	New Mexico	Kennecott Copper Corp.	Do.
6	Copper Queen—Lavender Pit	Warren (Bisbee)	Arizona	Phelps Dodge Corp.	Do.
7	New Cornelia	Ajo	do	do	Copper, gold-silver ores.
8	Ray Pit	Mineral Creek (Ray)	do	Kennecott Copper Corp.	Copper ore.
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 Company	Do.
12	Liberty Pit	Robinson (Ely)	do	Kennecott Copper Corp.	Do.
13	Mission	Pima	Arizona	American Smelting and Refining Co.	Do.
14	Esperanza	do	do	Duval Sulphur & Potash Co.	Do.
15	Silver Bell	Silver Bell	do	American Smelting and Refining Co.	Do.
16	Copper Cities	Globe-Miami	do	Tennessee Corp.	Do.
17	Pima	Pima	do	Pima Mining Co.	Do.
18	Magma	Pioneer (Superior)	do	Magma Copper Co.	Copper, gold-silver ores.
19	Copperhill	Polk County	Tennessee	Tennessee Copper Co.	Copper-zinc ore.
20	Calumet & Hecla, Inc.	Lake Superior	Michigan	Calumet & Hecla, Inc.	Copper ore and tailings.
21	Bagdad	Eureka (Bagdad)	Arizona	Bagdad Copper Corp.	Copper ore.
22	Miami	Globe-Miami	do	Tennessee Corp.	Copper precipitates.
23	Palo Verde	Pima	do	Banner Mining Co.	Copper ore.
24	Daisy	do	do	Pima Mining Co.	Do.
25	Ore Knob	Ashe County	North Carolina	Appalachian Sulfides, Inc.	Do.

TABLE 7.—Copper ore sold or treated in the United States in 1962, 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	78,868,147	1,200,945,700	0.76	117,362	4,571,370	$0.11
California	7,250	355,100	2.45	1,390	12,674	8.61
Colorado	24,909	1,786,100	3.59	4,733	602,287	32.89
Idaho	17,224	812,200	2.36	285	11,622	1.31
Michigan [2]	9,367,887	148,198,000	.79	------	401,491	.05
Montana	10,742,516	181,139,400	.84	15,034	2,506,824	.30
Nevada	12,991,011	165,173,100	.64	38,748	177,264	.12
New Mexico	7,323,561	107,821,000	.74	6,084	125,076	.05
North Carolina	222,914	7,214,000	1.62	416	5,894	.09
Tennessee [3]	1,469,500	28,596,000	.97	158	112,251	.09
Utah	29,181,415	397,275,300	.68	298,988	2,417,670	.45
Washington	376	10,100	1.34	45	99	4.47
Total [4]	150,216,710	2,239,326,000	.75	483,243	10,944,522	.19

[1] Excludes copper recovered from precipitates as follows: Arizona, 73,215,900 pounds; Montana, 4,813,600 pounds; New Mexico, 56,182,000 pounds; Utah, 32,692,400 pounds. Also excludes some copper recovered from precipitates in California; figures withheld to avoid disclosing individual company operations.
[2] Includes tailings.
[3] Copper-zinc ore.
[4] Excludes small quantities for Oregon. Bureau of Mines not at liberty to publish.

TABLE 8.—Copper ore concentrated in the United States in 1962, with content in terms of recoverable copper

State	Ore concentrated (short tons)	Recoverable copper content	
		Pounds	Percent
Arizona	[1] 78,436,884	[2] 1,107,547,800	0.71
California	6,700	333,000	2.49
Idaho	15,890	526,700	1.66
Michigan [3]	9,367,887	148,198,000	.79
Montana	10,742,316	181,120,400	.84
Nevada	[4] 8,876,658	[5] 112,242,000	.63
New Mexico	[6] 7,259,273	[7] 107,550,600	.74
North Carolina	222,914	7,214,000	1.62
Tennessee [8]	1,469,500	28,596,000	.97
Utah	29,181,300	397,266,700	.68
Washington	376	10,100	1.34
Total [9]	145,579,698	2,090,605,300	.72

[1] Includes 5,098,895 tons treated by both leaching and concentration.
[2] In addition 40,702,415 pounds of copper was recovered by leaching.
[3] Includes tailings.
[4] In addition 4,028,143 tons was treated by leaching.
[5] In addition 51,419,500 pounds of copper was recovered by leaching.
[6] In addition 10,000 tons was treated by heap leaching.
[7] In addition 123,500 pounds of copper was recovered by heap leaching.
[8] Copper-zinc ore.
[9] Excludes Colorado. Bureau of Mines not at liberty to publish.

TABLE 9.—Copper ore shipped to smelters in the United States in 1962, with content in terms of recoverable copper

State	Ore shipped to smelters		
	Short tons	Recoverable copper content	
		Pounds	Percent
Arizona	431,263	35,140,500	4.07
California	550	22,100	2.01
Colorado	24,559	1,778,700	3.62
Idaho	1,334	285,500	10.70
Montana	200	19,000	4.75
Nevada	86,210	1,511,600	.88
New Mexico	[1] 54,288	146,900	.14
Utah	115	8,600	3.74
Total [2]	598,519	38,912,900	3.25

[1] Primarily smelter fluxing material.
[2] Excludes small quantities for Oregon. Bureau of Mines not at liberty to publish.

TABLE 10.—Copper ores produced in the United States, and average yield in copper, gold, and silver

Year	Smelting ores		Concentrating ores		Total				
	Short tons	Yield in copper, percent	Short tons [1]	Yield in copper, percent	Short tons [1] [2]	Yield in copper, percent	Yield per ton in gold, ounce	Yield per ton in silver, ounce	Value per ton in gold and silver
1953–57 (average)	880,089	3.94	109,233,510	0.78	113,752,083	0.81	0.0050	0.090	$0.26
1958	631,714	4.78	114,027,754	.77	114,824,468	.79	.0040	.080	.21
1959	467,598	3.98	103,239,445	.72	103,715,843	.74	.0035	.066	.18
1960	669,502	3.26	134,306,380	.72	134,994,082	.73	.0040	.070	.20
1961	734,112	3.39	141,975,386	.74	142,721,798	.75	.0037	.073	.20
1962	598,519	3.25	145,580,048	.72	150,216,710	.75	.0032	.073	.19

[1] Includes some ore classed as copper-zinc ore.
[2] Includes copper ore leached.

Smelter Production.—Recovery of copper from domestic ores by smelters in the United States rose 10 percent over the 1961 record output. Copper produced from foreign materials dropped 10 percent to the lowest since compilation of these data was started in 1945, but output from secondary sources increased 11 percent. Total output of smelters rose 10 percent.

Smelter-production data are based upon reports from domestic primary smelters handling copper-bearing materials. Blister copper is accounted for in terms of copper content. Production of furnace-refined copper in Michigan is included in smelter and refinery production. Metallic and cement copper recovered from leaching solutions are 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 1845–1960 in Minerals Yearbook, 1960, volume I.

TABLE 11.—Copper produced by primary smelters in the United States

(Short tons)

Year	Domestic	Foreign	Secondary	Total
1953-57 (average)	996,744	105,203	73,427	1,175,374
1958	992,918	76,134	61,848	1,130,900
1959	799,329	42,466	54,895	896,690
1960	1,142,848	90,781	74,472	1,308,101
1961	1,162,480	44,874	78,377	1,285,731
1962	1,282,126	40,488	86,903	1,409,517

Refinery Production.—Primary copper production by the 15 primary refineries in the United States rose 4 percent. Nine plants employed electrolytic refining only; three used the furnace process; two used both electrolytic and furnace methods; and one fire-refined part of its blister copper, but shipped the remainder to electrolytic refineries. Inspiration Consolidated Copper Co. at Inspiration, Ariz., produced electrolytic copper directly from leaching solutions; a substantial part of this copper was shipped as cathodes to other refineries for melting and casting into commercial shapes.

The electrolytic plants, excluding Inspiration, had a rated capacity of 1,918,000 tons of refined copper per year and produced at 97 percent of capacity.

There were six large electrolytic refineries on the Atlantic seaboard (two at Baltimore, Md., and two at Perth Amboy, N.J., one at Carteret, N.J., and one at Laurel Hill, N.Y.). There were three refineries on the Great Lakes and four electrolytic refineries west of the Great Lakes (at Great Falls, Mont., Tacoma, Wash., El Paso, Tex., and Garfield, Utah). The El Paso plant of Phelps Dodge Refining Corp. and the Carteret plant of American Metal Climax, Inc., produced fire-refined copper in addition to electrolytic-grade copper.

TABLE 12.—Primary and secondary copper produced by primary refineries in the United States

(Short tons)

	1953-57 (average)	1958	1959	1960	1961	1962
Primary:						
From domestic ores, etc.:[1]						
Electrolytic	876,279	892,758	699,890	1,009,983	1,037,489	1,098,032
Lake	39,487	59,111	54,543	56,232	70,061	67,072
Casting	64,664	49,776	42,019	55,071	73,465	49,042
Total	980,430	1,001,645	796,452	1,121,286	1,181,015	1,214,146
From foreign ores, etc.:[1]						
Electrolytic	350,555	340,470	256,002	389,178	355,009	379,236
Casting and best select	17,876	10,405	45,793	8,463	14,115	18,348
Total refinery production of primary copper	1,348,861	1,352,520	1,098,247	1,518,927	1,550,139	1,611,730
Secondary:						
Electrolytic[2]	188,673	199,508	200,183	241,169	231,836	237,472
Casting	15,626	7,828	11,405	10,585	11,294	12,214
Total secondary	204,299	207,336	211,588	251,754	243,130	249,686
Grand total	1,553,160	1,559,856	1,309,835	1,770,681	1,793,269	1,861,416

[1] The separation of refined copper into metal of domestic and foreign origin is only approximate, as accurate separation is not possible at this stage of processing.

[2] Includes copper reported from foreign scrap.

TABLE 13.—Copper cast in forms at primary refineries in the United States

Form	1961		1962	
	Thousand short tons	Percent	Thousand short tons	Percent
Billets	176	10	199	10
Cakes	145	8	182	10
Cathodes	194	11	164	9
Ingots and ingot bars	164	9	149	8
Wirebars	1,096	61	1,150	62
Other forms	18	1	17	1
Total	1,793	100	1,861	100

Copper Sulfate.—Production and shipments of copper sulfate declined 18 and 13 percent, respectively. Shipments totaled 40,300 tons (46,500 in 1961), of which producers' reports indicated that 17,800 tons (17,800) was for agricultural uses, 20,400 (20,000) for industrial uses, and 2,100 (8,700) for other purposes, chiefly for export. Stocks at yearend were 17 percent less than at the end of 1961.

TABLE 14.—Production, shipments, and stocks of copper sulfate

(Short tons)

Year	Production		Shipments (gross weight)	Stocks Dec. 31 [1] (gross weight)
	Gross weight	Copper content		
1953-57 (average)	70,766	17,691	71,010	5,072
1958	48,596	12,149	46.580	5,168
1959	40.292	10,073	42,100	2,500
1960	58,000	14.500	54,272	5,480
1961	48,584	12,146	46.544	6.740
1962	39,984	9,996	40,332	5,572

[1] Some small quantities are purchased and used by producing companies, so that the figures given do not balance exactly.

Byproduct Sulfuric Acid.—Sulfuric acid produced from the sulfur content of sulfide ores at copper smelters totaled 403,700 tons, an 11-percent increase over 1961. The data include output from foreign and domestic materials and acid produced at a lead smelter.

TABLE 15.—Byproduct sulfuric acid [1] (100-percent basis) produced at copper, zinc, and lead plants in the United States

(Short tons)

Year	Copper plants [2]	Zinc plants [3]	Total
1953-57 (average)	340.179	738.977	1,079.156
1958	495.576	738.385	1,233.961
1959	282.461	803.578	1,086.039
1960	412.845	770.872	1,183.717
1961	362.630	776.109	1,138.739
1962	403,683	815.322	1,219,005

[1] Includes acid from foreign materials.
[2] Includes acid produced at a lead smelter. Excludes acid made from pyrites concentrates in Arizona, Montana, Tennessee, and Utah.
[3] Excludes acid made from native sulfur.

SECONDARY COPPER AND BRASS

Recovery of copper, in unalloyed and alloyed form, from all classes of nonferrous scrap metal in the United States totaled 921,800 tons, 9 percent more than in 1961 and the largest since 1959. The increase in recovery from copper-base scrap totaled 70,500 tons. Recovery rose 22 percent at brass mills, 2 percent at primary copper producers, and 4 percent at secondary smelters; however, foundries and chemical plants recorded a 3-percent decrease. More than half of the copper recovered came from new scrap.

Consumption of purchased copper-base scrap rose 8 percent over 1961. Brass mills, the largest user, consumed 33 percent of the total and 21 percent more than in 1961. Primary copper producers and secondary smelters registered increases of 3 and 5 percent, respectively, over 1961 consumption. New scrap contributed 85,000 tons more than old scrap to the raw material supply. Of the 419,900 tons of scrap consumed in brass mills, all but 13,400 tons was new scrap, mostly yellow brass. Primary copper producers used 169,400 tons of new scrap and 231,000 tons of old scrap. Secondary smelters consumed 343,900 tons of copper scrap, of which 269,400 tons was old scrap. Foundries and other plants consumed 101,000 tons of scrap, 3 percent less than in 1961.

Most of the unalloyed copper products were recovered as refined copper by primary copper refineries; output rose 3 percent in 1962. Brass and bronze ingot production increased 4 percent, and brass-mill products rose 21 percent.

Consumption of brass and bronze ingot reported by foundries increased 5 percent, to 246,500 tons; except for 1959, this was the highest since 1956. Leaded red brass continued to account for more than 50 percent of the total ingot tonnage consumed, and its use increased 6 percent over that in 1961. Consumption of leaded tin bronze rose 18 percent, and consumption of high-leaded tin bronze rose 7 percent.

TABLE 16.—Secondary copper produced in the United States

(Short tons)

	1953–57 (average)	1958	1959	1960	1961	1962
Copper recovered as unalloyed copper	244,620	255,121	261,588	300,259	[1] 290,805	301,374
Copper recovered in alloys [2]	667,365	542,267	668,982	571,129	[1] 558,134	620,454
Total secondary copper	911,985	797,388	930,570	871,388	848,939	921,828
Source:						
New scrap	459,181	386,021	459,563	442,023	437,829	506,154
Old scrap	452,804	411,367	471,007	429,365	411,110	415,674
Percentage equivalent of domestic mine output	92	81	113	81	73	75

[1] Revised figure.
[2] Includes copper in chemicals, as follows: 1953–57 (average), 16,896; 1958, 9,491; 1959, 10,061; 1960, 12,714; 1961, 10,708; and 1962, 9,986.

TABLE 17.—Copper recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

Kind of scrap	1961	1962	Form of recovery	1961 [1]	1962
New scrap:			As unalloyed copper:		
Copper-base	431,947	498,300	At primary plants	243,130	249,686
Aluminum-base	5,690	7,590	At other plants	47,675	51,688
Nickel-base	171	239			
Zinc-base	21	25	Total	290,805	301,374
Total	437,829	506,154	In brass and bronze	526,715	584,860
			In alloy iron and steel	2,608	2,956
Old scrap:			In aluminum alloys	17,921	22,470
Copper-base	406,354	410,475	In other alloys	182	182
Aluminum-base	4,181	4,579	In chemical compounds	10,708	9,986
Nickel-base	528	579			
Tin-base	24	22	Total	558,134	620,454
Zinc-base	23	19			
Total	411,110	415,674	Grand total	848,939	921,828
Grand total	848,939	921,828			

[1] Revised figures.

TABLE 18.—Copper recovered as refined copper, in alloys and in other forms, from copper-base scrap processed in the United States

(Short tons)

	From new scrap		From old scrap		Total	
	1961	1962	1961	1962	1961	1962
Recovered by—						
Secondary smelters	48,337	48,205	198,161	208,141	246,498	256,346
Primary copper producers	118,655	117,864	127,419	133,776	246,074	251,640
Brass mills	245,277	311,280	20,780	12,052	266,057	323,332
Foundries and manufacturers	18,510	19,562	54,399	51,014	72,909	70,576
Chemical plants	1,168	1,389	5,595	5,492	6,763	6,881
Total	431,947	498,300	406,354	410,475	838,301	908,775

TABLE 19.—Production of secondary copper and copper-alloy products in the United States

(Short tons)

Item produced from scrap	1961	1962
Unalloyed copper products:		
Refined copper by primary producers	[1] 243,130	249,686
Refined copper by secondary smelters	38,582	40,062
Copper powder	7,993	10,162
Copper castings	1,100	1,464
Total	[1] 290,805	301,374

Item produced from scrap	Nominal composition (percent) Cu	Sn	Pb	Zn	Ni	Gross weight 1961	Gross weight 1962
Brass and bronze ingots:							
Tin bronze	88	10		2		15,740	16,566
Leaded tin bronze	88	6	1.5	4.5		15,980	17,325
Leaded red bronze	85	5	5	5		81,594	82,510
Leaded semired brass	81	3	7	9		71,310	74,897
High-leaded tin bronze	80	10	10			13,488	14,750
Do	84	6	8	2		12,583	13,110
Do	75	5	20			3,842	4,554
Leaded yellow brass	66	1	3	30		9,952	9,092
Nickel silver	58	2	7	18	14	3,370	4,128
Do	65	4	3	5	22		
Low brass	80			20		3,361	3,001
Conductor bronze	94	2	2	2		638	615
Manganese bronze	60 Cu 40 Zn, ±Mn, Al, etc.					11,377	12,740
Aluminum bronze	90 Cu 10 Al, ±Mn, Zn, Fe, etc.					6,628	7,899
Silicon bronze	92 Cu +Si, ±Zn, Fe, Al, Mn					3,602	3,738
Copper-base hardeners and special alloys						11,551	11,625
Total						265,016	276,550
Brass-mill products						342,383	413,156
Brass and bronze castings						66,216	57,076
Brass powder						1,633	1,901
Copper in chemical products						10,708	9,986
Grand total						[1] 976,761	1,060,043

[1] Revised figure.

TABLE 20.—Composition of secondary copper-alloy production

(Short tons, gross weight)

Year	Copper	Tin	Lead	Zinc	Nickel	Aluminum	Total
Brass and bronze production: [1]							
1961	209,194	13,159	17,228	24,901	468	66	265,016
1962	217,649	13,798	17,907	26,921	212	63	276,550
Secondary metal content of brass-mill products:							
1961	266,088	112	2,857	71,705	1,582	39	342,383
1962	323,384	143	3,609	84,407	1,596	17	413,156
Secondary metal content of brass and bronze castings:							
1961	51,801	2,995	7,511	3,828	24	57	66,216
1962	44,742	2,436	6,157	3,653	18	70	57,076

[1] About 95 percent from scrap and 5 percent from other than scrap.

TABLE 21.—Stocks and consumption of copper scrap in the United States in 1962

(Short tons, gross weight)

Class of consumer and type of scrap	Stocks Jan. 1	Receipts: Purchased scrap	Receipts: Machine shop scrap	Consumption: Purchased scrap: New	Consumption: Purchased scrap: Old	Consumption: Purchased scrap: Total	Consumption: Machine shop scrap	Stocks Dec. 31
Secondary smelters:								
No. 1 wire and heavy copper	2,677	36,325	--------	2,628	33,539	36,167	--------	2,835
No. 2 wire, mixed heavy, and light copper	3,114	58,996	--------	5,889	53,350	59,239	--------	2,871
Composition or red brass	3,948	82,501	--------	27,351	54,266	81,617	--------	4,832
Railroad-car boxes	364	929	--------	--------	1,026	1,026	--------	267
Yellow brass	7,681	52,124	--------	6,974	46,961	53,935	--------	5,870
Cartridge cases and brass	47	629	--------	--------	618	618	--------	58
Auto radiators (unsweated)	2,581	44,813	--------	--------	44,213	44,213	--------	3,181
Bronze	1,571	30,323	--------	7,520	22,731	30,251	--------	1,643
Nickel silver	760	3,785	--------	345	3,559	3,904	--------	641
Low brass	261	2,517	--------	1,372	1,094	2,466	--------	312
Aluminum bronze	244	306	--------	66	347	413	--------	137
Low-grade scrap and residues	3,667	30,687	--------	22,347	7,708	30,055	--------	4,299
Total	26,915	343,935	--------	74,492	269,412	343,904	--------	26,946
Primary producers:								
No. 1 wire and heavy copper	1,683	44,956	--------	17,863	26,940	44,803	--------	1,836
No. 2 wire, mixed heavy, and light copper	5,419	135,428	--------	75,873	58,298	134,171	--------	6,676
Refinery brass	748	30,400	--------	12,997	16,211	29,208	--------	1,940
Low-grade scrap and residues	28,900	214,962	--------	62,670	129,573	192,243	--------	51,619
Total	36,750	425,746	--------	169,403	231,022	400,425	--------	62,071
Brass mills: [1]								
No. 1 wire and heavy copper	[2] 5,970	99,332	--------	90,128	9,204	99,332	--------	6,044
No. 2 wire, mixed heavy, and light copper	4,333	44,532	--------	44,491	41	44,532	--------	4,302
Yellow brass	15,867	187,836	--------	187,836	--------	187,836	--------	15,258
Cartridge cases and brass	2,328	43,773	--------	39,588	4,185	43,773	--------	2,001
Bronze	348	2,070	--------	2,070	--------	2,070	--------	1,036
Nickel silver	2,763	8,518	--------	8,518	--------	8,518	--------	3,595
Low brass	2,484	21,684	--------	21,684	--------	21,684	--------	2,841
Aluminum bronze	154	178	--------	178	--------	178	--------	344
Mixed-alloy scrap	8,830	12,002	--------	12,002	--------	12,002	--------	14,673
Total [1]	[2] 43,077	419,925	--------	406,495	13,430	419,925	--------	50,094
Foundries, chemical plants, and other manufacturers:								
No. 1 wire and heavy copper	2,359	23,119	626	9,072	14,229	23,301	488	2,316
No. 2 wire, mixed heavy, and light copper	1,435	14,115	1,189	6,070	8,276	14,346	937	1,456
Composition or red brass	1,606	3,392	16,042	1,181	2,535	3,716	15,608	1,716
Railroad car boxes	2,154	32,852	1,929	--------	32,907	32,907	1,970	2,058
Yellow brass	1,362	9,463	6,645	4,335	4,458	8,793	7,439	1,238
Auto radiators (unsweated)	395	5,017	84	--------	5,022	5,022	89	385
Bronze	1,164	2,661	1,420	1,231	1,411	2,642	1,556	1,047
Nickel silver	61	35	197	--------	47	47	211	35
Low brass	277	702	2,336	56	361	417	2,430	468
Aluminum bronze	259	393	758	160	284	444	701	265
Low-grade scrap and residues	795	10,024	2,075	2,747	6,665	9,412	1,989	1,493
Total	11,867	101,773	33,301	[3] 24,852	[3] 76,195	[3] 101,047	33,418	12,476
Grand total: [4]								
No. 1 wire and heavy copper	[2] 12,689	203,732	626	119,691	83,912	203,603	488	13,030
No. 2 wire, mixed heavy, and light copper	14,301	253,071	1,189	132,323	119,965	252,288	937	15,305
Composition or red brass	5,554	85,893	16,042	28,532	56,801	85,333	15,608	6,548
Railroad-car boxes	2,518	33,781	1,929	--------	33,933	33,933	1,970	2,325
Yellow brass	24,910	249,423	6,645	199,145	51,419	250,564	7,439	22,366
Cartridge cases and brass	2,375	44,402	--------	39,588	4,803	44,391	--------	2,059
Auto radiators (unsweated)	2,976	49,830	84	--------	49,235	49,235	89	3,566
Bronze	3,083	35,054	1,420	10,821	24,142	34,963	1,556	3,726
Nickel silver	3,584	12,338	197	8,863	3,606	12,469	211	4,271
Low brass	3,022	24,903	2,336	23,112	1,455	24,567	2,430	3,621
Aluminum bronze	657	877	758	404	631	1,035	701	746

See footnotes at end of table.

TABLE 21.—Stocks and consumption of copper scrap in the United States in 1962—Continued

(Short tons, gross weight)

Class of consumer and type of scrap	Stocks Jan. 1	Receipts		Consumption				Stocks Dec. 31
		Purchased scrap	Machine shop scrap	Purchased scrap			Machine shop scrap	
				New	Old	Total		
Grand total:[4]—Continued								
Low-grade scrap and residues[5]	34,110	286,073	2,075	100,761	160,157	260,918	1,989	59,351
Mixed-alloy scrap	8,830	12,002		12,002		12,002		14,673
Total[4]	[2]118,609	1,291,379	33,301	675,242	590,059	1,265,301	33,418	151,587

[1] Brass-mill stocks include home scrap; purchased scrap consumption assumed equal to receipts, so that lines in brass-mill and grand total sections do not balance.
[2] Revised.
[3] Of the totals shown, chemical plants reported the following: Unalloyed copper scrap, 1,058 tons of new and 4,150 old; copper-base alloy scrap, 1,670 tons of new and 6,643 old.
[4] Includes machine-shop scrap receipts and consumption for foundries, chemical plants, and other manufacturers.
[5] Includes refinery brass.

TABLE 22.—Consumption of copper and brass materials in the United States, by principal consuming groups

(Short tons)

Year and item	Primary producers	Brass mills	Wire mills	Foundries, chemical plants, and miscellaneous users	Secondary smelters	Total
1961:						
Copper scrap	390,043	347,840		103,952	328,262	1,170,097
Refined copper[1]		599,765	823,799	29,762	9,504	1,462,830
Brass ingot		5,463	35	[2]264,454		269,952
Slab zinc		113,117		2,714	12,692	128,523
Miscellaneous		32		211	2,717	2,960
1962:						
Copper scrap	400,425	419,925		101,047	343,904	1,265,301
Refined copper[1]		636,149	922,908	31,159	9,460	1,599,676
Brass ingot		6,998		[2]265,299		272,297
Slab zinc		116,138		3,244	10,423	129,805
Miscellaneous		57		137	5,080	5,274

[1] Detailed information on consumption of refined copper will be found in table 26.
[2] Shipments to foundries by smelters minus increase in stocks at foundries.

TABLE 23.—Foundry consumption of brass ingot, by types, in the United States

(Short tons)

Type of ingot	1953–57 (average)	1958	1959	1960	1961	1962
Tin bronze	14,763	10,272	11,257	9,689	11,152	9,677
Leaded tin bronze	26,318	20,591	24,868	23,818	22,876	27,034
Leaded red brass	148,748	138,183	162,798	142,817	149,405	158,047
High-leaded tin bronze	24,881	17,478	19,413	18,076	16,739	17,916
Leaded yellow brass	18,570	15,790	17,344	15,887	12,672	10,632
Manganese bronze	12,957	8,155	9,609	9,540	8,429	8,564
Hardeners	2,202	1,565	2,185	2,268	2,439	2,711
Nickel silver	3,363	2,428	2,921	2,732	2,792	3,303
Aluminum bronze	(1)	(1)	(1)	(1)	(1)	7,688
Low brass[2]	7,891	6,690	7,699	7,365	7,505	928
Total	259,693	221,152	258,094	232,192	234,009	246,500

[1] Included with low brass.
[2] Includes aluminum bronze for 1953–61.

TABLE 24.—Dealers' monthly average buying price for copper scrap and consumers' alloy-ingot prices at New York in 1962

(Cents per pound)

Grade	Jan.	Feb.	Mar.	Apr.	May	June
No. 2 copper scrap	21.75	21.75	21.75	21.75	21.70	21.25
No. 1 composition scrap	20.25	20.25	20.25	20.25	20.20	19.75
No. 1 composition ingot	32.00	32.00	32.00	32.00	32.00	32.00

Grade	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
No. 2 copper scrap	21.25	21.42	21.34	21.50	22.08	21.46	21.58
No. 1 composition scrap	19.75	19.75	19.84	20.00	20.21	20.25	20.06
No. 1 composition ingot	32.00	32.00	32.00	32.00	32.00	32.00	32.00

Source: Metal Statistics, 1963.

CONSUMPTION

Apparent withdrawals of primary copper rose 9 percent in 1962. Demand for copper was strong throughout the year, and consumption of new copper was the largest since 1956.

Actual consumption of refined copper increased 9 percent to 1,599,700 tons, the highest since compilation of these data was begun in 1945. These data are based on reports from consumers of quantities entering processing, with no adjustment for stock changes of material in process. Unlike table 25, in which only new copper is included as far as possible, table 26 does not distinguish between new and old copper but includes all copper in refined form. Except for June, August, and September, consumption in 1962 exceeded every month in 1961. The total for March (145,300 tons) was the largest for any month since March 1956.

The pattern of uses for refined copper was virtually unchanged. Wire mills consumed 58 percent of the total, and brass mills consumed 40 percent.

TABLE 25.—Primary refined-copper supply and withdrawals on domestic account

(Short tons)

Supply and withdrawals	1953-57 (average)	1958	1959	1960	1961	1962
Production from domestic and foreign ores, etc	1,348,861	1,352,520	1,098,247	1,518,927	1,550,139	1,611,730
Imports [1]	209,113	128,464	214,058	142,709	66,855	98,820
Stock Jan. 1 [1]	42,000	109,000	48,000	18,000	98,000	49,000
Total available supply	1,599,974	1,589,984	1,360,305	1,679,636	1,714,994	1,759,550
Copper exports [1]	218,896	384,868	158,938	433,762	[2] 428,718	336,525
Stock Dec. 31 [1]	59,000	48,000	18,000	98,000	49,000	71,000
Total	277,896	432,868	176,938	531,762	[2] 477,718	407,525
Apparent withdrawals on domestic account [3]	1,322,000	1,157,000	1,183,000	1,148,000	[2] 1,237,000	1,352,000

[1] May include some copper refined from scrap.
[2] Revised figure.
[3] Includes copper delivered by industry to the national strategic stockpile.

TABLE 26.—Refined copper consumed, by classes of consumers

(Short tons)

Year and class of consumer	Cathodes	Wire bars	Ingots and ingot bars	Cakes and slabs	Billets	Other	Total
1961:							
Wire mills	604	812,065	10,356			774	823,799
Brass mills	119,172	42,391	95,943	152,876	189,333	50	599,765
Chemical plants			720			549	1,269
Secondary smelters	6,782		2,390	172		160	9,504
Foundries	6,157	92	9,186		720	923	17,078
Miscellaneous [1]	2,532	4	4,072	25	505	4,277	11,415
Total	135,247	854,552	122,667	153,073	190,558	6,733	1,462,830
1962:							
Wire mills		913,131	8,964			813	922,908
Brass mills	113,402	42,799	97,090	184,085	198,676	97	636,149
Chemical plants			761			727	1,488
Secondary smelters	7,368		1,928	159		5	9,460
Foundries	5,760	41	8,417	30	327	1,083	15,658
Miscellaneous [1]	1,066	1	7,259	24	602	5,061	14,013
Total	127,596	955,972	124,419	184,298	199,605	7,786	1,599,676

[1] Includes iron and steel plants, primary smelters producing alloys other than copper, consumers of copper powder and copper shot, and miscellaneous manufacturers.

STOCKS

Yearend producers' inventories of refined copper increased 45 percent. For the first 6 months of 1962, stocks were below those held by producers at the end of 1961. Production curtailments were instituted in July to relieve the surplus that developed, but stocks turned upward in each month from July through December, except for September. Unrefined stocks rose 4 percent.

TABLE 27.—Stocks of copper at primary smelting and refining plants in the United States, Dec. 31

(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]
1953–57 (average)	59,000	230,000	1960	98,000	261,000
1958	48,000	257,000	1961	49,000	236,000
1959	18,000	253,000	1962	71,000	246,000

[1] May include some copper refined from scrap.
[2] Includes copper in transit from smelters in the United States to refineries therein.

Fabricators' stocks (table 28) of refined metal (including in-process copper and fabricated shapes) were 465,600 tons at yearend, less than 1 percent higher than on January 1. Working stocks rose 7 percent to 385,200 tons. After accounting for unfilled sales orders, copper classed as "available for sale" totaled 23,600 tons, little more than half the quantity available at the end of 1961.

On December 31, inventories in Government stockpiles totaled 1,133,230 tons. Of this quantity, 1,008,351 tons was in the national (strategic) stockpile, 113,430 tons was in Defense Production Authority inventory, 196 tons was in Commodity Credit Corporation inventory, and 11,253 tons was in the supplemental stockpile.

Included in these data were 24,784 tons of oxygen-free high-conductivity copper in the national stockpile, 196 tons in Commodity Credit Corporation inventory, and 5,199 tons in the supplemental stockpile. Also included were 2,171,449 pounds of beryllium-copper master alloy in the national stockpile and 12,623,973 pounds in the supplemental stockpile.

TABLE 28.—Stocks of copper in fabricators' hands Dec. 31

(Short tons)

Year	Stocks of refined copper [1] (1)	Unfilled purchases of refined copper from producers (2)	Working stocks (3)	Unfilled sales to customers (4)	Excess stocks over orders booked [2] (5)
1958	446,358	90,401	326,438	177,869	32,452
1959	414,757	130,324	340,349	202,775	1,957
1960	456,094	75,222	370,055	126,260	35,001
1961	461,252	89,745	361,286	144,344	45,367
1962	465,592	81,297	385,239	138,089	23,561

[1] Includes in-process metal and primary fabricated shapes. Also includes small quantities of refined copper held at refineries for fabricators' account.
[2] Columns (1) plus (2) minus (3) and minus (4) equal column (5).

Source: United States Copper Association.

PRICES

Copper-selling agencies indicated that 1,284,800 tons of domestic refined copper was delivered to purchasers at an average price of 30.8 cents per pound. The average price of foreign copper delivered in the United States was 30.6 cents per pound.

May 19 marked the end of a full year during which the primary producers' price for electrolytic copper had remained unchanged at 31 cents per pound, delivered. This was the longest period of price stability except when under Government control. Previous periods of an unchanged copper price occurred from May 1929 to March 1930 (18 cents per pound) and from November 12, 1959, to October 12, 1960 (33 cents per pound). The custom-smelter price established on May 31, 1961, at 31 cents also remained unchanged.

London Price.—The price of copper on the London Metal Exchange averaged £230 9s. per long ton (28.92 cents per pound) during January. Price rose in February to a high for the year of £235 0s. 8d. (29.53 cents), however, they were lowered in March. A producer-maintained price of approximately £234 (29.25 cents) was in effect thereafter. The average for the year was 2 percent more than in 1961.

TABLE 29.—Average weighted prices of copper deliveries,[1] consumer plants

(Cents per pound)

Year	Domestic copper	Foreign copper	Year	Domestic copper	Foreign copper
1958	26.3	25.0	1961	30.0	30.4
1959	30.7	31.6	1962	30.8	30.6
1960	32.1	32.5			

[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 U.S. selling agencies.

TABLE 30.—Average monthly quoted prices of electrolytic copper for domestic and export shipments, f.o.b. refineries, in the United States and for spot copper at London

(Cents per pound)

Month	1961				1962			
	Domestic, f.o.b. refinery [1]	Domestic, f.o.b. refinery [2]	Export, f.o.b. refinery [2]	London, spot [3 4]	Domestic, f.o.b. refinery [1]	Domestic, f.o.b. refinery [2]	Export, f.o.b. refinery [2]	London, spot [3 4]
January	28.82	29.057	26.746	27.57	30.82	30.600	28.060	28.92
February	28.82	28.600	27.040	27.95	30.82	30.600	28.620	29.53
March	28.82	28.600	27.303	28.13	30.82	30.600	28.600	29.51
April	28.82	28.600	27.781	28.63	30.82	30.600	28.598	29.43
May	30.19	29.985	29.505	30.24	30.82	30.600	28.545	29.40
June	30.82	30.605	28.701	29.45	30.82	30.600	28.571	29.35
July	30.82	30.600	27.873	28.58	30.82	30.600	28.538	29.33
August	30.82	30.600	28.087	28.89	30.82	30.600	28.564	29.31
September	30.82	30.604	28.036	28.81	30.82	30.600	28.588	29.28
October	30.82	30.600	27.875	28.74	30.82	30.600	28.529	29.29
November	30.82	30.600	28.005	28.82	30.82	30.600	28.488	29.29
December	30.82	30.600	28.072	28.84	30.82	30.600	28.466	29.30
Average	30.14	29.921	27.919	28.73	30.82	30.600	28.514	29.33

[1] American Metal Market.
[2] E&MJ Metal and Mineral Markets.
[3] Metal Bulletin (London).
[4] Based on average monthly rates of exchange by Federal Reserve Board.

FOREIGN TRADE [4]

Imports of unmanufactured copper rose 5 percent over 1961. As usual, Chile was the chief source of foreign copper, supplying 47 percent of the total but furnishing slightly less than in 1961. Canada regained second place as a principal supplier with 21 percent of the total, 26 percent more than in 1961. Peru furnished 15 percent of the imported copper but 20 percent less than in 1961.

Imports of refined copper exceeded those of 1961 by 48 percent, mainly because of large receipts from the Federation of Rhodesia and Nyasaland. Canada remained the chief source of refined metal, a position it had held since 1955. Canadian shipments accounted for 78 percent of the total refined copper and were 24 percent greater than in 1961. The blister-copper class declined 2 percent because increased receipts from Mexico, Chile, and the Republic of South Africa did not

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

offset the 21-percent decrease from Peru. The other unrefined classes—ore, concentrate, matte and cement copper—dropped 8 percent. Peru, the Republic of Philippines, and the Republic of South Africa furnished smaller quantities of these classes, but receipts from Canada rose 25 percent.

Exports.—Refined copper, the chief export class, decreased 22 percent. Although 72 percent of the total exported went to European countries, all of the purchasers took substantially smaller quantities than in 1961. India was the second largest recipient with 19 percent of the total shipments.

Exports of copper scrap and brass and bronze scrap dropped sharply. The Netherlands, Yugoslavia, and Japan were the principal destinations of scrap copper in 1962. Japan received 87 percent of the scrap brass and bronze exported, compared with 90 percent in 1961.

Tariff.—As the price of copper remained above 24 cents per pound throughout 1962, the 1.7-cent-per-pound excise tax, effective July 1, 1958, was applicable to imported copper. If the price were to drop below 24 cents, the tariff would be 2 cents per pound.

TABLE 31.—U.S. imports[1] of copper (unmanufactured), by classes and countries

(Short tons, copper content)

Year and country	Ore	Concentrates	Matte	Blister	Refined	Scrap	Total
1953-57 (average)[2]	11,354	104,134	6,844	272,202	209,113	7,317	610,964
1958	8,217	79,200	5,178	268,182	128,464	7,060	496,301
1959	7,330	65,311	8,949	269,048	214,058	6,195	570,891
1960	9,982	65,536	5,049	298,373	142,709	2,695	524,344
1961:							
North America:							
Canada	184	13,775	571	(3)	61,659	2,165	78,354
Mexico	152	6	142	20,519	34	110	20,963
Other	-------	1	3	---------	---------	304	308
Total	336	13,782	716	20,519	61,693	2,579	99,625
South America:							
Chile	-------	1,992	-------	221,520	1,983	1,476	226,971
Peru	1,583	5,210	840	82,748	54	-------	90,435
Other	-------	905	-------	---------	---------	-------	905
Total	1,583	8,107	840	304,268	2,037	1,476	318,311
Europe:							
United Kingdom	-------	---------	-------	---------	1,312	4	1,316
Other	-------	---------	-------	---------	16	9	25
Total	-------	---------	-------	---------	1,328	13	1,341
Asia: Philippines	3	13,888	7	---------	---------	-------	13,898
Africa:							
Union of South Africa	6,241	1,034	-------	14,402	1,797	-------	23,474
Other	21	---------	10	---------	---------	-------	31
Total	6,262	1,034	10	14,402	1,797	-------	23,505
Oceania:							
Australia	753	40	33	---------	---------	-------	826
Other	-------	---------	-------	---------	---------	163	163
Total	753	40	33	---------	---------	163	989
Grand total	8,937	36,851	1,606	339,189	66,855	4,231	457,669

See footnotes at end of table.

TABLE 31.—U.S. imports[1] of copper (unmanufactured), by classes and countries—Continued

(Short tons, copper content)

Year and country	Ore	Concentrates	Matte	Blister	Refined	Scrap	Total
1962:							
North America:							
Canada	298	17,730	148	53	76,600	3,924	98,753
Mexico	148	96		23,473	8	54	23,779
Other			2			366	368
Total	446	17,826	150	23,526	76,608	4,344	122,900
South America:							
Chile	17	5		224,516	856		225,394
Peru	1,788	4,628	483	65,234			72,133
Other	211	1,369				28	1,608
Total	2,016	6,002	483	289,750	856	28	299,135
Europe:							
Finland					709		709
United Kingdom				1	845		846
Other			1		21	17	39
Total			1	1	1,575	17	1,594
Asia:							
Philippines	2	10,123	1				10,126
Other						35	35
Total	2	10,123	1			35	10,161
Africa:							
Rhodesia and Nyasaland, Federation of			(3)		18,997		18,997
South Africa, Republic of	1,682	4,069		18,409		300	24,460
Other					784		784
Total	1,682	4,069	(3)	18,409	19,781	300	44,241
Oceania:							
Australia	751						751
Other						69	69
Total	751					69	820
Grand total	4,897	38,020	635	331,686	98,820	4,793	478,851

[1] Data are "general" imports, that is, they include copper imported for immediate consumption plus material entering the country under bond.
[2] Some copper in "Ore" and "Other" from the Philippines is not separately classified and is included with "Concentrates."
[3] Less than 1 ton.

Source: Bureau of the Census.

TABLE 32.—U.S. imports[1] of copper (unmanufactured), by countries

(Short tons, copper content)

Country	1953–57 (average)	1958	1959	1960	1961	1962
North America:						
Canada	109,017	74,813	112,318	117,641	78,354	98,753
Cuba	18,278	14,464	10,807	6,568	----------	----------
Mexico	53,454	50,023	29,493	22,656	20,963	23,779
Other	588	453	412	190	308	368
Total	181,337	139,753	153,030	147,055	99,625	122,900
South America:						
Bolivia	4,030	3,395	1,790	1,346	905	1,580
Chile	249,484	200,145	241,392	208,167	226,971	225,394
Peru	32,914	30,426	28,725	91,624	90,435	72,133
Other	423	963	464	11	(2)	28
Total	286,851	234,929	272,371	301,148	318,311	299,135
Europe:						
Belgium-Luxembourg	1,593	56	8,504	2,673	----------	----------
France	1,506	1,188	1,125	526	----------	1
Germany, West	2,506	4,173	24,342	8,739	14	----------
Malta, Gozo, and Cyprus	4,790	6,911	3,524	----------	----------	----------
Netherlands	500	392	727	506	----------	23
Norway	3,242	20	50	248	----------	----------
Sweden	1,237	1,063	3,428	2,789	----------	----------
United Kingdom	3,928	7,185	13,436	781	1,316	846
Other	2,793	----------	1	5,150	11	724
Total	22,095	20,988	55,137	21,412	1,341	1,594
Asia:						
Philippines	14,052	14,583	13,759	17,562	13,898	10,126
Turkey	4,837	1,094	1,094	547	----------	----------
Other	244	40	41	2	----------	35
Total	19,133	15,717	14,894	18,111	13,898	10,161
Africa:						
Congo, Republic of, and Ruanda-Urundi[3]	11,696	15,515	4,335	196	----------	----------
Rhodesia and Nyasaland, Federation of[4]	59,323	35,169	32,622	5,795	10	18,997
South Africa, Republic of[5]	15,097	29,169	30,981	28,228	23,474	24,460
Other	217	----------	49	625	21	784
Total	86,333	79,853	67,987	34,844	23,505	44,241
Oceania:						
Australia	15,214	5,061	7,472	1,774	826	751
Other	1	----------	----------	----------	163	69
Total	15,215	5,061	7,472	1,774	989	820
Grand total	610,964	496,301	570,891	524,344	457,669	478,851

[1] Data are "general" imports; that is, they include copper imported for immediate consumption plus material entering the country under bond.
[2] Less than 1 ton.
[3] Before July 1, 1960, classified as Belgian Congo.
[4] Before July 1, 1954, classified as Southern and Northern Rhodesia.
[5] Before Jan. 1, 1962, classified as Union of South Africa.

Source: Bureau of the Census.

TABLE 33.—U.S. imports for consumption of old brass and clippings from brass or Dutch metal[1]

Year	Short tons: Gross weight	Short tons: Copper content	Value (thousands)	Year	Short tons: Gross weight	Short tons: Copper content	Value (thousands)
1953-57 (average)	8,228	5,682	[2] $3,174	1960	566	309	$184
1958	6,763	4,201	1,852	1961	608	390	173
1959	2,054	1,257	698	1962	2,141	1,289	738

[1] For remanufacture.
[2] Data known to be not comparable with other years.

Source: Bureau of the Census.

TABLE 34.—U.S. imports for consumption of copper (copper content), by classes[1]

Year	Ore: Short tons	Ore: Value (thousands)	Concentrates: Short tons	Concentrates: Value (thousands)	Matte: Short tons	Matte: Value (thousands)
1953-57 (average)[2]	9,252	$5,534	90,572	$54,572	5,780	$3,851
1958	5,926	2,357	84,871	37,968	4,925	2,173
1959	60	20	9,299	5,505	7,113	4,260
1960	3,503	2,016	20,935	12,391	185	80
1961	2,587	1,526	21,914	12,516	95	57
1962	116	202	2,206	1,212	22	12

Year	Blister: Short tons	Blister: Value (thousands)	Refined: Short tons	Refined: Value (thousands)	Scrap: Short tons	Scrap: Value (thousands)	Total value (thousands)
1953-57 (average)	273,510	[3] $183,492	209,132	$143,685	7,282	[3] $4,328	[3] $395,462
1958	138,633	66,321	124,629	61,139	5,849	2,676	172,634
1959	203	126	237,304	146,478	2,984	1,635	158,024
1960	486	311	171,021	109,490	1,836	1,106	125,394
1961	5,929	3,508	87,206	51,852	1,643	870	70,329
1962	1,119	669	130,525	77,189	3,846	2,242	81,526

[1] Excludes imports for manufacture in bond and export, classified as "imports for consumption" by the Bureau of the Census.
[2] Some copper in "Ore" and "Other" from the Philippines is not separately classified and is included with "Concentrates."
[3] Data known to be not comparable with other years.

Source: Bureau of the Census.

TABLE 35.—U.S. exports of copper by classes and countries

(Short tons)

Year and destination	Ore, concentrates, matte (copper content)	Refined	Scrap	Pipes and tubing	Plates and sheets	Wire and cable, bare	Wire and cable, insulated	Other copper manufactures [1]
1953-57 (average)	9,027	218,896	43,225	1,403	362	8,612	17,881	818
1958	11,475	384,868	21,861	1,608	166	5,030	14,482	2,302
1959	2,982	158,938	10,721	799	313	3,378	21,863	4,352
1960	11,111	433,762	58,860	726	500	3,278	13,368	5,181
1961	4,478	[2] 428,718	35,257	949	355	1,995	15,550	7,362
1962:								
North America:								
Canada	34	1,013	181	142	115	161	1,661	489
Mexico	--------	107	--------	39	22	9	404	(3)
Other	--------	10	--------	122	16	145	1,678	5
Total	34	1,130	181	303	153	315	3,743	494
South America:								
Argentina	--------	8,931	--------	1	(3)	10	220	--------
Brazil	--------	4,765	--------	20	3	1	103	6
Colombia	--------	2	--------	44	6	9	214	2,034
Venezuela	--------	21	--------	52	7	64	505	2,520
Other	--------	100	--------	34	4	198	1,517	11
Total	--------	13,819	--------	151	20	282	2,559	4,571
Europe:								
Belgium-Luxembourg	--------	1,574	--------	1	5	(3)	80	(3)
France	--------	39,044	--------	12	21	4	105	6
Germany, West	1,036	67,353	--------	12	3	11	224	5
Italy	167	54,314	111	1	19	17	79	(3)
Netherlands	--------	6,467	440	4	1	22	179	--------
Norway	--------	2,658	--------	7	--------	--------	23	--------
Spain	100	418	4,428	42	--------	--------	37	--------
Sweden	--------	3,861	30	3	--------	21	72	1
Switzerland	--------	4,126	--------	20	2	1	13	135
United Kingdom	412	52,186	--------	28	94	11	120	2
Yugoslavia	--------	6,554	3,580	20	--------	5	206	1
Other	--------	2,823	211	38	2	14	208	1,457
Total	1,715	241,378	8,800	188	147	106	1,346	1,607
Asia:								
India	--------	65,124	712	21	2	1,421	45	1
Japan	167	13,134	2,904	5	--------	--------	127	53
Taiwan	--------	540	--------	2	--------	15	197	28
Other	--------	255	11	160	15	484	4,486	12
Total	167	79,053	3,627	188	17	1,920	4,855	94
Africa	--------	392	--------	31	11	245	770	(3)
Oceania	--------	753	--------	3	1	7	91	2
Grand total	1,916	336,525	12,608	864	349	2,875	13,364	6,768

[1] Beginning Jan. 1, 1958, copper rods not separately classified; included in "Other copper manufactures," 1953-57 (average) 578 tons.
[2] Changes in Minerals Yearbook, 1961, p. 516, table 34, exports of refined copper should read as follows: India, 12,022 short tons, total, 428,718 short tons.
[3] Less than 1 ton.

Source: Bureau of the Census.

TABLE 36.—U.S. exports of copper, by classes

Year	Ore, concentrates, and matte (copper content)		Refined copper and semimanufactures		Other copper manufactures		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1953-57 (average)	9,027	$6,538,098	290,379	$212,249,573	818	$777,830	300,224	$219,565,501
1958	11,475	5,864,534	[1] 428,015	[1] 229,534,839	[1] 2,302	[1] 1,567,100	441,792	236,966,473
1959	2,982	1,808,289	[1] 196,012	[1] 128,577,107	4,352	[1] 3,280,116	203,346	133,665,512
1960	11,111	6,832,050	[1] 510,494	[1] 327,935,628	5,181	[1] 4,006,049	526,786	338,773,727
1961	4,478	2,474,679	[2] 482,824	[1] 295,397,080	7,362	[1] 5,260,315	[2] 494,664	303,132,074
1962	1,916	1,045,181	[1] 366,585	[1] 234,604,915	6,768	[1] 5,106,603	375,269	240,756,699

[1] Beginning Jan. 1, 1958, copper rods not separately classified; included in "Other copper manufactures," have been included in 1957 with "Other copper manufactures."
[2] Revised figure.

Source: Bureau of the Census.

TABLE 37.—U.S. exports of copper-base alloys (including brass and bronze), by classes

Class	1961		1962	
	Short tons	Value	Short tons	Value
Ingots	469	$904,983	343	$466,053
Scrap and other forms	116,654	52,226,189	36,209	15,524,912
Bars, rods, and shapes	658	1,131,813	910	1,462,956
Plates, sheets, and strips	578	1,621,707	1,138	2,298,631
Pipes and tubing	1,343	1,743,463	1,763	2,496,430
Pipe fittings	1,398	3,415,918	1,376	3,384,113
Plumbers' brass goods	2,151	5,889,323	2,008	5,488,976
Welding rods and wire	689	1,738,423	785	1,844,610
Castings and forgings	502	1,013,570	933	2,353,930
Powder	483	518,494	519	576,257
Semifabricated forms, not elsewhere classified	13	35,863	46	126,858
Total	124,938	70,239,746	46,030	36,023,726

Source: Bureau of the Census.

TABLE 38.—U.S. exports of unfabricated copper-base alloy[1] ingots, bars, rods, shapes, plates, sheets, and strips

Year	Short tons	Value	Year	Short tons	Value
1953-57 (average)	2,820	$3,296,283	1960	1,920	$4,235,521
1958	1,396	2,228,688	1961	1,705	[2] 3,658,503
1959	1,471	2,874,206	1962	2,391	4,227,640

[1] Includes brass and bronze.
[2] Revised figure.

Source: Bureau of the Census.

TABLE 39.—U.S. exports of copper sulfate (blue vitriol)

Year	Short tons	Value	Year	Short tons	Value
1953-57 (average)	32,725	$6,996,601	1960	14,841	$3,376,649
1958	7,248	1,175,944	1961	7,575	1,542,212
1959	2,672	674,522	1962	1,916	455,665

Source: Bureau of the Census.

TABLE 40.—U.S. imports and exports of brass and copper scrap

(Short tons)

	1953–57 (average)	1958	1959	1960	1961	1962
Imports for consumption:						
Brass scrap (gross weight)	8,228	6,763	2,054	566	608	2,141
Copper scrap (copper content)	7,282	5,849	2,984	1,836	1,643	3,846
Exports:						
Copper-base-alloy scrap (new and old)	58,679	28,502	29,406	122,175	116,654	36,209
Copper scrap	43,225	21,861	10,721	58,860	35,257	12,608

Source: Bureau of the Census.

TABLE 41.—U.S. imports for consumption and exports of copper scrap, in 1962, by countries

(Short tons)

Country	Imports		Exports	
	Unalloyed copper scrap (copper content)	Copper alloy scrap (gross weight)	Copper alloy scrap	Unalloyed copper scrap
North America:				
Canada	3,136	1,503	181	179
Mexico	41	97		20
Other	247	458		25
Total	3,424	2,058	181	224
South America				4
Europe:				
France				255
Germany, West		9		595
Italy			111	2,569
Netherlands	2	28	440	52
Spain			4,428	124
United Kingdom				514
Yugoslavia			3,580	
Other	15		241	28
Total	17	37	8,800	4,137
Asia:				
India			712	141
Japan	34		2,904	31,568
Other	1	4	11	135
Total	35	4	3,627	31,844
Africa	300			
Oceania	70	42		
Grand total	3,846	2,141	12,608	36,209

Source: Bureau of the Census.

WORLD REVIEW

World production of copper continued upward for the fourth consecutive year. Voluntarily reduced production rates instituted by many leading world producers, coupled with labor and political disturbances in some countries, prevented even higher copper outputs. Production in the United States rose 5 percent to a new record, reflecting in part the completion of the first full year of operation at the Mission mine and the beginning of operations at the Christmas mine, both in Arizona. Stimulated by the demand of Japanese smelters for concentrate, Canada established a record high output. Chilean output rose 6 percent to a record high, and in the Republic of the Congo production was slightly higher than in 1961. Of the other principal producing countries, Peru and Northern Rhodesia recorded decreased outputs.

TABLE 42.—World mine production of copper (content of ore) recoverable where indicated, by countries [1] [2]

(Short tons)

Country	1953–57 (average)	1958	1959	1960	1961	1962
North America:						
Canada [3]	319,189	345,114	395,269	439,262	439,088	465,446
Cuba	18,469	14,343	9,942	[4] 13,058	[5] 5,500	[5] 5,300
Haiti	-------	-------	-------	1,000	3,800	-------
Mexico	62,853	71,609	63,134	66,502	54,359	51,945
Nicaragua	-------	-------	1,001	5,398	6,919	8,016
United States [3]	990,301	979,329	824,846	1,080,169	1,165,155	1,228,421
Total	1,390,812	1,410,395	1,294,192	1,605,389	1,674,821	1,759,128
South America:						
Bolivia (exports)	4,405	3,168	2,461	2,503	2,294	2,645
Brazil [5]	[6] 1,014	1,300	1,500	1,500	1,500	1,400
Chile	470,834	514,925	602,108	591,330	607,233	646,069
Ecuador	11	53	148	111	111	174
Peru	48,646	59,105	[3] 54,914	[3] 200,313	[3] 218,315	[3] 182,877
Total	524,910	578,551	661,131	795,757	829,453	833,165
Europe:						
Albania [5]	666	1,900	2,200	2,400	2,600	2,800
Austria	2,931	2,695	2,726	2,188	2,105	2,168
Bulgaria [5]	6,085	8,600	11,000	12,000	14,000	18,200
Finland	23,900	31,800	32,400	31,000	37,500	38,700
France [7]	402	757	592	619	565	456
Germany:						
East [5]	20,000	19,300	20,800	20,900	27,500	30,700
West	1,696	1,484	1,963	1,960	1,816	1,904
Ireland	-------	[5] 5,300	4,736	6,883	6,534	2,633
Italy [8]	2,091	4,073	3,941	3,301	2,658	[5] 2,900
Norway	15,608	17,501	15,828	16,966	15,379	16,100
Poland [5]	6,500	8,800	9,900	11,600	12,900	14,300
Portugal	718	819	791	579	622	[5] 370
Spain [9]	8,537	7,466	12,137	8,786	10,922	9,920
Sweden	17,025	20,453	19,079	18,369	18,629	21,050
U.S.S.R. [5] [10] [11]	390,000	470,000	480,000	550,000	600,000	700,000
Yugoslavia	34,369	38,840	38,141	36,681	41,786	57,008
Total [5] [10]	531,000	640,000	656,000	724,000	796,000	919,000

See footnotes at end of table.

TABLE 42.—World mine production of copper (content of ore) recoverable where indicated, by countries [1] [2]—Continued

(Short tons)

Country	1953–57 (average)	1958	1959	1960	1961	1962
Asia:						
Burma [5]	125	143	165	160	123	165
China [5]	12,000	35,000	55,000	80,000	110,000	110,000
Cyprus (exports) [9]	32,669	36,614	39,978	39,096	31,585	27,735
India	8,025	9,150	8,900	9,750	9,750	10,910
Israel	----------	287	3,704	4,800	5,300	5,700
Japan	78,998	89,837	93,970	98,307	106,273	113,681
Korea, Republic of	1,107	590	370	454	351	474
Philippines	24,663	51,842	54,587	48,513	57,182	60,327
Taiwan	1,368	1,702	1,793	2,315	2,460	2,323
Turkey	27,719	27,744	30,551	30,110	31,793	31,115
Total [5] [10]	186,700	253,000	289,000	313,500	355,000	362,000
Africa:						
Algeria	229	629	94	152	671	[5] 880
Angola	1,585	1,688	1,932	2,113	1,022	1,250
Congo, Republic of	----------	----------	----------	----------	175	[5] 925
Congo, Republic of the (formerly Belgian) [11]	256,242	261,867	310,955	333,175	325,400	325,442
Morocco	904	1,150	1,306	1,390	1,915	2,716
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia	434,121	441,073	598,835	635,326	633,139	619,856
Southern Rhodesia	1,367	8,430	12,016	15,128	15,243	15,146
South Africa, Republic of	47,586	54,615	54,066	50,846	57,952	51,115
South-West Africa	22,295	30,975	34,436	22,555	27,770	24,971
Tanganyika [12]	826	1,770	1,210	1,404	111	----------
Uganda	[13] 7,312	11,201	[11] 13,377	[11] 16,257	[11] 14,743	[11] 17,173
Total	772,467	813,398	1,028,227	1,078,346	1,078,141	1,059,474
Oceania: Australia	53,506	84,801	106,344	122,567	107,173	118,138
World total (estimate)	3,460,000	3,780,000	4,030,000	4,640,000	4,840,000	5,050,000

[1] Czechoslovakia, Hungary, and Iran also produce copper, but production data are not available. Argentina, Kenya, and Malaya are also producing a small amount of copper. No estimates for these countries are included in the total.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Recoverable.
[4] Exports.
[5] Estimate.
[6] Average annual production, 1955–57.
[7] Includes copper content of auriferous ores.
[8] Includes copper content of cupriferous pyrites.
[9] According to Yearbook of American Bureau of Metal Statistics except 1962. These data do not include content of iron pyrites, the copper content of which may or may not be recovered.
[10] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.
[11] Smelter production.
[12] Copper content of exports and local sales.
[13] Average annual production, 1956–57.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

TABLE 43.—World smelter production of copper, by countries [1]

(Short tons)

Country	1953-57 (average)	1958	1959	1960	1961	1962
North America:						
Canada	286,265	329,239	365,366	417,029	406,359	382,502
Mexico	54,008	67,109	61,105	64,861	52,498	50,177
United States [2]	1,101,946	1,069,052	841,795	1,233,629	1,207,354	1,322,614
Total	1,442,219	1,465,400	1,268,266	1,715,519	1,666,211	1,755,293
South America:						
Chile	438,970	484,678	570,593	556,464	578,068	614,947
Peru	34,197	42,403	38,024	181,650	200,699	164,927
Total	473,167	527,081	608,617	738,114	778,767	779,874
Europe:						
Albania [3]	[4] 800	1,100	1,100	1,200	1,300	1,400
Austria	10,212	10,525	11,601	12,964	13,044	14,186
Bulgaria	4,052	6,748	7,212	8,645	[3] 11,200	[3] 12,000
Finland	24,637	33,873	35,941	34,140	37,800	37,400
Germany:						
East [3]	28,100	27,500	33,000	35,000	35,000	38,000
West [5]	267,337	295,694	310,729	340,695	335,476	339,778
Italy [6]	379	117	405	[3] 440	[3] 440	[3] 440
Norway	15,431	19,365	21,218	23,825	24,218	21,051
Poland	17,519	19,146	19,127	23,961	24,504	26,608
Spain	6,596	5,556	7,660	9,041	20,029	20,580
Sweden	19,389	22,268	27,922	23,927	22,822	25,098
U.S.S.R. [3] [7]	390,000	470,000	480,000	550,000	600,000	700,000
Yugoslavia	33,701	37,117	38,858	39,384	34,027	50,421
Total [3] [7] [8]	818,000	949,000	995,000	1,103,000	1,160,000	1,287,000
Asia:						
China [3] [9]	12,000	35,000	55,000	80,000	110,000	110,000
India	7,803	8,782	8,459	9,822	9,189	10,781
Japan	91,461	131,651	169,318	204,494	232,659	233,828
Korea, Republic of	549	885	825	1,113	1,456	2,436
Taiwan	1,301	1,833	1,986	1,962	2,500	2,746
Turkey	26,674	24,835	27,599	28,674	22,040	28,412
Total [3] [7]	139,800	203,000	263,200	326,100	377,800	388,200
Africa:						
Angola	1,547	1,608	1,782	1,744	937	863
Congo, Republic of the (formerly Belgian)	256,242	261,867	310,955	333,175	325,400	325,442
Rhodesia and Nyasaland, (Federation of:						
Northern Rhodesia	421,943	420,164	595,093	625,958	627,137	602,999
Southern Rhodesia	----------	----------	----------	----------	12,915	13,599
South Africa, Republic of	45,624	53,406	53,842	50,846	57,652	50,905
South-West Africa	----------	----------	----------	----------	----------	1,338
Uganda	[10] 4,265	12,131	13,377	16,257	14,742	17,173
Total	729,621	749,176	975,049	1,027,980	1,038,783	1,012,319
Oceania: Australia	46,832	72,360	76,712	79,561	69,997	72,576
World total (estimate)	3,650,000	3,970,000	4,190,000	4,990,000	5,090,000	5,300,000

[1] This table incorporates some revisions. Data do not add to totals shown due 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: 1953-57 (average), 996,744 short tons; 1958, 992,918; 1959, 799,329; 1960, 1,142,848; 1961, 1,162,480; and 1962, 1,282,126.
[3] Estimate.
[4] Average annual production 1954-57.
[5] Includes scrap.
[6] In addition, Italy produced the following quantities of copper in cement copper in short tons: 1953-57, 5,050; 1958, 5,850; 1959, 6,100; 1960, 5,100; 1961, 5,200; and 1962, not available.
[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 Congo, Republic of the (formerly Belgian); it is not shown here, as that would duplicate output reported under latter country.
[9] Data represents estimated mine production.
[10] Average annual production 1956-57.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

NORTH AMERICA

Canada.[5]—A record output of copper was reported in Canada with mine production 6 percent greater than in 1961. Production curtailments continued at Gaspé Copper Mines, Ltd., and at Noranda Mines, Ltd.; curtailments were begun by The International Nickel Company of Canada, Ltd. (Inco), in the last quarter of the year. Waite Amulet Mines, Ltd., ceased operations in October. Output was reported from New Brunswick Province for the first time since 1958 when the Wedge mine began production in January. The substantial increase of production in British Columbia, resulting from shipments of concentrates to Japan, was largely responsible for Canada's record output. Production of 53,700 tons in British Columbia was 3 percent greater than in the previous record year of 1929.

The International Nickel Company of Canada, Ltd., Canada's leading producer, mined 13.8 million tons of ore from mines in Ontario and Manitoba, compared with 17.5 million tons in 1961. The lower output resulted from a 10-percent curtailment, effective in the fourth quarter of 1962. Scheduled capacity of the Clarabelle open-pit mine was attained in the second quarter, but production was suspended at the Ellen pit. Development of the Creighton, Garson, and Murray mines, in preparation for deep-level exploration, was continued. Deliveries of copper totaled 133,600 tons (134,400 in 1961), of which 60 percent was sold in Canada. The remainder went mostly to the United Kingdom.

Falconbridge Nickel Mines, Ltd., delivered 2.4 million tons of ore from company mines, compared with 2.5 million tons in 1961. More than half of the output came from mines in the northern area of the Sudbury basin (Hardy, Boundary, Onaping, and Fecunis). The Onaping mine, which began production in late 1961, offset the loss of ore caused by the closing of the Longvack mine and lower production from the Hardy mine. The remainder of the ore came from the southern area mines—Falconbridge and East. The company delivered 16,900 tons of copper to customers, 13 percent less than in 1961.

Geco Mines, Ltd., produced 1.3 million tons of ore from its copper-zinc mine in the Manitouwadge area. The mill produced 82,100 tons of concentrate containing 26.70 percent copper, which was shipped to the Noranda smelter. Copper production totaled 22,000 tons.

Noranda Mines, Ltd., Quebec, mined 1.3 million tons of ore averaging 1.98 percent copper from the Horne mine. The mill treated 901,500 tons of ore and produced 177,000 tons of copper concentrate. A total of 1.6 million tons of ore, including 0.8 million tons of custom ore, was smelted. Total output was 160,400 tons of copper in anodes. Production of copper from the Horne mine was 25,000 tons.

Canadian Copper Refiners, Ltd. (a subsidiary of Noranda and one of the two electrolytic refineries in Canada), produced 255,000 tons of refined copper, compared with 254,000 tons in 1961.

[5] A substantial part of the information in this section was taken from Mineral Information Bulletin MR 63. A Preliminary Survey of the Canadian Mineral Industry in 1962, Mineral Resources Division, Department of Mines and Technical Surveys, Ottawa, 1963. Killin, A. F. Copper, pp. 9–13.

Gaspé Copper Mines, Ltd., a subsidiary of Noranda, mined 2.8 million tons of ore, of which 37 percent came from the open pit. The smelter treated 288,600 tons of concentrate and fluxing ore, of which 70,500 tons was custom concentrate. Copper production totaled 47,700 tons.

After more than a quarter century of operations, mining ceased on October 26 at the Waite Amulet and Amulet Dufault mines of Waite Amulet Mines, Ltd., a subsidiary of Noranda. In the 26-year period, 9.7 million tons of ore averaging 4.5 percent copper was mined.

The Quemont Mining Corp., Ltd., concentrator treated 804,600 tons of ore averaging 1.25 percent copper. Copper concentrate, smelted at Noranda, totaled 52,300 tons and contained 9,100 tons of copper.

TABLE 44.—Canada: Copper production (mine output), by Provinces

(Short tons)

Province	1953-57 (average)	1958	1959	1960	1961	1962 (preliminary)
British Columbia	21,691	6,010	8,121	16,559	15,845	53,709
Manitoba	15,518	12,601	12,945	12,793	12,454	10,934
New Brunswick	1,156	328				6,628
Newfoundland	3,398	14,751	14,989	13,863	15,752	18,342
Northwest Territories	33	434	494	520	463	304
Nova Scotia	642					245
Ontario	149,148	142,035	188,272	206,272	211,647	184,683
Quebec	94,916	131,445	134,912	157,470	149,007	151,390
Saskatchewan	32,687	37,510	35,536	31,785	33,479	32,126
Yukon Territory					441	229
Total	319,189	345,114	395,269	439,262	439,088	458,590

Source: Dominion Bureau of Statistics, Department of Trade and Commerce, Government of Canada, Preliminary Report on Mineral Production, 1962.

The Normetal Mining Corp., Ltd., concentrator treated 355,000 tons of ore averaging 2.71 percent copper. Concentrate production of 38,400 tons, shipped to the Noranda smelter, contained 9,000 tons of copper.

Sullico Mines, Ltd., a subsidiary of East Sullivan Mines, Ltd., mined and milled 997,400 tons of ore averaging 0.723 percent copper. Copper production totaled 6,600 tons.

Production began in February at Hastings Mining & Development Co., Ltd., a subsidiary of Solbec Copper Mines, Ltd. The initial milling rate of 500 tons of ore per day was increased until 1,000 per day was treated in October. A total of 158,100 tons of ore, averaging 1.68 percent copper, was treated, and 2,300 tons of copper was produced. Cupra Mines, Ltd., continued to develop its mine 2.5 miles south of the Solbec plant. The ore reserve was estimated at 859,900 tons averaging 3.64 percent copper. Mining operations were expected to begin in 1964.

Five mining divisions of Campbell Chibougamau Mines, Ltd., produced 704,600 tons of ore averaging 2.15 percent copper in the 1961-62 fiscal year. The Henderson Division supplied 338,600 tons, more than double the 1960-61 tonnage, and accounted for 48 percent of the total ore produced. The Main Mine Division furnished 48,400 tons, Winze 18,800 tons, Kokko Creek 91,200 tons, and Cedar Bay 207,600 tons.

The ore reserve at Kokko Creek was expected to be exhausted in early 1963. Copper concentrate received at the Noranda smelter totaled 57,400 tons, and 14,500 tons of blister copper was shipped.

Copper Rand Mines Division, The Patiño Mining Corp., formerly Copper Rand Chibougamau Mines, Ltd., mined and milled 639,700 tons of ore averaging 2.48 percent copper. Of the total ore, the Copper Rand mine supplied 360,000 tons, Portage mine 201,900 tons, and Jacquet mine 70,200 tons. The remainder, 7,600 tons, was development ore from the Bouzan mine. Copper concentrate shipments totaled 59,600 tons and contained 15,200 tons of copper.

Opemiska Copper Mines (Quebec) Ltd. mined and milled 544,500 tons of ore averaging 2.95 percent copper in 1962. Operations were adversely affected by a strike, which began October 20, 1961, and ended April 1, 1962. The most serious effect was the delay in the development of the Perry mine. Copper production totaled 15,400 tons.

Willroy Mines, Ltd., produced 495,000 tons of ore averaging 1.70 percent copper from its mine in the Manitouwadge district. Copper concentrate containing 23.40 percent copper was shipped to the Noranda smelter and yielded 7,200 tons of blister copper.

Production in Newfoundland rose 16 percent in 1962, reflecting the first full year of operation of the Little Bay property of Atlantic Coast Copper Corp., Ltd. The company milled 351,700 tons of ore averaging 1.31 percent copper and produced 16,500 tons of concentrate. Copper production was 4,200 tons.

The Consolidated Mining & Smelting Co. of Canada, Ltd. (Comico), New Brunswick, began shipping ore from the Wedge mine in January; 750 tons of ore per day was sent to the Heath Steele Mines, Ltd., mill. Heath Steele continued the exploration and development of its zinc-copper mine, 35 miles north of Newcastle. Production began in June and was to be increased to 750 tons per day. Brunswick Mining & Smelting Corp., Ltd., was constructing a 3,000-ton-per-day mill at its No. 12 mine near Bathurst.

Hudson Bay Mining & Smelting Co., Ltd., and Sherritt Gordon Mines, Ltd., furnished all the copper produced in Saskatchewan and Manitoba. These Provinces accounted for 9 percent of Canada's output in 1962.

Hudson Bay Mining & Smelting Co., Ltd., mined and milled 1.7 million tons of ore, of which 55 percent came from the Flin Flon mine, 20 percent from Coronation, 20 percent from Chisel Lake, and 5 percent from Schist Lake. In addition, 7,200 tons of Coronation ore was shipped to the smelter for direct smelting, and some purchased ore was treated. Copper concentrate produced totaled 291,600 tons averaging 12.88 percent copper. The smelter treated 387,000 tons of Hudson Bay concentrate, residue, and direct smelting ore, and 10,200 tons of custom concentrate. Blister copper shipped to the refinery totaled 37,600 tons, and 37,000 tons of refined copper was produced. Preparation of the Stall Lake mine for production in the latter part of 1963 (when the Coronation mine will be exhausted) continued and development of the Osborne Lake mine began.

Sherritt Gordon Mines, Ltd., mined and milled 1.3 million tons of nickel-copper ore. Copper concentrate smelted at Flin Flon contained

5,300 tons of copper (5,600 tons in 1961). Sales of copper totaled 5,600 tons, compared with 5,400 tons in 1961. Diamond drilling indicated a substantial tonnage of copper-zinc ore at Fox Lake, 28 miles southwest of Lynn Lake.

The revival of copper mining in British Columbia, that began in 1960, resulted in the Province attaining third place among producing Provinces. The record output was due to the large demand of Japanese smelters for concentrates. Craigmont Mines, Ltd., which produced nearly three-fourths of the copper in British Columbia, shipped most of its concentrate to Japan. Production was begun at the Sunro mine of Cowichan Copper Co., Ltd., in March; concentrate from the 1,500-ton-per-day underground mill was shipped to Japan. In September, The Consolidated Mining & Smelting Co. of Canada, Ltd., started production at the Benson Lake property of Coast Copper Co., Ltd.; output was shipped to Japan for smelting. The 3,300-ton-per-day concentrator of Bethlehem Copper Corp., Ltd., was started in December and concentrate was to be sent to Japan.

Phoenix Copper Co., Ltd., a subsidiary of The Granby Mining Co., Ltd., treated 554,700 tons of ore averaging 0.8 percent copper. Production of copper totaled 3,400 tons. Expansion of the mill from 1,000 tons per day to 1,500 tons per day was completed in April. A 4-year sales contract was completed with Sumitomo Shoji Canada, Ltd., and Sumitomo Metal Mining Co., Ltd. Effective January 1, 1963, Phoenix concentrates were to be shipped to the Sumitomo smelter, Niihama, Japan.

North Rankin Nickel Mines, Ltd., Northwest Territories, ceased operations at its nickel-copper mine in October, and operations were suspended at the Johobo mine of Dominion Explorers, Ltd., Yukon Territory.

Production of refined copper in Canada dropped 6 percent to 382,500 tons. Consumption of refined copper totaled 151,500 tons, 7 percent more than in 1961 and 4 percent more than in the previous peak year of 1956 (145,000 tons).

Exports of copper in ore, concentrate, and matte were more than double those in 1961. Of the total of 95,500 tons (42,900 in 1961), 46,200 (2,200) went to Japan, 20,700 (14,700) to the United States, 17,200 (19,400) to Norway, 5,000 (600) to West Germany, 2,300 (2,900) to Spain, 1,900 (900) to Belgium-Luxembourg, 1,800 (2,200) to the United Kingdom, and 400 (none) to Portugal. Exports of ingots, bars, and billets were as follows:

Destination:	Short tons 1961	Short tons 1962
United Kingdom	115, 859	93, 693
United States	64, 189	76, 506
France	15, 885	13, 928
Germany, West	13, 355	11, 907
Sweden	4, 894	5, 376
Belgium-Luxembourg	5, 745	4, 951
Poland	6, 103	4, 759
India	673	3, 440
Japan	11, 207	2, 937
Italy	3, 497	2, 160
Australia	2, 239	1, 288
Other countries	22, 601	2, 098
Total	266, 247	223, 043

In addition, 27,700 tons of rods, strips, sheet, and tubing was shipped, of which 6,700 tons went to Norway, 5,000 tons to Switzerland, 3,500 tons to the United States, 3,200 tons to the United Kingdom, 2,900 tons to Denmark, 1,600 tons to New Zealand, and 1,400 tons to Pakistan.

Mexico.—Cananea Consolidated Copper Co., S. A., Sonora, produced 33,800 tons of copper, 57 percent more than in 1961. The entire output was shipped to Cobre de Mexico, S. A., Mexico City, for refining. Removal of waste from the new open pit was accelerated by additional equipment acquired in 1962.

SOUTH AMERICA

Chile.—Copper production in Chile reached a record high of 646,000 tons, a 6-percent increase over that in 1961. Labor disturbances at El Salvador and La Africana mines and announced production curtailments prevented even higher copper output.

Production of copper at the Chuquicamata mine of Chile Exploration Co., a subsidiary of The Anaconda Company, totaled 304,000 tons, compared with 275,200 tons in 1961. The concentrator expansion program was completed in October.

The El Salvador mine of Andes Copper Mining Co., another Anaconda subsidiary, produced 90,900 tons of copper, compared with 80,000 tons in 1961. Operations were interrupted by a 40-day strike. Construction of an electrolytic refinery, for operation in late 1963, was begun at Potrerillos.

La Africana mine of Santiago Mining Co., also an Anaconda subsidiary produced 21,400 tons of concentrate containing 28.5 percent copper, compared with 25,300 tons in 1961. The 16-percent decrease resulted from a 75-day strike.

The Braden Copper Co., a subsidiary of Kennecott Copper Corp., mined and milled 11.5 million tons of ore from the El Teniente mine, compared with 10.7 million tons in 1961. The grade of ore mined was 1.96 percent copper (1.91 percent in 1961). Refined-copper production was 181,300 tons, compared with 173,300 tons in 1961. (Production of 175,900 tons shown in the 1961 copper chapter was on a smelter basis.) Virtually all Braden copper continued to be sold to European markets and consisted of 42 percent fire-refined copper, 27 percent electrolytic copper, and 31 percent blister copper. In September, production was curtailed by reducing the workweek from 7 to 6 days.

The Paipote smelter operated by the Government's Empresa Nacional de Fundiciones produced 33,600 tons of blister copper. The Las Ventanas smelter, expected to begin operations by mid-1964, was expected to produce 26,500 tons of blister copper annually. Output of the small- and medium-size mines totaled 31,100 tons of copper in ore, concentrate, and cement copper. Fire-refined copper produced from these operations was 18,900 tons.

In mid-December, a contract was awarded for construction of an electrolytic refinery near the Las Ventanas smelter. Initial capacity was to be 61,700 tons of wire bars annually with possible expansion to 132,300 tons. Blister copper for refining was to be supplied by the Las Ventanas and Paipote smelters.[6] Construction was expected to begin in mid-1963 for completion by late 1965.

In addition to the exports shown in table 45, 25,200 tons of copper in ore and concentrate was shipped, of which 16,100 tons went to Japan, 6,500 tons to West Germany, 1,500 tons to Poland, 800 tons to the United States, and 300 tons to Sweden.

TABLE 45.—Chile: Exports of copper, by principal types

(Short tons)

Destination	1961 [1]				1962			
	Refined		Blister	Total	Refined		Blister	Total
	Electrolytic	Fire refined			Electrolytic	Fire refined		
Argentina		460		460	3,208	1,174		4,382
Belgium	924	3,256		4,180	111	2,273	8,618	11,002
Brazil		1,079		1,079	10,786	9,792		20,578
Czechoslovakia		112		112		1,119		1,119
France	10,442	332		10,774	10,447	1,054		11,501
Germany, West	22,766	17,396	46,795	86,957	27,732	12,562	39,358	79,652
Italy	11,872	12,273	1,498	25,643	16,570	19,448	771	36,789
Japan		402		402		995		995
Netherlands	67,384	3,792		71,176	52,297	3,419	84	55,800
Sweden	22,871	604	2,405	25,880	24,182	1,513	2,104	27,799
United Kingdom	25,536	34,736	52,938	113,210	36,021	28,316	44,841	109,178
United States	400	1,750	229,256	231,406	883		228,771	229,654
Yugoslavia		729		729				
Other countries						896		896
Total	162,195	76,921	332,892	572,008	182,237	82,561	324,547	589,345

[1] Revised figures.

Peru.—Production of copper by Cerro de Pasco Corp. (Cerro-Peru) from company mines and purchased ores totaled 37,900 tons, compared with 40,500 tons in 1961. The 6-percent decrease was caused largely by the closure of the smelter as a result of strikes.

Southern Peru Copper Corp. produced 9.3 million tons of ore averaging 1.51 percent copper at Toquepala. Blister copper output totaled 126,000, compared with 160,000 tons in 1961. Decreased production was caused by strikes and continuing decline in the grade of ore. Normal development of the mine resulted in the early mining of ore of much higher grade than the average for the ore body; therefore production of blister in 1961 was higher than it was expected to be in the future. About 45 percent of the output was sold in Europe through Southern Peru Copper Sales Corp. The remainder went to the four U.S. stockholders.

Exports of copper by type and country of destination are shown in table 46.

[6] Bureau of Mines. Mineral Trade Notes. V. 26, No. 3, March 1963, p. 9.

TABLE 46.—Peru: Exports of copper, by types, in 1962

(Short tons)

Destination	Ore, concentrate, and cement copper	Blister	Refined	Total
Argentina			2,008	2,008
Belgium		16,915		16,915
Brazil			8,125	8,125
Germany, West	319	22,967	9,934	33,220
Iran			771	771
Japan	9,266		367	9,633
Netherlands			5,037	5,037
Sweden	446			446
United Kingdom	44	19,855	14,710	34,609
United States	7,730	69,871		77,601
Total	17,805	129,608	40,952	188,365

EUROPE

Finland.—Most of the copper, the major nonferrous metal produced in Finland, came from mines of Otokumpu Oy. Production of 2.6 million tons of ore, 23 percent more than in 1961, was attributed largely to the beginning of operations at the Pyhäsalmi pyrite mine in August. The plant at Kokkola was completed in early 1962 and the treatment of Pyhäsalmi concentrates was begun during the summer. Copper production was as follows:

Mine	Ore (short tons)	Copper concentrate (short tons)	Copper (short tons)
Outokumpu	772,900	133,300	28,700
Ylöjärvi	349,800	10,700	2,400
Vihanti	490,800	13,600	3,600
Kotalahti	490,100	3,200	800
Pyhäsalmi	422,300	34,200	7,500
Total	2,525,900	195,000	43,000

In addition, 61,000 tons of ore was produced at the Korsnäs lead mine.

The Harjavalta smelter treated 176,200 tons of copper concentrate and 5,800 tons of copper scrap; copper production totaled 42,200 tons. The Pori plant produced 37,300 tons of copper cathodes, 36,700 tons of copper castings, 13,300 tons of brass castings, 6,100 tons of rolled products, and 10,500 tons of drawn products. Expansion of the electrolytic section of the plant was virtually completed by yearend.[7]

United Kingdom.—Consumption of primary and secondary copper in the United Kingdom was virtually unchanged from 1961; 579,900 tons was consumed, compared with 582,900 tons in 1961. Consumption of copper in scrap, however, fell from 180,400 tons to 147,300 tons, an 18-percent decrease, and total consumption dropped by 5 percent. Of the total of 727,200 tons consumed, 560,300 tons of refined copper and 83,700 tons of copper in scrap were used for semimanufactured products, and 19,500 tons of refined copper and 63,700 tons of copper in

[7] Edmond, Lester E. (counselor of Embassy for Economic Affairs, Helsinki, Finland), Mineral Industry—Finland 1962. State Department Dispatch A-870, May 11, 1963, 3 pp.

scrap were used for castings, copper sulfate, and miscellaneous products.

Copper sulfate production totaled 25,600 tons, 23 percent less than in 1961.

Industry inventories rose from 146,700 tons to 178,600 tons at the end of 1962.

Imports of copper into the United Kingdom are shown in table 47.

TABLE 47.—United Kingdom: Imports of copper, by countries

(Short tons)

Source	1961			1962		
	Blister	Electrolytic	Fire refined	Blister	Electrolytic	Fire refined
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia	80, 560	202, 470	829	43, 194	213, 078	1, 540
Chile	50, 402	21, 506	33, 861	50, 250	36, 541	29, 215
Canada		112, 890			98, 240	
United States	1, 025	49, 276	4, 481		53, 275	1, 063
Peru	22, 408			23, 024	6, 718	
Germany, West	34	547			22, 789	
Australia		4, 797			3, 196	
Congo, Republic of the		4, 043			3, 080	
South Africa, Republic of		101	593			1, 960
Spain					1, 915	
Belgium		815			772	
Norway		1, 463			342	
Other countries	3	28	19		171	275
Total	154, 432	397, 936	39, 783	116, 468	440, 117	34, 053

Source: British Bureau of Nonferrous Metal Statistics.

Exports and reexports of refined copper totaled 136,000 tons, 55 percent more than in 1961. Shipments by country of destination are shown in table 48. Blister copper had not been reexported since 1957.

TABLE 48.—United Kingdom: Exports and reexports, by countries

(Short tons)

Destination	1961	1962	Destination	1961	1962
Belgium	10, 573	47, 601	Argentina	5, 494	2, 768
Germany, West	5, 111	15, 221	Egypt	1, 531	2, 498
Poland	6, 847	14, 632	Hungary	3, 737	2, 107
Germany, East	13, 188	11, 173	Rumania	924	1, 960
Netherlands	7, 737	7, 936	France	1, 485	1, 543
Czechoslovakia	13, 420	7, 036	Other countries	9, 852	5, 989
China	3, 572	6, 269			
U.S.S.R	3, 286	5, 132	Total	87, 595	135, 960
Sweden	838	4, 095			

Source: British Bureau of Nonferrous Metal Statistics.

Yugoslavia.—Mine production rose substantially in 1962, reflecting increased output from the Majdanpek mine. The largest European open-pit porphyry copper mine had an initial output of 13,200 tons of ore per day, yielding 27,600 tons of copper per year.[8] Capacity could be doubled within a few years by purchasing additional equipment and by expanding the concentrator. Concentrates are smelted at Bor.

[8] Knoerr, A. W. Majdanpek. Eng. and Min. J., v. 163, No. 9, September 1962, pp. 77–88.

ASIA

Cyprus.—Cyprus Mines Corp. mined 721,400 tons of ore averaging 2.84 percent copper from its Mavrovouni mine, compared with 742,900 tons and 3.35 percent in 1961. Production of 120,800 tons (225,400 in 1961) consisted of 72,700 tons of copper concentrate, 46,600 tons of cupreous pyrite, and 1,500 tons of precipitate. In addition, 512,700 tons of pyrite was produced by flotation. Work was begun in March on the Skouriotissa-Apliki open-pit mines; modernization of the mill was to be completed and treatment of ore begun in the third quarter of 1963.

India.—National Development Corp., an agency of the Indian Government, was to operate the Khetri copper mines in the Khetri-Daribo region. Initial output of 22,000 tons annually was planned. Also plans included construction of a refinery and an ultimate refined-copper output of 33,000 tons per year for India. In 1962, all of the refined copper in India was produced at the Indian Copper Corp. refinery at Ghatsila.

Philippines.—With decontrol of the peso on January 21, 1962, the mining industry changed considerably. Most of the expansion in mining was to be in the copper industry where prospects considered marginal or uneconomical before decontrol had become sound business ventures. During most of 1962, the export dollar was 3.52 pesos, compared with 2.75 in the latter part of 1961, or the official rate of 2 pesos to the dollar in recent years. Decontrol, however, was not complete because exporters still had to pay 20 percent of export receipts to the Central Bank; Philippine mining was expected to continue to be an export industry for the next few years.[9]

Atlas Consolidated Mining & Development Corp., the largest producer, increased output from 23,300 tons in 1961 to 25,600 tons. The company operated a 12,000-ton-per-day concentrator and two open-pit mines near Lutopan on Cebu Island.

Lepanto Consolidated Mining Co., Ltd. milled 476,100 tons of ore containing 3.14 percent copper and produced 50,000 tons of 28.61-percent copper concentrate. The output of copper totaled 14,300 tons.

Turkey.—According to a report that described industrial activities pertaining to copper, mining was resumed after a long period of inactivity when operations began at Kuvarshan in 1937.[10] The Ergani mine came into production in 1939, but output did not increase appreciably until 1951 when the Murgul mine began operating. Blister copper production rose from 16,300 tons in 1951 to 25,700 tons in 1952 and reached 28,700 tons in 1960. The Kuvarshan mine was closed in 1945, and the Küre mine was brought into production in 1955.

Blister copper production was a record high at the Murgul mine during 1962. A total of 563,700 tons of ore averaging 1.91 percent copper was milled, and 10,100 tons of blister copper was produced. At the Ergani mine, 162,800 tons of smelting ore averaging 8.37 percent copper was produced. In addition, 123,700 tons of ore averaging 5.61 percent copper was milled, and 1,600 tons of cement copper

[9] Fisher, Glen H. (minerals officer, Manila, Philippines). Minerals Industry Report. State Department Airgram A-1052, May 3, 1963, 10 pp.
[10] Bureau of Mines. Mineral Trade Notes. V. 56, No. 2, February 1963, pp. 9–28.

(63.40 percent copper) from leaching operations was produced. Blister copper totaled 18,300 tons.

A decision was not reached on the process for the new concentrator and refinery, but Etibank abandoned the plan to recover cobalt contained in the Ergani ore. The possibility of building a third copper plant in the Black Sea area was being studied. Application had been made to Agency for International Development (AID) for a loan to finance a study for constructing a centrally located smelter to treat flotation concentrates from Murgul and Espiye and possibly the Küre cupreous pyrite deposit near Inebolu.

AFRICA

Congo, Republic of the.—Operations of Union Minière du Haut-Katanga, the only producer, were interrupted twice during 1962 by political and military events. The Lubumbashi plant and Kipushi mine, closed in December 1961, resumed operations in February and March, and in late December 1962 all facilities were closed because of lack of power caused by damage to power stations. Production, reduced by 10 percent in 1961, was lowered by an additional 5 percent effective July 1, 1962. The Luilu plant operated at capacity during 1962, compensating for loss of output at the Lubumbashi plant, and total production of 325,400 tons was slightly higher than in 1961 (323,500 tons). The new Kakanda concentrator began operations October 30.

A total of 10.1 million tons of ore was produced. Of this total, 7.0 million tons came from mines in the Western Group (Kamoto 3.0, Ruwe 2.7, Musonoi 0.8, and Kolwezi 0.5). The Kambove mine in the Central Group produced 2.0 million tons, and the Prince Leopold mine in the Southern Group produced 1.0 million tons. The remainder came from miscellaneous properties.

The Kolwezi mill treated 4.4 million tons of ore consisting of 3.7 million tons of siliceous oxide ore, mainly from Kamoto, and 746,200 tons of oxide-sulfide ore from Musonoi. The oxide ore was treated in three sections of the concentrator for 6 months and in all five sections for the rest of the year. Concentrate production totaled 758,400 tons containing 25.59 percent copper. The mixed oxide-sulfide ore was treated by sulfidizing and flotation in two sections from January to May and from September until November; 81,500 tons of concentrate averaging 31.16 percent copper was produced. The Kipushi mill treated 970,800 tons of copper and zinc ores from the Prince Leopold mine and produced 190,100 tons of 26.12-percent copper concentrate and 184,100 tons of 57.33-percent zinc concentrate. The Kambove concentrator treated 971,700 tons of mixed ore from the Kambove West mine by sulfidizing and flotation and produced 153,900 tons of concentrate averaging 31.75 percent copper. A washing plant began operations on October 12 to treat stocks of talcose oxide ore. A total of 11,400 tons of ore was treated, and 4,700 tons of products containing 7.46 percent copper was sent to the concentrator.

The new mill at Kakanda started in October and treated 86,000 tons of stockpiled siliceous oxide ore. Production totaled 7,700 tons of 22.53-percent copper concentrate. Initial capacity of the mill was 66,000 tons of ore per month. The Ruwe concentrator produced 97,700 tons of concentrate containing 22.28 percent copper and 108,100 tons of 5.10-percent copper products that required further treatment. The Ruashi washing plant treated 82,600 tons of ore, mainly from the Ruashi mine, that yielded 14,800 tons of concentrate averaging 17.56 percent copper; the plant also produced 9,700 tons of products that had to be retreated.

Production of copper at the Lubumbashi smelter was 11 percent lower than in 1961. Production of matte was halted at the end of October to permit production of raw material for conversion to anode copper at the Jadotville-Shituru plants. At the electrolytic plant at Shituru, output rose 18 percent and the Luilu plant recorded a 4-percent increase. Most of the cathode production was exported to Belgium for refining, and the remainder went to Jadotville. At the Jadotville electric smelter, the furnaces were shut down at the end of September. Total production was as follows:

	Short tons
Lubumbashi (blast furnaces and converters)	148,132
Jadotville-Shituru (leaching, electrolysis, and refining)	114,054
Luilu (leaching and electrolysis)	61,495
Jadotville-Panda electric smelter (recoverable copper in white cobalt alloy)	344
Recoverable copper in zinc, lead, and germanium concentrates and miscellaneous products	1,417
Total	325,442

Rhodesia and Nyasaland, Federation of.—Northern Rhodesia ranked behind the United States and Chile in free-world copper production, having dropped 2 percent below that of 1961. Increased output of Mufulira Copper Mines, Ltd., was partly offset by a 3-week strike at Rhodesian mines in May. A 10-percent production curtailment, in effect throughout fiscal year 1962, was increased to 15 percent in July.

On May 21 Rhodesian Selection Trust Group (RST) announced that development of the Chambishi mine would be undertaken. The Chambishi mine and the Baluba mine were two large undeveloped properties that RST has owned for 30 years. Preparation of the Chambishi and Baluba mines was postponed until the Roan Antelope and Mufulira mines were in production. Further delay was caused by World War II and by the decision of the Group to bring into operation a third mine, Chibuluma, following devaluation of the pound sterling in 1949; and later to the expansion program at Mufulira. The merger of Roan Antelope Copper Mines, Ltd., and RST companies in 1962 strengthened the financial position of the Group and would enable development of Chambishi. The mine, which was to be started as an open pit, had reserves of 35 million tons of oxide and sulfide ore averaging 3.37 percent copper. The oxide ores were to be mined first, because they were uppermost. A production rate of 8,400 tons of copper per year was expected in 1964, and 28,000 tons per year was expected by 1967.

Roan Antelope Division of Rhodesian Selection Trust, Ltd., mined and milled 5.4 million tons of ore averaging 1.85 percent copper in the fiscal year ended June 30, 1962. A total of 88,300 tons of anode copper was produced and, except for 5,000 tons produced as fire-refined copper, was sent to the Ndola plant for electrolytic refining. Refined-copper production totaled 84,700 tons.

Ndola Copper Refineries, Ltd., produced 107,700 tons of refined copper, of which 83 percent was for RST companies. The casting plant produced 84,700 tons of wirebars, and 22,900 tons was shipped as cathodes.

Rhodesia Copper Refineries, Ltd., produced 220,000 tons of refined copper in the fiscal year ended June 30, 1962, compared with 235,400 tons in the 1961 fiscal year. The company refined the outputs of the Rhokana and Nchanga mines.

At Nchanga Consolidated Copper Mines, Ltd., 4.8 million tons of ore averaging 5.52 percent copper was mined during the fiscal year ended March 31, 1962. The Nchanga West ore body supplied 3.4 million tons; Nchanga open pit, 1.0 million; and Chingola open pit, 0.4 million. Ore milled totaled 4.7 million tons and yielded 233,100 tons of copper in concentrate. Production of copper was 218,400 tons—19,600 tons of blister copper and 198,800 tons of electrolytic copper. Work continued on the expansion program; a leach plant to treat low-grade oxide ores was expected to be completed during the fiscal year and construction was to begin on a roasting plant for low-grade sulfide ores. The expansions would increase output by 16,800 tons of copper per year from current grades of ore at the present rate of mining.

At Rhokana Corporation Ltd., 5.3 million tons of ore averaging 2.44 percent copper was mined and milled in the fiscal year ended June 30, 1962. Production of concentrates totaled 345,200 tons averaging 33.79 percent copper and 0.62 percent cobalt. Copper production totaled 117,000 tons, of which 17,000 tons was blister and 100,000 tons was electrolytic. The smelter produced 306,100 tons of anode and blister copper, compared with 314,400 tons in fiscal year 1961. Of the total, 17,000 tons was blister and 99,000 tons was anode for Rhokana, 19,000 was blister and 118,000 was anode for Nchanga, and 53,100 was blister for Bancroft, and 130 tons of blister for others.

Chibuluma Mines, Ltd., mined and milled 501,100 tons of ore averaging 4.12 percent copper. Concentrate production totaling 61,000 tons was treated at the Mufulira smelter. Anode copper output was 18,700 tons, all of which was fire refined.

Mufulira Copper Mines, Ltd., mined 5.2 million tons of ore averaging 2.79 percent copper in the fiscal year ended June 30, 1962. Anode copper produced totaled 127,200 tons, compared with 113,200 tons in 1961 (excludes 22,600 tons from scrap). Most of the anode copper was sent to the refinery, and 93,300 tons of electrolytic copper was produced. The Mufulira expansion program announced in 1956 was completed during 1962. A production rate of 672,000 tons of ore per month and an estimated annual capacity of 168,000 tons of copper were assured.

Bancroft Mines, Ltd., mined and milled 1.8 million tons of ore averaging 3.59 percent copper. Concentrates treated at the Rhokana smelter yielded 53,100 tons of blister copper.

Production of copper in Southern Rhodesia came from mines of Messina (Transvaal) Development Co., Ltd., and M.T.D. (Mangula) Ltd. In the fiscal year ended September 30, 1962, 973,600 tons of ore from the Messina mine was milled and 14,500 tons of copper was produced; 87,500 tons from Umkondo was milled and 1,900 tons of copper in concentrates was produced; and 156,100 tons from Alaska was milled and 1,900 tons of copper in concentrates was produced. At the Mangula mine, 1.2 million tons of ore was milled and 13,500 tons of copper in concentrates was produced. Copper concentrate treated at the Alaska smelter, operated by The Messina Rhodesian Smelting and Refining Co., yielded 14,600 tons of copper.

South Africa, Republic of.—O'okiep Copper Co., Ltd., milled 1.8 million tons of ore averaging 2.27 percent copper in the fiscal year ended June 30, 1962. The smelter treated 141,100 tons of concentrate and other material and produced 39,700 tons of blister copper, compared with 38,900 tons in fiscal 1961. Exploration at the East O'okiep mine substantially increased ore reserves and extended the life of the mine several years beyond expected exhaustion in1963. Construction of the mill and development of the Carolusberg ore body were ahead of schedule, and production of 35,000 tons of ore per month would begin in early 1963. Completion of the mill to the capacity of 110,000 tons was postponed until exhaustion of the O'okiep mine.

Palabora Mining Co., Ltd., completed its underground development program and pilot plant design on a low-grade copper deposit in northeastern Transvaal. The open-pit mine was expected to yield 300 million tons of 0.69-percent copper ore; 33,000 tons of ore per day was to be treated to produce 80,000 tons of copper per year during the first 5 years.

South-West Africa.—Tsumeb Corp., Ltd., milled 714,900 tons of ore averaging 4.68 percent copper in the fiscal year ended June 30, 1962. Sales of copper totaled 28,100 tons, compared with 23,900 tons in the 1961 fiscal year. The copper smelter was completed in November, and output of blister copper was begun. The Kombat mine started production in April, and 102,700 tons of ore averaging 3.22 percent copper was milled by the end of 1962.

Uganda.—Kilembe Mines, Ltd., milled 982,600 tons of ore, compared with 920,100 tons in 1961. Blister copper production totaled 17,200 tons (14,700 in 1961).

OCEANIA

Australia.—Mount Isa Mines, Ltd., Queensland, a subsidiary of American Smelting and Refining Company, treated 2.7 million tons of ore in the fiscal year ended June 30, 1962. Refined-copper production was 43,600 tons, and 14,000 tons of copper in concentrate was exported.

The increase in refining capacity to 85,000 tons per year at Copper Refineries Pty., Ltd., Townsville, was completed, and work continued on the expansion program to increase milling rate to 16,000 tons per day.

Mount Morgan, Ltd., Queensland, milled 1.3 million tons of ore, a record tonnage, in the fiscal year ended June 30, 1962. Concentrates produced contained 9,400 tons of copper. The production of 10,300 tons of blister copper was an alltime record and resulted from smelting of concentrates accumulated when the smelter was rebuilt in the latter part of 1961.

The Mount Lyell Mining and Railway Co., Ltd., Tasmania, mined and milled 2.3 million tons of ore averaging 0.648 percent copper in the June 30, 1962, fiscal year. Concentrates produced totaled 50,600 tons. Blister copper production was 13,800 tons, and electrolytic copper output was 13,200 tons.

TECHNOLOGY

The Bureau of Mines published the results of laboratory experiments on processing copper ores, smelter slags, and blister copper.[11]

The results of studies of hydraulic backfill systems was published.[12] The work was done partly under a fellowship agreement cosponsored by the Bureau of Mines and the Montana School of Mines, Missoula, Mont.

Information was published also on mining methods, cost accounting, and monthly movement of major statistical measures for base metal industries.[13]

The Geological Survey published information on mining districts and copper deposits in Arizona, California, and Nevada.[14] Two geologic maps pertaining to copper were published.

The International Copper Research Association (originally Copper Products Development Association) initiated 37 technical studies in laboratories of private research institutions and universities in the United States, Canada, and Europe.[15] The research was oriented toward expanding uses of copper and copper alloys. Copper in gray

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[11] Brantley, F. E., and C. H. Schack. Deoxidization of Blister Copper by Gaseous Reduction. BuMines Rept. of Inv. 6113, 1962, 12 pp.

Colombo, A. F., and D. W. Frommer. Leaching Michigan Copper Ore and Mill Tailing With Acidified Ferric Sulfate. BuMines Rept. of Inv. 5924, 1962, 12 pp.

Fursman, O. C. Recovery of Mineral Values in Cupriferous and Nickeliferous Pyrrhotite. BuMines Rept. of Inv. 6043, 1962, 24 pp.

Irwin, L. M., R. E. Lubker, and R. A. Marsyla. A Study of Copper Reverberatory Slags From White Pine, Mich. BuMines Rept. of Inv. 5955, 1962, 23 pp.

McKinney, W. A., and P. T. Waddleton. Use of Various Salts as Copper Volatilizing Agents in the Segregation Process. BuMines Rept. of Inv. 6044, 1962, 7 pp.

[12] Bardill, J. D., D. R. Corson, and W. R. Wayment. Factors Influencing the Design of Hydraulic Backfill Systems (in Two Parts). 2. Trietion-Head Losses of Barite and Limestone Slurries During Pipeline Transport. BuMines Rept. of Inv. 6066, 1962, 33 pp.

Wayment, W. R., G. L. Wilhelm, and J. D. Bardill. Factors Influencing the Design of Hydraulic Backfill Systems (in Two Parts). 1. Trietion-Head Losses of Sand Slurries During Pipeline Transport. BuMines Rept. of Inv. 6065, 1962, 43 pp.

[13] Dale, V. B. Mining, Milling, and Smelting Methods, San Manuel Copper Corp., Pinal County, Ariz. BuMines, Inf. Circ. 8104, 1962, 145 pp.

Dow, V. T., F. D. Everett, and S. R. Wilson. Methods in Driving the 5490 Railroad Tunnel, Kennecott Copper Corp., Salt Lake County, Utah. BuMines, Inf. Circ. 8047, 1962, 40 pp.

Peterson, B. C., E. R. Nelson, and W. A. Beck. Cost Accounting and Control at Calumet Division, Calumet & Hecla, Inc., Calumet, Mich. BuMines, Inf. Circ. 8044, 1962, 37 pp.

Smith, M. C., and A. C. Johnson. Open-Pit Operations at the Tripp Pit, Consolidated Coppermines Corp., Kimberly, Nev. BuMines, Inf. Circ. 8129, 1962, 16 pp.

Staff, Office of Chief Economist. Copper, Lead, and Zinc in Three Recessions Following World War II. BuMines, Inf. Circ. 8064, 1962, 79 pp.

[14] Albers, J. P., and J. F. Robertson. Geology and Ore Deposits of East Shasta Copper-Zinc District, Shasta County, Calif. Geol. Survey Prof. Paper 338, 1962, 107 pp.

Brokaw, A. L., G. B. Gott, D. R. Mabey, H. McCarthy, and U. Oda. Mineralization Associated With a Magnetic Anomaly in Part of the Ely Quadrangle, Nevada. Geol. Survey Circ. 475, 1962, 7 pp.

Kinkle, A. R., and N. P. Peterson. Copper in the United States, Exclusive of Alaska and Hawaii. Geol. Survey Min. Inv. Res. Map MR–113, 1962.

Peterson, D. W. Preliminary Geologic Map of the Western Part of the Superior Quadrangle, Arizona. Geol. Survey Min. Inv. Field Study Map MF 235, 1962.

Peterson, N. P. Geology and Ore Deposits of the Globe-Miami District, Arizona. Geol. Survey Prof. Paper 342, 1962, 151 pp.

[15] Iron Age. V. 190, No. 23, Dec. 6, 1962, p. 76.

Steel. V. 151, No. 24, Dec. 10, 1962, p. 28.

Precambrian Mining in Canada (Winnepeg, Canada). V. 35, No. 11, November 1962, p. 34.

iron, protective coatings for copper, and combining copper with plastics were projects of high priority.

In 1957, a diamond-drill hole intersected 40 feet of magnetite and chalcopyrite on claims of Craigmont Mines, Ltd., near Merritt, southern British Columbia.[16] Subsequent drilling indicated the presence of a large subsurface ore body, which was under shallow cover at its eastern end. Early drilling was done on the basis of coinciding magnetic and geochemical anomalies. The mine was placed in production after 4½ years of intensive exploration and development. Mineralization occurs as replacement of calcareous rock, varying from limestone to limey tuff, along axes of sharp drag folds associated with intense brecciation. It was confined almost entirely to magnetite, hematite, and chalcopyrite, with associated calcite, quartz, and pink feldspar.

High-grade copper-lead-silver deposits occurring as small fracture fillings and gash veins were mined during the last century in the Ballyvergin area, County Clare, on the southwest coast of Ireland.[17] The zones of mineralization previously mined were associated with local structures and folds. Initial geophysical investigations consisted of induced-polarization measurements around and between old mines. The work located an anomaly that resulted from a small extension of lead-copper deposit at a nearby mine. However, a potentially more important zone of mineralization was disclosed by drilling another anomaly, which was indicated by induced polarization. The wide anomaly was attributed to a dome-shaped deposit of disseminated chalcopyrite at a depth of more than 100 feet. The deposit controlled by local folding was a type previously unknown in the district.

Debates centered on the genesis of important sedimentary copper deposits in the U.S.S.R.[18] Most arguments concerned the Dzhezkazgan deposits in Kazakhstan, a field closely comparable to the Rhodesian Copperbelt. The field was divided into two sectors, the northern and central, of which the former supplied 90 percent of the production and covered an area of 185 square miles. The latter had an area of about 50 square miles. The ores were similar to Rhodesian ores except for the presence of a little lead and zinc. Nine or ten ore-bearing horizons were mapped in a series of continental sandstones, shales, and conglomerates having a thickness of about 3,000 feet and believed to be of middle Carboniferous age. Supporters of the hydrothermal deposition hypothesis related the ores genetically to granitoid batholiths, which may have given rise to the important porphyry-type copper deposits of Kounrad and other localities far to the east. No granitic intrusions were known at the surface at Dzhezkazgan, but recent geophysical work provided evidence suggesting that granite occurred at depth.

The Mission unit of American Smelting and Refining Company included some of the most modern techniques in mine and concentrator

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[16] Chapman, E. P. Geophysical Surveys Compared to Known Ore Zones of Craigmont Deposits. Min. Eng., v. 14, No. 7, July 1962, pp. 53–56.

[17] Hallof, P. G., R. Schultz, and R. A. Bell. Induced Polarization and Geological Investigations of the Ballyvergin Copper Deposit, County Clare, Ireland. Trans. S.M.E., v. 223, No. 3, September 1962, pp. 312–318.

[18] Davidson, C. E. Some Genetic Problems of the Dzhezkazgan Copper Ores. Min. Mag. (London), v. 107, No. 4, October 1962, pp. 215–217.

design and operation.[19] The deposit was described as a low-grade replacement in altered limey sediments that were folded, faulted, and intruded by monzonite porphyry. It is overlain by approximately 200 feet of gravel wash, of which all but the lower 20 or 30 feet is loosely consolidated and amenable to low-cost mining methods. The lower portion is tightly cemented and forms a resistant layer immediately overlying the mineralized bedrock. Ore minerals were primarily chalcopyrite with minor bornite in the primary zone and chalcocite with some oxide copper in the thin, discontinuous secondary zone. The gangue is variable in mineralogical composition, depending upon where the ore occurs in the several sedimentary formations. Tactite and hornfels comprised two of three major ore-containing rock types; the third type was argillite or siltstone, and was usually much harder and lower in copper content than the other two. The eastern part of the deposit contained ore that was of higher grade and easier to grind than ore from the central and western parts. However, the waste-to-ore ratio was one-third greater in the eastern part. It was decided to enter the pit from the east at the lower elevation of the perimeter of the pit. This permitted having a haul road permanently aligned, supporting higher cost of waste removal by higher grade of ore mined, and postponing the mining of hard argillite ore until it represented only 5 percent of the total ore to be mined. Ultimately the pit was to be 2,500 by 5,000 feet and approximately 700 feet deep. Benches were 50 feet high in gravel and 40 feet high in rock and ore. From August 1959 to mid-November 1961, about 1.2 million tons of ore and 45.1 million tons of waste were removed from the pit. Scrapers and tractors were used primarily to open benches, and most of the material was moved by shovels and trucks. The primary crusher and two grizzlies, that permitted trucks to dump on two sides of the crusher pit, were installed underground. A two-way radio provided communications between the crusher crew and the pit foreman.

Hoisting ore and waste by means of a newly completed skip haulage system began at the open-pit mine of Kennecott Copper Corp., Santa Rita, N. Mex.[20] The system, which was installed to reduce costs of hauling ore and waste, consisted of two cable-drawn cars of 40-ton capacity each, traveling on inclined tracks 1,400 feet long. Railroad haulage from the bottom of the pit involved a trip of 4.5 miles to take ore to the assembly yard for shipment to the mill at Hurley, N. Mex., and about 8 miles to haul waste to the dump. All haulage of ore was on an adverse grade of 2 percent. By taking advantage of topography, the skip haulage system permitted ore to be removed from the pit at an elevation lower than that at which waste was dumped. Newly designed devices provided for better protection from the impact of large blocky pieces being loaded into or unloaded from the skips. Train haulage was to continue on upper benches, and two railroad bridges were built to allow train traffic to cross the skipway.

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[19] Engineering and Mining Journal. Asarco's Mission. V. 163, No. 1, January 1962, pp. 70–79.

[20] Huttl, John B. Chino Inaugurates New Skip Haulage System. Eng. and Min. J., v. 163, No. 11, November 1962, pp. 92–93.
Skillings' Mining Review. Skip Haulage System at Santa Rita Copper Mine. V. 51, No. 7, Feb. 17, 1962, p. 12.

The increase in milling capacity at the Ray Mines Division, Kennecott Copper Corp., required an additional water supply of 3,000 gallons per minute.[21] The additional supply came from reclaimed mill water because the quantity of water available to the company from the Gila River was limited by law. To reclaim water, a continuous onstream density measurement system was installed. The device used an encapsulated radioisotope for radiation, and its installation was believed to be the first application of controlled atomic energy in the copper industry. Operation was based on absorption of radiation by materials. An air-operated diaphram control valve on the pipe containing the flowing pulp opened or closed proportionately as the density of the pulp increased or decreased from a set point; the valve thus controlled the rate of flow of pulp from thickeners.

An article described salient features of the Esperanza concentrator of the Copper Division, Duval Sulphur and Potash Co., Tucson, Ariz.[22] Primary, secondary, and tertiary crushes were equipped with hydraulic mantles, which greatly facilitated adjustment of crusher setting. Wet grinding and flotation were conducted in two mill sections that were essentially metallurgically independent, which permitted plant-scale metallurgical testing to be conducted at will. The company announced plans to begin development of the Ithaca Peak open-pit copper mine north of Kingman, Ariz.[23]

A new shaft-sinking record for North America was established at No. 1 shaft, Southwest Project of White Pine Copper Co., in Michigan.[24] A four-deck, 60-foot-high shaft-sinking stage and a bench-drilling pattern were used during excavation of the shaft. Conveyor belt transportation and shuttle car haulage at the White Pine mine were described in an article which stated that shuttle car hauls between mining faces and conveyor dump pockets should not be greater than 1,200 feet.[25] The nature of the ore body and the rapid rate of mining advancement required a flexible materials-handling system. A new shuttle car of 20-ton capacity was developed. The car had the following features: Articulated chassis, telescopic conveyor, air-cooled diesel engine, and no-spin, four-wheel drive with articulated steering.

The first phase of the modernization of the smelter of Kennecott Copper Corp., Utah Copper Division, was completed.[26] This new materials-handling system was designed and constructed with modern automated and electronically controlled equipment. The system was designed so that the maximum handling time of any product was 10 minutes from the railway car to any point-of-use bin. A double-direction, rotary car dumper, the first of its type, was built to handle 100-ton standard railroad cars of varying lengths, widths, and heights. An electronic weighing and recording system was built into the dumper. Thirty-one separate belt conveyors were installed

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[21] Bogert, John R. Radiation Device Helps Kennecott Save 5,000,000 Gallons of Water a Day. Min. World, v. 24, No. 2, February 1962, pp. 24–25.
[22] Curtis, C. H. The Esperanza Concentrator. Min. Eng., v. 13, No. 11, November 1961, pp. 1234–1239.
[23] Mining World. Two New Mines for Duval Sulphur and Potash. V. 24, No. 13, December 1962, pp. 13, 41.
[24] Skillings, David N. Southwest Project of White Pine Copper Co. Skillings' Min. Rev., v. 51, No. 7, Feb. 17, 1962, pp. 1, 4–5.
[25] Taiple, J. M., and R. W. Whiton. White Pine Copper's Underground Ore Handling System. Skillings' Min. Rev., v. 51, No. 40, October 1962, pp. 4, 5, 18, 19, 22.
[26] Mining World. How Modern Materials Handling Improves Utah Smelter Metallurgy. V. 24, No. 11, October 1962, pp. 24–27, 46.

with a total conveyor length of 4,221 feet. Adequate dust collection systems were installed at all transfer points, crushers, and screens.

The Mantos Blancos deposits, located in the Atacama Desert of Chile, had been known since 1912.[27] Various attempts made to mine the high-grade parts of the deposit had been unsuccessful because of the high chloride content of the ore. The chloride in the ore ruled out conventional leaching-electrolysis schemes but lent itself to a process of precipitating copper as cuprous chloride. The first batch of refined copper ingots was produced in 1962 after 8 years of exploration, development, and metallurgical pioneering. The Mantos Blancos deposit consisted of a series of ore bodies in a zone approximately 1½ miles long by 2,500 feet wide. Only the largest known ore body was being mined. It had a reserve of about 8 million tons containing 1.9 percent copper, two-thirds of which occurred as atacamite and one-third as chrysocolla. Most of the copper was found in dacite porphyry cut by a system of andesite dikes and irregular masses that also contained copper. The copper minerals in both types of deposits occurred as inclusions or very fine veinlets. The host rocks behaved differently under leaching—the dacite was attacked only slightly by acid, but the andesite was readily attacked. To minimize acid loss and the formation of slimes, it was necessary to use low acid concentration, as short a treatment time as possible, and to blend andesite-dacite ore in proportions not exceeding 20 percent of andesite. Leaching was accomplished by percolation with sulfuric and hydrochloric acid solutions. A countercurrent leaching and washing system with intermittent advances was used. After leaching and before precipitating, a flocculant was added to pregnant solutions to eliminate minute particles of ore slimes, which caused severe difficulties in the centrifuge where the copper chloride was separated after precipitation. The precipitation occurred in empty spray towers made of steel with a lining of plastic and acid brick. A gas (14-percent sulfur dioxide) moved countercurrent to the solutions that were injected upward by spray nozzles from the bottom. The cuprous oxide sludge was moved to a centrifuge, washed free of adhering impurities, and dried. The dried copper sludge was mixed with a flux and a reducing agent, then pelletized, and smelted.

A series of plant tests using oxygen-enriched air for converting copper matte was performed at the reduction works, The Anaconda Company, Anaconda, Mont.[28] The tests were to determine if the use of enriched air would permit processing a high-grade matte without adding extraneous fuel and if use of enriched air would accelerate the converting process. Matte treated during the tests ranged from 42 to 49 percent copper, and the effectiveness of enriched air on converting high-grade mattes was not determined. However, the development of additional heat was demonstrated by the increased use of cold dope; therefore, by inference, it seemed that a high-grade matte could be processed satisfactorily with enriched air and without extraneous fuel.

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[27] Knobler, Richard R., and Werner Joseph. Copper Extraction and Refining at Mantos Blancos. J. Metals, v. 14, No. 1, January 1962, pp. 51–56.
Knobler, Richard R., and Werner Joseph. The Mantos Blancos Operation. Min. Eng., v. 14, No. 1, January 1962, pp. 40–45.

[28] Arentzen, C. Oxygen-Enriched Air for Converting Copper Matte. J. Metals, v. 14, No. 9, September 1962, pp. 641–643.

Diatomite

By John W. Hartwell [1] and Victoria R. Schreck [2]

PRODUCTION of diatomite in the United States continued to increase in 1962. Output exceeded 1961 production by 3 percent.

DOMESTIC PRODUCTION

California retained the position it had maintained since 1910 as the leading diatomite-producing State. Nevada was second, followed by Washington, Arizona, Maryland, and Oregon. Production in Maryland was reported for the first time in many years. Fourteen plants owned and operated by 12 companies reported production, compared with 14 plants owned by 13 companies in 1961. Three new companies with one plant each were added to the list of producers, while two companies with two plants reported no production. One company still listed as a producer stopped production at one plant.

Large undeveloped deposits of diatomite were reported to have been located in federally owned Yakima Firing Range in eastern Washington. Negotiations were underway to return the mineral rights to private owners for commercial development.

Eighteen diatomite claims owned by The Eagle-Picher Co. near Trinity Mountain, Nev., were leased on a royalty basis.

TABLE 1.—Diatomite sold or used by producers in the United States, 3-year totals

	1945–47	1948–50	1951–53	1954–56	1957–59	1960–62
Domestic production (sales)..short tons..	640,764	722,670	908,448	1,105,279	1,349,340	1,446,625
Average value per ton..........	$20.17	$25.55	$29.97	$39.21	$45.73	$50.08

CONSUMPTION AND USES

Diatomite continued to be the most widely used filter medium, and the quantity of filter-grade material used was 4 percent more than in 1961. However, the percentage of the total diatomite sold or used for this purpose remained the same. Filler-grade consumption was virtually unchanged from 1961, while the percentage of the total for this

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[2] Statistical clerk, Division of Minerals.

use dropped 1 percent. The quantity used for insulation increased 2 percent; its percentage of the total remained the same. Miscellaneous uses increased 10 percent in quantity, but constituted only 1 percent of the total used. Miscellaneous uses were for abrasives; absorbents; carriers for catalysts, herbicides, pesticides, and fungicides; fireproofing; glazes; enamels; flatting agents for paints; sodium and calcium silicate manufacture; and pozzolanic material.

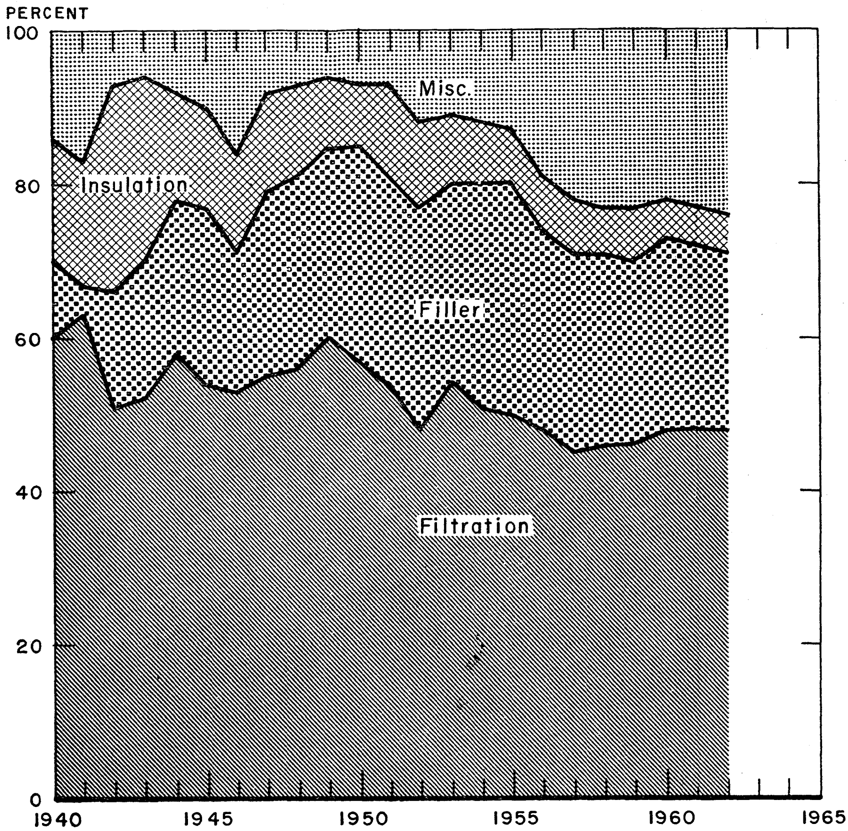

FIGURE 1.—Relative quantity of diatomite consumed in the United States for each principal class of use, 1940–62.

PRICES

Prices continued to rise for both filter and filler grades of diatomite and were lower for most other grades. Because of a drop in prices for miscellaneous uses, the average price for all diatomite was 1 percent lower than in 1961.

TABLE 2.—Average annual value per ton of diatomite, by uses

Use	1961	1962	Use	1961	1962
Filtration	$59.77	$61.30	Fillers	$50.53	$51.69
Insulation	47.61	45.13	Miscellaneous	31.71	26.45
Abrasives	137.00	137.00	Weighted average	50.65	50.06

FOREIGN TRADE

Exports of processed diatomite were substantial, but detailed statistics were not reported by the Department of Commerce. 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.

WORLD REVIEW

The United States was the world's leading country in diatomite production. Other principal producing countries were West Germany, France, Denmark, Italy, and Algeria.

Chile.—Numerous diatomite deposits occur from the Peruvian border in the north to the Island of Chiloe in the south. Production figures had not been reported for many years, but during the early 1950's the yearly production was estimated at 1,700 short tons for local consumption in insulation, filtration, and polishes. Because of the high tariff rates in other Latin American countries, only small quantities of diatomite had been exported. It was expected that foreign trade might be expanded if tariff rates were lowered with the establishment of the proposed Latin America Free Trade Association.[3]

Ecuador.—A report on industrial minerals of Ecuador listed diatomite occurrences in Cotopoxi Province. Production was not mentioned.[4]

Iceland.—Preliminary surveys were being made for the possible erection of a diatomite processing plant near Myvatn. Some raw diatomite was exported.[5]

Kenya.—The East African Diatomite Syndicate, Gilgil, Kenya, modernized its processing plant by installing a new rotary oil-fired calciner, a drier, and milling and air separation equipment. Diatomite produced from this plant reportedly was high-grade and was sold principally to the gold-mining and food-processing industries as a filter aid.[6]

Philippines, Republic of the.—Diatomite deposits were reported in eight provinces of the Philippines, but only one occurrence, in Nueva Ecija Province, was investigated. Diatomite in this deposit was of the fresh-water type and occurred near the surface with seams of clay.

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[3] Bureau of Mines. Mineral Trade Notes. V. 55, No. 3, September 1962, pp. 27–28.
[4] Stoll, W. C. Notes on the Mineral Resources of Ecuador. Econ. Goel., v. 57, No. 5, August 1962, pp. 799–808.
[5] Mining Journal (London). Diatomite in Iceland. V. 259, No. 6639, Nov. 16, 1962, p. 470.
[6] Chemical Trade Journal and Chemical Engineer (London). East African Diatomite. V. 151, No. 3920, July 20, 1962, p. 126.

TABLE 3.—World production of diatomite by countries [1] [2]

(Short tons)

Country [1]	1953–57 (average)	1958	1959	1960	1961	1962
North America:						
Canada	49	27	5	44	214	62
Costa Rica	2,506	2,205	2,425	2,425	717	[3] 700
Guatemala	15,719	21,190	-------	-------	-------	-------
Nicaragua	-------	-------	1,887	2,249	2,976	[3] 3,000
United States	371,575	[4] 449,780	[4] 449,780	[5] 482,202	[5] 482,202	[5] 482,202
South America:						
Argentina	4,178	4,540	4,829	[3] 4,800	[3] 4,800	[3] 4,800
Chile	118	-------	-------	-------	-------	-------
Colombia	[6] 275	220	330	440	330	[3] 330
Peru	15	117	254	1,284	2,048	[3] 2,000
Europe:						
Austria	4,145	4,086	4,492	4,431	5,993	4,613
Denmark:						
Diatomite	29,754	28,660	36,376	35,274	[3] 33,000	[3] 33,000
Moler [7]	40,533	46,486	40,542	36,330	55,000	[3] 55,000
Finland	1,964	2,315	1,410	1,457	805	[3] 770
France [8]	74,074	111,948	112,821	140,468	[3] 110,000	[3] 110,000
Germany, West [8] [9]	62,021	68,403	55,764	51,138	72,201	[3] 72,200
Italy	15,721	49,828	57,100	51,888	[3] 55,000	[3] 55,000
Portugal [8]	1,840	1,159	2,075	1,172	847	[3] 880
Spain [8]	12,162	12,858	11,561	13,840	19,351	[3] 19,000
Sweden	1,340	1,260	764	2,645	[3] 770	[3] 770
U.S.S.R.	(10)	275,000	[3] 275,000	[3] 300,000	[3] 330,000	[3] 330,000
United Kingdom	24,223	28,154	[3] 19,000	16,553	24,920	[3] 24,900
Yugoslavia	4,330	[3] 4,400	[3] 5,000	[3] 5,000	[3] 5,000	5,000
Asia: Korea, Republic of	2,080	518	1,865	2,646	1,989	758
Africa:						
Algeria	29,187	28,629	38,087	24,266	34,315	[3] 30,900
Kenya	4,402	3,892	4,041	3,791	3,537	[3] 3,300
Mozambique	18	61	-------	103	397	386
Rhodesia and Nyasaland, Federation of: Southern Rhodesia [8]	-------	-------	148	164	409	423
South Africa, Republic of	651	359	397	346	137	647
United Arab Republic (Egypt)	355	397	441	805	332	[3] 330
Oceania:						
Australia	6,033	4,749	5,700	5,218	6,117	[3] 6,000
New Zealand	923	6,336	8,152	6,992	3,961	[3] 4,000
World total (estimate) [1] [2]	1,040,000	1,350,000	1,330,000	1,390,000	1,450,000	1,440,000

[1] Diatomaceous earth is produced in Brazil, Bulgaria, and Japan, but data on output are not available; estimates are included in total. Hungary and Rumania may produce diatomaceous earth, but data are not available and no estimates are included in total.

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

[3] Estimate.

[4] Average annual production 1957–59.

[5] Average annual production 1960–62.

[6] Average for 1 year only as 1957 was first year of commercial production.

[7] A clay-contaminated diatomite used principally for lightweight building brick.

[8] Includes tripoli.

[9] Marketable.

[10] Data not available; estimate included in total.

Compiled by Helen L. Hunt, Division of Foreign Activities.

Some use tests were made on samples from this deposit, and results indicated that the materials could be used as a lightweight aggregate, and a mineral filler. Tests on its use as a filter aid were not encouraging, but with additional tests, improvements in the filtering quality were expected.[7]

South Africa, Republic of.—The diatomite producers in 1962 were Finchman's Base Mineral Mines (Pty.), Ltd., Postmasburg, and Marico Mineral Co. (Pty.), Ltd., Vereeniging. Total production was 647 short tons, compared with 137 tons in 1961.

[7] Quicho, R. B., T. A. Ejercito, and A. S. Malicsi. Preliminary Beneficiation and Use-Tests of Diatomaceous Earth Prospects in Nueva Ecija, Philippine Dept. of Agric. and Nat. Res., Bureau of Mines (Manila), Rept. of Inv. No. 36, May 1962, 15 pp.

TECHNOLOGY

Occurrences of diatomite in Kern County, Calif., were described. Most of the deposits consisted of thin layers; some, which were small in area, were several hundred feet thick, but all were less pure than those mined in Lompoc, Calif. None of the deposits had been developed commercially.[8] The analysis of diatomite samples from an undeveloped deposit in Long Valley, Mono County, Calif., indicated that the diatomite might be suitable for use as a low-grade filter aid. The deposit was estimated to contain 7 million tons of easily recoverable diatomite.[9]

Basic principles of filtration using filter aids were evaluated and characteristics of four filter-aid materials, including diatomite, were tabulated.[10]

Simultaneous flash drying and grinding of diatomite in a high-speed impact mill were described. The basic theory of flash drying and the design and applications of roller and impact mill systems were given.[11]

A water purification system was developed using an ion-exchange resin in conjunction with diatomite. This system, together with other additives and a final filtering with a diatomite filter aid, lowered the alkyl benzene sulfonate content in laundry water from 50 parts per million (ppm) to about 1.4 ppm and suspended solids from 150 ppm to 18 ppm.[12] A system by which iron was removed from water by filtering with diatomite was developed.[13]

A method of manufacturing agricultural granules carrying nutrients, herbicides, and/or insecticides was developed.[14] The major portion of the inert ingredients consisted of calcined attapulgite, or diatomite with a minor proportion of raw attapulgite. The manufacture of a noncaking, free-flowing insecticide was patented. The composite carrier material consisted of diatomite and other inorganic materials.[15]

A method of coloring portland cement concretes used an admixture of 1 part of pigment with 5 to 15 parts of diatomite or other pozzolanic material.[16]

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[8] Troxel, Bennie W., and Paul K. Morton. Mines and Mineral Resources of Kern County, California. Calif. Div. of Mines and Geol. County Rept. No. 1, 1962, p. 90.

[9] Cleveland, George B. Economic Geology of the Long Valley Diatomaceous Earth Deposit, Mono County, California., Calif. Dept. of Conservation, Div. of Mines and Geol., 1961, Map Sheet 1.

[10] Leppla, Paul W. Filteraids To Improve Filtration. Ind. and Eng. Chem., v. 54, No. 5, May 1962, pp. 40–43.

[11] Aldrich, R. J. Simultaneous Flash Drying and Grinding. Chem. Eng. Prog., v. 58, No. 6, June 1962, pp. 62–66.

[12] Chem & Engineering News. J–M Offers Latest ABS Removal System. V. 40, No. 44, Oct. 29, 1962, pp. 48, 51.

[13] Engineering News-Record. Diatomite Filter Removes Iron. V. 196, No. 19, Nov. 8, 1962, p. 55.

[14] Marples, J. O., and E. W. Sawyer, Jr. (assigned to Minerals & Chemicals Philipp Corp., Menlo Park, N.J.). Colloidal Clay Bonded Agricultural Granules. U.S. Pat. 3,062,637, Nov. 6, 1962.

[15] Alvin, W. D., and V. Smith (assigned to Velsicol Chemical Corp., Chicago, Ill.). Production of Free-Flowing Granular Heptachlor Compositions. U.S. Pat. 3,028,305, Apr. 3, 1962.

[16] Rodeffer, E. O. Material and Method for Coloring Portland Cement Concretes. U.S. Pat. 3,068,109, Dec. 11, 1962.

A lightweight plastic composition for use with ceramic liners in rocket thrust chambers, consisting of gypsum plaster, pulverized alumina, diatomite, ball clay, and water, was patented.[17]

Diatomite was used as a carrier for oil and a soluble alkali.[18] The mixture was employed as a coating to inhibit corrosion of metal articles.

Other patents granted in the United States describing uses for diatomite were a method of making molded thermal insulation and its composition;[19] a process of producing a thin, self-sustaining film of polyethylene blended with diatomite;[20] method for making polymerization catalysts;[21] a low-shrinkage insulating material using hydrous calcium silicate fines obtained by reacting lime with pulverized diatomite;[22] and methods of producing hydrous calcium silicate,[23] colloidal calcium magnesium silicate,[24] and a calcium silicate product.[25]

Patents originating in Canada included a method of producing a water softener material[26] and the preparation of porous material for storing and handling acetylene in solution.[27]

Patents issued in Great Britain included methods of preparing a filler,[28] a cement-like material for forming various shapes,[29] a calcium silicate thermal insulation material,[30] and a refractory product.[31]

Patents were issued in the U.S.S.R. for an improved filter aid;[32] in Belgium for making a heat-resistant element;[33] and in West Germany for frost-resistant concrete,[34] as a filter aid,[35] and as an insulating brick.[36]

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[17] Kimpel, R. F. (assigned to Aerojet General Corp., Azusa, Calif.). Cement Composition. U.S. Pat. 3,069,278, Dec. 18, 1962.

[18] Larrieu, L. J. (assigned to Morris P. Kirk & Son, Inc., Los Angeles, Calif.). Protective Composition for Metals. U.S. Pat. 3,035,926, May 22, 1962.

[19] Herrington, J. W. Thermal Insulation Composition and Preformed Fittings Made Therefrom. U.S. Pat. 3,025,176, Mar. 13, 1962.

[20] Toy, G. R., and M. E. Krasnow (assigned to Union Carbide Corp., New York, N.Y.). Process of Blending Polyethylene and Diatomaceous Earth and Product Thereof. U.S. Pat. 3,028,355, Apr. 3, 1962.

[21] Morrell, J. C. Polymerization Catalyst. U.S. Pat. 3,050,472–3, Aug. 21, 1962.

———. Catalyst and Process of Making the Same. U.S. Pat. 3,044,964, July 17, 1962.

[22] Bishop, D. L. (assigned to Owens-Corning Fiberglas Corp., Toledo, Ohio). Vinculum for Alkaline Earth Metal Silicate Insulating Materials. U.S. Pat. 3,042,536, July 3, 1962.

[23] Vander Linden, C. R. (assigned to Johns-Manville Corp., New York, N.Y.). Hydrothermal Process for the Manufacture of Hydrated Calcium Silicates. U.S. Pat. 3,033,648, May 8, 1962.

[24] Shiroishi, T. Method of Preparing Colloidal Calcium Magnesium Silicate. U.S. Pat. 3,046,152, July 24, 1962.

[25] Vander Linden, C. R., and J. P. Leineweber (assigned to Johns-Manville Corp., New York, N.Y.). Calcium Silicate Product and Method of Preparing the Same. U.S. Pat. 3,052,563, Sept. 4, 1962.

[26] Weber, H. (assigned to Farbenfabriken Bayer, A.G.). Canadian Pat. 635,566, Jan. 30, 1962.

[27] Miller, S. A., G. C. Wash, and J. A. Tebboth (assigned to The British Oxygen Co., Ltd.). Canadian Pat. 647,999, Sept. 4, 1962.

[28] Chemetron Corp. British Pat. 886,868, Jan. 10, 1962.

[29] Longely, C. A. British Pat. 721,318, Jan. 5, 1955.

[30] Smith, E. C. W., and J. D. Blakely (assigned to Insulex Mineral Products, Ltd.). British Pat. 722,012, Jan. 19, 1955.

[31] Austin, L. W., and C. A. Rick. British Pat. 721,916, Jan. 12, 1955.

[32] Kartashov, A. K., and V. E. Striplov. Russian Pat. 142,638, Dec. 28, 1961.

[33] Johns-Manville Corp. Belgian Pat. 608,953, Apr. 9, 1962.

[34] Brandt, K. West German Pat. 1,082,544, May 25, 1960.

[35] Riedel, E., and H. von Depka (assigned to Hein, Lehmann and Co., A. G.). West German Pat. 1,091,952, Nov. 3, 1960.

[36] Clark, L. J., and H. F. G. Crawley (assigned to North Thames Gas Board). West German Pat. 1,088,992, Sept. 15, 1960.

Feldspar, Nepheline Syenite, and Aplite

By Taber de Polo[1] and Gertrude E. Tucker[2]

FELDSPAR

DOMESTIC PRODUCTION of crude feldspar and flotation concentrate remained within 1 percent of the 1961 figure. During the first 6 months of 1962, foreign flat glass imports, up 31 percent, had an adverse effect on domestic feldspar requirements. In June there was an increase in import duty. Increased building activity, due partly to liberalized amortization and financing provisions, and increased automobile production helped to offset the loss from increased imports. A substantial increase in glass-container production helped to keep the demand for feldspar at a high level.

TABLE 1.—Salient feldspar statistics

	1953–57 (average)	1958	1959	1960	1961	1962
United States:						
Crude:						
Sold or used by producers[1] long tons	542,808	469,738	548,390	502,380	496,808	492,476
Value thousands	$5,026	$4,278	$5,372	$4,779	$5,120	$5,076
Average value per long ton	$9.26	$9.11	$9.79	$9.51	$10.31	$10.31
Imports for consumption long tons	1,283	73	45	44	24	33
Value thousands	$18	$5	$5	$5	$2	$1
Average value per long ton	$13.90	$63.82	$100.49	$106.95	$84.38	$39.55
Consumption, apparent[2] long tons	544,091	469,811	548,435	502,424	496,832	492,509
Ground:						
Sold by merchant mills[3] short tons	578,093	469,602	560,105	528,348	541,626	527,347
Value thousands	$8,046	$6,540	$7,659	$7,079	$6,694	$6,703
Average value per short ton	$13.92	$13.93	$13.67	$13.40	$12.36	$12.71
Imports for consumption long tons	1,519	6,584	5,160	6,980	2,529	3,297
Value thousands	$31	$101	$82	$110	$63	$87
Average value per long ton	$20.68	$15.27	$15.86	$15.69	$24.86	$26.45
World: Production long tons	1,180,000	1,190,000	1,380,000	1,510,000	1,490,000	1,500,000

[1] See table 2 for distribution of feldspar by derivation.
[2] Measured by quantity sold or used by producers plus imports.
[3] See table 4 for distribution of feldspar by derivation.

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

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DOMESTIC PRODUCTION

Crude Feldspar.—Approximately 50 percent of the total crude feldspar production came from North Carolina, the leading State for many years. California and Connecticut ranked second and third respectively. The quantity of feldspar produced by flotation in North Carolina and Georgia in 1961 constituted almost 91 percent of the feldspar from the area. Flotation accounted for almost 66 percent of the total U.S. feldspar output, a continuing upward trend.

Crude feldspar figures included hand-cobbed feldspar, flotation concentrate, and the feldspar content of feldspar-silica mixtures.

TABLE 2.—Crude feldspar sold or used by producers in the United States

Year	Derivation of feldspar [1]							
	Hand-cobbed		Flotation concentrate		Feldspar-silica mixtures [2]		Total	
	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)
1953-57 (average)	(3)	(3)	450,222	$4,293	92,586	$733	542,808	$5,026
1958	198,460	$1,346	218,178	2,450	53,100	482	469,738	4,278
1959	169,473	1,508	293,356	3,114	85,561	750	548,390	5,372
1960	147,912	1,123	278,503	2,881	75,965	775	502,380	4,779
1961	116,503	788	307,468	3,580	72,837	752	496,808	5,120
1962	113,168	783	324,462	3,806	54,846	487	492,476	5,076

[1] Partly estimated.
[2] Feldspar content.
[3] Included with flotation concentrate.

Ground Feldspar.—Production of ground feldspar was reported from 21 mills in 13 States. Ground feldspar sold by merchant mills in the United States decreased almost 3 percent in quantity, but the total value remained practically the same. North Carolina, California, Connecticut, and Georgia were the leading producers in descending order, accounting for 83 percent of the total ground feldspar. Five Southeastern States, Georgia, North Carolina, South Carolina, Tennessee, and Virginia, produced 61 percent of the total tonnage. Ground feldspar figures included flotation concentrate and the feldspar content of feldspar-silica mixtures. Statistical data were tabulated to show the origin of the feldspar (hand-cobbed, flotation concentrate, and feldspathic sands and rocks).

TABLE 3.—Ground feldspar sold by merchant mills[1] in the United States

Year	Mills	Domestic feldspar	
		Short tons	Value (thousands)
1953-57 (average)	24	[2] 578,093	[2] $8,046
1958	24	[3] 469,602	[3] 6,540
1959	26	[3] 560,105	[3] 7,659
1960	24	[3] 528,348	[3] 7,079
1961	21	541,626	6,694
1962	21	527,347	6,703

[1] Exclude potters and others who grind for consumption in their own plants.
[2] Includes Canadian feldspar, 1953-54.
[3] Includes Canadian feldspar.

TABLE 4.—Ground feldspar sold by merchant mills in the United States, by derivation[1] and uses

(Short tons)

Year	Hand-cobbed					Flotation concentrate				
	Glass	Pottery	Enamel	Other	Total	Glass	Pottery	Enamel	Other	Total
1953-57 (average)	(2)	(2)	(2)	(2)	(2)	234,730	187,589	21,835	30,971	475,125
1958	48,376	93,805	21,734	13,519	177,434	171,002	53,205	--------	8,489	232,696
1959	40,365	88,233	36,929	24,662	190,189	219,139	72,496	--------	10,558	302,193
1960	31,171	59,546	21,418	32,267	144,402	206,784	87,133	1,315	12,870	308,102
1961	23,248	56,875	17,160	26,083	123,366	232,365	88,170	4,012	12,135	336,682
1962	26,323	45,612	(3)	45,650	117,585	215,941	96,828	(3)	35,605	348,374

Year	Feldspar-silica mixtures[4]					Grand total				
	Glass	Pottery	Enamel	Other	Total	Glass	Pottery	Enamel	Other[5]	Total
1953-57 (average)	97,524	1,182	--------	4,262	102,968	332,254	188,771	21,835	35,233	578,093
1958	49,003	4,767	--------	5,702	59,472	268,381	151,777	21,734	27,710	469,602
1959	55,809	5,323	--------	6,591	67,723	315,313	166,052	36,929	41,811	560,105
1960	56,727	5,872	2,416	10,829	75,844	294,682	152,551	25,149	55,966	528,348
1961	65,950	6,983	--------	8,645	81,578	321,563	152,028	21,172	46,863	541,626
1962	50,993	4,726	--------	5,669	61,388	293,257	147,166	27,391	59,533	527,347

[1] Partly estimated.
[2] Included with flotation concentrate.
[3] Included with "Other" to avoid disclosing individual company confidential data.
[4] Feldspar content.
[5] Includes soaps, abrasives, and other ceramic and miscellaneous uses.

CONSUMPTION AND USES

Crude Feldspar.—Virtually all crude feldspar was either ground by the producing company or sold to merchant grinders. Some pottery, enamel, and soap manufacturers purchased crude feldspar for all or part of their requirements and ground it to company specifications in their own mills.

Ground Feldspar.—Most feldspar consumers bought material already ground, sized, and ready for use in their manufactured products. The glass, pottery, and enamel industries consumed 89 percent of the total ground feldspar used in 1962. Of these three major uses only enamel showed a gain, with a 29-percent increase. Use in glass and pottery declined 9 and 3 percent respectively. Additional uses, including soaps and abrasives and other ceramic uses showed a substantial gain of 27 percent. In 1962 the five major consuming States, California, Ohio, New Jersey, Illinois, and Pennsylvania, in descending order, accounted for 55 percent of the ground feldspar consumed in the United States. The use pattern changed radically in 1962 as revealed by increases of 40 percent in New Jersey and 13 percent in Ohio, and decreases of 52 percent in Indiana, 38 percent in Pennsylvania, 20 percent in California, and 17 percent in Illinois.

TABLE 5.—Ground feldspar shipped from merchant mills in the United States

(Short tons)

Destination	1958	1959	1960	1961	1962
California	77,407	87,332	91,452	99,149	79,075
Illinois	48,385	57,952	54,089	55,815	46,283
Indiana	16,353	34,212	28,426	39,700	19,139
Maryland	14,000	17,572	16,017	14,092	11,748
Massachusetts	3,738	4,229	5,101	6,235	4,603
New Jersey	24,306	28,577	25,989	38,245	53,640
New York	20,883	16,463	19,701	16,850	21,696
Ohio	56,367	71,293	67,324	67,304	76,287
Pennsylvania	60,322	56,332	60,907	55,947	34,843
Texas	(1)	22,057	21,440	22,994	22,502
West Virginia	(1)	51,965	36,216	27,384	(1)
Wisconsin	8,664	10,823	9,677	8,727	(1)
Other destinations [2]	139,177	101,298	92,009	89,184	157,531
Total	469,602	560,105	528,348	541,626	527,347

[1] Included with "Other destinations."
[2] Includes Alabama (1960-62), Arkansas, Colorado, Connecticut, Florida (1960-61), Georgia (1960), Hawaii (1961), Kansas (1958), Kentucky, Louisiana, Maine (1958-60), Michigan, Minnesota, Mississippi, Missouri, Oklahoma, Rhode Island, South Carolina (1962), Tennessee, Utah (1960), Vermont (1960 and 1962), Washington (1959-62), shipments that cannot be separated by States, and shipments indicated by footnote 1. Also includes exports to Canada, Colombia (1961), Cuba (1959-60), England (1958-59 and 1962), Mexico, Panama, Puerto Rico (1958-59), Venezuela (1959-62), West Germany (1958), and small quantities to other countries.

PRICES

Quotations of crude feldspar did not appear in trade publications. The average value of crude feldspar was $10.31 per long ton, the same as in 1961.

The average selling price of ground feldspar was $12.71 per short ton, a 3-percent increase above the $12.36 figure of 1961.

The following producing States had the highest selling price per short ton: Illinois, $22.85; New Hampshire, $21.55; Arizona, $20.16; Virginia, $20.10; Georgia, $19.90; and Tennessee, $18.87.

The highest average value by use was reported for pottery at $18.95 per short ton.

Quotations on ground feldspar in E&MJ Metal and Mineral Markets for December 1962 were as follows: North Carolina, bulk, 325 mesh, $18 to $22 per ton; 200 mesh, $17 to $21; 40 mesh, glass grade, $13.50; and 20 mesh semigranular, $7.50.

FOREIGN TRADE [3]

According to reports from grinders, ground feldspar exports were approximately three times those of 1961. Canada, Mexico, and a number of countries in South America were the major recipients.

Cornwall Stone.—Imports for consumption of ground Cornwall stone (from England) were 11 tons valued at $301 in 1962.

TABLE 6.—U.S. imports for consumption (all from Canada) of feldspar

Year	Crude		Ground		Year	Crude		Ground	
	Long tons	Value	Long tons	Value		Long tons	Value	Long tons	Value
1953–57 (average)	1,283	$17,828	1,519	$31,413	1960	44	$4,706	6,980	$109,547
1958	73	4,659	6,584	100,564	1961	24	2,025	2,529	62,859
1959	45	4,522	5,160	81,849	1962	33	1,305	3,297	87,205

Source: Bureau of the Census.

WORLD REVIEW

World production of feldspar remained approximately the same as in 1961. The United States furnished 33 percent of the estimated free world production. There had been little annual change in the distribution of production by countries during the past decade.

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

TABLE 7.—World production of feldspar by countries [1] [2]

(Long tons)

Country [1]	1953–57 (average)	1958	1959	1960	1961	1962
North America:						
Canada (shipments)	16,803	18,203	16,030	12,376	9,381	9,829
United States (sold or used)	542,808	469,738	548,390	502,380	496,808	492,476
Total	559,611	487,941	564,420	514,756	506,189	502,305
South America:						
Argentina	6,344	4,221	4,922	[3] 3,900	[3] 3,900	[3] 3,900
Brazil	(4)	(4)	(4)	[3] 44,000	[3] 44,000	[3] 44,000
Chile	1,200	984	1,476	1,095	2,280	[3] 2,000
Colombia	[5] 3,740	3,937	14,763	14,763	14,763	[3] 14,800
Peru	----------	----------	----------	236	992	354
Uruguay	405	267	352	713	877	692
Total [3]	28,500	39,000	56,000	65,000	67,000	66,000
Europe:						
Austria	2,254	2,613	3,445	4,573	3,907	4,976
Finland	10,259	11,969	9,114	9,158	14,554	14,822
France	66,622	81,104	78,737	73,816	91,532	[3] 92,000
Germany, West	142,767	164,303	175,353	264,204	258,552	[3] 260,000
Italy	43,867	55,523	59,990	85,076	88,230	91,126
Norway	38,693	41,618	77,368	84,958	68,895	54,132
Portugal	545	544	837	1,699	2,892	[3] 3,000
Spain	6,338	5,199	10,722	11,924	8,194	[3] 7,900
Sweden	48,388	42,785	46,159	54,328	56,002	[3] 56,000
U.S.S.R.	(4)	[3] 175,000	[3] 185,000	[3] 195,000	[3] 195,000	[3] 200,000
Yugoslavia	[6] 7,542	12,466	19,309	13,780	[3] 19,700	[3] 29,500
Total [1] [3]	525,000	595,000	670,000	800,000	810,000	820,000
Asia:						
Hong Kong	[7] 446	1,653	1,716	2,511	1,206	937
India	5,473	8,432	9,740	10,484	8,930	15,469
Japan [8]	36,195	44,507	60,196	91,454	50,986	[3] 49,000
Philippines	[9] 49	74	1,684	3,896	14,526	15,325
Viet-Nam, South	[5] 886	----------	----------	----------	----------	----------
Total	43,049	54,666	73,336	108,345	75,648	[3] 80,730
Africa:						
Eritrea	86	413	1,476	984	2,953	425
Kenya	24	26	----------	----------	1	----------
Malagasy Republic	45	----------	----------	----------	13	----------
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	----------	447	----------	----------	----------	----------
South Africa, Republic of	7,307	7,708	10,447	15,600	23,290	28,209
United Arab Republic (Egypt)	----------	----------	492	354	----------	----------
Total	7,462	8,594	12,415	16,938	26,257	28,634
Oceania: Australia [10]	14,309	7,016	6,750	8,414	8,209	[3] 6,300
World total (estimate) [1] [2]	1,180,000	1,190,000	1,380,000	1,510,000	1,490,000	1,500,000

[1] Feldspar is produced in China, Czechoslovakia, and Rumania, but data are not available; no estimates included in total except for Czechoslovakia.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Estimate.
[4] Data not available; estimate by senior author of chapter included in total.
[5] Average annual production 1954–57.
[6] Average annual production 1956–57.
[7] Average annual production 1955–57.
[8] In addition, the following quantities of aplite and other feldspathic rock were produced: 1953–57 (average), 71,753 tons; 1958, 76,856 tons; 1959, 88,451 tons; 1960, 91,339 tons; 1961, 132,017 tons; 1962, 165,303 tons.
[9] One year only, as 1957 was first year of commercial production.
[10] Includes some china stone.

Compiled by Liela S. Price, Division of Foreign Activities.

TECHNOLOGY

An extensive description of feldspar sources in Virginia, including pegmatites, alaskite-syenite deposits, and aplite, was published.[4]

The location, specifications for the ceramic industry, and physical and chemical properties of feldspar deposits of West Pakistan were presented at the Centro Symposium on Industrial Rocks and Minerals, Lahore, West Pakistan.[5]

The occurrence, geology, and ceramic properties of a number of feldspathic materials were presented.[6]

Basic studies were conducted on feldspar deposits in Canada [7] and U.S.S.R. (Siberia).[8]

A method of obtaining feldspar from granite in Poland was described.[9]

A patent was issued for a method of restoring charge susceptibility to feldspar and other minerals separated by electrostatic methods.[10]

The mining and milling operations of the Middletown, Conn., plant of The Feldspar Corp. were described in detail.[11]

Some patents were issued on froth flotation processes in feldspar and other mineral beneficiation.[12]

Experiments were conducted and formulas developed for the dissolution of alkali feldspars.[13]

Experiments determined the effect of surface, concentration, and time on the pH and alkali content of feldspar suspensions.[14]

Results of experiments on the quantitative determination of very fine-grained potassium feldspar were described.[15]

A patent involved the use of feldspar as a filler in flexible insulating boards.[16]

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[4] Brown, William R. Mica and Feldspar Deposits of Virginia. Virginia Div. Miner. Res., Dept. of Conserv. and Econ. Development, MRR-3, 1962, 195 pp.

[5] Azizul, Haq, and F. A. Faruqi. Ceramic Qualities of West Pakistan Feldspar, Quartz, and Talc. West Regional Laboratories, Pakistan Council of Sci. and Ind. Res., Lahore, West Pakistan, 1962, 9 pp.

[6] Jung, Dieter. (Deposits of Ceramic Raw Materials Between Birkenfeld and Oberthal/ Saar. Keram. Ztschr., v. 13, No. 11, November 1961, pp. 612–617; Ceram. Abs., v. 45, No. 5, May 1962, p. 124b.

[7] Clark, G. S. Feldspars in the St. Stephen Mafic Igneous Complex. Univ. of New Brunswick, New Brunswick, Canada, 1962, 85 pp.

[8] Naumov, V. P. Effect of Enclosing Rocks on the Distribution of Barium Feldspars and Barite in Deposits of the Irtysh Thrusted Zone. Econ. Geol., v. 57, No. 2, March–April 1962, p. 283.

[9] Mining Journal (London). Feldspar From Granite. V. 259, No. 6638, Nov. 9, 1962, p. 441.

[10] Cook, C. C. (assigned to International Minerals & Chemical Corp., Chicago, Ill.). Electrostatic Concentration of Minerals. U.S. Pat. 3,025,960, Mar. 20, 1962.

[11] Trauffer, Walter E. Feldspar Corporation's New Connecticut Plant Serves Northeastern Markets. Pit and Quarry, v. 54, No. 10, April 1962, pp. 138–141, 165.

[12] De Groote, M., and K. T. Shen (assigned to Petrolite Corp.). Froth Flotation Process Employing Polyamino Methyl Phenols. U.S. Pat. 3,056,498, Oct. 2, 1962.

Fenske, D. R. (assigned to International Minerals & Chemical Corp., Chicago, Ill.). Ore Beneficiation Proces. U.S. Pat. 3,032,195, May 1, 1962.

Sollin, I. (assigned to International Minerals & Chemical Corp., Chicago, Ill.). Ore Beneficiation Process. U.S. Pat. 3,032,196, May 1, 1962.

[13] Battelle Technical Review. Dissolution of Alkaline Feldspars. V. 11, No. 3, March 1962, p. 99a.

[14] Lehmann, H., and W. Lorenz. pH Measurements in Feldspar Suspensions. Tonindustr. Ztg, v. 86, No. 4, April 1962, pp. 79–81.

[15] Reynolds, Robert C., Jr. The Determination of Dioctahedral Mica and Potassium Feldspar in Submicroscopic Grain Sizes. Am. Mineralogist, v. 47, Nos. 7–8, July–August 1962, pp. 979, 982.

[16] Labino, D., and L. V. Gagin (assigned to Johns-Manville Fiber Glass Inc., Cleveland, Ohio). High Temperature Resistant Siliceous Compositions and Method of Producing. U.S. Pat. 3,017,318, Jan. 16, 1962.

NEPHELINE SYENITE

DOMESTIC CONSUMPTION

Consumption of imported nepheline syenite from Canada in the glass and ceramic industries increased a little over 1 percent in 1962 and the value increased almost 3 percent. Nepheline syenite, unsuitable for the glass and ceramic industries because of high-iron content, was mined in Arkansas for use as roofing granules. Production statistics are included in the Minerals Yearbook chapter on stone.

TABLE 8.—U.S. imports for consumption of nepheline syenite

Year	Crude		Ground		Year	Crude		Ground	
	Short tons	Value	Short tons	Value		Short tons	Value	Short tons	Value
1953-57 (average)	36	$132	120,827	[1]$1,848,357	1960	900	$18,585	195,166	$2,370,040
1958	160	2,696	164,814	2,253,062	1961	1,167	20,224	186,297	2,026,239
1959	808	18,652	184,464	2,403,079	1962	38	3,835	188,833	2,084,766

[1] Data known to be not comparable with other years.

Source: Bureau of the Census.

PRICES

Quotations[17] had not been generally published in recent years. The approximate price of glass-grade, f.o.b. Blue Mountain area, was $9 per ton. For the finest ground, high-quality product, bagged, in carlots, f.o.b. works prices ranged up to $28 per short ton.

FOREIGN TRADE

Imports of ground nepheline syenite from Canada, mostly for the glass industry, increased 1 percent in quantity and 3 percent in value in 1962. Only 38 short tons of crude nepheline syenite was imported from Canada.

WORLD REVIEW

Canada.—Canada, with a 3-percent increase in production, continued to be the major known producer of nepheline syenite for the ceramic industry in 1961. Estimated shipments in 1961 of 247,688 short tons represented a 3-percent increase over the revised 1960 figure of 240,636 tons.

Norway.—Limited production of nepheline syenite began.

U.S.S.R.—Substantial quantities of nepheline syenite were reported to have been produced as a ceramic raw material and as a source of alumina.

Other Countries.—Deposits of nepheline syenite occur in Belgium-Luxembourg, Finland, India, Republic of Korea, and Peru.

[17] Reeves, J. E. Nepheline Syenite—1961. Canada Dept. Mines and Tech. Surveys, April 1962, p. 2.

TABLE 9.—Canada: Production, exports, and consumption of nepheline syenite

	1960		1961 [1]	
	Short tons	Value	Short tons	Value
Production (shipments)	[2] 240,636	[2] $2,891,095	247,688	$2,473,118
Exports:				
Belgium-Luxembourg	353	6,326	2,692	44,058
Germany, West	368	6,820	392	7,559
Puerto Rico	900	12,225	1,450	21,665
United Kingdom	6,808	98,132	10,170	144,436
United States	183,864	2,231,761	177,740	1,972,665
Other	1,005	18,090	2,154	58,965
Total	193,298	2,373,354	194,598	2,249,348
Consumption:				
Glass, glass fiber, and mineral wool	33,429			
Clay products	2,372			
Miscellaneous	248			
Total	36,049			

[1] Preliminary figures.
[2] Revised figure.

Source: Reeves, J. E. Nepheline Syenite—1961. Canada Dept. Mines and Tech. Surveys, April 1962, p. 2.

TECHNOLOGY

A review covering technology, uses, and occurrences was issued.[18] The case history of the exploration and evaluation of an industrial mineral deposit including nepheline was reported in detail, covering geology, mineralogy, and beneficiation.[19]

APLITE

Sales of ground aplite, primarily for use in making amber glass, increased 28 percent to 140,000 short tons in 1962. There was a small increase in the average selling price.

Aplite was mined only in Virginia. Producers were Riverton Lime & Stone Co. Division, Chadbourn Gotham, Inc., Amherst County; Consolidated Feldspar Department, International Minerals & Chemical Corp., Nelson County; Buffalo Mines, Inc., Nelson County; and M & T Chemicals, Inc., Hanover County.

The aplite, byproduct recovery operation of M & T Chemicals, Inc., was reported, and a detailed flowsheet was published.[20]

[18] Reeves, J. E. Nepheline Syenite—1961. Canada Dept. Mines and Tech. Surveys, Ottawa, April 1962, 4 pp.
[19] Moyd, Louis, Pauline Moyd, and H. L. Noblitt. The Monteagle Nepheline-Corundum-Mica Deposit. Canadian Min. and Met. Bull., v. 55, No. 604, August 1962, pp. 563–570.
[20] Doud, K. E., and W. W. Coffen. Unique Mining Operation Yields Rutile and Aplite. Min. Eng., v. 14, No. 10, October 1962, pp. 59–62.

Ferroalloys

By Frank L. Fisher,[1] Gertrude C. Schwab,[2] and Hilda V. Heidrich [2]

DOMESTIC production of ferroalloys in 1962 increased 7 percent to 2 million short tons, and the quantity of shipments declined to 1.9 million tons. Producer stocks increased 25 percent and consumer stocks decreased 8 percent.

DOMESTIC PRODUCTION

In 1962, 52 producers in 18 States made approximately 2 million tons of ferroalloys in 58 plants; 41 of the plants were electric furnace, 12 were blast furnace, and 5 were aluminothermic. Ohio was the leading State with 546,084 short tons, and Pennsylvania was next with 513,221 tons. Production was also reported from Alabama, Florida, Idaho, Illinois, Iowa, Kentucky, Montana, New Jersey, New York, Oregon, South Carolina, Tennessee, Texas, Virginia, Washington, and West Virginia.

Manganese Alloys.—The 10 producers of ferromanganese made 7 percent more alloy in 1962 and shipped 4 percent less. The ferromanganese was produced in 11 States in 5 blast furnaces and 12 electric furnace plants. The average unit value of the electric furnace product decreased from 13.7 to 12.5 cents per pound of contained manganese. E. J. Lavino & Co. closed its Lynchburg, Va., plant in June for an indefinite period. The facility had 170 employees.

Silicomanganese was made by 8 companies in 13 electric-furnace facilities in 8 States. Production and shipments increased 13 and 7 percent respectively, with the average value reduced from 15.84 to 14.87 cents per pound of contained manganese.

Silicon Alloys.—Eleven companies produced silicon alloys at 23 electric and 1 blast furnace facilities in 10 States. Output increased 19 percent and shipments increased 2 percent.

Silvery Iron.—Six companies manufactured silvery iron in five blast furnace installations and four electric furnace facilities in nine plants. Production and shipments increased 26 and 9 percent respectively from 1961. The unit value of the product produced in the blast furnaces decreased from 41 to 39 cents per pound of contained silicon, and silvery iron produced in electric furnaces increased from 26 to 27 cents per pound.

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

TABLE 1.—Ferroalloys produced and shipped from furnaces in the United States

Alloy	1961				1962			
	Production		Shipments		Production		Shipments	
	Gross weight (short tons)	Alloy element contained (average percent)	Gross weight (short tons)	Value (thousands)	Gross weight (short tons)	Alloy element contained (average percent)	Gross weight (short tons)	Value (thousands)
Ferromanganese: [1]								
Blast furnace	504,744	76.90	508,441	$105,729	528,183	76.76	483,181	$86,694
Electric furnace	228,069	78.18	248,904	53,321	252,929	78.05	244,515	47,652
Total	732,813	77.30	757,345	159,050	781,112	77.18	727,696	134,346
Silicomanganese	120,238	65.77	121,229	25,238	136,197	65.82	129,925	25,429
Ferrosilicon	352,017	56.23	389,268	72,833	419,741	54.99	398,731	70,971
Silvery iron:								
Blast furnace	73,873	8.58	112,904	8,170	84,636	9.70	102,250	7,580
Electric furnace	100,029	15.76	105,224	8,712	133,751	15.76	136,589	11,513
Total	173,902	12.71	218,128	16,882	218,387	13.41	238,839	19,093
Chromium alloys:								
Ferrochromium	[2] 213,091	65.10	231,701	84,547	[2] 191,302	65.08	173,959	63,111
Other chromium alloys	[3] 80,365	40.13	82,104	19,653	[3] 70,257	39.93	71,004	17,957
Total	293,456	58.26	313,805	104,200	261,559	58.32	244,963	81,068
Ferrotitanium	2,607	27.46	2,831	1,919	2,572	22.55	2,440	1,727
Ferrophosphorus	94,841	24.04	51,020	2,708	96,655	24.08	51,650	2,735
Ferrocolumbium and ferrotantalum-columbium	993	58.21	1,015	4,014	1,351	58.25	1,342	5,285
Ferronickel	20,241	51.01	19,800	} 47,413	19,910	53.08	19,678	} 50,107
Other [4]	73,347	27.20	66,084		61,470	27.75	60,803	
Grand total	1,864,455	58.51	1,940,525	434,257	1,998,954	57.90	1,876,067	390,761

[1] Includes briquets.
[2] Includes low-and high-carbon ferrochromium and chromium briquets.
[3] Includes ferrochrome-silicon, exothermic chromium additives and other chromium alloys.
[4] Includes Alsifer, ferroboron, ferromolybdenum, ferrotungsten, ferrovanadium, simanal, spiegeleisen, zirconium-ferrosilicon, ferrosilicon-zirconium, aluminum-silicon alloy, and other miscellaneous ferroalloys.

Chromium Alloys.—Nine companies produced ferrochromium at 15 electric-furnace facilities in 8 States. Production and shipments decreased 11 and 22 percent respectively from 1961. The average unit value of the contained chromium increased from 28.4 to 28.6 cents per pound. Strategic Materials Corp. began producing ferrochrome on a commercial basis at Niagara Falls, Ontario, using the Strategic-Udy process.

Molybdenum Alloys.—Two companies produced ferromolybdenum using both the aluminothermic and the electric furnace methods. The average unit value decreased from $2.17 to $1.89 per pound of contained molybdenum.

Titanium Alloys.—Four companies produced ferrotitanium at three electric-furnace facilities and one aluminothermic installation in three States.

Ferrophosphorus.—Eight companies reported production of ferrophosphorus as a byproduct of the electric-furnace process used in smelting phosphate rock in making elemental phosphorus. Production and shipments increased 2 and 1 percent, respectively. The average value decreased from $53.07 to $52.96 per ton.

TABLE 2.—Producers of ferroalloys in the United States in 1962

Producer	Plant location	Product [1] and type of furnace [2]
The American Agricultural Chemical Co.	Pierce, Fla	FeP (E).
The Anaconda Company	Anaconda, Mont	FeMn (E).
Bethlehem Steel Co	Johnstown, Pa	FeMn (B).
Central Farmers Fertilizer Co	Georgetown, Idaho	FeP (E).
Chromium Mining and Smelting Corp., Ltd.	Riverdale, Ill	FeCr (E).
Climax Molybdenum Co	Langeloth, Pa	FeMo (T).
FMC Corp., Mineral Products Div	Pocatello, Idaho	FeP (E).
The Hanna Furnace Corp	Buffalo, N.Y	Silvery iron (B).
Hanna Nickel Smelting Co	Riddle, Oreg	FeSi, FeNi (E).
Hooker Chemical Corp	Columbia, Tenn	FeP (E).
Interlake Iron Corp	Beverly, Ohio	SiMn, FeSi, FeCr, silvery iron (E).
Do	Jackson, Ohio [3]	Silvery iron (B).
Do	Toledo, Ohio	Silvery iron (B).
Jackson Iron & Steel Co	Jackson, Ohio	Silvery iron (B).
Keokuk Electro-Metals Co., Division of Vanadium Corporation of America.	Keokuk, Iowa	FeSi, silvery iron (E).
Do	Wenatchee, Wash	FeSi, Si (E).
E. J. Lavino & Co	Sheridan, Pa.; Reusens, Va.[3]	FeMn (B).
Molybdenum Corporation of America.	Washington, Pa	FeMo (E) and (T); FeW, FeB, FeCb (E).
Monsanto Chemical Corp	Soda Springs, Idaho; Columbia, Tenn.	FeP (E).
Montana Ferro-Alloys, Co., Inc	Woodstock, Tenn	FeMn, SiMn, FeSi, FeC [5] (E).
The New Jersey Zinc Co	Palmerton, Pa.[4]	Spln (B) and (E).
Ohio Ferro-Alloys Corp	Brilliant, Ohio	FeSi, FeCr, Si (E).
Do	Philo, Ohio	FeMn, SiMn, FeSi, Si, other [5] (E).
Do	Powhatan Point, Ohio	FeSi, Si, other (E).
Do	Tacoma, Wash	FeSi, Si (E).
Pacific Northwest Alloys, Inc	Mead, Wash [3]	FeSi, FeCr (E).
Pittsburgh Metallurgical Co	Niagara Falls, N.Y	FeMn, SiMn, FeSi, FeCr, silvery iron, Si (E).
Do	Calvert City, Ky	FeMn, SiMn, FeSi, FeCr, silvery iron, Si (E).
Do	Charleston, S.C	FeSi, FeCr, Si (E).
Reading Chemicals	Robesonia, Pa	FeV, FeW, FeCb, NiCb, (T).
Shieldalloy Corp	Newfield, N.J	FeV, FeTi, FeCb, FeCbTa (T).
Tennessee Products & Chemical Corp	Chattanooga, Tenn	FeSi, FeCr (E).
Do	Rockwood, Tenn	FeMn, SiMn, FeSi, FeCr, Si (E), silvery pig (B).
Tennessee Valley Authority	Muscle Shoals, Ala	FeP (E).
Tenn-Tex Alloy & Chemical Corp	Houston, Tex	FeMn, SiMn, FeSi (E).
Titanium Alloy Manufacturing Division, National Lead Co.	Niagara Falls, N.Y	FeTi, other (E).
Union Carbide Metals Co	do	FeCr, FeW, FeB, FeTi, FeCb, FeCbTa, other (E).
Do	Alloy, W. Va	FeMn, SiMn, FeSi, FeCr, Si, other (E); FeV (T).
Do	Marietta, Ohio	FeMn, SiMn, Spln, FeSi, FeCr, other (E).
Do	Ashtabula, Ohio	FeMn, SiMn, FeSi (E).
Do	Sheffield, Ala	FeMn, SiMn, FeSi (E).
Do	Portland, Oreg	FeMn, SiMn, FeSi (E).
United States Steel Corp	Ensley, Ala.; Duquesne, Pa.	FeMn, (B).
Vanadium Corporation of America	Cambridge, Ohio	FeTi, FeV, FeCb, other (E).
Do	Vancoram, Ohio	FeSi, FeCr, other (E).
Do	Graham, W. Va	SiMn, FeSi, FeCr, other (E).
Victor Chemical Division, Stauffer Chemical Co.	Mt. Pleasant, Tenn	FeP (E).
Virginia-Carolina Chemical Corp	Nichols, Fla.; Charleston, S.C.	FeP (E).
Woodward Iron Co	Woodward, Ala	FeSi, (B) and (E).

[1] Abbreviations used: FeMn, ferromanganese; Spln, spiegeleisen; SiMn, silicomanganese; FeSi, ferrosilicon; FeP, ferrophosphorus; FeCr, ferrochromium; FeMo, ferromolybdenum; FeNi, ferronickel; FeTi, ferrotitanium; FeW, ferrotungsten; FeV, ferrovanadium; FeB, ferroboron; FeCbTa, ferrocolumbium-tantalum; FeCb, ferrocolumbium; NiCb, nickel columbium; Si, silicon metal.
[2] E, electric; B, blast; T, aluminothermic.
[3] Plant closed in 1962.
[4] New electric furnace started in 1962.
[5] Includes Alsifer, simanal, zirconium alloys, ferrosilicon boron, aluminum silicon alloys, and miscellaneous ferroalloys.

Ferrocolumbium and Ferrotantalum-Columbium.—Five companies reported production of ferrocolumbium at facilities located in four States. Production was obtained at three electric-furnace and two aluminothermic plants. Production increased 37 percent over that of 1961 and shipments were 32 percent higher. The unit value remained at $3.40 per pound of contained columbium.

Two companies reported production of ferrotantalum-columbium in plants which also produced ferrocolumbium. Production and shipments increased 14 and 47 percent, respectively. The average unit value increased from $2.99 to $3.15 per pound of contained columbium and tantalum.

Ferronickel.—Hanna Nickel Smelting Co., Riddle, Oreg., continued to be the only ferronickel producer.

Vanadium Alloys.—Four producers made ferrovanadium, containing 55 percent vanadium, in one electric furnace facility and three aluminothermic installations.

Zirconium Alloys.—One company continued the production of zirconium-ferrosilicon containing 13 percent zirconium. The unit value increased from 78 to 86 cents per pound of contained zirconium.

Ferroboron.—Ferroboron was produced by two companies in two electric furnace plants in two States. The average boron content increased from 17.3 percent in 1961 to 17.6 percent. The average unit value decreased from $6.80 to $6.74 per pound of contained boron.

Tungsten Alloys.—Ferrotungsten was produced by three companies in two electric-furnace plants and one aluminothermic plant in New York and Pennsylvania. Production and shipments of tungsten alloys decreased 12 and 18 percent, respectively. The average unit value of contained tungsten was $2.24 per pound compared with $2.47 per pound in 1961.

CONSUMPTION AND USES

As reported to the Bureau of Mines, 1,774,000 short tons of ferroalloys was used in the United States, 7 percent more than in 1961. The American Iron and Steel Institute (AISI) showed that 1,524,836 tons of ferroalloys was consumed by the steel industry.[3]

Most of the ferroalloys were consumed in alloy-steel production. The AISI reported that 8 million tons of alloy steel was produced in 1962 compared with 7.5 million tons in 1961. Included in the 8 million tons was 5.7 million tons of heat-treatable engineering steel; 1,194,000 tons of low-alloy, high-strength, and nonheat-treated engineering and construction steels; 883,000 tons of silicon electric sheet; 670,000 tons of nominal 18–8 nickel-chrominum stainless steels (AISI 300 series); 363,000 tons of essentially nickel-free chromium stainless steels (AISI 400 and 500 series); and 389 tons of miscellaneous alloy-steel ingot. The 8 million tons also included 283,000 tons of heat-treatable steel ingot containing boron. This quantity was 3,000 tons more than in 1961. Ferroalloys were also used in 1.1 million tons of cast steel and 11.5 million tons of cast iron in foundries independent of the steel producers.

[3] American Iron and Steel Institute Report 1962, p. 44.

Manganese Alloys.—The consumption of ferromanganese increased 28,000 tons. Most of the increase was in carbon steels.

The use of silicomanganese increased 11,000 tons over the quantity consumed in 1961, and most of the increase was also in carbon steels.

Silicon Alloys.—The consumption of silicon alloys was 72,000 tons more than in 1961, and of this quantity, 17,000 tons was silvery pig iron. Lithium ferrosilicon, a new alloy for lowering oxygen and hydrogen content of carbon alloy, and stainless steels was available in commercial quantities for the first time.

Titanium Alloys.—Consumption of ferrotitanium continued to decrease for the third successive year.

Ferrophosphorus.—Consumption of ferrophosphorus declined for the second successive year.

Ferroboron.—Consumption of ferroboron increased 60 percent.

Chromium Alloy.—Consumption of chromium alloys increased 3,486 tons over that of 1961. The use of chromium alloys in the manufacture of space-age steels rose sharply.

Molybdenum Alloys.—An increase of 449 tons in consumption of molybdenum alloys was a gain of 12 percent over that of 1961.

Tungsten Alloys.—Consumption increased 18 percent or 93 tons with "other tool steel", again sharply increasing its use.

Vanadium Alloys.—The quantity of vanadium alloys consumed was approximately 15 percent more than for the previous 2 years.

Ferrocolumbium and Ferrotantalum-Columbium.—Consumption of ferrocolumbium and ferrotantalum-columbium increased sharply, continuing a rise that began in 1960. Consumption was 32 percent and 41 percent more for ferrocolumbium and ferrotantalum-columbium, respectively, with major gains in the use of "other alloy steels" and carbon steels. The increase in consumption of tantalum and columbium ferroalloys was attributed to their use as aerospace materials, especially high-temperature alloys. The addition of small quantities of columbium (¼ to 1 pound per ton) in mild-carbon, semikilled steels gave them improved strength and weldability with only a minor loss in ductility.

Zirconium Alloys.—The steel producers reported to the AISI that they consumed 1,360 short tons of minor zirconium alloys. The minor alloys showed an increase over 1961, whereas ferrozirconium continued to decrease with a 24-percent decline in consumption from that of 1961.

TABLE 3.—Consumption by major end uses, and stocks, of silicon alloys, in the United States in 1962

(Short tons, gross weight)

Alloy	Silicon content (percent)	Stainless steels	Other alloy steels [1]	Carbon steels	Tool steels	Steel mill rolls	Gray and malleable castings	Aluminum base alloys	High temperature alloys	Other nonferrous alloys [2]	Miscellaneous uses	Total consumption	Stocks December 31
Silvery pig iron	5-13	----------	933	1,297	----------	795	81,143	----------	----------	1	201	84,370	7,564
Do	14-20	----------	5,901	16,703	----------	136	90,547	----------	----------	149	[3] 6,129	119,565	17,164
Ferrosilicon	[4] 21-55	6,471	46,042	76,968	845	698	64,560	42	195	2,228	[5] 11,218	209,267	20,863
Do	56-70	795	9,415	14,960	----------	----------	568	----------	----------	----------	[5] 3,657	29,395	1,435
Do	71-80	7,720	15,378	5,304	417	132	10,264	----------	14	29	[6] 5,705	44,963	4,753
Do	81-89	52	915	1,798	----------	101	3,181	----------	----------	33	3	6,083	675
Do	90-95	19	2,397	137	----------	37	175	2,773	27	38	51	5,654	579
Silicon metal	96-99	15	48	40	15	----------	581	35,538	577	628	[7] 7,417	44,859	2,320
Ferrosilicon briquets	40-50	----------	180	285	----------	19	23,977	----------	----------	2	2	24,465	3,684
Miscellaneous silicon alloys [8]	----------	254	5,544	8,270	59	117	10,590	131	57	37	3,298	28,357	1,959
Total	----------	15,326	86,753	125,762	1,336	2,035	285,586	38,484	870	3,145	37,681	596,978	60,996

[1] Includes quantities of carbon steels because some firms failed to specify individual uses.
[2] Includes cutting and wear-resistant materials, welding rods, alloy hard-facing rods, permanent-magnet alloys, copper-base alloys, nickel-base alloys, electrical resistance alloys, anodes, and other nonferrous alloys.
[3] Mainly in high-silicon iron and to beneficiate iron ore.
[4] Mainly from 40 to 55 percent silicon.
[5] Mainly in producing ferronickel.
[6] Mainly in magnesium reduction, pig iron, etc.
[7] Mainly in silicones and other chemical compounds.
[8] Includes calcium-silicon, calcium-manganese-silicon, silicon-manganese-zirconium, ferrocarbon (including briquets), Alsifer, and other miscellaneous silicon alloys.

TABLE 4.—Consumption by end uses of ferroalloys as additives in the United States in 1962 [1]

(Short tons, gross weight)

Alloy	Stainless steels	Other alloy steels [2]	Carbon steels	Tool steels [3]	Gray and malleable castings	Miscellaneous uses [4]	Total
Ferromanganese [5]	9,852	140,917	669,995	3,717	28,241	13,573	866,295
Silicomanganese	5,504	35,625	75,450	1,132	3,476	1,155	122,342
Silicon alloys [6]	15,326	88,788	125,762	1,336	285,586	80,180	596,978
Ferrotitanium	342	661	896	53	2	237	2,191
Ferrophosphorus	13	2,754	9,531	----------	853	84	13,235
Ferroboron	2	63	88	----------	12	5	170
Total	31,039	268,808	881,722	6,238	318,170	95,234	1,601,211

[1] Except for gray and malleable castings, other items may include steel castings as well as steel ingots.
[2] Includes steel mill rolls.
[3] Includes high-speed, hot-work, and other tool steels.
[4] Includes cutting and wear-resistant materials, high-temperarure alloys, welding rods, alloy hard-facing rods and materials, permanent-magnet alloys, soft-magnetic alloys, nickel-base alloys, titanium-base alloys, wire, rod, and sheet, aluminium-base alloys, high-silicon alloys, anodes, powdered-premixed ferrophosphorus, pig iron, and ground-coat frit.
[5] Includes spiegeleisen, manganese metal, and briquets.
[6] See table 3 for more detail on silicon alloys.

TABLE 5.—Consumption by end uses of ferroalloys as alloying elements in the United States in 1962

(Short tons of contained alloy)

Alloy	Stainless steels	Other alloy steels	Carbon steels	High-speed steels	Other tool steels [1]	Gray and malleable castings	High temperature alloys	Miscellaneous uses [2]	Total
Ferrochromium [3]	111,536	[4] 40,579	--------	1,077	1,439	3,559	5,360	1,896	165,446
Ferromolybdenum [5]	896	[4] 894	--------	387	131	1,380	121	448	4,257
Ferrotungsten	--------	[6] 105	--------	282	177	----------	31	9	604
Ferrovanadium	17	[7] 1,031	145	296	152	21	14	34	1,710
Ferrocolumbium [8]	268	150	112	--------	2	----------	82	32	646
Ferrotantalum-columbium [8]	23	--------	--------	--------	--------	1	24	[9] 4	52
Total	112,740	42,759	257	2,042	1,901	4,961	5,632	2,423	172,715

[1] Includes hot-work and die steels.
[2] Includes diamond-drill bit matrices, electrical-contact points, welding rods, permanent magnet alloys, nickel-base alloys, electrical resistance alloys, and carbon steels.
[3] Includes ferrochromium alloys and chromium metals.
[4] Includes quantities believed used in producing high-speed and other tool steels and stainless steels, because some firms failed to specify individual uses.
[5] Includes calcium molybdate and molybdenum silicide.
[6] Includes stainless steels, steel mill rolls, and other alloy steels.
[7] Includes steel mill rolls.
[8] See table 6 for more detail on end uses.
[9] Includes 11 tons of Cb and Ta chemicals.

TABLE 6.—Consumption by end uses of ferrocolumbium and ferrotantalum-columbium in the United States

(Pounds of contained columbium and tantalum)

Product	1961	1962	Product	1961	1962
Stainless steels	591,389	582,563	High-temperature alloys	180,869	213,331
Other alloy steels	155,138	300,554	Permanent-magnet alloys	2,122	2,827
Carbon steels	77,967	223,530	Refractory alloys	3,500	----------
Tool steels	234	3,289	Miscellaneous uses	7,999	[1] 33,003
Welding rods	30,687	36,212			
Gray and malleable castings	2,276	2,329	Total	1,052,181	1,397,638

[1] Includes 23,000 pounds of Cb and Ta chemicals.

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STOCKS

Producer stocks increased 25 percent and consumer stocks declined 8 percent compared with 1961. Major increases were registered by the manganese ferroalloys, ferrochromium, and ferrophosphorus for producer stocks. A sharp decline occurred in consumer stocks of ferrochromium. No ferroalloys were stored in the Defense Product Act stockpile as of December 31.

TABLE 7.—Stocks of ferroalloys held by producers and consumers in the United States as of Dec. 31

(Short tons)

Alloy	Producers		Consumers	
	1961, gross weight	1962, gross weight	1961, gross weight	1962, gross weight
Manganese ferroalloys [1]	[2] 180,147	245,306	171,616	167,819
Silicon alloys [3]	[2] 123,829	125,256	[4] 64,782	[4] 60,996
Ferrochromium [5]	[2] 57,440	72,796	28,203	15,802
Ferrotitanium	[2] 760	993	695	459
Ferrophosphorus	[2] 154,044	199,049	3,610	3,306
Ferroboron	78	177	57	26
Total	[2] 516,298	643,577	268,963	248,408
	1961, contained alloy	1962, contained alloy	1961, contained alloy	1962, contained alloy
Ferromolybdenum [6]	(7)	(7)	545	626
Ferrotungsten	(7)	(7)	89	121
Ferrovanadium	(7)	(7)	262	267
Ferrocolumbium	156	174	76	103
Ferrotantalum-columbium	(7)	(7)	12	8
Total	993	857	984	1,125

[1] Includes silicomanganese, spiegeleisen, manganese metal, and briquets.
[2] Revised figure.
[3] Includes silvery iron, aluminum-silicon alloy, ferrosilicon-boron, ferrosilicon-zirconium, Alsifer, and silicon-manganese-aluminum.
[4] For more detail on stocks see table 3.
[5] Includes other chromium ferroalloys and chromium metal.
[6] Includes calcium molybdate and molybdenum silicide.
[7] Figure withheld to avoid disclosing individual company confidential data.

TABLE 8.—Government inventory of ferroalloys, Dec. 31, 1962

(Short tons)

Alloy	National (strategic stockpile)	CCC and supplemental stockpile	Total
Ferrochromium:			
High-carbon	126,000	257,000	383,000
Low-carbon	128,000	189,000	317,000
Ferrochromium-silicon, low-carbon	26,000	33,000	59,000
Ferrocolumbium	224		224
Ferrotantalum-columbium	70		70
Ferromanganese, standard high-carbon	143,000	690,000	833,000
Ferromolybdenum (contained molybdenum)	2,011		2,011
Ferrotungsten (contained tungsten)	826		826
Ferrovanadium (contained vanadium)	1,001		1,001
Total	427,132	1,169,000	1,596,132

Source: General Services Administration.

PRICES

Quotations of the major ferroalloys remained firm. Twenty-six of the 30 ferroalloys, the prices of which were regularly quoted weekly in the American Metal Market, were unchanged during the year. Eleven ferroalloys dropped in price, five of which were chromium ferroalloys. Prices rose for 12 to 15 percent zirconium alloy and for high-carbon ferrotitanium. The price of 50 percent ferrosilicon, the important deoxidizer in steelmaking, was reduced in August from 14.5 cents per pound to 13.5 cents per pound.

Lower prices for low-carbon ferrochrome and charge chrome were announced by a major producer and became effective September 20. Lower price adjustments of several other interrelated chromium alloys were also made at the same time.

FOREIGN TRADE [4]

Foreign trade in ferroalloys dropped sharply in 1962 after showing increases each year since 1958. The decrease resulted from the termination of the barter for surplus agricultural products for Indian ferromanganese with the U.S. Department of Agriculture, Commodity Credit Corporation (CCC). France was the major exporter of ferromanganese to the United States followed by West Germany. Imports of ferrosilicon showed a slight increase in 1962, the bulk of the ferrosilicon coming from Canada. U.S. exports of ferroalloys dropped sharply during the year to 26,912 tons, a decrease of 54,900 tons. Ferrosilicon, ferrophosphorus, and ferrochrome showed sharp declines. Ferromanganese exports increased from 469 tons to 4,414 tons.

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

TABLE 9.—U.S. imports for consumption of ferroalloys and ferroalloy metals

Alloy	1961			1962		
	Gross weight (short tons)	Content (short tons)	Value	Gross weight (short tons)	Content (short tons)	Value
Calcium silicide	279	(1)	$82,561	685	(1)	$200,163
Chromium metal	692	(1)	1,149,916	648	(1)	992,655
Chromium-nickel and chromium vanadium	12	(1)	5,703	3	(1)	3,352
Ferroboron	9	(1)	14,190	10	(1)	16,032
Ferrocerium and other cerium alloys	11	(1)	63,210	10	(1)	60,421
Ferrochrome and ferrochromium—						
Containing 3 percent or more carbon	14,406	9,433	3,125,214	12,029	7,437	2,074,245
Containing less than 3 percent carbon	13,408	9,265	4,486,413	24,290	17,365	7,948,547
Ferrochromium-tungsten, chromium-tungsten, chromium-cobalt-tungsten, tungsten-nickel, and other alloys of tungsten, n.s.p.f. (tungsten content)	(1)	5	14,998	(1)	21	47,044
Ferromanganese—						
Containing not over 1 percent carbon	551	487	233,131	1,040	940	442,035
Containing over 1 and less than 4 percent carbon	7,813	6,396	1,755,700	12,826	10,517	2,883,891
Containing not less than 4 percent carbon	213,572	163,316	32,407,357	111,748	85,585	13,305,508
Ferromolybdenum, molybdenum metal and powder, calcium molybdate, and other compounds and alloys of molybdenum (molybdenum content)	(1)	5	36,514	(1)	39	189,455
Ferrosilicon	13,730	2,307	803,283	16,329	2,573	975,892
Ferrosilicon-aluminum and ferroaluminum silicon and alsimin	-------	-------	----------	2,502	(1)	1,044,917
Ferrotitanium	182	(1)	93,460	120	(1)	87,702
Ferrotungsten	214	170	421,746	329	267	531,071
Ferrovanadium	-------	-------	----------	88	(1)	231,028
Manganese metal (manganese content)	(1)	565	262,460	(1)	1,989	692,087
Manganese silicon (manganese content)	(1)	13,471	2,525,407	(1)	17,153	3,026,073
Silicon metal (silicon content)	31	30	8,206	12	12	5,015
Tungsten in combinations, in lump, grains, or powder (tungsten content)	(1)	28	139,370	(1)	249	937,950
Tungstic acid and other alloys of tungsten, n.s.p.f. (tungsten content)	(1)	194	373,503	(1)	(2)	890
Zirconium silicon	-------	-------	----------	70	(1)	12,999

1 Not recorded.
2 356 pounds.

Source: Bureau of the Census.

TABLE 10.—U.S. imports for consumption of ferromanganese and ferrosilicon, by countries

Country	Ferromanganese (manganese content), excluding silicomanganese				Ferrosilicon (silicon content)			
	1961		1962		1961		1962	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
North America:								
Canada	166	$36,255	135	$29,127	2,203	$690,250	2,396	$791,954
Mexico	1,513	235,955	1,236	196,815	------	------	------	------
Total	1,679	272,210	1,371	225,942	2,203	690,250	2,396	791,954
South America:								
Brazil	------	------	4,231	637,856	------	------	------	------
Chile	2,877	646,884	4,534	940,318	------	------	------	------
Total	2,877	646,884	8,765	1,578,174	------	------	------	------
Europe:								
Belgium-Luxembourg	------	------	2,922	465,946	------	------	------	------
France	31,391	5,745,190	35,403	5,759,434	------	------	9	1,873
Germany, West	16,816	2,572,525	17,671	2,658,997	87	109,403	163	180,948
Italy	363	97,119	217	52,693	------	------	------	------
Norway	1,710	245,000	894	127,486	------	------	4	845
Spain	1,058	163,858	------	------	------	------	------	------
Sweden	844	126,000	------	------	------	------	------	------
Yugoslavia	6,432	1,005,466	2,089	324,450	------	------	------	------
Total	58,614	9,955,158	59,196	9,389,006	87	109,403	176	183,666
Asia:								
India	73,058	17,290,849	5,702	1,166,690	------	------	------	------
Japan	12,463	3,104,794	9,707	2,426,943	------	------	------	------
Total	85,521	20,395,643	15,409	3,593,633	------	------	------	------
Africa: South Africa, Republic of [1]	21,508	3,126,293	12,301	1,844,679	17	3,630	1	272
Grand total	170,199	34,396,188	97,042	16,631,434	2,307	803,283	2,573	975,892

[1] Effective Jan. 1, 1962; formerly Union of South Africa.

Source: Bureau of the Census.

TABLE 11.—U.S. experts of ferroalloys and ferroalloy metals

Alloy	1959		1960		1961		1962	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Ferrochrome	6,127	$2,095,978	15,588	$5,248,750	7,844	$2,837,518	3,075	$1,182,382
Ferromanganese	947	388,134	751	202,457	469	146,178	4,114	629,401
Ferromolybdenum	124	280,495	212	489,140	179	501,476	95	305,126
Ferrophosphorus	49,903	1,798,592	47,897	2,094,527	[1] 32,860	[1] 1,425,568	14,130	594,666
Ferrosilicon	10,558	980,658	5,501	867,140	34,764	6,104,913	4,101	1,348,661
Ferrotitanium and ferrocarbon-titanium	321	145,621	245	157,419	212	93,389	130	95,265
Ferrotungsten	38	57,147	------	------	(2)	1,569	6	26,136
Ferrovanadium	152	529,697	162	506,624	120	436,208	201	745,912
Other ferroalloys	323	194,187	3,845	846,888	4,839	1,234,682	345	231,656
Spiegeleisen	380	37,862	148	15,056	525	46,617	715	59,275
Total	68,873	6,508,371	74,349	10,428,001	[1] 81,812	[1] 12,828,118	26,912	5,218,480

[1] Revised figure.
[2] Less than 1 ton.

Source: Bureau of the Census.

WORLD REVIEW

EUROPE

France.—Péchiney Compagnie de Produits Chimiques et Electrometallurgiques, Paris, announced plans for constructing a ferrochrome plant in the Northern France region of Pas de Calais, at Isberques. The plant was to be adjacent to the stainless steel producer Forges de Chatillon-Commentry et Nueves-Maisons, which was expected to be an important consumer for the ferrochrome production.

Italy.—Societa Nazionale Electro-metallurgica announced that its new facility near Sondino, for the production of extra-fine low-carbon ferrochrome, would be in operation before the end of 1962. The plant used the Ugine-Perrin process and its output was expected to fulfill Italian domestic requirements.

United Kingdom.—Barrow Haematite Steel Co., Ltd., a subsidiary of General & Engineering Industries, Ltd., ceased production of ferromanganese at its Darwen and Mostyn works at the end of 1962.

Yugoslavia.—The annual capacity of the Electro-Bosna ferrosilicon works at Jajne was increased to 9,000 tons by adding new facilities. This brought the Yugoslavian annual capacity to 19,000 tons, of which 13,600 tons was exported in 1962.

ASIA

India.—Twenty-nine papers were presented on the latest technology and research developments in the ferroalloy industry of India at a symposium sponsored by the National Metallurgical Laboratory, Jamshedpur, in February.

Japan.—Forty-six Japanese ferroalloy manufacturers produced an estimated 705,478 tons of various ferroalloys. The quantity was a slight increase over that of 1961 despite cutbacks in the Japanese steel industry. Production of ferromanganese was 184,086 tons, ferrochromium production totaled 93,176 tons. Ferrosilicon and ferronickel production were 82,673 and 39,683 tons, respectively.

The world's largest facilities for the production of low-carbon ferroalloys began operating in September at the Toyama Steel Works of Nippon Kokan K.K. at Shinminato, in Toyama Perfecture, north of Honshu. The plant had a 20,000 kilovolt-ampere finishing furnace with a capacity of 85 tons per day and a 6,000 kilovolt-ampere crude refining furnace with 20 tons per day capacity. The Japanese ferrosilicon industry is discussed in the chapter on silicon.

Philippines.—The Bureau of Mines published two reports that indicated commercial production of ferronickel from Philippine nickel-bearing deposits was feasible.[5] The Bureau conclusions were based on a 6-year series of pilot plant tests on nickeliferous laterite and serpentine ores from Nonoc Island, near Mindanao.

Turkey.—The ferrochrome works of S. A. Turque pour l'Industrie Electrometallurgique began operating at Antalya in October. The

[5] Banning, L. H., W. E. Anable, R. B. Quicho, H. D. Hess, and P. C. Good. Metallurgical Investigations of Philippine Nickeliferous Ores. BuMines Rept. of Inv. 6063, 1962, 71 pp.
Katell, S., J. H. Faber, T. J. Joyce, and P. Wellman. Economic Analysis of the Production of Ferronickel and Steel from Philippine Nickeliferous Ores. BuMines Inf. Circ. 8116, 1962, 45 pp.

plant had an annual capacity of 8,000 tons of high-purity ferrochrome. It was a joint venture of the Turkish Etibank and the French firms, Péchiney and Compagnie pour l'Etude de Developpment des Eschanges Commerciaux (Compadec). Chromite was to be supplied from mines in the Antalya, Mugla, and Burder areas, and anthracite was to be imported from Western Europe. The output would be exported to France.

AFRICA

Rhodesia and Nyasaland, Federation of.—Production of ferrochromium began in November at the Que Que plant of Windsor Ferroalloys (Pvt.) Ltd. Initial production was 31 tons per day, but production was expected to increase ultimately to 20,000 tons annually.

South Africa, Republic of.—An extensive expansion program was undertaken in 1962. New ferroalloy producers included RMB Alloys, Germiston, a subsidiary of Rand Mines Ltd. Planned annual capacity was 25,000 tons of 52 percent low-carbon ferrochromium. The Anglo-American Corporation of South Africa, Ltd. joined with Avesta Jernverks Aktiebolag of Sweden to form Transalloys (Pty), Ltd. A ferrochromium plant was constructed near Witbank, Transvaal. Ferroalloys, Ltd., announced plans to double its 100,000 ton annual capacity for producing ferromanganese at Cato Ridge, Natal. Palmiet-Chrome Corp., West Rand, began constructing ferrochromium production facilities.

United Arab Republic (Egypt).—An agreement was reached in July between the Sinai Manganese Society and a group entitled Norwegian Companies for constructing a 10,000-ton-per-year ferromanganese plant at an estimated cost of $33 million.

Egyptian and Russian authorities signed an agreement for constructing ferrosilicon facilities at Aswan using Soviet credit.

OCEANIA

Australia.—The first large-scale ferroalloy industry began production at Bell Bay, northern Tasmania. High-carbon ferromanganese was produced by Tasmanian Electro-Metallurgical Co., Pty., Ltd., a subsidiary of Broken Hill Pty. Co., Ltd. Initial capacity was 26,000 tons annually. Manganese ore was obtained from the Pilbara deposits in Western Australia.

TECHNOLOGY

Precision metering of ferroalloys, introduced into molten steel by ladle addition feeders using load-cell weighing systems in the feeder bins, was announced by Baldwin-Lima-Hamilton Corp.[6] This innovation, when in operation, was expected to result in up to 20 percent higher recovery of alloys because of better dispersion in the melt and less carry-off in the slag by utilizing closer control of blending weights and rates.

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[6] Steel Alloy Addition Accuracy Insured With Load Cells. V. 151, No. 2, July 9, 1962, p. 73.

The Soviets announced the application of electroslag remelting for the production of ferroalloys.[7] Ferroalloys of high quality were obtained. The successful desulfurizing and dephosphorizing of the alloy minimized gases and nonmetallic inclusions.

Research and development continued on the use of rare-earth metals as ferroalloys; effective deoxidizers, desulfurizers, inoculators, and degasifiers of steel; and for increasing fluidity and improving the structure of steel.

The demand for higher purity and more versatile ferroalloys resulted in the introduction of several new ferroalloys. Among these were Inoculoy 63, a graphitizing inoculant that improved the structure of gray iron,[8] lithium ferrosilicon that lowered the oxygen and hydrogen content of carbon, alloy, and stainless steels,[9] and an improved ferromanganese-silicon that produced more economical stainless steel castings.[10]

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[7] Paton, B. Y., B. I. Medovar, and Y. B. Latach. Present Status and Prospects for Further Development of Electroslag Remelting in the Ukraine. Metallurgicheskaya i Gornorudnaya Promyshlennost' [Metallurgical and Ore Mining Industry] Kiev, No. 5, September–October 1962, pp. 12–19.

[8] American Metal Market. V.C.A. Develops Inoculant for Gray Iron. V. 69, No. 100, May 24, 1962, p. 20.

[9] Blast Furnace and Steel Plant. Lithium Ferrosilicon Developed. V. 5, No. 10, October 1962, p. 989.

[10] Foundry. More Economical Stainless Castings. V. 90, No. 3, March 1962, p. 141.

Fluorspar and Cryolite

By William V. Kuster [1]

FLUORSPAR

SHIPMENTS of finished fluorspar from domestic mines were up slightly over those in 1961 and imports for consumption were up 18 percent; however, fluorspar consumption was down 5 percent from the record high of 1961. Inventories of fluorspar held at domestic mines and at consumers' plants increased 11 percent above those at the end of 1961. Quoted prices were changed in March. During January and February, domestic acid-grade concentrates were quoted at $45 per short ton, whereas in March they were quoted at $45 to $49 per ton.

TABLE 1.—Salient fluorspar statistics

	1953–57 (average)	1958	1959	1960	1961	1962
United States:						
Production:						
Crude:						
Mine production short tons	792,080	818,100	404,900	575,700	615,075	623,750
Material milled or washed short tons	736,060	814,800	442,000	558,600	[1] 524,400	586,700
Beneficiated material recovered short tons	293,580	310,600	195,100	225,900	[1] 185,200	192,000
Finished (shipments) do	300,359	319,513	185,091	229,782	[1] 197,354	206,026
Value thousands	$14,139	$15,071	$8,680	$10,391	[1] $8,940	$9,166
Imports for consumption short tons	426,646	392,164	555,750	534,020	505,759	595,695
Value thousands	$11,201	$9,777	$13,368	$14,393	$13,644	$15,596
Exports short tons	647	3,374	1,144	458	338	1,308
Value thousands	$55	$191	$69	$38	$30	$119
Consumption short tons	580,695	494,227	589,979	643,759	[1] 687,940	652,888
Stocks Dec. 31:						
Domestic mines:						
Crude [2] short tons	180,685	207,210	155,534	137,723	[1] 221,961	277,876
Finished do	23,637	18,677	21,417	16,013	21,001	14,549
Consumer plants do	185,914	185,291	179,771	216,330	[1] 188,413	186,772
Importers do	40,185	39,035	46,422	61,578	75,811	75,303
World: Production do	1,650,000	2,025,000	1,915,000	2,255,000	2,345,000	2,405,000

[1] Revised figure.
[2] This crude (run-of-mine) fluorspar in most cases is subjected to some type of processing before it can be marketed.

LEGISLATION AND GOVERNMENT PROGRAMS

Senate Resolution 206, adopted September 23, 1961, authorized the Federal Tariff Commission to conduct an investigation of the domestic fluorspar market under Section 332 of the Tariff Act of 1930. A

[1] Commodity specialist, Division of Minerals.

public hearing was held before the Tariff Commission on January 30, 1962, and as a result of the hearing, the Commission recommended that no change be made in the tariff structure.

The Office of Minerals Exploration (OME) encouraged exploration for certain minerals, including fluorspar, by participating to the extent of 50 percent of the financial risk with private industry in approved exploratory ventures. No exploration contracts for fluorspar were in force on December 31.

The Federal Government, under authority contained in the Agricultural Trade Development Act of 1954, acquired fluorspar through barter of surplus agricultural products. Barter contracts were executed by the Commodity Credit Corporation, U.S. Department of Agriculture.

DOMESTIC PRODUCTION

Fluorspar was mined in Colorado, Illinois, Kentucky, Montana, Nevada, and Utah in 1962. Shipments of finished fluorspar from mines totaled 206,000 short tons as follows: Acid grade, 141,000 tons valued at $6.9 million; ceramic grade, 35,000 tons at $1.4 million; and metallurgical grade, 30,000 tons at $753,000. Producers in Illinois, the leading producing State, supplied 74 percent of the domestic output.

Output of crude ore from domestic mines was 624,000 tons, about 1 percent more than in 1961. Of the total, 90 percent was obtained from mills that produced over 20,000 tons each. Ten independent and consumer-operated mills processed 586,700 tons of crude ore from which 138,000 tons of flotation concentrate was recovered. Also, 120,000 tons of crude ore was treated in heavy-medium plants, but only 12,000 tons of heavy-medium concentrate was marketed; additional material recovered was further processed in flotation mills. Crude fluorspar marketed as mined totaled 10,801 tons, compared with 37,583 tons in 1961.

Captive mines produced 234,000 tons of ore and their mills recovered 82,000 tons of concentrate from 194,000 tons of ore.

Fluorspar mining by open-pit methods began in September along Dry Creek southwest of Superior, Mineral County, Mont., on properties formerly operated by Jay Bettles of Wallace, Idaho. The new operator, Superior Mines, Inc., Superior Mont., shipped both metallurgical and acid-grade fluorspar to Miller Chemical Co., Seattle, Wash.

Louis O. Macloon acquired the Snowbird fluorspar mine near Fish Creek, Mineral County, Mont., and planned to reopen it in June. This mine was the second largest fluorspar producer in Montana and produced 6,800 tons of acid-grade during the summer of 1958. Mining operations were limited to about 20 weeks per year because of weather conditions. The mine was at an altitude of 8,000 feet.

Harvey Aluminum, Inc., announced an International Division to establish additional sources outside the United States for bauxite, fluorspar, and carbon materials as well as titanium, zirconium, and rare minerals.

Kaiser Aluminum & Chemical Corp., Oakland, Calif., purchased from The Heil Co., Milwaukee, Wis., two buildings in Hillside, N.J., for an Eastern area warehousing location. Kaiser planned to erect bulk distribution facilities on the site for its fluorocarbon products to be made at Gramercy, La.

TABLE 2.—Number and production of domestic crude fluorspar mines by size of operation

Annual production (short tons)	1961			1962		
	Mines	Short tons	Percent	Mines	Short tons	Percent
Less than 1,000[1]	13	2,004	0.3	13	3,076	0.5
1,000 to 10,000	6	38,845	6.3	5	26,805	4.3
10,000 to 20,000	2	30,793	5.0	2	28,758	4.6
Over 20,000	7	543,433	88.4	6	565,111	90.6
Total	28	615,075	100.0	26	623,750	100.0

[1] Includes prospects and reworked dumps and tailings of previous mining and milling operations.

TABLE 3.—Shipments of finished fluorspar, by States

State	1961			1962		
	Short tons	Value		Short tons	Value	
		Total	Average per ton		Total	Average per ton
Illinois	116,908	$5,956,350	$50.95	132,830	$6,391,673	$48.12
Kentucky	[1] 31,169	[1] 1,420,055	[1] 45.56	33,830	1,492,000	44.10
Montana	14,905	(2)	(2)	(2)	(2)	(2)
Nevada	18,129	356,610	19.67	(2)	(2)	(2)
Utah	610	17,608	28.87	399	11,571	29.00
Other [3]	15,633	1,189,496	50.00	38,967	1,271,101	32.59
Total [4]	[1] 197,354	[1] 8,940,000	[1] 45.30	206,026	9,166,000	44.49

[1] Revised figure.
[2] Figure withheld to avoid disclosing individual company confidential data; included with "Other."
[3] Includes Colorado and States indicated by footnote 2.
[4] Total value rounded.

CONSUMPTION AND USES

Domestic fluorspar consumption amounted to 652,888 tons compared with a record 687,940 tons in 1961. Fluorspar consumption was reported in 38 States, but 6 States, New Jersey, Texas, Pennsylvania, Ohio, Kentucky, and Illinois, reported over half of the total consumption.

Hydrofluoric acid producers used 11 percent less than in 1961.

A hydrofluoric acid (HF) unit was under construction at the La Porte works of the E. I. du Pont de Nemours & Co., Inc., near Houston, Tex. Construction started in the summer and was planned for completion late in 1963. Du Pont planned to use most of its output, which was to be shipped by water to plants at East Chicago, Ind., Louisville, Ky., Antioch, Calif., and Deepwater Point, N.J., to make Freon and Teflon fluorcarbon products. The La Porte works, close to sulfur and fluorspar raw materials, was to support Du Pont HF production at the Chambers works at Deepwater Point.[2]

Allied Chemical Corp. began construction of a plant to make tetrafluoroethylene polymers at Elizabeth, N.J. The plant, to be operated by the General Chemical Division, was to go on stream about the middle of 1963; the resin was to be sold by the company's Plastics Division, which marketed other fluorohalocarbon resins based on chlorotrifluoroethylene. The principal uses were expected to be for electrical insulation, gaskets and pump packing, tubing and sheeting for chemical process operations, and antifriction bearings. The 1963 market for the material was estimated at 15 million pounds. Allied's resin was to be priced competitively with other similar resins.[3]

Construction was started on the anhydrous and aqueous hydrofluoric acid plant of Allied Chemical Corp. at Port Chicago, Calif. This was the site of Allied's Nichols hydrogen fluoride plant, which formerly supplied the aluminum industry. Allied planned to use almost half of Nichol's gaseous hydrogen fluoride (estimated capacity was 12,000 tons per year of 100 percent HF) for its new anhydrous and aqueous operation. The new plant, to be operated by the General Chemical Division, was expected to be on stream about September 1963.[4]

Allied Chemical Corp. started building another fluorinated hydrocarbon plant at El Segundo, Calif., that was expected to be on stream late in 1963. The anticipated capacity was more than 20 million pounds per year, raising Allied's total capacity for fluorinated hydrocarbons to about 120 million pounds annually. Allied manufactured these products at Elizabeth, N.J., Danville, Ill., and Baton Rouge, La.[5]

Allied Chemical Corp., General Chemical Division, placed on stream a new plant to make sulfur hexafluoride at Metropolis, Ill. The Compound, which Allied claimed was the first commercial chemical to be produced from elemental fluorine, was replacing oil as an insulator in electrical and electronic equipment.[6]

Rare earth fluorides were available from Kleber Laboratories, Inc., Burbank, Calif. Fifteen fluorides were prepared from the oxides of scandium, yttrium, lanthanum, cerium, praseodymium, neodymium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, and ytterbium.[7]

Trifluoroacetic acid became available in commercial quantities from Halocarbon Products Corp., Hackensack, N.J., in 80 pound carboys. The acid was claimed to be useful in a wide range of applications from an acid catalyst to a zein solvent.[8]

Du Pont, Wilmington, Del., placed on the market a new fluorocarbon cleaning agent, trichlorotrifluoroethane ($C_2Cl_3F_3$) with a minimum purity of 99.9 percent. The cleaning agent shipped in stainless steel tank trucks or in epoxy-modified, phenolic-lined drums was offered

[2] Chemical & Engineering News. V. 40, No. 22, May 28, 1962, p. 25.
[3] Chemical & Engineering News. V. 40, No. 45, Nov. 5, 1962, p. 17.
[4] Chemical & Engineering News. V. 40, No. 13, Mar. 26, 1962, p. 19.
[5] Chemical & Engineering News. V. 40, No. 47, Nov. 19, 1962, p. 21.
[6] Chemical Week. Sulfur Hexafluoride. V. 90, No. 11, Mar. 17, 1962, p. 45.
[7] Chemical & Engineering News. V. 40, No. 8, Feb. 19, 1962, p. 56.
[8] Chemical & Engineering News. V. 40, No. 50, Dec. 10, 1962, p. 57.

for use in missile applications and electronics where extreme cleanliness was necessary.[9]

TABLE 4.—Fluorspar shipped from mines in the United States, by grades and industries

Grade and industry	1961				1962			
	Quantity		Value		Quantity		Value	
	Short tons	Percent of total	Total	Average per ton	Short tons	Percent of total	Total	Average per ton
Ground and flotation concentrates:								
Hydrofluoric acid	[1] 125,094	[1] 80.7	[1] $6,517,257	[1] $52.10	134,796	76.4	$6,687,677	$49.61
Glass	[1] 16,537	[1] 10.7	[1] 717,449	[1] 43.38	23,747	13.4	999,156	42.08
Ceramic and enamel	4,357	[1] 2.8	199,298	45.74	3,978	2.3	171,126	43.02
Nonferrous	2,179	[1] 1.4	97,445	44.72	2,684	1.5	115,548	43.05
Ferrous	4,083	[1] 2.6	166,878	40.87	2,401	1.4	98,208	40.90
Miscellaneous [2]	2,788	[1] 1.8	131,952	47.33	8,817	5.0	363,758	41.26
Total	[1] 155,038	100.0	[1] [3] 7,830,000	[1] 50.51	176,423	100.0	[3] 8,436,000	47.82
Fluxing gravel and foundry lump:								
Nonferrous	13	--------	520	40.00	38	--------	1,426	37.53
Ferrous	31,574	74.6	874,799	27.71	19,533	66.0	607,060	31.08
Miscellaneous	10,729	25.4	234,521	21.86	10,032	34.0	121,386	12.10
Total	42,316	100.0	[3] 1,110,000	26.23	29,603	100.0	[3] 730,000	24.66
All grades:								
Hydrofluoric acid	[1] 125,094	[1] 63.4	[1] 6,517,257	[1] 52.10	134,796	65.4	6,687,677	49.61
Glass	[1] 16,537	[1] 8.4	[1] 717,449	[1] 43.38	23,747	11.5	999,156	42.08
Ceramic and enamel	4,357	[1] 2.2	199,298	45.74	3,978	1.9	171,126	43.02
Nonferrous	2,192	1.1	97,965	44.69	2,722	1.3	116,974	42.97
Ferrous	35,657	[1] 18.1	1,041,677	29.21	21,934	10.7	705,268	32.15
Miscellaneous [2]	13,517	[1] 6.8	366,473	27.11	18,849	9.2	485,144	25.74
Total	[1] 197,354	100.0	[1] [3] 8,940,000	[1] 45.30	206,026	100.0	[3] 9,166,000	44.49

[1] Revised figure.
[2] Includes exports.
[3] Total value rounded.

The position of perchloroethylene (perc) as a drycleaning agent was being challenged by a solvent, trichlorotrifluoroethane plus specially formulated additives. The manufacturer claimed that the fluorinated solvent cleaned faster than perc and was less harmful to fabric and dyes. The cleaning-drying cycle was only one-fourth as long as when perc was used. Other advantages claimed for the fluorocarbon agent included extremely low toxicity for human beings, odorless, and harmlessness to plastic buttons, belts, and buckles, glued-on clothing accessories, and linings.[10]

General Chemical Division of Allied Chemical Corp. placed on stream a plant for making two specialty packaging films, near Pottsville, Pa. The products, fluorohalocarbon and polyamide, were the first of a number of plastic films Allied planned to make at Pottsville. Allied purchased the site from Landis Tool Co. in the summer of 1961.[11]

[9] Chemical Engineering. V. 69, No. 18, Sept. 3, 1962, p. 96.
[10] Chemical Week. Solvent Target: Coin-op Cleaners. V. 91, No. 9, Sept. 1, 1962, pp. 56–58.
[11] Chemical & Engineering News. V. 40, No. 7, Feb. 12, 1962, p. 32.

TABLE 5.—Fluorspar (domestic and foreign) consumed and in stock in the United States, by grades and industries

(Short tons)

Grade and industry	1961 Consumption	1961 Stocks at consumer plants Dec. 31	1962 Consumption	1962 Stocks at consumer plants Dec. 31
Acid grade:				
Hydrofluoric acid	418,612	[1] 36,226	366,298	39,778
Glass	2,643	465	3,113	510
Enamel	262	46	359	22
Welding rod coatings	960	65	1,350	83
Nonferrous	54	35	(2)	----------
Special flux				
Ferroalloys	1,639	1,020	2,182	822
Primary aluminum				
Total	[1] 424,170	[1] 37,857	373,302	41,215
Ceramic grade:				
Glass	24,340	3,505	24,703	3,307
Enamel	4,495	713	4,807	599
Welding rod coatings	1,279	157	1,761	169
Nonferrous	53	120	302	78
Special flux	5,422	1,142	6,870	970
Ferroalloys				
Total	35,589	5,637	38,443	5,123
Metallurgical grade:				
Glass	713	148	1,059	97
Enamel	4	2	3	1
Welding rod coatings	506	28	455	68
Nonferrous	10,039	1,520	[2] 10,005	2,159
Special flux				
Ferroalloys	2,024	3,993	1,728	6,343
Primary magnesium				
Iron foundry	10,053	4,778	13,454	3,538
Basic open-hearth steel	155,938		133,721	
Basic oxygen steel	(3)	134,450	45,922	128,228
Electric-furnace steel	48,894		34,627	
Bessemer steel	10		169	
Total	228,181	144,919	241,143	140,434
All grades:				
Hydrofluoric acid	[1] 418,612	[1] 36,226	366,298	39,778
Glass	27,696	4,118	28,875	3,914
Enamel	4,761	761	5,169	622
Welding rod coatings	2,745	250	3,566	320
Nonferrous	10,146	1,675	10,307	2,237
Special flux	4,227	963	5,543	899
Ferroalloys	2,401	615	2,172	594
Primary aluminum	2,457	4,577	3,065	6,642
Primary magnesium				
Iron foundry	10,053	4,778	13,454	3,538
Basic open-hearth steel	155,938		133,721	
Basic oxygen steel	(3)	134,450	45,922	128,228
Electric furnace steel	48,894		34,627	
Bessemer steel	10		169	
Total	[1] 687,940	[1] 188,413	652,888	186,772

[1] Revised figure.
[2] A small amount of acid grade is included with metallurgical grade in order not to reveal individual company operations.
[3] Breakdown not available prior to 1962.

TABLE 6.—Production of steel and consumption and stocks of fluorspar (domestic and foreign) at basic open-hearth, basic oxygen, and electric-furnace steel plants

	1953-57 (average)	1958	1959	1960	1961	1962
Production of basic and acid open-hearth steel ingots and castings at plants consuming fluorspar ____ thousand short tons__	94,094	75,215	76,500	83,668	81,999	82,877
Consumption of fluorspar in basic open-hearth steel production ____ thousand short tons__	217	150	158	169	156	134
Consumption of fluorspar per short ton of basic open-hearth steel made ____ pounds__	4.6	4.0	4.1	4.0	3.8	3.2
Stocks of fluorspar at basic open-hearth steel plants at end of year ____ thousand short tons__	132	111	108	137	121	102
Production of basic oxygen steel ingots and castings at plants consuming fluorspar thousand short tons__	(1)	(1)	[2] 1,864	[2] 3,346	[2] 3,967	5,471
Consumption of fluorspar in basic oxygen steel production ____ thousand short tons [3]__	----	----	----	----	----	41
Consumption of fluorspar per short ton of basic oxygen steel made ____ pounds [3]__	----	----	----	----	----	16.5
Stocks of fluorspar at basic oxygen steel plants at end of year ____ thousand short tons [3]__	----	----	----	----	----	15
Production of electric-furnace steel ingots and castings at plants consuming fluorspar thousand short tons__	7,695	6,462	7,953	7,883	8,187	[4] 9,223
Consumption of fluorspar in electric-furnace steel production ____ thousand short tons__	31	24	36	46	49	35
Consumption of fluorspar per short ton of electric-furnace steel made ____ pounds__	8.2	7.4	9.2	11.6	11.9	7.6
Stocks of fluorspar at electric-furnace steel plants at end of year ____ thousand short tons__		8	16	17	14	11

[1] Data not available.
[2] Data from American Iron and Steel Institute.
[3] Data not available prior to 1962.
[4] Includes Bessemer converters.

TABLE 7.—Fluorspar (domestic and foreign) consumed in the United States, by States

(Short tons)

State	1961	1962	State	1961	1962
Alabama, Georgia, North Carolina, South Carolina	8,220	19,919	Kentucky	39,330	50,941
Arkansas, Kansas, Louisiana, Mississippi, Oklahoma	89,859	62,463	Maryland	5,012	5,648
California and Hawaii	43,030	44,055	Massachusetts	193	180
Colorado and Utah	19,592	19,260	Michigan	27,933	24,500
Connecticut	1,247	1,617	Missouri	3,190	2,476
Delaware and New Jersey	122,198	114,781	New York	15,266	14,612
Florida, Rhode Island, Virginia	1,094	892	Ohio	[1] 55,573	55,008
Illinois	83,721	46,718	Oregon and Washington	1,045	904
Indiana	19,143	22,684	Pennsylvania	61,767	60,260
Iowa, Minnesota, Nebraska (1962), South Dakota, Wisconsin	3,388	3,618	Tennessee	1,167	2,069
			Texas	38,358	69,963
			West Virginia	47,614	30,320
			Total	[1] 687,940	652,888

[1] Revised figure.

TABLE 8.—Fluorspar in Government inventories, as of December 31, 1962

Fluorspar	Objective	National (strategic) stockpile	D.P.A. inventory	C.C.C. and supplemental stocks
Acid grade	280,000	458,089	17,370	668,684
Metallurgical grade	375,000	369,443		42,800

TABLE 9.—Stocks of fluorspar at mines or shipping points in the United States, by States, Dec. 31

(Short tons)

State	1961		1962	
	Crude [1]	Finished	Crude [1]	Finished
Illinois	197,518	13,271	244,709	12,064
Kentucky	(2)	3,819	5,926	
Colorado, Nevada,[3] Montana, Utah	[4] 24,443	3,911	27,241	2,485
Total	[4] 221,961	21,001	277,876	14,549

[1] This crude (run-of-mine) fluorspar usually is subjected to some type of processing before it can be marketed.
[2] Figure withheld to avoid disclosing individual company confidential data.
[3] Crude only.
[4] Revised figure.

PRICES

E&MJ Metal and Mineral Markets reported prices of fluorspar as follows: Domestic acid-grade concentrates, 97 percent calcium fluoride (CaF_2), dry basis, per short ton, bulk carlots, f.o.b. Illinois, $45.00 January and February, and $45.00 to $49.00 March through December; ceramic-grade concentrates, 95 percent CaF_2, bulk carlots, f.o.b. Illinois, $45.00 to $48.00; in 100-pound paper bags, $3.00 extra; European acid-grade, duty paid, c.i.f. port of entry, 0.3 percent maximum moisture, contracts, bags $50.00, spot $1.00 more, large discount for high moisture; and European metallurgical-grade fluorspar, 72.5 percent effective CaF_2 units, spot, $31.00 to $33.00 and contracts, $30.00 to $33.00. Mexican metallurgical grade, 72.5 percent effective CaF_2, f.o.b. mid-bridge border, all rail, duty paid, $26.50 to $28.00; from Brownsville, Tex., by barge, duty paid, $30.50 to $32.50; from Tampico, Mexico, in vessels, cargo lots, $21.00 to $23.50; all U.S. Atlantic ports, in cars, duty paid, $34.00 to $36.50; Lake Erie port, cars, duty paid, $37.00 to $39.50.

FOREIGN TRADE[12]

Imports.—Fluorspar imports for consumption totaled 595,695 tons valued at $15.6 million, an increase of 18 percent over those in 1961. Mexico, the main foreign source, supplied 75 percent of the 1962 imports; Spain 14 percent; and Italy 8 percent. Remaining imports came from France, West Germany, the United Kingdom, and the Republic of South Africa. The increase in total imports was composed of an 11-percent increase in acid-grade fluorspar and a 35-percent increase in metallurgical-grade material. The Federal Government imported 46,080 tons duty free from Mexico, compared with 74,700 tons in 1961.

Exports.—Exports totaled 1,308 tons, an increase of 287 percent over those in 1961.

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

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TABLE 10.—U.S. imports for consumption of fluorspar, by countries and customs districts

Country and customs district	1961						1962					
	Containing more than 97 percent calcium fluoride		Containing not more than 97 percent calcium fluoride		Total		Containing more than 97 percent calcium fluoride		Containing not more than 97 percent calcium fluoride		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
North America:												
Canada:												
Laredo			697	$12,809	697	$12,809						
Ohio	1,604	$39,800	49	4,725	1,653	44,525						
St. Lawrence			1	100	1	100						
Total	1,604	39,800	747	17,634	2,351	57,434						
Mexico:												
Arizona	28,249	876,826			28,249	876,826	8,446	$262,682			8,446	$262,682
Buffalo			4,094	89,458	4,094	89,458			14,075	$325,286	14,075	325,286
Chicago			4,489	97,636	4,489	97,636						
El Paso	30,785	793,967	24,839	527,000	55,624	1,320,967	38,832	967,926	34,475	740,305	73,307	1,708,231
Galveston	150	4,844			150	4,844	159	5,143			159	5,143
Laredo	125,643	3,903,675	66,220	1,178,122	191,863	5,081,797	[1] 154,544	[1] 4,670,692	82,598	1,576,615	[1] 237,142	[1] 6,247,307
Los Angeles							45	1,117			45	1,117
Maryland			2,570	51,876	2,570	51,876						
Massachusetts	74	1,879	21	432	95	2,311						
Michigan	3,781	111,399	19,019	406,353	22,800	517,752	3,875	116,000	16,877	355,093	20,752	471,093
Mobile			6,693	157,948	6,693	157,948			5,829	105,484	5,829	105.484
New Orleans							3,931	140,130	9,139	164,417	13,070	304,547
Ohio	1,468	37,126	7,883	175,344	9,351	212,470			9,632	205,233	9,632	205,233
Philadelphia	2,565	83,330	14,067	284,117	16,632	367,447	36,515	1,150,926	26,440	525,206	62,955	1,676,132
Sabine	306	9,855			306	9,855	317	10,018			317	10,018
St. Louis	935	19,287			935	19,287	1,596	33,763			1,596	33,763
San Diego	290	8,375			290	8,375						
Vermont									39	793	39	793
Total	194,246	5,850,563	149,895	2,968,286	344,141	8,818,849	248,260	7,358,397	199,104	3,998,432	447,364	11,356,829
Total North America	195,850	5,890,363	150,642	2,985,920	346,492	8,876,283	248,260	7,358,397	199,104	3,998,432	447,364	11,356,829
Europe:												
France:												
New York							28	1,539			28	1,539
Philadelphia							7,923	229,881			7,923	229,881
Total							7,951	231,420			7,951	231,420

Germany, West:												
Maryland	6,816	229,194	-----	-----	6,816	229,194	-----	-----	-----	-----	-----	-----
Philadelphia	-----	-----	-----	-----	-----	-----	3,273	147,388	-----	-----	3,273	147,388
Puerto Rico	299	19,995	-----	-----	299	19,995	199	13,064	-----	-----	199	13,064
Total	7,115	249,189	-----	-----	7,115	249,189	3,472	160,452	-----	-----	3,472	160,452
Italy:												
New Orleans	10,456	298,862	-----	-----	10,456	298,862	12,349	332,640	-----	-----	12,349	332,640
Ohio	6,001	198,000	-----	-----	6,001	198,000	8,951	291,799	-----	-----	8,951	291,799
Philadelphia	45,853	1,393,878	-----	-----	45,853	1,393,878	26,503	810,443	-----	-----	26,503	810,443
Total	62,310	1,890,740	-----	-----	62,310	1,890,740	47,803	1,434,882	-----	-----	47,803	1,434,882
Spain:												
Maryland	9,834	381,530	-----	-----	9,834	381,530	-----	-----	-----	-----	-----	-----
New Orleans	5,152	206,080	-----	-----	5,152	206,080	-----	-----	-----	-----	-----	-----
Ohio	18,269	464,126	-----	-----	18,269	464,126	15,213	398,509	-----	-----	15,213	398,509
Philadelphia	54,739	1,545,867	-----	-----	54,739	1,545,867	67,656	1,911,723	-----	-----	67,656	1,911,723
Total	87,994	2,597,603	-----	-----	87,994	2,597,603	82,869	2,310,232	-----	-----	82,869	2,310,232
United Kingdom: Puerto Rico	-----	-----	-----	-----	-----	-----	101	4,280	-----	-----	101	4,280
Total Europe	157,419	4,737,532	-----	-----	157,419	4,737,532	142,196	4,141,266	-----	-----	142,196	4,141,266
Africa: South Africa, Republic of:[2]												
Maryland	-----	-----	1,848	30,247	1,848	30,247	-----	-----	-----	-----	-----	-----
Philadelphia	-----	-----	-----	-----	-----	-----	-----	-----	6,135	98,241	6,135	98,241
Total Africa	-----	-----	1,848	30,247	1,848	30,247	-----	-----	6,135	98,241	6,135	98,241
Grand total	353,269	10,627,895	152,490	3,016,167	505,759	13,644,062	390,456	11,499,663	205,239	4,096,673	595,695	15,596,336

[1] Adjusted by Bureau of Mines. [2] Effective Jan. 1, 1962; formerly Union of South Africa. Source: Bureau of the Census.

TABLE 11.—Imported fluorspar delivered to consumers in the United States, by uses

Use	1961			1962		
	Short tons	Selling prices at tidewater, border, or f.o.b. mill in the United States including duty		Short tons	Selling prices at tidewater, border, or f.o.b. mill in the United States including duty	
		Total	Average per ton		Total	Average per ton
Hydrofluoric acid	230,884	$9,348,137	$40.49	164,904	$5,944,998	$36.05
Glass, ceramic, and enamel	5,380	244,243	45.40	14,427	665,825	46.15
Ferrous	73,048	2,362,767	32.35	105,270	2,867,167	27.24
Nonferrous	1,620	50,120	30.94			
Other	15,568	350,556	22.52	34,605	1,228,642	35.50
Total	326,500	12,355,823	37.84	319,206	10,706,632	33.54

TABLE 12.—U.S. exports of fluorspar

Year	Short tons	Value		Year	Short tons	Value	
		Total	Average per ton			Total	Average per ton
1953-57 (average)	647	$55,248	$85.39	1960	458	$38,250	$83.52
1958	3,374	191,386	56.72	1961	338	30,419	90.00
1959	1,144	69,204	60.49	1962	1,308	118,749	90.79

Source: Bureau of the Census.

WORLD REVIEW [13]

NORTH AMERICA

Canada.—A method was developed and a patent was issued for a one-step process for the production of substantially pure pentafluorides of tantalum and columbium from carbide mixtures obtained by the reduction of tantalum-columbium minerals with a carbonaceous material. The crude carbide cake was then reacted with a stream of gaseous and anhydrous hydrofluoric acid (HF) at above 400° C, and the resulting vapor condensed at a temperature above the condensation temperature of anhydrous HF.[14]

[13] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.
[14] Gustison, R. A. (assigned to Union Carbide Corp., Canada). Canadian Pat. 641,371, May 15, 1962.
Engineering and Mining Journal. V. 163, No. 10, October 1962, p. 106.

TABLE 13.—World production of fluorspar by countries[1][2]

(Short tons)

Country[1]	1953–57 (average)	1958	1959	1960	1961	1962
North America:						
Canada	108,394	[3] 62,000	[3] 74,000	[3] 77,000	[3] 80,000	[3] 75,000
Mexico	278,789	462,049	362,456	404,487	439,286	553,642
United States (shipments)	300,359	319,513	185,091	229,782	197,354	206,026
Total	687,542	843,562	621,547	711,269	716,640	834,668
South America:						
Argentina	11,294	14,258	17,989	[3] 17,600	[3] 17,600	[3] 17,600
Bolivia (exports)	220	------	------	------	------	------
Total	11,514	14,258	17,989	[3] 17,600	[3] 17,600	[3] 17,600
Europe:						
France	92,010	107,104	110,425	149,345	210,000	220,000
Germany:						
East[3]	84,000	72,000	72,000	80,000	80,000	80,000
West	170,015	137,048	135,956	143,474	133,490	108,572
Italy	115,504	162,916	174,091	178,957	165,814	171,474
Norway	422	------	------	------	------	------
Spain	77,966	99,743	98,318	122,377	161,954	158,667
Sweden (sales)	2,863	3,188	2,995	3,197	3,560	[3] 3,300
United Kingdom[4]	96,894	86,694	93,078	109,249	99,868	78,153
Total[1][3]	645,000	675,000	690,000	790,000	860,000	825,000
Asia:						
China[3]	93,000	165,000	220,000	275,000	275,000	220,000
Japan	7,434	6,069	5,684	10,108	16,326	17,094
Korea:						
North	(5)	(5)	(5)	(5)	[3] 55,000	[3] 55,000
Republic of	8,419	1,786	6,748	20,834	30,790	36,343
Mongolia, Outer	[3] 19,800	[3] 37,000	[3] 37,000	44,423	41,888	[3] 44,000
Thailand	------	------	------	3,814	5,241	11,806
Turkey	26	88	75	359	42	640
U.S.S.R.[3][6]	130,000	180,000	190,000	210,000	230,000	230,000
Total[3]	275,000	445,000	515,000	620,000	655,000	615,000
Africa:						
Morocco	912	------	------	------	869	546
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	402	6	10	19	------	20
South Africa, Republic of	28,207	48,251	70,317	113,550	95,862	111,683
South-West Africa	1,881	4	141	------	------	265
Tunisia	560	------	------	------	------	------
Total	31,962	48,261	70,468	113,569	96,731	112,514
Oceania: Australia	465	1,042	528	8	4	[3] 550
World total (estimate)[1][3]	1,650,000	2,025,000	1,915,000	2,255,000	2,345,000	2,405,000

[1] Fluorspar is also produced in Bulgaria, data not available; estimate included in total.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Estimate.
[4] Includes fluorspar recovered from old lead and zinc mine dumps, production of which is reported as follows: 1953–57 (average), 14,686 tons; 1958, 7,467 tons; 1959, 10,064 tons; 1960, 13,552 tons.
[5] Data not available; estimate by senior 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 U.S.S.R.

Compiled by Liela S. Price, Division of Foreign Activities.

TABLE 14.—Production and trade of fluorspar in 1961, by major countries.

(Short tons)

Exports, by countries of origin	Production	Exports	Exports by countries of destination: North America: Canada	North America: United States	South America	Europe: East	Europe: West	Asia: Japan	Asia: Other	Africa	Oceania	Other countries
North America:												
Canada	[1] 80,000	2,048		2,048								
Mexico	439,286	456,850	48,278	400,463	607			4,805	2,697			
United States	[2] 197,354	337	307		24						6	
South America: Argentina	[1] 17,600	925			925							
Europe:												
Bulgaria	(3)	[4] 3,951					[5] 527	[5] 3,424				
France	210,000	42,228		8,609			32,210			328		1,081
Germany:												
East	[1] 80,000	[4] 4,251				[5] 4,251						
West	133,490	[4] 21,732		[5] 7,115			[5] 14,617					
Italy	165,814	73,931		61,113			[5] 11,261					1,557
Spain	161,954	111,888		87,743			24,145					
Sweden	[6] 3,560	384					372					12
United Kingdom	99,868											
Asia:												
China	[1] 275,000	[4] 76,570			[5] 494	[5] 42,880	[5] 6,560	[5] 23,646	[5] 2,582		[5] 408	
Japan	16,326	845							845			
Korea:												
North	[1] 55,000	[5] 3,256						[5] 3,256				
Republic of	30,790	36,798						34,758	2,040			
Mongolia, Outer	41,888	[5] 40,896				[5] 40,896						
Thailand	5,241	5,656						5,325	331			
Turkey	42											
U.S.S.R.	[1] [7] 230,000	9,259						9,259				
Africa:												
Morocco	869	256								256		
South Africa, Republic of	95,862	86,618	1,848	6,037	675		24,857	46,407	316	4,672	1,806	
Oceania: Australia	4											
Total	[8] 2,345,000	978,679	50,433	573,128	2,725	88,027	114,549	130,880	8,811	5,256	2,220	2,650

[1] Estimate.
[2] Shipments.
[3] Fluorspar is also produced in Bulgaria, data not available; estimate included in total.
[4] Incomplete data.
[5] Imports.
[6] Sales.
[7] U.S.S.R. in Europe included with U.S.S.R. in Asia, as the deposits are predominantly in Asiatic U.S.S.R.
[8] Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

Compiled by Corra A. Barry, Division of Foreign Activities.

Mexico.—Quimobasicos, S.A., formed by Delulosa Y Derivados, S.A., and Allied General Chemical Division of Allied Chemical Corp., started production of fluorinated hydrocarbon refrigerants and aerosol propellants at Monterey, Nueva Leon. Anhydrous hydrofluoric acid was also being produced for the company's own operations and for use in the Mexican petroleum industry.[15]

For the first time, San Francisco Mines of Mexico produced fluorspar concentrate from a newly completed plant with a 60,000-ton-annual capacity. A major part of the production was sold under a long-term contract, but the terms were not announced. Ore reserves were 5,966,000 tons averaging 0.49 grams of gold, 170 grams of silver, 5.61 percent lead, 0.57 percent copper, and 7.95 percent zinc. The operating company, Minera Frisco, S.A., recently entered into an agreement with the Banco de Commercial S.A. of Mexico City to purchase 51 percent of the share capital for subsequent distribution to Mexican investors. San Francisco Mines retained the remaining 49 percent.[16]

EUROPE

Austria.—The aluminum industry became independent of imports of aluminum fluoride when a production unit was opened by the State-owned chemical company, Oesterreichische Stickstoffwerk A.G. of Linz. Aluminum fluoride was manufactured at Linz by a new process developed by the company.[17]

France.—Air Liquide of France developed a technique for concentrating and stockpiling ozone (O_3) at concentrations as high as 50 percent in stable solutions that could be stored indefinitely at minus 60° F or lower. The process involved dissolving the ozone in liquid Freon. Until 1962, ozone had been generated at low pressure at the site where it was to be used. Bottled by the new method, the gas became available at pressures up to 100 atmospheres, indicating new possibilities for chemical oxidation experiments. Liquid ozone also had great potential in rocket propulsion and sterilization. Opening a small bottle of concentrated ozone in a closed room gave 10^{-5} percent by volume that killed both bacteria and viruses.[18]

Greece.—No cavities! was the boast that most modern Greek children could make, and it might have been made as well by the children of ancient Greece, a U.S. study showed. The low incidence of tooth decay among Greeks was apparently the result of a diet that was high in fluoride and low in selenium. Fluoride ingested in small amounts when the crown of the permanent teeth was developing, was known to prevent tooth decay, and there was increasing laboratory evidence that selenium might be a factor contributing to tooth decay. The source of fluoride in the diet of contemporary Greeks came from fish rather than from the drinking water because the water supply had little fluoride content. The levels of selenium in both ancient and modern

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[15] Chemical & Engineering News. V. 40, No. 13, Mar. 26, 1962, p. 33.
[16] Investors Guardian, incorporating Mining World and Engineering Record (London). V. 179, No. 4574. July 27, 1962, pp. 258–259.
[17] Mining Journal (London). V. 258, No. 6612. May 11, 1962, p. 476.
[18] Chemical Engineering. Bottled Ozone Now a Reality. V. 69, No. 25, Dec. 10, 1962, p. 60.

Greek teeth were found to be considerably lower than those reported in teeth from persons in the Pacific Northwest region of the United States where the prevalence of tooth decay was high. The study was reported by a member of the University of Oregon Dental School, and a chemist from the University of Portland, Portland, Oreg.[19]

Italy.—Fluorspar production in 1961 decreased to 165,814 tons, 8 percent less than in 1960. Italy imported 8,255 tons in 1961 and exported 73,931 tons. The apparent consumption was 100,538 tons.[20]

Spain.—Fluorspar output at the Zubelzu mines near San Narciso, south of Irun, Spain, was to be raised. The ore was to be concentrated at the flotation mill of the Real Asturiana mine, and the concentrates then shipped to domestic iron and steel producers on the north coast of Spain.[21]

United Kingdom.—An article, the first of two installments, described the uses, occurrences, and distribution of fluorspar. A concluding installment discussed aspects of marketing and possible future trends.[22]

Cornish stone was a flux widely used in the British whiteware industry. As normally mined it contained fluorspar, and fluorine was given off during firing. This was undesirable, and in recent years steps had been taken to remove fluorspar from Cornish stone by froth flotation. Various combinations of promoter, depressant, and frothing agents were tested and a satisfactory method was developed for pilot-scale trials, using a commercial promoter, sodium carbonate as the depressant, and pine oil as the frothing agent. Grinding between 100 and 300 mesh yielded the optimum grain size for flotation; finer grinding appeared to hinder flotation.[23]

Heavy-media separation was used in England to obtain an unusual three-product separation of galena, barite, and fluorspar from a limestone gangue.[24]

Reorganization of Laporte Industries Group chemical interests in Yorkshire under Laporte Acids Ltd. and of their mineral interests in Derbyshire under Glebe Mines Ltd. went into effect April 1, 1962. Laporte Acids absorbed two Yorkshire manufacturing companies—James Wilkinson and Sons, Ltd. and the Sheffield Chemical Co., Ltd. Both companies had works at Sheffield and Rotherham, and became wholly owned subsidiaries of Laporte Industries, Ltd. in 1959. Wilkinson's specialized in the production of aqueous hydrofluoric acid and inorganic fluorine compounds, and the main products of Sheffield Chemical were ammonia, gas-purifying materials, and sulfuric acid. Glebe Mines Ltd. and the Cupola Mining and Milling Co. Ltd., Laporte Industries' two Derbyshire mineral companies, were amalgamated under the name of Glebe Mines Ltd. which became a wholly owned subsidiary of Laporte Industries in 1959 and Cupola, formerly a subsidiary of Head Wrightson & Co. Ltd., joined the Laporte Group

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[19] Science News Letter. Tooth Decay Found Low in Old and New Greece. V. 81, No. 4, Jan. 27, 1962, p. 56.
[20] Bureau of Mines. Mineral Trade Notes. V. 56, No. 3, March 1963, p. 11.
[21] Mining Journal (London). Fluorspar in Spain. V. 258, No. 6603, Mar. 9, 1962, p. 244.
[22] Schnellmann, G. A. Occurrence and Distribution of Fluorspar. Mining J. (London), v. 258, No. 6611, May 4, 1962, pp. 442–443; Production and Consumption of Fluorspar, Mining J. (London), v. 258, No. 6614, May 25, 1962, pp. 526–527.
[23] Worrall, W. E. Fluorine in Cornish Stone. Trans. Brit. Ceram. Soc., J. Am. Ceram. Soc., v. 45, No. 1, January 1962, p. 20.
[24] Mining World. HMS Drum Makes Three Product Separation. V. 24, No. 4, April 1962, pp. 24–25.

in 1960. During 1961, these two plants were responsible for three-quarters of the United Kingdom's production of high-grade fluorspar.[25]

By an agreement with Westinghouse Electric Corp. of America, G.E.C. (Engineering) Ltd. was to manufacture a range of circuit-breakers using sulfur hexafluoride (SF_6) gas as the insulating and arc extinguishing medium. Westinghouse already had such circuit-breakers with breaking capacities up to 230 kilovolts and 15,000 millivolt amperes in service and the two companies were to develop jointly and extend the ratings up to 500 kilovolts and 35,000 millivolt amperes at current ratings up to 4,000 amperes. The hexafluoride (SF_6) was an electronegative gas and possessed remarkable properties as an arc-quenching medium. The time-constant of the arc for SF_6 was about 40 times less than that for air at the same pressure. The hexafluoride was also a good insulating medium, and its dielectric quality increased rapidly with pressure. At 10 pounds per square inch, the dielectric strength was about equal to that of good insulating oil. Being inert, nontoxic, nonflammable, and highly stable, the sulfur hexafluoride was safe to handle.[26]

G.E.C. (Engineering) Ltd. was manufacturing for Colvilles, Ltd., a $560,000 heavy-medium separation plant for upgrading fluorspar to be installed at a small mine at Blanchland, County Durham. The mine supplied metallurgical-grade fluorspar to the Ravenscraig steelworks.[27]

Localities wishing to add fluoride to water supplies where a deficiency existed would receive Government backing, financial support, and indemnification against the costs of any legal action, it was stated by the Minister of Health in the House of Commons. It was recommended that the Government encourage the fluoridation of water supplies.[28]

Laporte Industries, Ltd., announced that its sodium fluoride was being used in water fluoridation in Canada, Australia, and Maritius, and its modern fluoride plants were able to handle a steady increase in demand. Laporte laboratories also constructed a small plant to produce stannous fluoride for use in fluoridated toothpaste.[29]

U.S.S.R.—The fluorspar deposits of Central Asia were studied over a period of 20 years. The fluorspar-bearing veins of the Kuraminskii and Chatkal'skii regions were of the late hydrothermal stage and of Lower Triassic age. About 60 percent of the fluorspar reserves were associated with local tear faults which could be followed for 3 to 12 miles. The principal fluorspar deposits of the Kuraminskii region occurred in limestone of Upper Devonian to Lower Carboniferous age, Upper Palezoic effusives, and Karamazar granitoids. In both regions fluorspar was associated with quartz, barite, calcite, cinnabar, antimonite and lead-zinc mineralization. In the Chatkal'skii region, fluor-

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[25] Chemical Age (London). Laporte Reorganization Involves Yorkshire Chemical Companies and Derbyshire Mineral Interests. V. 87, No. 2228, Mar. 24, 1962, p. 477.

[26] Chemical Trade Journal and Chemical Engineer (London). Sulfur Fluoride's New Uses. V. 150, No. 3896, Feb. 2, 1962, p. 226.

[27] South African Mining and Engineering Journal (Johannesburg, Republic of South Africa). HMS Fluorspar Plant. V. 73, pt. 1, No. 3610, Apr. 13, 1962, p. 813.

[28] Chemical Age (London). Ministry Backing for Water Fluoridation Should Boost Laporte Business. V. 88, No. 2266, Dec. 15, 1962, p. 916.

[29] Chemical Trade Journal and Chemical Engineer (London). Fluorine Products for Water Treatment. V. 151, No. 3920, July 20, 1962, p. 138.

spar deposits were localized in a comparatively narrow section ranging in age from Middle Tournaisian to Middle Visean. All fluorspar deposits were formed at depths of 1,300 to 8,200 feet and attained maximum concentration at 5,200 to 5,700 feet below the surface.[30]

The fluorspar deposits of the western Transbaikal region were epithermal and occurred mainly within the Caledonian folded zone. Only minor occurrences of fluorspar were known in the Baikalian orogenic zone and none in the Hercynian belt. All fluorspar deposits were associated with regional faults along the flanks of the Mesozoic depression filled with coal-bearing deposits. The fluorspar deposits were of post-Lower Cretaceous (possibly Tertiary) age and were paragenetically related to syenitic dikes containing accessory fluorspar. The minerals in the veins were quartz and fluorspar, with some hematite, kaolinite, calcite, apatite, pyrite, galena, chalcopyrite, sphalerite, and nacrite (rare). Evidently the fluorspar deposits were formed from acidic hydrothermal deposits at low temperatures.[31]

ASIA

India.—A sizable deposit of high-grade fluorspar was discovered in the Baroda district of Gujarat State.[32]

Outer Mongolia.—The Berkh fluorite mine, 42 miles east of Undurkhan, in operation since 1954, exceeded its production quota by 6 percent in 1961 and by 2 percent in the first quarter of 1962. Nearly all the production was exported to the U.S.S.R. It was probably the leading fluorite mine in the country. Fluorite production in Outer Mongolia was reported as 42,000 tons in 1961.[33]

Japan.—The Du Pont Co., Wilmington, Del., and Nitto Chemical Industry Co., Ltd., of Tokyo planned a jointly owned company to manufacture fluorinated hydrocarbons. The new company was to acquire an existing plant at Nitto's Yokohama works and modify it to utilize Du Pont patents and knowledge to make fluorocarbon propellants, refrigerants, and polymers for sale in Japan.[34]

Korea, Republic of.—Exports in 1961 totaled 33,383 tons valued at $688,000; Japan was the principal market, taking 31,532 tons. Construction of a custom fluorspar processing plant began in May 1962 at Kumsan, Cholla Pukto Province. This 50-ton-per-day plant, financed by Korea Tungsten Mining Co., would service 10 or 12 small fluorspar mines in the area.[35]

OCEANIA

Australia.—Pacific Chemical Industries Pty. Ltd., brought on stream its fluorinated hydrocarbons plant at Parramatta. The company, a joint venture of Stauffer Chemical Co. (Australia) Pty. Ltd. and the Société d'Electro-Chimie d'Electro-Metallurgie et des Aciéries Electriques d'Ugine (Ugine) of France, was launched in April 1960

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[30] Economic Geology. V. 57, No. 6, September–October 1962, p. 992.
[31] Economic Geology. V. 57, No. 7, November 1962, p. 1143.
[32] Bureau of Mines. Mineral Trade Notes. V. 54, No. 6, June 1962, p. 37.
[33] Bureau of Mines, Division of Foreign Activities. Monthly Commodity Report, Nonmetallic Minerals. September 1962, 1 p.
[34] Chemical & Engineering News. V. 40, No. 8, July 1962, p. 29.
[35] Bureau of Mines. Mineral Trade Notes. V. 55, No. 4, October 1962, p. 12.

to produce a range of fluorinated hydrocarbons based on the initial production of anhydrous hydrofluoric acid. Another hydrofluoric acid plant went on stream in October 1961. Production of the complete range of fluorine compounds made by Stauffer and Ugine would be undertaken by Pacific Chemical Industries Pty. Ltd., as required by industry.

Following the completion of its Roselle plant in December 1961, Australian Fluorine Chemicals Pty. Ltd., (AFC) was the first company to manufacture fluorocarbons in Australia. AFC was jointly owned by Monsanto Chemicals (Australia) Ltd. and Consolidated Zinc Pty. Ltd.[36]

TECHNOLOGY

A polycrystalline compact was made by hot-pressing powdered magnesium fluoride at 650° C and a pressure of 30,000 pounds per square inch for 15 minutes. The powder had to be free of impurities which would form a second phase, and water and bound hydroxyl groups had to be kept to an absolute minimum. The physical properties demonstrated the suitability of the product for infrared optical components which would withstand severe conditions in use.[37]

Current knowledge regarding the chemical and physical properties of sulfur tetrafluoride was reviewed. The structural features of the compound were discussed and its toxicological properties presented.[38]

A fluid fluorine recovery process was developed by Union Carbide Nuclear Co. at the Atomic Energy Commission gaseous diffusion plant at Paducah, Ky. In producing uranium hexafluoride (UF_6), uranium tetrafluoride (UF_4) was reacted with excess fluorine in a tower flame reactor at 2,000° F. After removing the UF_6, the process gas was passed through a fluid bed reactor used in the fluorine recovery process. Approximately 99 percent of the fluorine was recovered from the inlet gas stream, which contained 25 to 35 percent fluorine.[39]

Long-range research in fluorine chemistry revealed a number of commercial materials that showed striking contrasts in properties; some featured stability and others high reactivity. Also new fluorination techniques were being developed to synthesize new compounds at both ends of the reaction spectrum. Among the stable compounds were a new fluoropolymer and a series of fluoroaromatic chemicals. The reactive category included a new series of fluorinated steroids and a range of nitrogen-containing inorganic fluorides.[40]

With the aid of a special hydrofluoric acid treatment and an (acetoxymercuri) aniline staining technique, scientists at U.S. Department of Agriculture Forest Products Laboratory, Madison, Wis., used the electron microscope to learn about the distribution of lignin in the cell walls of some woods.[41]

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[36] Chemical Trade Journal and Chemical Engineer (London). Australian Fluorocarbons. V. 150, No. 3905, Apr. 6, 1962, p. 722.

[37] Buckner, Dean A., Harold C. Hafner, and Norbert J. Kriedl. Hot-Pressing Magnesium Fluoride. J. Am. Ceram. Soc., v. 45, No. 9, September 1962, pp. 435–438.

[38] Smith, Dr. William C. The Chemistry of Sulfur Tetrafluoride. Angewandte Chemie, Intern. Ed., v. 1, No. 9, September 1962, pp. 467–475.

[39] Chemical & Engineering News. Carbide Develops Fluid Bed Fluorine Recovery Process. V. 40, No. 34, Aug. 20, 1962, p. 42.

[40] Chemical Week. Fresh Fields for Fluorochemicals. V. 91, No. 5, Aug. 4, 1962, pp. 43–44.

[41] Chemical & Engineering News. Techniques Locate Lignin in Wood Cells. V. 40, No. 45, Nov. 5, 1962, pp. 41–42.

Extrusions of a ceramic-like fluorocarbon, fluorosint, were developed by the Polymer Corp., Reading, Pa. The material was created from special ceramics with a Teflon TFE (tetrafluoroethylene) fluorocarbon binder. The fluorosint extrusions had a low rate of thermal expansion and excellent resistance to deformation at elevated temperatures, the company reported. Extrusions were produced in shapes and sizes up to 1 square inch in cross section and in simple circular shapes. Dimensional tolerances were maintained within 0.002 inches.[42]

Allegheny Plastics, Inc., Coraopolis, Pa., reinforced TFE fluorocarbon with additives to improve physical properties and the product was sold. Features of the compounds included reduction of thermal expansion to about one-third that of pure TFE fluorocarbon. Another compound had 3.5 times the deformation resistance of pure TFE fluorocarbon at 450° F. The compounds had considerably higher coefficients of heat transfer than pure TFE fluorocarbon and were considered advantageous where heat build-up was a problem.[43]

The discovery of tetrafluorohydrazine (N_2F_4) and of its dissociation into the difluoramino free radical (NF_2) opened a new area of organic and inorganic chemistry, according to Rohm & Haas, Redstone Arsenal Research Division, Huntsville, Ala. The compound took part in a variety of free radical reactions with chlorine, nitric acid, and alkyl radicals. Mass spectroscopy, infrared, electron paramagnetic resonance, and ultraviolet spectroscopy contributed to the study. The University of California Lawrence radiation laboratory found that alkyl radicals also reacted with N_2F_4. They prepared methyl and ethyl difluoramine by irradiating the corresponding iodides with ultraviolet radiation in the presence of N_2F_4. Others recently found that N_2F_4 or its free radical NF_2 reacted with trifluoronitrosomethane. A new class of compounds, the N-fluoroazoxy compounds, stem from these reactions.[44]

Natural sunlight was converted directly into a continuous beam of coherent infrared radiation with a solid-state laser. Radio Corporation of America personnel performed the experiment using a 12-inch hemispherical mirror for focusing the sunlight, a laser consisting of a calcium fluoride crystal bathed in liquid neon, and a spectrometer for detecting the laser output. Continuous radiation at 2.36 microns was emitted by the laser when exposed to about 50 watts of radiant power from the sun. The achievement opened the possibility of sun-powered lasers on board future space satellites, producing intense light rays for use in communications tracking and geodetic measurements.[45]

Chemical bonding of copper to Teflon was the heart of a process that was claimed to increase the peel strength of copper-Teflon printed circuit boards by as much as 500 percent. Activation treatment enabled the initial copper overlay to bond with the plastic.

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[42] Iron Age. Fluorocarbon Plastic. V. 190, No. 12, Sept. 20, 1962, p. 149.
[43] Chemical & Engineering News. Teflon Reinforced with Additives. V. 40, No. 38, Sept. 17, 1962, p. 86.
[44] Chemical & Engineering News. N_2F_4 Forms Difluoramino Radical. V. 40, No. 39, Sept. 24, 1962, pp. 54–55.
[45] Chemical & Engineering News. Natural Sunlight Has Been Converted Directly into a Continuous Beam. V. 40, No. 43, Oct. 22, 1962, p. 59.

After the chemical deposition of the first layer, the copper thickness was built up by ordinary electroplating.[46]

A fluorine cell research pilot plant built by the Atomic Energy Commission to study the behavior of electrodes in an operating fluorine cell was described. The facility was a complete miniature fluorine plant with three cells, each of which was about one-sixth the size of the improved medium temperature fluorine cell or one-eighth the size of the currently utilized 32-blade large fluorine cell. The three cells could be operated simultaneously with a potential production of 5 pounds of fluorine per hour. Small quantities of the fluorine produced were used in the laboratory.[47]

After preliminary laboratory work to determine the optimum bath composition and operating conditions, a pilot plant was set up for the production of high-purity chromium. This plant, which used a fluoride-type bath, produced about 4 kilograms of chromium per week with cathodic current efficiency of about 38 percent.[48]

Stauffer Chemical Co. developed a continuous process for extracting anhydrous hydrogen fluoride from fluosilicic acid. Pilot plant tests showed that the process was commercially and technically feasible. Stauffer expected to use the process in several of its phosphate processing plants, but no definite plans were announced. They planned to offer a license for the process to others.[49]

The discovery of trifluoroiodomethane about 14 years ago opened up a wide range of possibilities for preparing new organometallic and organometalloidal compounds containing fluoroalkyl radicals. Also it offered for the first time the possibility of examining and explaining the difference between such compounds and their alkyl or aryl analogs. A brief recapitulation of some earlier results was followed by a review of recent progress, especially in the chemistry of fluoroalkyls of sulfur and nitrogen as well as certain metallic elements.[50]

Fluorine-containing polymers, because of their excellent chemical and temperature resistance, were being widely used as seals and gaskets for lip seals, O-rings, packings, and piston rings. Various important criteria in the selection and use of gaskets were discussed with particular reference to the specific advantages obtained by using fluorocarbon resins.[51]

Three properties of the fluoride ion which may be related to its action in reducing dental decay were discussed. It enters the apatite lattice of bone and teeth, and analyses of different areas of these tissues showed that it was distributed in a definite pattern. Fluorapatite is less soluble than hydrooxyapatite, suggesting that one action of the entry of fluoride is to lower the solubility of the tooth. It favors the precipitation of calcium phosphate from saturated solutions, such as

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[46] Chemical Engineering. V. 69. No. 3, Feb. 5, 1962, p. 58.
[47] Chemical Age (London). Fluorine Cell Research Plant Built in U.S. V. 88, No. 2266, Dec. 15, 1962, p. 924.
[48] Brandes, E. A., and J. A. Whittaker. Fulmer Research Institute Production of High-Purity Chromium from an Aqueous Fluoride Bath. Metallurgia (Manchester, England), v. 65, No. 391, May 1962, pp. 209–212.
[49] Chemical & Engineering News. Research and Technology Concentrates. V. 40, No. 2, Jan. 8, 1962, p. 43.
[50] Emeleus, Dr. H. J. Recent Studies on Fluoroalkyls and Related Compounds. Angewandte Chemie, International Edition, v. 1, No. 3, March 1962, pp. 129–133.
[51] Whitcut, H. M. Fluorocarbon Resin Seals. Chemical & Process Engineering (London), v. 43, No. 5, May 1962, pp. 209–213.

saliva. There is evidence, therefore, that fluoride may intermittently reverse the removal of calcium salts in a dental cavity and thus slow the development of decay. Fluoride is an enzyme poison and could possibly reduce decay by inhibiting the production of acid by mouth bacteria.[52]

The use of oxygen difluoride as a high-energy space storable oxidizer was being studied, and research was being conducted on new propellants from metal hydride coordination compounds.[53]

Five types of fluorspar briquettes used as a flux in basic open hearth, basic electric furnace, and cupola operations were described.[54]

The discovery that the rare gases, xenon and radon, reacted with fluorine was one of the outstanding chemical discoveries of 1962. Preparation of xenon tetrafluoride was quantitative when one part of xenon and five parts of fluorine (by pressure) were heated at 400° C for 1 hour. Xenon tetrafluoride (XeF_4) crystals were stable at room temperature with a vapor pressure of about 3 millimeters, and at minus 78° C had a negligible vapor pressure. The compound remained unchanged during a month storage in evacuated nickel or glass vessels.[55]

CRYOLITE

The only commercial cryolite deposit in the world was operated by the Danish company, Kryolitselskabet Oresund Ald, at Ivigtut, Greenland, through a concession from the Danish Government. Part of the mine output was exported to Pennsalt Chemicals Corp., Philadelphia, and was concentrated in their plant at Natrona, Pa. In 1962, 5,527 tons were sold to the aluminum industry and 2,483 tons to other industries, principally to abrasive manufacturers.

Synthetic cryolite was manufactured by the action of hydrofluoric acid (made from fluorspar) on aluminum hydroxide in the presence of soda by Reynolds Metals Co. at Bauxite, Ark., Aluminum Company of America at Point Comfort, Tex., and Kaiser Aluminum & Chemical Corp. at Chalmette, La. Kaiser was constructing a hydrofluoric acid plant at Gramercy, La., with facilities for making aluminum fluoride and synthetic cryolite.

PRICES

Cryolite quotations reported by the Oil, Paint and Drug Reporter of Dec. 31, 1962, were as follows: Natural, industrial, in bags, carlots, at works, 100 pounds, $13.00; and in bags, less than carlots, at works, 100 pounds, $14.25.

FOREIGN TRADE

Exports of cryolite in 1962 totaled 2,218,039 pounds valued at $196,418, most of which went to Australia and Canada.

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[52] Chemical Trade Journal and Chemical Engineer (London). Fluoride and Tooth Decay. V. 151, No. 3938, Nov. 23, 1962, p. 1058.
[53] Research and Development. News and Notes. V. 13, No. 9, September 1962, p. 45.
[54] Foundry. Literature for Foundrymen. V. 90, No. 2. February 1962, p. 141.
[55] Chemical & Engineering News. Chemistry of Rare Gases Unfolds. V. 40, No. 53, Dec. 31, 1962, pp. 51–52.

TABLE 15.—U.S. imports for consumption of cryolite

Year and country	Short tons	Value
1953–57 (average)	25,682	$3,167,326
1958	24,186	2,332,459
1959	22,102	1,934,473
1960	17,246	1,669,841
1961:		
North America: Greenland [1]	9,391	425,475
Europe:		
France	364	59,409
Italy	4,059	708,956
Total	4,423	768,365
Grand total	13,814	1,193,840
1962:		
North America: Greenland [1]	9,464	$424,175
Europe:		
Denmark	111	5,838
France	684	109,029
Germany, West	22	3,942
Italy	2,191	390,027
Total	3,008	508,836
Grand total	12,472	933,011

[1] Crude natural cryolite.

Source: Bureau of the Census.

A brief note on the history of cryolite production in the U.S.S.R. stated that the only industrial cryolite deposit was in Greenland and the developing aluminum industry throughout the world was forced to produce artificial cryolite from fluorspar. In the U.S.S.R., cryolite had been produced in the Polevskii works since 1932 by an acid method developed by the Institute of Applied Mineralogy and Metallurgy. This process, however, was hindered by the high silica content of the fluorspar which caused considerable fluorine losses. Alkaline methods were developed and fluorspar beneficiation methods were perfected that made it possible to increase and improve cryolite and fluorspar production considerably in the Polevskii works. Production in the Southern Urals cryolite works used the acid method. To conserve expensive and scarce fluorspar, methods were developed, tested, and partially introduced into production in the U.S.S.R. for the manufacture of cryolite and fluorine salts from waste gases of superphosphate works.[56]

[56] Segal, V. A. Izvestiya Vysshikh Uchebnykh Zaredeniy (Communications of Institutions of Higher Learning). Metallurgiya (Series), No. 2, 1961, pp. 150–157.

Gem Stones

By John W. Hartwell[1] and Betty Ann Brett[2]

PRODUCTION of gem materials and mineral specimens in the United States during 1962 was valued at approximately $1,296,-000, a $13,000 decrease from 1961.

Public Law 87-713, passed by Congress in 1962, stated that deposits of petrified wood were excluded from appropriation under the mining laws. Petrified wood was no longer to be considered a mineral that could be used to establish a valid mining claim. It was defined as "agatized, opalized, petrified, or silicified wood, or any material formed by the replacement of wood by silica or other matter."

DOMESTIC PRODUCTION

Production data were collected by the Bureau of Mines by canvassing amateur and professional producers of gem stones, but it was not possible to contact all operators. Therefore, information was based on a partial survey.

Gem material and mineral-specimen production was reported from 45 States, the same as in 1961. During both years California, Oregon, and Texas were the leading producing States. Twelve States, with production valued at $25,000 or over, produced 89 percent of the total value. These States were Arizona, California, Colorado, Maine, Montana, Nevada, New Mexico, Oregon, Texas, Utah, Washington, and Wyoming.

The reported find of a 14-ounce pink sapphire and a 24-ounce ruby in North Carolina during 1961 was discovered to be a hoax.[3]

Gem grade pollucite was reported mined during 1962 at the Walden Gem mine, Portland, Conn. A cut and polished gem of more than 12 carats and a 49 carat uncut stone of gem quality were some of the larger pieces produced. Many 1 to 4 carat pieces were recovered and offered for sale.

Agate.—About 125 tons of agate valued at $92,000 was reported produced in 18 States. The variety and quantity of agate included in the total was classified as: Moss, 4,300 pounds; turritella, 5,100 pounds; and fire agate, 1,400 pounds; the balance were miscellaneous types. Principal States, in decreasing order of production, were Oregon,

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[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.
[3] The Knoxville News-Sentinel. Rockhounds Go To "Gem Fields." Aug. 13, 1961, p. B-9.

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Arizona, New Mexico, Washington, California, South Dakota, Texas, and Utah.

Diamond.—Diamond production at Crater of Diamonds near Murfreesboro, Ark., was reported at 200 carats valued at $8,850. A frosty-white diamond was reported weighing 4.39 carats and valued at $3,000.

Jade.—Production of jade from Alaska, California, and Wyoming was 45,600 pounds valued at nearly $100,000. California was the leading State with 23,000 pounds valued at nearly 25,000. A 2,250-pound jade rock discovered in 170 feet of water off Catalina Island, Calif., was valued at $75,000.

Mineral Specimens.—About 140,000 pounds of mineral specimens were produced and valued at nearly $50,000. Arizona, Colorado, and New Mexico were the leading States; each produced more than 25,000 pounds. Copper mineral specimens production, not included in the above total, was reported at 21,900 pounds valued at $12,700. Most of the copper minerals came from Arizona.

Obsidian.—Production, totaling 122,000 pounds valued at $24,000, was reported from five States. California was the leading State with nearly 83,000 pounds valued at $17,000.

Petrified Wood.—Production of 174 tons valued at $92,000 was reported from 11 States during 1962. Utah led with nearly 32 tons followed in descending order by Arizona, Wyoming, South Dakota, California, Colorado, New Mexico, and Texas. Petrified palm wood production was only 138 pounds valued at $138, and petrified bone produced was 3,000 pounds valued at $2,000.

Quartz Crystal.—Output from 18 States was reported at 72,100 pounds valued at $30,200. Rose quartz production was estimated at 37,000 pounds with a value of $1,200. Smokey quartz production was 570 pounds valued at about $1 per pound.

Turquoise.—Production in 1962 was reported at 11,500 pounds valued at $44,500. Arizona was the leading turquoise-producing State with 7,400 pounds valued at nearly $17,000. New Mexico followed with 2,250 pounds valued at $6,000. Two other States that also reported production were Nevada and California. Nevada material was rated more valuable with values ranging from $5 to $20 per pound.

Miscellaneous Gem Material.—Jasper production was estimated at nearly 59,000 pounds valued at $15,000. Principal production was reported from Arizona. All grades of opal mined during the year were reported at 104,000 pounds valued at about $13,000. Only 10 pounds of fire opal valued at $150 was declared. Nevada was the leading-producing State with an estimated 101,000 pounds valued at $8,000. Most of this material was produced in Virgin Valley. Garnet production was 2,400 pounds valued at $1,200. Sales of 196 carats of cut and polished stones valued at nearly $500 were reported from a garnet mine at North Creek, N.Y. Black coral obtained by divers off the island of Maui was valued at $6,000 with a production of 1,200 pounds. No production was reported from the ocean near the other islands. Peridot gems from Arizona and New Mexico were reported to be valued at $14,000 with a production of 22,300 pounds.

The quantity and value of some other gem and ornamental stone reported produced were: Amethyst, 3 pounds, $180; beryl specimens, 1,300 pounds, $3,200; feldspar gems, 3,900 pounds, $1,500; fluorite, 23,100 pounds, $8,200; fossils, 1,600 pounds, $800; geodes, 1,100 pounds, $560; gold nuggets, 20 ounces, $700; idocrase, 4,500 pounds, $1,400; marcasite, 1,000 pounds, $700; onyx, 32,000 pounds, $8,000; ornamental stone, 73,100 pounds, $4,400; rhodonite, 6,300 pounds, $3,400; rhyolite, 42,000 pounds, $4,900; sapphire, 14 pounds, $2,100; topaz, 600 pounds, $1,500; and vesuvianite, 1,400 pounds, $280.

CONSUMPTION

Gem diamond consumption, $192 million, was nearly the same as in 1961; sales of imported imitation and synthetic gem stones, $4.3 million, were 20 percent lower; and sales of natural and cultured pearls, $18.9 million, were 12 percent higher.

Apparent consumption (production plus imports minus exports and reexports) of gem stones in the United States was $167 million, compared with $181 million in 1961.

PRICES

Prices quoted during January for cut and polished unmounted gem diamonds were: 0.25 carat, $65 to $318; 0.5 carat, $200 to $550; 1 carat, $525 to $1,500; 2 carats, $1,200 to $4,364; and 3 carats, $2,400 to $8,162. The price range of each size depended upon quality (cut, clarity, and color).

A report on the diamond industry contained information on diamond marketing and world prices of gem and industrial diamonds during 1961.[4]

FOREIGN TRADE [5]

Imports.—Gem stone imports increased less than 1 percent in value, compared with 1961. Gem diamonds accounted for 85 percent of total imports but decreased 711,352 carats in quantity and $1.6 million in value, compared with 1961.

Diamonds, rough or uncut, were principally imported, by quantity, from the United Kingdom (53 percent), followed by Venezuela (9 percent), British West Africa (9 percent), and the Republic of South Africa (8 percent). Diamonds, cut but unset, were principally imported from Belgium-Luxembourg (49 percent) and Israel (36 percent). The average values per carat of cut but unset diamond imports were Belgium-Luxembourg, $95.49; Israel, $79.36; the Netherlands, $103.58; Republic of South Africa, $182.43; the United Kingdom, $129.64; and West Germany, $71.63.

Imports of emeralds, cut but unset, decreased 30,600 carats under 1961; 93 percent came from India, 2 percent each from Colombia and Switzerland, 1 percent from West Germany, and the balance from 18 other countries. The average value per carat of emerald imports

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[4] Switzer, George. Thirty-Seventh Annual Report on the Diamond Industry—1961. Jewelers' Circ.-Keystone, 1962. 48 pp.

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

from the principal exporting countries were Colombia, $124,28; India, $10.95; Switzerland, $45.64; and West Germany, $10.87.

Rubies and sapphires, cut but unset, valued at $1,207,700 were imported from 15 countries, principally from Colombia (86 percent), the United Kingdom (4 percent), India (3 percent), and Republic of South Africa (3 percent). Imports from Colombia, the principal source, were valued at $1,033,000—more than a 100-percent increase, compared with 1961.

Cultured pearl imports were about $1.8 million more than 1961, and imports of natural pearls were $237,000 more. The principal countries from which natural pearls were imported were Japan (49 percent) and India (41 percent).

The largest quantity of rough or uncut and cut but unset gem stones imported into the United States came from Hong Kong ($658,000) and Brazil ($285,000).

TABLE 1.—U.S. imports for consumption of precious and semiprecious stones, exclusive of industrial diamonds

Stones	1961		1962	
	Quantity	Value (thousands)	Quantity	Value (thousands)
Diamonds:				
Rough or uncut, suitable for cutting into gem stones, duty free ..... carats..	2,274,923	$114,670	1,420,443	$102,446
Cut, but unset, suitable for jewelry, dutiable ..... carats..	839,150	78,605	982,278	89,188
Emeralds: Cut but not set, dutiable ..... do....	227,284	2,090	196,649	2,798
Pearls and parts, not strung or set, dutiable:				
Natural	(1)	500	(1)	737
Cultured or cultivated	(1)	16,425	(1)	18,198
Other precious and semiprecious stones:				
Rough or uncut, duty free	(1)	1,169	(1)	1,765
Cut but not set, dutiable	(1)	(2) 3,900	(1)	5,098
Imitation, except opaque, dutiable:				
Not cut or faceted	(1)	54	(1)	61
Cut or faceted:				
Synthetic ..... number..	664,932	(2) 345	1,176,058	457
Other	(1)	4,907	(1)	3,740
Imitation, opaque, including imitation pearls, dutiable	(1)	14	(1)	18
Marcasites: Real and imitation, dutiable	(1)	36	(1)	(3)
Total	(1)	222,715	(1)	224,506

[1] Quantity not recorded.
[2] Revised figure.
[3] Less than $1,000.

Source: Bureau of the Census.

Exports.—Precious and semiprecious gem stones exported were $18.8 million, compared with $14.8 million in 1961. Diamonds, cut but unset, accounted for 74 percent of the total. The value of gem stones exported, except diamonds, was over $3 million.

Reexports of gem stones, precious and semiprecious, were $40 million, compared with $28 million in 1961. Diamonds, rough, uncut, and suitable for cutting into gem stones, accounted for 86 percent of the total.

TABLE 2.—U.S. imports for consumption of diamonds (exclusive of industrial diamonds), by countries

Country	1961				1962			
	Rough or uncut		Cut but unset		Rough or uncut		Cut but unset	
	Carats	Value (thousands)	Carats	Value (thousands)	Carats	Value (thousands)	Carats	Value (thousands)
North America:								
Canada	7,772	$833	79	$10	5,128	$655	217	$16
Mexico	257	3	160	14			198	22
Panama			23	3				
Total	8,029	836	262	27	5,128	655	415	38
South America:								
Brazil	42,962	759	706	36	996	39	1,469	121
British Guiana	26,150	686	93	8	9,852	346	133	10
Venezuela	111,700	3,151			128,264	4,025		
Total	180,812	4,596	799	44	139,112	4,410	1,602	131
Europe:								
Austria							130	13
Belgium-Luxembourg	210,419	15,391	428,054	41,957	39,877	2,381	478,795	45,721
France	47,857	1,522	10,578	1,018	4,902	413	14,291	1,459
Germany, West	896	28	52,154	3,480	2,144	59	75,301	5,394
Ireland							1	(1)
Italy			541	59			201	66
Malta and Gozo							169	16
Netherlands	50,563	2,360	28,756	3,234	22,367	1,652	23,786	2,463
Portugal							12	1
Spain							7	5
Switzerland	6,526	269	349	205	503	95	526	66
U.S.S.R.			1,023	85			2,640	262
United Kingdom	1,561,423	81,702	5,238	680	752,905	67,087	5,901	765
Total	1,877,684	101,272	526,693	50,718	822,698	71,687	601,760	56,231
Asia:								
Hong Kong			1	(1)			46	12
India			9	3			38	50
Iran			56	4			74	6
Israel	50,744	1,938	278,229	21,971	20,001	949	351,306	27,881
Japan	244	26	942	91			831	70
Malaya, Federation of							7	10
Singapore, Colony of			38	11				
Thailand			83	1				
Total	50,988	1,964	279,358	22,081	20,001	949	352,302	28,029
Africa:								
British West Africa and Sierra Leone					125,407	4,622		
Cameroon, Federal Republic of					2,218	28	321	38
Congo, Republic of the and Ruanda-Urundi	10,860	228	10	1	34,945	1,309		
Ghana					23,962	253		
Liberia	8,113	280			10,456	1,211		
Nigeria					778	190		
South Africa, Republic of [2]	54,331	3,346	31,951	5,725	120,213	12,255	25,878	4,721
Western Africa, n.e.c.[3]	80,243	2,097			57,030	2,772		
Western Equatorial Africa, n.e.c.[3]	3,863	51			58,495	2,105		
Total	157,410	6,002	31,961	5,726	433,504	24,745	26,199	4,759
Oceania: Australia			77	9				
Grand total	2,274,923	114,670	839,150	78,605	1,420,443	102,446	982,278	89,188

[1] Less than $1,000.
[2] Effective Jan. 1, 1962; formerly Union of South Africa.
[3] Not elsewhere classified.

Source: Bureau of the Census.

WORLD REVIEW[6]

NORTH AMERICA

Canada.—De Beers Consolidated Mines, Ltd., an associate of Anglo-American Corporation of South Africa, Ltd., acquired the exploration license that was granted to W. G. Wahl, Ltd., to explore for diamonds in Ontario.[7] Mineral sources in eastern Ontario that could be easily reached by collectors were reported.[8] Boulders of jade were reported discovered in Vital Creek, near Takla Landing, British Columbia. Two stones weighing 5,000 and 3,000 pounds each were shipped to Vancouver for display. Vancouver dealers in jade were reported to be exporting about 40 tons a year, the greater portion being destined for West Germany.[9]

TABLE 3.—World production of diamonds, by countries

(Thousand carats)

Country	1961		1962	
	Gem	Industrial	Gem	Industrial
Africa:				
Angola	688	460	701	380
Central African Republic	41	70	80	185
Congo, Republic of the	405	17,738	[1 2] 456	[1 2] 17,700
Ghana	[3] 654	[3] 1,560	628	2,580
Guinea [2 4]	490	730	140	210
Ivory Coast	219	330	102	182
Liberia [4]	[3] 596	500	225	680
Sierra Leone [2 4]	[3] 799	[3] 1,497	707	1,200
South Africa, Republic of:				
Pipe mines:				
Premier	360	1,200	425	1,260
De Beers Group	953	760	883	750
Other pipe mines [2]	35	80	36	84
Alluvial mines [2]	240	160	290	190
South-West Africa	816	90	800	227
Tanganyika	340	345	323	324
Other regions:				
Brazil	175	175	175	175
British Guiana	68	45	60	40
Venezuela	60	74	94	83
U.S.S.R., India, and others [2]	80	420	75	425
World total	[3] 7,019	[3] 26,234	6,200	26,675

[1] Including exports reported from Congo (excluding French).
[2] Estimate.
[3] Revised figure.
[4] Exports.

SOUTH AMERICA

Brazil.—New diamond deposits were reported discovered near Grao Mogol, Minas Gerais,[10] and at Chapada dos Guimarees, Mato Grosso.[11]

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[6] Values in this section are U.S. dollars, based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.
[7] Northern Miner (Toronto). De Beers Comes to Canada Looking for Diamonds. V. 48, No. 11, June 7, 1962, p. 16, sec. 1.
[8] Marshall, John W., Jr. Mineral Collecting in Eastern Ontario, Canada. Rocks and Minerals, v. 37, Nos. 5–6, May–June 1962, pp. 229–232, 328.
[9] Western Miner and Oil Review (Vancouver). Jade Boulders in Omineca. V. 35, No. 12, December 1962, p. 52.
[10] Engineering and Mining Journal. V. 163, No. 10, October 1962, p. 154.
[11] Mining Journal (London). Diamond Find in Brazil. V. 259, No. 6624, Aug. 3, 1962, p. 110.

A large-scale diamond-prospecting program by the Pacific Tin Co. near Diamantina, Minas Gerais, on the Rio São Francisco was in progress, and about 65 to 70 men were employed. An amethyst discovery was reported. Production was estimated at 3 tons, 10 percent of which was faceting grade. The available varieties of colors and sizes were described.[12]

British Guiana.—Diamond production decreased 12 percent from 1961. Bad weather at midyear, hampering the individual prospectors, was blamed for the reduced production.[13]

Venezuela.—Three gem-mining concessions were granted by the Government: One for rubies, another for precious stones in the State of Merida, and the third was for diamonds in the State of Bolivar.[14]

EUROPE

Belgium.—Imports of cuttable diamonds were reported to be about 3.4 million carats valued at $95 million in 1961. Nearly 192,000 carats of this quantity came from the United States. Polished diamond imports were 221,000 carats valued at $36 million. Polished diamond exports were 916,000 carats valued at $102 million.[15]

Switzerland.—Data on gem stone and jewelry imports for 1960 and 1961 were reported. Statistics on output of manufactured and semimanufactured precious and semiprecious stones were not available. Tariff rates and import duties were given.[16]

ASIA

Burma.—The Kachin State Supreme Council announced plans to develop and nationalize the jade industry, which was centralized about 65 miles west of Mogaung, Myitkyina District, where the mining and trading was monopolized by the Chinese. Plans included development of abandoned mines and establishment of plants to manufacture household articles of low-grade jade.[17]

Ceylon.—Gem stone mining followed the same pattern as in previous years. Value of exports which was the only figure published was $420,000. The principal varieties produced were ruby, sapphire, cat's eye, topaz, zircon, aquamarine, and moonstone.[18]

Hong Kong.—Jewelry and gem stones available, prices, methods of manufacturing and processing, and items for sale that should be avoided by U.S. buyers were described. Nearly 700 jewelry stores and lapidaries flourished in this British island colony. Jewelry manufacture was limited to small, simple articles of jade and ivory; no figure carving was attempted. Every carved stone object originated

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[12] Bookstone, Harry. New Brazilian Amethyst Find. Jewelers' Circ.-Keystone, v. 132, No. 11, July 1962, pp. 66, 68, 78.
[13] U.S. Consulate, Georgetown, British Guiana. State Department Dispatch A-231. Feb. 17, 1963, p. 14.
[14] Mining World. World Wide Mining Activities. V. 25, No. 5, Apr. 25, 1963, p. 124.
[15] U.S. Consulate, Antwerp, Belgium. State Department Airgram 37. Nov. 2, 1962, encl. 8, p. 1; encl. 10, pp. 1, 2.
[16] Nelson, John H. What's Current in Commodities? Jewellery, Switzerland. Foreign Trade, v. 118, No. 3, Aug. 11, 1962, pp. 8, 9.
[17] Bureau of Mines. Mineral Trade Notes. V. 55, No. 4, October 1962, p. 18.
[18] Mining World. World Wide Mining Activities. V. 25, No. 5, Apr. 25, 1963, p. 107.

in China and could not be purchased for import into the United States.[19]

India.—Crude emerald production in 1960 and 1961 was 321,000 and 304,000 carats, respectively, and no value was given. In 1960 trimmed or processed emeralds, weighing 59,000 carats, were valued at $12,200, and in 1961, 14,000 carats were processed valued at $2,700.[20] The diamond mines in the Ramkherya and Majhgawan areas in the Panna District, Madhya Pradesh, were expected to start producing in 1963. Recovered during the prospecting of these areas in 1960–62 were 540 gems and 284 industrial diamonds. Surveys of other diamond deposits in the Kurnool, Anantpur, Mahboobnagar, and Krishna Districts were planned.[21]

Japan.—During 1962 exports of pearls from the extensive pearl-forming area in Mie Prefecture was reported to be 62,850 kilograms valued at $41,850,000. The quantity exported was 2,000 kilograms more than during 1961. The United States was still the leading customer, followed by Switzerland.[22] Cultured pearl exports in 1961, reported by the All Japan Pearl Culture Cooperative, reached a record of 27,350 pounds valued at $35.8 million, an increase of 20 percent over 1960.[23] The Japanese jewelry industry was reviewed. Pearls, opal, and coral ranked high in gem stone sales. Quantities of jade were sold at prices higher than in the United States. Carved ivory was also offered for sale. Prices for pearls, opals, coral, and jade were quoted.[24]

AFRICA

Angola.—Diamond production was normal in the Lunda District. Following several years of exploration, a new diamond field in the Guango Basin was expected to start producing in 1963. Diamond output in 1962 was 1,081,100 carats, of which 65 percent was gem quality.[25]

British East Africa.—Tanganyika Corundum Corp., Ltd., continued to work the ruby-corundum deposit near Longido during 1961. Exports to Germany of green zoisite matrix and rough ruby were reported for the first time. Federal Ventures, Ltd., completed a preliminary examination of the ruby and sapphire deposits of the Umba River in the Lushoto District and applied for a mining lease. Negotiations were underway for the sale of these gem materials. One prospecting license for zircon in the Lushoto District was granted. The zircons found were described as suitable for use as gem stones. An important development for the semiprecious stone industry was the establishment of a lapidary by Tanganyika Crystals, Ltd., at Arusha.[26] Owners of the Williamson Diamond mines made an agreement with the Tan-

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[19] Pough Frederick H. A Glance at Jewelry Scene in Hong Kong, Jeweler's Circ.-Keystone, v. 133, No. 1, October 1962, pp. 88, 90, 103–105; Hong Kong Hokus Pokus, No. 2, November 1962, pp. 66, 68, 85–86.
[20] Bureau of Mines. Mineral Trade Notes. V. 55, No. 6, December 1962, p. 10.
[21] Journal of Mines, Metals and Fuels (Calcutta). V. 10, No. 8, August 1962, p. 30.
[22] U.S. Consulate, Nagoya, Japan. State Department Airgram A–92. Mar. 12, 1963, pp. 1, 2.
[23] Bureau of Mines. Mineral Trade Notes. V. 55, No. 3, September 1962, p. 29.
[24] Pough, Frederick H. The Japanese Jewelry Scene. Jeweler's Circ.-Keystone, v. 133, No. 3, December 1962, pp. 48, 50, 56.
[25] Mining World. World Wide Mining Activities. V. 25, No. 5, Apr. 25, 1963, p. 114.
[26] Mining Magazine (London). Tanganyika Mining Industry, 1961. V. 106, No. 6, June 1962, pp. 337–340.

ganyikan Government to examine new ruby and sapphire deposits found near the Umba River.[27]

Ivory Coast.—Two government corporations were formed to prospect for diamonds in the vicinity of Seguela. Other organizations to which the government considered granting concessions were consolidated African Selection Trust, Diamond Distributors, Inc., and Harry Winston, Inc. The Israeli Government was granted exclusive diamond prospecting rights for 1 year in two large areas.[28]

Mozambique.—Tourmaline was produced in 1961 by Empresa Mineira do Alto Ligonha, Lda., from the pegmatite area of the Zambezia District. Production in 1961 was estimated at 500,000 carats, compared with 70,000 carats in 1960. Most of the production was exported to West Germany.[29]

Rhodesia and Nyasaland, Federation of.—Progress continued in the development of the Sandawana emerald deposit. Drilling indicated that emeralds may be found in some areas at deeper levels than was expected.[30] Four exclusive precious stone prospecting licenses were granted by the Southern Rhodesian Government to Sandawana Mines (Pvt.), Ltd., in July 1962.[31] Amethyst veins discovered southeast of Kalomo, Northern Rhodesia, were described. Mining was done by manual selection of gem quality stones from weathered vein material. Reserves of quality material were estimated at over 2 million pounds.[32] According to the Central Statistical Office, Salisbury, amethyst production in Northern Rhodesia was nearly 10,000 pound valued at $22,400. Agate output in Southern Rhodesia in 1961 was 3,700 pounds valued at $1,500.[33] A report on Rhodesian gem-stone production and problems in marketing was published.[34]

South Africa, Republic of.—Exports of emerald crystals decreased to 353 pounds valued at $311,500, compared with 1,200 pounds valued at $145,000 in 1961 and 2,880 pounds at $113,000 in 1960. The crystals exported in 1961 and 1962 went principally to the United Kingdom. Tiger's eye production was 206,000 pounds in 1962 and 34,000 pounds in 1961. Exports were 126,000 pounds valued at $37,500 in 1962 and 12,000 pounds valued at $760 in 1961. The only producer of tiger's eye was P. C. Beukes, Niekerkshope, Cape Province.[35] A 32-carat gem diamond and several 10-carat stones were found by miners at Windsorton.[36] The Treasure Trove Diamond mine on the West Rand near Postmasburg was expected to resume production. This mine, which was closed in 1930, produced principally gem quality stones.[37]

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[27] Mining Journal (London). Ruby Deposits in Tanganyika. V. 259, No. 6627, Aug. 24, 1962, p. 175.
[28] Mining Journal (London). Diamond Prospecting in the Ivory Coast. V. 258, No. 6618, June 22, 1962, p. 652.
[29] Bureau of Mines. Mineral Trade Notes. V. 55, No. 3, September 1962, p. 29.
[30] South African Mining & Engineering Journal (Johannesburg). V. 73, pt. 1, No. 3616. May 25, 1962, pp. 1145.
[31] Mining Journal (London). V. 259, No. 6624, Aug. 3, 1962, p. 110.
[32] Brown, A. G. The Amethyst Deposits of Mwakambiko. Rhodesian Min. and Eng. (Salisbury, Southern Rhodesia), v. 27, No. 12, November 1962, p. 28.
[33] Bureau of Mines. Mineral Trade Notes. V. 55, No. 3, September 1962, p. 29.
[34] Broeksma, J. B. A. Rhodesia May Be on the Way to "Gem Country" Status. Rhodesian Min. and Eng. (Salisbury, Southern Rhodesia), v. 27, No. 10, October 1962, pp. 19–20, 30.
[35] U.S. Consulate, Johannesburg. State Department Airgram A–362. Mar. 28, 1963. 5 pp.
Bureau of Mines. Mineral Trade Notes. V. 55, No. 2, August 1962, pp. 28, 29.
[36] Engineering and Mining Journal. V. 163, No. 10, October 1962, p. 161.
[37] Mining Journal (London). V. 259, No. 6633, Oct. 5, 1962, p. 321.

South-West Africa.—Marine Diamond Corp., Ltd., dredged for diamonds off the South-West African coast. By July, 9,000 carats were produced and 250 carats per day were expected to be recovered during the balance of the year. Southern Diamonds Corporation, Ltd., was formed to operate off the Atlantic coast near the Cape of Good Hope. Fifty percent of the operating expenses were being furnished by the owner of Marine Diamond Corp., and the balance, from two other companies.[38] Ocean diamond mining was still considered to be in the experimental stage, and no official estimate of the payable reserves of diamondiferous gravel was made. Diamond and mineral deposits were discovered along the Skeleton coast between the dry beds of the Ugab and Unjab Rivers. Over 800 diamonds, 90 percent being of gem quality, were reported recovered in this area.[39] Semiprecious stone production in 1961 was reported to be about 38,000 pounds; principally amethyst, chalcedony, rose quartz, and tourmaline. Exports were 14,000 pounds valued at $10,300, almost all of which was shipped to West Germany. Producers of semiprecious stones were listed.[40]

TABLE 4.—South-West Africa: Production and exports of gem stones in 1962

Gem	Production	Exports	
	Quantity	Quantity	Value
Diamonds carats	[1] 1,027,233	800,497	$40,000,000
Amethyst pounds	312,000	9,560	9,800
Chalcedony do	8,000	4,740	2,150
Rose quartz do	500		
Tourmaline do	11		
Aragonite do	98,000	8,000	1,120

[1] Industrial and gem diamonds combined.

Source: U.S. Consulate, Johannesburg, Republic of South Africa. State Department Airgram A-334. Mar. 13, 1963, pp. 1-2.

OCEANIA

Australia.—Opal exports were about $900,000 per year from the producing areas of Coober Pedy and Andamooka, South Australia, and Lightning Ridge, New South Wales. The Australian Government considered the industry to be of sufficient importance to station officials full time at the fields and to incur expenditures to provide water for the areas.[41] Rise in prices of sapphire caused an increased interest in mining this gem. The sapphire mining district of Inverell in New South Wales and the Anakie District of Queensland reported increased activity.[42] The potential of sapphire and opal mining was discussed in a report by the Queensland Government.[43]

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[38] Mining Magazine (London). Diamonds Mined Off the Seabed. V. 107, No. 1, July 1962, p. 40.
[39] Mining Journal (London). Diamonds and Salt in South West Africa. V. 258, No. 6610, Apr. 27, 1962, p. 419.
[40] Bureau of Mines. Mineral Trade Notes. V. 55, No. 2, August 1962, pp. 29, 30.
[41] Mining Magazine (London). Opals. V. 107, No. 3, September 1962, p. 167.
[42] Mining Magazine (London). Gems. V. 106, No. 3, March 1962, p. 158.
[43] Queensland Government Mining Journal (Australia). Gemstones. V. 63, No. 729, July 1962, p. 334.

TECHNOLOGY

Nineteen gem and mineral localities in Kern County, Calif., were described. The names and locations of the deposits and the materials found were published.[44]

Opal occurrences in New Mexico were described and identification and infrared absorption data were given.[45]

A world-wide review of emerald deposits was published.[46]

A report on the diamond industry contained information on diamond marketing, and the prices of gem and industrial diamonds throughout the world during 1961.[47]

Each monthly issue of The Mineralogist Magazine, beginning with November–December 1960, described methods of mineral identification. In the 1960 through 1962 issues the titles of the articles in chronological order were Introduction, Physical Characteristics of Minerals, Chemistry and the Blowpipe, Heat Tests for Elements, The Native Elements, The Sulfides and Sulfosalts, The Halides and Oxides, The Carbonates, The Anhydrous Silicates, The Hydrous Silicates, The Oxygen Salts Part I, The Oxygen Salts Part II, and Evaluation and Tests for Unknowns.

A series of articles on quartz minerals starting in October 1961 was concluded. The gem variety of quartz minerals described were formed by hot and cold solutions and included rock crystal, smoky and rose quartz, cairngorm, and amethyst.[48]

Analyses and physical properties were given for three types of garnets found in a mine near Gabbs, Nev.[49]

Each monthly issue of Mine and Quarry Engineer (London) beginning with October 1953 described a mineral, giving the synonyms, nomenclature, varieties, compositions, crystallography, physical and optical properties, tests, occurrences, and uses. Each mineral was illustrated in color. In the 1962 issues the minerals in chronological order were spheene, rosasite, petalite, silver, marcasite, descloizite, cobaltite, anhydrite, willemite, zircon, pyrolusite, and covellite.

Black coral found in Hawaii was softer than red coral, took a good polish, could be cut with a wood saw or a knife before drying, was soft and pliable in warm water, shrank when it dried and hardened, and developed concentric separation cracks in sections through the trunk and limbs on shrinkage.[50]

Orange (natural and synthetic) gem stones were described. Yellow and golden natural gems are common but orange gems, which include diamond, opal, scapolite, and sapphire, were considered the rarest of all colors in the gem world. The makers of synthetic orange sapphires

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[44] Troxel, Bennie W., and Paul K. Morton. Mines and Mineral Resources of Kern County, Calif. California Div. of Mines, County Rept. No. 1, 1962, pp. 90–92.

[45] Sun, Ming-Shan. Tridymite (Low Form) in Some Opal of New Mexico. Am. Miner., v. 47, No. 11–12, November–December 1962, pp. 1453–1455.

[46] Rhodesian Mining and Engineering (Salisbury, Southern Rhodesia). Emeralds: Where and How They Occur. V. 27, No. 1, January 1962, pp. 23–24.

[47] Switzer, George. Thirty-Seventh Annual Report on the Diamond Industry—1961. Jewelers' Circ.-Keystone, 1962, 48 pp.

[48] Pough, Frederick H. The Many Faces of Quartz. Jewelers' Circ.-Keystone, v. 132, No. 4, January 1962, pp. 60, 62, 64.

[49] Lee, Donald E. Grossularite-Spessartite Garnet From the Victory Mine, Gabbs, Nevada. Am. Miner., v. 47, No. 1–2, January–February 1962, pp. 147–151.

[50] Pough, Frederick H. Black Beauty in Hawaii. Jewelers' Circ.-Keystone, v. 132, No. 13, September 1962, pp. 100, 102, 129.

produced the change in color by adding nickel oxide to the formula.[51]

Methods and devices used in prospecting for gem stones were described. To facilitate the recognition of water-worn gems in gravel deposits, 12 gem stones were described and data on what to look for when prospecting given.[52]

A system of prospecting for kimberlite pipes from the air was described. Prepared and coordinated supplemental data from an aeromagnetic survey provided a basis for final ground operation.[53]

A method of cleaning bedrock for the recovery of diamonds was described.[54]

The Diamond Research Laboratory in Johannesburg, Republic of South Africa, discovered a method whereby diamonds can be separated optically from waste rock or gravel.[55]

Methods of cutting and polishing semiprecious gems in cabochon form were described.[56]

Methods employed in Hong Kong for cutting and polishing jade were described.[57]

A brilliant silicon carbide gem of about 0.5 carat required special techniques for cutting and polishing.[58]

Calcium titanate boules approximately 1 inch long and 0.5 inch in diameter were grown by the flame fusion technique then heat-treated to produce untwinned crystals. This colorless crystal had an index of refraction of 2.40, slightly less than diamond; a hardness of 6.5 to 7, slightly less than quartz; conchoidal fracture, melting point of 1,960° C, and a specific gravity of 4.10, about as heavy as zircon—one of the heaviest gem stones.[59]

A process of producing large emerald crystals synthetically by Bell Laboratories was described. Even though the temperature during crystallization was about 1,000° C, the crystals could be removed quickly from the furnace for cooling, because of their high resistance to thermal shock.[60]

The artificial growth of oxide crystals was described as a method of providing insight into the forces that hold solids together and of furthering understanding of how to use solids in technology.[61]

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[51] Jewelers' Circ.-Keystone. The Padparadschah: A Color for Collectors. V. 132, No. 12, August 1962, pp. 140, 160–161.

[52] Goldberg, I. Hints for Prospectors on Recognition of Gemstones. Rhodesian Min. and Eng. (Salisburg, Southern Rhodesia), v. 27, No. 10, October 1962, pp. 26–27, 30.

[53] Barygin, V. M. Poiski kimberlitovykh trubok aèrometodami (Prospecting for Kimberlite Pipes from the Air). Trud. yakutskogo filiala sibirskogo otdel. Akad. Nauk U.S.S.R., No. 6, 1961, pp. 172–179; trans. by N. W. Wilson, Min. Mag. (London), v. 107, No. 2, August 1962, pp. 73–78

[54] Mining Magazine (London). Cleaning Bedrock by Vacuum. V. 107, No. 1, July 1962, p. 28.

[55] Mining Magazine (London). Optical Sorting of Diamonds. V. 106, No. 4, April 1962, pp. 246–248.

[56] Rhodesian Mining and Engineering (Salisbury, Southern Rhodesia). Give 'Cabochon Charm' to our Semi-Precious Stones. V. 27, No. 10, October 1962, pp. 20–21.

[57] Shreve, R. N. How Jade Is Cut Today. Gemmologist (London), v. 31, No. 369, April 1962, p. 63.

[58] Mitchell, R. K. A Rare Synthetic. J. Gemmology (London), v. 8, No. 6, April 1962, pp. 218–220.

[59] Merker, Leon. Synthesis of Calcium Titanate Single Crystals by Flame Fusion Technique. J. Am. Ceram. Soc.: Ceram. Abs., v. 45, No. 8, Aug. 1, 1962, pp. 366–369.

[60] Chemistry. Growing Emeralds. V. 36, No. 2, October 1962, pp. 23, 26.

[61] Laudise, R. A. Growing Oxide Crystals. Bell Laboratories Record, v. 40, No. 7, July–August 1962, pp. 244–250.

A method of growing crystals, similar to the Verneuil method but adding supplementary heat to all portions of the crystalline mass before shutting off the burner, was patented.[62]

A process of growing a pegmatitic crystal by thermally inducing a circulation of nutrient solution in the seed-growing region was described.[63]

Several patents were granted for methods of producing diamonds synthetically.[64]

The changes of coloration, transparency, and origin of beryls during heating to 1,200° C were studied. Coloration usually increased during heating. At temperatures above 600° C, transparency and glassy luster disappeared, and refractive indicies and birefringence decreased.[65]

A series of articles on the Brazilian gem market described the discovery of kunzite, tourmaline, and aquamarine deposits, what the tourist or jeweler can see in Brazil, and the difficulties of the Brazilian miners in producing gem stones.[66]

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[62] Merker, Leon (assigned to National Lead Co., New York). **Method for Growing Crystals.** U.S. Pat. 2,012,374, Dec. 12, 1961.

[63] Sawyer, Charles B. (assigned to Sawyer Research Products, Inc., Eastlake, Ohio). Production of Artificial Crystals. U.S. Pat. 3,013,867, Dec. 19, 1961.

[64] Bovenkerk, Harold P. (assigned to General Electric Co.). Method for Producing Improved Diamond Crystals. U.S. Pat. 2,992,900, July 18, 1961; Method of Diamond Growth and Apparatus Therefor, U.S. Pat. 3,031,269, Apr. 24, 1962.

Custers, J. F. H., H. B. Dyer, B. W. Senior, and P. T. Wedepohl, Canadian Pat. 643,290, June 19, 1962.

Eversole, William G. (assigned to Union Carbide Corp., Kenmore, N.Y.). Synthesis of Diamond. U.S. Pat. 3,030,187, Apr. 17, 1962; U.S. Pat. 3,030,188, Apr. 17, 1962.

[65] Gavrusevich, B. S., and F. Ya. Sarapulov. (Concerning the Change of Color and Optical Properties of Beryls on Heating.) Trans. Akad. Nauk S.S.S.R., Doklady, v. 31, No. 8, 1941, pp. 771–774; Tech. Trans. (Dept. of Commerce), v. 7, No. 9, May 15, 1962, p. 637.

[66] Pough, Frederick H. Brazilian Gem Market, 1962. Jewelers' Circ.-Keystone, v. 132, No. 5, February 1962, pp. 70, 75, 93–94; No. 6, March 1962, pp. 74, 76, 91–92; No. 7, April 1962, pp. 76, 78, 80, 144; No. 8, May 1962, pp. 78, 80, 82, 90–91; No. 9, June 1962, pp. 50, 52 60–61.

Gold

By J. P. Ryan [1] and Ethel M. Tucker [2]

MINE output of recoverable gold in the United States dropped slightly in 1962 to 1.5 million ounces valued at $54.0 million, the lowest peacetime level in more than 75 years. World gold production, however, continued to rise for the ninth consecutive year, reaching a new high of 50 million ounces valued at $1.75 billion.

The decline in domestic production of gold was caused chiefly by the lower yield from byproduct sources not being completely offset by increased output from gold mines. Three large placer mining operations were closed because economically minable reserves were depleted. The gain in world output of gold, as in several preceding years, was attributed to expansion of mining operations in the Republic of South Africa, which accounted for about half of the total world output.

Consumption of gold in domestic arts and industries rose sharply to nearly 3.6 million ounces, about twice domestic production, and an alltime high for domestic consumption, except for 1946, when demand generated by wartime conditions reached a peak.

The outflow of gold, resulting from the continued balance-of-payments deficit and conversion-of-dollar credits by foreign central banks, reduced the U.S. gold stock about $900 million to $16.1 billion, the lowest level since 1939. Free world gold reserves totaled $41.5 billion, a gain of about $300 million for the year.

The price of gold in the principal world markets remained relatively stable and did not vary much from the official price of $35. The statement by President Kennedy via *Telstar I* that this price would be maintained and the market operations of the international gold pool were the principal factors contributing to relative price stability in the London gold market.

LEGISLATION AND GOVERNMENT PROGRAMS

Hearings were held in June by the Subcommittee on Minerals, Materials, and Fuels of the Senate Committee on Interior and Insular Affairs on S.J. Res. 44 to encourage the discovery, development, and production of domestic gold by paying subsidies to operators of domestic gold mines.

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[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

Bills were introduced in the 87th Congress, 2d session, to provide for a study by the Secretary of the Interior of the gold mining industry (H.R. 11294) and to establish in the Interior Department a gold procurement and sales agency (H.R. 12872). These bills were referred to the Committee on Interior and Insular Affairs of the House of Representatives, but no further action was taken.

Nine contracts, totaling $517,800, were executed for gold exploration under the Government program of financial assistance, administered by the Office of Minerals Exploration. The Government share of the exploration cost was 50 percent.

DOMESTIC PRODUCTION

U.S. mine output of recoverable gold dropped slightly to 1.54 million ounces valued at $54.0 million, the lowest peacetime production since 1884. Although Alaskan output of gold rose sharply and smaller increases were recorded in California, Nevada, and South Dakota, these gains failed to offset declines in production in other gold-producing States. The gold mining industry continued to be adversely affected by rising costs in relation to the fixed price of gold. Three large placer mines closed when minable reserves were depleted; operations were begun at one large lode mine.

Gold production in Alaska rose 45 percent as a result of higher recoveries per yard washed in dredging operations of the United States Smelting, Refining & Mining Co., principally in the Fairbanks district. The two company dredges in the Nome district were closed down. In California, placer dredging operations on the Yuba River by Yuba Consolidated Industries, Inc., yielded an increased quantity of gold which more than offset the loss of output resulting from closing down the last dredging operation on the American River by The Natomas Co. in March. The gain in gold output in Nevada was attributed to reopening the Getchell mine, which began bullion shipments in July. Increased gold production in South Dakota reflected increased productive capacity resulting from mine-and-mill expansion at the Homestake mine.

The closing of the Carlton mill at Cripple Creek in January was the principal factor in the 28-percent drop in the Colorado gold output. A 31-percent decline in gold production in Montana to the lowest level in more than 86 years resulted from a 3-month labor strike at mines of The Anaconda Company.

The two leading gold-producing States, South Dakota and Utah, furnished 58 percent of the total domestic output. Virtually all of the gold production in South Dakota came from the Homestake mine, which contributed more than one-third of the total gold production in the Nation. Nearly all of the gold produced in Utah was recovered as a byproduct of base-metal ores, chiefly copper ore at the Utah Copper mine. Gold production in Arizona, like that in Utah, was chiefly as a byproduct of copper ore production. Alaskan gold come almost entirely from placers and was recovered chiefly by bucket-line dredging. Of the total gold produced, 47 percent was recovered from gold ores, 17 percent from placers, and 36 percent as a byproduct of base-metal ores.

Of the 25 leading sources of gold in the United States, 6 were lode gold mines, 5 placer mines, 9 copper mines, 3 lead-zinc mines, and 2 copper-lead-zinc mines. The 25 leading mines supplied 97 percent of the total domestic output.

TABLE 1.—Salient gold statistics

	1953-57 (average)	1958	1959	1960	1961	1962
United States:						
Mine production thousand troy ounces	1,859	1,739	1,603	1,667	1,548	1,543
Value thousands	$65,076	$60,874	$56,103	$58,337	$54,189	$53,990
Ore (dry and siliceous) produced:						
Gold ore thousand short tons	2,259	2,411	2,289	2,267	2,060	2,159
Gold-silver ore do	122	107	137	347	248	353
Silver ore do	641	639	597	641	565	555
Percentage derived from—						
Dry and siliceous ores	42	47	50	47	48	47
Base-metal ores	37	32	28	37	39	36
Placers	21	21	22	16	13	17
Secondary—returned from industrial use thousand troy ounces	855	769	654	700	1,138	910
Imports, general thousand troy ounces	3,358	8,120	8,485	9,322	1,615	4,312
Exports do	1,410	886	50	47	22,146	10,884
Stocks Dec. 31: Monetary [1] millions	$22,048	$20,582	$19,507	$17,804	$16,947	$16,057
Consumption in industry and the arts thousand troy ounces	1,513	1,833	2,522	3,000	2,775	3,576
Price: Average per troy ounce [2]	$35.00	$35.00	$35.00	$35.00	$35.00	$35.00
World: Production thousand troy ounces	36,600	40,600	42,800	[3] 45,300	[3] 47,400	50,000

[1] Includes gold in Exchange Stabilization Fund.
[2] Price under authority of Gold Reserve Act of Jan. 31, 1934.
[3] Revised figure.

TABLE 2.—Gold produced in the United States, according to mine and mint returns

(Troy ounces of recoverable metal)

	1953-57 (average)	1958	1959	1960	1961	1962
Mine	1,859,300	1,739,249	1,602,931	1,666,772	1,548,270	1,542,511
Mint	1,874,206	1,759,000	1,635,000	1,679,800	1,566,800	1,556,000

TABLE 3.—Mine production of gold in the United States in 1962, by months

Month	Troy ounces	Month	Troy ounces
January	120,017	August	142,639
February	116,026	September	142,044
March	123,510	October	152,966
April	115,139	November	121,554
May	125,295	December	124,355
June	126,199		
July	132,767	Total	1,542,511

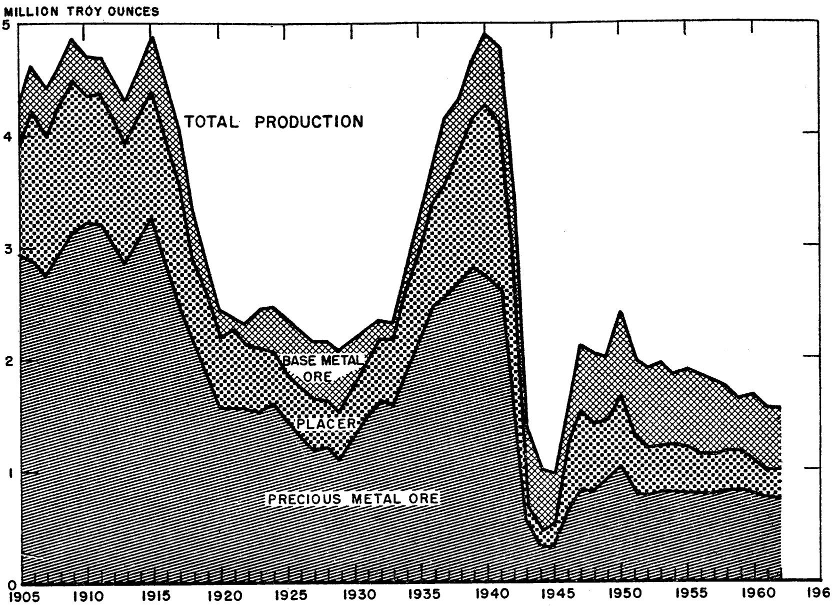

FIGURE 1.—Gold production in the United States, 1905–62.

Homestake Mining Co., the leading gold producer in the Nation, continued to increase ore output and the recovered value of gold bullion increased nearly 4 percent to $20.3 million; output was the greatest since inception of the Homestake mine in 1877. Ore milled increased to 1.87 million tons with an average recoverable value of $10.85 per ton, compared with 1.78 million tons yielding $11.00 per ton in 1961. Metallurgical recovery was 97.4 percent. Measured ore reserves at yearend were 15.4 million tons averaging $11.31 per ton, compared with 15.0 million tons averaging $11.39 per ton at the end of 1961.[3]

According to preliminary data compiled by the Bureau of Mines, approximately 4,300 persons were employed in the gold and gold-silver mining industry at 660 lode and placer mining operations.

Ore production and classification, methods of recovery, and metal yields for all ores from which gold was produced in the United States in 1962 are given in tables 6 to 10. Terminology and definitions used in classifying ores were published in the gold chapter of the 1960 Minerals Yearbook.

[3] Homestake Mining Co. 85th Annual Report. Dec. 31, 1962, p. 9.

TABLE 4.—Twenty-five leading gold-producing mines in the United States in 1962, 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	Yuba Unit	Yuba River	California	Yuba Consolidated Gold Fields.	Dredge.
4	Fairbanks Unit	Fairbanks	Alaska	United States Smelting, Refining and Mining Co.	Do.
5	Knob Hill & Gold Dollar.	Republic	Washington	Knob Hill Mines, Inc.	Gold ore.
6	Copper Queen-Lavender Pit.	Warren	Arizona	Phelps Dodge Corp	Copper ore.
7	Liberty Pit	Robinson	Nevada	Kennecott Copper Corp.	Do.
8	New Cornelia	Ajo	Arizona	Phelps Dodge Corp	Copper, gold-silver ores, gold tailings.
9	Idarado	Red Mountain-San Miguel.	Colorado	Idarado Mining Co	Copper, lead-zinc ores.
10	Getchell Group	Potosi	Nevada	Getchell Mines, Inc	Gold ore.
11	Nome Unit	Nome	Alaska	United States Smelting, Refining and Mining Co.	Dredge.
12	Iron King	Big Bug	Arizona	Shattuck Denn Mining Corp.	Lead-zinc ore.
13	Gold King	Wenatchee River	Washington	L-D Mines	Gold ore.
14	San Manuel	Old Hat	Arizona	Magma Copper Co	Copper ore.
15	Hogatza River	Hughes	Alaska	United States Smelting, Refining and Mining Co.	Dredge.
16	Morenci	Copper Mountain	Arizona	Phelps Dodge Corp	Gold-silver, copper ores.
17	Chicken Creek	Fortymile	Alaska	United States Smelting, Refining and Mining Co.	Dredge.
18	Berkeley Pit	Summit Valley (Butte).	Montana	The Anaconda Company.	Copper ore.
19	United States and Lark.	West Mountain (Bingham).	Utah	United States Smelting, Refining and Mining Co.	Gold-silver, lead-zinc ores.
20	Magma	Pioneer	Arizona	Magma Copper Co	Copper, gold-silver ores.
21	Eagle	Red Cliff (Battle Mountain).	Colorado	The New Jersey Zinc Co.	Copper, lead-zinc ores.
22	Kelley	Summit Valley (Butte).	Montana	The Anaconda Company.	Copper ore.
23	Camp Bird	Sneffels	Colorado	Camp Bird Colorado, Inc.	Lead-zinc ore.
24	Brush Creek	Downieville	California	Best Mines Co., Inc.	Gold ore.
25	Original Sixteen to One.	Alleghany	do	Original Sixteen to One Mine Co.	Do.

TABLE 5.—Mine production of recoverable gold in the United States, by States

(Troy ounces)

	1953-57 (average)	1958	1959	1960	1961	1962
Alaska	235,270	186,435	178,918	168,197	114,216	165,259
Arizona	130,762	142,979	124,627	143,064	145,959	137,207
California	217,783	185,385	145,270	123,713	97,644	106,272
Colorado	97,907	79,539	61,097	61,269	67,515	48,882
Idaho	12,592	15,896	10,479	6,135	5,718	5,845
Montana	29,488	26,003	28,551	45,922	35,377	24,387
Nevada	79,714	105,087	113,443	58,187	54,165	62,863
New Mexico	2,911	3,378	3,155	5,423	6,201	7,529
North Carolina	532	876	965	1,826	2,094	460
Oregon	4,567	1,423	686	835	1,054	822
Pennsylvania	[1] 812	(2)	(2)	(2)	(2)	(2)
South Dakota	548,590	570,830	577,730	554,771	557,855	577,232
Tennessee	219	124	99	123	152	158
Utah	424,501	307,824	239,517	368,255	342,988	311,924
Vermont	486	----	----	----	----	----
Washington	72,807	113,353	118,394	129,012	117,331	93,671
Wyoming	359	117	----	40	1	----
Total	1,859,300	1,739,249	1,602,931	1,666,772	1,548,270	1,542,511

[1] For 1957, Pennsylvania included in Vermont.
[2] Included in Washington.

TABLE 6.—Ore, gold tailings, etc., yielding gold, produced in the United States, and average recoverable content, in troy ounces of gold per ton in 1962

State	Gold ore		Gold-silver ore		Silver ore		Copper ore	
	Short tons	Average ounces of gold per ton	Short tons	Average ounces of gold per ton	Short tons	Average ounces of gold per ton	Short tons	Average ounces of gold per ton
Alaska	162	1.809	----	----	----	----	----	----
Arizona	2,795	.030	128,718	0.010	31,565	----	78,868,533	0.001
California	33,646	.261	20	.800	----	----	7,296	.191
Colorado	4,036	3.303	278	.180	1,585	0.001	24,909	.190
Idaho	1,167	.858	146	.247	352,635	.003	17,224	.017
Montana	3,051	.949	31,383	.079	28,912	.023	10,742,516	.001
Nevada	123,609	.181	----	----	1,393	.029	12,991,011	.003
New Mexico	10	.300	46,919	.028	1,423	.003	7,313,561	----
South Dakota	1,868,741	.309	----	----	----	----	----	----
Utah	3	.333	145,123	.005	137,555	.010	29,181,456	.010
Undistributed [4]	122,032	.762	796	.175	292	.065	223,290	.002
Total	2,159,252	.333	353,383	.024	555,360	.006	139,369,796	.004

See footnotes at end of table.

TABLE 6.—Ore, old tailings, etc., yielding gold, produced in the United States, and average recoverable content, in troy ounces of gold per ton in 1962—Con.

State	Lead ore		Zinc ore		Zinc-lead, zinc-copper, and zinc-lead-copper ores		Total ore	
	Short tons	Average ounces of gold per ton	Short tons	Average ounces of gold per ton	Short tons	Average ounces of gold per ton	Short tons	Average ounces of gold per ton
Alaska							162	1.808
Arizona	2,281	0.014	19,435		[1] 465,399	0.039	79,518,726	.002
California	210	.005			1,770	.092	[1] 42,942	.241
Colorado	6,280	.167	23	0.043	834,607	.034	871,718	.054
Idaho	213,739	.009	77,531		882,250	.001	1,544,692	.004
Montana	2,233	.106	940,000	.003	187	.027	[2] 11,748,282	.002
Nevada	4,816	.105	581	.002			13,121,410	.005
New Mexico	2,884	.003	311,200		1,300	.014	[3] 7,677,297	.001
South Dakota	27	.037					1,868,768	.309
Utah	3	.333	57,777		458,585	.024	29,980,502	.010
Undistributed [4]			3,100		3,250,557		[1] 3,600,067	.026
Total	232,473	.016	1,409,647	.021	5,894,655	.010	149,974,566	.009

[1] Includes gold recovered from tungsten ore.
[2] Includes manganese ore.
[3] Includes gold recovered from lead-barite ore.
[4] Includes North Carolina, Oregon, Pennsylvania, Tennessee, and Washington.

TABLE 7.—Mine and refinery production of gold in the United States in 1962, by States and sources

(Troy ounces of recoverable metal)

State	Mine production							Refinery production [1]
	Placers	Dry ore	Copper ore	Lead ore	Zinc ore	Zinc-lead, zinc-copper, lead-copper, and zinc-lead-copper ores	Total	
Alaska	164,966	293					165,259	164,800
Arizona	58	1,345	117,387	32	6	18,379	137,207	140,500
California	95,918	8,801	1,390	1		[2] 162	106,272	105,600
Colorado	1,601	13,381	4,733	1,049	1	28,117	48,882	54,300
Idaho	376	2,148	285	1,907	11	1,118	5,845	5,500
Montana	110	6,046	15,034	236	2,956	5	24,387	26,600
Nevada	1,249	22,357	38,748	508	1		62,863	64,300
New Mexico		[3] 1,322	6,084	9	96	18	7,529	7,600
North Carolina			416			[2] 44	460	600
Oregon	411	411					822	800
Pennsylvania	(4)	(4)	(4)	(4)	(4)	(4)	(4)	940
South Dakota		577,231		1			577,232	569,500
Tennessee						158	158	160
Utah		2,071	299,008	1	30	10,814	311,924	315,200
Washington	4	92,707	45		2	913	[5] 93,671	99,600
Total	264,693	728,113	483,130	3,744	3,103	59,728	1,542,511	1,556,000
Percent	17.2	47.2	31.3	0.2	0.2	3.9	100.0	

[1] U.S. Bureau of the Mint.
[2] Includes gold recovered from tungsten ore.
[3] Includes gold recovered from lead-barite ore.
[4] Included with Washington.
[5] Includes gold recovered from magnetite-pyrite ore in Pennsylvania.

TABLE 8.—Gold produced in the United States from ore and old tailings in 1962, by States and methods of recovery, in terms of recoverable metal

State	Total ore, old tailings, etc., treated (short tons)	Ore and old tailings to mills					Crude ore to smelters	
		Short tons	Recoverable in bullion		Concentrates smelted and recoverable metal			
			Amalgamation (troy ounces)	Cyanidation (troy ounces)	Concentrates (short tons)	Troy ounces	Short tons	Troy ounces
Alaska	162	162	293	----------	----------	----------	----------	----------
Arizona	79,582,853	78,934,106	----------	31	2,507,708	117,268	648,747	19,850
California	42,942	39,476	6,458	12	5,441	3,195	3,466	689
Colorado	871,725	842,076	5,560	3,367	130,203	23,121	29,649	15,233
Idaho	1,586,185	1,536,344	431	----------	241,141	4,774	49,841	264
Montana	11,834,866	11,673,454	207	----------	397,899	18,004	161,412	6,066
Nevada	13,121,451	13,028,696	184	21,999	282,886	37,922	92,755	1,509
New Mexico	7,721,545	7,584,758	3	----------	305,470	6,188	136,787	1,338
South Dakota	1,868,768	1,868,741	442,158	135,073	----------	----------	27	1
Utah	30,000,939	29,638,525	----------	----------	846,621	309,769	362,414	2,155
Undistributed [1]	6,461,895	6,457,127	118	12,904	[2] 266,836	79,303	1,463,627	2,371
Total	153,093,331	151,603,465	455,412	173,386	4,984,205	599,544	2,948,725	49,476

[1] Includes North Carolina, Oregon, Tennessee, Washington, and Wyoming.
[2] Excludes magnetite-pyrite-chalcopyrite ore and concentrates therefrom in Pennsylvania.

TABLE 9.—Gold produced at amalgamation and cyanidation mills in the United States and percentage of gold recoverable from all sources

Year	Bullion and precipitates recoverable (troy ounces)		Gold from all sources (percent)			
	Amalgamation	Cyanidation	Amalgamation	Cyanidation	Smelting [1]	Placers
1953–57 (average)	443,364	269,787	23.8	14.5	41.0	20.7
1958	446,886	245,397	25.7	14.1	38.9	21.3
1959	459,857	236,046	28.7	14.7	34.3	22.3
1960	438,207	210,354	26.3	12.6	45.2	15.9
1961	434,134	186,086	28.0	12.0	46.9	13.1
1962	455,412	173,386	29.5	11.2	42.1	17.2

[1] Both crude ores and concentrates.

TABLE 10.—Gold production at placer mines in the United States, by methods of recovery

Method and year	Mines producing	Washing plants (dredges)	Material treated (thousand cubic yards)	Gold recoverable: Thousand troy ounces	Gold recoverable: Value (thousands)	Gold recoverable: Average value per cubic yard
Bucketline dredging:						
1953–57 (average)	21	34	55,038	328	$11,474	$0.208
1958	17	31	43,693	287	10,038	.230
1959	16	30	36,998	251	8,767	.237
1960	17	24	33,464	228	7,986	.239
1961	19	24	33,806	177	6,192	.183
1962	20	22	25,590	242	8,456	.330
Dragline dredging:						
1953–57 (average)	15	11	569	3	96	.169
1958	11	11	132	1	40	.301
1959	12	12	157	2	73	.464
1960	20	20	144	1	47	.329
1961	16	16	[1] 608	1	43	.071
1962	13	13	532	1	47	.088
Hydraulicking:						
1953–57 (average)[2]	43	2	211	2	63	.299
1958	49		348	3	115	.331
1959	35	35	102	3	87	.855
1960	33	33	282	3	93	.330
1961	19	19	104	3	107	1.029
1962	21	21	124	2	83	.669
Nonfloating washing plants:						
1953–57 (average)	116	115	2,559	50	1,760	.688
1958	107	118	2,601	77	2,698	1.037
1959	89	97	2,569	100	3,511	1.367
1960	80	80	938	30	1,045	1.114
1961	81	81	957	19	668	.698
1962	45	45	839	16	551	.657
Underground placer, small-scale hand methods, and suction dredging:						
1953–57 (average)[3]	111	2	174	[4] 3	[4] 108	.621
1958	105	3	83	3	93	1.130
1959	79	4	47	[5] 2	[5] 82	1.732
1960	89	89	60	2	73	1.207
1961	103	103	141	2	73	.518
1962	74	74	314	4	128	.408
Grand total, placers:						
1953–57 (average)	306	164	58,551	[4] 386	[4] 13,501	.231
1958	289	163	46,857	371	12,984	.277
1959	231	178	39,873	[5] 358	[5] 12,520	.314
1960	239	246	34,888	264	9,244	.265
1961	238	243	[1] 35,616	202	7,083	.199
1962	173	175	27,399	265	9,265	.338

[1] Does not include commercial sand and gravel operations recovering byproduct gold.
[2] Includes suction dredges.
[3] Suction dredges included with hydraulicking.
[4] Includes 1,476 ounces of gold valued at $51,660 recovered from unclassified placers in 1954.
[5] Includes 103 ounces of gold valued at $3,605 recovered from electrostatic separation.

CONSUMPTION AND USES

Industry and the Arts.—Continuing the trend of recent years, the net consumption of gold in domestic industries rose 29 percent to 3.6 million ounces, about 2.0 million ounces more than domestic mine production. Except for 1946, when demand generated by wartime conditions reached a peak of 4.4 million ounces, 1962 was an alltime high for domestic consumption of gold. Domestic consumption is equivalent to the total amount of gold issued by the U.S. Mint and private refiners and dealers, less secondary gold (scrap) from domestic sources, received by the U.S. Mint, private refiners, and dealers.

Although overall consumption of gold had been increasing, particularly in the newer industrial and defense-related applications, precise quantitative data on end uses were not available. However, it was estimated that about three-fourths of the total industrial gold was consumed for jewelry, decorative products, and dental materials. New applications of gold in the electronics industry and in various components of missiles and space vehicles, such as *Mariner* and *Telstar*, continued to expand. Essentially, these applications were based on the high electrical conductivity of gold, its superior resistance to corrosion, and its high reflectivity of heat and light. In jet-aircraft and space-vehicle components, gold was generally applied as coating to structural metals to reduce the heat-transfer rate in surfaces exposed to high temperatures and in various parts of the communication and control systems where reliability of performance was essential.

Major gold producers of the world formed the Committee for Research on Properties and Uses of Gold, Inc., to promote increased industrial use of gold and to define new applications for which the special properties of gold gave it preference on a technical or engineering basis.

Monetary.—Very little gold was purchased by European central banks in 1962. It was estimated that more gold was absorbed into industrial and private holdings, and less went into official reserves, than in any post-World War II year.

Of the total free world production plus market sales by the U.S.S.R., aggregating 43 million ounces valued at $1.5 billion, approximately 28.5 million ounces valued at more than $1.0 billion went into private holdings. Demand for gold coins increased and some countries resumed minting of coins for use as a commodity rather than for circulation. Far East and Middle East countries absorbed about 6.5 million ounces, most of which was sold during the first 10 months of 1962 before exchange controls in Laos and the discontinuance of the gold market in India reduced the demand from these countries.[4]

TABLE 11.—Gold consumption in industry and the arts, in the United States

(Troy ounces)

Year	Issued for industrial use	Returned from industrial use	Net industrial consumption
1953-57 (average)	2,367,970	855,438	1,512,532
1958	2,602,512	769,261	1,833,251
1959	3,175,386	653,586	2,521,800
1960	3,700,000	700,000	3,000,000
1961	3,912,554	1,137,554	2,775,000
1962	4,485,670	909,670	3,576,000

Source: U.S. Bureau of the Mint.

MONETARY STOCKS

U.S. gold stock declined $890 million to $16.1 billion at yearend, marking the fifth consecutive annual loss and the lowest level of the

[4] S. Montague & Co. Ltd. Annual Review 1962, pp. 5–7.

gold stock since 1939. Most of the gold was sold to France and the United Kingdom. Although the U.S. balance-of-payments deficit was reduced $200 million to $2.2 billion, the gold loss increased about $33 million, reflecting a higher dollar conversion rate by foreign central banks. The ratio of gold reserve to Federal Reserve note and deposit liabilities dropped 3 percent to 32 percent at yearend, 25 percent being required for legal cover.

Gold reserves reported by central banks and governments and international banking institutions at yearend aggregated $41.5 billion, about $300 million more than at the end of 1961. The U.S. reserve of $16.1 billion thus constituted nearly 39 percent of the total free world gold reserve. Gold reserves of other principal free world countries in billions of dollars were as follows: West Germany, 3.7; United Kingdom, 2.9; France, 2.6; Switzerland, 2.5; Italy, 2.3; Netherlands, 1.6; Belgium, 1.4; and Canada, 0.7. The International Monetary Fund reported gold reserves of $2.2 billion.

U.S. net short-term liabilities to foreign interests increased $2.2 billion to $19.9 billion at yearend as a result of the 1962 deficit in balance of payments. These liabilities, payable in dollars, constituted a potential claim on the U.S. gold reserve. About 60 percent of the total net liabilities was payable to Western European countries and Canada.[5]

PRICES

The persistent gold outflow from the United States and increased short-term liabilities to foreigners, resulting from a continued deficit in the balance of payments, again prompted speculation regarding revaluation of gold. In this connection on July 23, the President stated in his news conference, part of which was relayed to Europe by the *Telstar I* communications satellite:

> We hope that we can bring our balance of payments into balance by the end of next year. We are not going to devalue. There is no possible use in the United States devaluing. Every other currency in a sense is tied to the dollar; if we devalued, all other currencies would devalue and so that those who speculate against the dollar are going to lose. The United States will not devalue its dollar. And the fact of the matter is the United States can balance its balance of payments any day it wants if it wishes to withdraw its support of our defense expenditures overseas and our foreign aid.

Again, in an address at the annual meeting of the International Monetary Fund in September, the President stated:

> We are pledged to keep the dollar fully convertible into gold and to back that pledge with our resources of gold and credit.

The position of the United States as to the official price of gold also was stated in the remarks of the Secretary of the Treasury, Douglas Dillon, at the ninth Annual Monetary Conference of the American Bankers Association in May as follows:

> The Free World's monetary system, as it has evolved since World War II, rests inescapably on the full acceptability of the dollar as a supplement to gold in financing world trade. No practicable alternative is in sight. This means that the dollar holdings of the central banks must continue, in the future as in

[5] Federal Reserve Bulletin. V. 49, No. 4, April 1963, pp. 562–565.

the past, to be readily convertible into gold upon demand at the fixed price of $35 an ounce.

The U.S. Treasury mint institutions and licensed refiners and dealers continued to buy virtually all the newly mined gold from domestic mines and gold offered by foreigners at the official price of $35 an ounce, less handling and refining charges of 0.25 percent. These official agencies also sold gold to domestic consumers and foreign central banks at the official price plus handling charges.

The intention of the U.S. Treasury to adhere firmly to the policy of buying and selling gold at $35 an ounce and to maintain free convertibility of dollars into gold at that price was explained by an official of the Treasury.[6]

On the London gold market the price of gold fluctuated in the narrow range between $38.18625 and $35.0675. The reduction in U.S. Treasury gold stock and decline in stock market prices, coupled with a deteriorating international political situation, created increased demand for gold and upward pressure on prices. The Bank of England sold gold to stabilize the price with the understanding that it could replenish the gold thus sold from the U.S. gold stock. This understanding was supplemented by an informal agreement between central banks to refrain from buying gold in London when the supply was short. These banks participated with the United States in forming a gold pool to maintain an orderly flow of gold to the market and to stabilize its price. The announcement of President Kennedy via *Telstar I* that the United States was determined to maintain the price of $35 brought a temporary falloff in the London market price. As in 1961, sales of gold by the U.S.S.R. in the London market (3.1 million ounces) also contributed to price stability. Except for a brief interval of rising prices in the last quarter, during the Cuban crisis, the price of gold remained relatively stable, and at yearend was quoted at $35.0675.

Free gold bars (12.5 kilograms) were traded in most of the principal gold markets outside London at prices that did not vary greatly from the London price, except in the Bombay market where trading was in local currencies, not readily convertible, which reflected local political conditions and monetary habits. These prices per ounce were as follows:

Market:	*Price*	Market:	*Price*
Manila	$36.28	Beirut	$35.27
Hong Kong	38.73	Paris	35.56
Bombay	53.04	Buenos Aires	35.85

World demand for gold coins continued at a high level, although the quantity traded was less than in 1961. The average premium over the value of the gold content increased slightly. The premium on the

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[6] Morris, Frank E. U.S. Treasury Department. Policy on Gold and Silver. Mines Magazine, v. 52, No. 8, August 1962, pp. 26–27.

U.S. $20 double eagle in London fluctuated between a low of nearly 21 percent in March and a high of 30 percent in October; on new £1 sovereigns the premium fluctuated between 12 and 18 percent; and on the French 20 francs Napoleon the premium ranged between 21 and 35 percent.

The initial minting of 2-rand gold coins by the Republic of South Africa was a significant feature of 1962. These coins were marketed in Switzerland at a premium of about 10 percent.

FOREIGN TRADE [7]

Outflow of gold from the United States continued at a high rate, although the quantity exported was about half that of 1961. Most of the gold exports, valued at $381 million, went to the United Kingdom; a part was sold by the Bank of England in connection with the operations of the gold pool. Imports of gold greatly increased. Brazil and Colombia supplied slightly more than three-fourths of the total imports, 4.3 million ounces valued at $150.9 million; Philippines provided 8 percent; Canada, 7 percent; and nearly all of the remainder came from 15 other countries. About 90 percent of the total imports was refined bullion; the remainder was contained in ore and base bullion, mostly from Western Hemisphere countries. Nearly all exports were refined bullion.

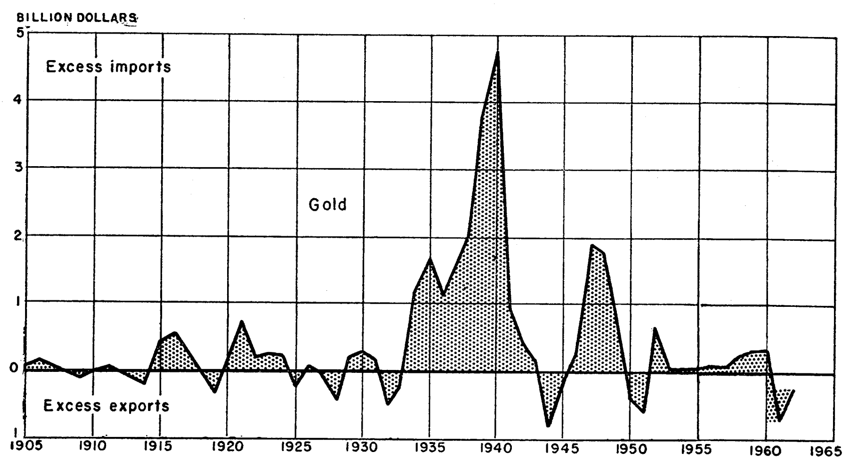

Figure 2.—Net imports or exports of gold, 1905–62.

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

TABLE 12.—U.S. imports of gold in 1962, by countries

Country	Ore and base bullion		Refined bullion	
	Troy ounces	Value	Troy ounces	Value
North America:				
Canada	42,020	$1,435,736	245,718	$8,604,453
El Salvador	692	24,208		
Guatemala	8	280		
Honduras	2,132	72,829	9	300
Mexico	40,902	1,423,788		
Nicaragua	150,834	5,255,807		
Panama	66	2,335		
Total	236,654	8,214,983	245,727	8,604,753
South America:				
Bolivia	1	30		
Brazil			1,997,845	69,924,571
Chile	25,846	963.825		
Colombia	884	30.127	1,351,269	47,294,397
Ecuador	18,973	659,182		
Peru	25,504	862,888		
Venezuela			78	2,741
Total	71,208	2,516,052	3.349,192	117,221,709
Europe:				
Austria			80	2,803
Germany, West			113	3,954
Portugal	10,063	352,205		
Switzerland	91	2,818		
United Kingdom			4,397	154,355
Total	10,154	355,023	4,590	161,112
Asia:				
Hong Kong	25	880		
Japan	51	1,770	31,361	1,113,347
Philippines	47,673	1,639,423	298,229	10,529,361
Total	47,749	1,642,073	329,590	11,642,708
Africa:				
Rhodesia and Nyasaland, Federation of	409	14,282		
South Africa, Republic of	398	13,930		
Total	807	28.212		
Oceania: Australia	15,896	524.423	619	21,307
Grand total	382,468	13,280,766	3,929,718	137,651,589

Source: Bureau of the Census.

TABLE 13.—U.S. exports of gold in 1962, by countries

Destination	Ore and base bullion		Refined bullion	
	Troy ounces	Value	Troy ounces	Value
North America:				
Bahamas			7	$282
Canada	5	$170	33	1,173
Mexico			442,770	15,497,133
Total	5	170	442,810	15,498,588
Europe:				
Belgium-Luxembourg	4,593	160,755		
France	9	309		
Germany, West	599	20,659		
Portugal			8,733	305,958
Spain			1,955	68,417
Sweden			307,972	10,779,019
United Kingdom	17,518	627,061	9,200,040	322,001,312
Total	22,719	808,784	9,518,700	333,154,706
Asia: Lebanon			900,000	31,500,020
Grand total	22,724	808,954	10,861,510	380,153,314

Source: Bureau of the Census.

WORLD REVIEW [8]

World gold production rose 2.6 million ounces to 50 million ounces valued at $1.75 billion. The 1962 gain in gold output marked the ninth consecutive annual increase and was attributed principally to continued expansion of mining operations in the Republic of South Africa, which more than doubled production since 1953.

Production increased slightly in India and Ghana but declined in Canada, Colombia, Mexico, Japan, Philippines, Republic of the Congo, and Southern Rhodesia. Australian output remained virtually unchanged.

Australia.—Mine production of gold continued its remarkably stable pattern with an output of 1.07 million ounces in 1962, virtually unchanged from 1961. About the same average annual production has been maintained since 1952.

[8] Values in this section are U.S. dollars, based on the average rate of exchange by the Federal Reserve Board, unless otherwise specified.

TABLE 14.—World production of gold by countries [1] [2]

(Troy ounces)

Country [1]	1953-57 (average)	1958	1959	1960	1961	1962
North America:						
Canada	4,356,376	4,571,347	4,483,416	4,628,911	4,473,699	4,156,233
Central America and West Indies:						
Costa Rica [3]	[4] 620	310				
Cuba [3]	1,161	804	615	348		
Dominican Republic	115	780	513	[3] 308		
El Salvador	6,914	2,372	2,394	1,121		
Guatemala [5]	320	370				[3] 8
Honduras	14,481	1,714	[3] 2,798	[3] 2,172	[3] 1,685	[3] 2,132
Nicaragua	230,453	214,882	218,302	210,200	226,250	221,984
Mexico	389,963	332,246	313,663	300,256	268,684	236,758
United States [6]	1,874,206	1,759,000	1,635,000	1,679,800	1,566,800	1,556,000
Total	6,875,000	6,884,000	6,657,000	6,823,000	6,537,000	6,173,000
South America:						
Argentina	7,739	3,054	[3] 1,782	[3] 201	[3] 1	
Bolivia (exports)	29,256	19,115	35,246	45,457	81,216	35,052
Brazil	151,400	186,000	125,000	120,000	[5] 120,000	[5] 120,000
British Guiana	20,795	17,500	3,448	2,364	1,702	1,903
Chile	117,955	110,952	78,640	107,030	[5] 100,000	[5] 100,000
Colombia	391,810	371,715	397,929	433,947	401,060	396,825
Ecuador	19,077	19,685	18,450	15,159	15,210	20,591
French Guiana	5,520	20,000	16,100	18,940	7,944	5,273
Peru	156,054	159,127	150,299	141,001	137,418	126,223
Surinam	6,742	4,258	5,826	4,932	4,011	2,592
Venezuela	60,800	76,009	53,766	46,868	30,071	28,774
Total [5]	967,000	987,000	886,000	936,000	899,000	837,000
Europe:						
Finland	19,181	22,152	23,374	20,351	20,609	15,249
France	35,340	35,559	42,150	46,040	48,676	45,011
Germany, West	4,590	2,485	1,929	1,283	[5] 2,000	[5] 2,000
Greece	5,541	5,787	4,340	4,823		
Italy	7,292	4,802	3,261	3,310	600	
Portugal	21,528	17,747	20,769	21,927	22,377	22,500
Spain	10,360	14,211	15,239	13,986	8,231	7,588
Sweden	98,021	127,574	102,979	94,266	83,174	[5] 90,000
U.S.S.R. [5] [7]	9,400,000	10,000,000	10,000,000	11,000,000	11,800,000	12,200,000
Yugoslavia	44,567	55,364	59,640	63,980	67,195	[5] 80,000
Total [1] [5]	9,800,000	10,500,000	10,500,000	11,600,000	12,500,000	12,900,000
Asia:						
Burma	245	190	212	304	194	[5] 170
Cambodia	[4] 1,045	322	4,823	4,180	4,180	965
India	212,371	170,110	165,383	160,593	156,510	163,326
Japan	241,224	260,630	261,547	261,496	294,534	286,200
Korea:						
North [8]	130,000	130,000	130,000	130,000	130,000	130,000
Republic of	46,475	72,071	65,690	65,814	84,105	107,880
Malaya	18,697	22,484	26,739	20,745	12,486	6,923
Philippines	420,387	422,833	402,615	410,618	423,983	423,394
Sarawak	584	864	2,450	3,326	4,132	2,885
Saudi Arabia	23,173					
Taiwan	26,798	21,345	13,497	15,699	17,490	24,029
Total [1] [5] [7]	1,340,000	1,410,000	1,380,000	1,380,000	1,435,000	1,455,000

See footnotes at end of table.

TABLE 14.—World production of gold by countries [1] [2]—Continued

(Troy ounces)

Country [1]	1953-57 (average)	1958	1959	1960	1961	1962
Africa:						
Angola	29	26	42	42	48	77
Bechuanaland	733	215	198	203	261	288
Cameroon, Republic of	2,725	2,009	971	416	538	------------
Central Africa, Republic of	569	932	495	291	80	100
Congo, Republic of the (formerly Belgian)	366,983	352,276	347,967	316,195	232,611	[5] 200,000
Congo, Republic of	9,718	6,048	3,665	2,628	3,376	3,718
Eritrea	2,145	6,430	16,718	5,144	5,529	2,315
Ethiopia	26,670	36,369	41,439	40,915	[5] 41,500	43,000
Gabon, Republic of	33,212	16,558	16,172	17,696	15,304	16,075
Ghana	726,665	852,834	913,141	893,113	852,619	888,038
Kenya	9,394	7,753	9,145	8,646	12,299	8,917
Liberia	710	[5] 400	1,401	1,036	2,088	2,184
Malagasy Republic	1,164	804	193	273	347	325
Morocco	2,127	------------	------------	104	136	------------
Mozambique	1,327	695	295	225	105	91
Nigeria, Federation of	586	646	950	994	676	384
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia	2,925	3,729	4,685	6,300	4,279	3,625
Southern Rhodesia	526,970	554,838	566,883	562,703	570,095	554,647
Ruanda-Urundi	3,922	3,858	3,119	1,566	900	[5] 2,900
South Africa, Republic of	14,541,486	17,656,447	20,065,515	21,383,019	22,941,561	25,491,993
Sudan	1,903	1,571	1,419	2,116	1,500	[5] 1,500
Swaziland	52	------------	------------	806	1,325	2,214
Tanganyika [9]	71,265	68,250	95,794	107,009	101,067	101,597
Uganda (exports)	408	346	405	744	453	412
United Arab Republic (Egypt)	9,774	1,812	2,486	1,000	[5] 1,000	[5] 1,000
Upper Volta	725	4,598	4,019	1,161	15,497	[5] 43,400
Total	16,340,000	19,580,000	22,100,000	23,350,000	24,810,000	27,370,000
Oceania:						
Australia	1,071,145	1,103,980	1,085,104	1,086,709	1,068,690	1,068,724
Fiji	72,379	86,794	72,565	72,203	83,417	87,354
New Guinea	85,678	43,254	46,663	45,019	41,820	39,002
New Zealand	32,614	24,981	36,758	33,326	28,294	21,747
Papua	438	558	156	132	31	45
Total	1,262,254	1,259,567	1,241,246	1,237,389	1,222,252	1,216,872
Grand total (estimate) [1]	36,600,000	40,600,000	42,800,000	45,300,000	47,400,000	50,000,000

[1] Gold is also produced in Austria, Bulgaria, China, Czechoslovakia, East Germany, Hungary, Indonesia, Rumania, and Thailand, but production data are not available; estimates for these countries are included in total. For some countries accurate figures are not possible to obtain owing to clandestine trade in gold (as, for example, in former French West Africa).
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Imports into the United States.
[4] Average annual production 1956-57.
[5] Estimate.
[6] Refinery production.
[7] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.
[8] Estimate according to Minerais et Metaux (France), except 1962.
[9] Including gold in lead concentrates exported amounting to: 6,816 ounces, 1953-57 (average); 11,951 ounces, 1958; 10,391 ounces, 1959; 8,963 ounces, 1960; 521 ounces, 1961; data not available, 1962.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

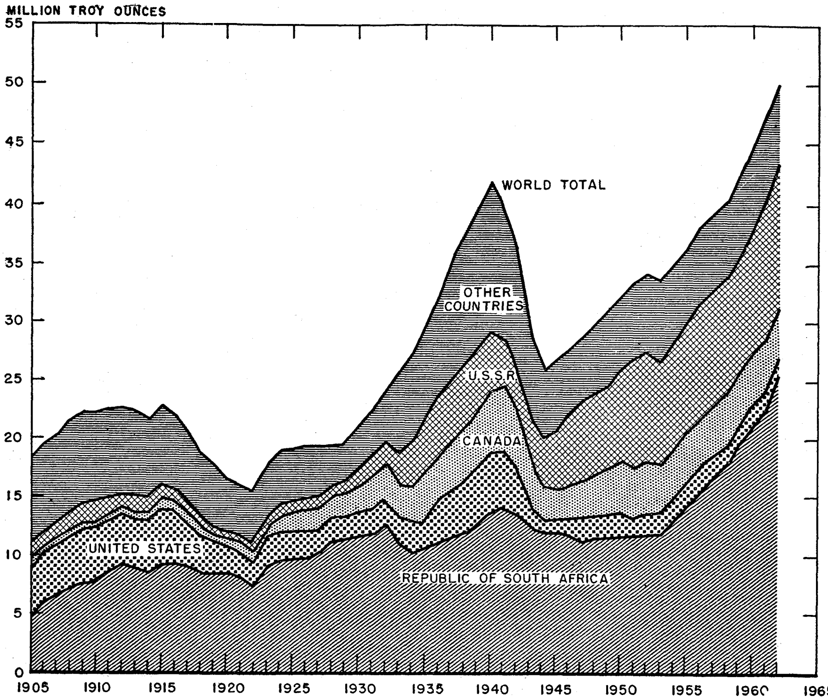

FIGURE 3.—World production of gold, 1905–62.

Western Australia continued as the leading gold mining State, again contributing about 81 percent of the total Australian output. Northern Territory produced nearly 7 percent of the total; Queensland, 6 percent; Tasmania, 3 percent; and Victoria, 3 percent. Part of the gold sold to the Reserve Bank was resold by the Gold Producers Association in world markets at prices averaging slightly higher than the official price. The Commonwealth paid subsidies to the gold producers under the Gold Mining Assistance Act totaling £A675,700, equivalent to about $1.5 million. An amendment to the act in 1962 extended subsidy payments on production to June 1965. Premiums received by producers from the sale of gold in world markets were offset against subsidy payments.

The Gold Mines Development Assistance Act 1962, passed in December, provided assistance to gold producers not receiving production subsidies, by paying a development allowance to encourage the development of new ore reserves. Annual payments were determined by how much the allowable expenditure on development exceeded the base expenditure for a mine—normally the average annual expenditure of the preceding 3 years. About 5,400 persons were employed in the gold mining industry.

Lake View and Star, Kalgoorlie, the leading gold producer, treated about 680,000 tons of ore and reported ore reserves of 3.7 million tons, averaging $8.61 per ton. Great Boulder Gold Mines, Ltd., reported ore reserves of 2.1 million tons, averaging $9.62 per ton, a slight increase in the quantity of reserves but a slight drop in grade. Central Norseman Gold Corp. treated 182,200 tons of ore, recovering 106,165 ounces of gold; ore reserves increased to 595,000 tons averaging $17.50 per ton. Mount Morgan, Ltd., Queensland, recovered 55,640 ounces of gold from gold-copper ore.

Canada.—Gold production dropped 7 percent to 4.2 million ounces valued at Can$155.5 million, notwithstanding an advance in the average mint price to $37.41 from $35.46 in 1961. The price rise resulted from a decline in the quoted value of the Canadian dollar in relation to the U.S. dollar.

The decline in gold output reflected a sharp drop in gold production at Kerr-Addison Gold Mines, Ltd., the largest producer; closing of two older mines late in 1961; and mining lower grade ore and milling at a reduced rate at several other mines. Lower grade, high-cost mines continued to receive cost-assistance payments under terms of the Emergency Gold Mining Assistance Act (E.G.M.A.). Of 52 operating lode gold mines, 42 received cost assistance.

All prinicipal gold-producing Provinces, except British Columbia and Newfoundland, recorded lower gold output; Quebec contributed 24 percent; Northwest Territories, nearly 10 percent; and British Columbia, 4 percent.

About 85 percent of the total gold output came from lode and placer mines; the remainder was recovered as a byproduct at base-metal mines. Approximately 15,300 persons were employed at lode gold mines.

At Kerr-Addison Gold Mines, Ltd., gold output dropped nearly 22 percent to 418,150 ounces, valued at $15.7 million. The decline in production resulted from the lower tonnage of ore milled, a drop from 4,083 in 1961 to 3,405. Average grade of ore also dropped slightly, but an increase of $1.91 in the price per ounce of gold recovered resulted in a slight increase in value recovered per ton, from $12.04 to $12.47. Total mine operating cost increased 42 cents per ton to $7.54 per ton. Proven ore reserves dropped 0.9 million tons to 6.8 million tons averaging 0.41 ounces per ton ($14.40).

The Yukon Consolidated Gold Corp., Ltd., operated five dredges and two hydraulic-mechanical placer operations in the Dawson area of the Yukon Territory and produced gold valued at $1.5 million, about 16 percent less than in 1961. Nearly 4.5 million cubic yards averaging 29.1 cents per yard was dredged. Operating costs were 27.9 cents per yard. Proved gravel reserves at yearend aggregated 13.9 million cubic yards averaging 42.6 cents per yard. The corporation received cost aid under the Emergency Gold Mining Assistance Act.

Colombia.—Production of gold dropped 1 percent to 396,800 ounces. South American Gold & Platinum Co. recovered 147,470 ounces of gold from dredging operations and underground mining, about 6 percent less than in 1961. Although the quantity of gravel dredged dropped 2 percent to 21.1 million cubic yards, the tons milled from underground mines rose 14 percent to 185,000.

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Five dredges were operated throughout 1962, four in the Choco district and one in Narino. Dredging reserves increased substantially as a result of intensive exploration in Narino. At yearend developed reserves were 87.9 million cubic yards, averaging 41.7 cents per yard, compared with 64.2 million cubic yards, averaging 46.9 cents per yard, at the end of 1961. Underground reserves declined to 444,000 tons averaging 0.69 ounce of gold per ton, from 539,000 tons of the same grade at the end of 1961. All gold production was sold either to the Bank of the Republic or through the Colombian Mining Association. Gold sold at the free rate of exchange realized an average of $35.24 per ounce.[9]

Pato Consolidated Gold Dredging, Ltd., operated six dredges throughout the year and produced 93,200 ounces of gold from 24.7 million cubic yards of gravel, compared with 105,100 ounces from 23.2 million cubic yards in 1961. Average value per cubic yard dropped 2 cents to 14.1 cents. Minable reserves of gravel at yearend aggregated 402.3 million cubic yards averaging 15.2 cents per cubic yard. The average value per ounce realized was Can$37.41 compared with Can$35.46 in 1961.[10]

Ghana.—Gold output rose 4 percent to 888,000 ounces. Ashanti Goldfields Corp., Ltd., the leading producer, continued to expand its productive operations for the sixth consecutive year. The tonnage milled increased 6 percent to 480,600, and gold recovered rose nearly 10 percent to 417,400 ounces, almost half of the total gold output of Ghana. Average grade of ore was $33.77 per ton, compared with $32.35 in 1961. Operating costs, excluding development charges, were $13.37 per ton of ore milled, compared with $12.44 in 1961. The rise in operating costs reflected an increase in taxes on diesel fuel and additional expense attributed to new Exchange Control regulations. The company reported ore reserves of 2.9 million tons, averaging 1.04 ounces per ton, compared with 3 million tons, averaging 0.94 ounce per ton, in 1961.

Philippines.—Output of gold, the most valuable mineral commodity in the Philippines, was 423,400 ounces, valued at $14.8 million, slightly less than in 1961. Benguet Consolidated, Inc., the largest producer, recovered 245,430 ounces—about 58 percent of the total gold produced. Gold was sold to the central bank at the official price of $35 per ounce plus a Government subsidy to make a total price neither exceeding ₱200 nor less than ₱160 per troy ounce, approximately equivalent to $55 and $44, respectively. Under provisions of The Gold Mining Industry Act of 1961, 7.5 percent of the assistance a mine received was given as a bonus to employees whose salaries did not exceed ₱500 ($140) per month.

South Africa, Republic of.—Gold production in South Africa rose for the 11th consecutive year, establishing a new record of 25.5 million ounces, valued at $892 million, nearly 11 percent more than in 1961. The production gain again reflected an increase in tons milled and in average grade of ore. Three new mines, Western Deep Levels,

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[9] South American Gold & Platinum Co. 46th Annual Report 1962, pp. 17–19.
[10] Pato Consolidated Gold Dredging, Ltd. 29th Annual Report 1962.

Bracken, and Leslie, began milling operations during 1962 and others expanded milling operations. Although profits from uranium declined for the second successive year, total working profit of gold and uranium combined increased $34 million to $398.8 million. The estimated ore reserve was 169.2 million tons averaging 0.408 ounce per ton. The supply of both African and European labor was adequate to meet requirements of the gold mining industry. The average number of employees was 48,640 Europeans and 392,730 Africans. Three older mines of the Central Rand were closed as economically minable reserves were depleted. However, the effects of closing these mines were more than offset by increased outputs of the newer mines in the Orange Free State, the Western Transvaal, and the Evander area.

Anglo-American Corporation of South Africa, Ltd., reported that its mines produced 8.5 million ounces of gold valued at $298 million, about one-third of the gold produced in South Africa and about 22 percent of that produced in the free world. Western Deep Levels, Ltd., started milling ore in March at the rate of 110,000 tons per month; the rate was substantially increased by yearend.[11]

Consolidated Gold Fields of South Africa, Ltd., reported that its Gold Fields group of mines continued to expand output of gold and uranium. Group mines treated 13.3 million tons, an increase of 1.2 million tons, and recovered 4.6 million ounces of gold, 0.6 million ounces more than in 1961. Average yield per ton rose 0.15 ounce to 6.9 ounces; and working costs decreased 14 cents to $21.37 an ounce. Working profits and dividends increased to record high levels. Doornfontein Gold Mining Co., Ltd., increased the quantity of ore milled and production of gold and lowered production costs. The company treated 1.5 million tons, averaging 0.44 ounce per ton at a cost of $18.92 an ounce. West Driefontein Gold Mining Co., Ltd., the leading gold producer in the world, again increased ore output and gold production, but average grade of ore was lower than in 1961; working cost per ounce advanced. The company milled 2.2 million tons, averaging $27.48 per ton at a cost of $11.48 per ounce. Working profit advanced $4.3 million to $42.7 million, the highest profit ever declared by a gold mine.[12]

Union Corp., Ltd., reported a substantial increase in ore output and gold production, resulting from the commencement of operations at two new mines, Bracken and Leslie, in the Evander area and from the increased tonnage milled at other mines in the Orange Free State and East Rand. The group of company mines milled 11.4 million tons of ore, yielding $8.24 per ton at a working cost of $4.65 per ton. Ore reserves increased 2.6 million to 34.8 million tons, averaging 0.32 ounce per ton ($11.20). Grootvlei Proprietary Mines on the East Rand milled a record tonnage for the seventh consecutive year, but average yield per ton and working revenue declined; working cost increased slightly over 1961. The company milled 2.7 million tons of ore, yield-

[11] Anglo American Corporation of South Africa, Ltd. 46th Annual Report. 1962, pp. 8, 19.

[12] The Consolidated Gold Fields of South Africa, Ltd. 75th Annual Report. 1962, pp. 25, 38, 43.

ing 0.20 ounce per ton ($7.04) at a cost of $4.45 per ton and reported that yearend ore reserves dropped 0.8 million tons to 10 million tons, averaging 0.22 ounce per ton across a stoping width of 50 inches. At St. Helena Gold mines in the Orange Free State, operating results for 5 years, 1958–62, showed that the quantity of ore milled, yield per ton, and working profit continued to rise; working costs declined for the second successive year. In 1962, 2.4 million tons of ore was milled, yielding 0.39 ounce ($13.65) per ton at a working cost of $5.63 per ton. Ore reserves increased by 1 million tons to 7 million tons, averaging 0.49 ounce per ton across a stoping width of 57 inches. Milling operations were begun in March at the Bracken and Leslie mines, and by the end of 1962 these mines were treating 100,000 and 90,000 tons per month, respectively. Ore reserves at Bracken were 2 million tons, averaging 0.39 ounce per ton across a stoping width of 44 inches. At Leslie, the ore reserve was 2 million tons, averaging 0.36 ounce per ton across a stoping width of 44 inches.[13]

TABLE 15.—South Africa, Republic of: Salient statistics of the gold mining industry

	1953–57 (average)	1958	1959	1960	1961 [1]	1962 [1]
Ore milled .... thousand tons..	64, 179	65. 542	70, 479	71, 259	67, 365	70, 805
Gold recovered .... thousand troy ounces..	[2] 14, 026	[3] 17, 656	[3] 20, 067	[3] 21, 386	[3] [4] 22, 395	[3] 24, 991
Gold recovered .... ounces per ton..	2. 18	. 261	. 278	. 293	. 325	. 344
Working revenue (gold) ...... thousands..	[2] $492,331	[3] $613,650	[3] $700,426	[3] $750,550	[3] $773,892	[3] $857,989
Working revenue per ton milled	7. 65	9. 21	9. 79	10. 38	11. 49	11. 56
Working cost .... thousands..	367, 102	430, 715	448, 130	464, 386	[4] 460, 068	514, 348
Working cost per ton	5. 71	6. 57	6. 35	6. 51	7. 06	7. 25
Working cost per ounce of gold	26. 21	25. 03	22. 74	22. 12	21. 63	21. 05
Total working profit from gold thousands..	125, 229	171, 797	241, 019	274, 341	297, 685	343, 641
Estimated working profit per ton from gold	1. 95	2. 64	3. 44	3. 87	[4] 4. 43	4. 85
Uranium profits .... thousands..	$59, 059	$105, 678	$76, 268	$77, 033	$67, 136	$55, 147
Dividends paid .... do....	$70, 202	$119, 199	$127, 040	$131, 528	$134, 221	$148, 676

[1] Excludes primary uranium producers.
[2] Excludes gold produced by nonmembers of Chamber of Mines for years 1953–55.
[3] Included non-Chamber of Mines Properties for 1956–62. Source: The Mining Journal (London).
[4] Revised figure.

TECHNOLOGY

A method of extracting complex gold and silver cyanides directly from cyanide solutions with a solution in kerosine of *n*-trialkylamines on an alcohol base was described by scientists from the U.S.S.R.[14] The ion-exchange method was highly selective and yielded high-purity gold and silver. One advantage of this method of extracting complex gold and silver cyanides, according to the authors, was the easier re-extraction conditions compared with known desorption methods using anion-exchange resins.

[13] Union Corporation, Ltd. Reports and Accounts for the Year Ended 31st December, 1962, pp. 24–28.
[14] Plaksin, I. N., B. N. Laskorin, and G. N. Shvirin. Liquid Extraction of Complex Gold and Silver Cyanides from Cyanide Solutions. Soviet J. Nonferrous Metals, v. 2, No. 9, 1962, pp. 19–22.

A patent[15] was issued for an electrolytic method of extracting gold from a gold-bearing solution, which consisted of moving a liquid-pervious cathode through the solution at a speed high enough to deposit an adherent metallic layer on the cathode and low enough to prevent dislodgement of the deposited gold.

Tests on the effectiveness of mechanical sorting of gold ore at the President Steyn mine in the Republic of South Africa indicated that the adoption of mechanical sorting may prove economically feasible.[16]

The principle of the mechanical sorter was based on the close correlation between uranium and gold in the ores. When a piece of ore falls past a scintillometer, its radioactivity, and consequently its gold content, is determined; this determination is used to actuate an air-blast to deflect either the ore or waste, as desired, into a separate bin.

A method of recovering free gold associated with arsenopyrite, pyrrhotite, pyrite, and graphite in a quartz and slate gangue was described.[17] The treatment combined gravity, amalgamation, and flotation, followed by cyanidation of the flotation concentrate. Overall extraction was 90 to 95 percent. The flowsheet was developed from batch and pilot tests with the required flexibility to permit initial operation as a 50-ton gravity mill and to be expanded later to 150 tons per day.

Some problems related to the design of a small gold cyanide plant were discussed, and a flowsheet that could be adapted to meet conditions best suited for the character of ore to be treated was described.[18]

Principles and procedures for valuation of large, gold-bearing placers based on drill log data, areal valuation, and application of management and experience factors were described.[19]

The general features, development, and technological aspects of the newest gold mine in South Africa, the largest in the world, were described in a series of articles.[20]

The mechanical and physical properties of gold-platinum alloys, their melting and working technology, and their resistance to oxidation and corrosion were analyzed in relation to their industrial applications.[21]

The development of a successful method of treating the complex arsenical gold ores at the Getchell mine led to reopening the mine and establishing it as the second largest straight gold producer in the United States. Fluidized-bed roasting at 1,100° F eliminated most of

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[15] Leibowitz, A. (assigned to Rand Mines Ltd. and others). Method of and Apparatus for the Electrolytic Extraction of Gold from Gold-Bearing Solution. U.S. Pat. 3,063,921, Nov. 13, 1962.

[16] Saunders, J. N. J. South Africa Inst. Min. and Met., v. 63, No. 6, January 1963, pp. 260–261.

[17] Deco Trefoil. Gold Recovery By Gravity, Amalgamation, Flotation, Cyanidation. V. 26, No. 4, November–December 1962, pp. 15–16.

[18] Deco Trefoil. 25-Ton Per Day Counter-Current, Cyanide Plant. V. 26, No. 1, January–February 1962, pp. 15–16.

[19] Daily, A. Valuation of Large, Gold-Bearing Placers. Eng. and Min. J., v. 163, No. 7, pp. 80–88.

[20] Waspe, L. A. Western Deep Levels 1, 2, 3. Min. Magazine (London), v. 107, No. 4, October 1962, pp. 201–214; v. 107, No. 5, November 1962, pp. 274–282; v. 107, No. 6, December 1962, pp. 333–338.

[21] Darling, A. S. Gold-Platinum Alloys. Platinum Metals Rev., v. 6, No. 3, July 1962, pp. 106–111.

the arsenic, but close control of the reactor atmosphere had to be maintained.[22]

Submerged-arc electric furnaces, which had replaced reverberatory coal-fired furnaces for smelting gold at most mines of the Anglo American Corporation Group, increased efficiency, economy, and safety on gold smelting operations.[23]

Causes of rock bursts at three Kolar Gold Mines in India from 1956 to 1960 were analyzed with particular reference to rock inhomogeneity, triggering by blasting, and sequences of bursts. Characteristics of the rock bursts at each of the mines were distinguished. Closure of steel sets, vertical displacement, strain in the footwall, stope closure, and pressure on stope supports were measured, and readings correlated. Rock movement was generally similar to subsidence at coal mines, except that it occurred along a vertical plane.[24]

Gold-plated quartz crystals were developed by Bliley Electric Co. for frequency control in communications equipment.[25]

The Canadian Department of Mines and Technical Surveys research staff, in cooperation with industry, developed a test for measuring the dissolving power of a cyanide solution for gold, based on the time required for dissolving a given quantity of gold leaf.

The use of this test in various gold mills has shown that the rate at which cyanide solutions attack gold varies widely depending principally on the impurities present in the solution. The test permits operating the cyanide circuit at optimum alkalinity and cyanide concentration, conditions essential for maximum efficiency in gold extraction.[26]

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[22] Huttl, J. B. Getchell Mine Resumes Gold Production. Eng. and Min. J., v. 164, January 1963, pp. 70–73.

[23] South African Mining & Engineering Journal (Johannesburg, Republic of South Africa). Development of Electric Arc Furnaces for Gold Smelting. V. 73, pt. 2, No. 3643, Nov. 30, 1962, pp. 1245–1246, 1248.

[24] Taylor, J. T. M. Research on Ground Control and Rockbursts on the Kolar Gold Field, India. Bull. Inst. Min. and Met. (London), v. 72, No. 675, pt. 5, February 1963, pp. 317–338.

[25] American Metal Market. Magnetic Bearing, Gold-Plated Crystals, Chart Printers Debut at Electronic Show. V. 70, No. 58, Mar. 26, 1963, pp. 1–2.

[26] Mines Memo 1961, Ann. Review of the Work of the Mines Branch, Dept. of Mines and Tech. Surv., 1963, Ottawa. P. 13.

Graphite

By Harold J. Drake [1] and Betty Ann Brett [2]

DEMAND for natural graphite in the United States rose in 1962 to 44,400 tons, nearly 9,000 more than in 1961. One domestic producing firm, Graphite Corporation of America, closed its mine and mill at Chester Spring, Pa.

Leading free world producers were Austria, the Malagasy Republic, Mexico, and the Republic of Korea. The principal suppliers of graphite to the United States were Ceylon, the Malagasy Republic, Mexico, Norway, and West Germany.

TABLE 1.—Salient graphite statistics

	1953-57 (average)	1958	1959	1960	1961	1962
United States:						
Consumption .... short tons..	38, 900	28, 800	40, 200	37, 300	35, 700	44, 400
Value .... thousands..	$5, 389	$3, 972	$5, 395	$4, 773	$4, 651	$5, 648
Imports for consumption..short tons..	46, 100	27, 100	37, 000	48, 300	29, 700	39, 500
Value .... thousands..	$2, 436	$1, 203	$1, 527	$1, 755	$1, 332	$1, 783
Exports .... short tons..	1, 300	1, 200	1, 400	1, 900	1, 600	1, 200
Value .... thousands..	$178	$193	$222	$289	$257	$223
World: Production .... short tons..	275, 000	350, 000	410, 000	465, 000	[1] 440, 000	570, 000

[1] Revised figure.

DOMESTIC PRODUCTION

Crystalline flake graphite was produced by Southwestern Graphite Co. at Burnet, Tex.

Manufactured (artificial) graphite products were produced by National Carbon Co., Division of Union Carbide Corp., Niagara Falls, N.Y., Clarksburg, W. Va., and Columbia, Tenn.; by Great Lakes Carbon Corp., Niagara Falls, N.Y., Morganton, N.C., and Antelope Valley, Calif.; by International Graphite & Electrode Division, Speer Carbon Co., St. Marys, Pa., and Niagara Falls, N.Y.; and by Stackpole Carbon Co., St. Marys, Pa. The Dow Chemical Co. produced graphite anodes for its own use at Midland, Mich.

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

CONSUMPTION AND USES

Domestic consumption of all types of natural graphite in 1962 increased 24 percent. Consumption of amorphous graphite rose 30 percent, and crystalline flake use increased 2 percent. Most of the additional tonnage of amorphous graphite came from Mexico although consumption of Ceylon amorphous graphite rose 34 percent.

Almost every end use showed tonnage increases. Use in crucibles, foundry facings, lubricants, pencils, refractories, and steelmaking accounted for 85 percent of consumption. The 37,650 short tons consumed in these applications in 1962 was greater than the entire consumption of graphite in 1961.

TABLE 2.—Consumption of natural graphite in the United States

Year	Short tons	Value	Year	Short tons	Value
1953-57 (average)	38,919	$5,388,700	1960	37,289	$4,773,400
1958	28,823	3,971,800	1961	35,652	4,651,200
1959	40,239	5,394,800	1962	44,383	5,648,000

TABLE 3.—Consumption of natural graphite in the United States in 1962, by uses

Use	Crystalline flake		Ceylon amorphous		Other amorphous [1]		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Batteries	103	$34,856			1,049	$118,297	1,152	$153,153
Bearings	93	37,637	106	$45,287	30	6,000	229	88,924
Brake linings	361	94,553	236	61,536	836	131,489	1,433	287,578
Carbon brushes	156	62,632	323	178,687	561	72,297	1,040	313,616
Crucibles, retorts, stoppers, sleeves, and nozzles	[2] 3,412	[2] 558,985					3,412	558,985
Foundry facings	184	37,070	474	96,927	14,722	1,077,902	15,380	1,211,899
Lubricants	1,505	325,581	2,042	360,930	2,690	315,070	6,237	1,001,581
Packings	279	130,259	29	15,033	269	43,785	577	189,077
Paints and polishes					495	39,207	495	39,207
Pencils	645	177,141	678	199,343	535	71,047	1,858	447,531
Refractories					4,103	421,453	4,103	421,453
Rubber	61	29,507			81	10,914	142	40,421
Steelmaking	255	42,489			6,405	517,849	6,660	560,338
Other [3]	420	135,735	151	68,203	1,094	130,312	1,665	334,250
Total	7,474	1,666,445	4,039	1,025,946	32,870	2,955,622	44,383	5,648,013

[1] Includes small quantities of crystalline flake and Ceylon amorphous, and mixtures of natural and manufactured graphite.
[2] Includes some amorphous.
[3] Includes adhesives, carbon resistors, catalyst manufacture, chemical equipment and processes, electronic products, gray iron castings, powdered-metal parts, small packages, specialties, and other uses not specified.

PRICES

Published prices for graphite merely indicate the range of prices; actual prices are negotiated between buyer and seller on the basis of a wide range of specifications.

Prices quoted per pound of crystalline graphite by Oil, Paint and Drug Reporter were as follows: 88 to 90 percent carbon, 19 to 21.5 cents; 90 to 92 percent carbon, 21 to 24.5 cents; 95 to 97 percent carbon, 29 to 31.5 cents; and No. 1 and 2 flakes, 90 to 95 percent carbon, 29 to 31 cents. Amorphous graphite prices per pound are shown by this publication as 6 to 9.5 cents.

Prices shown by E&MJ Metal and Mineral Markets for flake and crystalline graphite, f.o.b. source, bags, per short ton were: Malagasy Republic, $81 to $181; Norway, $73 to $127; and West Germany, $103 to $610. Ceylon graphite was listed at $85 to $223 per short ton. Amorphous graphite was quoted as follows: Mexico (bulk) per short ton, $15 to $18; Republic of Korea (bulk) per short ton, $14; and Hong Kong (bags) per short ton, $19.

FOREIGN TRADE [3]

Imports of natural graphite for domestic consumption rose 18 percent in 1962 because Ceylon, the Malagasy Republic, Mexico, Norway, and West Germany recorded substantially increased exports to the United States. The tonnage of crystalline flake imported from the Malagasy Republic jumped 32 percent. Mexico shipped to the United States 4,439 short tons of artificial graphite valued at slightly over $19 per ton.

Exports of natural graphite decreased for the second consecutive year. U.S. exports in 1961 of carbon and graphite electrodes for electric furnace and electrolytic use gained 25 percent over the 1960 figure.[4] Over 40 percent of the electrodes went to Sweden, 15 percent to Brazil, and 7 percent to Italy. Other countries getting more electrodes in 1961 were India, Indonesia, Japan, Lebanon, Peru, and West Germany.

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

[4] Foreign Commerce Weekly. U.S. Exports of Carbon, Graphite Electrodes Up. V. 67, No. 23, June 1962, p. 1023.

TABLE 4.—U.S. imports for consumption of natural and artificial graphite, by countries

Year and country	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
1953-57 (average)	7,894	$1,092,131	229	$37,286	37,789	[1] $1,296,892	164	[1] $9,206	46,076	[1] $2,435,515
1958	2,905	358,880	101	21,890	24,036	819,211	25	3,122	27,067	1,203,103
1959	5,208	457,313	94	23,968	31,741	1,043,977	5	1,620	37,048	1,526,878
1960	3,753	340,753	121	36,630	44,265	1,321,137	185	56,952	48,324	1,755,472
1961:										
North America:										
Mexico	--	--	--	--	19,408	381,029	--	--	19,408	381,029
Europe:										
Austria	--	--	--	--	16	905	--	--	16	905
Denmark	--	--	--	--	55	4,134	--	--	55	4,134
France	45	17,272	--	--	--	--	--	--	45	17,272
Germany, West	160	30,515	55	17,138	640	69,618	50	14,813	905	132,084
Norway	28	3,969	--	--	1,435	113,569	--	--	1,463	117,538
Switzerland	--	--	--	--	--	--	20	7,974	20	7,974
Asia:										
Ceylon	--	--	--	--	2,393	264,281	--	--	2,393	264,281
Hong Kong	--	--	--	--	[2] 1,299	[2] 29,921	([3])	([3])	1,299	29,921
Africa:										
British East Africa	267	28,948	--	--	--	--	--	--	267	28,948
Malagasy Republic	3,877	348,089	--	--	--	--	--	--	3,877	348,089
Total	4,377	428,793	55	17,138	[2] 25,246	[2] 863,457	[2] 70	[2] 22,787	29,748	1,332,175
1962:										
North America:										
Canada	--	--	--	--	58	1,142	--	--	58	1,142
Mexico	--	--	--	--	22,519	431,806	4,439	86,462	26,958	518,268
Europe:										
Austria	--	--	--	--	15	585	36	1,433	51	2,018
France	25	10,326	--	--	--	--	--	--	25	10,326
Germany, West	215	40,138	181	55,769	1,556	164,245	5	875	1,957	261,027
Norway	--	--	--	--	2,106	170,763	--	--	2,106	170,763
United Kingdom	--	--	--	--	([4])	134	28	2,478	28	2,612
Asia:										
Ceylon	--	--	--	--	2,811	327,849	17	1,512	2,828	329,361
Hong Kong	--	--	--	--	129	2,498	114	2,514	243	5,012
Korea, Republic of	--	--	--	--	56	1,050	--	--	56	1,050
Turkey	110	10,710	--	--	--	--	--	--	110	10,710
Africa: Malagasy Republic	5,108	471,096	--	--	--	--	--	--	5,108	471,096
Total	5,458	532,270	181	55,769	29,250	1,100,072	4,639	95,274	39,528	1,783,385

[1] Owing to changes in tabulating procedures by the Bureau of the Census, some data known to be not comparable with other years.
[2] Revised figure.
[3] Revised to none.
[4] Less than 1 ton.

Source: Bureau of the Census.

TABLE 5.—U.S. exports of natural graphite, by countries

Year and destination	Amorphous		Crystalline flake, lump, or chip		Natural, n.e.c.[1]		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1961:								
North America:								
Canada	544	$68,488	26	$11,706	4	$1,460	574	$81,654
Costa Rica			1	258			1	258
Dominican Republic			1	208			1	208
El Salvador			7	1,335			7	1,335
Guatemala	1	202					1	202
Mexico	41	4,753	25	11,325	35	8,964	101	25,042
South America:								
Argentina					10	4,292	10	4,292
Bolivia					4	678	4	678
Brazil	220	32,127			5	2,216	225	34,343
Colombia	7	1,249	14	3,389			21	4,638
Ecuador			2	410			2	410
Peru			(2)	216			(2)	216
Venezuela	7	1,124	6	2,250	7	1,420	20	4,794
Europe:								
Czechoslovakia	11	2,020					11	2,020
France	32	6,085			26	6,265	58	12,350
Germany, West	9	1,358					9	1,358
Netherlands					1	620	1	620
Sweden	2	935					2	935
Switzerland					1	540	1	540
United Kingdom	435	63,684			11	1,164	446	64,848
Asia:								
India	6	952	2	888	20	3,830	28	5,670
Korea, Republic of			(2)	125			(2)	125
Pakistan					4	828	4	828
Philippines			7	2,090	11	4,393	18	6,483
Saudi Arabia			(2)	228			(2)	228
Oceania: Australia	13	2,886					13	2,886
Total	1,328	185,863	91	34,428	139	36,670	1,558	256,961
1962:								
North America:								
Canada	325	44,302	57	17,167	6	2,280	388	63,749
Dominican Republic			2	432			2	432
Honduras			(2)	100			(2)	100
Mexico			19	11,081	10	3,940	29	15,021
South America:								
Argentina					5	2,117	5	2,117
Brazil	90	14,188			2	928	92	15,116
Chile	2	476			2	294	4	770
Colombia			26	6,058	5	900	31	6,958
Ecuador			2	410			2	410
Peru					(2)	202	(2)	202
Venezuela	7	969	12	1,930	19	3,872	38	6,771
Europe:								
Denmark					11	2,061	11	2,061
France	38	7,378	(2)	608	136	20,241	174	28,227
Germany, West					1	464	1	464
Italy					3	1,300	3	1,300
Netherlands					1	618	1	618
Sweden					6	1,295	6	1,295
Switzerland					1	770	1	770
United Kingdom	264	38,620			26	4,925	290	43,545
Asia:								
India	8	1,465	1	657			9	2,122
Pakistan					9	1,720	9	1,720
Philippines	12	2,253	3	2,502	13	3,998	28	8,753
Viet-Nam					4	994	4	994
Africa: South Africa, Republic of					3	622	3	622
Oceania: Australia			5	1,319	23	17,422	28	18,741
Total	746	109,651	127	42,264	286	70,963	1,159	222,878

[1] Not elsewhere classified.
[2] Less than 1 ton.

Source: Bureau of the Census.

WORLD REVIEW

World production of natural graphite was 30 percent greater than in 1961.

Austria, Mexico, and the Republic of Korea recorded substantial increases, reversing declines reported in 1961. The Republic of Korea more than doubled its production, while production in Mexico rose 61 percent.

TABLE 6.—World production of natural graphite by countries [1] [2]
(Short tons)

Country [1]	1953-57 (average)	1958	1959	1960	1961	1962
North America:						
Canada	1,186	----	----	----	1	----
Mexico	29,676	21,564	30,684	37,826	19,846	31,993
United States	[3] 6,281	(4)	(4)	(4)	(4)	(4)
South America:						
Argentina	251	525	554	[5] 550	[5] 550	[5] 550
Brazil	796	1,323	1,334	1,433	1,599	[5] 1,500
Europe:						
Austria	19,292	23,318	68,444	97,043	89,255	98,416
Germany, West	11,123	12,021	12,361	12,786	13,349	[5] 13,500
Italy	3,754	4,393	3,457	4,098	4,484	3,703
Norway	5,009	4,927	5,396	6,437	6,283	[5] 6,300
Spain	357	227	457	288	303	[5] 300
Sweden	314	593	----	----	----	----
U.S.S.R. [5]	41,888	50,000	50,000	50,000	55,000	60,000
Asia:						
Ceylon (exports)	9,458	6,342	8,816	10,107	10,016	9,665
China	(6)	[5] 35,000	[5] 45,000	[5] 45,000	[5] 45,000	[5] 45,000
Hong Kong	2,088	3,680	3,676	4,255	1,865	902
India	864	(6)	(6)	(6)	(6)	(6)
Japan	4,433	3,817	4,453	4,979	3,836	3,812
Korea:						
North	14,625	[5] 45,000	[5] 55,000	[5] 55,000	[5] 55,000	[5] 55,000
Republic of	73,211	103,806	91,045	101,777	98,892	204,032
Taiwan	1,009	915	621	551	882	[5] 900
Africa:						
Kenya	494	738	635	1,113	----	----
Malagasy Republic	16,002	13,427	12,614	15,923	16,473	[5] 16,500
Morocco	75	----	132	----	----	----
South Africa, Republic of	1,450	875	617	894	963	1,308
South-West Africa	225	----	----	----	----	----
Tanganyika	10	----	28	26	----	----
Oceania: Australia	26	----	----	----	----	----
World total (estimate) [1] [2]	275,000	350,000	410,000	465,000	440,000	570,000

[1] Graphite has been produced in Czechoslovakia, but production data are not available; estimates by senior author of chapter included in total.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Data for 1953.
[4] Figure withheld to avoid disclosing individual company confidential data, included in world total.
[5] Estimate.
[6] Data not available; estimate by senior author of chapter included in total.

Compiled by Liela S. Price, Division of Foreign Activities.

Canada.—A small quantity of high-purity natural graphite for use in lubricants came in 1961 from Laurentide Mineral Products Corp. at Labelle, Quebec.[5] This was the first production of natural graphite in Canada since 1954.

Canada Graphite Mines, Ltd., was reported to be exploring a graphite deposit just north of Bancroft, Ontario.[6] Great Lakes Carbon

[5] Reeves, J. E. Graphite, Preliminary Review. Canada Dept. Mines and Tech. Surveys (Ottawa), June 1962, 5 pp.
[6] Northern Miner (Toronto). Canada Graphite Program Launched on Bancroft Group. V. 48, No. 18, July 26, 1962, p. 3.
Precambrian-Mining in Canada (Winnipeg). Canada Graphite To Produce Pure Natural Graphite in Ontario. V. 35, No. 9, September 1962, p. 36.

Corp., New York, N.Y., planned production, through its Canadian subsidiary, of graphite electrodes and specialties at a plant located at Berthierville, Quebec.

India.—Discovery of a large deposit of graphite in Uri Tahsil was reported.[7] The deposit was estimated to contain over 14 million tons of graphite with an average carbon content of 10.06 percent.

TABLE 7.—Ceylon: Exports of graphite by countries [1]
(Short tons)

Destination	1961	1962	Destination	1961	1962
North America:			Asia:		
Canada	46	31	India	492	555
United States	2,218	2,615	Japan	2,917	2,056
Europe:			Pakistan	108	239
Belgium	45	37	Philippines	56	------
Czechoslovakia	242	137	Singapore	7	29
France	196	399	Thialand	22	28
Germany, West	55	74	Oceania: Australia	355	647
Netherlands	45	45	Other countries	13	17
Poland	14	27			
United Kingdom	3,184	2,729	Total	10,015	9,665

[1] This table incorporates some revisions.

Compiled from Ceylon Customs Returns by Bertha M. Duggan, Division of Foreign Activities.

TABLE 8.—Ceylon: Exports of graphite to the United States, by grades, in 1962 [1]

Grade	Short tons	Percent of total	Value per ton
97 percent carbon or higher	924	42	$140.00
90 to 96 percent carbon	1,000	45	104.37
Less than 90 percent carbon	280	13	90.00
Total	2,204	100	117.48

[1] U.S. Embassy, Colombo, Ceylon. State Department Dispatch A-80, July 31, 1962, pp. 1-3; State Department Dispatch A-437, Jan. 15, 1963, pp. 1-2.

Italy.—Data on production and value, types of products, imports sources, and export markets were given for carbon and graphite products in Italy in 1959, 1960, and 1961.[8]

Japan.—A Japanese electrode manufacturer was reported to be negotiating with Italian interests to establish a plant of 11,000 tons annual capacity in Italy for the production of manufactured graphite electrodes.[9]

Korea, Republic of.—Production of natural graphite in 1961 amounted to 98,900 tons, which included 1,349 tons of crystalline graphite with a carbon content of 80 percent.[10] The value of this production was reported to be slightly over $8.50 per ton. Exports amounted to 63,327 tons, 97 percent of which went to Japan. Total output in 1962 was 204,000 tons.

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[7] Mining Journal (London). Graphite in Kashmir. V. 258, No. 6604, Mar. 16, 1962, p. 264.

[8] Foreign Commerce Weekly. Italian Carbon, Graphite Output Trade in Uptrend. V. 67, No. 7, Feb. 12, 1962, p. 273.

[9] Chemical Trade Journal and Chemical Engineer (London). Japanese Synthetic Graphite. V. 151, No. 3924, Aug. 17, 1962, p. 330.

[10] Bureau of Mines. Mineral Trade Notes. V. 55, No. 4, October 1962, p. 15.

Malagasy Republic.—Graphite was mined in 1961 near Tamatave by six French companies, and most of the product was exported to the United States, the United Kingdom, France, and West Germany.[11] Some graphite was produced at Moramanga, about 60 miles east of Tananarive. Unexploited deposits occur in the central plateau between Tananarive and Fianarantsoa. The ratio of flake to fine graphite produced in 1960 was 49:51.

TABLE 9.—Malagasy Republic: Exports of graphite, by countries
(Short tons)

Destination	1960	1961	Destination	1960	1961
North America:			Europe—Cntinued		
Canada	--------	66	Rumanioa	38	--------
United States	3,638	3,887	Spain	14	121
Europe:			United Kingdom	3,947	3,874
Belgium-Luxembourg	53	29	Africa: South Africa, Republic of	24	--------
France	3,663	3,375	Asia: Japan	368	709
Germany, West	4,156	3,135	Oceania: Australia	106	55
Italy	1,372	1,076	Other countries	14	28
Netherlands	39	55			
Poland	11	3	Total	17,443	16,413

Compiled from Customs Returns of the Malagasy Republic by Bertha M. Duggan, Division of Foreign Activities.

Norway.—Production of Norwegian graphite was expected to reach 7,500 tons in 1963. Most of the graphite produced in 1962 was sold to the United States and West Germany.[12]

South Africa, Republic of.—Principal producers of natural graphite in 1961 were Silica (Pty.), Ltd., Johannesburg, and Transvaal Graphite Co. (Pty.), Ltd., Cleveland, Transvaal.[13] Most of the graphite produced was sold locally.

U.S.S.R.—A large deposit of graphite was reported in Buryat near the Trans-Siberian Railroad.[14] Reserves were estimated to be 150 million tons averaging 4 to 5 percent graphite.

TECHNOLOGY

Properties and design and fabrication of carbon and graphite materials, such as conventional carbon and graphite, recrystallized and oriented graphites, graphite textiles, and carbon materials reinforced with carbon and graphite felt and cloth, were reviewed.[15]

A technique was evolved that produced a scratch-free, highly polished prism plane surface on pyrolytic graphite in a relatively short time.[16] Also, another method for obtaining polished surfaces rapidly and easily was described.[17]

[11] Bureau of Mines. Mineral Trade Notes. V. 55, No. 1, July 1962, pp. 20–21.
[12] Chemical Trade Journal and Chemical Engineer (London). Norwegian Graphite. V. 151, No. 3942, Dec. 21, 1962, p. 1279.
[13] Bureau of Mines. Mineral Trade Notes. V. 55, No. 2, August 1962, p. 31.
[14] Bureau of Mines. Mineral Trade Notes. V. 55, No. 6, December 1962, p. 11.
Engineering and Mining Journal. This Month in Mining in Europe. V. 163, No. 11, November 1962, p. 150.
[15] Ford, C. E., R. M. Bushong, and R. C. Stroup. The New Graphites—Versatile Engineering Materials. Metal Prog., v. 82, No. 6, December 1962, pp. 101–107.
Riley, Malcolm W. The New World of Carbon and Graphite. Mat. in Design Eng., v. 56, No. 3, September 1962, pp. 113–128.
[16] Coons, William C. A Rapid Method for Polishing Pyrolytic Graphite. Metal Prog., v. 81, No. 6, June 1962, pp. 83–85.
[17] Brassard, Theresa V., and Andrew S. Holik. Preparing Various Graphites for Metallographic Examination. Metal Prog., v. 81, No. 5, May 1962, pp. 109–111.

The effect of microstructures on properties of pyrolytic graphite was discussed [18] and the oxidation of pyrolytic graphite under varying conditions was described.[19]

Pyrolytic graphite was codeposited with other elements, principally boron, to form alloys having a greater high-temperature strength than the graphite alone.[20]

Pyrolytic graphite was produced in the form of foam, which was compressible and easily cut and could be made in a variety of densities.[21]

Boron silicide and other materials were used experimentally as new coatings for conventional graphites.[22] Oxidation of the graphite at elevated temperatures was inhibited considerably by the coatings but not eliminated.

Carbon-containing gases were used to sheath graphite with an impermeable layer of carbon, making the graphite virtually impervious to gases and liquids.[23] The gas was made to penetrate the graphite before being thermally cracked to deposit carbon in pores and on the surface as a coating.

Graphite dies were used in a unique hot-pressing technique to form tungsten-graphite parts,[24] and liquid-phase sintering of preformed powder compacts gave graphite-rich, metal-bonded materials for anti-friction, electrical, and refractory uses.[25]

A study of the frictional behavior of various solid lubricants, including graphite, was made,[26] and synthetic graphite crystals were developed to determine the suitability of graphite as a lubricant for outer space vehicles.[27]

New, more impervious graphite was developed [28] along with special grades for use in electrodes,[29] and jigs and fixtures.[30]

Graphite was used as mold material in the centrifugal casting of intricate parts.[31] The high cost of cast iron or steel prototype molds led to the use of graphite, which can readily be altered to suit design variations.

A study of a number of synthetic graphites indicated that the mean linear coefficient of thermal expansion gradually increased with tem-

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[18] Diefendorf, R. J., and E. R. Stover. Pyrolytic Graphites . . . How Structure Effects Properties. Metal Prog., v. 81, No. 5, May 1962, pp. 103–108.

[19] Levy, Milton. Oxidation of Pyrolytic Graphite in Air Between 1,250° and 1,850° F. I&EC Product Res. and Devel., v. 1, No. 1, March 1962, pp. 19–23.

[20] Technical Survey. Aviation, Missiles, and Rockets. V. 17, No. 9, March 1961, p. 146.

[21] Metal Progress. Lightweight, Anisotropic Graphite. V. 82, No. 5, November 1962, p. 21–D.

[22] Colton, Ervin. How New Ceramic Materials Coat Graphite. Ceram. Ind., v. 78, No. 6, June 1962, pp. 62–64.

[23] Rhodesian Mining and Engineering. New Uses for Graphite Could Boost Market Demand. V. 26, No. 13, December 1961, p. 37.

[24] Judge, John F. W–C Parts Formed by Hot Pressing. Missiles and Rockets, v. 10, No. 11, March 1962, pp. 26–27.

[25] Humenik, Michael, Jr., D. W. Hall, and R. L. Van Alsten. Graphite-Base Cermets. Metal Prog., v. 81, No. 4, April 1962, pp. 101–108, 132.

[26] Reynolds, J. H., R. F. Smart, and D. Hall. Graphite Lubrication Developments. Metal Ind. (London), v. 101, No. 16, October 1962, pp. 143–145.

[27] Science News Letter. Synthetic Graphite Made for Space Lubrication. V. 81, No. 1, January 1962, p. 9.

[28] Revilock, Joseph F., and Robert P. Stambaugh. Lower Permeability Graphite. Chem. Eng., v. 69, No. 13, June 1962, pp. 148, 150, 152.

[29] Electronic News. Graphite Carbon Materials Offered for Electrode Use. V. 7, No. 335, August 1962. p. 42.

[30] Electronic News. Small Grain Ultra Pure Graphite Set. V. 7, No. 337, September 1962, p. 46.

[31] Foundry. Centrifugal Casting in Graphite Molds. V. 90, No. 2, February 1962, pp. 63–65.

perature,[32] and a study of natural graphite indicated that surface or lattice imperfections may be the loci where oxidation begins.[33]

Fibrous celluloses were carbonized for high-temperature use as a reinforcing material in structural and ablative composites.[34]

Graphite slabs 9 feet wide, 3 feet thick, and 20 feet long or graphite shapes over 16 feet in diameter can be produced by a forming press expected to be in operation at the end of 1962.[35] The press, owned by National Carbon Co., Division of Union Carbide Corp., was to be installed in Niagara Falls, N.Y.

Graphite was an ingredient of a compound used for preventing thread seizure in jet engines.[36] Artificial graphite bodies containing metallic carbide impurities were purified using chlorinated hydrocarbons.[37] The impurities were converted to chlorides and volatilized.

Artificial graphite articles were impregnated with sodium fluoride[38] and a method was developed for making carbide-bonded graphite bodies.[39]

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32 Allen, Robert D. Thermal Expansion of Synthetic Graphites Between 80° and 2,000° F. Am. Ceram. Soc., v. 41, No. 7, July 1962, pp. 460–466.

33 Hedley, J. A., and D. R. Ashworth. Imperfections in Natural Graphite. J. Nuclear Mat., v. 4, No. 1, May–June 1961, pp. 70–78.

34 Schmidt, D. L., and W. C. Jones. Carbon-Base Fiber Reinforced Plastics. Chem. Eng. Prog., v. 58, No. 10, October 1962, pp. 42–50.

35 Waste Trade Journal. Worlds Largest Graphite Press Purchased From Luria Bros. V. 12, No. 16, January 1962, p. 38.

36 Pfefferkorn, O. T. (assigned to North American Aviation, Inc.). Anti-Seize and Sealing Composition and Method. U.S. Pat. 3,041,277, June 26, 1962.

37 Best, Bushnell (assigned to Great Lakes Carbon Corp., New York, N.Y.). Purification of Graphite With Chlorinated Hydro-carbons. U.S. Pat. 3,035,901, Apr. 2, 1959.

38 Kertesz, Francois, and Henry J. Buttram (assigned to U.S. Atomic Energy Commission). Graphite Impregnation Method. U.S. Pat. 3,031,342, Oct. 27, 1959.

39 Cline, Carl F. (assigned to The Carborundum Co., Niagara Falls, N.Y.). Carbide-Bonded Graphite Bodies and Method of Making the Same. U.S. Pat. 3,007,805, Aug. 22, 1957.

Gypsum

By William V. Kuster[1] and Jewel B. Mallory[2]

OUTPUT of crude gypsum exceeded that of 1961 by 5 percent and value increased 4 percent over that of 1961. Imports of gypsum increased 9 percent over those in 1961. The value of gypsum products sold set a new record.

TABLE 1.—Salient gypsum statistics

(Thousand short tons and thousand dollars)

	1953–57 (average)	1958	1959	1960	1961	1962
United States:						
Active establishments [1]	87	85	93	96	98	102
Crude: [2]						
Mined	9,497	9,600	10,900	9,825	9,500	9,969
Value	$29,693	$32,495	$39,231	$35,690	[3] $34,996	$36,343
Imports for consumption	3,842	4,047	6,132	5,301	4,967	5,421
Calcined:						
Produced	8,008	8,122	9,268	8,591	8,246	8,819
Value	$81,241	$91,402	$111,740	$120,984	[3] $118,145	$127,436
Products sold (value)	$291,855	$329,070	$388,335	$361,190	$358,811	$392,300
Gypsum and gypsum products:						
Imports for consumption (value)	$6,900	$7,864	$13,196	$10,426	$10,306	$11,912
Exports (value)	$1,501	$2,465	$1,296	$1,293	$1,299	$1,302
World: Production	33,990	[3] 41,670	[3] 47,400	[3] 46,560	[3] 48,320	49,965

[1] Each mine, calcining plant, or combination mine and plant is counted as 1 establishment.
[2] Excludes byproduct gypsum.
[3] Revised figure.

DOMESTIC PRODUCTION

Crude.—Domestic gypsum output was over 9.9 million short tons, compared with 9.5 million tons in 1961. The production rate increased in every quarter of 1962 over the corresponding quarter of 1961, the greatest increase occurred in the second quarter. Three-fourths of the crude gypsum mined in Iowa and Texas and one-third of that mined in Michigan was calcined in those States. More than half of the California output was sold uncalcined for agricultural purposes. Seventy mines were operated; 54 open pit and 16 underground. Eighty-four percent of the total output came from 39 mines operated by companies having calcining equipment.

Calcined.—Calcined gypsum was produced from domestic and imported ores by 68 plants that had 222 kettles and 62 other pieces of calcining equipment. The 8.8 million short tons of calcined gyp-

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

sum, valued at $127 million, produced in 1962, was 7 percent more than the 1961 output.

Oil, natural gas, and coal were the fuels used to calcine gypsum.

TABLE 2.—Crude gypsum mined in the United States, by States

(Thousand short tons and thousand dollars)

State	1961			1962		
	Active mines	Quantity	Value	Active mines	Quantity	Value
Arkansas	1	167	$531	1	83	$261
California	12	1,574	[1] 3,733	11	1,747	4,113
Colorado	4	85	320	5	108	383
Iowa	5	1,239	5,276	5	1,256	5,318
Michigan	4	1,295	5,095	5	1,278	4,791
Nevada	3	729	2,625	3	817	2,952
New Mexico	3	105	386	3	151	564
New York	5	663	3,441	5	601	3,122
Oklahoma	(2)	(2)	(2)	7	509	1,668
South Dakota	1	22	89	1	23	93
Texas	7	1,074	[1] 3,832	7	1,120	3,956
Other States [3]	24	2,547	9,668	17	2,276	9,122
Total	69	9,500	[1] 34,996	70	9,969	36,343

[1] Revised figure.
[2] Included with "Other States."
[3] Includes the following States to avoid disclosing individual company confidential data: Louisiana, Virginia, and Washington (1961), 1 mine each; Indiana, Kansas, Montana, Ohio, Utah, and Wyoming, 2 mines each; Arizona, 3 mines; and Oklahoma (1961), 6 mines.

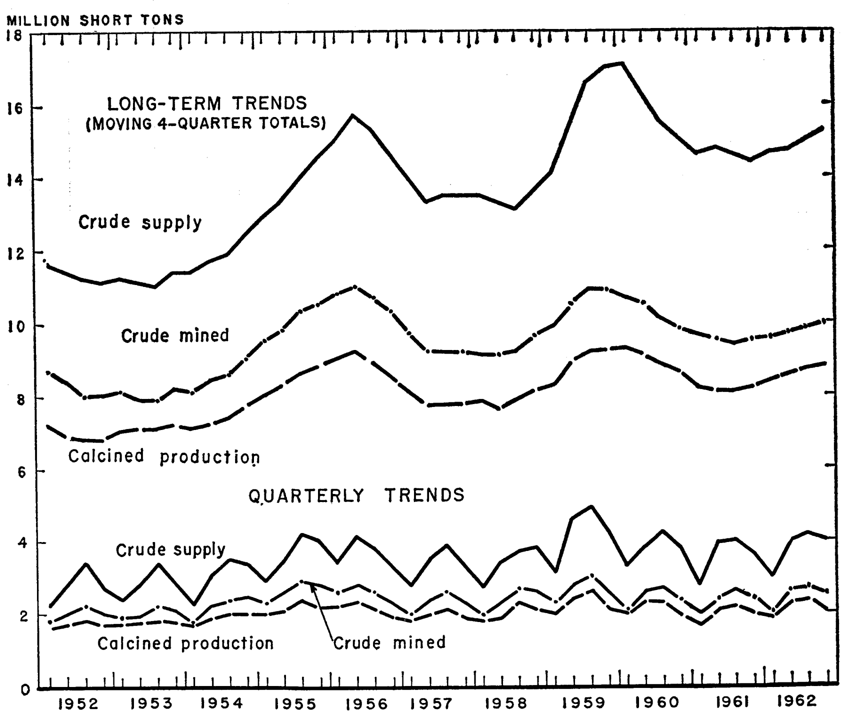

FIGURE 1.—Trends of new crude supply, domestic crude mined, and production of calcined gypsum, 1952–62, by quarters.

TABLE 3.—Calcined gypsum produced in the United States, by States

(Thousand short tons and thousand dollars)

State	1961					1962				
	Active plants	Quantity	Value	Calcining equipment		Active plants	Quantity	Value	Calcining equipment	
				Kettles	Other [1]				Kettles	Other [1]
California	6	789	$7,514	18	12	6	843	$8,002	18	12
Iowa	5	797	11,471	23	4	5	845	12,704	23	4
Louisiana	(2)	(2)	(2)	(2)	(2)	3	229	4,084	6	1
Michigan	4	382	5,887	18	1	4	359	5,151	14	1
New York	7	1,173	17,132	24	6	7	1,153	17,389	24	6
Ohio	3	287	4,221	9	1	3	296	4,573	9	1
Texas	6	756	[3] 11,936	29		6	821	13,135	29	
Other States [4]	34	4,062	59,984	100	37	34	4,273	62,398	99	37
Total	65	8,246	[3] 118,145	221	61	68	8,819	127,436	222	62

[1] Includes rotary and beehive kilns, grinding-calcining units, Holo-Flites, and Hydrocal cylinders.
[2] Figure withheld to avoid disclosing individual company confidential data; included with "Other States."
[3] Revised figure.
[4] Comprises States and number of plants as follows: Arizona, 1; Colorado, 2; Connecticut, 1; Delaware (1962) 1; Florida (1961) 1, (1962) 2; Georgia, 2; Illinois, 1; Indiana, 3; Kansas, 2; Louisiana (1961) 3; Maryland (1961) 1, (1962) 2; Massachusetts, 1; Montana, 1; Nevada, 2; New Hampshire, 1; New Jersey, 2; New Mexico, 2; Oklahoma, 1; Pennsylvania, 1; Utah, 2; Virginia, 2; Washington, 1; and Wyoming, 1.

Mine and Products-Plant Development.—Bestwall Gypsum Co. put on stream a new calcining and wallboard plant at Wilmington, Del., in January. The plant was located on the Marine Terminal and was to operate wholly on 200,000 tons of ore per year imported from Nova Scotia and the Dominican Republic.

Southeastern Gypsum Co., Inc., began producing agricultural gypsum at its Hartford, Ala., site in April. The gypsum was marketed around Hartford in an area of roughly 100 miles.

National Gypsum Co. budgeted capital expenditures of about $20 million, an increase from $17 million in 1961. The addition at the Raritan, N.J., plant manufactured polyurethane foam for insulation purposes, and the addition at the Shoals, Ind., plant manufactured the company's new partition panels. The new multimillion-dollar gypsum-products plant at Tampa, Fla., was put on stream in August. Facilities at the Mobile, Ala., plant were expanded, and production there increased 15 percent.

The Flintkote Co. started construction of a new multimillion-dollar gypsum board plant in Camden, N.J. Completion was scheduled for October. Site of the new plant was the 25-acre property of the former Camden Coke Co. Gypsum rock was to be shipped to Camden from Flintkote's new mine in Newfoundland at a rate of more than 165,000 tons per year.

Texas Gypsum Co. planned to construct a new wallboard plant in Irving, Tex., with the help of an Area Redevelopment Administration (ARA) loan, and move its headquarters there from El Paso. Raw gypsum from Oklahoma was to be processed into about 300,000 feet of wallboard per day.

The first commercial gypsum production began at the 1.3-billion-ton deposit near Weatherford, Okla., where Southwestern Gypsum Co. opened a quarry for the production of agricultural gypsum. The deposit was found in 1956 during a coring program, which was promoted and financed by the Chambers of Commerce of Weatherford and Clinton, Okla.

Completion of the new $5 million United States Gypsum Co. plant in Baltimore, Md., was scheduled for September. The plant was to be built on a 35-acre tract in the harbor area. This was the firm's first plant in the Baltimore area and its seventh on the eastern seaboard.

Nashville, Ark., was the location of a new $1.5 million gypsum wallboard plant being constructed by Dierks Forests, Inc. Gypsum was to be mined from large reserves in the area and processed to about 400,000 square feet of ½-inch wallboard per day. The new plant, scheduled to be in production early in 1962, was the company's first venture outside the forest products field.

National Gypsum Co. purchased a large gypsum deposit in Mexico, and optioned a large tract of land on San Francisco Bay near Berkeley, Calif., as the site for a multimillion-dollar gypsum-products plant. The plant site was on deep water and was to be supplied with gypsum by ship from the Mexican deposit which also was along the Pacific. The exact location of the Mexican deposit, which had already been drilled, was not stated. Studies were being made of the Mexican operation but no date had been set for actual construction.

CONSUMPTION AND USES

The value of new construction put in place in the United States advanced to a new record exceeding $61 billion—an increase of $3.5 billion or 6 percent over that of 1961. A new record was also set for physical volume of new construction (dollar value adjusted for price changes) inasmuch as construction costs during the year rose only a little over 2 percent. Although gains were sizable in both private and public construction, 80 percent of the total increase in value of all new construction was in private construction. Residential building, the dominant factor in the private sector, was marked by a further shift to apartment-house units which accounted for one-third of the near-record 1.4 million private, nonfarm housing starts.

Overall outlays for new construction moved unevenly during the year. The seasonally adjusted annual rate dropped from $59 billion in January to a low of $56.5 billion in February, then climbed to a peak of $63.5 billion in October, and remained at this level for the rest of the fourth quarter to bring the annual total to $61 billion. New construction put in place in 1962 accounted for 11 percent of the gross national product.

The year 1962 was another good one for private home construction. About 1,430,000 private, nonfarm housing units were started—nearly 150,000 (12 percent) more than in 1961 and just 65,000 fewer than in 1959, the peak year. The 23,660 private, farm housing starts were 4,600 or 17 percent less than those in 1961; and the 29,400 public housing starts were 43 percent less than the record 1961 total of 52,000. The rate of starts fluctuated throughout the year but by yearend totaled 1,480,000 units of all types, private and public, the highest since the record of 1,553,500 in 1959.

Expenditures for private, nonfarm housing units topped $18 billion, an increase of $2 billion over that of 1961.

Apartment-house construction continued to flourish. The percentage of apartment units, defined as residential structures with 2 or more units, to total housing units of all types rose from 20 percent in 1959 to 28 percent in 1961 and to more than 33 percent in 1962. The number of apartment units started approached 500,000, about 125,000 more than in 1961. This contrasted with the number of single-family-unit starts which increased only 15,000 in 1962.

TABLE 4.—Gypsum products (made from domestic, imported, and byproduct crude gypsum) sold or used in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1961		1962	
	Quantity	Value	Quantity	Value
Uncalcined:				
Portland-cement retarder	2,763	$11,791	2,765	$12,365
Agricultural gypsum	1,088	3,808	1,241	4,222
Other uses [1]	48	562	43	510
Total	3,899	16,161	4,049	17,097
Calcined:				
Industrial:				
Plate-glass and terra-cotta plasters	45	677	43	714
Pottery plasters	46	1,006	48	1,073
Dental and orthopedic plasters	13	499	13	487
Industrial molding, art, and casting plasters	78	1,640	85	1,806
Other industrial uses [2]	76	2,506	80	2,665
Total	258	6,328	269	6,745
Building:				
Plasters:				
Base-coat	1,023	18,381	1,026	18,294
Sanded and premixed perlite	534	12,957	504	12,247
Mixing plants	2	31	1	16
Gaging and molding	116	2,386	119	2,521
Prepared finishes	11	961	10	869
Roof-deck	342	5,619	344	5,186
Keene's cement	35	931	35	924
Other [3]	16	857	16	997
Total	2,079	42,123	2,055	41,054
Prefabricated products [4]	[5] 7,023	294,199	[5] 7,711	327,404
Total	------------	336,322	------------	368,458
Grand total, value	------------	358,811	------------	392,300

[1] Includes uncalcined gypsum for use as filler and rock dust, in brewer's fixe, in color manufacture, and for unspecified uses.
[2] Includes dead-burned filler, granite polishing, and miscellaneous uses.
[3] Includes joint filler, patching, painter's, insulating, and unclassified building plasters.
[4] Excludes tile.
[5] Includes weight of paper, metal, or other materials.

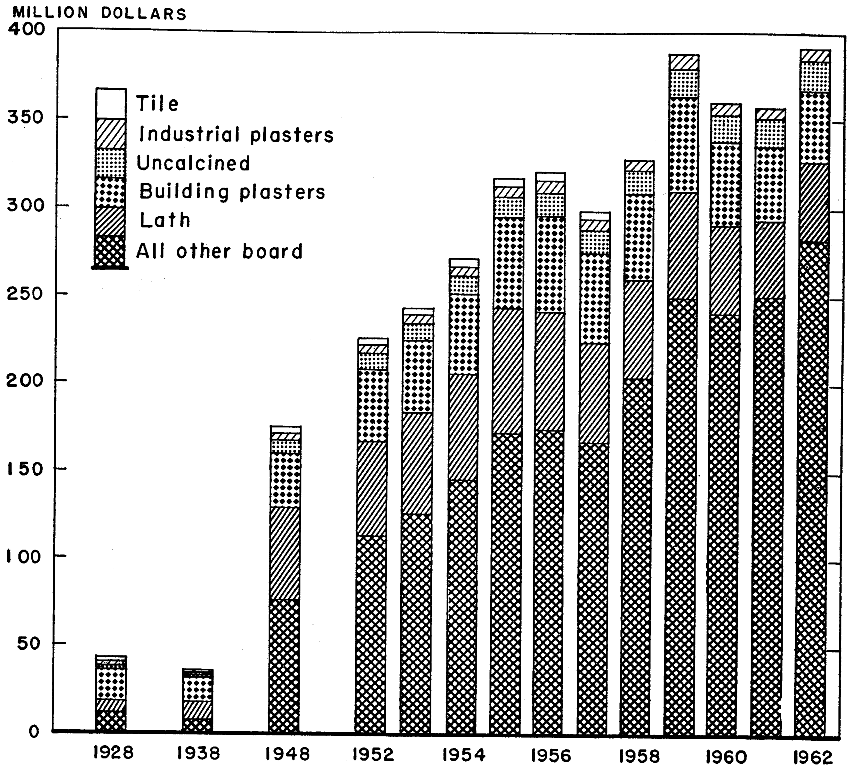

FIGURE 2.—Value of gypsum products sold or used in 1928, 1938, 1948, and 1952–62, by uses.

TABLE 5.—Prefabricated products sold or used in the United States, by products

Product	1961			1962		
	Thousand square feet	Thousand short tons [1]	Value (thousands)	Thousand square feet	Thousand short tons [1]	Value (thousands)
Lath:						
⅜-inch	1,601,303	1,199	$42,515	1,529,652	1,142	$41,863
½-inch	44,203	45	1,439	51,154	52	1,766
Other [2]	956	2	65	3,964	6	275
Total	1,646,462	1,246	44,019	1,584,770	1,200	43,904
Wallboard:						
¼-inch	156,350	89	4,557	145,968	81	4,578
⅜-inch	1,991,365	1,522	71,520	1,962,121	1,498	71,093
½-inch	3,483,983	3,529	147,624	4,112,080	4,145	175,040
⅝-inch	299,670	391	17,107	402,745	523	23,201
1-inch [3]	4,233	9	374	8,841	17	795
Total	5,935,601	5,540	241,182	6,631,755	6,264	274,707
Sheathing	180,589	189	7,011	186,265	195	6,706
Laminated board	[4] 4,691	5	248	[4] 7,141	8	380
Formboard	40,999	43	1,739	42,013	44	1,707
Grand total [5]	7,808,342	7,023	294,199	8,451,944	7,711	327,404

[1] Includes weight of paper, metal, or other materials.
[2] Includes a small amount of ¼-inch, ⅝-inch, and 1-inch lath.
[3] Includes a small amount of 5/16-inch, ¾-inch, 1⅝-inch, and 3¾-inch wallboard.
[4] Area of component board and not of finished product.
[5] Excludes tile, for which figures are withheld to avoid disclosing individual company confidential data.

STOCKS

Producers reported that stocks of crude gypsum on hand December 31 totaled 3.61 million short tons, a slight decrease from the 3.65 million tons at the end of 1961.

PRICES

According to reports from producers, the average value of crude gypsum mined in the United States was $3.65 per short ton, compared with $3.68 in 1961. The reported values were not sales prices but rather values assigned arbitrarily by producers as a calculated or book cost of mining crude gypsum. These assigned values were applied by integrated or affiliated organizations where costs varied considerably among producers.

The average value of cement retarder was $4.47 per short ton, a 5 percent increase above 1961; average value of agricultural gypsum decreased to $3.40. The average value of industrial plasters was 2 percent higher and that of building plasters and prefabricated gypsum products also increased 2 percent.

Based on 1957–59 averages equaling 100, prices of gypsum products, as reported by the U.S. Department of Commerce in 1962, were 105.0 unchanged from December 1961.

FOREIGN TRADE [3]

Imports of crude gypsum increased 9 percent to 5.4 million tons from 5.0 million tons in 1961. Canada provided 75 percent of the total domestic imports; Jamaica, 5 percent; Mexico, 11 percent; and the Dominican Republic, 8 percent of the total. Exports of gypsum and gypsum products totaled $1,302,000 and were composed of 20,000 tons of crude, crushed, or calcined material valued at $736,000 and manufactured gypsum products valued at $566,000.

TABLE 6.—U.S. imports for consumption of gypsum and gypsum products [1]

Year	Crude (including anhydrite)		Ground or calcined		Alabaster manufactures,[2] value (thousands)	Other manufactures n.e.s., value (thousands)	Total value (thousands)
	Short tons	Value (thousands)	Short tons	Value (thousands)			
1953-57 (average)	3,842,026	[3] $6,170	905	[3] $32	[3] $346	[3] $352	[3] $6,900
1958	4,046,999	6,864	787	33	612	355	7,864
1959	6,131,625	11,862	1,025	46	946	342	13,196
1960	5,301,224	8,990	1,159	48	963	425	10,426
1961	4,967,061	9,043	1,127	51	836	376	10,306
1962	5,420,876	10,490	1,780	55	1,025	342	11,912

[1] In addition, Keene's cement was imported as follows: 1953-57 (average), 2 short tons ($254); 1958-61, none; 1962, 2,760 short tons ($2,073).
[2] Includes imports of jet manufactures, which are believed to be negligible.
[3] Data known to be not comparable with other years.

Source: Bureau of the Census.

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

TABLE 7.—U.S. imports for consumption of crude gypsum (including anhydrite), by countries

(Thousand short tons and thousand dollars)

Country	1961		1962	
	Quantity	Value	Quantity	Value
North America:				
Canada	3,909	$7,127	4,086	$7,473
Dominican Republic	398	1,023	453	1,240
Jamaica	100	284	283	1,052
Mexico	560	608	599	725
Total	4,967	9,042	5,421	10,490
Europe [1]	(2)	1	(2)	(3)
Grand total	4,967	9,043	5,421	10,490

[1] 1961: Italy and United Kingdom; 1962: Italy.
[2] Less than 1,000 tons.
[3] Less than $1,000.

Source: Bureau of the Census.

TABLE 8.—U.S. exports of gypsum and gypsum products

Year	Crude, crushed, or calcined		Plasterboard, wallboard, and tile		Other manufactures n.e.c., value (thousands)	Total (thousands)
	Short tons (thousands)	Value (thousands)	Square feet (thousands)	Value (thousands)		
1953–57 (average)	23	$734	18,263	$636	$131	$1,501
1958	29	921	(1)	(1)	1,544	2,465
1959	14	641	(1)	(1)	655	1,296
1960	17	687	(1)	(1)	606	1,293
1961	20	731	(1)	(1)	568	1,299
1962	20	736	(1)	(1)	566	1,302

[1] Effective Jan. 1, 1958, plasterboard, wallboard, and tile not separately classified included with "gypsum manufactures n.e.c."

Source: Bureau of the Census.

WORLD REVIEW [4]

NORTH AMERICA

Canada.—Beginning in October or early November, exports were planned from a gypsum mine being developed on Newfoundland's west coast by the Canadian subsidiary of The Flintkote Co. More than 132,000 tons of crushed gypsum was to be exported before the end of 1962. Another 48,000 tons was to be supplied to the gypsum plant at Corner Brook. The Flintkote mine is at Flat Bay, 48 miles southwest of Corner Brook.[5]

Of Canada's total output of 5,060,000 tons valued at Can$9,099,000 in 1961, Nova Scotia produced 4,197,000 tons valued at Can$6,824,000.

Anhydrite was produced by Fundy Gypsum Co. at Wentworth, Nova Scotia, and by National Gypsum (Canada) Ltd. at Walton, Nova Scotia. Annual output was about 170,000 tons. Most of the

[4] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board, unless otherwise specified.
[5] Canadian Mining Journal (Gardenvale, Quebec). Gypsum Shipments Will Start Soon. V. 83, No. 9, September 1962, p. 138.

anhydrite was exported to the United States for manufacture of portland cement and as a fertilizer for peanut crops.[6]

At the Milford open pits in Nova Scotia, where the National Gypsum operated a mine, some 300,000 tons of gypsum rock was blasted at one time. The shot required 90,000 pounds of explosive, with about 1,500 pounds of dynamite in each of 65 drill holes. Despite this large quantity of explosive, the blast was comparatively quiet; it could only be heard a few miles away. At Halifax the only indication of the largest blast in the history of the Province was a record on the seismograph at Dalhousie University. The blast was concentrated on a 380-foot face of the pit, and it required a week to prepare the charge, which was fired electrically with millisecond delay caps.[7]

TABLE 9.—World production of gypsum by countries [1] [2]

(Thousand short tons)

Country [1]	1953–57 (average)	1958	1959	1960	1961	1962
North America:						
Canada [3]	4,434	3,977	5,983	5,093	5,060	5,184
Cuba	[4] 34	[4] 45	[4] 45	([5])	([5])	([5])
Dominican Republic	56	84	175	358	451	[4] 485
Guatemala	[6] 13	18	20	16	13	[4] 11
Jamaica	142	672	524	275	250	[4] 220
Mexico	[4] 478	821	913	871	857	876
Nicaragua	----	----	----	----	----	4
Trinidad	[7] 2	3	5	7	4	[4] 4
United States	9,497	9,600	10,900	9,825	9,500	9,969
Total [4]	14,656	15,220	18,565	16,445	16,135	16,753
South America:						
Argentina	167	196	127	[4] 120	[4] 120	[4] 120
Brazil	128	143	202	114	178	[4] 176
Chile	83	[4] 55	87	45	88	[4] 127
Colombia	55	66	77	77	83	[4] 83
Peru	72	69	61	90	65	67
Venezuela	----	----	[4] 1	6	8	11
Total [4]	505	529	555	452	542	584
Europe:						
Austria [3]	453	597	621	730	750	754
Bulgaria	([8])	90	120	130	[4] 500	[4] 550
Czechoslovakia	196	277	319	364	[4] 385	[4] 410
France [3]	3,735	4,046	4,126	4,163	4,771	[4] 4,740
Germany:						
East [9]	231	249	279	[4] 275	[4] 275	[4] 275
West [9]	967	958	1,058	1,152	1,131	[4] 1,150
Greece	13	24	2	----	----	----
Ireland	126	118	152	200	184	130
Italy	885	1,366	2,184	2,098	[4] 2,205	[4] 2,205
Luxembourg	6	6	7	9	8	9
Poland	344	[4] 386	[4] 518	[4] 573	516	605
Portugal	60	48	60	68	79	[4] 77
Spain	1,218	2,104	2,357	2,296	2,822	[4] 2,756
Switzerland	210	99	[4] 110	[4] 110	[4] 110	[4] 110
U.S.S.R	3,157	7,055	[4] 7,275	[4] 7,715	[4] 8,000	[4] 8,275
United Kingdom [3]	3,368	3,641	3,794	4,026	4,179	4,454
Yugoslavia	90	84	102	137	138	[4] 110
Total [4]	15,150	21,230	23,170	24,130	26,135	26,720

See footnotes at end of table.

[6] The Northern Miner (Toronto, Ontario). Gypsum Production Important Factor for Nova Scotia. No. 40, Dec. 27, 1962, p. 19, section 2.

[7] Jarman, Hugh G. Large Blast in a Canadian Open-Pit. Min. Mag. (London), v. 107, No. 2, August 1962, pp. 80–82.

TABLE 9.—World production of gypsum by countries [1] [2]—Continued

(Thousand short tons)

Country [1]	1953–57 (average)	1958	1959	1960	1961	1962
Asia:						
Burma	[10] 1	----------	2	1	1	[4] 1
China [4]	265	450	550	650	550	450
Cyprus [4]	183	155	217	220	220	220
India	821	876	945	1,099	953	1,239
Iran [4] [11]	448	415	440	440	606	606
Iraq [4]	330	440	440	440	([8])	([8])
Israel [4]	45	44	66	66	44	44
Japan	398	528	596	810	799	878
Jordan	----------	----------	----------	----------	8	10
Pakistan	42	74	109	100	112	167
Philippines	----------	2	2	10	9	16
Saudi Arabia	----------	----------	----------	----------	----------	[4] 12
Syrian Arab Republic [12]	1	[4] 3	[4] 7	15	9	17
Taiwan	8	11	11	12	13	14
Thailand	([13])	10	9	16	13	23
Turkey	28	50	[4] 57	67	[4] 66	154
Total [4]	2,570	3,058	3,451	3,946	3,843	4,291
Africa:						
Algeria	89	140	189	195	[4] 195	[4] 195
Angola	10	5	15	[4] 14	[4] 14	18
Congo, Republic of the	10	[4] 11	----------	----------	----------	----------
Kenya	2	12	15	19	22	[4] 22
Morocco	22	[4] 28	[4] 28	[4] 28	[4] 28	[4] 28
South Africa, Republic of	182	256	224	216	191	212
Sudan	4	[4] 2	[4] 2	----------	6	[4] 2
Tanganyika	7	10	8	5	1	2
Tunisia	26	18	13	15	[4] 15	[4] 15
United Arab Republic (Egypt)	259	584	577	441	510	[4] 440
Total	611	1,066	1,071	933	982	934
Oceania:						
Australia	490	566	579	651	681	[4] 683
New Caledonia	5	----------	----------	----------	----------	----------
Total	495	566	579	651	681	[4] 683
World total (estimate) [1] [2]	33,990	41,670	47,400	46,560	48,320	49,965

[1] Gypsum is also produced in Rumania, but production data are not available; an estimate is included in the total. Production in Ceylon, Ecuador, and Korea is negligible.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Includes anhydrite.
[4] Estimate.
[5] Data not available; no estimates included in total.
[6] Average for one year only, because 1957 was first year of commercial production.
[7] Average annual production for 1956–57.
[8] Data not available; estimate included in total.
[9] Crude production estimates based on calcined figures.
[10] Average annual production for 1954–57.
[11] Year ended March 20 of year following that stated.
[12] Some pure, and some 60-percent gypsum and 20-percent limestone.
[13] Less than 500 tons.

Compiled by Helen L. Hunt, Division of Foreign Activities.

Ontario's two producers of gypsum reported an increase in production in 1961 over 1960. The Canadian Gypsum Co. Ltd. mine at Hagersville produced more than 1,000 tons per day, and the tonnage of gypsum mined at Caledonia by Gypsum Lime and Alabastine Ltd. was increased to meet the needs of a new board plant and those of cement producers.[8]

Extensive modernization of crushing and loading facilities at its Windermere gypsum quarry resulted in greater production efficiency

[8] Skillings Mining Review. Ontario Gypsum Output Increased During 1961. V. 51, No. 11, Mar. 17, 1962. p. 10.

for Western Gypsum Products Ltd. The large deposits in the Windermere area of interior British Columbia supplied gypsum rock to Western's Vancouver plant on the shore of Burrard Inlet, "the most modern plaster mill and board plant in the industry." The Windermere quarry also supplied the company's board plant at Calgary. The company built 11.5 miles of road which permitted the use of off-highway vehicles.

The expanded facilities included a stockpile area for 100,000 tons of quarry-run rock. This permitted the stockpiling of as much rock as possible during the dry season, and allowed shipment of clean, fresh-crushed material, free from the large frozen pieces that caused many unloading problems.

One of the timesavers at Windermere was the car puller designed by the Western Gypsum engineering department at Calgary. Adapted from the front wheel section of an old locomotive, the arrangement exceeded all expectations. It handled 17 loaded cars at the rate of 15 per minute in either direction along a 5-percent grade spur. Car moving and spotting was done by remote control. Material handling in the new plant at Vancouver, British Columbia, was also described.[9]

Dominican Republic.—Exports of crude gypsum from the Dominican Republic to the United States were 13 percent greater than in 1961.

Jamaica.—Exports of crude gypsum from Jamaica to the United States almost tripled in 1962 compared with 1961.

Mexico.—Exports of crude gypsum from Mexico to the United States increased 7 percent over 1961.

SOUTH AMERICA

Chile.—Production of crude gypsum in 1961 nearly doubled the output of 1960. Compãnia Industrial El Volcan, the largest producer, operated mines at Cajón del Maipo several miles southeast of Santiago in the Andes Mountains. In 1961, production from these mines was about 60,000 tons; 15,000 tons was sold to cement manufacturers and the remainder was used in the company's plaster and wallboard plants. El Volcan also operated a mine at Coquimbo, which produced 2,000 tons in 1961 for the company's calcining plant in the area.[10]

EUROPE

Bulgaria.—Gypsum was first mined near the village of Radnevo, in the Stara Zagora district.[11] Before 1947, mining methods were primitive, extraction losses were high, and accidents to workmen were too frequent. Nationalization of the mines in December 1947 ended haphazard mining. Systematic and thorough prospecting for gypsum in the area was conducted during 1950–53. As a result, the extent of gypsum-bearing strata was estimated at 23 square miles. The Radnevo area was the only source of gypsum. The geology of this area, the geological characteristics of the openpit mining field, and a description of openpit mine No. 5 were given.

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[9] Canadian Mining Journal (Gardenvale, Quebec). Western Gypsum's Windermere Expansion and Improvement. V. 83, No. 1, January 1962, pp. 47–48.

[10] Bureau of Mines. Mineral Trade Notes. V. 55, No. 3, September 1962, p. 32.

[11] Mine and Quarry Engineering (London). Open-cast Gypsum Mining in Bulgaria. V. 28, No. 8, August 1962, pp. 366–369.

France.—Société des Gypses et Platres de France, a subsidiary of Lafarge Ciment Co., officially opened a gypsum mine and a 100,000-ton-per-year plasterboard plant at Carressee, Basses-Pyrénées, on December 20, 1961. Lafarge had similar plants in three other villages in southern France and ranked as the third largest cement and plaster producer in the country.[12]

One of the leading French producers of cement, plaster, and lime was Poliet et Chausson with headquarters in Paris. The company operated five gypsum plaster plants in the Paris region, and recently carried out a far-reaching reorganization. An existing plaster plant at Vaujours, in the Department of Seine-et-Oise, 12 miles east of Paris, became the subject of a large capital investment program. The company listed three objectives: (1) Modernization of methods for gypsum recovery in mines; (2) installation of a new processing unit correlated with the original plant; and (3) realignment of general services in the new plant. The steps taken to reach these objectives were explained.[13]

A steel belt conveyor distributed crushed gypsum to bulk storage in a new cement plant. A steel belt was selected because of its long life expectancy, low maintenance costs, and the inaccessibility of the conveyor location high in the roof trusses. The conveyor ran the full length of the storage shed and measured 180 feet between terminal pulley centers.

The steel belt was 32 inches wide and 0.048 inches thick and traveled 30 feet per minute. Both top and bottom strands were supported on idler rollers. The terminal pulley at the foot of the conveyor was mounted on a movable carriage which is spring-loaded to maintain the belt under constant tension at all times regardless of expansion and contraction caused by weather changes.[14]

ASIA

India.—The Government announced an agreement with Pakistan Industrial Development Corp. for importing 150,000 tons of high-grade gypsum to supply the Sindri fertilizer plant of the Government-owned Fertilizer Corporation of India. The gypsum was to be imported at the rate of 1,000 tons per month.[15]

The Madras Minister for Industries invited chemical manufacturers to exploit the gypsum deposits in Tiruchirapalli district in Madras State for the production of sulfuric acid.[16]

Tata Chemicals Ltd. proposed to establish a plant in Mithapur to manufacture 9,000 tons of sulfuric acid per year using both sulfur and gypsum; the gypsum being supplied from the company's salt works.[17]

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[12] Bureau of Mines. Mineral Trade Notes. V. 54, No. 5, May 1962, p. 18.
[13] Grindrod, J. Capacity Doubled With New Plant of French Gypsum Plaster Producer. Pit and Quarry, v. 55, No. 5, November 1962, pp. 126–129, 139.
[14] Nonmetallic Minerals Processing. Steel Belt Conveyor for Gypsum Storage. V. 3, No. 12, December 1962, p. 21.
[15] Bureau of Mines. Mineral Trade Notes. V. 55, No. 1, July 1962, p. 23.
[16] Chemical Trade Journal and Chemical Engineer (London). Sulphuric Acid from Gypsum. V. 151, No. 3941, Dec. 14, 1962, p. 1219.
[17] Chemical Trade Journal and Chemical Engineer (London). Gypsum Acid Plant for India. V. 149, No. 3888, Dec. 8, 1961, p. 1269.

AFRICA

South Africa, Republic of.—Gypsum was produced from deposits in Cape Province and Orange Free State.

TABLE 10.—Republic of South Africa: Gypsum data

	1960		1961	
	Short tons	Value	Short tons	Value
Production	215,815	----------	191,099	----------
Local sales	188,427	$685,045	169,999	$635,440
Exports	25,737	116,214	22,217	96,016

TABLE 11.—Republic of South Africa: Exports of gypsum by countries

Destination	1960		1961	
	Short tons	Value	Short tons	Value
Mozambique	3,528	$17,780	2,268	$11,431
Federation of:				
Rhodesia	20,781	90,930	18,434	76,623
Nyasaland	1,428	7,504	1,512	7,938
South-West Africa	----------	----------	3	24
Total	25,737	$116,214	22,217	$96,016

The leading producers of gypsum in 1961 were as follows:[18]

Producer:	*Location*
Daroba Gypsum Co. (Pty.), Ltd	Vanrhynsdorp, Cape Province.
Fincham's Gypsum Mines (Pty.), Ltd	Postmasburg, Cape Province.
W. Melville	Riverton, Cape Province.
National Portland Cement Co., Ltd	Claremont, Cape Province.
Dr. J. Nortje and J. Gauché	Vredendal, Cape Province.
Potgieters Gypsum Operations (Pty.), Ltd	Kimberly, Cape Province.
Gypsum Industries	Johannesburg.
Kimberley Gypsum Supplies (Pty.), Ltd	Johannesburg.
Permanent Gypsum & Allied Minerals Co. (Pty.), Ltd	Johannesburg.

United Arab Republic (Egypt).—Reflecting increased output from the Ras Malaab gypsum deposits by the Sinai Manganese Co. (owned by the Economic Development Organization), production of crude gypsum exceeded 500,000 tons in 1961, and then decreased 14 percent in 1962.

As reported for 1961, gypsum of high quality occurs in surface deposits in the area of Ras Malaab (Sinai). The deposits were said to exceed 500 feet in thickness at several points, and detailed investigations showed that 50 to 65 feet readily accessible near the surface

[18] Republic of South Africa, Department of Mines (Pretoria). Quarterly Information Circular, Minerals. October–December 1961, p. 45.

were of uniformly high purity. The gypsum in this area was exploited to a small extent by the Ras Malaab Co., a private firm whose properties and assets were purchased by the Sinai Manganese Co. Exports totaled 77,000 tons in 1961 compared with 45,000 tons in 1960. Sinai Manganese Co. made plans to expand port facilities for automatic conveyor shiploading of gypsum from the Ras Malaab deposits.[19]

The United Arab Republic's Economic Development Organization, State-owned holding corporation controlling many of the mining and industrial concerns, investigated the manufacture of ammonium sulfate fertilizers from gypsum deposits recently found in Sinai peninsula.[20]

OCEANIA

Australia.—A new mineral field, covering 90,000 square miles, was proclaimed in Western Australia. The South-Western Mineral Field, extended from about 100 miles north of Geraldton to Ravensthorpe, excluding previously existing fields of Northhampton, Collie, and Greenbushes. Several minerals, including gypsum were found.[21]

TECHNOLOGY

A rapid and reliable method for determining the dihydrate present in calcium sulfate hemihydrate in amounts less than 1 percent was described. The method was not affected by most impurities which interfered with wet-chemical analysis of calcium or sulfate or which contributed to the weight loss on heating below 225° C.[22]

Folded ½-inch gypsum board formed the studs for a low-cost drywall system developed by the Barrett Division of Allied Chemical Corp. Workers snapped and folded factory-scored pieces of wallboard. Gypsum board ½ or ⅝ inch thick, glued and screwed in place, completed the nonload-bearing partition. This system can be used for walls from 3 to 6 inches thick. According to the manufacturer, fire ratings of 45 minutes, 1 hour, and 2 hours were achieved by applying ½-inch, ⅝-inch, and two-ply ⅝-inch fire-rated gypsum board, respectively.[23]

An exterior load-bearing wall panel under development would eliminate wood-wall studs in house construction. The panels were 2⅜ inches thick and consisted of an asbestos-cement exterior surface, a rigid polyurethane core, and a gypsum-board interior surface. These wall panels were used to build two test houses in Piqua, Ohio, one by National Gypsum Co. and the other by Inland Homes Corp. The first house erected in 1959 demonstrated the physical properties of the exterior panels; the new house was to be tested under normal living conditions by a family of five. Electrical wiring was installed in the polyurethane core in ¾-inch square chases located 3 inches in from the panel edges. Holes were cut from the inside for switches and out-

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[19] Bureau of Mines. Mineral Trade Notes. V. 54, No. 4, April 1962, p. 11.
[20] Chemical Week. V. 88, No. 23, June 10, 1962, p. 28.
[21] Steel and Coal (London). New Australian Mineral Field. V. 184, No. 4885, Mar. 2, 1962, p. 422.
[22] Kuntze, R. A. The Determination of Small Amounts of Gypsum in Calcium Sulfate Hemihydrate by Differential Thermal Analysis. Materials Research and Standards, v. 2, No. 8, August 1962, pp. 640–642.
[23] Engineering News-Record. Gypsum Studs Frame Dry-wall. V. 169, No. 5, Aug. 2, 1962, p. 45.

lets. Both houses were constructed with 2⅜-inch, nonload-bearing partitions made of two sheets of gypsum wallboard laminated with a core of hardwood spirals. These were already on the market.[24]

Experimental work was reported on the preparation of story-high panels made of foam anhydrite and foam gypsum reinforced with basalt fibres. The characteristics of the raw material, its preparation, composition, and the technology of the process were described. The strength of the panels was satisfactory and the units were inexpensive and did not require plastering.[25]

Experimental results were reported of a study in which small gypsum plaster specimens were exposed to controlled fires similar to those to which large building elements had been subjected in tests by a recognized standard method. The small specimens were tested without structural load or restraint. Their fire performances were judged on time-to-temperature rise criteria. The results were analyzed to determine the effects on fire resistance of variation in mix ratio, aggregate type and density, duration of aging, and relative humidity of the environment in which the specimens were aged. Three different aggregates were used: Perlite, vermiculite, and sand. In addition, the perlite used were in three density ranges designated as high, intermediate, and low. Mix ratio and aggregate density, over the ranges normally used, had little effect, if any, on fire performance. The time-to-temperature rise for perlite and vermiculite aggregate plasters was essentially equal, but shorter times were observed for sanded plasters. Duration of aging and relative humidity of the environment had a significant effect only for short aging periods and very high relative humidity conditions.

Estimates of thermal properties of gypsum plasters at elevated temperatures were derived from the data. These estimates were considered useful for predicting fire endurances of building elements containing gypsum plaster.[26]

Sulfuric acid was made from calcium sulfate minerals in a process under study at Iowa State University, Ames, Iowa. Anhydrite ($CaSO_4$) or gypsum ($CaSO_4 \cdot 2H_2O$) was first crushed to about ⅛ inch, then heated to a white heat (about 1,100° C) by hot gases generated from the combustion of natural gas with limited quantities of air. Hydrogen and carbon monoxide in the gas reacted with calcium sulfate to yield lime and sulfur dioxide. The sulfur dioxide was recovered and converted into sulfuric acid in the usual way. The process was studied first on a laboratory scale, and then a pilot plant was built for further study.[27]

In an open-circuit cement mill, the addition of gypsum increased the specific surface (Blaine) of cement by 600 to 900 square centimeters per gram compared with cement without gypsum regardless of the amount of charge. This was because in a small charge the gypsum acts as a grinding agent and in a large charge it accumulates in fine particles. The addition of gypsum caused no deviation from

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[24] Engineering News-Record. Frameless House Passes Tests. V. 168, No. 25, June 21, 1962, p. 150.

[25] Gürtler, Rudolph. (Foam Anhydrite and Foam Gypsum.) Silikat Technik (Berlin), v. 11, No. 7, 1960, pp. 334–336; J. Am. Ceram. Soc., v. 45, No. 2, February 1962, p. 28.

[26] Ryan, J. V. Study of Gypsum Plasters Exposed to Fire. J. of Research of the National Bureau of Standards, v. 66C, section C, No. 4, October–December 1962, pp. 373–387.

[27] Chemical Engineering. V. 69, No. 9, Apr. 30, 1962, p. 74.

normal grinding. An experimental formula for the relationship between electric power consumption and specific surface of cement was derived; this formula was applicable to the whole range from normal to abnormal grinding.[28]

The reaction of calcium carbonate with mixed solutions of 20 percent sulfuric acid and 10 to 70 percent phosphoric acid was studied. The content of residual phosphorous pentoxide (P_2O_5) in the gypsum increased with increasing concentration of phosphoric acid and was not affected by the reaction temperature and time. A study of the relationship between the dissolution of gypsum in water at 75° to 80° C. and the amount of dissolved P_2O_5 showed that the P_2O_5 adhered to the crystal surfaces and was distributed uniformly through the crystals.[29]

The hydration of hemihydrate produced large crystals of dihydrate that were easily filtered and washed. In a concentrated (30 percent) solution of P_2O_5, the growth of dihydrate from hemihydrate occurred along the plane (111), and it was necessary to add seeds of dihydrate consisting of twinned crystals. The growth of dihydrate and the hydration of hemihydrate were disturbed in the presence of organic impurities in phosphate rock, and the removal of organic impurities with silica gel was necessary. However, in the presence of fluorine, silica gel, which reacts with fluorine, was ineffective.[30]

An experimental apparatus (internal diameter 200 millimeters) was used to obtain useful data for scaling up the size of the fluidized bed, the temperature distribution, and the relationship between reaction time and volume of the charge of gypsum.[31]

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[28] Suzuki, Sueo. (Effect of Gypsum on Cement Grinding.) Semento Gijutsu Nempô (Tokyo, Japan), v. 13, 1959, p. 107–113; Am. Ceram. Soc. J., v. 45, No. 2, February 1962, p. 28.

[29] Yamada, Tamotsu, Teruisha Kawase, and Schoichiro Nagai. (By-product Gypsum from the Phosphoric Acid Process: VI Distribution of Phosphoric Acid in the Gypsum Crystal.) Sekkō to Sekkai (Tokyo, Japan), No. 53, 1961, pp. 164–168; Am. Ceram. Soc. J., v. 45, No. 3, March 1962, p. 54.

[30] Murakami, Keüchi, Hirobumi Tanaka, and Bukan Sudo. (Byproduct Gypsum From Phosphoric Acid Manufacture: II.) Sekkō to Sekkai (Tokyo, Japan), No. 54, 1961, pp. 207–215; Am. Ceram. Soc. J., v. 45, No. 3, March 1962, p. 54.

[31] Hiyama, Sinpei, Iwao Muchi, Manabu Takatsu, Masayuki Okuya, and Susumu Masuoka. (Calcination of Gypsum by Fluidization: III Temperature Distribution in the Bed.) Sekkō to Sekkai (Tokyo, Japan), No. 54, 1961, pp. 215–219; Am. Ceram. Soc. J., v. 45, No. 3, March 1962, p. 54

Iodine

By Henry E. Stipp[1] and Victoria R. Schreck[2]

OUTPUT of crude iodine in the United States in 1962 rose significantly, reversing the downward trend of the previous 2 years. Consumption decreased slightly while imports increased.

DOMESTIC PRODUCTION

Crude iodine extracted from well brines in the United States increased 29 percent in quantity and value over that of 1961. Iodine was recovered by The Dow Chemical Co., in plants at Seal Beach, Venice, and Inglewood, Calif., and Midland, Mich.

CONSUMPTION AND USES

Consumption of crude iodine decreased slightly below the record consumption of 1961. Iodine and its compounds were used in industry, agriculture, and medicine. Some of these applications were in pharmaceuticals, human and animal nutrition, germicides and disinfectants, soaps and detergents, photographic plates and papers, catalytic and analytic reagents, dyes, pigments, process engraving and lithography, leather manufacture, paints, insecticides, rubber and plastics, paper, and petroleum. Potassium iodide, the principal compound consumed, was used chiefly in photographic film processes, medicinal compounds, food supplements, and analytical reagents and catalysts. Sodium and ammonium iodides had virtually the same uses as potassium iodide. Calcium iodate, a stock feed supplement, was another important compound consumed. Resublimed iodine was used in the preparation of inorganic and organic iodine compounds. Titanium tetraiodide, used in the preparation of high-purity titanium, proved to be another important iodine consumption item. Iodides of other metals in the fourth, fifth, and sixth subgroups of the periodic table of elements were used to prepare high-purity metals. Numerous iodine compounds were used in various minor applications; for example, silver iodide was applied to clouds to produce precipitation; lithium iodide crystals were used in fast-neutron detection devices; and cuprous iodide crystals were studied for application in laser or maser optical modulation devices.

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TABLE 1.—Crude iodine consumed in the United States

Product	1961			1962		
	Number of plants	Crude iodine consumed		Number of plants	Crude iodine consumed	
		Thousand pounds	Percent of total		Thousand pounds	Percent of total
Resublimed iodine	5	104	4	8	106	4
Potassium iodide	10	1,467	56	11	1,079	43
Sodium iodide	4	(1)	(1)	5	(1)	(1)
Other inorganic compounds	21	566	22	24	774	31
Organic compounds	31	460	18	27	538	22
Total	[2] 47	2,597	100	[2] 45	2,497	100

[1] Included with "Other inorganic compounds" to avoid disclosing individual company confidential data.
[2] Nonadditive total because some plants produce more than 1 product.

Radioactive iodine was used for physical therapy and examinations, process control, tracer studies, and general research.

STOCKS

Stocks held by firms that convert crude iodine into resublimed iodine and iodine compounds totaled 1,035,333 pounds on December 31, 1962.

PRICES

Prices of iodine and iodine compounds were virtually the same as in 1961. The following prices were quoted by Oil, Paint and Drug Reporter for January through December:

	Per pound
Crude iodine, kegs	$1.10
Resublimed iodine, U.S.P., drums, f.o.b. works	2.20–2.22
Ammonium iodide, National Formulary (N.F.), 25-pound jars, f.o.b. works	4.51
Calcium iodide, 25-pound jars, f.o.b. works	4.27
Potassium iodide, U.S.P., crystals, granular, 250-pound drums, f.o.b. works	1.55
Sodium iodide, U.S.P., 300-pound drums, f.o.b. works	2.13

FOREIGN TRADE [3]

Imports.—Imports of crude iodine increased slightly in quantity but decreased somewhat in value. This was the third consecutive year that imports rose. Chile's share of the U.S. market increased at the expense of Japan. Resublimed iodine imports from Japan totaled 9,050 pounds valued at $11,391.

Exports.—Exports of iodine, iodides, and iodates increased to 178,115 pounds valued at $295,605, compared with 175,781 pounds valued at $282,072 in 1961. Major shipments went to Canada, the United Kingdom, Brazil, India, and West Germany. Thirty-four other

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

countries received varying quantities. Reexports of iodine, iodides, and iodates totaled 64,382 pounds valued at $71,095, compared with 85,000 pounds valued at $94,000 in 1961.

TABLE 2.—U.S. imports for consumption of crude iodine, by countries

(Thousand pounds and thousand dollars)

Country	1953-57 (average)		1958		1959		1960		1961		1962	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Chile	1,063	$1,235	1,401	$1,180	1,243	$892	1,420	$1,011	1,964	$1,822	2,229	$2,054
France	(1)	(2)										
Japan	442	585	160	149	223	191	474	414	1,053	1,030	797	787
Total	1,505	1,820	1,561	1,329	1,466	1,083	1,894	1,425	3,017	2,852	3,026	2,841

[1] Less than 1,000 pounds.
[2] Less than $1,000.

Source: Bureau of the Census.

TABLE 3.—U.S. exports of iodine, iodide, and iodates

(Thousand pounds and thousand dollars)

Year	Quantity	Value	Year	Quantity	Value
1953-57 (average)	319	$476	1960 [1]	251	$353
1958 [1]	199	314	1961 [1]	176	282
1959 [1]	175	249	1962 [1]	178	296

[1] Data not strictly comparable with earlier years.

Source: Bureau of the Census

TABLE 4.—U.S. reexports of iodine, iodide, and iodates

(Thousand pounds and thousand dollars)

Year	Quantity	Value	Year	Quantity	Value
1953-57 (average)	81	$106	1960 [1]	38	$37
1958 [1]	30	30	1961 [1]	85	94
1959 [1]	35	34	1962 [1]	64	71

[1] Data not strictly comparable with earlier years.

Source: Bureau of the Census.

WORLD REVIEW

Chile.—Crude iodine output increased to 5,191,833 pounds in the year that ended June 30, 1962, compared with 4,060,873 pounds during fiscal year 1961.[4] Exports totaled 5,229,311 pounds in fiscal year 1962, compared with 4,098,351 pounds in fiscal year 1961.

Indonesia.—Production of iodine during 1961 totaled 7,710 pounds, compared with 7,922 pounds in 1960.[5]

[4] Bureau of Mines. Mineral Trade Notes. V. 56, No. 2, February 1963, p. 34.
[5] U.S. Embassy, Djakarata, Indonesia. State Department Dispatch 761, May 11, 1962, encl. 1, p. 1.

Italy.—Iodine imports from the United States no longer required a license, following an agreement negotiated at the 20th session of the General Agreement on Tariffs and Trade.[6]

Japan.—Recovery of elemental iodine in 1961 totaled 2,469,152 pounds, compared with 2,094,000 pounds in 1960.[7]

TECHNOLOGY

Ten parts of iodine added to 100 million parts of smog inhibited or reduced the formation of ozone.[8] Ozone is the chief irritating substance in smog. Iodine reportedly quenched the free radical chain reaction that generated ozone. Toxicity of the iodine-smog reaction products was not determined.

Gallium phosphide single crystals up to 2 millimeters in length and diameter were grown from a polycrystalline gallium phosphide, hydrogen, and iodine reaction at temperatures from 780° to 935° C.[9] The crystals formed at atmospheric pressure in a sealed quartz tube. The largest crystals were produced when the temperature gradient along the tube was small.

Good yields of boron triiodide were obtained by reacting iodine and sodium borohydride in an inert solvent.[10] Pure boron triiodide was obtained by distilling it with metallic tin or aluminum and rectifying the iodide in a sieve-plate column.

When iodine gas and argon were passed over molybdenum samples in a fluidized-bed reactor at 1,800° to 1,900° F iodine combined with silicon in the bed to form silicon teraiodide, which then reacted with the molybdenum object, forming a coating of molybdenum disilicide on it after 1 to 3 hours.[11] The coated molybdenum withstood a temperature of 3,000° F for 1.5 to 2 hours. Columbium alloys coated by this method withstood temperatures of 2,600° F for up to 12 hours.

An anode made entirely of lead dioxide was found to be superior to other material used to prepare iodates from iodides, to prepare periodic acid from iodine, and to regenerate periodic acid from iodic acid.[12] Yields were almost quantitative and current efficiency was good.

Potassium iodide mixed with quinoline was reported to inhibit the corrosion of steel in acid solutions.[13] The polarization of steel was increased by adding potassium iodide to acid and quinoline solutions.

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[6] International Commerce. Italy Frees Some U.S. Imports by Terms of Accord. V. 69, No. 2, Jan. 14, 1963, p. 30.

[7] U.S. Embassy, Tokyo, Japan. State Department Dispatch 820, Apr. 4, 1962, encl. 1, p. 3.

[8] Chemical & Engineering News. Iodine May Be Smog Weapon. V. 40, No. 39, Sept. 24, 1962, p. 68.

[9] Roy, A. S. Gallium Phosphide Crystal Growth by Vapor Phase Iodide Transport. J. Electrochem. Soc., v. 109, No. 8, August 1962, pp. 750–751.

[10] Ivanov-Emin, B. N., L. A. Nisel'son, and I. V. Petrusevich. (Synthesis and Purification of Boron Bromide and Iodide.) J. Appl. Chem. (U.S.S.R.), v. 34, No. 10, November 1961, pp. 2256–2260.

[11] Chemical & Engineering News. Fluidized Bed Coats Refractory Metals. V. 40, No. 41, Oct. 8, 1962, pp. 46, 48.

[12] Aiya, Yoshihiko, Shojiro Fujii, Kiichiro Sugino, and Koza Shirai. Improved Electrolytic Processes for the Production of Iodic Acid, Periodic Acid, and Their Salts Using A Special Lead Dioxide Anode. J. Electrochem. Soc., v. 109, No. 5, May 1962, pp. 419–424.

[13] Pogarel'skii, E. I. (Influence of Quinoline and Iodide Ions on the Corrosion of Steel in Sulfuric and Hydrochloric Acids), J. Appl. Chem. (U.S.S.R.), v. 34, No. 9, September 1961, pp. 1955–1959.

An adsorption mechanism was thought to be responsible for the inhibiting action.

Studies on the purification of chromium by decomposition of its iodides were conducted to obtain data for increasing the efficinecy of the process or devising a more productive process.[14] Iodine vapor at 10^{-3} to 10^{-4} millimeters of mercury was reacted with chromium at 150° to 1,100° C. Between 500° and 1,100° C mostly chromium diiodide deposited on the reactor walls; at 400° C, chromium triiodide; and at lower temperatures, chromium tetraiodide. The degree of chromium diiodide dissociation was found from the equilibrium constant in the range 500° to 1,200° C. Chromium diiodide dissociated from 0.90 percent at 500° C to 96 percent at 1,200° C. Between 500° and 600° C, 96 to 99 percent iodine was utilized by adjusting the rate of flow of the iodine vapor and the height of the chromium bed.

A book that described the design and operation of a device for preparing pure metals from metal iodides was published.[15] Methods for preparing metal iodides, and descriptions of their properties also were presented. The use of iodide compounds in preparing high-purity elements or alloys was reviewed.

The physical properties and crystalline structure of tellurium iodide, tellurium tetraiodide, antimony triiodide, and antimony-tellurium iodide were described.[16] The microhardness, electric conductivity, thermoelectromotive force, and heat conductivity of the compounds were studied. The value of the energy gap for tellurium iodide was 1.1 electron volts, that for antimony triiodide, 2.5 electron volts, and that for antimony-tellurium iodide, 2.1 electron volts.

A method was devised for preparing anhydrous lithium iodide by heating hydrated lithium iodide, followed by subliming in vacuum at 800° to 850° C and approximately 0.01 millimeter of mercury.[17] Several other methods of preparing anhydrous lithium iodide were described.

A method was patented for separating and recovering iodine from an aqueous iodide solution by passing it through the bed of an anion-exchange resin.[18]

An iodine compound was added to the alkali electrolyte of a rechargeable dry cell to prevent formation of excessive gas pressure upon recharge.[19]

Radioactive iodine 131 was prepared by bombarding tellurium dioxide with slow neutrons.[20] The tellurium dioxide was then im-

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[14] Tumarev, A. S., and L. A. Panyushin. (A Study of the Interaction of Chromium with Iodine Vapor.) J. Appl. Chem. (U.S.S.R.), v. 35, No. 5, May 1962, pp. 1000–1007.

[15] Rolsten, Robert F. Iodide Metals and Metal Iodides. John Wiley & Sons, Inc., New York, 1961, 441 pp.

[16] Abrikosov, N. Kh., and A. N. Zobnitsa. (Investigations of Tellurium and Antimony Compounds With Iodine), Vopr. Metallurgii i Fiz. Poluprovodnikov, Moscow, AN. S.S.S.R., 1961, pp. 110–112; abs. in Sov. Sci. Tech. Exploitation Program, transl. by Library of Congress.

[17] Tananaev, I. V., S. M. Petushkova, and G. V. Shpineva. (The Preparation of Anhydrous Lithium Iodide.) J. Inorg. Chem. (U.S.S.R.), v. 3, No. 5, 1958, pp. 9–14.

[18] Mills, Jack F. (assigned to The Dow Chem. Co., Midland, Mich.). Recovery of Iodine From Aqueous Iodide Solutions. U.S. Pat. 3,050,369, Aug. 21, 1962.

[19] Kordesch, Karl (assigned to Union Carbide Corp., New York, N.Y.) Electrolytes for Rechargeable Dry Cell. U.S. Pat. 2,991,325, July 4, 1961.

[20] Huising, Wilhelmus B., Herman H. P. Moeken, and Dirk Nonhebel (assigned to North American Philips Co., Inc., New York, N.Y.). Process for Isolating Radio-Active Iodine–131. U.S. Pat. 3,053,644, Sept. 11, 1962.

mersed in an aqueous solution of sulfuric acid and an oxidizing agent and heated to expel iodine 131. The suspension was distilled and the distillate containing iodine 131 was collected in a lye solution.

The effect of iodine 131 on the thyroid glands of some New York State children was surveyed.[21] Iodine 131, a known cause of cancer, contaminates the milk supply and becomes concentrated in the thyroid gland. According to the survey radioiodine appeared to have been underestimated as a radioactive hazard in bomb fallout.

Iodine 131 in a polyethylene capsule was inserted beneath the skin of a meadow mouse.[22] The animal was traced with a Geiger-Müller counter.

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[21] Science News Letter. Thyroid Survey To Show Effect of Radiation Levels. V. 82, No. 12, Sept. 22, 1962, p. 192.

[22] Science. Use of Iodine-131 To Measure Movements of Small Animals. V. 138, No 3537, Oct. 12, 1962, pp. 147–148.

Iron Ore

By R. W. Holliday,[1] and Helen E. Lewis [2]

WORLD PRODUCTIVE capacity, already more than adequate, continued to expand and competition for iron ore markets was intensified. Nevertheless, additional large-scale mining and milling facilities were under construction in several areas. Over the next few years, new or increased competition for markets was foreseen from developments in Canada, Chile, Peru, Brazil, Sweden, Malaya, India, Angola, Liberia, Mauritania, Republic of South Africa, Australia, and possibly other areas. Expansion of taconite plants signified the determination of domestic producers to retain a major share of the U.S. market. Current imports were equivalent to one-third of the U.S. supply. European consumers also showed an increasing tendency to import high-grade ores and to curtail production from low-grade domestic mines.

TABLE 1.—Salient iron ore statistics

(Thousand long tons and thousand dollars)

	1953–57 (average)	1958	1959	1960	1961	1962
United States:						
Iron ore (usable; [1] less than 5 percent Mn):						
Production [2]	100,630	67,709	60,276	88,784	71,329	71,829
Shipment [3]	99,933	66,288	59,164	82,963	72,379	69,969
Value [3]	$736,198	$569,154	$514,067	$724,131	$650,500	$618,242
Average value at mines per ton	$7.37	$8.59	$8.69	$8.73	$8.99	$8.84
Imports for consumption	22,880	27,544	35,617	34,578	25,805	33,431
Value	$185,849	$231,617	$312,447	$321,919	$250,226	$324,702
Exports	4,485	3,573	2,967	5,273	[4] 4,958	5,898
Value	$38,109	$34,898	$33,831	$57,899	[4] $54,230	$62,833
Consumption	119,186	91,900	93,662	108,050	99,254	99,562
Stocks Dec. 31:						
At mines	5,862	7,033	7,358	12,337	[4] 10,335	11,642
At consuming plants	46,641	53,599	53,038	61,569	58,869	59,553
At U.S. docks	5,780	5,577	7,575	6,839	6,100	6,429
Manganiferous iron ore (5 to 35 percent Mn):						
Shipments	760	465	420	588	201	302
Value	$4,910	$3,532	$3,153	$4,466	$1,480	(5)
World: Production	363,293	398,740	432,140	513,817	503,779	504,012

[1] Direct shipping ore, washed ore, concentrates, agglomerates, and byproduct pyrites cinder and agglomerates.
[2] Includes byproduct ore.
[3] Excludes byproduct ore.
[4] Revised figure.
[5] Not published to avoid disclosing individual company data.

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

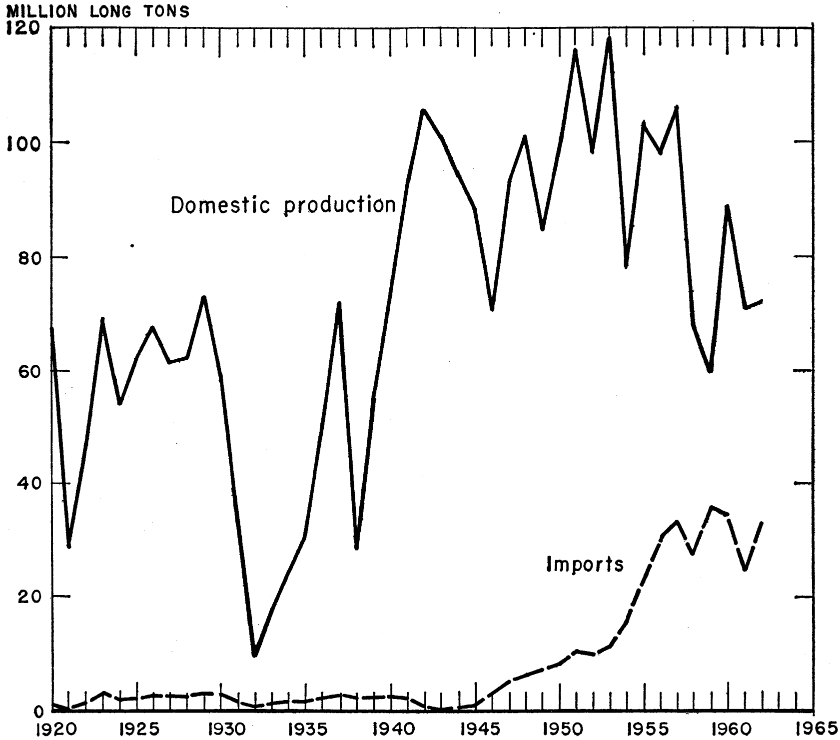

FIGURE 1.—Production of iron ore in the United States and iron ore imports for consumption, 1920–62.

EMPLOYMENT

The total number of man shifts worked in 1961 decreased by 21 percent from the 1960 total. This paralleled the reduction in production of usable ore which decreased by 20 percent.

Crude ore production per shift and per hour, table 2, was computed on the basis of total industry employment (mine and mill) and this indicates a mine productivity somewhat lower than actual.

TABLE 2.—Employment at iron ore mines and beneficiating plants, quantity and tenor of ore produced, and average output per man in 1961, by districts and States

District and State	Employment: Average number of men employed	Employment: Time employed: Average number of days	Employment: Time employed: Total man shifts (thousands)	Employment: Time employed: Man-hours: Average per shift	Employment: Time employed: Man-hours: Total (thousands)	Production[1]: Crude ore (thousand) long tons	Production[1]: Usable ore: (Thousand) long tons	Production[1]: Usable ore: Iron contained: (Thousand) long tons	Production[1]: Usable ore: Iron contained: Natural (percent)	Production[1]: Average per man: Crude ore: Per shift	Production[1]: Average per man: Crude ore: Per hour	Production[1]: Average per man: Usable ore: Per shift	Production[1]: Average per man: Usable ore: Per hour	Production[1]: Average per man: Usable ore: Iron contained: Per shift	Production[1]: Average per man: Usable ore: Iron contained: Per hour
Lake Superior:															
Minnesota	9,915	267	2,647	8.0	21,178	92,982	43,789	24,238	55.35	35.13	4.39	16.54	2.07	9.16	1.12
Michigan	4,477	207	927	8.0	7,412	12,241	8,432	4,623	54.83	13.20	1.65	9.10	1.14	4.99	.62
Wisconsin	662	233	154	8.0	1,235	1,129	1,129	605	53.58	7.33	.91	7.33	.91	3.93	.49
Total	15,054	248	3,728	8.0	29,825	106,352	53,350	29,466	55.23	28.53	3.57	14.31	1.79	7.90	.95
Southeastern States:															
Alabama and Georgia	2,242	204	457	8.1	3,704	6,150	3,539	1,303	36.82	13.46	1.66	7.74	.96	2.85	.35
Northeastern States:															
New Jersey and Pennsylvania	1,875	226	423	8.1	3,420	3,109	1,692	1,082	63.94	7.35	.91	4.00	.49	2.56	.32
New York	1,250	170	213	8.0	1,702	6,697	2,356	1,433	60.82	31.44	3.93	11.06	1.38	6.73	.84
Total[2]	3,125	204	636	8.0	5,123	9,806	4,048	2,515	62.13	15.41	1.91	6.36	.79	3.95	.49
Western States:															
California, New Mexico, Texas	840	242	204	8.1	1,647	8,360	4,292	2,360	54.99	40.98	4.90	21.04	2.61	11.57	1.43
Idaho and Montana	26	254	4	7.8	31	46	46	24	52.17	11.50	1.48	11.50	1.48	6.00	.77
Colorado, Nevada, Utah	687	217	149	8.8	1,188	4,961	4,466	2,367	53.00	33.30	4.18	29.97	3.76	15.89	1.99
Total[2]	1,553	229	356	8.1	2,866	13,367	8,804	4,751	53.96	37.55	4.66	24.73	3.07	13.46	1.66
Undistributed[3]	736	205	151	8.2	1,231	1,758	1,055	455	43.13	11.64	1.43	6.99	.86	3.01	.37
Grand total[2]	22,710	235	5,329	8.0	42,749	137,433	70,796	38,490	54.37	25.79	3.21	13.29	1.66	7.22	.90

[1] Includes manganese bearing from the Lake Superior district.
[2] In some instances data do not add to totals because of rounding.
[3] Includes Arizona, Missouri, South Dakota, Tennessee, Wyoming, to avoid disclosing individual company confidential data.

DOMESTIC PRODUCTION

Domestic production of usable ore[3] was virtually equal to that of 1961. The 71.2-million-ton output, though not the lowest in the last decade, was considerably below the 5-year averages of 84.2 million tons (1956–60) and 102.7 million tons (1951–55).

Most interest was in the decreasing proportion of domestic direct-shipping ore (table 3) relative to the encroachment of other ore types and imports. The competition to supplant domestic direct-shipping ores appeared to rest chiefly between pellet producers and importers.

The situation in the iron ore industry, with particular reference to the Minnesota industry, was reviewed in a report[4] prepared for that State's government.

Most new production was from pellet producers, and most of the curtailment was among producers of direct-shipping ore.

TABLE 3.—Domestic production by types and imported iron ore as percentages of total new supply

(Thousand long tons and percent)

Year	Domestic production						Imports		Domestic production plus imports	
	Direct-shipping		Concentrates		Agglomerates					
	Gross weight	Percent of total	Gross weight	Percent of toatl	Gross weight	Percent of total	Gross weight	Percent of total	Gross weight[1]	Percent of total
1950	70,309	66	22,811	21	4,925	5	8,281	8	106,326	100
1951	85,282	67	25,709	20	5,514	5	10,140	8	126,645	100
1952	70,358	65	22,037	21	5,522	5	9,761	9	107,679	100
1953	82,164	64	29,162	23	6,669	5	11,074	8	129,069	100
1954	49,106	52	23,173	25	5,850	6	15,792	17	93,921	100
1955	66,746	53	28,772	23	7,481	6	23,472	18	126,471	100
1956	59,895	47	27,343	21	10,639	8	30,411	24	128,288	100
1957	64,503	46	29,255	21	12,390	9	33,651	24	139,799	100
1958	36,242	38	21,873	23	9,596	10	27,544	29	95,253	100
1959	29,975	31	19,971	21	10,330	11	35,617	37	95,893	100
1960	38,968	32	32,643	26	17,175	14	34,578	28	123,362	100
1961	25,924	27	28,630	30	16,775	17	25,805	26	97,134	100
1962	22,132	21	28,459	27	21,238	20	33,431	32	105,260	100

[1] In some instances data do not add to total shown because of rounding.

In Minnesota, the Reserve Mining Co. expansion of the E. W. Davis plant from an annual capacity of 6,000,000 to 9,000,000 tons of pellets neared completion. The Hanna Mining Co. expanded the

[3] Definition of terms.

Usable ore is defined as the product of mine or beneficiating plant and is measured in the form shipped to the consumer. Thus, it includes direct shipping ore, concentrate, and agglomerate.

Direct-shipping ore is sufficiently high in quality for shipment directly to the consumer as mined. The grade may vary according to the consumer's specifications.

Crude ore includes direct-shipping and all other ore mined prior to any treatment for removing waste constituents or otherwise improving the product.

Beneficiation is any treatment to improve the chemical composition or physical structure of iron ore. Concentration and agglomeration are included in the more general term beneficiation.

Concentration is the treatment of ore to remove waste constituents. The treatment includes any of numerous procedures ranging from simple washing or gravity separations to complex operations involving crushing, grinding, flotation, magnetic separation, or other mineral dressing techniques. Although concentrate (and direct-shipping ore) may subsequently be agglomerated, the term as used here refers only to concentrate shipped to consumers in the unagglomerated form.

Agglomeration is the binding or compaction of fine-sized ore particles into compact masses by any means including sintering, pelletizing, nodulizing, and briquetting.

[4] Natural Resources of Minnesota: 1962. Rept. of Minnesota Nat. Res. Council, 1962, 64 pp.

capacity of its Groveland concentrating plant in Michigan from 700,000 to 1,500,000 tons and nearly completed a 1,250,000-ton-capacity pelletizing component. Also in Michigan, Cleveland Cliffs expanded capacity at the Republic plant from 800,000 to 1,600,000 tons and began constructing a plant at the Empire mine to produce 1,200,000 tons of pellets per year by 1964. In Wyoming, the Atlantic City operation of Columbia Geneva Steel Division, United States Steel Corp., began shipment of taconite pellets to the iron and steel mill at Geneva, Utah. The Meramac Mining Company planned to produce pellets at the rate of about 2,000,000 tons per year from its new underground mine and plant at Pea Ridge, Mo., by October 1963. Bethlehem Steel Co.'s new underground Grace mine in southeastern Pennsylvania nearly reached its full production of 2,000,000 tons of pellets per year.

Among the underground mines closed in 1962 were the Montreal mine on the Gogebic Range in Wisconsin after 77 years of continuous operation; the Zenith mine with 60 years and the Soudan mine with 76 years of operation on the Vermillion Range in Minnesota; the Cannon and Tobin mines on the Menominee Range in Michigan; and the Wenonah mine on Red Mountain near Birmingham, Ala.

Some open-pit mines also curtailed or suspended operations and some owners reportedly relinquished ore reserves in preference to continued payment of taxes.

Crude Ore.—Only 15 percent of the 1962 crude ore production was shipped directly to consuming plants, whereas 85 percent was treated at some type of beneficiating plant before shipment. The grade of crude ore continued downward; the grade of usable ore, upward. A correlation existed between the increase in crude ore treated and the increase in percentage of magnetite produced. Magnetite responded to a simple magnetic separation procedure, and production of it increased from 13 percent of the total crude ore in 1952 to 41 percent in 1962.

Crude ore output in the Lake Superior district represented 78 percent of the U.S. total. Northeastern States produced 8 percent, Southeastern States 5 percent, and Western States 9 percent.

Of the 200 domestic mines reporting production of iron ore, only 111 produced more than 100,000 tons to account for 98 percent of the U.S. total. Of the 30 mines that produced 1 million tons or more of crude ore, 20 were in Minnesota, 3 in Michigan, and 1 in Alabama.

Usable Ore.—Pellets comprised 26 percent and other agglomerates produced at the mine sites comprised 4 percent of the usable ore produced in the United States. The figure for other agglomerates included briquettes, nodules, and sinter. Concentrate (not agglomerated) comprised 38 percent of the total output, and direct-shipping ores 32 percent. Agglomerates produced in sintering facilities at consuming-plant sites are not included in the usable ore total.

The Lake Superior district accounted for 78 percent of total domestic usable ore; Northeastern and Southeastern States produced 11 percent; and Western States, stimulated by expanding Western population and by sales to Japan, supplied 11 percent. The grade of ore from the Lake Superior district showed increases in iron content and decreases in silica content.

TABLE 4.—Crude iron ore mined in the United States, by districts and varieties

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

District and State	1961					1962				
	Number of mines	Hematite	Brown ore	Magnetite	Total	Number of mines	Hematite	Brown ore	Magnetite	Total
Lake Superior:										
Michigan	23	12,173	-----	-----	12,173	24	13,513	-----	48	13,561
Minnesota	74	51,441	897	39,865	92,203	69	51,454	681	45,052	97,187
Wisconsin	2	1,129	-----	-----	1,129	2	1,081	-----	-----	1,081
Total	99	64,743	897	39,865	105,505	95	66,049	681	45,100	111,829
Southeastern States:										
Alabama	[1] 27	2,688	2,868	-----	5,556	[1] 24	(2)	6,525	-----	6,525
Georgia	11	-----	594	-----	594	10	-----	832	-----	832
Total	38	2,688	3,462	-----	6,150	34	-----	7,357	-----	7,357
Northeastern States:										
New Jersey and Pennsylvania	4	-----	-----	3,109	3,109	} 8	-----	-----	} 11,232	} 11,232
New York	5	-----	-----	6,697	6,697					
Total	9	-----	-----	9,806	9,806	8	-----	-----	11,232	11,232
Western States:										
Arkansas	-----	-----	-----	-----	-----	1	-----	51	-----	51
Colorado	4	-----	26	(3)	26	(3)	-----	(3)	-----	(3)
Idaho	3	5	-----	7	12	3	(2)	-----	5	5
Missouri	10	(2)	799	-----	799	11	(2)	923	-----	923
Montana	3	16	-----	18	34	2	-----	-----	9	9
Nevada	17	(2)	-----	1,102	1,102	13	(2)	-----	741	741
New Mexico	1	-----	-----	(3)	(3)	2	-----	-----	42	42
South Dakota	1	22	-----	-----	22	2	25	-----	-----	25
Utah	6	3,833	-----	(2)	3,833	6	3,058	-----	(2)	3,058
Wyoming	(3)	(3)	-----	(3)	(3)	4	(2)	-----	1,496	1,496
Total	44	3,876	825	1,127	5,828	44	3,083	974	2,293	6,350
Undistributed [3]	16	8,741	-----	555	9,296	19	3,933	2,401	201	6,535
Grand total [4]	206	80,048	5,184	51,353	136,585	200	73,064	11,413	58,825	143,303

[1] Excludes a number of small pits. Output of these pits included in total.
[2] Included with other varieties in the same State.
[3] Included in "Undistributed" to avoid disclosing individual company confidential data. Totals for 1961 include Tennessee, Arizona, California, New Mexico, Texas, Wyoming; totals for 1962 include Tennessee, Arizona, California, Colorado, Oregon, Texas.
[4] In some instances data do not add to totals because of rounding.

TABLE 5.—Crude iron ore mined in the United States, by districts, States and mining methods

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

State	1961			1962		
	Open pit	Underground	Total [1]	Open pit	Underground	Total [1]
Lake Superior:						
Michigan	4,893	7,280	12,173	6,859	6,702	13,561
Minnesota	90,627	1,576	92,203	95,576	1,611	97,187
Wisconsin		1,129	1,129		1,081	1,081
Total	95,521	9,984	105,505	102,435	9,394	111,829
Southeastern States:						
Alabama	2,878	2,678	5,556	6,525	(2)	6,525
Georgia	594		594	832		832
Total	3,472	2,678	6,150	7,357		7,357
Northeastern States:						
New Jersey and Pennsylvania		3,109	3,109		} 11,232	} 11,232
New York	6,697	(2)	6,697	(3)		
Total	6,697	3,109	9,806		11,232	11,232
Western States:						
Arkansas				51		51
Colorado	26		26	(4)		(4)
Idaho	12		12	5		5
Missouri	799	(2)	799	923	(2)	923
Montana	34		34	9		9
Nevada	1,102	(2)	1,102	741	(2)	741
New Mexico	(4)		(4)	42		48
South Dakota	22		22	25		26
Utah	3,833		3,833	3,058		3,058
Wyoming	(4)	(2)	(4)	1,496	(2)	1,496
Total	5,829		5,829	6,350		6,350
Undistributed [4]	9,296		9,296	6,535		6,535
Grand total [1]	120,813	15,772	136,585	122,676	20,626	143,303

[1] In some instances data does not add to total because of rounding.
[2] Included with open pit.
[3] Included with underground.
[4] Included with "Undistributed" to avoid disclosing individual company confidential data. Totals for 1961 include Tennessee, Arizona, California, New Mexico, Texas, Wyoming; totals for 1962 include Tennessee, Arizona, California, Colorado, Oregon, Texas.

TABLE 6.—Crude iron ore shipped from mines in the United States, by districts, States, and disposition

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

District and State	1961			1962		
	Direct to consumers	To beneficiation plants	Total	Direct to consumers	To beneficiation plants	Total [1]
Lake Superior:						
Michigan	6,041	6,120	12,161	5,557	7,956	13,513
Minnesota	12,635	79,825	92,460	11,466	85,729	97,195
Wisconsin	1,122	-----	1,122	1,045	-----	1,045
Total	19,798	85,945	105,743	18,067	93,685	111,753
Southeastern States:						
Alabama	1,595	4,052	5,647	(2)	6,528	6,528
Georgia	(2)	594	594	-----	832	832
North Carolina	(3)	-----	(3)	1	-----	1
Total	1,595	4,646	6,241	1	7,360	7,361
Northeastern States:						
New Jersey and Pennsylvania	-----	3,418	3,418	-----	} 11,124	} 11,124
New York	-----	6,696	6,696	-----		
Total	-----	10,114	10,114	-----	11,124	11,124
Western States:						
Arkansas	-----	-----	-----	43	-----	43
Colorado	[4] 27	-----	[4] 27	(3)	-----	(3)
Idaho	12	-----	12	5	-----	5
Missouri	-----	858	858	-----	923	923
Montana	34	-----	34	9	-----	9
Nevada	(2)	1,108	1,108	742	(5)	742
New Mexico	(3)	-----	(3)	(2)	28	28
South Dakota	22	-----	22	34	-----	34
Utah	3,742	(5)	3,742	2,727	(5)	2,727
Wyoming	(3)	(3)	(3)	-----	1,450	1,450
Total	3,837	1,966	5,803	3,559	2,400	5,960
Undistributed [3]	688	8,153	8,841	485	6,002	6,487
Grand total	25,917	110,824	136,741	22,113	120,571	142,684

[1] In some instances data do not add to totals because of rounding.
[2] Included with ore shipped to beneficiation plants.
[3] Included with "Undistributed" to avoid disclosing individual company confidential data. Totals for 1961 include Tennessee, Arizona, California, New Mexico, North Carolina, Texas, Wyoming; totals for 1962 include Tennessee, Arizona, California, Colorado, Oregon, Texas.
[4] Revised figure.
[5] Included with ore shipped direct to consumers.

TABLE 7.—Plant capacity for producing iron-ore pellets, United States and Canada

(Plants existing or under construction)

State or Province and company and plant	Date of first production	Approximate annual capacity (thousand long tons pellets)
United States:		
Michigan:		
Humboldt Mining Co., Humboldt	1955	650
Marquette Iron Mining Co., Republic	1955	800
Marquette Iron Mining Co., Republic (expansion)	1962	800
Marquette Iron Mining Co. (Eagle Mill)	1956	800
Empire Iron Mining Co., Empire	1963	1,200
The Hanna Mining Co., Groveland	1963	1,250
Minnesota:		
Erie Mining Co., Hoyt Lakes	1958	7,500
Reserve Mining Co., E. W. Davis	1955	6,000
Reserve Mining Co., E. W. Davis (expansion)	1963	3,000
Missouri: Meramac Mining Co., Pea Ridge	1963	2,000
Pennsylvania:		
Bethlehem-Cornwall Corp., Grace	1963	2,000
Bethlehem-Cornwall Corp., Cornwall	1958	600
Wyoming: United States Steel Corp., Atlantic City	1962	1,500
Total		28,100
Canada: [1]		
British Columbia: Consolidated Mining & Smelting Co. of Canada, Ltd., Kimberly	1961	100
Labrador:		
Carol Pellet Co., Labrador City	1963	5,500
Wabush Mines, Labrador City (concentrate and possibly pellets)	1964–65	[2] (5,500)
Ontario:		
The International Nickel Company of Canada, Ltd., Sudbury	1957	300
The International Nickel Company of Canada, Ltd., Sudbury (expansion)	1963	450
Jones and Laughlin Steel Corp., Kirkland Lake	1964	1,000
Quebec:		
Hilton Mines, Ltd., Bristol	1958	800
Marmoraton Mining Co., Ltd., Marmora	1955	500
Total		8,650

[1] Source: Canadian Dept. of Mines and Tech. Surveys Miner. Inf. Bull. MR 63, 1963, 48 pp.
[2] Not included in total.

TABLE 8.—Usable iron ore produced in the United States, by districts and varieties

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

District and State	1961				1962			
	Hematite	Brown ore	Magnetite	Total [1]	Hematite	Brown ore	Magnetite	Total [1]
Lake Superior:								
Michigan	8,364			8,364	9,259			9,259
Minnesota	30,062	491	13,161	43,714	30,119	362	14,735	45,216
Wisconsin	1,129			1,129	1,081			1,081
Total	39,555	491	13,161	53,207	40,459	362	14,735	55,556
Southeastern States:								
Alabama	2,583	800		3,383	(2)	2,978		2,978
Georgia		156		156		208		208
Total	2,583	956		3,539		3,186		3,186
Northeastern States:								
New Jersey and Pennsylvania			1,692	1,692			} 4,584	4,584
New York			2,356	2,356				
Total			4,048	4,048			4,584	4,584
Western States:								
Arkansas						51		51
Colorado		26	(2)	26		(3)		(3)
Idaho	5		7	12	(2)		5	5
Missouri	317	(2)		317	356	(2)		356
Montana	16		18	34			9	9
Nevada	(2)		837	837	(2)		617	617
New Mexico			(3)	(3)			11	11
South Dakota	22			22	25			25
Utah	3,602		(2)	3,602	2,614		(2)	2,614
Wyoming	(3)		(3)	(3)	(2)		750	750
Total	3,962	26	862	4,850	2,995	51	1,392	4,438
Undistributed [3]	4,783		224	5,007	3,409	(2)	77	3,485
Total all States	50,883	1,473	18,295	70,653	46,863	3,599	20,788	71,250
Byproduct ore [4]				676				579
Grand total	50,883	1,473	18,295	71,329	46,863	3,599	20,788	71,829

[1] In some instances data do not add to totals because of rounding.
[2] Included with other varieties in the same State.
[3] Included with undistributed to avoid disclosing individual company confidential data. Totals for 1961 include Tennessee, Arizona, California, New Mexico, Texas, Wyoming; totals for 1962 include Arizona, California, Colorado, Oregon, Texas.
[4] Cinder and sinter obtained from treating pyrites. Ore was treated in Arizona, Colorado, Tennessee, Pennsylvania, Virginia.

TABLE 9.—Usable iron ore produced in the United States, by districts, States and types of products

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

District and State	1961				1962			
	Direct-shipping ore	Agglomerates [1]	Concentrates	Iron content (natural percent) [2]	Direct-shipping ore	Agglomerates [1]	Concentrates	Iron content (natural percent) [2]
Lake Superior:								
Michigan	5,041	1,475	1,849	54.86	5,064	2,427	1,768	55.73
Minnesota	12,579	13,161	17,973	55.39	11,385	14,840	18,991	55.83
Wisconsin	1,129	---	---	53.58	1,081	---	---	54.21
Total	18,749	14,637	19,822	55.27	17,531	17,267	20,759	55.78
Southeastern States:								
Alabama	1,914	(3)	1,470	36.35	(3)	(3)	2,978	28.52
Georgia	(3)	---	156	46.15	---	---	208	47.60
Total	1,914	---	1,626	36.81	---	---	3,186	29.76
Northeastern States:								
New Jersey and Pennsylvania	---	(3)	1,692	63.94	---	} 3,392	} 1,192	63.05
New York	---	1,463	893	60.82	---			
Total	---	1,463	2,585	62.13	---	3,392	1,192	63.05
Western States:								
Arkansas	---	---	---	---	51	---	---	48.53
Colorado	26	---	---	65.38	(4)	---	---	(4)
Idaho	12	---	---	50.00	5	---	---	60.95
Missouri	---	---	317	50.15	---	---	356	52.62
Montana	34	---	---	52.94	9	---	---	45.00
Nevada	837	---	(3)	59.97	617	---	(3)	61.42
New Mexico	(4)	---	---	(4)	(3)	---	11	63.64
South Dakota	22	---	---	50.00	25	---	---	42.00
Utah	3,602	---	(2)	51.27	2,614	---	(3)	51.68
Wyoming	(4)	---	(4)	(4)	750	(3)	(3)	50.18
Total	4,534	---	317	52.78	4,072	---	367	52.79
Undistributed [4]	728	---	4,280	52.83	530	---	2,955	53.86
Total all States	25,924	16,099	28,630	54.47	22,132	20,659	28,459	54.80
Byproduct ore [5]	---	676	---	67.15	---	579	---	69.79
Grand total	25,924	16,775	28,630	54.51	22,132	21,238	28,459	54.93

[1] Exclusive of agglomerates produced at consuming plants.
[2] Average iron content of all types shipped. For breakdown by type see table 8.
[3] Included with other types in the same State.
[4] Included with Undistributed to avoid disclosing individual company confidential data. Totals for 1961 include Tennessee, Arizona, California, New Mexico, Texas, Wyoming; totals for 1962 include Tennessee, Arizona, California, Colorado, Oregon, Texas.
[5] Cinder and sinter obtained from treating pyrites.

TABLE 10.—Shipments of usable iron ore from mines in the United States in 1962, by States and types of product

(Thousand long tons and thousand dollars; exclusive of ore containing 5 percent or more manganese)

District and State	Gross wieght of ore shipped				Iron content of ore shipped				Total value [1]
	Direct shipping ore	Agglomerates	Concentrates	Total quantity [1]	Direct-shipping ore	Agglomerates	Concentrates	Total quantity [1]	
Lake Superior:									
Michigan	5,557	2,222	1,644	9,422	2,924	} 10,003	} 11,162	} 29,959	$85,597
Minnesota	11,466	14,085	18,744	44,295	5,870				385,997
Wisconsin	1,045			1,045	567			567	(2)
Total	18,068	16,307	20,387	54,761	9,360	10,003	11,162	30,526	471,594
Southeastern States:									
Alabama	(3)	(3)	2,962	2,962	(3)	(3)	1,204	1,204	17,838
Georgia			215	215			99	99	1,118
North Carolina	1			1	1			1	13
Total	1		3,177	3,179	1		1,302	1,303	18,969
Northeastern States:									
New Jersey and Pennsylvania		(3)	2,082	2,082		(3)	1,345	1,345	37,394
New York		2,099	(3)	2,099		1,314	(3)	1,314	24,953
Total		2,099	2,082	4,180		1,314	1,345	2,660	62,347
Western States:									
Arkansas	43			43	21			21	296
Idaho	5			5	3			3	35
Missouri			346	346			179	179	3,188
Montana	9			9	4			4	62
Nevada	617		(3)	617	379		(3)	379	3,238
New Mexico	(3)		9	9	(3)		6	6	121
South Dakota	34			34	14			14	113
Utah	2,630		(3)	2,630	1,359		(3)	1,359	18,242
Wyoming	739	(3)	(3)	739	369	(3)	(4)	369	6,441
Total	4,078		355	4,433	2,151		185	2,335	31,736
Undistributed [2]	488		2,928	3,416	53		1,839	1,892	33,596
Total all States	22,634	18,405	28,930	69,969	11,565	11,318	15,834	38,715	618,242
Byproduct ore [5]		441		441		298		298	6,278
Grand total	22,634	18,846	28,930	70,410	11,565	11,615	15,834	39,013	624,520

[1] In some instances data do not add to totals shown because of rounding.
[2] Undistributed includes totals for Arizona, Colorado, New Mexico, Oregon, Tennessee, Virginia, Texas, California to avoid disclosing individual company confidential data.
[3] Included with other types in the same State.
[4] Not available.
[5] Cinder and sinter obtained from treating pyrites. Ore was treated in Arizona, Colorado, Pennsylvania, Tennessee, Virginia.

TABLE 11.—Iron ore produced in the Lake Superior district, by ranges

(Thousand long tons and exclusive after 1905 of ore containing 5 percent or more manganese)

Year	Marquette	Menominee	Gogebic	Vermillion	Mesabi	Cuyuna	Total [1]
1854-1957	295,855	258,095	303,190	[2] 93,566	2,161,385	[3] 61,242	3,173,333
1958	4,111	2,896	2,549	(4)	40,860	[3] 1,360	51,777
1959	2,851	2,677	2,546	(4)	34,556	[3] 1,321	43,950
1960	6,619	4,079	3,653	[3] 1,834	54,442	1,166	71,792
1961	3,205	4,097	2,190	[3] 1,421	41,199	1,095	53,207
1962	4,563	3,460	2,318	[3] 1,521	43,041	655	55,556
Total	317,204	275,304	316,446	98,342	2,375,481	66,839	3,449,615

[1] In some instances data do not add to totals due to rounding of figures.
[2] Production for 1957 included with Mesabi range.
[3] Includes production from Spring Valley district not in the true Lake Superior district.
[4] Included with Mesabi range to avoid disclosing individual company confidential data.

TABLE 12.—Average analyses of total tonnages (bill-of-lading weights) of all grades of iron ore from all ranges of Lake Superior district

Year	Long tons	Content (natural), percent					
		Iron	Phosphorus	Silica	Manganese	Moisture	Alumina [1]
1953-57 (average)	80,020,266	51.05	0.092	9.95	0.70	10.50	----------
1958	52,243,820	53.78	.086	8.76	.53	8.49	----------
1959	44,402,848	53.81	.085	8.93	.61	8.29	----------
1960	67,438,764	53.84	.083	8.90	.63	8.26	----------
1961	55,402,968	55.20	.080	8.60	.56	7.19	1.21
1962	55,009,704	55.60	.077	8.45	.51	7.04	1.24

[1] Alumina analyses not available prior to 1961.

TABLE 13.—Beneficiated iron ore shipped from mines in the United States [1]

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

Year	Beneficiated	Total	Proportion of beneficiated to total (percent)
1953-57 (average)	36,024	99,933	36.0
1958	31,968	66,288	48.2
1959	30,363	59,164	51.3
1960	46,012	82,963	55.5
1961	46,125	72,379	63.7
1962	46,942	69,969	67.1

[1] Excludes byproduct ore.

CONSUMPTION AND USES

Tables 14 and 15 contain a revision in reporting format and are not strictly comparable with tables of preceding years in this series. However, the tonnage difference is relatively small and the new format provides consumption in blast and steel furnaces rather than consumption in ore preparation plants. Previously the weight of iron ore and concentrate used in making agglomerate was counted as consumption even though the agglomerate might not be consumed during the year in which it was produced.

In table 14, the ratio of iron ore consumed to agglomerate produced (table 15) was applied to total agglomerate consumed to derive the figure for iron ore.

Iron ore consumed in making sinter included foreign and domestic concentrates, foreign and domestic direct-shipping ores, and ore fines generated in shipping. Materials such as limestone, flue dust, mill scale, and coke breeze were also used in sintering, but these materials are excluded from the iron ore consumption total.

Monthly consumption of ore by the iron and steel industry declined from an average of about 10 million long tons in the first 4 months to lower the 1962 total below 101 million tons.

Miscellaneous uses included consumption in Portland and other hydraulic cements; minor quantitites in special heavy density concrete; and use as a heavy medium (magnetite) in coal preparation plants. Precise data on the tonnage of magnetite used in coal washing plants were unavailable, but an estimate based on 0.5 pounds per ton of washed material placed consumption at about 13,000 tons, which was not included in table 14.

TABLE 14.—Consumption of iron ore and iron ore agglomerates in the United States in 1962

(Long tons and exclusive of ore containing 5 percent or more manganese)

State	Iron ore (not agglomerated)		Agglomerates consumed [1]		Miscellaneous [2]	Total
	Blast furnaces	Steel furnaces	Blast furnaces	Steel furnaces		
Alabama, Kentucky, Tennessee, Texas	4,757,969	281,266	3,787,396	524	102,318	8,929,473
California, Colorado, Utah	2,869,859	355,728	2,771,846		(3)	5,997,433
Maryland and West Virginia	3,786,464	693,380	5,748,008		(3)	10,227,852
Illinois and Indiana	8,485,617	1,610,623	11,361,523	234,185	(3)	21,691,948
Michigan and Minnesota	2,515,820	273,980	5,291,036	1,400	539,801	8,622,037
New York, Ohio, Pennsylvania, New Jersey	15,005,042	2,716,125	27,659,452	813,472	56,040	46,250,131
Undistributed [3]					149,816	149,816
Total	37,420,771	5,931,102	56,619,261	1,049,581	847,975	101,868,690
Consumption of iron ore. (Computed—assuming iron ore in agglomerate equivalent to 96 percent of gross weight)						99,562,000

[1] Includes 1.3 million tons of agglomerate produced in foreign countries.
[2] Miscellaneous includes iron ore used in making paint and cement, also ore consumed in ferroalloy furnaces.
[3] Included in "Undistributed" to avoid disclosing individual company confidential data.

TABLE 15.—Iron ore [1] consumed in agglomerating plants and agglomerate produced in 1962, by States

(Long tons)

State	Iron ore [1] consumed	Agglomerate produced
Alabama, Kentucky, Tennessee, Texas	3,775,886	5,094,792
California, Colorado, Utah, Wyoming	2,768,648	3,069,022
Maryland and West Virginia	5,242,948	5,554,528
Illinois and Indiana	8,408,050	9,016,476
Michigan and Minnesota	20,615,096	20,345,361
New York, Ohio, Pennsylvania	17,552,771	17,823,568
Total	58,363,399	60,903,747

[1] Iron ore including taconite concentrate used in making agglomerate.

TABLE 16.—Production and consumption of agglomerates in the United States in 1962, by types

(Long tons)

Type	Agglomerate produced	Agglomerate consumed	
		Blast furnace	Steel furnace
Sinter [1]	42,008,882	41,746,647	21,789
Pellets	18,424,619	13,671,170	305,773
Nodules	(2)	170,781	246,993
Other	470,246	183,935	(3)
Foreign		846,728	475,028
Total	60,903,747	56,619,261	1,049,583

[1] Includes 11,995,000 tons of self-flexing sinter.
[2] Included with other.
[3] Included with sinter.

STOCKS

Stocks at consuming plants and mines at yearend were 59.5 million and 11.6 million long tons, respectively. Stocks at U.S. docks totaled 6.4 million tons, according to the American Iron Ore Association.

TABLE 17.—Stocks of usable iron ore at mines, Dec. 31, by States

(Thousand long tons)

State	1961	1962
Michigan, Minnesota, Wisconsin	[1] 7,989	8,784
Alabama and North Carolina	44	58
New Jersey, New York, Pennsylvania	1,463	1,873
Arizona, California, Nevada, New Mexico, Utah	[1] 709	814
Arkansas, Colorado, Idaho, Missouri, Texas, Wyoming	[1] 131	112
Total [2]	[1] 10,335	11,642

[1] Revised figures.
[2] Data do not add to totals because of rounding.

PRICES

The Oliver Mining Division of United States Steel Corp. reduced the price of untreated Mesabi Range iron ores by $0.80 per long ton effective April 1, and most other producers followed this lead with comparable reductions. New base prices for Lake Superior standard iron ores containing 51.5 percent iron, natural, at rail of vessel, lower lake ports were: Mesabi non-Bessemer $10.65; Mesabi Bessemer, $10.80; Old Range non-Bessemer $10.90; and Old Range Bessemer $11.05. Lake Superior pellets were quoted at $0.252 per iron unit or about $16.00 per ton, depending upon grade.

The average value of domestic usable ore per long ton f.o.b. mines excluding byproduct ore was $8.84 compared with $8.99 in 1961 and $8.69 in 1959. These values were compiled from producers' statements and approximated the commercial selling price less the cost of mine-to-market transportation.

TABLE 18.—Average value of iron ore shipped from mines in the United States in 1962

(Per long ton)

District	Direct-shipping ore			Iron ore concentrates			Iron ore agglomerates
	Hematite	Brown ore	Magnetite	Hematite	Brown ore	Magnetite	
Lake Superior	$7.26			$7.70	(1)		$11.77
Southeastern	7.20		$12.00	(2)	$5.36		(3)
Northeastern						$14.59	14.99
Western	6.52	$5.75	6.54	6.69	11.18	6.43	11.96
Total	7.15	5.75	6.54	7.55	7.02	12.69	12.25

1 Included with hematite.
2 Included with brown ore.
3 Included with total.

TRANSPORTATION

The first upper lake cargoes of 1962 were from Taconite Harbor, Minn., and Escanaba, Mich., on April 17. The final cargo was from Taconite Harbor on December 13. Dates of first and final cargoes from other ports were published.[5] Great Lakes shipments from domestic ports totaled 53,709,688 long tons, according to the American Iron Ore Association. Shipments to lower lake ports, from foreign sources, totaled 9,593,987 tons.

Freight rates from the Minnesota range to Pittsburgh via the rail-lake-rail system totaled about $6.70 per long ton compared with a rail rate (excluding port handling charges) of about $3.76 from East Coast ports.

The Contrecoeur Transfer Dock, 30 miles downstream from Montreal, Canada, and the new iron ore loading facility at Long Beach, Calif., were described.[6]

The Contrecoeur dock was used for transshipping iron ore from ocean-going ships to smaller lake vessels to transit the St. Lawrence Seaway. The Long Beach facility was used principally for loading exports to Japan. Several ore carriers exceeding 50,000 tons were in service, and, reportedly, a 67,000-ton carrier was ordered by a Norwegian shipping firm for delivery in 1964 to carry ore from Lourenco Marques, Mozambique, to Japan.

FOREIGN TRADE[7]

Imports increased nearly to those of 1959 and 1960 and comprised 32 percent of the total new supply in 1962. Two large new producers in Canada, affiliated with U.S. consuming interests, accounted for much of the increase in imports from Canada. Exports, chiefly to Canada and Japan, totaled nearly 6 million tons. Values listed in table 19 represent reported values at points of shipment.

[5] Skillings' Mining Review. V. 51, No. 52, Dec. 29, 1962, pp. 4, 5.
[6] Skillings, David N., Jr. Contrecoeur Transfer Dock. Skillings' Min. Rev., v. 51, No. 46, Nov. 17, 1962, pp. 1, 4, 5.
Skillings' Mining Review. New Bulk Ship Loading Facility at Long Beach, Calif. V. 51, No. 17, Apr. 28, 1962, pp. 1, 4, 5.
[7] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 19.—U.S. imports for consumption of iron ore,[1] by countries

(Thousand long tons and thousand dollars)

Country	1953–57 (average)		1958		1959		1960		1961		1962	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
North America:												
Canada	8,343	$70,635	8,289	$77,329	13,458	$128,940	10,595	$104,709	9,683	$99,164	16,844	$169,925
Cuba	80	751	--	--	4	40	3	30	--	--	--	--
Dominican Republic	117	1,451	21	298	50	552	--	--	--	--	--	--
Mexico	186	646	221	739	106	356	150	513	123	421	145	546
Other	(2)	2	14	164	--	--	--	--	--	--	--	--
Total	8,726	73,485	8,545	78,530	13,618	129,888	10,748	105,252	9,806	99,585	16,989	170,471
South America:												
Brazil	944	12,062	832	12,004	1,200	13,613	1,461	15,518	889	9,613	1,319	14,303
Chile	1,873	11,410	3,257	25,876	3,590	27,815	3,942	30,684	2,604	21,913	3,400	28,812
Peru	1,710	14,501	1,674	16,785	2,236	21,358	2,758	26,828	1,209	11,752	571	6,182
Surinam	--	--	--	--	2	23	--	--	--	--	--	--
Venezuela	7,173	49,655	12,180	87,976	13,542	104,347	14,555	133,138	10,478	99,118	10,313	96,836
Total	11,700	87,628	17,943	142,641	20,570	167,156	22,716	206,168	15,180	142,396	15,603	146,133
Europe:												
Spain	2	26	(2)	6	(2)	6	(2)	7	(2)	3	--	--
Sweden	1,308	15,055	113	1,640	136	1,737	94	1,543	78	1,156	32	566
United Kingdom	(2)	37	1	54	19	195	(2)	29	2	147	--	--
Other	(2)	2	(2)	5	16	162	1	13	1	7	1	24
Total	1,310	15,120	114	1,705	171	2,100	95	1,592	81	1,313	33	590
Asia:												
Iran	2	134	2	167	3	187	2	133	--	--	--	--
Philippines	5	76	54	1,131	71	1,491	1	22	--	--	49	1,018
Portuguese Asia	--	--	--	--	--	--	57	367	--	--	--	--
Other	--	--	--	--	--	--	--	--	(2)	1	(2)	12
Total	7	210	56	1,298	74	1,678	60	522	(2)	1	49	1,030
Africa:												
British West Africa	190	1,163	49	351	62	481	46	315	--	--	--	--
Liberia	927	8,003	837	7,092	1,105	10,981	907	8,034	715	6,728	757	6,478
Other	20	240	--	--	17	163	6	36	23	203	--	--
Total	1,137	9,406	886	7,443	1,184	11,625	959	8,385	738	6,931	757	6,478
Grand total	22,880	185,849	27,544	231,617	35,617	312,447	34,578	321,919	25,805	250,226	33,431	324,702

[1] In addition pyrites cinder (byproduct iron ore) were imported as follows: 1953–57 (average) 3,765 long tons ($16,345); 1958, 2,721 tons ($9,212) all from Canada; 1959, Canada 6,741 tons ($22,988), Italy 3,416 tons ($24,812); 1960, 5,884 tons ($19,679); 1961, 3,504 tons ($17,822) all from Canada; 1962, 4,248 tons ($26,345) all from Canada.

[2] Less than 1,000 tons. Source: Bureau of the Census.

TABLE 20.—U.S. imports for consumption of iron ore in 1962, by customs districts

Customs district	Long tons	Value	Customs district	Long tons	Value
Buffalo	1,349,464	$17,486,445	New York	68	$275
Chicago	1,900,915	18,739,116	Ohio	4,630,107	43,256,629
Connecticut	1,302	18,228	Philadelphia	11,120,559	110,555,488
Duluth and Superior	201	1,983	St. Lawrence	390	38,385
Galveston	377,503	3,442,250	San Francisco	1,555	14,617
Laredo	144,770	545,828	Virginia	349,482	3,250,975
Maryland	9,576,963	88,321,238	Wisconsin	270	3,625
Michigan	1,712,640	17,839,392			
Mobile	1,453,188	13,368,084	Total	33,431,077	324,701,829
New Orleans	811,700	7,819,271			

Source: Bureau of the Census.

TABLE 21.—U.S. exports of iron ore, by countries

(Thousand long tons and thousand dollars)

Destination	1953-57 (average)		1958		1959		1960		1961		1962	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Canada	3,877	$31,997	3,077	$29,701	2,453	$28,189	3,428	$48,989	3,889	$42,269	4,781	$51,377
Germany, West	(1)	2	(1)	(2)	-------	-------	(1)	(2)	[3] 172	[3] 1,993	64	326
Japan	606	6,022	493	5,044	507	5,247	839	8,622	883	[3] 9,655	981	10,213
South Africa, Republic of [4]	1	62	3	140	3	127	4	174	4	179	5	164
United Kingdom	-------	-------	-------	-------	-------	-------	-------	-------	6	70	64	714
Other	1	26	(5)	13	4	268	2	114	4	[3] 64	3	39
Total	4,485	38,109	3,573	34,898	2,967	33,831	5,273	57,899	[3] 4,958	[3] 54,230	5,898	62,833

[1] Less than 1,000 tons.
[2] Less than $1,000.
[3] Revised figure.
[4] Effective Jan. 1, 1962; formerly Union of South Africa.
[5] Includes countries receiving less than 1,000 tons each.

Source: Bureau of the Census.

WORLD REVIEW

The United States produced 14 percent of the world iron ore output in 1962, compared with 17 percent in 1960 and 40 percent in 1950. This decline in relative importance was chiefly the result of vastly increased foreign production. Major factors in the world situation were the slackening requirements in West European, United States, and Japanese markets; the trend to high-quality ores at the expense of lower grade ores from established producers; and the large number of iron ore sources controlled by many different groups. Probably the most important new areas were the Pilbara iron ore field in Western Australia and a major discovery in the Yukon and the Northwest Territories, Canada.

TABLE 22.—World production of iron ore, iron ore concentrates, and iron ore agglomerates by countries [1]

(Thousand long tons)

Country	1953–57 (average)	1958	1959	1960	1961	1962
North America:						
Canada	13,353	14,042	21,864	19,241	18,177	24,909
Cuba	123	16	[2] 15	[2] 15	[2] 15	[2] 15
Dominican Republic	127	30	[2] 12	121	------	------
Guatemala	3	5	[2] 4	[2] 4	[2] 5	[2] 2
Mexico	699	[2] 955	[2] 875	924	1,189	1,130
United States [3]	100,630	67,709	60,276	88,784	71,329	71,829
Total	114,935	82,757	83,046	109,089	90,715	97,885
South America:						
Argentina	71	65	108	157	118	118
Brazil	3,764	5,103	8,766	9,197	9,628	[2] 9,842
Chile	2,369	3,700	4,576	5,946	6,879	[2] 7,874
Colombia	[4] 349	553	399	645	665	[2] 615
Peru	2,201	3,532	3,519	6,880	8,599	6,569
Venezuela	8,377	15,240	16,929	19,182	14,335	13,057
Total	17,131	28,193	34,297	42,007	40,224	38,075
Europe:						
Albania	(5)	88	173	[2] 245	[2] 225	[2] 245
Austria	2,966	3,356	3,329	3,486	3,635	3,692
Belgium	112	121	140	157	113	79
Bulgaria	168	288	367	405	411	618
Czechoslovakia	2,418	2,755	2,921	3,071	3,242	3,422
Finland [6]	148	212	224	269	280	291
France	48,635	58,534	59,976	65,907	65,525	65,272
Germany:						
East	1,522	1,482	1,574	1,616	1,616	1,617
West	16,000	17,704	17,778	18,571	18,568	16,380
Greece	219	275	154	292	287	[2] 295
Hungary	358	365	432	508	595	671
Italy	1,325	1,272	1,217	1,241	1,183	1,133
Luxembourg	7,027	6,533	6,406	6,867	7,340	6,404
Norway	1,315	1,617	1,558	1,665	1,647	1,919
Poland	1,552	1,931	1,982	2,148	2,348	2,398
Portugal	191	228	238	297	230	230
Rumania	642	731	1,047	1,437	1,710	1,714
Spain	3,824	4,954	4,536	5,549	5,967	5,752
Sweden	17,427	18,023	18,061	20,983	22,766	21,675
Switzerland	115	[2] 75	[2] 60	[2] 125	[2] 85	[2] 100
U.S.S.R. [7]	70,515	87,414	92,531	104,343	116,137	126,077
United Kingdom	16,140	14,613	14,870	17,088	16,518	15,277
Yugoslavia	1,359	1,965	2,062	2,165	2,150	2,155
Total [7]	194,017	224,536	231,636	258,435	272,578	277,416
Asia:						
Burma	[4] 4	6	4	16	[2] 16	9
China [2] [8]	8,661	29,500	44,300	54,100	44,300	34,400
Hong Kong	109	105	120	115	117	110
India	4,565	6,033	7,856	10,514	12,076	12,972
Iran [9]	10	138	59	57	41	10
Japan [10]	1,740	2,056	2,508	2,809	2,826	2,445
Korea:						
North	(5)	1,527	2,660	3,059	[2] 3,400	[2] 3,900
Republic of	64	257	278	386	497	464
Lebanon	40	22	3	8	------	[2] 2
Malaya	1,832	2,795	3,761	5,641	6,734	6,508
Pakistan [11]	[12] 16	8	2	6	4	[2] 4
Philippines	1,350	1,082	1,211	1,121	1,153	1,365
Portuguese India	1,974	2,889	3,025	5,764	6,381	5,354
Taiwan [13]	[12] 4	10	9	8	13	6
Thailand	6	15	6	11	55	44
Turkey	777	936	859	778	746	761
Total [2] [8]	21,900	47,400	66,650	84,400	78,350	68,350

See footnotes at end of table.

TABLE 22.—World production of iron ore, iron ore concentrates, and iron ore agglomerates by countries [1]—Continued

(Thousand long tons)

Country	1953-57 (average)	1958	1959	1960	1961	1962
Africa:						
Algeria	3,018	2,298	1,897	3,384	2,822	2,029
Angola	60	282	343	649	799	742
Guinea, Republic of	705	405	337	764	533	689
Liberia	1,683	2,264	2,647	3,003	3,200	3,550
Mauritania					295	984
Morocco	1,543	1,514	1,245	1,552	1,439	1,131
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	92	143	128	156	382	609
Sierra Leone	1,211	1,300	1,426	1,447	1,668	[14] 1,983
South Africa, Republic of	1,969	2,177	2,845	3,023	3,898	4,263
Sudan				3		20
Tunisia	1,085	1,086	966	1,017	836	749
United Arab Republic (Egypt)	[12] 190	175	242	237	415	453
Total	11,556	11,644	12,076	15,235	16,287	17,202
Oceania:						
Australia	3,624	3,917	4,141	4,355	5,342	4,780
Fiji	[15] 1	3	12	24	10	6
New Caledonia	[12] 129	290	282	272	273	298
Total	3,754	4,210	4,435	4,651	5,625	5,084
World total (estimate) [1]	363,293	398,740	432,140	513,817	503,779	504,012

[1] This table incorporates some revisions. Data do not add to totals shown because of rounding where estimated figures are included in the detail.
[2] Estimate.
[3] Includes byproduct ore.
[4] Average annual production 1954-57.
[5] Data not available, estimate included in the total.
[6] Iron concentrates and pellets.
[7] U.S.S.R. in Asia included with U.S.S.R. in Europe.
[8] Roughly equivalent of 50 percent iron.
[9] Year ending March 21 of year following that stated.
[10] Includes iron sand production as follows: 1953-57 (average), 714,065; 1958, 898,913; 1959, 1,335,655; 1960, 1,539,346; 1961, 1,685,137; and 1962, 1,366,044 tons.
[11] Obtained principally during exploration activities.
[12] Average annual production 1956-57.
[13] Principally magnetite sands with limonite.
[14] Exports.
[15] 1 year only because 1957 was the first year of commercial production.

Compiled by Liela S. Price, Division of Foreign Activities.

TABLE 23.—World trade of iron ore, iron ore concentrates, and iron-ore agglomerates in 1961

(Thousand long tons)

Exports by countries of origin	Fe (percent)[1]	Production	Exports	Exports by countries of destination																	
				North America		Europe													Asia	Oceania	
				Canada	United States	Austria	Belgium-Luxembourg	Czechoslovakia	France	Germany, East	Germany, West	Hungary	Italy	Netherlands	Poland	Rumania	United Kingdom	Other Europe	Japan	Australia	Other countries
North America:																					
Canada	55	18,177	14,868		9,381		348		[2] 34		[2] 1,437		104	89			2,315		1,159		1
Cuba	62	[1] 15																			
Mexico	57	1,189	121		121																
United States	49	[3] 71,329	4,958	3,889							172						6		883		8
South America:																					
Brazil	67	9,628	6,138	119	889			509	[2] 163		2,621		289	186	312	27	508	60	398	22	35
Chile	63	6,879	6,634		3,528		27	4			499			36					2,403		137
Colombia	42	665																			
Peru	54	8,599	5,506		1,245				15		1,462		83				140		2,442		119
Venezuela	60	14,335	14,335		10,280						1,573		908				1,574				
Europe:																					
Austria	30	3,635	10					10													
Belgium-Luxembourg	35	7,453	186						184												2
Bulgaria	45	411	12															12			
Finland	30	280	219			[2] 31		[2] 41			[2] 4				[2] 143						
France	35	65,525	25,446				15,651				9,364						431				
Germany, West	30	18,568	254			238	4		6				(4)	5			(4)	1			(4)
Greece	49	287	270			158					90							22			
Italy	47	1,183	26								26										(4)
Norway	65	1,647	1,124			55					770				88		200				11
Poland	35	2,348	8																		8
Portugal	50	230	94				2				3						89				
Spain	50	5,967	[2] 2,070			[2] 68			[2] 220		[2] 1,038			[2] 1			[2] 740	[2] 3	(4)		
Sweden	60	22,766	19,930		78	178	4,117	210	476		8,333	19	318	652	559		4,738	241			11
Switzerland	35	[1] 85	60								60										
U.S.S.R.	55	[5] 116,137	16,026			288		4,998		2,014	29	1,698	3		5,898	1,051		39			8
United Kingdom	30	16,518	(6)																		
Yugoslavia	42	2,150	122									122									
Other East Europe		7,388	(6)																		

Asia:																					
China	50	44,300	(6)																		
Hong Kong	56	117	127																127		
India	61	12,076	3,462		(4)	9	10	974		22	74	81	155	32	108	169	(4)	199	1,619		10
Japan	55	2,826	(4)		(4)													(4)			
Korea, Republic of	50	497	437		8														421	2	6
Malaya	55	6,734	6,435																6,382		53
Philippines	55	1,153	1,289																1,289		
Portuguese India	55	6,381	6,458			27		140	47		1,885		637	109	10			97	3,506		(4)
Turkey	60	746	[1] 303					[2] 48			[2] 107		107					[2] 41			
Other Asia		3,529	(6)																		
Africa:																					
Algeria	52	2,822	2,737			21	42		123		653		309	58			1,531				
Angola	65	799	487					50	73		284							(4)	20		60
Guinea, Republic of	50	533	526					13			20				254		221				18
Liberia	66	3,200	2,792	165	476						[2] 937		325	424	57		408				
Morocco	55	1,439	1,879		(4)			181	187		605		4	59			482	361			
Sierra Leone	60	1,668	1,758		(4)	29			74		603		(4)	466			586				(4)
South Africa, Republic of	63	3,898	558			113			2		[2] 33		1						408		1
Tunisia	50	836	885			[2] 40		69	[2] 60		[2] 69		[2] 135		32		[2] 465	(4)			15
Other Africa		1,092	(6)																		
Oceania:																					
Australia	64	5,342																			
Fiji	50	10	9		1														8		
New Caledonia	55	273	253																	253	
Other countries		114	(7)																		
Total		503,779	148,812	4,173	26,007	1,255	20,201	7,247	1,664	2,036	32,751	1,920	3,378	2,117	7,461	1,247	14,434	1,076	21,065	277	503

1 Estimate.
2 From import detail of customs returns of the respective country.
3 Includes byproduct ore.
4 Less than 500 tons.
5 U.S.S.R. in Asia included with U.S.S.R. in Europe.
6 Data not available.
7 Incomplete data.

Compiled by Corra A. Barry, Division of Foreign Activities.

NORTH AMERICA

Canada.—Mine shipments of iron ore reached a record high of 24,909,000 tons. New plants under construction assured additional increases during the next several years. Productive capacity of almost 45 million tons was forecast by 1965.[8] Two very large new discoveries, not yet fully explored, also were reported.

Sixteen mines accounted for nearly all Canadian production. About 41 percent of total shipments was from Quebec, 28 percent from Newfoundland, 24 percent from Ontario, and 7 percent from British Columbia.

The largest producer, the Iron Ore Company of Canada, continued shipments of direct-shipping ore from Schefferville, Quebec, and began shipping concentrate from the new Carol Lake operation near Labrador City, Newfoundland, in July. Carol Pellet Co. continued constructing a nearby plant designed to pelletize 5.5 million tons of the annual 7.0-million-ton output from the Carol Lake concentrating plant.

Quebec Cartier Mining Co., Gagnon, Quebec, operated for its first full year and produced about 4.5 million tons of high-grade concentrate. When capacity operation is reached, the company expected to produce 8 million tons of concentrate per year from 20 million tons of crude ore.

A large plant was under construction as part of the Wabush Mines project, a joint venture managed by Pickands Mather & Co. The plant at Wabush Lake, near Labrador City, Newfoundland, was expected to produce at an annual rate of 5.5 million tons of concentrate or possibly pellets by 1964 or 1965.

New mines in British Columbia, though small by comparison, were important to the local economies.

A mine to be operated as the Northern Ontario Ore Division of Jones & Laughlin Steel Corp., at Kirkland Lake, was scheduled to begin production of 1 million tons per year of pellets containing 66 percent iron or more, in 1964.

Among the new discoveries was one along the Yukon and Northwest Territories boundary at latitude 60°15′ N. The deposit was reported to be a very extensive, bedded jasper-hematite formation of 50 percent iron or more. The discoverer, Crest Exploration Limited, a subsidiary of the Standard Oil Co. of California, was exploring the deposit.

Another discovery of possible importance was announced by British Ungava Explorations Ltd. The deposit of unusually high-grade hematite near the Mary River on Baffin Island was being explored.

Mexico.—Officials of the Mexican Government and the United Nations' Special Fund signed an agreement for a 3-year mineral prospecting program. The primary objective of the program was to locate and evaluate iron ore deposits as an aid in planning the expansion of the iron and steel industry. Installed steel ingot capacity was expected to approach 4 million tons per year by 1965 compared with 1.7 million tons in 1960.

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[8] Elver, R. B. Iron Ore. Canadian Min. J., v. 84, No. 2, February 1963, pp. 91–95.

The 14-mile aerial tramway from the crushing plant of the El Encino iron ore mine near Colima to the railhead at Alzada began operating in November. The capacity of the tramway was about 5,000 tons per day. The rail distance from Alzada to the steel plant of Hojalata y Lamina, S.A., was about 530 miles.

SOUTH AMERICA

Brazil.—Although the high-grade iron ore reserves were among the largest in the world, the production rate had not exceeded 10 million tons per year. There was evidence that the Government policy regarding participation by private enterprise might be easing. Priority to use the limited transportation facilities was retained, however, by the Government-owned Companhia Vale do Rio Doce, the operations of which were described.[9] Recent improvements included new crushing and screening facilities to permit a wider range of product size. A sinter grade, minus 2 inches, was available in the last half of 1962.

Chile.—Production increased for the fifth consecutive year, and the expectation was that 10 million tons might be produced in 1963. In the last decade, Chile had emerged as a major producer of high-grade iron ore.

Bethlehem-Chile Iron Mines Co., a subsidiary of Bethlehem Steel Co., proceeded with plans to invest $8.7 million in the construction of the first two iron ore concentrating plants in Chile: One for treating fines accumulated at the El Tofo mine and one to upgrade ore from the new El Romeral mine.

The new open-pit mine and crushing and screening plant, El Algarroba,[10] owned by Cia. de Acero del Pacifico, S.A., began producing high-grade direct-shipping ore early in 1962.

Peru.—The first ore was loaded from the dock at Marcona's new iron ore processing complex at San Nicolas Bay in February. The dock was to be capable of handling vessels up to 100,000 deadweight tons. First production of pellets from the complex was scheduled for early 1963.

Venezuela.—A Supreme Court ruling,[11] published in the Official Gazette of November 24, 1962, upheld Ministry of Mines and Hydrocarbons Resolution No. 1,862 of December 29, 1959, which declared the Maria Louisa Ore Co. iron ore concessions Nos. 1, 2, 3, 7, and 12 as lapsed because of lack of exploitation.

Matanzas Steel (Division Siderurgica del Orinoco, Corporacion Venezolana de Guayana) plant at yearend was consuming iron ore at a rate of about 800,000 long tons per year. The plant included nine electric furnaces. Eight were of the Tysland-Hole type, each with a capacity of 200 long tons per day. The ninth was adapted to the Strategic Udy process and had a capacity of 400 tons per day. Iron ore was obtained from Orinoco Mining Co. (U.S. Steel subsidiary) and Iron Mines Co. of Venezuela (Bethlehem Steel subsidiary).

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[9] Metal Bull. (London), Itabira of Brazil. No. 4,689, Apr. 17, 1962, 4 pp.
[10] Aiken, G. E., and R. C. Temps. El Algarroba, New Open Pit Iron Mine in the Atacama Desert. Min. Eng., v. 14, No. 3, March 1962, pp. 52–57.
[11] U.S. Embassy, Caracas, Venezuela. State Department Airgram A–397, Dec. 4, 1962, 2 pp.

EUROPE

The European Coal and Steel Community.—Production of iron ore fell 4 percent to 89 million tons compared with 49 million tons produced by West European nations outside the Community, 139 million tons produced by Soviet bloc European nations, and 72 million tons produced by the United States.

France.—Production decreased from 65.5 million tons in 1961 to 65.3 million tons. The ore contained an average of about 30 percent iron. Of the total, 38.4 million tons was consumed in domestic furnaces, 9.1 million was exported to West Germany, 0.3 million to Great Britain, and 16.5 million to Belgium-Luxembourg.

Although plans called for a modest expansion through 1965, the last 2 years showed slight reductions in output. The current slowing of activity in the European steel industry and the increasing availability of high-grade ores from overseas tended to impede further expansion plans.

Germany, West.—The trend was continued to use high-grade imported ores with a resulting curtailment of domestic mine production. Even the high-grade Swedish ores were reduced in price as new African developments neared completion.

It was announced that one of the two Krupp-Renn plants in West Germany would close at yearend. The plant, Rennenlage Salzgitter-Rurh Gmbh, produced 250,000 tons, annually, of iron "luppen" in its four kilns. The decision to close resulted from a slackening in demand and the lower cost of pig iron produced from high-grade Swedish and Brazilian ore.

The other plant, Essen-Borbeck Renn six-kiln plant, was expected to continue operation at its current rate of 500,000 tons of luppen. However, this plant had converted to imported ore and, therefore, offered little or no encouragement to the local iron mining industry.

Norway.—The Dunderland iron ore deposits, near the State-owned iron and steel plant of Norsk Jernverk A/S at Mo i Rana, were under development with production scheduled by 1965.[12] Some $30 million was to be invested in mining and in an ore dressing plant; 750,000 tons of concentrate averaging 66 percent iron was to be produced annually from crude ore averaging 33 percent iron.

Expansion plans called for doubling the iron production to 720,000 tons and increasing the steel capacity to 600,000 tons by 1964. The pig iron was produced in electric furnaces; the four existing furnaces, with a combined capacity of 360,000 tons, were to be equalled in output by only two of the new furnaces. Iron ore was shipped by boat from the Sydvaranger mine at Kirkenes in the far north.

Sweden.—Production was about 5 percent less than in 1961, and exports were about 3 percent less. Contracts with West German buyers for 1963 delivery provided for a 7 percent reduction in prices.[13] However, expansion of production and transport facilities continued during 1962. The State-owned Luossavaara-Kiirunavaara, A.B.

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[12] Skillings' Mining Review. Norway to exploit New Iron Ore Deposits. Apr. 28, 1962, pp. 6, 7.

[13] U.S. Embassy, Stockholm, Sweden. State Department Airgram A-500, Dec. 14, 1962, 3 pp.

(LKAB) continued work on rail and townsite facilities at Svappavaara, 30 miles east of Kiruna in Swedish Lapland.

Extensive rebuilding and expansion in the port of Oxelosund, the ore port for Grangesberg operations, began in the spring of 1962 and was scheduled for completion in 1965.

U.S.S.R.—Production of iron ore increased again in 1962 to meet increasing domestic needs and to supply an estimated 50 percent of the growing needs of other East European pig iron producers.

Vast reserves of direct-shipping and taconite-type ores of the Kursk magnetic anomaly, 300 miles south of Moscow, were seen as gradually replacing ores of the Krivoy Rog Basin.[14]

Another, even larger, resource in the Kustanay (Turgay) Territory, in northwestern Kazakhstan was described.[15] Depletion of iron supplies for the Ural and Kazakhstan metallurgical plans was seen as necessitating development of the Kustanay deposits. The shortage of water, transportation, and technological problems, such as high phosphorous content in some of the ores, were serious obstacles.

United Kingdom.—Production of iron ore decreased 7 percent and imports declined 14 percent. Improvements in ore handling, blending, and preparation facilities were the major developments.

ASIA

China.—There was little information available on the iron ore industry of China. Although the general economic situation may have improved somewhat toward the yearend, production of iron and steel throughout the year was believed to be less than that in 1961. Some negotiation was reported for the export of iron ore to Japan, but prospects in this market were not promising. High-grade ores were available to Japan from many other sources, and the recent phenomenal expansion of the Japanese iron and steel industry appeared to be slowing down.

India.—Productive capacity continued to expand in keeping with increasing domestic requirements, which were expected to reach 30 million tons by 1970.

One major development was completion of the plant for crushing and shipping ore from the Barsua mine on the Bonai Range of Orissa State, 250 miles west and slightly south of Calcutta. The system included a 2-mile conveyor and crushing, screening, stockpiling, and railroad loading facilities. The initial production of 1.6 million tons per year and full scale production of 3 million tons per year were to supply the new Rourkela steel plant, 55 miles to the north.[16]

Goa.—Exports of iron ore declined from 6.5 million tons in 1961 to about 5.3 million tons.

Japan.—Imports of iron ore for the fiscal year ending March 31, 1963, were expected to total 22.5 million tons based on a total requirement of 37.0 million tons for the production of 18.6 million tons of pig iron.

[14] Bureau of Mines. Mineral Trade Notes. V. 54, No. 3, March 1962, pp. 14–17.

[15] Agafonov, N. T. Ob Ocherednosti Osvoyeniya Prirodnyhh Ressursov v Kustanayskoy Oblasti (In Reference to the Priority in the Development of Natural Resources in Kustanay Territory). Vestnik Leningradskogo Universiteta (Leningrad Univ.) Bull., No. 24, 1961, pp. 69–76.

[16] Engineering and Mining Journal. Materials Handling System Unlocks Barsua, Feeds India's Burgeoning Steel Industry. V. 163, No. 8, August 1962, pp. 100–103.

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A modest downward revision of plans for pig iron production and iron ore imports was announced as follows:

Year	Pig iron (thousand tons)	Iron ore imports [1] (thousand tons)
1963	19, 750	29, 950 (28, 990)
1964	21, 170	26, 790 (32, 230)
1965	23, 340	29, 800 (32, 910)
1966	24, 960	31, 990 (34, 570)
1967	26, 680	34, 340 (36, 470)

[1] Figures in parentheses represent previous plan.

The Japanese iron and steel industry was described in an annual volume [17] giving plant descriptions, trends, problems, and statistics.

Malaya.—Iron ore production decreased 0.2 million tons to 6.5 million tons because of reduced demand. However, a new $50 million mine development, the Rompin mine, 50 miles north of Singapore, at Bukit Ibam in Pahang State, was completed at midyear. Production at yearend was reported at the rate of 2 million tons per year. Plans were being made for expansion to 4 million tons. The project involved construction of a 50-mile railroad, a townsite, crushing, washing, screening, and stockpiling facilities, and a port installation.

A list of producing iron mines in the Federation of Malaya was published.[18]

AFRICA

Algeria.—Production and exports dropped to about 2 million tons as both major markets (United Kingdom and West Germany) encountered a slowing rate of steel productivity together with increasing availability of high grade ores. However, a new steel works at Bone, Bonoise de Siderurgie, was scheduled to begin operations in 1963. Thus, the outlook was that the 2 million ton level of ore production might continue.

Angola.—A 40-mile rail connection was completed between the Cuima mine and a rail line to the coast. A 60-mile rail link between the Cassinga mine and the Mocamedes railway and an ore loading pier at the Port of Mocamedes was reported in the final stages of negotiation but work was not started by yearend.

Gabon, Republic of.—A report [19] on iron ore reserves at Mékambo in northeast Gabon (Société des Mines de Fer de Mékambo) indicated an overall reserve of 946 million tons averaging 64 percent iron.

Although this was one of the world's largest high-grade iron ore deposits, construction of about 400 miles of railroad and port facilities was necessary for its exploitation. A series of studies concerned with these problems was expected to start in 1963.

Liberia.—A new, second large producer of iron ore, the National Iron Ore Co., Ltd., began regular shipments in mid-1962 (the first ship-

[17] Tokyo Foreign Service. Japan's Iron and Steel Industry 1962. Ed. by Sukeyuki Kawata. Tokyo Foreign Service, Central P.O. Box 1157, Tokyo. 1962, 287 pp.
[18] Bureau of Mines. Mineral Trade Notes. V. 55, No. 3, September 1962, pp. 34–38.
[19] Bureau of Mines. Mineral Trade Notes. V. 56, No. 3, March 1963, p. 16.

ment was made in December of 1961) from its Mano River concession. Initial production rate was 2 million tons per year with later expansion to 4.5–5 million tons planned.

The Lamco project (Liberia-American-Swedish Minerals Co., (Lamco)) continued, with production from the Mt. Nimba deposit scheduled to begin in 1963. The initial rate of shipment was expected to be 6 million tons of ore per year with subsequent expansion to 10 million or more tons.

The Liberia Mining Co. continued operating the Bomi Hills deposit and preparations were begun by DELIMCO (German Liberian Mining Co.) for developing the Bong range deposit 50 miles northwest of Monrovia.

In addition to port construction at Buchanan for shipment of the Lamco ore, major improvements were underway at the port of Monrovia where shipments were expected to reach 10 to 15 million tons annually by 1965.

Mauritania.—Work was nearly completed on the 420-mile railroad from the MIFERMA (Société Anonyme de Mines de Fer de Mauritanie) mine near Fort-Gourand to Port Etiene. A stock of iron ore was reportedly being mined at yearend for shipment beginning early in 1963. Shipments of the high-grade ore were planned at the rate of 4 million tons per year by the end of 1963 with subsequent expansion to 6 million tons. Ownership of MIFERMA was divided among French (60 percent), British (20 percent), Italian (15 percent), and German companies (5 percent).

Swaziland.—The Swaziland Iron Ore Development Co., Ltd., with financial backing from the Anglo-American Corporation of South Africa, Ltd. and DeBeers began developing the Ngwenya (Brown Ridge) mine site.[20] Simultaneously the Government of Swaziland was constructing a 140-mile railroad from the mine site to connect on the Mozambique border with the Portuguese East Africa Railways, which was to carry ore a distance of 42 miles to the port of Lourenco Marques. Initial shipment at a rate of 1.2 to 1.4 million tons per year was expected late in 1964.

OCEANIA

Australia.—At yearend the iron ore situation was not clearly or completely delineated. There was no question, however, that many large deposits existed. The Pilbara deposit was described [21] as "roughly in the shape of an ellipse about 150 miles long by 70 miles wide running from the region of Dales and Wittenoom Gorges in the Hamersley Ranges to the Robe River where the deposits come to about 50 miles of the (west) coast." Four major groups were investigating the potential of this area: (1) Consolidated Zinc-Rio Tinto-Kaiser Steel, (2) Consolidated Gold Fields—Cypress Mines—Utah Construction, (3) Howe Sound-Garrick Agnew, and (4) Broken Hill Pty. Co., Ltd.

[20] Skillings' Mining Review. V. 52, No. 13, Mar. 30, 1963, pp. cover, 4, 5.
[21] Mining Journal (London). V. 260, No. 6,646, Jan. 4, 1963, p. 11.

TECHNOLOGY [22]

Although the tonnage of sinter produced in the United States was nearly twice the tonnage of pellets, the latter product gained appreciably. According to one forecast,[23] the productive capacity in Canada and the United States was expected to be about 42 million tons of pellets in 1965. This total included facilities operating or under construction. Further improvement in the composition, properties, or production cost of pellets appeared likely in view of the intensive research effort in progress.

Self-fluxing pellets and partially reduced pellets both showed promise after initial testing. An experimental run at the Republic mine in Michigan, operated by Cleveland Cliffs Iron Co., produced 35,000 tons of self-fluxing pellets. (Essentially this involved incorporation of the necessary limestone in the pellets, and eliminated adding limestone separately to the blast furnace burden). This commercial-scale test, using the grate-kiln system, demonstrated that production involved no insurmountable problems.[24] Additional studies were underway to determine optimum chemical and physical properties, smelting characteristics, and overall economics.

Partially reduced pellets are discussed below with other Bureau of Mines research.

A trend to increased iron content and decreased silica content was also noted; the ratio was largely dependent upon consumers specifications. An average iron-to-silica ratio of 11 to 1 with an iron content of 63.5 percent was forecast for pellets by 1965. Some pellets with silica as low as 2 or 3 percent were undergoing tests. A comprehensive bibliography [25] of the literature on pelletizing, combined with comments on the process, was published.

Many research groups sought improved methods of concentrating iron ore. Most effort was devoted to flotation and magnetic oxide conversion techniques; both aimed primarily toward recovery of hematite.

Pilot plant studies by two major companies in Minnesota on conversion to artificial magnetite by roasting nonmagnetic minerals continued for the second year. The process, long known to be technologically feasible, appeared to be approaching a stage of economic feasibility.

Flotation research was largely on the development of flowsheets for specific ores. Among the problems were those connected with the filtering or settling of very small particles and the lack of uniformity in mineral deposits.

Two articles [26] described the operations of heavy density plants. A

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[22] See also the Minerals Yearbook chapters Review of Metallurgical Technology and Iron and Steel.

[23] Arms, C. S. State of the Iron Ore Industry. Skillings' Min. Rev., v. 51, No. 41, Oct. 13, 1962, pp. 1, 4, 5.

[24] Johnson, Edwin B. In Steel's Future—Self-Fluxed Pellets? Min. Eng. v. 15, No. 3, March 1963, pp. 49–52.

[25] Banks, G. N., R. A. Campbell, and G. E. Viens. Iron Ore Pelletizing—A Literature Survey. Canadian Min. and Met. Bull. (Montreal), v. 55, No. 608, December 1962, pp. 853–858.

[26] Van Slyke, W. R. Heavy-Media Cyclones in Iron Ore Beneficiation. Min. Cong. J., v. 48, No. 1, January 1962, pp. 41–45.
Oss, Donald G., and Stephen E. Erickson. Instrumentation and Control of the Heavy Media Process. Min. Eng., v. 14, No. 5, May 1962, pp. 41–45.

process for the caustic extraction of silica from taconite-type ores was described.[27]

Autogenous grinding circuits were operating or being installed at several of the new taconite-type iron ore beneficiating plants, and two articles[28] outlined the status of autogenous grinding.

Procedures for concentrating iron ore were reviewed in a series of three articles.[29]

The Bureau of Mines, in cooperation with 22 major iron and steel firms, continued a major blast furnace research program to evaluate various burdens and to develop new operating techniques.

Recent changes in blast furnace productivity, based on records of the 10 leading U.S. furnaces, were reviewed.[30] Average production for the 10 leading furnaces increased from 1,729 net tons of hot metal per day in 1957 to 2,190 tons in 1961. The production rate for the 10 leading furnaces was expected to reach 4,000 tons per day by 1972 without a drastic increase in furnace size. Among the improvements judged necessary to reach this goal were: (1) Increase in hot-blast temperature; (2) incorporation of more of the flux in the agglomerates; (3) greater uniformity in the chemistry and size of the coke and iron-bearing materials; (4) increase in top pressure; and (5) oxygen enrichment of the blast. The improvements were expected to involve several operating innovations, such as injection of supplementary fuels and better charging and tapping facilities.

Another article[31] on blast furnace productivity agreed with the conclusions of Stapleton, Stephensen, and Regelin, but emphasized the importance of improved raw materials such as fluxed pellets and prereduced or partially reduced pellets. The importance of injecting such auxiliary fuels as natural gas, oil, and especially coal was noted.

Twenty-three papers[32] on iron ore reduction processes and reactions presented at an earlier symposium were published.

A bulletin[33] on the geology of the eastern Mesabi district of Minnesota contributed significantly to the complex problem of ore classification with regard to its metallurgical response.

The trend toward bigger mining equipment was exemplified at Kaiser Steel Corp. Eagle Mountain open-pit mine. Use of a 12-yard shovel, loading 12,000 to 14,000 short tons per shift into 100-ton trucks (tractors and semitrailers) was described.[34]

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[27] Tiemann, Theodore D. Caustic Extraction of Silica from Low Grade Siliceous Iron Ores. Trans. Soc. Min. Eng., v. 223, No. 2, June 1962, pp. 173–178.

[28] Everard, F., and R. Jones. Dry Autogenous Grinding and Dry Magnetic Separation of Iron Ores. Trans. Soc. Min. Eng., v. 223, No. 1, March 1962, pp. 88–96.

Bernstrom, Bernard. Grinding Iron Ore in a Wet Autogenous Mill. Trans. Soc. Min. Eng., v. 223, No. 3, September 1962, pp. 304–311.

[29] Sundelin, L. The Concentration of Iron Ores. Mine and Quarry Eng. (London), February 1962, v. 28, No. 2, March 1962, pp. 74–82; v. 28, No. 3, 1962, pp. 119–128; and v. 28, No. 4, April 1962, pp. 163–175.

[30] Stapleton, J. M., R. L. Stephensen, and D. H. Regelin. Future of Ironmaking. J. Metals, v. 14, No. 10, October 1962, pp. 749–753.

[31] Strassburger, J. H., E. J. Ostrowski. and J. R. Diety. Blast Furnace Practice of Tomorrow. J. Metals, v. 14, No. 4, April 1962, pp. 295–298.

[32] Pergamon Press, The MacMillan Co. Proceedings of a Symposium of the Electrothermics and Metallurgy Division of the Electrochemical Society, Chicago, May 3–5, 1960. New York, 1962, 359 pp.

[33] Gunderson, James Novotny, and George M. Schwartz. The Geology of the Metamorphosed Biwabick Iron-Formation, Eastern Mesabi District, Minnesota. Univ. of Minnesota, Minnesota Geol. Survey Bull. 43, 1962, 139 pp.

[34] Kaiser Open Pit Proves Large Machine Concept. Skillings' Min. Rev., v. 57, No. 17, Apr. 27, 1963, pp. 6–7.

A review of the economic situation and new technological developments in underground mining was published.[35] New methods, equipment, and cost cutting procedures necessary for competitive operation of underground mines were outlined. Another report described the underground use of ammonium nitrate explosives.[36]

Bureau of Mines Research.—Two publications on Lake Superior iron resources were issued.[37] Both reports dealt with the problem of the metallurgical classification of nonmagnetic taconite resources. Another publication[38] described titaniferous magnetite deposits in Los Angeles County, Calif.

Bureau reports[39] described research on the flotation of Alabama hematite ores and iron-bearing materials in Minnesota.

A promising new approach to pellet preparation was investigated and described.[40] In this research, pellets were prepared by the conventional procedure except induration was conducted in a reducing atmosphere. The iron content was raised to about 80 percent by partial removal of oxygen. Preliminary testing indicated that blast furnace productivity might be increased by 35 percent by using these pellets.

Two Bureau investigations with the experimental blast furnace were described.[41] Research on the magnetic concentration and electric furnace smelting of a Montana ore was also described.[42]

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35 Pearson, Philip D. New Developments in Underground Mining. Skillings' Min. Rev. v. 51, No. 9, Mar. 3, 1962, pp. 1, 6–8.

36 Matson, R. P. Blasting with Ammonium Nitrate Explosives Underground. Min. Cong. J., v. 48, No. 4, April 1962, pp. 26–29.

37 Frommer, D. W., and P. A. Wasson. Lake Superior Iron Resources—Further Metallurgical Evaluation of Mesabi Range Nonmagnetic Taconites (Reduction Roasting and Magnetic Separation). BuMines Rept. of Inv. 6104, 1962, 47 pp.

Wasson, P. A., D. W. Frommer, L. F. Heising, R. E. Lubker and R. L. Blake. Lake Superior Iron Resources—Metallurgical Evaluation and Classification of Nonmagnetic Taconite Drill Cores From the West Central Mesabi Range. BuMines Rept. of Inv. 6081, 1962, 62 pp.

38 Benson, W. T., A. L. Engel, and H. J. Heinen. Titaniferous Magnetite Deposits, Los Angeles County, Calif. BuMines Rept. of Inv. 5962, 1962, 40 pp.

39 Perry, R. E., W. E. Lamont, I. L. Feld, and B. H. Clemmons. Flotation of Northeast Birmingham, Ala., Hematite Ores. BuMines Rept. of Inv. 6123, 1962, 14 pp.

Wasson, P. A., R. T. Sorensen, and E. W. Frommer. Anionic Flotation of Silica from Goethitic Iron-Bearing Materials, Cuyuna Range, Minn. BuMines Rept. of Inv. 6199, 1962, 11 pp.

40 Fine, M. M., J. P. Hansen, and Norwood B. Melcher. Prereduced Iron Ore Pellets: A New Blast Furnace Raw Material. BuMines Rept. of Inv. 6152, 1962, 19 pp.

41 Kusler, David J. An Improved Gravimetric Method for Analyzing Blast Furnace Top Gas. BuMines Rept. of Inv. 6168, 1962, 21 pp.

Woolf, P. L., and W. M. Mahan. Fuel-Oil Injection in an Experimental Blast Furnace. BuMines Rept. of Inv. 6150, 1962, 23 pp.

42 Holmes, Wesley T., II, W. Floyd Holbrook, and Lloyd H. Banning. Beneficiating and Smelting Carter Creek, Mont., Iron Ore. BuMines Rept. of Inv. 5922, 1962, 21 pp.

Iron and Steel

By Joseph H. Bilbrey, Jr.,[1] and Gail Knight[2]

Contents

DURING 1962, the U.S. steel industry operated at about the same level of volume as during 1960 and 1961. Total production of pig iron was up 1.2 percent, and total steel production increased by 0.3 percent. Output was uninterrupted by strikes, but the possibility of a strike in mid-1963 caused some extra buying and kept production volume during the last quarter of 1962 at a higher level than required by consumption demands.

Advances in technology rapidly accelerated the production of steel products from ore. Changes in technology, including the increased use of agglomerated products of higher iron content; injection of gas, oil, and coal; use of higher blast temperatures and higher top pressures; and oxygen enrichment of the blast increased the rate of iron production from the blast furnace. In large oxygen converters, steelmaking rates of over 300 tons per hour were achieved in normal commercial operation, while the use of oxygen in lances and for flame enrichment resulted in production rates of over 100 tons per hour in open-hearth furnaces. Continuous- and pressure-casting techniques promised to decrease the time from molten steel to rolled products.

Shipments of steel products, all grades including exports, totaled 70.6 million tons, compared with 66.1 million tons in 1961. Nearly all consuming industries bought more steel than in 1961. The automotive industry, the major consumer, consumed most of the increase in shipments, taking 15.2 million tons in 1962 (22 percent of the total domestic shipments), contrasted with 12.6 million tons in 1961 (20 percent of the total domestic shipments).

Imports of major iron and steel products totaled 4.3 million tons, compared with 3.3 million tons in 1961 and 4.6 million tons in the peak year 1959. The European Coal and Steel Community and Japan supplied 50.5 and 26.5 percent, respectively, of the imports. Exports were 2.3 million tons, up slightly from the 1961 total of 2.2 million tons.

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No general increase in steel prices occurred, although average hourly labor costs increased. According to the American Iron and Steel Institute (AISI), the 1962 payroll of the steel industry was $3.8 billion, compared with $3.6 billion in 1961. The net billing value of products shipped and other services was $13.8 billion, compared with $13.1 billion in 1961. Net income was $567 million, the lowest since 1952, and 17.8 percent lower than in 1961.

TABLE 1.—Salient iron and steel statistics

(Thousand short tons)

	1953–57 (average)	1958	1959	1960	1961	1962
United States:						
Pig iron:						
Production	72,617	57,155	60,210	66,501	64,853	65,638
Shipments	72,249	56,918	61,245	65,612	65,307	65,727
Imports for consumption	343	210	700	331	377	500
Exports	243	103	10	112	416	154
Steel: [1]						
Production of ingots and castings (all grades):						
Carbon	99,494	78,591	84,539	90,864	89,339	89,162
Stainless	1,086	896	1,131	1,004	1,137	1,085
All other alloy	8,398	5,768	7,776	7,414	7,538	8,081
Total	108,978	85,255	93,446	99,282	98,014	98,328
Capacity, annual, Jan. 1	125,905	140,743	147,634	148,571	(2)	(2)
Percent of capacity	86.6	60.6	63.3	66.8	(2)	(2)
Index (1953-57=100)	100.0	78.2	85.7	91.1	89.9	90.2
Total shipments of steel mill products	78,234	59,914	69,377	71,149	66,126	70,552
Imports of major iron and steel products [3] [4]	1,292	1,820	4,615	3,570	3,308	4,291
Exports of major iron and steel products	4,302	3,225	1,973	3,247	[5] 2,221	2,267
World production:						
Pig iron [6]	205,530	216,750	247,100	[5] 285,100	[5] 287,350	294,200
Steel ingots and castings	287,550	[5] 298,300	[5] 336,250	[5] 381,200	[5] 390,400	397,350

1 American Iron and Steel Institute.
2 Data not available.
3 Data not comparable for all years.
4 Bureau of the Census.
5 Revised figure.
6 Includes ferroalloys.

PRODUCTION AND SHIPMENTS OF PIG IRON

U.S. production of pig iron was 1 percent higher than in 1961, but it was 10 percent below the 1953–57 5-year average. The number of operating blast furnaces decreased from 172 at the beginning of 1962 to 138 at yearend. According to the AISI the average production of pig iron per blast-furnace day was 1,349.4 tons, compared with 1,305.4 tons in 1961 and 1,181.5 tons in 1960. Pig iron production increased in most parts of the Nation, but decreased slightly in the South and sharply in the West. Pennsylvania, Ohio, and Indiana continued to be the major producers, supplying 24, 18, and 13 percent, respectively, of the pig iron produced.

The number of blast furnaces in the United States was 247, 12 less than in 1961. Six of the 12 were abandoned, and the other 6 were being dismantled. Two new blast furnaces were under construction, one at Ashland, Ky., for Armco Steel Corp. and the other at Cleveland, Ohio, for Jones & Laughlin Steel Corp.

Metalliferous Materials Consumed in Blast Furnaces.—A total of 102.5 million tons of ores and agglomerates, 3.4 million tons of scrap, and 6.7 million tons of miscellaneous materials were consumed in making pig iron in 1962. The combined net charge was 1.715 tons per ton of pig iron produced, compared with 1.728 tons per ton of pig iron in 1961. Consumption of miscellaneous materials consisted of 3,087,427 tons of mill cinder and roll scale, 3,382,385 tons of open-hearth and Bessemer slag, and 212,362 tons of other materials.

The agglomerate charge consisted of 36,649,719 tons of sinter; 10,106,526 tons of self-fluxing sinter, 15,311,710 tons of pellets, 191,275 tons of nodules, and 206,007 tons of unclassified agglomerates, plus 948,335 tons of agglomerates from foreign sources. Canada, Venezuela, and Chile were the major sources for the foreign iron ore and manganiferous iron ore consumed in U.S. blast furnaces.

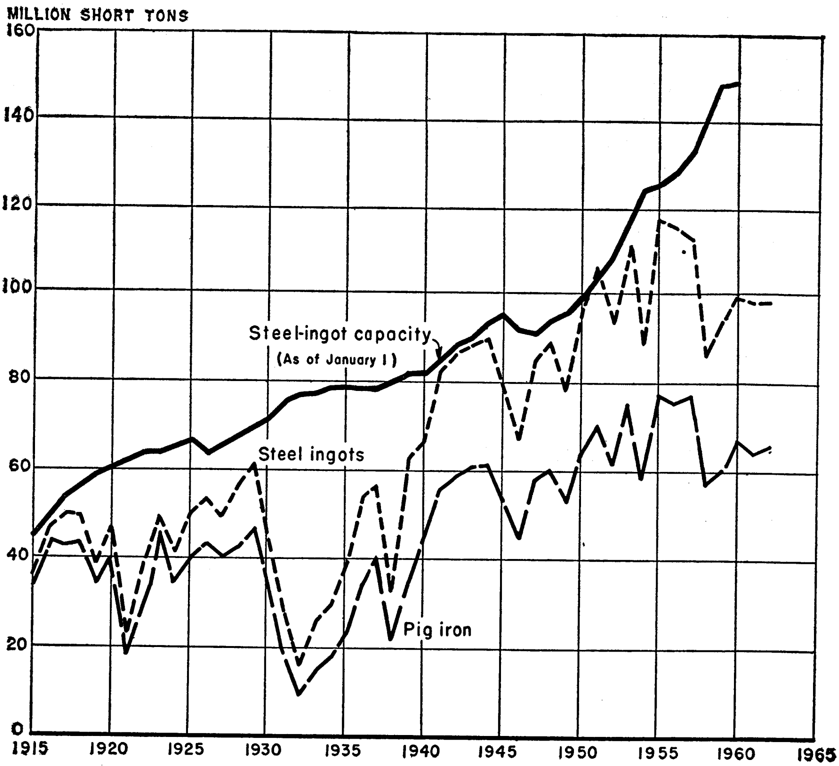

FIGURE 1.—Trends in production of pig iron and steel ingots, 1915-62, and steel-ingot capacity in the United States, 1915–60.

TABLE 2.—Pig iron produced and shipped in the United States, by States

(Thousand short tons and thousand dollars)

State	Produced		Shipped from furnaces			
	1961	1962	1961		1962	
	Quantity		Quantity	Value	Quantity	Value
Alabama	3,531	3,628	3,585	$202,946	3,595	$206,565
Illinois	4,725	4,715	4,775	288,469	4,775	282,210
Indiana	8,877	8,817	8,865	522,733	8,796	504,326
Ohio	10,984	11,548	11,007	669,033	11,470	686,860
Pennsylvania	15,205	15,726	15,272	908,363	15,886	936,184
California, Colorado, Utah	4,657	3,708	4,700	237,348	3,719	191,866
Kentucky, Tennessee, Texas	1,689	1,499	1,723	97,247	1,507	81,396
Maryland and West Virginia	6,418	6,650	6,493	397,606	6,608	391,136
Michigan and Minnesota	5,005	5,432	5,059	267,726	5,415	307,634
New York	3,762	3,915	3,828	229,890	3,956	233,962
Total	64,853	65,638	65,307	3,821,361	65,727	3,822,139

According to the AISI, 11.4 billion cubic feet of oxygen was used in blast furnaces, compared with 8.9 billion cubic feet in 1961 and 4.4 billion cubic feet in 1960. Data collected by the Bureau of Mines showed that 39.2 billion cubic feet of natural gas, 3.8 billion cubic feet of coke-oven gas, and 7.4 million gallons of oil were injected through the tuyères of blast furnaces in the United States.

TABLE 3.—Foreign iron ore and manganiferous iron ore consumed in manufacturing pig iron in the United States, by sources of ore

(Short tons)

Source	1961	1962 [1]	Source	1961	1962 [1]
Brazil	32,546	91,804	Venezuela	4,175,675	4,299,230
Canada	4,107,871	4,652,643	Other countries	115,863	133,772
Chile	1,026,282	1,117,112			
Peru	633,931	363,348	Total	10,092,168	10,657,909

[1] Excludes 17,514,110 tons used in making agglomerates.

TABLE 4.—Pig iron shipped from blast furnaces in the United States, by grades [1]

(Thousand short tons and thousand dollars)

Grade	1961			1962		
	Quantity	Value		Quantity	Value	
		Total	Average per ton		Total	Average per ton
Foundry	1,402	$83,856	$59.81	1,398	$82,304	$58.87
Basic	58,601	3,413,110	58.24	58,919	3,412,990	57.93
Bessemer	2,641	160,518	60.78	2,764	166,105	60.10
Low-phosphorus	207	13,561	65.51	171	10,846	63.43
Malleable	2,213	137,844	62.29	2,295	140,550	61.24
All other (not ferroalloys)	243	12,472	51.33	180	9,344	51.91
Total	65,307	3,821,361	58.51	65,727	3,822,139	58.15

[1] Includes pig iron transferred directly to steel furnaces at same site.

TABLE 5.—Number of blast furnaces (including ferroalloy blast furnaces) in the United States, by States

State	January 1, 1962			January 1, 1963		
	In blast	Out of blast	Total	In blast	Out of blast	Total
Alabama	10	12	22	11	10	21
California	4	----------	4	3	1	4
Colorado	3	1	4	3	1	4
Illinois	14	8	22	11	11	22
Indiana	19	4	23	17	6	23
Kentucky	2	1	3	2	----------	2
Maryland	10	----------	10	6	4	10
Michigan	9	----------	9	9	----------	9
Minnesota	1	2	3	1	1	2
New York	13	4	17	9	8	17
Ohio	29	21	50	25	24	49
Pennsylvania	46	29	75	33	35	68
Tennessee	1	2	3	1	2	3
Texas	2	----------	2	2	----------	2
Utah	4	1	5	2	3	5
Virginia	1	1	2	----------	2	2
West Virginia	4	1	5	3	1	4
Total	172	87	259	138	109	247

Source: American Iron and Steel Institute.

TABLE 6.—Iron ore and other metallic materials, coke and fluxes consumed and pig iron produced in the United States, by States

(Short tons)

Year and State	Metalliferous materials consumed: Iron and manganiferous ores: Domestic	Metalliferous materials consumed: Iron and manganiferous ores: Foreign	Metalliferous materials consumed: Agglomerates	Metalliferous materials consumed: Net ores and agglomerates [1]	Metalliferous materials consumed: Net scrap [2]	Metalliferous materials consumed: Miscellaneous [3]	Metalliferous materials consumed: Net total	Net coke	Fluxes	Pig iron produced	Metalliferous materials consumed per ton of pig iron made: Net ores and agglomerates [1]	Metalliferous materials consumed per ton of pig iron made: Net scrap [2]	Metalliferous materials consumed per ton of pig iron made: Miscellaneous [3]	Metalliferous materials consumed per ton of pig iron made: Total	Coke and fluxes consumed per ton of pig iron: Net coke	Coke and fluxes consumed per ton of pig iron: Fluxes
1961:																
Alabama	3,882,466	568,796	2,544,007	6,770,800	166,243	40,387	6,977,430	3,269,210	976,522	3,531,259	1.917	0.047	0.011	1.975	0.926	0.277
Illinois	3,744,386	----------	4,237,649	7,622,930	264,687	546,635	8,434,252	3,528,673	995,013	4,725,149	1.613	.056	.116	1.785	.747	.211
Indiana	4,940,813	453,764	9,346,618	14,213,899	129,564	1,300,087	15,643,550	5,790,429	1,267,459	8,876,721	1.601	.015	.146	1.762	.652	.143
Ohio	7,088,492	1,724,955	8,577,942	16,637,884	671,941	1,155,755	18,465,580	8,089,270	2,848,371	10,984,279	1.515	.061	.105	1.681	.736	.259
Pennsylvania	5,652,054	2,995,887	14,628,877	22,413,958	965,908	2,064,630	25,444,496	10,600,071	3,182,827	15,204,824	1.474	.064	.136	1.674	.697	.209
California, Colorado, Utah	(4)	(4)	3,706,911	8,373,454	78,550	108,065	8,560,069	3,006,754	752,656	4,656,696	1.798	.017	.023	1.838	.646	.162
Kentucky, Tennessee, Texas	506,971	329,724	1,708,896	2,640,333	101,735	245,426	2,987,494	1,188,165	427,931	1,689,353	1.563	.060	.145	1.768	.703	.253
Maryland and West Virginia	(4)	(4)	6,355,084	9,769,063	167,627	654,810	10,591,500	4,390,500	874,675	6,418,333	1.522	.026	.102	1.650	.684	.136
Michigan and Minnesota	(4)	(4)	5,198,835	8,199,403	164,007	221,874	8,585,284	3,219,402	1,166,763	5,004,685	1.638	.033	.044	1.715	.643	.233
New York	1,780,301	314,416	4,080,013	5,945,525	175,547	241,860	6,362,932	2,761,167	1,095,696	3,761,427	1.581	.047	.064	1.692	.734	.291
Total	35,972,636	10,092,168	60,384,832	102,587,249	2,885,809	6,579,529	112,052,587	45,843,641	[5] 13,587,913	64,852,726	1.582	.045	.101	1.728	.707	.210

1962:																
Alabama	3,697,017	748,471	2,711,811	6,985,348	120,462	123,439	7,229,249	3,215,390	930,027	3,628,060	1.925	.033	.034	1.992	.886	.256
Illinois	3,603,758	(4)	4,222,202	7,533,847	280,962	604,221	8,419,030	3,540,610	947,136	4,715,200	1.598	.060	.128	1.786	.751	.201
Indiana	5,048,076	886,883	8,502,704	13,783,844	59,861	1,426,294	15,269,999	5,775,139	1,262,642	8,816,526	1.563	.007	.162	1.732	.655	.143
Ohio	5,625,619	1,923,772	10,445,052	17,229,531	861,265	1,266,226	19,357,022	8,185,856	2,976,021	11,547,845	1.492	.074	.110	1.676	.709	.258
Pennsylvania	5,066,984	2,345,637	16,270,271	22,943,918	946,298	2,009,737	25,899,953	10,763,289	2,682,734	15,725,819	1.459	.060	.128	1.647	.684	.171
California, Colorado, Utah	(4)	(4)	3,104,467	6,770,470	494,582	103,291	7,368,343	2,350,123	628,964	3,707,880	1.826	.133	.028	1.987	.634	.170
Kentucky, Tennessee, Texas	538,569	363,309	1,530,072	2,393,757	116,922	133,654	2,644,333	768,030	328,205	1,498,471	1.597	.078	.089	1.764	.513	.219
Maryland and West Virginia	(4)	(4)	6,437,769	10,134,669	167,094	559,817	10,861,580	4,386,140	885,911	6,650,302	1.524	.025	.084	1.633	.660	.133
Michigan and Minnesota	(4)	(4)	5,925,960	8,635,490	216,942	211,959	9,064,391	3,532,664	1,234,232	5,432,269	1.590	.040	.039	1.669	.650	.227
New York	1,725,440	352,494	4,263,264	6,109,912	117,349	243,536	6,470,797	2,725,353	1,003,797	3,915,160	1.561	.030	.062	1.653	.696	.256
Total	32,291,374	10,657,909	63,413,572	102,520,786	3,381,737	6,682,174	112,584,697	45,242,594	[6] 12,879,669	65,637,532	1.562	.051	.102	1.715	.689	.196

[1] Net ores and agglomerates equal ores plus agglomerates plus flue dust used minus flue dust recovered.

[2] Excludes home scrap produced at blast furnaces.

[3] Does not include recycled material.

[4] Included in total.

[5] Fluxes consisted of 9,401,285 tons of limestone and 4,186,628 tons of dolomite, excluding 4,533,355 tons of limestone and 1,421,140 tons of dolomite used in agglomerate production at or near steel plants and an unknown quantity used in making agglomerates at mines.

[6] Fluxes consisted of 9,100,454 tons of limestone and 3,779,215 tons of dolomite, excluding 4,424,975 tons of limestone and 1,629,284 tons of dolomite used in agglomerate production at or near steel plants and an unknown quantity used in making agglomerates at mines.

PRODUCTION AND SHIPMENTS OF STEEL

Production of steel in the United States was 98,328 short tons, an increase of less than 1 percent over 1961. Steel castings made by independent foundries, not included in the production figure, totaled 1,244,509 tons, compared with 1,078,182 tons in 1961. Of the total steel produced, 84.4 percent was made in open-hearth furnaces, 9.2 percent in electric furnaces, 5.6 percent in basic oxygen converters, and 0.8 percent in Bessemer converters. Corresponding percentages for 1961 were 86.2, 8.8, 4.1, and 0.9. Pennsylvania continued to be the major U.S. steel producer, followed by Ohio, Indiana, and Illinois, in descending order. Percentages of total production were Pennsylvania, 23.3; Ohio, 17.1; Indiana, 14.3; and Illinois, 8.8.

Shipments of steel products increased 4.4 million tons over 1961 shipments. More than one-half of the increase was due to a 21 percent increase in shipments for automotive uses, and the remainder of the increase occurred mainly in the rail transportation and machinery categories.

Alloy Steel.[3]—Alloy steel production, excluding stainless, was 8,080,310 tons, including 48,064 tons of alloy steel for castings, an increase of 7 percent over 1961 production. Total stainless steel production was 1,085,271 tons, including 1,272 tons of steel for castings, 5 percent less than in 1961. Production of the manganese-nickel-chromium AISI 200 series reached a record at 39,105 tons, nearly 23 percent more than in 1961, the previous record year. Production of AISI 300 series stainless steel and related nickel-chromium alloys was 661,361 tons, a drop of 7 percent from 1961 production.

Of the total alloy steel production (including stainless), 58.8 percent was produced in the open hearth, 40.7 percent in the electric furnace, and 0.5 percent by the basic oxygen process.

Total output of carbon steel was 89,162,204 tons, compared with 89,339,766 tons in 1961.

Materials Used in Steelmaking.—Consumption of pig iron and scrap for steelmaking totaled 110.2 million tons. Pig iron made up 55 percent of the total, the same percentage as in 1961. Consumption of ore decreased 8 percent to 6,643 tons. Foreign ore comprised 72 percent of the total ore used. According to the AISI, 211,467 tons of fluorspar, 4,750,508 tons of limestone, 1,493,195 tons of lime, and 527,173 tons of other fluxes were consumed in steelmaking. Total consumption of oxygen in steelmaking was 54,675 million cubic feet, 23.8 percent more than in 1961. Approximately 77 percent of the total oxygen

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[3] The Bureau of Mines uses the American Iron and Steel Institute specifications for alloy steels, which include stainless and any other steel containing one or more of the following elements in the designated percentages: Manganese in excess of 1.65 percent, silicon in excess of 0.60 percent, and copper in excess of 0.60 percent. It also includes steel containing the following elements in any quantity specified or known to have been added to obtain a desired alloying effect: Aluminum, boron, chromium, cobalt, columbium, molybdenum, nickel, titanium, tungsten, vanadium, zirconium, and other alloying elements.

Stainless steel includes all grades of steel that contain 10 percent or more of chromium with or without other alloys or a minimum combined content of 18 percent of chromium and other alloys. Valve or bearing steels, high-temperature alloys, or electrical grades with analyses meeting the definition for stainless steels are included. All tool-steel grades are excluded.

Heat-resisting steel includes all steel containing 4 percent or more but less than 10 percent of chromium (excluding tool-steel grades).

consumed in steelmaking was used in open-hearth furnaces, and only 20 percent was used in basic oxygen converters.

TABLE 7.—Steel production in the United States, by type of furnace [1]

(Thousand short tons)

Year	Open hearth		Bessemer	Basic oxygen process	Electric [2]	Total
	Basic	Acid				
1953-57 (average)	97,550	582	3,085	[3] 224	7,537	108,978
1958	75,502	378	1,396	1,323	6,656	85,255
1959	81,225	444	1,380	1,864	8,533	93,446
1960	85,964	404	1,189	3,346	8,379	99,282
1961	84,108	394	881	3,967	8,664	98,014
1962	82,578	379	805	5,553	9,013	98,328

[1] Includes only that steel for castings produced in foundries operated by companies manufacturing stee ingots. Omits about 2 percent of total steel production.
[2] Includes crucible, oxygen converter steel, 1953-55.
[3] Data for 2-year period only.

Source: American Iron and Steel Institute.

CONSUMPTION OF PIG IRON

Domestic consumption of pig iron increased by 1 percent in 1962. Consumption was centered in the East, North Central, and Middle Atlantic States, which took 76 percent of the total.

TABLE 8.—Metalliferous materials consumed in steel furnaces in the United States

(Thousand short tons)

Year	Iron ore		Agglomerates [1]	Pig iron	Ferroalloys [2]	Iron and steel scrap
	Domestic	Foreign				
1953-57 (average)	3,277	4,410	1,633	64,132	1,540	57,196
1958	2,092	4,742	1,261	51,299	1,115	43,024
1959	1,690	5,238	961	54,699	1,380	49,794
1960	1,570	6,251	931	60,092	1,395	51,140
1961	1,913	5,277	855	59,418	1,367	49,455
1962	1,875	4,768	[3] 1,176	60,561	1,408	49,606

[1] Includes consumption of pig iron and scrap by ingot producers and iron and steel foundries.
[2] Includes ferromanganese, spiegeleisen, silicomanganese, manganese briquets, manganese metal, ferrosilicon, ferrochromium alloys, and ferromolybdenum.
[3] Includes 20,039 tons of sinter, 342,466 tons of pellets, 276,632 tons of nodules, 702 tons of briquets, 3,661 tons of other agglomerates. (532,031 tons of foreign origin.) 1958-61 see Iron and Steel chapter, Minerals Yearbook, v. I, p. 691.

TABLE 9.—Consumption of pig iron in the United States, by type of furnace

Type of furnace or equipment	1961		1962	
	Thousand short tons	Percent of total	Thousand short tons	Percent of total
Open hearth	54,611	83.0	54,509	81.8
Bessemer	976	1.5	792	1.2
Oxygen converter	3,552	5.4	5,020	7.5
Electric [1]	279	.4	240	.4
Cupola	3,438	5.2	3,402	5.1
Air	178	.3	186	.3
Direct castings	2,763	4.2	2,446	3.7
Total	65,797	100.0	66,595	100.0

[1] Includes a small quantity of pig iron consumed in crucible furnaces.

TABLE 10.—Consumption of pig iron in the United States, by districts and States

(Short tons)

District and State	1961	1962
New England:		
Connecticut	29,410	33,024
Maine and New Hampshire	4,136	2,251
Massachusetts	63,281	59,876
Rhode Island	36,958	41,836
Vermont	8,038	7,288
Total	141,823	144,275
Middle Atlantic:		
New Jersey	144,530	119,757
New York	3,219,625	3,355,305
Pennsylvania	15,315,543	15,975,716
Total	18,679,698	19,450,778
East North Central:		
Illinois	4,975,379	4,932,854
Indiana	9,075,150	8,972,216
Michigan	5,159,290	5,534,555
Ohio	10,937,800	11,430,509
Wisconsin	175,747	186,327
Total	30,323,366	31,056,461
West North Central:		
Iowa	69,451	71,050
Kansas and Nebraska	5,706	5,337
Minnesota	393,744	446,331
Missouri	24,246	29,247
Total	493,147	551,965
South Atlantic:		
Delaware and Maryland	4,418,830	4,802,288
Florida and Georgia	11,521	11,445
South Atlantic—Con.		
North Carolina	27,971	29,457
South Carolina	15,882	18,684
Virginia and West Virginia	2,143,204	1,950,305
Total	6,617,408	6,812,179
East South Central:		
Alabama	3,222,653	3,104,152
Kentucky, Mississippi, Tennessee	907,614	852,388
Total	4,130,267	3,956,540
West South Central:		
Arkansas, Louisiana, Oklahoma	7,749	8,302
Texas	856,118	780,226
Total	863,867	788,528
Rocky Mountain:		
Arizona and Nevada	88	162
Colorado, Idaho, Montana, Utah	2,351,978	2,012,961
Total	2,352,066	2,013,123
Pacific Coast:		
California and Hawaii [1]	2,191,936	1,817,823
Oregon and Washington	3,720	3,810
Total	2,195,656	1,821,633
Grand total	65,797,298	66,595,482

[1] Hawaii included in 1962 figure only.

PRICES

Pig iron and steel prices remained fairly constant during 1962. The average composite pig iron price, published by Iron Age, was $58.86 per short ton, compared with $59.32 in 1961. The Iron Age figure for the composite price of finished steel was 6.196 cents per pound, unchanged since 1959.

TABLE 11.—Average value of pig iron at blast furnaces in the United States, by States

(Per short ton)

State	1953–57 (average)	1958	1959	1960	1961	1962
Alabama	$49.17	$55.14	$56.81	$56.52	$56.62	$57.46
California, Colorado, Utah	52.94	57.53	60.47	59.73	50.50	51.59
Illinois	52.86	61.32	60.12	60.30	60.42	59.10
Indiana	52.45	58.41	58.82	58.90	58.96	57.34
New York	54.32	64.48	61.01	62.54	60.05	59.13
Ohio	51.29	57.93	59.50	57.79	60.78	59.89
Pennsylvania	53.52	62.45	59.84	60.12	59.48	58.93
Other States [1]	53.07	60.53	58.38	58.06	57.44	57.66
Average	52.58	59.60	59.33	59.53	58.51	58.15

[1] Comprises Kentucky, Maryland, Michigan, Minnesota, Tennessee, Texas, West Virginia, and Massachusetts (1953–60).

TABLE 12.—Average prices of chief grades of pig iron

(Per short ton)

Month	Foundry pig iron at Birmingham furnaces 1962	Foundry pig iron at Valley furnaces 1962	Bessemer pig iron at Valley furnaces 1962	Basic pig iron at Valley furnaces 1962
January–December	55.39	58.93	59.38	58.48

Source: Metal Statistics.

TABLE 13.—Free-on-board value of steel mill products in the United States, in 1961 [1]

(Cents per pound)

Product	Carbon	Alloy	Stainless	Average
Ingots	4.038	10.066	32.067	9.371
Semifinished shapes and forms	5.278	10.435	36.234	6.380
Plates	6.612	11.048	59.964	7.398
Sheets and strips	7.074	15.616	49.977	8.023
Tin mill products	9.106			9.106
Structural shapes and piling	6.394	(2)		6.394
Bars	7.580	13.466	65.443	9.170
Rails and railway-track material	8.499			8.499
Pipes and tubes	14.944	19.098	158.165	18.707
Wire and wire products	13.045	38.557	84.702	14.009
Other rolled and drawn products	(3)	42.117	59.820	45.026
Average total steel	7.602	14.283	57.752	8.560

[1] This table represents the weighted average value based on the quantity of each type of steel shipped; therefore, it reflects shifts in the distribution of the 3 classes of steel.
[2] Included with "Plates."
[3] Included with "Rails and railway-track material."

Source: Computed from figures supplied by the U.S. Department of Commerce, Bureau of the Census.

FOREIGN TRADE [4]

For the fourth consecutive year, imports of steel mill products exceeded exports. Imports were 232 percent higher than the 1953–57

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

5-year average, and exports were only 53 percent of the 1953–57 average.

Imports.—Imports of iron and steel products totaled 4.3 million tons, the second highest total on record and 30 percent higher than the total for 1961. The bulk of the imports were supplied by the European Coal and Steel Community and Japan. Imports of pig iron (77 percent from Canada) were 500,010 tons, 33 percent higher than in 1961.

Exports.—Exports of iron and steel products totaled 2.3 million tons, slightly higher than in 1961. Exports of pig iron (55 percent to Japan) were 154,380 tons, compared with 415,668 tons in 1961.

TABLE 14.—U.S. imports for consumption of pig iron, by countries

(Short tons)

Country	1953–57 (average)	1958	1959	1960	1961	1962
North America: Canada	258,717	182,128	437,095	281,593	349,403	386,232
South America: Brazil	3,924	2				
Europe:						
Belgium-Luxembourg				4,408		
Finland	34		10,253			681
Germany, West	7,085	13,933	[1] 71,805	386	719	56,341
Netherlands	5,547	1,125	4,427	1,575		
Norway	1,347	334	168			3,584
Portugal			4,395			
Spain	3,874	7,867	78,499	21,551	19,113	42,416
Sweden	13,058	1,615	1,071	1,445	1,201	1,416
U.S.S.R.			1,550	1,298	396	
United Kingdom			51			94
Total	30,945	24,874	172,219	30,663	21,429	104,532
Asia:						
India	6,336		56	6,742		
Japan			10,674			
Total	6,336		10,730	6,742		
Africa:						
Rhodesia and Nyasaland, Federation of [2]	1,758		4,863	392		
South Africa, Republic of [3]	1,414		70,519	7,543	4,096	5,030
Total	3,172		75,382	7,935	4,096	5,030
Oceania: Australia	40,143	2,739	4,167	3,914	2,252	4,216
Grand total:						
Short tons	343,237	209,743	699,593	330,847	377,180	500,010
Value	$17,043,294	$12,026,015	$35,493,259	$18,351,333	$20,511,391	$24,681,598

[1] Includes 110 tons from East Germany.
[2] Classified as Southern Rhodesia through June 30, 1954; 1,562 short tons was produced from January through June 1954.
[3] Effective Jan. 1, 1962, formerly Union of South Africa.

Source: Bureau of the Census.

TABLE 15.—U.S. imports for consumption of major iron and steel products

Products	1961		1962	
	Short tons	Value	Short tons	Value
Iron products:				
Bar iron, iron slabs, blooms, or other forms	60	$18,971	211	$64,710
Pipes and fittings:				
Cast-iron pipe and fittings	[1] 21,932	[1] 2,438,665	35,540	4,043,946
Malleable cast-iron pipe fittings	2,300	917,052	3,325	1,304,389
Castings and forgings	[1] 6,865	[1] 2,419,492	15,056	5,220,909
Total	31,157	[1] 5,794,180	54,132	10,633,954
Steel products:				
Steel bars:				
Concrete reinforcement bars	582,807	48,468,456	607,024	44,284,929
Solid and hollow, n.e.s	112,663	14,276,382	126,358	17,009,912
Hollow and hollow drill steel	1,486	631,019	2,567	1,188,238
Wire rods, nail rods, and flat rods up to 6 inches in width	451,209	59,015,135	644,594	62,049,125
Boiler and other plate iron and steel, n.e.s	71,045	8,407,821	216,069	26,319,439
Steel ingots, blooms, and slabs; billets, solid and hollow	178,915	12,536,560	170,605	13,323,271
Die blocks or blanks, shafting, etc	1,083	439,999	2,100	828,928
Circular saw plates	37	39,837	54	67,991
Sheets of iron or steel, common, or black and boiler or other plate of iron or steel	64,700	8,993,987	215,179	26,261,302
Sheets and plates and steel, n.s.p.f	6,823	2,397,182	10,976	4,669,932
Tinplate, terneplate, and taggers' tin	15,151	2,651,937	52,479	8,586,908
Structural iron and steel	553,155	59,775,317	709,295	75,589,902
Rails for railways	14,231	1,172,742	10,560	905,247
Rail braces, bars, fishplates, or splice bars and tie plates	472	67,573	268	29,123
Steel pipes and tubes	[1] 521,270	79,845,253	632,329	92,979,275
Wire:				
Barbed	82,457	11,810,235	66,598	8,762,116
Round wire, n.e.s	172,026	31,036,899	242,250	44,608,626
Telegraph, telephone, etc., except copper, covered with cotton jute, etc	[1] 1,441	507,815	782	452,765
Flat wire and iron and steel strips	59,881	14,244,943	86,366	17,337,359
Rope and strand	34,178	10,164,586	39,323	11,958,768
Galvanized fencing wire and wire fencing	59,955	8,340,744	73,042	9,641,734
Iron and steel used in card clothing	(2)	250,364	(2)	243,397
Hoop and band iron and steel, for baling	18,432	2,367,807	24,694	3,174,978
Hoop, band and strips, or scroll iron or steel, n.s.p.f	10,576	1,957,941	12,909	2,265,682
Nails	252,713	36,930,374	281,800	40,084,942
Steel castings and forgings	10,619	1,936,801	8,384	1,490,612
Total	[1] 3,277,325	418,267,709	4,236,605	514,114,501
Advanced manufactures:				
Bolts, nuts, and rivets	[1] 43,584	13,583,140	67,934	20,096,908
Chains and parts	7,052	4,784,443	9,506	6,102,429
Hardware, builders'		1,709,896		2,961,011
Hinges and hinge blanks		1,594,101		1,875,449
Screws (wholly or chiefly of iron or steel)		[1] 1,656,239		3,137,480
Tools		18,070,497		[3] 20,071,345
Other		694,652		1,550,041
Total		[1] 42,092,968		55,794,663
Grand total		[1] 466,154,857		580,543,118

[1] Revised figure.
[2] Weight not recorded.
[3] Due to changes in classifications, data not strictly comparable with 1961.

Source: Bureau of the Census.

TABLE 16.—U.S. exports of major iron and steel products

Products	1961 Short tons	1961 Value	1962 Short tons	1962 Value
Semimanufactures:				
Steel ingots, blooms, billets, slabs, and sheet bars	138,044	$13,981,224	252,667	$20,499,709
Iron and steel bars and rods:				
Carbon-steel bars, hot-rolled, and iron bars	51,712	9,058,636	52,491	9,682,725
Concrete reinforcement bars	15,688	2,121,988	22,398	2,950,860
Other steel bars	[1] 23,916	[1] 11,095,127	27,731	12,037,785
Wire rods	5,378	1,893,402	17,006	3,853,784
Iron and steel plates, sheets, skelp, and strips:				
Plates, including boilerplate, not fabricated	[1] 97,403	[1] 19,603,178	119,856	26,187,475
Skelp iron and steel	42,025	4,264,356	11,528	1,121,853
Iron and steel sheets, galvanized	65,933	13,061,939	124,692	25,046,171
Steel sheets, black, ungalvanized	[1] 492,826	[1] 105,036,071	458,073	102,825,501
Strip, hoop, band, and scroll iron and steel:				
Cold-rolled	[1] 35,298	[1] 16,251,769	33,196	15,784,152
Hot-rolled	[1] 34,919	[1] 8,672,301	31,617	6,779,069
Tinplate and terneplate	401,752	66,811,505	329,852	53,011,244
Tinplate circles, cobbles, strip, and scroll shear butts	23,475	2,491,455	24,633	2,756,006
Total	[1] 1,428,369	[1] 274,342,951	1,505,740	282,536,334
Manufactures—steel mill products:				
Structural iron and steel:				
Water, oil, gas, and other storage tanks (unlined), complete and knockdown material	18,536	7,192,752	20,282	8,502,263
Structural shapes:				
Not fabricated	[1] 214,263	[1] 29,152,709	145,702	20,841,902
Fabricated	[1] 53,948	[1] 22,858,191	58,841	29,516,584
Plates and sheets, fabricated, punched, or shaped	8,374	2,708,165	17,507	6,641,010
Metal lath	1,379	514,187	1,215	479,552
Frames, sashes, and sheet piling	14,423	3,097,900	13,881	2,940,590
Railway-track material:				
Rails for railways	89,307	12,218,490	102,191	12,922,089
Rail joints, splice bars, fishplates, and tieplates	14,084	3,793,503	19,921	4,645,589
Switches, frogs, and crossings	1,175	579,105	3,816	1,158,206
Railroad spikes	1,047	293,371	381	110,574
Railroad bolts, nuts, washers, and nut locks	1,050	476,422	881	445,877
Tubular products:				
Boiler tubes	[1] 12,092	[1] 7,975,036	10,424	7,552,287
Casing and line pipe	[1] 92,159	[1] 30,176,471	86,083	27,581,701
Seamless black and galvanized pipe and tubes, except casing, line and boiler, and other pipes and tubes	25,589	7,931,028	32,066	8,681,474
Welded black pipe	9,510	2,631,292	10,168	3,157,823
Welded galvanized pipe	4,480	1,240,594	5,609	1,305,537
Malleable-iron screwed pipe fittings	1,223	1,277,355	1,192	1,389,825
Cast-iron pressure pipe and fittings	14,414	2,852,644	22,630	4,209,718
Cast-iron soil pipe and fittings	5,457	1,362,743	6,373	1,651,629
Iron and steel pipe, fittings, and tubing, n.e.c	[1] 69,883	[1] 45,487,128	50,451	41,977,794
Wire and manufactures:				
Barbed wire	969	266,219	12,896	2,685,658
Galvanized wire	8,312	2,366,257	10,108	3,116,705
Iron and steel wire, uncoated	9,814	4,105,670	16,206	5,504,412
Spring wire	1,301	892,997	1,469	986,920
Wire rope and strand	8,322	4,940,903	9,553	5,332,085
Woven-wire screen cloth	1,659	[2] 1,951,917	1,956	[2] 2,031,332
All other	13,692	9,865,044	15,123	9,587,889
Nails and bolts, iron and steel, n.e.c.:				
Wire nails, staples, and spikes	3,469	2,967,169	4,060	3,062,177
Bolts, screws, nuts, rivets, and washers, n.o.c	12,784	16,842,185	15,025	19,210,961
Tacks	612	411,871	692	455,429
Castings and forgings: Iron and steel, including car wheels, tires, and axles	79,461	23,976,477	64,343	24,534,486
Total	[1] 792,788	[1] 252,405,795	761,045	262,220,078

See footnotes at end of table.

TABLE 16.—U.S. exports of major iron and steel products—Continued

Products	1961		1962	
	Short tons	Value	Short tons	Value
Advanced manufactures:				
Buildings (prefabricated and knockdown)		$6,930,535		$7,606,979
Chains and parts	8,410	9,992,243	7,993	10,069,098
Construction material	8,259	6,179,827	9,264	6,598,605
Hardware and parts		22,152,741		23,563,072
House-heating boilers and radiators		6,650,939		6,666,330
Oil burners and parts		8,709,159		8,856,731
Plumbing fixtures and fittings		3,525,125		2,701,981
Tools		[1] 54,835,512		59,161,606
Utensils and parts (cooking, kitchen, and hospital)		3,338,624		3,774,726
Other		37,532,316		45,572,134
Total		[1] 159,847,021		174,571,262
Grand total		[1] 686,595,767		719,327,674

[1] Revised figure.
[2] Includes wire cloth as follows: 1961, $1,418,345 (8,213,881 square feet); 1962, $1,455,917 (7,463,741 square feet).

Source: Bureau of the Census.

WORLD REVIEW [5]

World production of pig iron (including ferroalloys) reached a new high with a 2-percent increase. The largest increase, 5.1 million tons (9 percent), was in the U.S.S.R. World steel production was also at a new high with an increase of 2 percent over 1961. Again the U.S.S.R. showed the greatest gain—6.3 million tons (8 percent). The United States produced 23 percent of the total pig iron and 25 percent of the total steel, the same as in 1960 and 1961.

[5] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.

TABLE 17.—World production of pig iron including ferroalloys) by countries [1] [2]

(Thousand short tons)

Country [1]	1953-57 (average)	1958	1959	1960	1961	1962
North America:						
Canada	3,326	3,172	4,318	4,416	5,043	5,427
Mexico	370	547	617	733	939	937
United States	74,961	58,867	62,135	68,620	66,717	67,636
Total	78,657	62,586	67,070	73,769	72,699	74,000
South America:						
Argentina	39	32	39	198	440	440
Brazil	1,219	1,550	1,750	1,965	2,045	[3] 1,650
Chile	353	336	320	293	314	428
Colombia	[4] 123	164	138	194	209	220
Venezuela						136
Total	1,734	2,082	2,247	2,650	3,008	2,874
Europe:						
Austria	1,737	2,004	2,025	2,460	2,493	2,335
Belgium	5,638	6,084	6,575	7,223	7,104	7,439
Bulgaria	19	100	195	212	227	243
Czechoslovakia	3,396	4,160	4,679	5,176	5,480	5,730
Denmark	54	49	64	76	71	74
Finland	110	111	119	116	163	377
France	11,568	13,400	13,951	15,921	16,367	14,990
Germany:						
East	1,576	1,957	2,092	2,199	2,237	2,287
West (including Saar)	19,960	21,784	23,814	28,372	28,033	26,732
Hungary	899	1,210	1,235	1,390	1,455	1,548
Italy	1,910	2,389	2,416	3,113	3,528	4,053
Luxembourg	3,371	3,621	3,795	4,173	4,226	3,965
Netherlands	714	1,011	1,259	1,485	1,606	1,732
Norway	419	575	686	794	837	801
Poland	3,379	4,259	4,822	5,030	5,258	5,860
Portugal		19	40	45	134	244
Rumania	599	812	933	1,118	1,211	1,665
Spain	1,030	1,479	1,889	2,124	2,340	2,362
Sweden	1,380	1,559	1,655	1,793	2,091	2,000
Switzerland	47	[3] 40	[3] 50	[3] 60	[3] 60	[3] 60
U.S.S.R. [5]	36,040	43,650	47,370	51,540	56,100	61,200
United Kingdom	14,107	14,532	14,092	17,655	16,517	15,490
Yugoslavia	565	860	995	1,123	1,163	1,216
Total [5]	108,518	125,665	134,751	153,198	158,701	162,403
Asia:						
China	4,200	[6] 10,470	[6] 22,600	30,300	[3] 22,000	[3] 19,800
India	2,129	2,352	3,427	4,621	5,170	6,516
Japan	6,224	8,510	10,908	13,604	18,059	20,325
Korea, North	125	350	765	940	1,025	1,340
Taiwan (Formosa)	14	19	36	26	67	69
Thailand	3	6	8	7	6	6
Turkey	233	254	260	272	207	166
Total [5]	12,928	21,961	38,004	49,770	46,534	48,222
Africa:						
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	60	94	79	77	77	77
South Africa, Republic of	1,434	1,744	1,992	2,204	2,566	2,663
United Arab Republic (Egypt)	8	[3] 45	130	163	[3] 110	[3] 110
Total	1,502	1,883	2,201	2,444	2,753	2,850
Oceania: Australia	2,190	2,553	2,806	3,228	3,538	3,844
World total (estimate)	205,530	216,750	247,100	285,100	287,350	294,200

[1] Pig iron is also produced in Republic of the Congo, but quantity produced is believed insufficient to affect estimate of world total.
[2] This table incorporates some revisions. Data do not add to totals shown because of rounding where estimated figures are included in the detail.
[3] Estimate.
[4] Average annual production 1954-57.
[5] U.S.S.R. in Asia included with U.S.S.R. in Europe.
[6] Based on figures from Chinese sources. 1958 does not include approximately 4 million tons substandard grade iron produced at small plants. 1959 production probably includes pig iron obtained from reworking the low-grade product of 1958 and an unreported quantity (probably relatively small) of substandard iron from small plants, most of which were shut down early in the year.
[7] Average annual production 1955-57.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

TABLE 18.—World production of steel ingots and castings by countries [1]

(Thousand short tons)

Country	1953–57 (average)	1958	1959	1960	1961	1962
North America:						
Canada	4,443	4,359	5,901	5,790	6,466	7,173
Mexico	841	1,144	1,442	1,713	1,846	1,855
United States [2]	108,978	85,255	93,446	99,282	98,014	98,328
Total	114,262	90,758	100,789	106,785	106,326	107,356
South America:						
Argentina	274	269	236	305	486	550
Brazil	1,427	1,581	1,910	2,186	2,382	[3] 2,390
Chile	374	384	457	465	400	546
Colombia	62	133	120	173	194	151
Peru	---------	22	56	66	83	83
Venezuela	---------	---------	---------	---------	6	165
Total	2,137	2,389	2,779	3,195	3,551	3,885
Europe:						
Austria	2,060	2,638	2,769	3,487	3,418	3,274
Belgium	6,161	6,626	7,096	7,923	7,728	8,114
Bulgaria	[4] 98	233	254	279	375	465
Czechoslovakia	5,106	6,074	6,764	7,460	7,764	8,300
Denmark	255	280	322	320	326	405
Finland	198	209	260	285	310	365
France	13,307	15,947	16,617	18,907	19,401	19,004
Germany:						
East	2,786	3,354	3,535	3,678	3,796	3,994
West (including Saar)	25,873	28,930	32,446	37,589	36,881	35,895
Greece	69	125	99	[3] 140	[3] 150	[3] 170
Hungary	1,644	1,793	1,939	2,078	2,263	2,572
Ireland [3]	30	31	44	44	50	50
Italy	5,687	6,913	7,454	9,071	10,057	10,459
Luxembourg	3,452	3,725	4,038	4,502	4,534	4,422
Netherlands	1,106	1,585	1,841	2,141	2,173	2,301
Norway	230	409	470	540	550	539
Poland	4,915	6,242	6,790	7,585	7,974	8,470
Rumania	828	1,030	1,564	1,991	2,345	2,702
Spain	1,335	1,734	1,995	2,157	2,456	2,542
Sweden	2,338	2,653	3,155	3,547	3,921	3,979
Switzerland [5]	194	270	275	300	327	337
U.S.S.R.[6]	49,540	60,539	66,107	71,973	77,791	84,100
United Kingdom	22,014	21,914	22,609	27,222	24,737	22,950
Yugoslavia	853	1,233	1,432	1,590	1,689	1,758
Total [6]	150,079	174,487	189,875	214,809	221,016	227,167
Asia:						
China	3,600	8,820	14,720	20,340	[3] 15,000	[3] 13,000
India	1,871	2,030	2,726	3,623	4,488	5,557
Israel	---------	[7] 29	26	45	68	88
Japan	10,691	13,358	18,330	24,403	31,160	30,364
Korea:						
North [3]	140	400	500	710	850	1,150
Republic of	9	22	42	55	52	79
Taiwan	61	118	175	220	218	201
Thailand	3	6	7	8	9	8
Turkey	198	176	236	330	312	322
Total [6]	16,573	24,959	36,762	49,734	52,157	50,769
Africa:						
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	52	79	51	88	88	88
South Africa, Republic of	1,674	2,019	2,090	2,328	2,738	3,251
United Arab Republic (Egypt) [3]	85	110	110	150	165	165
Total	1,811	2,208	2,251	2,566	2,991	3,504
Oceania: Australia	2,690	3,509	3,803	4,129	4,338	4,663
World total (estimate)	287,550	298,300	336,250	381,200	390,400	397,350

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[2] Data from American Iron and Steel Institute. Excludes production of castings by companies that do not produce steel ingots.
[3] Estimate.
[4] Average annual production 1953–57.
[5] Including secondary.
[6] U.S.S.R. in Asia included with U.S.S.R. in Europe.
[7] Includes 1957 production when plant came into operation.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

NORTH AMERICA

Canada.—Production of pig iron and steel set records in 1962. Pig iron production of 5.4 million short tons was 8 percent higher than the previous record of 5.0 million tons set in 1961. Production of steel ingots and castings was a record 7.2 million tons, 11 percent higher than the previous record 6.5 million tons produced in 1961. Open-hearth furnaces and oxygen converters accounted for 89 percent of the total steel production, and electric furnaces, 11 percent. Total production of carbon steel hot-rolled products was 5.5 million tons, compared with 4.9 million tons in 1961. Imports of iron and steel products were 803,339 tons, and exports were 1,291,229 tons. Pig iron constituted 459,443 tons of the exports. Consumption of 1,203 pounds of coke per ton of pig iron produced was a substantial drop from the 1,418 pounds per ton reported for 1961.[6]

The planned $35 million expansion of Algoma Steel Corp., Ltd., Sault Ste. Marie, Ontario, included a new wide-strip mill, soaking pits, furnaces, and increased oxygen steelmaking capacity.[7]

Atlas Steel, Ltd., was reported to be spending $40 million for the construction of a new stainless steel plant at Tracey, Quebec. The mill was to be completed in 1963 to produce stainless sheet up to 48 inches wide. An unusual feature of the plants was the planned use of 50 to 65 percent hot metal in the charge.[8]

Consolidated Mining & Smelting Co. of Canada, Ltd. (Cominco), announced plans to spend $4 million to triple its pig iron production to 110,000 tons per year. Cominco's main pig iron markets were Western Canada and the Western United States.[9]

Mexico.—The International Finance Corp., and the Mexican financing institution, Credito Bursatil, formed a syndicate to underwrite a $4 million issue of capital shares of Compania Fundidora de Fierro y Acero de Monterrey, S.A., the largest private steel company in Mexico. The underwriting was to assist the company in completing its program of expansion from 200,000 to 500,000 tons annually.[10]

A new steel plant, designed by Friedrich Krupp, was to be constructed on the lower Balsas River. Production from the mill, scheduled to go into operation in 1965, was expected to be 250,000 tons per year. The iron ore deposits at Las Truchas, Michoacan, to be utilized by the plant, were estimated to be sufficient for 100 years of operation.[11]

SOUTH AMERICA

Argentina.—On November 30, 1962, Siderurgica Campana S.A. officially inaugurated its new electric-furnace steel mill in Campana, Buenos Aires Province. Construction of the mill, having an annual capacity of 165,000 tons of steel, was started in 1961. One furnace went into operation a month before the official ceremony, which was postponed until both furnaces were operating. The plant began opera-

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[6] Dominion Bureau of Statistics. Primary Iron and Steel. V. 18, No. 1, January 1963, 27 pp.; No. 3, March 1963, 27 pp.
[7] Iron Age. V. 189, No. 3, Jan. 18, 1962, p. 13.
[8] Iron Age. V. 189, No. 2, Jan. 11, 1962, p. 42.
[9] Western Mines and Oil Review (Vancouver, Canada). V. 35, No. 5, May 1962, pp. 50–51.
[10] Steel & Coal (London). V. 185, No. 4904, July 13, 1962, p. 78.
[11] Skillings' Mining Review. V. 51, No. 48, Dec. 1, 1962, p. 15.

tions using purchased power, but was expected to complete its own 44,500-kilovolt-ampere power installation early in 1963. Plans were made for expansion to a capacity of 330,000 tons per year.[12]

Four Japanese steel firms signed an agreement on February 1, 1962, with the Misiones Provincial Government for the construction of a charcoal blast furnace at Posades in Northeastern Argentina.[13]

The Argentine Government certified the plans of Industrias Argentinas de Acera for expansion of plant facilities in Rosario and Villa Constitucion to an annual capacity of 530,000 tons, triple the former capacity. The estimated cost of the expansion was $90 million, and it was scheduled for completion in mid-1964.[14]

Brazil.—A contract for the construction of a steel plant in the State of Guanabara, costing $250 million, was signed by representatives of a European financial group and by the president of the Cia. Siderurgica da Guanabara. The proposed plant was expected to have an initial annual capacity of 500,000 tons of steel with provision for eventual expansion to 2 million tons. The European financial group consisted of the German firm Krupp, the Belgian firm Syndicat Belge d'Enterprises a l'Etranger, and the French firm Cie. des Ateliers et Forges de France. Approval by the Brazilian Government was necessary before construction could be started.[15]

Companhia Siderurgica da Amazonia was reported to be planning the construction of a steel mill with an estimated annual capacity of 100,000 tons in Manaus, State of Amazonas. Krupp was to supply the equipment and technicians for the new installation in exchange for iron ore from the company's mines.[16]

The steel plant of the Cia. Siderurgica Paulista at Piassaquera was reported ready to start production at an annual rate of 800,000 tons of steel ingots before the end of 1962.[17]

The National Steelworks (Volta Redonda) announced an expansion from 1.1 million tons to 1.5 million tons of ingots annually. Future expansion plans envisaged doubling the output. Acos Anhanguera, a new steel mill for the production of steel for springs, screws, automobile parts, and ball bearings, was organized. Initial annual capacity of 70,000 tons was planned.[18]

Companhia Ferro Brasileiro, a concern that manufactured iron pipe, inaugurated a new 180-ton-per-day blast furnace on August 2.[19]

The first blast furnace of the new Independente Camara steel mill of Usinas Siderurgicas de Minas Gerais S. A. (USIMINAS) was inaugurated on October 26, and the first pig iron was poured October 27. The plant, located at Ipatinga, Minas Gerais (about 100 miles east of Belo Horizonte), cost about $250 million and was an integrated operation with an annual production capacity of 500,000 tons. Future plans called for expansion to 2 million tons annually. About 40 per-

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[12] U.S. Embassy, Buenos Aires, Argentina. State Department Airgram A-837, Dec. 7, 1962.
[13] Bureau of Mines. Mineral Trade Notes. V. 54, No. 5, May 1962, p. 22.
[14] Bureau of Mines. Mineral Trade Notes. V. 55, No. 6, December 1962, p. 16.
[15] Steel & Coal (London). V. 184, No. 4883, Feb. 16, 1962, p. 326.
[16] Foreign Trade (Ottawa, Canada). V. 117, No. 10, May 19, 1962, p. 32.
[17] Mining Journal (London). V. 259, No. 6623, July 27, 1962, p. 89.
[18] Mining Journal (London). V. 259, No. 6624, Aug. 3, 1962, p. 110.
[19] U.S. Consulate, Belo Horizonte, Brazil. State Department Airgram A-9, Aug. 14, 1962.

cent of the shares of USIMINAS were owned by a group of Japanese steel companies headed by Yawata Iron and Steel Co., Ltd.[20]

The Brazilian Government authorized the construction of a small steel mill in the southern State of Santa Catarina. The mill, in which the Government was to have a 51-percent interest, was to be called Siderurgica de Santa Catarina S. A. and was expected to have an initial capital of $3 million.[21]

Chile.—Development plans for the next 3 years at the Huachipato plant of Compañía de Acero del Pacifico called for an increase in blast-furnace capacity from the present 1,000–1,100 tons per day to 1,300–1,600 tons per day by using higher iron content concentrates and by injecting gas and fuel oil into the furnace. The capacity of two open-hearth furnaces was to be increased from 100 to 200 tons, and oxygen lancing was to be used in all open hearths. The changes, which were estimated to cost $50 million, were expected to raise the plant capacity to 600,000 ingot tons per year.[22]

Colombia.—As a result of a study of long-range demand for steel products, in Colombia a plan for increasing the annual capacity of Acerias Paz del Rio from 120,000 tons to 550,000 tons per year was submitted to the International Bank for Reconstruction and Development. Financial assistance totaling $50 million was requested to finance the expansion.[23]

Peru.—The West German consortium Ferrostaal agreed to finance the expansion of the Government-owned steel plant at Chimbote from 60,000 to 350,000 ingot tons per year. The expansion was estimated to cost about $130 million.[24]

It was reported that a four-strand continuous-casting machine would be installed at the Chimbote plant by a German firm.[25]

Venezuela.—The new Orinoco steel plant poured its first metal on July 9. Work on the fully integrated steel plant began in 1956, and when completed, it was expected to cost about $312 million. When full production was achieved, the plant was expected to produce annually 770,000 tons of steel ingots and 550,000 tons of pig iron. The planned annual output of steel products from the completed plant was 600,000 tons, which included 325,000 tons of seamless pipe, 94,960 tons of rods, 77,000 tons of structural steel, and 67,800 tons of rails.[26]

EUROPE

The European Coal and Steel Community (ECSC).—Crude steel production decreased 0.7 percent from 1961 to a total of 80.1 million short tons, 0.6 million tons lower than the 80.7 million tons produced during 1961. Production increased by 5 percent in Belgium and the Netherlands and by 4 percent in Italy. It decreased by 3 percent in West Germany and Luxembourg and by 2 percent in France. Production of steel by oxygen processes amounted to 4.8 percent of the total, compared with 3.2 percent in 1961.

[20] U.S. Embassy, Rio de Janeiro, Brazil. State Department Airgram A–558, Nov. 16, 1962.
[21] Foreign Trade (Ottawa, Canada). V. 118, No. 12, Dec. 15, 1962, p. 33.
[22] Bureau of Mines. Mineral Trade Notes. V. 55, No. 2, August 1962, p. 41.
[23] U.S. Embassy, Bogota, Colombia. State Department Airgram A–331, Nov. 30, 1962.
[24] Mining Journal (London). V. 258, No. 6619, June 29, 1962, p. 675.
[25] Steel. V. 150, No. 7, Feb. 12, 1962, p. 86.
[26] Foreign Trade (Ottawa, Canada). V. 118, No. 5, Sept. 8, 1962, pp. 15–16.

Production of pig iron was an estimated 59.2 million tons, compared with 60.2 million tons in 1961. Consumption of pig iron per ton of steel was 1,378 pounds, down slightly from the 1961 figure of 1,384 pounds. A total of 32.3 million tons of scrap was used in steel production, for an average of 830 pounds per ton, up slightly from the corresponding figures of 32.0 million tons and 816 pounds per ton for 1961.

The increased use of agglomerates in the blast furnace, 1,726 pounds per ton of iron produced, compared with 1,426 pounds per ton in 1961, caused a decrease in coke usage. Coke consumption in ECSC blast furnaces amounted to 52.1 million tons, down from 55.4 million tons in 1961. The corresponding coke rates were 1,620 pounds per ton of iron produced, contrasted with 1,714 pounds per ton in 1961. The use of scrap in blast furnaces decreased slightly from that of 1961, totaling 24.3 million tons, or 81 pounds per ton of iron produced.[27]

United Kingdom.—The first steel was produced in July by one of the L–D (Linz-Donawitz) converters of the new $336 million Spencer Steelworks of Richard Thomas and Baldwins, Ltd. The plant, when fully completed, was expected to have a capacity of over 1.25 million tons per year.[28]

Stewarts and Lloyds, Ltd., planned to replace its Bessemer converter capacity with three LD/AC converters. The LD/AC vessels were to increase the capacity by an unspecified amount over the 800,000-ton-per-year capacity of the Bessemer converters. The new converters, which were estimated to cost $11 million, were expected to be in production by late 1964 or early 1965.[29]

The Panteg works of Richard Thomas and Baldwins began operation of a single-strand continuous-casting machine, designed primarily for the production of stainless steel slabs. Both killed carbon steel and stainless steel slabs, 4⅝ inches by 34 or 38 inches, were initially produced at a speed of 48 inches per minute.[30]

The planned change from open hearth to electric furnaces at the Steel, Peech and Tozer branch of the United Steel Cos., Ltd., was partially completed. Three of the 14 open-hearth furnaces in the Templebrough melting shop were demolished, and 2 electric furnaces were installed. One electric furnace went into operation late in 1962. Upon completion of the changeover in 1965 at an estimated total cost of $31 million, the Steel, Peech and Tozer plant would be the largest electric steelmaking plant in the world, with an annual capacity of 1.35 million tons.[31]

A new 750-ton-per-day blast furnace was blown in at the Dagenham works of Ford Motor Co., Ltd. The new furnace, which cost approximately $3 million, had a hearth diameter of 20 feet and a height of 220 feet. It replaced Ford's original 28-year-old, 500-ton-per-day furnace, which was shut down early in November 1961.[32]

Yugoslavia.—A total of 1,448,500 tons of steel was produced in the first 11 months of 1962. This was an increase of 5 percent over the

[27] European Coal and Steel Community. Eleventh General Report on the Activities of the Community. Jan. 31, 1963, pp. 78–95.
[28] Steel & Coal (London). V. 185, No. 4906, July 27, 1962, p. 157.
[29] Metal Industry (London). V. 101, No. 20, Nov. 15, 1962, p. 295.
[30] Steel & Coal (London). V. 185, No. 4924, Nov. 30, 1962, p. 1043.
[31] Metallurgia (Manchester, England). V. 66, No. 397, November 1962, pp. 215–220.
[32] Metal Industry (London). V. 101, No. 25, Dec. 20, 1962, p. 484.

same period in 1961 and 99 percent of the production planned for the period. Production goals were not attained owing to a lag in orders during the first half of 1962.[33]

The largest producer of special steels, Jesenice Iron and Steel Works, ordered $4.2 million worth of steel mill control equipment and other electrical apparatus from the United States. The equipment included the first card-programmed control system for a reversing hot-strip mill exported from the United States.[34]

A supply contract for approximately $78 million worth of steelmaking and rolling-mill equipment was concluded between two British companies and a new Yugoslavian steel plant, Rudnici i Zelezara. The contract covered the supply of equipment for a new integrated steelworks at Skopje, which was to produce steel plate and strip at an annual rate of 600,000 tons. Total cost of the plant was estimated at $224 million, and construction was expected to require 5 years.[35]

ASIA

China.—During the first 6 months of 1962, production of high-quality steel was more than 50 percent above the total for the entire year 1961. Tool steel production during the first half of 1962 was 40 percent higher than for all of 1961.[36]

Japan.—Steel production declined slightly in 1962. Although pig iron production increased rather sharply (up nearly 13 percent from 1961), total steel production was down to only 98 percent of 1961. Pig iron production increases were attributed to the increasing proportion of oxygen converter steel to total steel and to the starting up of three new blast furnaces, two of them of over 2,000-tons-per-day capacity. The drop in steel production was the result of a temporary shutdown of a number of open-hearth furnaces caused by decreasing demand for ingots and increasing production by oxygen converters.

Production of ingots by oxygen converters was 31 percent of the total, compared with 19 percent in 1961, while open-hearth ingots dropped to 49 percent from 60 percent in 1961. The large increase in production of oxygen-converter steel was attributed mainly to production from the two new 150-ton-capacity converters of Yawata Steel and the two new 130-ton-capacity converters of Kawasaki Steel Corp.

Total production of hot-rolled ordinary steel products was up 2 percent over 1961. Major increases were noted in the production of wire rod (up 21 percent) and electric- and arc-welded pipe (up 21 percent). These large increases were caused mainly by greatly increased exports of these items to the United States.[37]

Yawata Steel was licensed to use the R–N direct-reduction process to treat Japanese iron-bearing sand. Yawata planned to build two plants to produce iron briquettes for use in steel furnaces and to produce sponge iron for use in making electric-furnace pig iron. The

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[33] Weekly Economic Report on Western Europe. No. 440, p. 11.
[34] Steel & Coal (London). V. 185, No. 4910, Aug. 24, 1962. p. 366.
[35] Metallurgia (Manchester, England). V. 66, No. 398, December 1962, p. 287.
[36] Steel & Coal (London). V. 185. No. 4923, Nov. 23, 1962, p. 991.
[37] Far East Iron and Steel Trade Reports. Japan's Iron and Steel Output for 1962. No. 57, February 1963, pp. 8–9.

plants were expected to have a combined annual capacity of over 200,000 tons of iron to be produced from underwater sand deposits in Ariake Bay, Kyushu.[38]

Yawata installed gas recovery equipment on its two 130-ton capacity L–D converters at its Tobata No. 2 plant. Carbon monoxide produced during the blow was kept in the unburned state by an airtight recovery hood over the converter mouth and was stored in a gasholder. The calorific value of the recovered gas was about 225 to 280 Btu per cubic foot. It was claimed that the cost of installing equipment of this type was only about 40 percent of the cost of the conventional waste-heat boiler system normally used to recover heat from converter waste gas. An additional advantage was that the total volume of gas from the converters was reduced to about one-fourth of the normal amount because it was not mixed with air, thus allowing the use of a much smaller dust collection system. In a typical test run, about 1,940 cubic feet of gas with a calorific value of about 250 Btu per cubic foot was recovered per ingot ton of steel produced.[39]

Korea, Republic of.—On November 30, the Korean Government signed an agreement with Blaw-Knox Associates for the construction of a $150 million integrated steel plant. The plant, to be finished in mid-1966, was to have an annual capacity of 300,000 tons.[40]

TECHNOLOGY

Injection of fuel continued to be one of the major areas of attention in the continuing drive to increase blast-furnace efficiency. At Sparrows Point, Md., Bethlehem Steel Co. began injecting natural gas into 4 of its 10 blast furnaces. Up to 20 million cubic feet of natural gas per day at a pressure of 60 to 90 pounds per square inch gage was required for the operation. Savings in coke of up to 390 tons per day, as well as increased iron production, were predicted for the installation. Natural gas was also used to enrich the blast-furnace gas used for stove heating with the object of raising the blast temperature to 1,800° F from 1,300° to 1,500° F to further increase efficiency.[41]

Plans were announced to install a coal-injection system on a blast furnace at Weirton Steel Co., Weirton, W. Va. The crushed raw coal was to be injected through the tuyères in the same manner as that used for natural gas or oil. Coal was considered to be more economical than other fuels for this use in many areas of the country, and it could be used as a greater proportion of the total fuel.[42]

Armco Steel Corp. was also reported to be planning the use of coal injection on its largest furnace at Ashland, Ky. The system to be used, which included a pulverizer to grind and dry the coal, was expected to have a capacity of 600 tons per day. The use of coal to replace part of the coke in the burden was expected to result in a decrease of at least $1 per ton in the cost of making pig iron. The installation was expected to be completed early in 1964.[43]

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[38] American Metal Market. V. 69, No. 201, Oct. 18, 1962, p. 22.
[39] Yukawa, M., and K. Okaniwa Yawata Installs Gas Recovery Equipment on Oxygen Converter. Iron and Steel Eng., v. 39, No. 12, December 1962, pp. 141–147.
[40] Steel. V. 151, No. 25, Dec. 17, 1962, p. 33.
[41] Blast Furnace and Steel Plant. V. 50, No. 11, November 1962, pp. 1083–1085.
[42] Iron and Steel Engineer. V. 39, No. 7, July 1962, p. 167.
[43] American Metal Market. V. 69, No. 195, Oct. 9, 1962, pp. 1–2.

A coal injection system was under trial by the National Coal Board at a blast furnace in The Stanton Iron Works Co., Ltd., in England. It was possible to replace part of the coke charge by an equal weight of coal. It was believed that a replacement of up to 30 percent of the normal coke charge was possible on this basis without any sacrifice in iron quality.[44]

The Fuji Iron and Steel Co., Ltd., of Japan started using fuel-oil injection on six of its nine blast furnaces in January. Both pressure and air atomization systems were installed. Oil injection rates of up to 164 pounds per net ton of hot metal were used. The coke-to-oil ratio was between 1.2 and 1.7 within the oil injection range of 100 to 160 pounds per net ton of hot metal. Although the oil injected had a higher sulfur content than the coke used, sulfur content of the metal was kept down by increasing the slag basicity.[45]

The Colorado Fuel and Iron Corp. reported on a series of tests conducted on its F furnace at Pueblo, Colo. The injection of various fuels, with and without oxygen enrichment of the blast, was involved. The effect of increasing oxygen was similar to the effect of increasing blast temperature and permitted the use of more injected fuel with greater utilization efficiency. Also, with continuous oxygen enrichment plus fuel injection (up to 210 pounds of fuel per ton of hot metal at a corrected coke replacement ratio of 1.60), an increase of 1 percent oxygen content in the blast, in the range of 21 to 29 percent, at a constant blast temperature, increased the iron production rate about 5.8 percent. The effects of oxygen enrichment and increasing blast temperature were additive, so that the use of a blast oxygen content of 27 percent plus an increase of 138° F in blast temperature resulted in an increase in production rate of 44 percent. Intermittent oxygen injection resulted in slightly higher production-rate increases. Extra iron produced per ton of oxygen consumed was 1.62 tons during continuous enrichment and 1.71 tons during intermittent enrichment.[46]

A group of 22 major iron and steel producers in the United States and Canada formed Blast Furnace Research, Inc. The organization was intended to represent the producers in a 2-year cooperative research program with the Bureau of Mines, U.S. Department of the Interior, to increase productivity in blast-furnace operation and to improve the quality of pig iron produced in blast furnaces. The work was to be conducted on the Bureau of Mines experimental blast furnace at Bruceton, Pa. The initial studies were aimed at determining the most effective methods of injecting such fuels as natural gas, oil, coal, and oil-coal and oil-water slurries. Members of Blast Furnace Research, Inc., are Alan Wood Steel Co., Algoma Steel Corp., Ltd., Armco Steel Corp., Bethlehem Steel Co., Dominion Foundries and Steel, Ltd., Dominion Steel and Coal Corp., Ltd., Ford Motor Co., Granite City Steel Co., Inland Steel Co., Interlake Iron Corp., Jones & Laughlin Steel Corp., Kaiser Steel Co., Lone Star Steel Co.,

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[44] Steel & Coal (London). Solid Fuel Injection May Improve Furnace Efficiency. V. 185, No. 4925, Dec. 7, 1962, pp. 1092–1095.

[45] Blast Furnace and Steel Plant. Fuel Oil Injection Into Blast Furnaces of Fuji Iron and Steel Co., Ltd. V. 51, No. 1, January 1963, pp. 25–31.

[46] The Colorado Fuel and Iron Corp. (Pueblo, Colo.) and Newark Laboratories, Linde Company, Division of Union Carbide Corp. (Newark, N.J.). Continuous and Intermittent Blast Furnace Oxygen Enrichment With Various Injected Fuels at the Colorado Fuel and Iron Corporation's Pueblo Plant. Pres. at meeting of Association of Iron and Steel Engineers, Colorado Springs, Colo., June 5, 1962, 23 pp.

National Steel Corp., Pittsburgh Steel Co., Republic Steel Corp., The Shenango Furnace Co., The Steel Co. of Canada, Ltd., United States Steel Corp., Wheeling Steel Corp., Wisconsin Steel Division, International Harvester Co., and The Youngstown Sheet and Tube Co.[47]

Huron Valley Steel Corp. developed a small water-cooled furnace and superior hot-blast system that was claimed to reduce blast-furnace installation costs by 75 to 80 percent. The furnace operated at a blast temperature of 1,875° F and converted scrap to pig iron in 15 minutes. Output of over 2,000 tons per week was sold at approximately $10 per ton less than other domestic pig iron.[48]

Improvements in blast-furnace technology resulted in setting new production records. In March, a blast furnace at the Middletown, Ohio, plant of Armco Steel Corp. set a U.S. record of 89,551 tons of iron produced in 1 month. This record was soon broken by the B furnace at the Bethlehem, Pa., plant of the Bethlehem Steel Co., which produced 92,124 tons of iron in May. The new mark was credited to the use of a higher quality burden. Most of the ore fed to the furnaces was in pellets having an iron content of 65 percent and a silica content of 4 percent. A special low-sulfur (0.73 percent), low-ash (7.8 percent) coke was used. Holding fines to a minimum in the burden allowed a higher-than-normal wind rate. Coke consumption was only 1,172 pounds per ton of iron produced.[49]

The No. 3 blast furnace at the Clay Lane Ironworks of Dorman Long, Ltd., set a new British record for iron production during a single campaign. The furnace produced a total of 2,482,000 tons during 6 years of continuous operation.[50]

In steelmaking, major interest was in the oxygen converter; however, improvements in open-hearth technology continued to be introduced in an effort to make the open-hearth furnace more economically competitive with the oxygen converter. The trend toward the use of oxygen to increase the speed of open-hearth steelmaking continued, and before the end of 1962 it was estimated that about one-third of the Nation's open-hearth furnaces (generally the larger and more modern furnaces) had been converted to use oxygen. It was estimated that these furnaces produced approximately 50 percent of the open-hearth steel made in the United States.[51]

Tests on oxygen for selective flame enrichment, carried out in a French steel plant, showed that this technique could reduce overall charging time by 23 percent and tap-to-tap time by 32 percent, resulting in a production increase of 37 percent, while reducing fuel consumption by 20 percent. The method, developed by the International Flame Research Foundation at Ijmuiden, the Netherlands, employed an oxygen lance located about 2 feet below the burner and extending about 4 feet farther into the furnace than the burner. By enriching only the lower part of the flame in this manner, a high-oxygen atmosphere was maintained over the metal bath, thus decreasing the time required for refining reactions; at the same time, the cooler upper por-

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47 Iron and Steel Engineer. V. 39, No. 9, September 1962, p. 244.
U.S. Department of the Interior News Release. Cooperative Blast Furnace Studies with Steel Industry Now Underway. P.N. 16425-62, Oct. 15, 1962, 1 p.
48 American Metal Market. V. 69, No. 53, Mar. 19, 1962, p. 16.
49 Skillings' Mining Review. V. 51, No. 24, June 16, 1962, p. 6.
50 Metallurgia (Manchester, England). V. 66, No. 398, December 1962, p. 274.
51 Steel. V. 151, No. 12, Sept. 17, 1962, p. 100.

tion of the flame protected the roof refractories, thus increasing their useful life. This method generated a smaller volume of iron oxide fume than with conventional roof lancing.[52]

Using oxygen in the open hearth, combined with improved refractories, accelerated steelmaking, reduced costs, and made the open hearth more competitive with the oxygen converter. As an indication of the rapid progress in the improvement of the open hearth, a large Canadian furnace achieved steelmaking rates of slightly over 100 tons per hour.[53] This was still far less than the 300 tons and more per hour achieved on some large oxygen converters, but it was a remarkable achievement when contrasted with the rate of 15 to 20 tons per hour considered normal only 10 years ago.

Another improvement that promised lower operating costs for open-hearth furnaces was the use of cast bottoms. Sharon Steel Corp. installed a cast bottom on one of its furnaces at its Roemer Works, Farrell, Pa., and reported that it was in excellent condition after more than 300 heats. The high-density bottom, prepared from a castable mix with a magnesium oxide content of over 90 percent, was installed in only 18 hours.[54]

Carbon subhearths consisting of carbon blocks 28.5 inches wide and 13.5 inches thick laid on top of a bed of insulating refractory material were installed in three open-hearth furnaces of Republic Steel Corp. Observations made on 1 furnace after 2,351 heats showed that the line of physical separation between the carbon and working hearths was clearly visible, and there was no evidence of wetting or metallic penetration of the subhearth.[55]

Improved methods of repairing roof refractories also gave promise of reducing costs. The Algoma Steel Corp. nearly doubled the roof life of its furnaces by using a gunning technique to repair the basic refractories. Average roof life of the company's 360-ton furnaces rose from 274 heats in 1961 to 502 heats with the new technique, and the average roof life of the 180-ton furnaces rose from 380 heats in 1961 to 777. Although refractory consumption and cost were higher with the gunning technique than with conventional methods, the savings in labor and reduction in downtime resulted in a significant lowering of maintenance cost.[56]

Basic oxygen steelmaking continued its rapid expansion, accounting for about 5.5 percent of the total domestic production of steel during 1962. Two plants went into operation in the United States during the year, raising the existing capacity to approximately 10.8 million tons, and plans were announced for the construction of seven additional plants over the next 2 years which would double this capacity.

Both plants that went into operation during 1962 represented important changes in U.S. steelmaking technology. On September 30, Great Lakes Steel Corp. of Detroit, Mich., began operating the largest oxygen converters ever built. The two 300-ton capacity vessels gave

[52] Madsen, I. E. Developments in the Iron and Steel Industry During 1962. Iron and Steel Eng., v. 40, No. 1, January 1963, pp. 137–200.
[53] Journal of Metals. V. 14, No. 1, January 1962, p. 15.
[54] Steel. Cast Open Hearth Bottom Reduced Steelmaking Cost. V. 150, No. 25, June 18, 1962, p. 104.
[55] Work cited in footnote 51.
[56] American Metal Market. V. 70, No. 65, Apr. 4, 1963, p. 4.

the plant an annual capacity of about 2.3 million tons, making it the world's largest basic oxygen facility.[57]

The other new plant that began operating was the Stora-Kaldo plant of Sharon Steel Corp., Sharon, Pa. This plant, with an initial annual capacity of about 1 million tons, went into operation on October 16, marking the first use of the Stora-Kaldo process in the Western Hemisphere. The Sharon plant was also the first domestic steelmaking plant to use digital-computer control.[58]

A list of the existing and planned basic oxygen steelmaking plants in the United States is shown in table 19.

Oxygen steelmaking facilities were being expanded throughout the rest of the world also. Kaiser Engineers, Oakland, Calif., released the results of a survey on plants using the L–D oxygen steelmaking process. The survey showed that existing free world annual capacity, exclusive of the United States, totaled 24.38 million tons, with an additional 32.89 million tons planned for completion before the end of 1965.[59]

TABLE 19.—Existing and planned basic oxygen steelmaking plants in the United States as of Dec. 31, 1962

Company	Location	Number of furnaces	Capacity of each furnace, tons per heat	Annual plant capacity, tons	
				Existing	Planned
Acme Steel Co.	Riverdale, Ill.	2	75	450,000	
Armco Steel Corp.	Ashland, Ky.	2	140		1,400,000
Bethlehem Steel Co.	Lackawanna, N.Y.	2	200		1,700,000
The Colorado Fuel and Iron Corp.	Pueblo, Colo.	2	100	1,000,000	
Ford Motor Co.	Dearborn, Mich.	2	225		1,800,000
Great Lakes Steel Corp.	Detroit, Mich.	2	300	2,300,000	
International Harvester Co.	Chicago, Ill.	2	120		1,200,000
Jones & Laughlin Steel Corp.	Aliquippa, Pa.	2	80	880,000	
Do.	Cleveland, Ohio	2	200	1,850,000	
Kaiser Steel Co.	Fontana, Calif.	3	110	1,440,000	
McLouth Steel Corp.	Trenton, Mich.	3	60	1,880,000	
Do.	do.	2	80		
Do.	do.	1	110		
Pittsburgh Steel Co.	Monessen, Pa.	2	150		1,500,000
Sharon Steel Corp.	Sharon, Pa.	[1] 2	150	1,000,000	
United States Steel Corp.	Duquesne, Pa.	2	150		1,500,000
Wheeling Steel Corp.	Steubenville, Ohio	2	200		1,700,000
Total				10,800,000	10,800,000

[1] Stora-Kaldo type.

One of the drawbacks in replacing open hearths by L–D converters was the increased hot-metal capacity needed to supply the converters. Additional hot metal was necessary because of the inability of the L–D converter to handle more than about 25 percent of scrap. Recent experiments conducted at the United Austrian Iron & Steel Works, Linz, Austria, indicate that this disadvantage may be overcome in the future. By adding coke in the cold charge as a source of heat or by injecting gas or liquid fuel with oxygen in the lance, almost any desired proportion of scrap may be used in the charge.

[57] Iron Age. V. 190, No. 15, Oct. 11, 1962, p. 115.
[58] Scrap Age. V. 19, No. 11, November 1962, p. 49.
[59] Skillings' Mining Review. Growth of the L–D Steelmaking Process. V. 51, No. 28, July 14, 1962, pp. 1, 6–8.

In some experiments a completely solid charge, consisting of alternate layers of scrap and coke, was converted to steel.[60]

There were indications that basic oxygen furnaces, which have been replacing open-hearth furnaces at a rapid rate for carbon steel production, may soon be used in alloy and stainless steel production, thus threatening to replace electric furnaces for some of these uses. According to the AISI, alloy steel production (excluding stainless steel) by the basic oxygen process totaled 50,454 tons in the United States compared with only 6,274 tons in 1961. Although no basic-oxygen production of stainless steel was reported in the United States in 1962, experiments in Germany and Austria indicated that stainless steel production in oxygen converters was feasible. Two different methods were used for stainless steel production. In one method, the alloying additions were premelted in an electric furnace and added to the converter in the final stage of the process or added to the ladle. In the other method, the solid alloying materials, either cold or preheated, were added to the converter and melted by the heat generated during the refining process.[61] In the United States, Allegheny Ludlum Steel Co. was reported to be considering the production of stainless steels in the basic oxygen converter.[62]

The increased use of oxygen converters for steelmaking resulted in a greatly increased demand for lime. A new type of high-capacity shaft kiln, suitable for on-site operation at oxygen steel plants, was announced by Union Carbide Metals Co., New York. It was claimed that the new kiln had a production capacity 500 percent greater than most conventional shaft kilns. It was also claimed that, compared with a conventional rotary kiln, there was a 33-percent reduction in labor costs, a 40-percent reduction in maintenance costs, and a 20-percent reduction in lime production costs.[63]

A research program for determining the efficiency of lime in oxygen steelmaking processes was started at the Southern Research Institute, Birmingham, Ala. In the program, which was sponsored by the National Lime Association, Washington, D.C., hard-burned lime of low chemical reactivity and soft-burned lime of high chemical reactivity (both made from the same type of limestone) were to be compared for effectiveness in removing impurities. The study was to be made in an induction furnace, using oxygen and lime rates comparable to commercial practice. Chemical analyses of the hot metal were to be made at intervals of 5, 10, 15, 20, and 30 minutes from the beginning of the blow.[64]

Improvements in refractories for basic oxygen converters resulted in substantially increased lining life and a lowering of overall steelmaking costs. Jones & Laughlin Steel Corp. reported a lining life of 436 heats in a converter at its Aliquippa, Pa., plant, using a high-purity MgO brick.[65]

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[60] Steel. Breakthrough: 95% Scrap in Oxygen Steelmaking. V. 150, No. 25, June 18, 1962, pp. 102, 104.
[61] American Metal Market. V. 69, No. 180, Sept. 18, 1962, p. 5.
[62] Iron Age. V. 190, No. 16, Oct. 18, 1962, pp. 132–133.
[63] American Metal Market. V. 69, No. 147, Aug. 1, 1962, pp. 1, 20
[64] American Metal Market. V. 69, No. 211, Nov. 1, 1962, p. 6.
[65] Journal of Metals. V. 14, No. 1, January 1962, p. 15.

McLouth Steel Corp., using a larger converter, claimed a world tonnage record for basic oxygen furnace linings of 40,027 tons of steel produced in 388 heats.[66]

Interest by U.S. steelmakers in the use of continuous casting continued to grow. McLouth Steel Corp. ordered the first full-scale continuous-casting machine in the United States. A contract was let to Concast Ltd., New York, a subsidiary of Concast Ltd., of Switzerland, for a single-strand machine capable of turning out steel slabs 10 inches thick and 66 inches wide. Both carbon and stainless steel slabs were scheduled to be produced.[67]

National Steel Corp. was reported to have entered into a joint engineering study of the continuous-casting process with Concast Ltd. of Switzerland. The study was to evaluate the economic factors and the physical adaptability of the process to the existing steelmaking and processing facilities of the National Steel Corp. plant.[68]

A number of other firms were reported to be interested in continuous casting. United Engineering & Foundry Co., Loftus Engineering Corp., National Patent Development Corp., and H. K. Ferguson Co. were all reported to have entered into agreements with various foreign firms over continuous-casting patent rights.[69] Kaiser Steel Co. also exhibited interest in continuous casting.[70]

The first plant in the United States for the continuous casting of iron began operating at the Skokie, Ill., plant of the Wells Manufacturing Co. The casting machine used water-cooled graphite molds to produce round bars ranging in diameter from 0.75 inch to 4 inches, and square or rectangular shapes could also be manufactured. Bars of gray, alloy, and ductile iron were produced. Continuous-cast bars were claimed to have fine-grain structure and uniform hardness.[71]

Atlas Steel, Ltd., of Canada ordered a large machine for casting slabs of stainless and alloy steels up to 50 inches wide. The machine was to be equipped with a slab bending and straightening system.[72]

One disadvantage of the continuous-casting method was the rather limited capacity of the available machines. Although this has not been a serious problem for plants with oxygen converters, which produce relatively small heats at short intervals, it is a major problem for plants with large open hearths, which may produce 400 to 600 tons of steel in a single heat. It may also prove to be a problem for plants equipped with large oxygen converters of 200- to 300-ton capacity. Although continuous-casting plants of high capacity were being planned, they required either high towers or deep pits and heavy lifting equipment. An article suggested that a semicontinuous process, similar to the direct-chill casting process widely used by the aluminum industry, could overcome some of the difficulties inherent in the continuous-casting process while retaining its advantages. The

[66] Iron and Steel Engineer. V. 39. No. 9. September 1962. p. 266.
[67] American Metal Market. V. 69. No. 199. Oct. 16. 1962. p. 16.
[68] American Metal Market. V. 69, No. 196, Oct. 10, 1962, pp. 1, 5.
[69] Iron age. V. 190. No. 24. Dec. 13. 1962. pp. 75-76.
[70] Metalworking News V. 3, No. 116. Dec. 24. 1962. p. 18.
[71] American Metal Market. V. 69. No. 125. June 29, 1962, p. 4.
[72] Iron and Steel Engineer. V. 39, No. 12, December 1962, pp. 212, 214.

semicontinuous process would use water-cooled split ingot molds that could be unloaded by a hydraulic ram from below to cast billets and slabs suitable for rolling into finished shapes. It was claimed that such molds would yield a larger proportion of sound ingots than the conventional practice and that the surfaces would be good enough to minimize or completely eliminate surface treatment before rolling.[73]

[73] Balster, H. W. Semicontinuous Casting of Steel Ingots. Metal Prog., v. 81, No. 3, March 1962, pp. 85–88, 122, 124, 126, 128.

Iron and Steel Scrap

By James E. Larkin [1]

HIGH domestic consumption during the first 4 months of 1962, the increased scrap-to-pig iron ratio during the remainder of the year, the 14 percent increase in scrap consumed by foundries, and the rise of 3 percent in scrap used for all purposes served to offset partially the large drop from 1961 in exports of iron and steel scrap.

The greater demand for domestic scrap that existed during the last quarter of 1961 continued throughout the first 4 months of 1962, when steel mills operated at their highest level. Scrap requirements were at their highest level during the first quarter of 1962 when steel mills operated at a rate 55 percent greater than during the first quarter of 1961. The high and low months for consumption of scrap for all purposes were March, 6.8 million short tons, and July, 4.2 million tons.

The combined use of scrap and pig iron in steelmaking furnaces was 2 percent higher than in 1961. Scrap used in steel furnaces showed a slight increase over 1961 and the use of pig iron rose 2 percent. The use of scrap in steelmaking furnaces, comprised 45 percent of the combined total of scrap and pig iron used, remained unchanged from 1961. In March, when steel production was at its highest level, steelmaking furnaces consumed 77 percent of the scrap used for all purposes.

TABLE 1.—Salient iron and steel scrap, and pig iron statistics in the United States

(Short tons)

	1961	1962
Stocks Dec. 31:		
Scrap at consumer plants	[1] 8,823,815	8,592,426
Pig iron at consumer and supplier plants	3,183,115	3,124,846
Total	[1] 12,006,930	11,717,272
Consumption:		
Scrap	64,326,698	66,159,747
Pig iron	65,797,298	66,595,482
Imports for consumption, scrap (including tinplate scrap)	268,389	210,127
Exports, iron and steel scrap	[1] 9,713,863	5,113,409
Price: Scrap, No. 1 heavy-melting, Pittsburgh, average per long ton	[1,2] $34.89	$28.53
Value: Scrap, all grades, for export [3]	[1] $40.81	$31.53

[1] Revised figure.
[2] Iron Age.
[3] As computed from export data obtained from the Bureau of the Census.

[1] Commodity specialist, Division of Minerals.

LEGISLATION AND GOVERNMENT PROGRAMS

Legislation that continued the suspension of import duties on metal scrap to June 30, 1963, was enacted on July 1, 1962.

Joint Government-industry meetings were held during the latter part of 1962 to discuss a cooperative research program. Areas of research to be considered were increased scrap consumption in the Linz-Donowitz steelmaking process; increased use of some low-grade scrap; removal of contaminants; improved methods of identifying scrap metals; and leaching of scrap to remove nonmetallic and nonferrous materials, such as copper.

AVAILABLE SUPPLY

During 1962, consumers of iron and steel scrap had a net supply of 65.9 million short tons available at their plants, an increase of 3 percent over the quantity available during the preceding year. Home scrap produced increased 6 percent over 1961. Scrap received by consumers from dealers and other sources dropped for the third consecutive year. During the past 3 years a trend developed toward using more home-produced scrap in the total scrap charge, increasing from 56 percent in 1959 to 62 percent in 1962. This was caused by improved melting practices which resulted in less scrap being purchased outside the iron and steel plants. These data exclude scrap on hand in dealers' yards.

TABLE 2.—Iron and steel scrap supply[1] available for consumption in 1962, by districts and States

(Short tons)

District and State	Home production	Receipts from dealers and all others	Total new supply	Shipments[2]	New supply available for consumption
New England:					
Connecticut	77,907	87,591	165,498	5,739	159,759
Maine and New Hampshire	5,143	8,749	13,892	671	13,221
Massachusetts	83,710	93,608	177,318	7,480	169,838
Rhode Island	48,148	56,409	104,557	1,522	103,035
Vermont	9,979	13,055	23,034		23,034
Total:					
1962	224,887	259,412	484,299	15,412	468,887
1961	239,504	247,911	487,415	34,712	452,703
Middle Atlantic:					
New Jersey	174,094	444,473	618,567	16,175	602,392
New York	1,786,682	1,101,024	2,887,706	66,038	2,821,668
Pennsylvania	9,002,883	4,369,238	13,372,121	646,636	12,725,485
Total:					
1962	10,963,659	5,914,735	16,878,394	728,849	16,149,545
1961	10,657,983	6,029,368	16,687,351	854,397	15,832,954
East North Central:					
Illinois	3,722,616	3,742,528	7,465,144	178,417	7,286,727
Indiana	5,221,586	2,437,185	7,658,771	158,555	7,500,216
Michigan	3,587,514	2,908,046	6,495,560	42,223	6,453,337
Ohio	7,436,767	3,965,131	11,401,898	383,466	11,018,432
Wisconsin	501,736	451,666	953,402	108,955	844,447
Total:					
1962	20,470,219	13,504,556	33,974,775	871,616	33,103,159
1961	18,521,637	12,731,930	31,253,567	729,499	30,524,068

See footnotes at end of table.

TABLE 2.—Iron and steel scrap supply[1] available for consumption in 1962, by districts and States—Continued

(Short tons)

District and State	Home production	Receipts from dealers and all others	Total new supply	Shipments[2]	New supply available for consumption
West North Central:					
Iowa	170,975	298,169	469,144	989	468,155
Kansas and Nebraska	46,348	107,952	154,300	4,038	150,262
Minnesota	235,151	171,538	406,689	4,657	402,032
Missouri	201,497	645,970	847,467	18,569	828,898
Total:					
1962	653,971	1,223,629	1,877,600	28,253	1,849,347
1961	599,893	1,246,151	1,846,044	30,552	1,815,492
South Atlantic:					
Delaware and Maryland	2,333,720	411,227	2,744,947	131,116	2,613,831
Florida and Georgia	82,763	311,540	394,303	1,515	392,788
North Carolina	22,407	56,158	78,565		78,565
South Carolina	19,232	20,487	39,719	3	39,716
Virginia and West Virginia	829,681	836,381	1,666,062	21,802	1,644,260
Total:					
1962	3,287,803	1,635,793	4,923,596	154,436	4,769,160
1961	3,205,392	2,037,056	5,242,448	109,365	5,133,083
East South Central:					
Alabama	1,412,932	1,200,645	2,613,577	168,637	2,444,940
Kentucky, Mississippi, Tennessee	614,837	941,296	1,556,133	67,527	1,488,606
Total:					
1962	2,027,769	2,141,941	4,169,710	236,164	3,933,546
1961	2,022,980	2,259,915	4,282,895	230,721	4,052,174
West South Central:					
Arkansas, Louisiana, Oklahoma	56,354	114,793	171,147	1,686	169,461
Texas	652,017	766,916	1,418,933	4,780	1,414,153
Total:					
1962	708,371	881,709	1,590,080	6,466	1,583,614
1961	747,341	1,091,970	1,839,311	38,862	1,800,449
Rocky Mountain:					
Arizona and Nevada	22,043	78,386	100,429	510	99,919
Colorado, Idaho, Montana, Utah	891,813	379,018	1,270,831	7,854	1,262,977
Total:					
1962	913,856	457,404	1,371,260	8,364	1,362,896
1961	1,071,981	484,210	1,556,191	[3] 3,504	1,559,695
Pacific Coast:					
California and Hawaii	1,288,811	1,122,395	2,411,206	158,369	2,252,837
Oregon and Washington	105,294	356,927	462,221	6,854	455,367
Total:					
1962	1,394,105	1,479,322	2,873,427	165,223	2,708,204
1961	1,408,351	1,424,428	2,832,779	223,335	2,609,444
U.S. total:					
1962	40,644,640	27,498,501	68,143,141	2,214,783	65,928,358
1961	38,475,062	27,552,939	66,028,001	2,247,939	63,780,062

[1] New supply available for consumption is a net figure computed by adding home production to receipts from dealers and all others and deducting consumers scrap shipped, transferred, or otherwise disposed of during the year. The plus or minus difference in stock levels at the beginning and end of the year are not taken into consideration.
[2] Includes scrap shipped, transferred, or otherwise disposed of during the year.
[3] Data shown in shipments column are plus figures owing to adjustments in accounting procedures.

TABLE 3.—Consumption of iron and steel scrap and pig iron in the United States in 1962, by type of consumer and type of furnace or equipment

(Short tons)

Type of furnace or equipment	Scrap	Pig iron	Total
	Manufacturers of steel ingots and castings [1]		
Open-hearth	36,235,623	54,419,123	90,654,746
Basic oxygen converter	1,846,790	5,020,145	6,866,935
Bessemer	91,878	791,059	882,937
Electric [2]	8,977,487	178,924	9,156,411
Total steelmaking furnaces	47,151,778	60,409,251	107,561,029
Cupola	853,682	250,552	1,104,234
Air	31,842	12,573	44,415
Blast [3]	3,781,558		3,781,558
Direct castings		1,522,353	1,522,353
Miscellaneous	147,582		147,582
Total:			
1962	51,966,442	62,194,729	114,161,171
1961	51,772,246	61,392,576	113,164,822
	Manufacturers of steel castings [4]		
Open-hearth	547,967	90,147	638,114
Bessemer	11,234	120	11,354
Electric	1,734,348	30,479	1,764,827
Total steelmaking furnaces	2,293,549	120,746	2,414,295
Cupola	340,548	14,926	355,474
Air	256,432	43,059	299,491
Miscellaneous	143		143
Total:			
1962	2,890,672	178,731	3,069,403
1961	2,541,651	166,259	2,707,910
	Iron foundries and miscellaneous users		
Bessemer	988	395	1,383
Electric [2]	159,328	30,537	189,865
Total steelmaking furnaces	160,316	30,932	191,248
Cupola	9,515,868	3,136,886	12,652,754
Air	924,485	130,216	1,054,701
Direct castings		923,988	923,988
Ferroalloy	302,150		302,150
Miscellaneous	399,814		399,814
Total:			
1962	11,302,633	4,222,022	15,524,655
1961	10,012,801	4,238,463	14,251,264
	Total		
Open-hearth	36,783,590	54,509,270	91,292,860
Basic oxygen converter	1,846,790	5,020,145	6,866,935
Bessemer	104,100	791,574	895,674
Electric [2]	10,871,163	239,940	11,111,103
Total steelmaking furnaces	49,605,643	60,560,929	110,166,572
Cupola	10,710,098	3,402,364	14,112,462
Air	1,212,759	185,848	1,398,607
Blast [3]	3,781,558		3,781,558
Direct castings		2,446,341	2,446,341
Ferroalloy	302,150		302,150
Miscellaneous	547,539		547,539
Total:			
1962	66,159,747	66,595,482	132,755,229
1961	64,326,698	65,797,298	130,123,996

[1] Includes only those castings made by companies producing steel ingots.
[2] Includes small quantities of scrap and pig iron consumed in crucible furnaces.
[3] Includes consumption in all blast furnaces producing pig iron.
[4] Excludes companies that produce both steel ingots and steel castings.

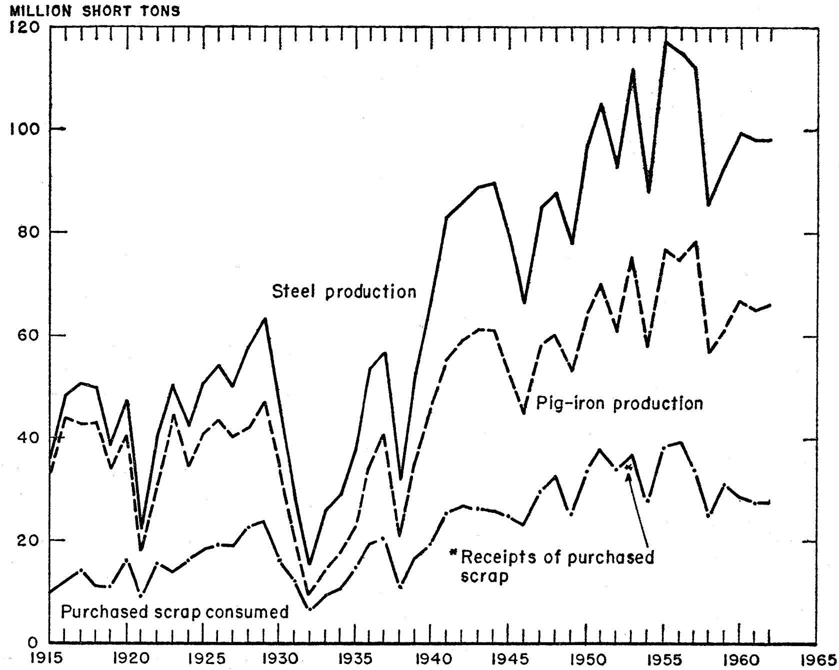

FIGURE 1.—Consumption of purchased scrap in the United States, 1915–52, and output of pig iron and steel, 1915–62. Figures on consumption of purchased scrap from 1915–32 are from *State of Minnesota* v. *Oliver Iron Mining Co., et al.*, Exhibits, v. 5, 1935, p. 328; those for 1933–34 are estimated by author; and those for 1935–52 are based on Bureau of Mines records. Data for 1953–62 represent receipts of purchased scrap by consumers, based on Bureau of Mines records. Data on steel output were supplied by the American Iron and Steel Institute.

TABLE 4.—Proportion of iron and steel scrap and pig iron used in furnaces in the United States

(Percent)

Type of furnace	1961		1962	
	Scrap	Pig iron	Scrap	Pig iron
Open-hearth	41.0	59.0	40.3	59.7
Basic oxygen converter	27.8	72.2	26.9	73.1
Bessemer	10.0	90.0	11.6	88.4
Electric [1]	97.3	2.7	97.8	2.2
Cupola	73.4	26.6	75.9	24.1
Air	84.7	15.3	86.7	13.3

[1] Includes crucible furnaces.

CONSUMPTION BY DISTRICTS AND STATES

The use of domestic scrap for all purposes increased in five of the nine geographical areas. The largest tonnage and percentage increase was in the East North Central district. Four districts reported decreases in the use of scrap, and the South Atlantic district reported the greatest decrease both in tonnage and percent. As in previous years, the districts consuming the most scrap were the East North Central, Middle Atlantic, and South Atlantic. The States consuming the largest quantities of scrap and the percentages consumed were Pennsylvania, 19; Ohio, 17; Indiana, 11; and Illinois, 11. This same order of States and the identical percentages prevailed in 1961.

TABLE 5.—Consumption of iron and steel scrap and pig iron in the United States in 1962, by districts and States

(Short tons)

District and State	Scrap	Pig iron	Total
New England:			
Connecticut	152,402	33,024	185,426
Maine and New Hampshire	13,448	2,251	15,699
Massachusetts	174,548	59,876	234,424
Rhode Island	102,055	41,836	143,891
Vermont	23,485	7,288	30,773
Total:			
1962	465,938	144,275	610,213
1961	465,166	141,823	606,989
Middle Atlantic:			
New Jersey	623,281	119,757	743,038
New York	2,773,824	3,355,305	6,129,129
Pennsylvania	12,682,498	15,975,716	28,658,214
Total:			
1962	16,079,603	19,450,778	35,530,381
1961	15,803,728	18,679,698	34,483,426
East North Central:			
Illinois	7,262,725	4,932,854	12,195,579
Indiana	7,618,932	8,972,216	16,591,148
Michigan	6,417,615	5,534,555	11,952,170
Ohio	11,114,027	11,430,509	22,544,536
Wisconsin	859,790	186,327	1,046,117
Total:			
1962	33,273,089	31,056,461	64,329,550
1961	31,018,837	30,323,366	61,342,203
West North Central:			
Iowa	463,536	71,050	534,586
Kansas and Nebraska	145,594	5,337	150,931
Minnesota	453,169	446,331	899,500
Missouri	864,994	29,247	894,241
Total:			
1962	1,927,293	551,965	2,479,258
1961	1,842,738	493,147	2,335,885
South Atlantic:			
Delaware and Maryland	2,335,396	4,802,288	7,137,684
Florida and Georgia	381,330	11,445	392,775
North Carolina	76,886	29,457	106,343
South Carolina	45,542	18,684	64,226
Virginia and West Virginia	1,691,367	1,950,305	3,641,672
Total:			
1962	4,530,521	6,812,179	11,342,700
1961	5,201,095	6,617,408	11,818,503
East South Central:			
Alabama	2,518,868	3,104,152	5,623,020
Kentucky, Mississippi, Tennessee	1,522,705	852,388	2,375,093
Total:			
1962	4,041,573	3,956,540	7,998,113
1961	3,956,561	4,130,267	8,086,828

TABLE 5.—Consumption of iron and steel scrap and pig iron in the United States in 1962, by districts and States—Continued

District and State	Scrap	Pig iron	Total
West South Central:			
Arkansas, Louisiana, Oklahoma	155,961	8,302	164,263
Texas	1,542,263	780,226	2,322,489
Total:			
1962	1,698,224	788,528	2,486,752
1961	1,730,971	863,867	2,594,838
Rocky Mountain:			
Arizona and Nevada	110,611	162	110,773
Colorado, Idaho, Montana, Utah	1,321,754	2,012,961	3,334,715
Total:			
1962	1,432,365	2,013,123	3,445,488
1961	1,587,237	2,352,066	3,939,303
Pacific Coast:			
California and Hawaii	2,262,910	1,817,823	4,080,733
Oregon and Washington	448,231	3,810	452,041
Total:			
1962	2,711,141	1,821,633	4,532,774
1961	2,720,365	2,195,656	4,916,021
U.S. total:			
1962	66,159,747	66,595,482	132,755,229
1961	64,326,698	65,797,298	130,123,996

TABLE 6.—Consumption of iron and steel scrap and pig iron by districts and States, by type of manufacturers in 1962

(Short tons)

District and State	Steel ingots and castings [1]		Steel castings [2]		Iron foundries and miscellaneous users	
	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron
New England:						
Connecticut	47,540	-	4,290	180	100,572	32,844
Maine and New Hampshire	-	-	2,962	141	10,486	2,110
Massachusetts	-	-	5,800	176	168,748	59,700
Rhode Island	49,649	21,784	-	-	52,406	20,052
Vermont	-	-	-	-	23,485	7,288
Total:						
1962	97,189	21,784	13,052	497	355,697	121,994
1961	89,818	20,625	20,339	629	355,009	120,569
Middle Atlantic:						
New Jersey	159,322	17,020	50,582	2,240	413,377	100,497
New York	2,040,558	3,182,810	124,085	8,491	609,181	164,004
Pennsylvania	11,607,183	15,284,891	384,021	59,213	691,294	631,612
Total:						
1962	13,807,063	18,484,721	558,688	69,944	1,713,852	896,113
1961	13,749,182	17,725,126	502,740	66,797	1,551,806	887,775
East North Central:						
Illinois	5,930,849	4,506,479	353,210	14,589	978,666	411,786
Indiana	6,850,848	8,748,221	156,970	14,317	611,114	209,678
Michigan	3,842,656	4,939,970	177,590	1,739	2,397,369	592,846
Ohio	9,357,641	10,877,111	445,167	47,085	1,311,219	506,313
Wisconsin	-	-	271,208	6,027	588,582	180,300
Total:						
1962	25,981,994	29,071,781	1,404,145	83,757	5,886,950	1,900,923
1961	24,936,976	28,341,622	1,132,325	75,198	4,949,536	1,906,546

See footnotes at end of table.

TABLE 6.—Consumption of iron and steel scrap and pig iron by districts and States, by type of manufacturers in 1962—Continued

(Short tons)

District and State	Steel ingots and castings [1]		Steel castings [2]		Iron foundries and miscellaneous users	
	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron
West North Central:						
Iowa	------------	------------	39,525	454	424,011	70,596
Kansas and Nebraska	------------	------------	94,662	330	50,932	5,007
Minnesota	293,633	400,554	38,311	86	121,225	45,691
Missouri	650,901	968	81,115	5,601	132,978	22,678
Total:						
1962	944,534	401,522	253,613	6,471	729,146	143,972
1961	958,410	351,156	230,123	4,707	654,205	137,284
South Atlantic:						
Delaware and Maryland	2,215,933	4,793,599	30,350	465	89,113	8,224
Florida and Georgia	334,226	------------	13,112	84	33,992	11,361
North Carolina	------------	------------	------------	------------	76,886	29,457
South Carolina	------------	------------	------------	------------	45,542	18,684
Virgina and West Virginia	1,409,453	1,807,241	63,921	9,515	217,993	133,549
Total:						
1962	3,959,612	6,600,840	107,383	10,064	463,526	201,275
1961	4,629,766	6,441,013	111,367	8,654	459,962	167,741
East South Central:						
Alabama	1,689,820	2,493,060	76,193	168	752,855	610,924
Kentucky, Mississippi, Tennessee	1,025,747	669,877	24,599	1,203	472,359	181,308
Total:						
1962	2,715,567	3,162,937	100,792	1,371	1,225,214	792.232
1961	2,710,103	3,265,139	93,802	1,507	1,152.656	863.621
West South Central:						
Arkansas, Louisiana, Oklahoma	54,790	270	53,910	969	47,261	7,063
Texas	1,133,618	724,809	91,847	557	316,798	54,860
Total:						
1962	1,188,408	725,079	145,757	1,526	364,059	61,923
1961	1,266,194	805,031	133,813	1,644	330,964	57,192
Rocky Mountain:						
Arizona and Nevada	28,366	------------	59,275	162	22,970	------------
Colorado, Idaho, Montana, Utah	1,109,573	2,002,109	27,054	947	185,127	9,905
Total:						
1962	1,137,939	2,002,109	86,329	1,109	208,097	9,905
1961	1,300,536	2,340,954	86,548	895	200.153	10.217
Pacific Coast:						
California and Hawaii	1,795,942	1,722,936	147.366	2,703	319.602	92.184
Oregon and Washington	338,194	1,020	73,547	1,289	36,490	1,501
Total:						
1962	2,134,136	1,723,956	220,913	3,992	356.092	93,685
1961	2,131,261	2,101,910	230,594	6,228	358.510	87,518
U.S. total:						
1962	51,966,442	62,194,729	2,890,672	178.731	11,302,633	4,222,022
1961	51,772,246	61,392,576	2,541,651	166,259	10,012,801	4,238,463

[1] Includes only those castings made by companies producing steel ingots.
[2] Excludes companies that produce both steel ingots and steel castings.

TABLE 7.—Consumption of iron and steel scrap and pig iron in open-hearth furnaces in the United States in 1962, by districts and States

(Short tons)

District and State	Scrap	Pig iron	Total
New England and Middle Atlantic:			
New Jersey and Rhode Island	207,048	38,804	245,852
New York	1,766,469	3,185,690	4,952,159
Pennsylvania	8,387,345	13,507,337	21,894,682
Total:			
1962	10,360,862	16,731,831	27,092,693
1961	10,352,646	16,002,140	26,354,786
East North Central:			
Illinois	3,641,529	3,820,484	7,462,013
Indiana	6,697,636	8,727,871	15,425,507
Michigan and Wisconsin	2,449,869	3,417,195	5,867,064
Ohio	5,994,359	9,120,582	15,114,941
Total:			
1962	18,783,393	25,086,132	43,869,525
1961	18,646,388	25,108,999	43,755,387
West North Central: Minnesota and Missouri	396,823	405,968	802,791
Total:			
1962	396,823	405,968	802,791
1961	521,776	354,025	875,801
South Atlantic: Delaware, Maryland, West Virginia	3,197,439	6,604,207	9,801,646
Total:			
1962	3,197,439	6,604,207	9,801,646
1961	3,968,781	6,443,592	10,412,373
East and West South Central: Alabama, Kentucky, Texas	2,210,832	3,555,734	5,766,566
Total:			
1962	2,210,832	3,555,734	5,766,566
1961	2,113,735	3,677,717	5,791,452
Rocky Mountain and Pacific Coast: California, Colorado, Utah	1,834,241	2,125,398	3,959,639
Total:			
1962	1,834,241	2,125,398	3,959,639
1961	2,268,963	3,024,777	5,293,740
U.S. total:			
1962	36,783,590	54,509,270	91,292,860
1961	37,872,289	54,611,250	92,483,539

TABLE 8.—Consumption of iron and steel scrap and pig iron in Bessemer converters in the United States in 1962, by districts and States

(Short tons)

District and State	Scrap	Pig iron	Total
New England and Middle Atlantic: Connecticut and Pennsylvania	54,271	269,510	323,781
Total:			
1962	54,271	269,510	323,781
1961	52,194	318,562	370,756
East North Central and West South Central: Illinois, Ohio, Louisiana	49,463	522,054	571,517
Total:			
1962	49,463	522,054	571,517
1961 [1]	56,117	657,565	713,682
Rocky Mountain and Pacific Coast: Colorado and Washington	366	10	376
Total:			
1962	366	10	376
1961	346	40	386
U.S. total:			
1962	104,100	791,574	895,674
1961	108,657	976,167	1,084,824

[1] Includes Delaware and Louisiana.

TABLE 9.—Consumption of iron and steel scrap and pig iron in electric[1] steel furnaces in the United States in 1962, by districts and States

(Short tons)

District and State	Scrap	Pig iron	Total
New England:			
Connecticut and New Hampshire	59,205	1,389	60,594
Massachusetts	5,800	176	5,976
Total:			
1962	65,005	1,565	66,570
1961	76,731	1,764	78,495
Middle Atlantic:			
New Jersey	25,200	3,806	29,006
New York	198,393	4,229	202,622
Pennsylvania	2,004,842	33,950	2,038,792
Total:			
1962	2,228,435	41,985	2,270,420
1961	2,137,127	37,449	2,174,576
East North Central:			
Illinois	1,717,079	52,530	1,769,609
Indiana	111,919	2,838	114,757
Michigan	518,252	15,490	533,742
Ohio	1,856,839	25,998	1,882,837
Wisconsin	184,623	3,913	188,536
Total:			
1962	4,388,712	100,769	4,489,481
1961	3,978,934	123,869	4,102,803
West North Central:			
Iowa, Kansas, Nebraska	137,535	893	138,428
Minnesota and Missouri	646,019	1,040	647,059
Total:			
1962	783,554	1,933	785,487
1961	654,197	1,542	655,739

See footnote at end of table.

TABLE 9.—Consumption of iron and steel scrap and pig iron in electric[1] steel furnaces in the United States in 1962, by districts and States—Continued

(Short tons)

District and State	Scrap	Pig iron	Total
South Atlantic:			
Delaware and Maryland	100,053	1,716	101,769
Florida, Georgia, North Carolina	344,187	303	344,490
Virginia and West Virginia	166,604	122	166,726
Total:			
1962	610,844	2,141	612,985
1961	547,350	1,936	549,286
East South Central:			
Alabama	427,980	53,660	481,640
Kentucky, Mississippi, Tennessee	517,531	6,806	524,337
Total:			
1962	945,511	60,466	1,005,977
1961	1,028,571	76,634	1,105,205
West South Central:			
Arkansas, Louisiana, Oklahoma	105,594	2,796	108,390
Texas	536,809	19,448	556,257
Total:			
1962	642,403	22,244	664,647
1961	622,919	25,489	648,408
Rocky Mountain: Arizona, Colorado, Nevada, Utah	104,527	653	105,180
Total:			
1962	104,527	653	105,180
1961	76,340	428	76,768
Pacific Coast:			
California and Hawaii	693,440	6,317	699,757
Oregon and Washington	408,732	1,867	410,599
Total:			
1962	1,102,172	8,184	1,110,356
1961	980,761	9,605	990,366
U.S. total:			
1962	10,871,163	239,940	11,111,103
1961	10,102,930	278,716	10,381,646

[1] Includes small quantities of scrap and pig iron consumed in crucible furnaces.

TABLE 10.—Consumption of iron and steel scrap and pig iron in cupola furnaces in the United States in 1962, by districts and States

(Short tons)

District and State	Scrap	Pig iron	Total
New England:			
Connecticut	58,088	23,795	81,883
Maine and New Hampshire	7,543	373	7,916
Massachusetts	154,453	58,034	212,487
Rhode Island	43,116	18,912	62,028
Vermont	23,485	7,288	30,773
Total:			
1962	286,685	108,402	395,087
1961	283,254	106,742	389,996
Middle Atlantic:			
New Jersey	379,638	98,250	477,888
New York	505,532	154,881	660,413
Pennsylvania	485,575	167,010	652,585
Total:			
1962	1,370,745	420,141	1,790,886
1961	1,255,156	429,961	1,685,117

TABLE 10.—Consumption of iron and steel scrap and pig iron in cupola furnaces in the United States in 1962, by districts and States—Continued

(Short tons)

District and State	Scrap	Pig iron	Total
East North Central:			
Illinois	857,609	171,672	1,029,281
Indiana	533,308	204,030	737,338
Michigan	2,770,735	658,777	3,429,512
Ohio	1,293,717	336,544	1,630,261
Wisconsin	520,820	154,476	675,296
Total:			
1962	5,976,189	1,525,499	7,501,688
1961	5,036,173	1,498,777	6,534,950
West North Central:			
Iowa	295,837	67,875	363,712
Kansas and Nebraska	50,932	5,007	55,939
Minnesota	129,715	42,872	172,587
Missouri	88,497	21,167	109,664
Total:			
1962	564,981	136,921	701,902
1961	506,427	129,791	636,218
South Atlantic:			
Maryland	107,375	8,363	115,738
Florida	6,213	2,759	8,972
Georgia	26,918	8,602	35,520
North Carolina	76,588	29,238	105,826
South Carolina	40,352	18,684	59,036
Virginia	207,662	91,611	299,273
West Virginia	10,699	40,401	51,100
Total:			
1962	475,807	199,658	675,465
1961	472,619	165,640	638,259
East South Central:			
Alabama	696,150	616,338	1,312,488
Kentucky	153,418	32,625	186,043
Tennessee	283,230	149,389	432,619
Total:			
1962	1,132,798	798,352	1,931,150
1961	1,076,560	867,588	1,944,148
West South Central:			
Arkansas, Louisiana, Oklahoma	46,326	5,506	51,832
Texas	309,860	80,246	390,106
Total:			
1962	356,186	85,752	441,938
1961	337,489	106,800	444,289
Rocky Mountain: Colorado, Idaho, Montana, Utah	191,150	35,249	226,399
Total:			
1962	191,150	35,249	226,399
1961	186,683	44,616	231,299
Pacific Coast:			
California	326,326	90,457	416,783
Oregon and Washington	29,231	1,933	31,164
Total:			
1962	355,557	92,390	447,947
1961	356,157	88,724	444,881
U.S. total:			
1962	10,710,098	3,402,364	14,112,462
1961	9,510,518	3,438,639	12,949,157

TABLE 11.—Consumption of iron and steel scrap and pig iron in air furnaces in the United States in 1962, by districts and States

(Short tons)

District and State	Scrap	Pig iron	Total
New England:			
Connecticut	37,066	7,878	44,944
Massachusetts, New Hampshire, Rhode Island	15,665	4,543	20,208
Total:			
1962	52,731	12,421	65,152
1961	50,062	12,600	62,662
Middle Atlantic:			
New Jersey and New York	27,353	11,038	38,391
Pennsylvania	163,382	49,889	218,271
Total:			
1962	195,735	60,927	256,662
1961	146,858	52,119	198,977
East North Central:			
Illinois	157,891	13,056	170,947
Indiana	82,503	13,957	96,460
Michigan	148,480	2,439	150,919
Ohio	398,693	43,901	442,594
Wisconsin	98,516	24,038	122,554
Total:			
1962	886,083	97,391	983,474
1961	713,877	96,749	810,626
West North Central: Iowa, Minnesota, Missouri	10,989	7,004	17,993
Total:			
1962	10,989	7,004	17,993
1961	11,290	7,533	18,823
South Atlantic: North Carolina and West Virginia	9,286	6,173	15,459
Total:			
1962	9,286	6,173	15,459
1961	9,991	6,213	16,204
East and West South Central: Alabama and Texas	49,630	1,153	50,783
Total:			
1962	49,630	1,153	50,783
1961	43,447	1,576	45,023
Pacific Coast: California	8,305	779	9,084
Total:			
1962	8,305	779	9,084
1961	9,614	924	10,538
U.S. total:			
1962	1,212,759	185,848	1,398,607
1961	985,139	177,714	1,162,853

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TABLE 12.—Consumption of iron and steel scrap in blast furnaces in the United States in 1962, by districts and States

(Short tons)

District and State	Scrap	District and State	Scrap
Middle Atlantic:		South Atlantic, East and West South Central:	
New York	185,113	Alabama	155,307
Pennsylvania	1,175,058	Kentucky, Maryland, Tennessee, Texas, West Virginia	380,257
Total:		Total:	
1962	1,360,171	1962	535,564
1961	1,357,578	1961	550,256
East and West North Central:		Rocky Mountain: Colorado and Utah	73,705
Illinois	388,760		
Indiana	184,154	Total:	
Michigan and Minnesota	196,089	1962	73,705
Ohio	1,043,115	1961	81,845
Total:		U.S total:	
1962	1,812,118	1962	3,781,558
1961	1,561,222	1961	3,550,901

TABLE 13.—Consumption of iron and steel scrap by ferroalloy producers in the United States in 1962, by districts

(Short tons)

District	Scrap	District	Scrap
Middle Atlantic:		East South Central:	
1962	31,881	1962	72,591
1961	20,751	1961	52,407
East North Central:		Pacific Coast:	
1962	51,893	1962	9,538
1961	41,627	1961	8,023
West North Central:		U.S. total:	
1962	122,530	1962	302,150
1961	103,596	1961	245,118
South Atlantic:			
1962	13,717		
1961	18,714		

TABLE 14.—Consumption of iron and steel scrap in miscellaneous uses in the United States in 1962, by districts and States

(Short tons)

District and State	Scrap	District and State	Scrap
New England and Middle Atlantic:		East and West South Central:	
Massachusetts and New York	71,463	Alabama and Texas	7,960
New Jersey	59,959	Total:	
Pennsylvania	87,936	1962	7,960
Total:		1961	39,197
1962	219,358	Rocky Mountain: Arizona, Colorado, Idaho, Montana, Utah	32,125
1961	241,730	Total:	
East North Central:		1962	32,125
Illinois and Indiana	105,413	1961 [2]	30,131
Michigan and Wisconsin	3,901	Pacific Coast: California and Washington	47,154
Ohio	82,031	Total:	
Total:		1962	47,154
1962	191,345	1961	42,030
1961	183,166	U.S. total:	
West North Central: Minnesota and Missouri	43,888	1962	547,539
Total:		1961	580,148
1962	43,888		
1961	41,362		
South Atlantic: Florida, Georgia, Virginia	5,709		
Total:			
1962	5,709		
1961 [1]	2,532		

[1] Includes Georgia, Virginia, and West Virginia.
[2] Excludes Idaho.

TABLE 15.—Consumption of iron and steel scrap by type of manufacturers, by grades, in 1962

(Short tons)

Grades	Steel ingots and castings	Steel castings	Iron foundries and miscellaneous users
No. 1 heavy-melting steel	20,204,901	307,545	388,802
No. 2 heavy-melting steel	4,003,316	18,505	190,019
No. 1 and electric furnace bundles	5,171,427	61,560	228,872
No. 2 and all other bundles	3,342,891	61,041	80,163
Low phosphorus scrap	1,802,610	1,288,794	1,029,105
Cast iron scrap, other than borings	3,419,501	207,973	6,476,693
Turnings and/or borings, alloy free	1,974,965	41,943	820,589
Rerolling rails	107,761		251,339
Scrap rails	25,849	29,157	262,151
High speed steel	29,762		565
Stainless steel	596,812	27,842	19,085
All other alloy iron and steel	1,927,729	128,802	109,230
All other prepared scrap	7,924,431	485,376	876,966
Unprepared scrap	1,434,487	232,134	569,054
Total:			
1962	51,966,442	2,890,672	11,302,633
1961	51,772,246	2,541,651	10,012,801

TABLE 16.—Consumption of iron and steel scrap, by grades, by districts and States, in 1962

(Short tons)

District and State	No. 1 heavy-melting steel	No. 2 heavy-melting steel	No. 1 and electric furnace bundles	No. 2 and all other bundles	Low phosphorus scrap	Cast iron scrap, other than borings	All others
New England:							
Connecticut	3,481	50	3,013	548	32.726	37,911	74,673
Maine and New Hampshire	3,256				180	7.431	2.581
Massachusetts	3,236	1,271			10,232	132.965	26.844
Rhode Island	4,012	27,463	3,222		9,737	24,834	32,787
Vermont	4,063	169				19,245	8
Total: 1962	18,048	28,953	6,235	548	52,875	222,386	136,893
Total: 1961	19.133	24,550	4,480	465	56.543	230.182	129,813
Middle Atlantic:							
New Jersey	9,701	30,094	58,520	15,831	35.379	338,924	134.832
New York	1,019,116	20,560	159,921	126.904	136.162	423,810	887.351
Pennsylvania	4,919.704	490,516	921,495	369,049	817,240	1.246,533	3,917,961
Total: 1962	5,948,521	541,170	1,139,936	511,784	988.781	2,009.267	4.940,144
Total: 1961	5,670,632	610,477	1,098,993	626,707	883,428	1,974,819	4,938,672
East North Central:							
Illinois	1,862,999	1,004,500	672,611	634.632	591,516	928,842	1,567,625
Indiana	3.815,737	143,539	924,022	373,136	177,259	754,013	1,431,226
Michigan	958,245	2,196	1,019,033	253,670	398,974	1,668,910	2,116,587
Ohio	3,229,029	305,224	829,810	651,241	1,024,129	1,271,069	3,803,525
Wisconsin	68,176	21,266	767	6,606	227,735	312.369	222,871
Total: 1962	9,934,186	1,476,725	3,446,243	1,919,285	2,419,613	4,935,203	9.141,834
Total: 1961	9,366.508	1,431,810	3,651,873	1,828,519	2.310,925	4.202.045	8,227,157
West North Central:							
Iowa	40,317	11,612			65.297	183.428	162,882
Kansas and Nebraska	2,472				50,254	47,387	45,481
Minnesota	126,269	36,854	3,929	45,055	14,941	121.900	104.221
Missouri	22,541	582,686	197	12,107	21,817	128,875	96,771
Total: 1962	191,599	631,152	4,126	57,162	152.309	481,590	409,355
Total: 1961	148.407	660,012	3,358	54,557	141,103	465,068	370.233
South Atlantic:							
Delaware and Maryland	1,045,790	20,214	152,004	54,004	34,043	235,393	793,948
Florida and Georgia	125,758	133,151	16,223	8,112	1,238	28,646	68,202
North Carolina					2,012	72.096	2,778
South Carolina						30,031	15,511
Virginia and West Virginia	133,275	67,473	250,025	249,233	101,313	172,145	717,903
Total: 1962	1,304,823	220,838	418,252	311,349	138,606	538,311	1.598,342
Total: 1961	1.759,007	298,312	413,149	434,450	117,164	662,973	1,516,040
East South Central:							
Alabama	814,905	146,473	103,182	246,589	101.275	669,864	436,580
Kentucky, Mississippi, Tennessee	587,047	100,684	141,647	141,478	42,253	322,883	186,713
Total: 1962	1,401,952	247,157	244,829	388,067	143,528	992.747	623.293
Total: 1961	1.309,307	282,276	265,515	378,727	156,383	916.783	647,570
West South Central:							
Arkansas, Louisiana, Oklahoma		40,053		18,056	49.472	36,379	12,001
Texas	199,809	705,906	39,685	1,980	84,751	326,162	183,970
Total: 1962	199,809	745,959	39,685	20.036	134,223	362,541	195,971
Total: 1961	103,826	922,833	52,410	19,277	120,343	353.373	158,909

TABLE 16.—Consumption of iron and steel scrap, by grades, by districts and States, in 1962—Continued

(Short tons)

District and State	No. 1 heavy-melting steel	No. 2 heavy-melting steel	No. 1 and electric furnace bundles	No. 2 and all other bundles	Low phosphorus scrap	Cast iron scrap, other than borings	All others
Rocky Mountain:							
Arizona and Nevada	8,558	19,963	----------	5,947	----------	1,194	74,949
Colorado, Idaho, Montana, Utah	703,273	61,057	12,400	58,828	3,658	177,382	305,156
Total:							
1962	711,831	81,020	12,400	64,775	3,658	178,576	380,105
1961	851,052	58,512	20,683	45,159	3,125	208,155	400,551
Pacific Coast:							
California and Hawaii	1,011,155	155,766	136,251	170,909	66,789	354,178	367,862
Oregon and Washington	179,324	83,100	13,902	40,180	20,127	29,368	82,230
Total:							
1962	1,190,479	238,866	150,153	211,089	86,916	383,546	450,092
1961	1,289,185	222,017	140,776	181,012	96,074	407,138	384,163
U.S. total:							
1962	20,901,248	4,211,840	5,461,859	3,484,095	4,120,509	10,104,167	17,876,029
1961	20,517,057	4,510,799	5,651,237	3,568,873	3,885,088	9,420,536	16,773,108

TABLE 17.—Iron and steel scrap production, receipts, consumption, consumer stocks, imports and exports

(Short tons)

Year	Home scrap produced	Purchased scrap received from dealers and all others	Consumption	Stocks Dec. 31	Imports [1]	Exports [2]
1958	33,713,535	25,190,513	56,359,935	9,593,600	332,622	2,927,860
1959	37,418,199	31,128,252	66,061,516	9,993,488	309,448	4,939,043
1960	39,632,100	28,469,125	66,468,708	9,287,881	179,401	[3] 7,054,964
1961	38,475,062	27,552,939	64,326,698	[3] 8,823,815	268,389	[3] 9,713,863
1962	40,644,640	27,498,501	66,159,747	8,592,426	210,127	5,113,409

[1] Includes tinplate scrap.
[2] Excludes circles, cables, strip, and scroll shear butts from tinplated scrap.
[3] Revised figure.

STOCKS

Total iron and steel scrap stocks held by consumers on December 31, 1962, were 2 percent below the quantity available on the same date of 1961, and were equivalent to a 48-day supply at an average daily scrap-consumption rate of 181,000 tons. The lowest tonnage held during the year was 8,456,000 tons on January 31, and the highest was 9,276,000 tons on July 31. Decreases occurred in six of the nine geographical districts; the largest decrease—147,000 tons—was in the East North Central district. Three districts showed an increase, and the South Atlantic district had the largest increase—261,000 tons. Stocks of pig iron held by consumers and suppliers on December 31 were 2 percent lower than those on hand December 31, 1961.

TABLE 18.—Consumer stocks of iron and steel scrap and pig iron Dec. 31, in the United States, by districts and States

(Short tons)

District and State	1961		1962	
	Scrap	Pig iron	Scrap	Pig iron
New England:				
Connecticut	12,822	4,002	14,925	4,542
Maine and New Hampshire	1,742	387	1,338	293
Massachusetts	27,286	9,430	24,157	8,385
Rhode Island	8,805	6,676	12,230	6,119
Vermont	1,419	578	974	232
Total	52,074	21,073	53,624	19,571
Middle Atlantic:				
New Jersey	80,829	36,406	58,382	24,414
New York	622,878	431,394	671,199	384,471
Pennsylvania	[1] 1,928,438	736,936	1,894,534	605,837
Total	[1] 2,632,145	1,204,736	2,624,115	1,014,722
East North Central:				
Illinois	1,006,971	242,107	1,004,255	215,429
Indiana	832,401	127,353	770,540	143,698
Michigan	424,059	242,207	442,012	257,619
Ohio	1,304,833	536,692	1,207,789	624,909
Wisconsin	57,991	17,138	54,257	24,915
Total	3,626,255	1,165,497	3,478,853	1,266,570
West North Central:				
Iowa	28,196	31,882	33,451	18,757
Kansas and Nebraska	16,032	555	20,155	654
Minnesota	122,407	62,561	77,524	43,625
Missouri	194,021	14,414	158,214	16,714
Total	360,656	109,412	289,344	79,750
South Atlantic:				
Delaware and Maryland	202,256	58,390	484,508	74,487
Florida and Georgia	17,592	1,852	42,650	1,540
North Carolina	2,001	810	3,685	1,417
South Carolina	5,348	2,936	4,703	1,969
Virginia and West Virginia	143,053	44,466	95,274	58,076
Total	370,250	108,454	630,820	137,489
East South Central:				
Alabama	375,470	279,403	301,360	328,705
Kentucky, Mississippi, Tennessee	222,005	90,486	188,274	81,264
Total	597,475	369,889	489,634	409,969
West South Central:				
Arkansas, Louisiana, Oklahoma	25,301	1,855	34,304	1,506
Texas	368,075	53,351	248,943	41,209
Total	393,376	55,206	283,247	42,715
Rocky Mountain:				
Arizona and Nevada	14,033	119	21,505	62
Colorado, Idaho, Montana, Utah	262,657	97,701	203,651	82,605
Total	276,690	97,820	225,156	82,667
Pacific Coast:				
California and Hawaii	412,178	49,124	400,085	56,847
Oregon and Washington	102,716	1,904	117,548	14,546
Total	514,894	51,028	517,633	71,393
U.S. total	[1] 8,823,815	3,183,115	8,592,426	3,124,846

[1] Revised figure.

TABLE 19.—Consumer stocks of iron and steel scrap, by grades, by districts and States, Dec. 31, 1962

(Short tons)

District and State	No. 1 heavy-melting steel	No. 2 heavy-melting steel	No. 1 and electric furnace bundles	No. 2 and all other bundles	Low phos-phorus scrap	Cast iron scrap, other than borings	All others
New England:							
Connecticut	896		68	22	3,731	2,798	7,410
Maine and New Hampshire	266				27	875	170
Massachusetts	612	73			869	8,886	13,717
Rhode Island	1,364	4,852			1,249	2,889	1,876
Vermont	443	13				518	
Total:							
1962	3,581	4,938	68	22	5,876	15,966	23,173
1961	1,920	3,763	180	23	3,705	17,390	25,093
Middle Atlantic:							
New Jersey	1,006	2,737	4,095	1,187	4,909	30,511	13,937
New York	363,298	3,226	74,657	47,188	16,406	38,765	127,659
Pennsylvania	703,316	80,260	203,637	44,862	176,834	159,431	526,194
Total:							
1962	1,067,620	86,223	282,389	93,237	198,149	228,707	667,790
1961	948,798	104,315	277,509	121,133	182,107	212,397	703,316
East North Central:							
Illinois	191,395	54,648	250,270	126,449	65,529	95,855	220,109
Indiana	283,738	8,590	159,810	28,401	29,943	127,132	132,926
Michigan	37,350	92	151,344	8,649	42,603	91,602	110,372
Ohio	324,538	11,603	146,251	43,724	117,062	127,037	437,574
Wisconsin	3,094	564	35	33	23,147	16,215	11,169
Total:							
1962	840,115	75,497	707,710	207,256	278,284	457,841	912,150
1961 [1]	1,069,153	104,056	453,893	318,108	295,816	474,875	992,924
West North Central:							
Iowa	1,784	468			4,632	12,448	14,119
Kansas and Nebraska	73				4,313	2,892	12,877
Minnesota	23,102	14,773		5,557	1,660	5,832	26,600
Missouri	3,427	102,294	233	916	1,695	33,081	16,568
Total:							
1962	28,386	117,535	233	6,473	12,300	54,253	70,164
1961	23,408	125,440		23,997	10,434	78,223	99,154
South Atlantic:							
Delaware and Maryland	375,410	628	1,961	5,761	3,493	61,679	35,576
Florida and Georgia	18,643	16,704	1,370	684	50	1,670	3,529
North Carolina					324	3,262	99
South Carolina						831	3,872
Virginia and West Virginia	7,119	8,570	866	10,407	12,075	13,384	42,853
Total:							
1962	401,172	25,902	4,197	16,852	15,942	80,826	85,929
1961	116,658	28,382	7,897	54,790	14,049	60,313	88,161
East South Central:							
Alabama	135,729	23,175	11,307	17,997	15,669	43,829	53,654
Kentucky, Mississippi, Tennessee	71,687	7,842	47,848	15,816	919	13,397	30,765
Total:							
1962	207,416	31,017	59,155	33,813	16,588	57,226	84,419
1961	276,629	48,179	48,995	49,060	17,756	70,194	86,662
West South Central:							
Arkansas, Louisiana, Oklahoma		23,711		11	3,087	5,830	1,665
Texas	64,376	112,263	6,791		8,150	26,828	30,535
Total:							
1962	64,376	135,974	6,791	11	11,237	32,658	32,200
1961	18,891	255,964	36,714	229	12,672	29,912	38,994

See footnote at end of table.

TABLE 19.—Consumer stocks of iron and steel scrap, by grades, by districts and States, Dec. 31, 1962—Continued

(Short tons)

District and State	No. 1 heavy-melting steel	No. 2 heavy-melting steel	No. 1 and electric furnace bundles	No. 2 and all other bundles	Low phosphorus scrap	Cast iron scrap, other than borings	All others
Rocky Mountain:							
Arizona and Nevada	609	8,358		466		49	12,023
Colorado, Idaho, Montana, Utah	55,439	4,174	2,397	1,101	847	99,575	40,118
Total:							
1962	56,048	12,532	2,397	1,567	847	99,624	52,141
1961	84,938	31,766	14,732	35,600	942	63,983	44,729
Pacific Coast:							
California and Hawaii	130,599	29,608	20,048	31,687	8,109	60,323	119,711
Oregon and Washington	54,531	38,459	2,282	2,320	1,731	5,092	13,133
Total:							
1962	185,130	68,067	22,330	34,007	9,840	65,415	132,844
1961	213,477	77,566	43,755	38,322	6,336	52,772	82,666
U.S. total:							
1962	2,853,844	557,685	1,085,270	393,238	549,063	1,092,516	2,060,810
1961 [1]	2,753,872	779,431	883,675	641,262	543,817	1,060,059	2,161,699

[1] Revised figures.

TABLE 20.—Consumer stocks, production, receipts, consumption, and shipments of iron and steel scrap, by grades, in 1962

(Short tons)

Grades of scrap	Stocks Jan. 1 [1]	Home scrap produced	Receipts from dealers and all others	Total consumption	Shipments	Stocks Dec. 31
No. 1 heavy-melting steel	2,753,872	16,258,402	4,345,535	20,901,248	} 253,274 (No. 1 heavy-melting steel through Cast iron scrap)	2,853,844
No. 2 heavy-melting steel	779,431	1,542,663	2,449,317	4,211,840		557,685
No. 1 and electric furnace bundles.	883,675	1,082,764	4,553,617	5,461,859		1,085,270
No. 2 and all other bundles	641,262	692,237	2,605,411	3,484,095		393,238
Low phosphorus scrap	543,817	1,275,430	2,958,591	4,120,509		549,063
Cast iron scrap, other than borings.	1,060,059	6,379,555	4,262,970	10,104,167		1,092,516
Turnings and/or borings, alloy free.	267,961	671,784	2,325,721	2,837,497	214,702	213,267
Rerolling rails	143,128	3,834	349,922	359.100	17,025	120,759
Scrap rails	60,797	38,225	280,379	317,157	10,082	52,162
High speed steel	4,147	19,315	11,478	30,327	616	3,997
Stainless steel	134,933	440,898	229,246	643,739	24,620	136,718
All other alloy iron and steel	335,883	1,899,734	356,471	2,165,761	32,439	393,888
All other prepared scrap	719,721	6,411,543	2,259,707	9,286,773	} 1,662,025 (All other prepared scrap and Unprepared scrap)	611,317
Unprepared scrap	495,129	3,928,256	510,136	2,235,675		528,702
Total	8,823,815	40,644,640	27,498,501	66,159,747	2,214,783	8,592,426

[1] Revised figures.

TABLE 21.—Stocks of iron and steel scrap and pig iron at major consuming industries plants, Dec. 31

(Short tons)

Year	Manufacturers of steel ingots and castings	Manufacturers of steel casting	Iron foundries and miscellaneous users	Total
	Scrap stocks			
1962	7,300,562	426,736	865,128	8,592,426
1961	[1] 7,612,431	383,792	827,592	[1] 8,823,815
	Pig iron stocks			
1962	2,648,683	27,514	448,649	3,124,846
1961	2,715,271	33,584	434,260	3,183,115

[1] Revised figure.

PRICES [2]

The average price per long ton for No. 1 Heavy-Melting scrap at Pittsburgh was estimated at $28.53 during 1962, a drop of $6.36 from the 1961 average and the lowest annual average price at Pittsburgh since 1949. The price for this grade of scrap was $38.25, in January, which was the highest price for the year and the highest since February 1960. The price fluctuated below $38.25 for the remainder of the year and dropped to $23 in November, the lowest level since August 1949. In December the price was quoted at $26 per long ton, 32 percent lower than at the beginning of the year.

No. 1 Heavy-Melting scrap in Chicago averaged $28.67 per long ton for the year—$6.96 lower than the average for the previous year. The highest price was $37.50 in January, and the lowest price was $24.10 in June, which was also the lowest since August 1949.

The average composite price of No. 1 Heavy-Melting iron and steel scrap was $28.22 for the year, $8.06 lower than the 1961 average and the lowest price since 1949. The composite price ranged between a high of $37.41 per long ton in January and a low of $23.58 in November. The quoted average price for this grade of scrap was $25.66 in December, 31 percent lower than at the beginning of the year.

The composite price for No. 2 Bundles averaged $20.44 per long ton for the year. The highest price was $25.75 in January, and the lowest price was $17.83 in November.

The average value of exports (see table 1), including all grades of scrap, from the United States during 1962 was $31.53 per long ton, $9.28 lower than the 1961 average.

[2] Iron Age. V. 191, No. 1, Jan. 3, 1963, p. 166.

TABLE 22.—Average monthly price and composite price for No. 1 heavy melting scrap in 1962

(Per long ton)

Month	Chicago	Pittsburgh	Philadelphia	Composite price [1]
January	$37.50	$38.25	$36.50	$37.41
February	35.00	36.25	34.75	35.33
March	31.75	32.50	31.50	31.91
April	29.10	30.70	31.10	30.30
May	25.50	27.00	25.00	25.83
June	24.10	25.50	24.50	24.70
July	27.75	26.50	24.50	26.25
August	29.50	27.30	25.30	27.36
September	26.16	25.83	26.50	26.16
October	24.50	23.50	24.50	24.17
November	24.75	23.00	23.00	23.58
December [2]	28.50	26.00	22.50	25.66
Average:				
1962 [2]	28.67	28.53	27.47	28.22
1961 [3]	35.63	34.89	38.33	36.28

[1] Composite price, Chicago, Pittsburgh, and Philadelphia.
[2] Estimate.
[3] Revised figures.

FOREIGN TRADE [3]

The export-licensing regulations governing exportation of iron and steel scrap remained in effect through 1962.

Imports.—Imported iron and steel scrap, including tinplate, dropped 22 percent in quantity and 33 percent in value when compared with 1961. Most of the imported scrap came from Canada. Of the total imports, 11 percent was tinplate, all from Canada, compared with 12 percent during 1961.

TABLE 23.—U.S. imports for consumption of iron and steel scrap, by countries

(Short tons)

Country	1961	1962
North America:		
Bahamas	343	368
Canada	266,873	[1] 205,593
Canal Zone		4
Cuba	600	
Dominican Republic		896
French West Indies		562
Mexico	209	1,878
Total	268,025	209,301
South America:		
Brazil		[1] 56
Colombia		39
Ecuador		132
Total		227
Europe:		
France	3	114
Germany, West	66	45
Sweden		389
United Kingdom	79	13
Total	148	561
Asia:		
India		33
Japan	13	4
Total	13	37
Oceania: Australia	203	1
Grand total:		
Short tons	268,389	[1] 210,127
Value	$9,084,698	[1] $6,067,233

[1] Adjusted by Bureau of Mines.

Source: Bureau of the Census.

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

TABLE 24.—U.S. exports of iron and steel scrap, by countries[1]

(Short tons)

Destination	Iron and steel scrap including tinplate and terneplate scrap[2]		Rerolling material	
	1961	1962	1961	1962
North America:				
Canada	305,075	360,946	398	2,527
Mexico	[3] 374,540	306,150	13,956	3,042
Nicaragua	12,070	17,532		
Other	[3] 191	162		
Total	[3] 691,876	684,790	14,354	5,569
South America:				
Argentina	4,269	50		
Brazil	11,106	1,283		
Chile	36		11	
Colombia	19	467	22	
Peru	158	209		
Venezuela	36	32,787		
Total	15,624	34,796	33	
Europe:				
Belgium-Luxembourg	9,873	2,464		
France	247,028	22,640		
Germany, West	504,980	38,098		
Greece	14,696	74		
Italy	1,202,772	1,508,824		
Netherlands	32,401	1,855		
Norway	42,654			
Spain	206,615	74,807		
Sweden	148,177	5,343		
United Kingdom	534	1,257	989	138
Yugoslavia	134,921	37,475		
Other	269	15		
Total	2,544,920	1,692,852	989	138
Asia:				
Hong Kong	20,095	16		980
India	5,179	4,564		
Israel	47	2,013		
Japan	[3] 6,049,748	2,475,270	222,001	73,085
Korea, Republic of		19,999		
Nansei and Nanpo Islands			16,546	6,991
Taiwan	107,686	90,466	23,247	11,357
Other	881	276	598	
Total	[3] 6,183,636	2,592,604	262,392	92,413
Africa:				
United Arab Republic (Egypt)		9,882		
Other	31	343		
Total	31	10,225		
Oceania		22	8	
Grand total:				
Short tons	[3] 9,436,087	5,015,289	277,776	98,120
Value	[3] $338,436,647	$143,958,811	$15,491,368	$5,014,390

[1] Bureau of Mines. 1961 Minerals Yearbook. V. 1, p. 750, table 24. Iron and steel scrap, including tinplate and terneplate scrap 1960 should read: Argentina, 1,093 short tons; total South America, 19,331 short tons; grand total, 7,054,964 short tons.
[2] Excludes circles, cobbles, strip, and scroll shear butts from tinplated scrap.
[3] Revised figure.

Source: Bureau of the Census.

Exports.—The greatly reduced demand for iron and steel scrap by three major sources (Canada, Italy, and Japan) during 1962 was the primary cause of a 47 percent decline from 1961 in total exports from the United States. Iron and steel scrap exported, excluding rerolling materials, dropped 47 percent in quantity and 57 percent in value from 1961. Scrap exported to Japan, including rerolling materials, totaled 2.5 million tons, a decrease of 59 percent from the record quantity purchased by that country in 1961. Italy, the second largest importer of U.S. scrap, increased its imports and received 1.5 million tons, 25 percent higher than in 1961 but less than during some previous years. Japan and Italy received 79 percent of the total scrap exported from the United States. The third largest quantity exported went to Canada.

TABLE 25.—U.S. imports for consumption and exports of iron and steel scrap by classes [1]

Class	1961		1962	
	Short tons	Value	Short tons	Value
Imports:				
Iron and steel scrap	235,350	$8,315,133	[2] 189,035	[2] $5,726,353
Tinplate scrap	33,039	769,565	21,092	340,880
Total	268,389	9,084,698	[2] 210,127	[2] 6,067,233
Exports:				
Nos. 1 and 2 heavy-melting steel scrap	[3] 5,560,193	[3] 213,794,305	2,681,519	82,326,263
Nos. 1 and 2 baled steel scrap	[3] 2,394,608	[3] 72,510,549	1,521,328	37,155,258
Borings, shovelings, and turnings	163,014	4,509,035	186,232	3,932,823
Iron scrap	634,097	23,133,538	312,890	9,396,565
Rerolling material	277,776	15,491,368	98,120	5,014,390
Other steel scrap (terneplated and tinplated)[4]	[3] 684,175	[3] 24,489,220	313,320	[2] 11,147,902
Total	[3] 9,713,863	[3] 353,928,015	5,113,409	[2] 148,973,201

[1] Bureau of Mines. 1961 Minerals Yearbook. V. 1, p. 751, table 25. Nos. 1 and 2 baled steel scrap 1960 should read: 1,670,143 short tons; total should read 7,180,778 short tons.
[2] Adjusted by the Bureau of Mines.
[3] Revised figure.
[4] Excludes circles, cobbles, strip, and scroll shear butts from tinplated scrap.

Source: Bureau of the Census.

WORLD REVIEW

European Coal and Steel Community (ECSC).—Although iron and steel scrap prices had remained unchanged in recent months, experts in Luxembourg viewed future developments in the ECSC with pessimism.[4] Dealer sales in West Germany developed satisfactorily as to quantity but were down 16 percent from the previous year on deliveries to other ECSC countries. Sales in France were down 10 percent in the first 10 months of 1962, compared with the same period of 1961. However, sales to outside sources showed an increase.

In view of the free scrap imports from Great Britian and the United States, the Federation of West German Scrap Wholesalers asked the Economics Minister to appeal to the High Authority for a lifting of the ban on scrap exports to third countries.

Australia.—The Minister of Trade announced that effective August 29, 1962, restrictions formerly applying to the export of iron and steel scrap were no longer operative.[5] It was reported that the quantities

[4] Metal Industry. V. 101, No. 25, Dec. 20, 1962, p. 498.
[5] Bureau of Mines. Mineral Trade Notes. V. 55, No. 6, December 1962, p. 21.

of scrap offered to Australian users were in excess of local requirements and controls were no longer necessary.

Belgium.—The Belgian Government brought to the attention of the High Authority of the ECSC the difficulties experienced by shipbreaker yards and demanded a measure of protection for scrap metal from broken-up ships.[6] Declining prices in the domestic scrap market, a drop in production of scrap in Belgian yards, and the closing of nearly half of the yards were the reasons for the Government's demand. A negative reply was given by the High Authority.

Italy.—Europe's fastest growing steel producer also became one of the fastest growing markets in the world for raw materials, especially scrap.[7] Requirements for about 5 million tons of outside scrap annually were being filled from France, Germany, and the United States. Approximately one-third of these requirements, 1.5 million tons, were imported from the United States.

Japan.—A lack of orders for iron and steel scrap from Japan resulted in the U.S. export market passing through its most depressed period in recent years.[8] The causes of this decrease in scrap purchases from the United States were foreign exchange difficulties, declining exports of finished steel products, changes in Japanese steelmaking techniques which were expected to reduce future scrap requirements, and competition from the United Kingdom.

In preparing for the operation of a newly constructed plant in Osaka, it was decided to import scrap from abroad and the first order was placed with suppliers in Australia.[9]

Luxembourg.—Steel plants using Bessemer and Thomas furnaces in Luxembourg had much lower iron and steel scrap requirements than plants using electric and Martin furnaces. During 1961, the steel industry had a total iron and steel scrap consumption of 910,146 tons, compared with 904,204 tons in 1960. According to industry officials, most of the iron and steel scrap requirements were filled locally from rejects of finished steel products.[10]

Peru.—The export ban on scrap metal was extended for 3 years by Supreme Decree No. 32 dated December 29, 1961 (El Peruano, January 9, 1962). This decree extended the provision of Supreme Decree No. 20 of December 22, 1958, which suspended exports not only of scrap iron and steel and foundry waste but also of copper, lead, zinc, aluminum, and their alloys, including ingots and bars containing scrap of the various metals. Decree No. 32 specified that the scarcity which prompted the ban continued, and that the products named were essential to the industrial activity of the country.[11]

United Kingdom.—The export license issued in October 1961, permitting the export of lower grades of iron and steel scrap, had little effect on the overall market.[12] Therefore, to solve the problem of growing stockpiles, the National Federation of Scrap Iron, Steel and

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[6] Metal Industry. Belgian Scrap Production. V. 101, No. 14, Oct. 4, 1962, p. 56.
[7] American Metal Market. Fast-Growing Market For U.S. Scrap. V. 69, No. 39, Feb. 27, 1962, pp. 1–16.
[8] American Metal Market. Scrap Export Market Mired In Depression. V. 69, No. 96, May 18, 1962, p. 19.
[9] American Metal Market. Japanese Firm Buys Australian Scrap. V. 69, No. 199, Oct. 16, 1962, p. 24.
[10] Bureau of Mines. Mineral Trade Notes. V. 56, No. 1, January 1963, p. 24.
[11] Bureau of Mines. Mineral Trade Notes. V. 54, No. 4, April 1962, p. 8.
[12] Steel and Coal. International Trade In Scrap. V 184, No. 4877, Jan. 5, 1962, p. 11.

Metal Merchants applied to the Ministry of Power for an open general license to export all grades of scrap.

Upon the request by the Ministry of Power, the British Board of Trade issued an open general license order to permit exports of iron and steel scrap to any destination. The periods covered by this order were January 25 to April 25, 1962; April 26 to July 25; July 26 to September 25; September 26 to November 25; and November 26 to December 31, 1962.

Japanese interest purchased 10 cargoes of scrap before the issuance of the open general license. These cargoes were subject to the removal of the ban on exports.[13] After its removal the Japanese chartered three vessels and were arranging to charter seven more for transporting scrap to Japan. At the same time, scrap purchases from the United States by Japan were decreasing.

U.S.S.R.—According to the All-Union Council of National Economy, supplies of scrap were inadequate to meet the increased requirements in metal production caused by the erection of new plants and better utilization of existing melting units. Resources of this material were virtually inexhaustible but were not being fed to the open-hearth plants because existing obsolete facilities were not being dismantled and made available to consumers.[14]

TECHNOLOGY

A new semiautomatic ship-loading device engineered for easy handling and maneuverability was developed by a plant in Union, N.J. The sturdy steel construction of this device permitted easier loading, and it was designed to assure even distribution so that there would be no danger of cargo shift and waste of cargo space.[15]

A new open-hearth scrap-charging machine that was more efficient and reduced costs was developed at a plant in Pittsburgh, Pa.[16] It was estimated that through the use of this equipment, the scrap-charging function of a well equipped open-hearth furnace could be reduced from approximately 90 minutes to about 15 minutes furnace time.

A report on the origin, collection, movement, and consumption of high-temperature alloy scrap in California and Nevada during 1959 and 1960 was placed on open file at the U.S. Department of Interior Library in Washington, D.C.[17] The objectives of this report were to determine the existence of a metallurgical problem wherein the Bureau of Mines research facilities might aid the industry and the degree to which the generation and collection of high-temperature alloy scrap in California and Nevada could augment the production of this grade of scrap in the United States.

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[13] American Metal Market. Japan Buys Scrap Iron In England; Exports Here Slow. V. 69, No. 18, Jan. 12, 1962, p. 22.

[14] U.S.S.R. Industrial Development, Soviet Ferrous Metallurgy, No. 78, U.S. Department of Commerce, Office of Technical Services, Joint Publications Research Service, Oct. 28, 1962, p. 15.

[15] Waste Trade Journal. New Scrap Loading Device Cuts Time, Fills All Voids. V. 112, No. 21, Feb. 17, 1962, p. 35.

[16] American Metal Market. Blaw Knox Claims Scrap Charging Machine Cuts Steel Making Costs. V. 69, No. 239, Dec. 14, 1962, p. 18.

[17] Branner, George C., and John W. Padan. High-Temperature Alloy Scrap in California and Nevada. U.S. Department of Interior Library. Open File Report, August 1962, 24 pp.

Iron Oxide Pigments

By John W. Hartwell[1] and Betty Ann Brett[2]

DEMAND for all finished iron oxide pigments in the United States during 1962 increased 6 percent by weight and 8 percent by value over 1961. Crude iron oxide pigments sold or used increased 31 percent over 1961 but remained 15 percent below the 1960 record.

TABLE 1.—Salient iron oxide pigments statistics in the United States

	1953–57 (average)	1958	1959	1960	1961	1962
Mine production ... short tons	[1] 51,300	54,700	53,900	70,300	46,000	57,500
Crude pigments sold or used ... do	[1] 47,800	55,300	54,000	71,100	45,900	60,100
Value ... thousands	[1] $430	$445	$470	$635	$453	$500
Finished pigments sold ... short tons	108,100	98,400	117,600	106,000	106,500	113,000
Value ... thousands	$15,841	$15,822	$19,037	$17,948	$18,345	$19,798
Imports for consumption ... short tons	12,400	11,700	14,800	14,500	10,500	13,100
Value ... thousands	$1,072	$1,160	$1,495	$1,422	$1,059	$1,295
Exports ... short tons	4,200	3,900	4,300	3,900	3,200	3,800
Value ... thousands	$842	$1,065	$1,040	$1,113	$855	$1,076

[1] Average for 1954–57 only.

DOMESTIC PRODUCTION

Finished iron oxide pigments were sold by 14 companies with 18 plants in 9 States. Eight companies in six States mined and sold or used iron oxide pigments.

TABLE 2.—Finished iron oxide pigments sold by processors in the United States, by kinds

Pigment	1961		1962	
	Short tons	Value	Short tons	Value
Natural:				
Black and brown	10,140	$1,320,500	11,695	$1,580,100
Red	17,376	1,028,200	18,214	1,103,000
Yellow	4,685	347,500	4,650	351,600
Total	32,201	2,696,200	34,559	3,034,700
Manufactured:				
Black and brown	3,963	1,202,400	4,497	1,495,600
Red	45,284	9,105,600	48,528	9,889,100
Yellow	15,287	3,722,100	16,611	4,084,500
Total	64,534	14,030,100	69,636	15,469,200
Unspecified including mixtures of natural and manufactured red iron oxides	9,767	1,618,700	8,770	1,294,100
Grand total	106,502	18,345,000	112,965	19,798,000

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

PRICES

Fluctuations in the quoted prices shown in table 3 were the result of different methods used by various trade journals in obtaining data. Some changes in prices were also caused by differences in quantity, quality, locality, or individual suppliers' views. The variation in high and low prices of Venetian red was due to different grades ranging from 20 to 40 percent iron oxide. Prices were not quoted for Turkish umber, burnt and raw, and for natural and Spanish red.

TABLE 3.—Prices quoted on finished iron oxide pigments, per pound, in bags, unless otherwise specified, in 1962

Pigment	High	Low	Pigment	High	Low
Black:			Red:		
Pure	$0.1475	$0.1475	Domestic (pure)	$0.1425	$0.1450
Synthetic	.1475	.1500	Persian Gulf	.0950	.0950
Brown:			Sienna, burnt	.0725	.0725
Pure	.1575	.1600	Venetian	.0525	.0725
Metallic	.0550	.0625	Yellow:		
Umber, American, burnt	.0850	.0850	Ocher, natural, French	.0675	.0700
Umber, American, raw	.0850	.0850	Ocher, natural, Peruvian	.0250	.0250
Vandyke (barrels)	.1200	.1100	Ocher, hydrated, pure	.1200	.1250
			Sienna, raw	.0750	.0750

Source: Oil, Paint and Drug Reporter and Chemical & Engineering News.

FOREIGN TRADE [3]

All imports of crude ocher (36 short tons) and 82 percent of the refined ocher (90 tons) came from the Republic of South Africa. The remainder of the refined ocher (20 tons) came from the United Kingdom.

Cyprus, Italy, and Malta supplied all the crude sienna imported, with 266, 384, and 22 tons, respectively; refined sienna with an average value of 6 cents per pound came from Cyprus (39 tons), Italy (163 tons), and the United Kingdom (5 tons).

Crude umber was imported from Cyprus (2,207 tons) and Malta (248 tons). The refined umber was from Cyprus (123 tons) and the United Kingdom (85 tons) with an average value of 3.6 cents per pound.

The United States exported iron oxide pigments to 51 countries with an average value of 14 cents per pound, compared with 13 cents per pound in 1961.

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

TABLE 4.—U.S. imports for consumption of selected iron oxide pigments

Pigments	1961		1962	
	Short tons	Value	Short tons	Value
Natural:				
Ocher, crude and refined	[1] 91	[1] $5,171	146	$8,585
Siennas, crude and refined	546	56,910	879	83,941
Umber, crude and refined	2,685	93,240	2,663	94,497
Vandyke brown	168	13,042	256	20,663
Other [2]	2,248	113,710	2,937	127,536
Total	5,738	282,073	6,881	335,222
Manufactured (synthetic)	4,806	776,780	6,206	960,073
Grand total	10,544	1,058,853	13,087	1,295,295

[1] Refined only.
[2] Classified by the Bureau of the Census as "Natural iron-oxide and iron-hydroxide pigments, n.s.p.f."

Source: Bureau of the Census.

TABLE 5.—U.S. imports for consumption of iron-oxide and iron-hydroxide pigments, n.s.p.f.,[1] by countries

Country	Natural				Synthetic			
	1961		1962		1961		1962	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
North America: Canada			3	$509	1,177	$240,677	1,143	$218,725
Europe:								
Belgium-Luxembourg					(2)	504	13	2,000
France					1	1,991	39	5,944
Germany, West	29	$3,520			2,728	396,315	3,918	565,148
Netherlands					45	7,500	26	4,020
Spain	2,131	101,422	2,835	117,762				
Sweden					(2)	266	1	993
United Kingdom	88	8,768	99	9,265	832	128,395	1,066	163,243
Total	2,248	113,710	2,934	127,027	3,606	534,971	5,063	741,348
Asia: India					23	1,132		
Grand total	2,248	113,710	2,937	127,536	4,806	776,780	6,206	960,073

[1] Not specifically provided for.
[2] Less than 1 ton.

Source: Bureau of the Census.

TABLE 6.—U.S. exports of iron oxide pigments, by countries

Destination	1961		1962	
	Short tons	Value	Short tons	Value
North America:				
Bahamas	15	$3,172	(1)	$242
Canada	1,748	392,031	1,987	455,367
Costa Rica	13	4,680	6	1,787
Guatemala	33	6,451	37	9,073
Mexico	61	25,842	68	20,109
Netherlands Antilles	3	1,258	10	4,062
Other	20	8,063	54	16,729
Total	1,893	441,497	2,162	507,369
South America:				
Argentina	18	11,340	5	4,160
Brazil	31	11,760	34	10,766
Chile	18	6,529	7	1,704
Colombia	110	40,758	75	27,443
Ecuador	9	4,002	12	3,613
Peru	14	5,690	11	4,567
Venezuela	111	24,463	63	15,545
Total	311	104,542	207	67,798
Europe:				
Belgium-Luxembourg	10	7,578	31	17,845
France	67	21,889	79	28,882
Germany, West	94	29,637	66	26,121
Iceland	1	268	5	1,772
Italy	29	7,917	4	1,828
Netherlands	73	4,888	35	3,317
Portugal	14	4,021	10	3,078
Sweden	---	---	8	5,663
Switzerland	26	8,322	30	8,926
United Kingdom	95	30,490	132	38,579
Other	13	5,877	15	4,641
Total	422	120,887	415	140,652
Asia:				
Afghanistan	14	3,331	---	---
Hong Kong	5	2,229	4	1,801
Japan	165	48,359	290	82,500
Pakistan	8	4,380	27	5,961
Philippines	215	77,278	140	45,239
Taiwan	---	---	27	14,900
Other	14	5,797	34	17,638
Total	421	141,374	522	168,039
Africa:				
Congo, Republic of the, and Ruanda-Urundi	---	---	16	4,656
South Africa, Republic of [2]	---	---	12	5,188
United Arab Republic (Egypt)	49	13,437	53	12,090
Other	1	266	1	716
Total	50	13,703	82	22,650
Oceania	116	32,688	366	169,275
Grand Total	3,213	854,691	3,754	1,075,783

[1] Less than 1 ton.
[2] Effective Jan. 1, 1962; formerly Union of South Africa.

Source: Bureau of the Census.

WORLD REVIEW [4]

Canada.—Production of natural iron oxide pigments in 1961 was 690 tons valued at Can$57,110, compared with 909 tons (revised) valued at Can$76,780 in 1960. This was 95 percent less in quantity than the record production in 1950. Natural iron oxide use has declined because of the greater variety of qualities available in the synthetic product.

Until 1958 the domestic output of natural iron oxide pigments was consumed mainly by the coke and gas industries, but in 1961 much of the refined material was exported and most of the balance was used for abrasive purposes.

Exports of synthetic and natural iron oxide pigments in 1961 was 2,200 tons valued at Can$376,000. Imports of ochers, siennas, and umbers principally from the United States was 649 tons in 1961, compared with 615 tons in 1960.

Consumption of synthetic and natural iron oxide by the paint industry remained fairly constant in 1961 at over 2,000 tons valued at Can$489,000.[5]

India.—Production of ocher in 1961 was over 21,000 tons valued at $73,000, compared with 22,500 tons valued at $80,200 in 1960.[6]

Morocco.—Output of iron oxide pigments was nearly 1,700 tons in 1961, compared with 1,600 tons in 1960. In 1961, 1,300 tons were exported principally to Algeria, France, and the United Kingdom.[7]

South Africa, Republic of.—In 1961, production of iron oxide pigments was 5,626 tons, and total sales were 4,366 tons valued at $102,000.[8] Producers of iron oxide pigments listed by the Republic of South Africa, Department of Mines, were African Golden Ochre Co. (Pty.), Ltd., Albertinia; Via Gellia Colour Co., Ltd., Riversdale; Bullalo Oxides (Pty.), Ltd., Newcastle; and S.A. Oxides (Pty), Ltd., Germiston.

TECHNOLOGY

Natural iron oxide pigment in an aqueous suspension, when exposed to ultrasonic waves, coagulated and precipitated three times faster than normal. Higher wetability was noted, reducing the time required for density determination. The pH of the medium decreased as the amount of dispersed phase and the time of exposure to the ultrasonic field increased.[9]

A Canadian process for producing pure red or yellow iron oxide powder, suitable for use as a pigment, involved separating both the

[4] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board, unless otherwise specified.
[5] Ross, J. S. Mineral Pigments and Fillers, 1961 (Preliminary). Canadian Miner. Ind., Dept. Mines and Tech. Surveys, Ottawa, May 1962, pp. 1–6.
[6] Bureau of Mines. Mineral Trade Notes. V. 55, No. 6, December 1962, p. 31.
[7] Bureau of Mines. Mineral Trade Notes. V. 56, No. 1, January 1963, p. 21.
[8] Bureau of Mines. Mineral Trade Notes. V. 55, No. 2, August 1962, pp. 39–41.
[9] Ryumin, V. P. (Ultrasonics in The Study of Aqueous Suspensions of Native Iron Oxide Pigments.) Zh. Prikl. Khim., No. 35, 1962, pp. 50–60; Chem. Abs., v. 56, No. 12, June 11, 1962, col. 14424e.

iron oxide and other compounds from a chemical solution then segregating the iron oxide by centrifuging.[10]

A process of producing stable black iron oxide pigment from ferric oxide-containing flue dust was described in a patent.[11] Another patent was granted for a process of producing an iron oxide pigment composition consisting essentially of colloidal hydrous iron oxide particles having a bound hydrophobic surface layer.[12]

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[10] Technical Survey. (Gaylor Technical Survey Corp., Elizabeth, N.J.). V. 18, No. 30, Aug. 11, 1962, pp. 536, 537.

[11] Frey, Friedrich. Process of Producing Black Oxide of Iron. U.S. Pat. 3,036,889, May 29, 1962.

[12] Edwards, W. H. (assigned to E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.). Pigment Composition and Process. U.S. Pat. 3,052,644, Sept. 4, 1962.

Kyanite and Related Minerals

By James D. Cooper[1] and Gertrude E. Tucker[2]

PRODUCTION of domestic kyanite in 1962 was 5 percent greater than in 1961. No other natural minerals of the kyanite group were produced in the United States. Production of synthetic mullite increased 29 percent. Apparent consumption of kyanite and related minerals, including synthetic mullite, was 10 percent higher than in 1961.

Kyanite, sillimanite, andalusite, dumortierite, topaz, and synthetic mullite are discussed in this chapter because all are aluminum silicates with similar properties, and all can be used to produce mullite refractories.

DOMESTIC PRODUCTION

Production of minus 35-mesh kyanite concentrate increased 5 percent in 1962 and for the second consecutive year established a new high. Output of crude kyanite ore increased 6 percent, indicating a slight decline of the concentrate-to-ore recovery ratio. Quantitative data on output are withheld to prevent disclosing production of the individual companies—Commercialores, Inc., with mines near Clover, S.C., and Kyanite Mining Corp., with mines near Farmville and Dillwyn, Va.

A kyanite flotation plant capable of producing about 9,000 tons of concentrate per year was completed by Aluminum Silicates, Inc., at Washington, Ga., to process kyanite-quartzite rock from Graves Mountain in Lincoln County. Shakedown operations were started in September, and several runs were made to produce large samples for testing by potential consumers. Commercial production began about the end of the year.

Output of synthetic mullite, made from siliceous and aluminous raw materials including bauxite, alumina, sand, and clay, increased 29 percent in quantity and 21 percent in value over that of 1961. There were six producers in 1962:

The Babcock & Wilcox Co., Refractories Division, New York, N.Y. (plant at Augusta, Ga.).
The Carborundum Co., Niagara Falls, N.Y. (plant at Niagara Falls, N.Y.).
Harbison-Walker Refractories Co., Pittsburgh, Pa. (plant at Vandalia, Mo.).
H. K. Porter Co., Inc., Refractories Division, St. Louis, Mo. (plant at Shelton, Conn.).

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

Remmey Division, A. P. Green Fire Brick Co., Philadelphia, Pa. (plant at same address).

The Chas. Taylor Sons Co., subsidiary of National Lead Co., Cincinnati, Ohio (plant at South Shore, Ky.).

TABLE 1.—Synthetic mullite production in the United States

Year	Short tons	Value (thousands)
1953–57 (average)	[1] 18,500	[1] $1,850
1958	16,280	1,632
1959	18,218	2,017
1960	21,497	2,212
1961	14,798	1,720
1962	19,021	2,090

[1] Estimate.

CONSUMPTION AND USES

The principal use of the kyanite group minerals is in production of mullite superrefractories, but significant quantities of domestic kyanite concentrate are used in ceramic mixes, where expansion of the kyanite upon heating compensates for firing shrinkage of the other ceramic materials.

About 90 percent of all mullite refractory products was used by the metallurgical and glass industries, and the rest was used mostly in kiln furniture for the ceramic industry.

Although the price of mullite refractories was higher than that of fire clay refractories, the lower maintenance cost under the severe operating conditions of metallurgical and glass furnaces more than offset the higher initial cost.

PRICES

Prices for domestic and imported kyanite reported in E&MJ Metal and Mineral Markets remained unchanged throughout 1962: Domestic kyanite concentrates, per short ton, f.o.b. point of shipment, 35 mesh, carlots, in bulk, $44 to $45, in bags, $47; 200 mesh, in bags, carlots, $53 to $55 (additional cost for calcining, per ton, $9 to $10). Prices for imported kyanite (60 percent grade) in bags were $76 to $81 per ton c.i.f. Atlantic ports.

FOREIGN TRADE [3]

Imports of kyanite and related minerals declined 2 percent in quantity and 4 percent in value in 1962. Exports declined 11 percent in quantity and 10 percent in value.

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

TABLE 2.—U.S. imports for consumption and exports of kyanite and related minerals

Imports

Year and country	Short tons	Value
1953-57 (average)	6,395	[1]$278,569
1958	1,965	95,489
1959	5,633	251,638
1960	6,052	265,364
1961:		
Europe: Netherlands	255	19,143
Asia: India	3,809	173,307
Africa: Union of South Africa	1,351	51,739
Total	5,415	244,189
1962:		
North America: Canada	108	9,980
Asia: India	3,845	174,948
Africa: South Africa, Republic of [2]	1,328	49,483
Total	5,281	234,411

Exports

Year and country	Short tons	Value
1953-57 (average)	1,563	$75,965
1958	2,493	126,862
1959	2,734	167,432
1960	3,255	209,950
1961:		
North America:		
Canada	647	100,237
Mexico	677	33,748
South America:		
Argentina	76	4,314
Venezuela	37	4,642
Europe:		
Austria	11	1,285
France	45	2,821
Germany, West	395	30,252
Italy	135	9,379
Netherlands	46	64,362
United Kingdom	878	50,536
Asia:		
Indonesia	89	,200
Japan	880	45,668
Viet-Nam	30	2,559
Africa: Union of South Africa	34	2,590
Oceania: Australia	20	1,040
Total	4,000	317,633
1962:		
North America:		
Canada	611	100,480
Dominican Republic	2	208
Mexico	587	33,073
South America:		
Argentina	53	3,028
Colombia	15	757
Venezuela	81	3,782
Europe:		
Belgium-Luxembourg	30	1,377
France	99	7,012
Finland	30	1,746
Germany, West	719	45,464
Italy	424	28,426
Portugal	3	384
Sweden	20	1,020
United Kingdom	530	30,754
Yugoslavia	22	5,452
Asia:		
Hong Kong	4	1,000
Indonesia	57	3,248
Japan	242	15,792
Oceania: Australia	39	3,737
Total	3,568	286,740

[1] 1954 data known to be not comparable with other years.
[2] Formerly Union of South Africa.

Source: Bureau of the Census.

WORLD REVIEW

Australia.—Production of sillimanite in 1961 was 2,001 short tons. In the first 6 months of 1962 production was 1,419 tons. None was exported.[4]

[4] The Australian Mineral Industry. Commonwealth of Australia, Bureau of Mineral Resources, Geology, and Geophysics. V. 15, No. 2, pt. 2, December 1962, p. 8.

India.—Production of kyanite in 1961 was 29,933 short tons, a 35-percent increase over that of 1960. Sillimanite production was 8,943 tons, 2 percent less than that of 1960.[5]

Korea, Republic of.—Production of andalusite in Korea was 270 short tons in 1960 and 562 tons in 1961.[6]

South Africa, Republic of.—Production of andalusite and sillimanite was 79,367 short tons, a decrease of 22 percent from that of 1961. Local sales totaled 5,864 tons valued at $98,000, and exports were 50,989 tons valued at $2.4 million.[7]

South-West Africa.—Kyanite production was 1,667 short tons, 44 percent less than that of 1961. Exports totaled 2,177 tons valued at $62,600.[8]

TECHNOLOGY

The Pella corundum-sillimanite deposits in Namaqualand, Republic of South Africa, were described. Exploitation is difficult because of the extreme hardness and toughness of the ore, illustrated by the fact that in several tests the average penetration by diamond-drill bits was only 3 inches. Oxygen lancing was tried with some success, but percussion drilling with tungsten-carbide-tipped steel bits was found to be the most efficient method of preparing the material for blasting.[9]

Research on mullite-forming mixtures containing various quantities of the impurities, titanium dioxide, ferric oxide, and alkalis, and tests on sintered mullite shapes made from siliceous bauxite were reported. Satisfactory mullite was prepared from mixtures containing up to a total of 5 percent impurity oxides. Shapes made with mullite prepared from siliceous bauxite were equivalent to those made from imported kyanite.[10]

A monograph was published on the properties, structure, formation, and significance of mullite. Coverage of Russian research on mullite was included.[11]

Research results were presented which indicated that there is a complete isomorphous series between sillimanite (Al_2O_3-SiO_2) and 3/2 mullite ($3Al_2O_3$-$2SiO_2$).[12]

Significant revisions of the Al_2O_3-SiO_2 equilibrium diagram were made, based on 190 tests in sealed noble-metal containers at temperatures up to 1,850° C. Differences in equilibrium data obtained in past research may have resulted to a considerable extent from the conditions under which the experimental data were obtained, particularly with regard to the amount of evaporation of SiO_2 from the liquid phase.[13]

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[5] U.S. Embassy, New Delhi, India. State Department Dispatch 892, Apr. 27, 1962, p. 2.

[6] U.S. Embassy, Seoul, Republic of Korea. State Department Dispatches 455, Apr. 4, 1961, encl. 1, p. 1 and 413, Apr. 27, 1962, encl. 1, p. 1.

[7] U.S. Consulate, Johannesburg, Republic of South Africa. State Department Airgram A–362, Mar. 28, 1963, p. 1.

[8] U.S. Consulate, Johannesburg, Republic of South Africa. State Department Airgram A–334, Mar. 13, 1963, p. 2.

[9] Weidner, P. J. Pella Corundum-Sillimanite. Mine & Quarry Eng. (London), v. 28, No. 11, November 1962, pp. 494–498.

[10] Tyrrell, M. E. Effects of Impurities on Sintered Mullite. BuMines Rept. of Inv. 5957, 1962, 15 pp.

[11] Grofcsik, Janos. Mullite, Its Structure, Formation, and Significance. Akademiai Kiado (Publishing House of the Hungarian Academy of Sciences), 1961, 163 pp. Abs. in J. Am. Ceram. Soc., v. 45, No. 10, October 1962, p. 252.

[12] Durovic, Slavomil. Isomorphism Between Sillimanite and Mullite. J. Am. Ceram. Soc., v. 45, No. 4, April 1962, pp. 157–161.

[13] Aramaki, Shigeo, and Rustum Roy. Revised Phase Diagram for the System Al_2O_3-SiO_2. J. Am. Ceram. Soc., v. 45, No. 5, May 1962, pp. 229–242.

Lead

By Richard N. Spencer,[1] Edith E. den Hartog,[2] and Mary E. Graves [2] [3]

Contents

MINE OUTPUT of recoverable lead decreased 10 percent to 237,000 tons, production of primary refined and antimonial lead at primary refineries decreased 15 percent to 403,400 tons and production of secondary lead decreased 2 percent to 444,200 tons. Consumption of lead in battery uses increased 14 percent, but lead in gasoline antiknock additives decreased 1 percent. Lead consumption in other classifications varied, most of which increased and some decreased slightly to moderately. Import quotas remained in effect during 1962 but some countries fell slightly short of filling their quotas. Deliveries to the supplemental stockpile were completed for the two barter contracts negotiated by the Commodity Credit Corporation (CCC) with two foreign producers. Deliveries to the CCC and supplemental stockpile were 84,300 tons. The price of common grade lead (New York market) declined on January 5 from 10.25 cents to 10.00 cents; on February 1 declined to 9.75 cents; on February 9 declined further to 9.50 cents; and then on November 1 advanced to 10.00 cents.

LEGISLATION AND GOVERNMENT PROGRAMS

Import quotas established in October 1958 continued in effect. The U.S. Tariff Commission submitted a report to the President on October 25, in accordance with Executive Order 10401 as required by escape clause procedure, recommending that trade conditions affecting the domestic industry had not changed sufficiently to warrant relaxing protective import restrictions on lead and zinc, and that no formal investigation was required.

No barter contracts for lead for Government stockpiling were negotiated during 1962, but 83,513 tons of lead was delivered to the CCC by Broken Hill Associated Smelter and Consolidated Mining & Smelting Co. to satisfy the remainder of the two barter contracts made in 1961. No acquisitions for Government stockpiles were contemplated.

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.
[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

Public Law 87–347, to subsidize small lead-zinc mines was implemented by approval of funds. Participation in the program, by eligible producers, was retroactive for production from January 1, 1962. Participation in the program was less than that expected; only $654,140 was disbursed to producers from the $4.5 million appropriated by Congress. The program was to continue 3 more years but at a diminishing scale.

The Office of Minerals Exploration (OME) continued its assistance for approved exploration projects for lead-zinc through June 30, at which time lead, zinc, and copper were removed from the list of minerals eligible under the OME program. Government participation by OME in these projects was limited to 50 percent of approved costs with $250,000 the maximum for any one contract. Two applications for assistance were received, and one new contract was executed and two contracts were amended to increase contract amounts authorizing total new expenditures of $220,230 of which Government participation was $110,115. One contract from OME for lead and zinc was terminated.

The International Lead-Zinc Study Group met in Geneva, Switzerland in plenary session March 15 to 21 at which time it was suspended to reconvene May 28 to 31, and October 24 to 26. Efforts were continued to evaluate means of bringing lead and zinc production and consumption into better balance, and the working group adopted measures to improve the quality of Study Group World Statistics for lead and zinc.

TABLE 1.—Salient lead statistics

	1953–57 (average)	1958	1959	1960	1961	1962
United States:						
Production:						
Domestic ores, recoverable lead content...short tons..	339,426	267,377	255,586	246,669	261,921	236,956
Value..........thousands..	$97,437	$62,566	$58,785	$57,722	$53,956	$43,602
Primary lead (refined):						
From domestic ores and base bullion short tons..	333,655	269,082	225,270	228,899	288,078	245,645
From foreign ores and base bullion short tons..	168,265	201,074	115,661	153,537	161,487	130,418
Antimonial lead (primary lead content)...short tons..	16,399	16,446	12,402	2,385	24,966	27,383
Secondary lead (lead content) short tons..	493,139	401,787	451,387	469,903	452,792	444,202
Imports, general:						
Lead in ores and matte short tons..	178,914	201,599	138,834	145,692	147,186	138,906
Lead in base bullion...do....	205	460	80	293	422	4,599
Lead in pigs, bars, and old.. short tons..	314,813	375,022	271,695	213,671	261,794	259,522
Exports of refined pig lead..do....	2,153	1,359	2,756	1,967	2,133	2,108
Stocks December 31 (lead content):						
At primary smelters and refineries..........short tons..	120,834	234,290	171,079	250,142	262,102	196,661
At consumer plants...do....	121,833	122,900	126,496	97,268	99,140	93,496
Consumption of metal, primary and secondary.....short tons..	1,171,390	986,387	1,091,149	1,021,172	1,027,216	1,109,635
Price: New York, common lead, average, cents per pound.......	14.67	12.11	12.21	11.95	10.87	9.63
World:						
Production:						
Mine..........................	2,430,000	2,590,000	2,560,000	2,615,000	2,625,000	2,765,000
Smelter.......................	2,295,000	2,495,000	2,410,000	2,560,000	2,665,000	2,665,000
Price: London, common lead, average, cents per pound.......	12.46	9.13	8.88	9.04	8.03	7.06

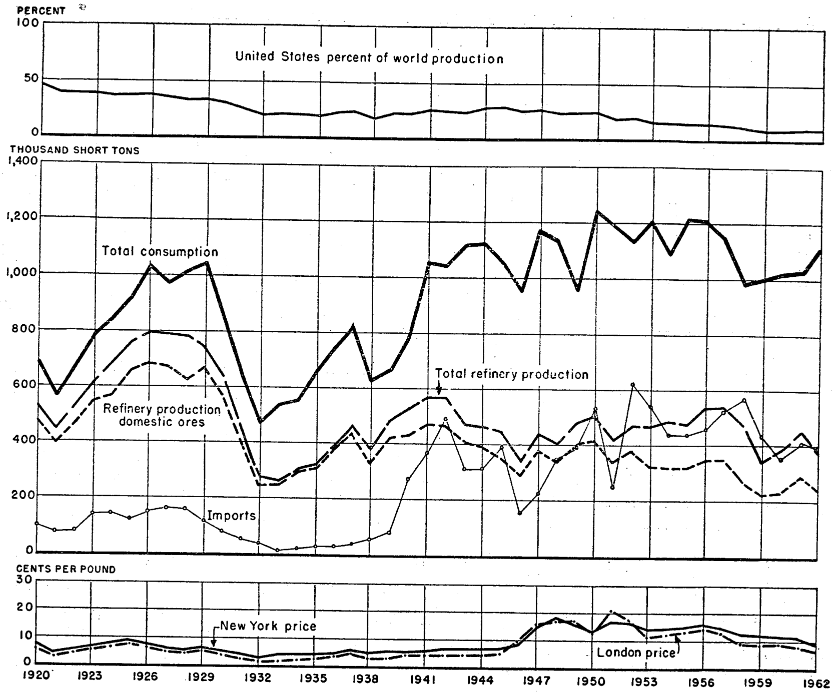

FIGURE 1.—Trends in the lead industry in the United States, 1920–62. Consumption includes primary refined, antimonial, and secondary lead, and lead in pigments made directly from ore. Imports are factored to include 95 percent of the lead content of ores, mattes, and concentrates and 100 percent of pigs, bars, base bullion, and scrap.

DOMESTIC PRODUCTION

MINE PRODUCTION

Mines in the United States produced 237,000 tons of recoverable lead, 25,000 tons less than that produced in 1961 and 34,000 tons less than that produced in 1900; it was also the lowest production since 1900. Production was normal for recent years up to July 27, when a labor strike closed all Missouri mines. The strike of all Missouri mines of St. Joseph Lead Co. lasted the remainder of 1962 and continued into 1963, resulting in zero output from that area for the duration of the strike. Missouri had long been the principal lead-producing State, but this prolonged strike caused it to drop to second place.

The four largest lead producing States were Idaho, 84,100 tons; Missouri, 61,000 tons; Utah, 38,200 tons; and Colorado, 17,400 tons. Mines from these four States produced 200,700 tons, or 85 percent of the total U.S. output. The remaining 15 percent came from 17 States having a combined production of 36,300 tons.

TABLE 2.—Mine production of recoverable lead in the United States, by States

(Short tons)

State	1953-57 (average)	1958	1959	1960	1961	1962
Arizona	10,414	11,890	9,999	8,495	5,937	6,966
Arkansas	----------	----------	38	----------	----------	----------
California	6,471	140	227	440	103	455
Colorado	19,248	14,112	12,907	18,080	17,755	17,411
Idaho	68,807	53,603	62,395	42,907	71,476	84,058
Illinois	3,594	1,610	2,570	3,000	3,430	3,610
Kansas	4,954	1,299	481	781	1,449	970
Kentucky	154	516	409	558	656	743
Missouri	125,337	113,123	105,165	111,948	98,785	60,982
Montana	16,748	8,434	7,672	4,879	2,643	6,121
Nevada	4,613	4,150	1,357	987	1,791	771
New Mexico	3,692	1,117	829	1,996	2,332	1,134
New York	1,387	579	481	775	879	1,063
North Carolina	5	----------	----------	424	318	219
Oklahoma	11,433	3,692	601	936	980	2,710
Utah	46,194	40,355	36,630	39,398	40,894	38,199
Virginia	3,256	2,934	2,770	2,152	3,733	4,059
Washington	11,147	9,020	10,310	7,725	8,053	6,033
Wisconsin	1,957	800	745	1,165	680	1,394
Other States	15	3	----------	23	27	58
Total	339,426	267,377	255,586	246,669	261,921	236,956

Major mines in these less productive States, with a combined total of 29,500 tons that represented 12 percent of the total output, were located in Washington, Arizona, Virginia, Illinois, Montana, and Oklahoma. Mines in New Mexico, New York, Wisconsin, Kansas, and Nevada produced 5,300 tons or 2 percent of the total, and 1 percent came from the 6 remaining States.

By area, the Western States supplied 68 percent of the total production, the West Central States 27 percent, and the States east of the Mississippi, 5 percent.

The 25 leading lead-producing mines accounted for 91 percent of total domestic mine output; the 10 leading mines yielded 74 percent, and the 4 largest mines 46 percent.

Southeast Missouri continued to be favored by more lead exploration activity than any other mineral area in the United States. Most of the major U.S. mining companies were actively engaged in leasing and exploring in Missouri. Exploration results were encouraging, but no plans for new Missouri mine production were announced. A unitized development contract was signed between the St. Joseph Lead Co. and the U.S. Department of the Interior for integrating mining development on 14,173 acres comprised of 6,000 acres of federally owned and 8,173 acres of privately owned land. Two Kennecott Copper Corp. subsidiaries started exercising their options on land containing a lead deposit in Reynolds and Shannon Counties in Missouri. No developments or production plans were announced.

Lead production from mines in Idaho was 18 percent higher than that in 1961. This higher production, uninterrupted by strikes, contrasted with the prolonged closure of mines in Missouri, enabled Idaho to become first in lead production. Most mines in the Coeur d'Alene district contributed to this record production, exceeded only once (in 1950) since 1942. Day Mines, Inc., closed the Dayrock lead-silver mine in September after 40 years of continuous operation.

TABLE 3.—Ores yielding lead and zinc in the United States in 1962

(Short tons)

State	Lead ore			Zinc ore			Lead-zinc ore			Copper-lead, copper-zinc, and copper-lead-zinc ores			All other sources [1]			Total		
	Gross weight	Lead	Zinc	Gross weight	Lead	Zinc	Gross weight	Lead	Zinc	Gross weight	Lead	Zinc	Gross weight	Lead	Zinc	Gross weight	Lead	Zinc
Arizona	2, 281	119	14	19, 435	49	2, 515	290, 733	6, 756	18, 997	174, 666	41	11, 071	24, 556, 740	1	291	25, 043, 855	6, 966	32, 888
Arkansas	---	---	---	8, 000	---	211	---	---	---	---	---	---	---	---	---	8, 000	---	211
California	210	76	1	---	---	---	1, 770	369	78	---	---	---	39, 483	10	243	41, 463	455	322
Colorado	2, 093	42	13	---	---	---	441, 255	8, 074	31, 115	[2] 427, 734	9, 296	12, 223	(2)	---	---	871, 082	17, 411	43, 351
Idaho	213, 739	23, 083	2, 013	77, 531	712	1, 915	882, 250	56, 318	54, 163	---	---	---	412, 613	3, 945	4, 774	1, 586, 133	84, 058	62, 865
Illinois	---	---	---	312, 751	202	10, 194	258, 407	635	6, 872	---	---	---	399, 742	2, 773	10, 347	970, 900	3, 610	27, 413
Kansas	---	---	---	51, 931	174	2, 107	72, 602	796	1, 836	---	---	---	---	---	---	124, 533	970	3, 943
Kentucky	---	---	---	---	---	---	---	---	---	---	---	---	85, 869	743	1, 172	85, 869	743	1, 172
Missouri	2, 991, 463	60, 982	2, 792	---	---	---	---	---	---	---	---	---	---	---	---	2, 991, 463	60, 982	2, 792
Montana	2, 233	355	33	940, 000	4, 608	30, 487	147	52	9	---	---	---	126, 352	1, 106	7, 149	1, 068, 732	6, 121	37, 678
Nevada	1, 308	221	36	581	44	145	41	2	2	---	---	---	12, 995, 912	504	98	12, 997, 842	771	281
New Mexico	132	12	---	311, 200	1, 042	21, 985	1, 300	25	7	---	---	---	7, 374, 698	55	23	7, 687, 330	1, 134	22, 015
Oklahoma	---	---	---	239, 445	1, 386	7, 167	110, 241	1, 324	2, 846	---	---	---	---	---	---	349, 686	2, 710	10. 013
Tennessee	---	---	---	2, 028, 718	---	61, 982	---	---	---	1, 469, 500	51	9, 566	---	---	---	3, 498, 218	51	71, 548
Utah	---	---	---	254	8	40	453, 063	37, 523	30, 431	5, 345	---	89	340, 310	668	3, 753	798, 972	38, 199	34, 313
Washington	1, 067	113	1	3, 208	5	212	829, 655	5, 901	21, 430	---	---	---	2, 321	14	1	836, 251	6, 033	21, 644
Wisconsin	---	---	---	411, 820	1, 394	13, 292	---	---	---	---	---	---	---	---	---	411, 820	1, 394	13. 292
New Jersey						15, 309		---	---					---			---	15, 309
New York						9, 900		1, 063	43, 754					---			1, 063	53, 654
North Carolina	---	---	---	919, 936	---	---	1, 155, 694			---	---	---	322, 198	219	---	2, 397, 828	219	
Pennsylvania						24, 308		---	---					---			---	24, 308
Virginia						6, 265		4, 059	20, 214					---			4, 059	26, 479
Other States	27	3	---	---	---	---	---	---	---	---	---	---	1, 212	4	---	1. 239	7	---
Total	3, 214, 553	85, 006	4, 903	5, 324, 810	9, 624	208, 034	4, 497, 158	122, 897	231, 754	2, 077, 245	9, 387	32, 949	46, 657, 450	10, 042	27, 851	61, 771, 216	236, 956	505. 491

[1] Lead and zinc recovered from other ores (copper, gold, silver, etc.) and from mill slags, tailings, and dumps.
[2] Combined to avoid disclosing individual company confidential data.

TABLE 4.—Mine production of recoverable lead in the United States, by months

(Short tons)

Month	1961	1962	Month	1961	1962
January	23,305	22,726	August	23,011	16,641
February	20,948	21,994	September	20,822	13,932
March	24,681	23,675	October	21,327	15,092
April	22,098	23,943	November	20,405	14,284
May	22,867	24,984	December	19,792	14,551
June	23,070	23,955			
July	19,595	21,179	Total	261,921	236,956

TABLE 5.—Twenty-five leading lead-producing mines in the United States in 1962, in order of output

Rank	Mine	District or region	State	Operator	Source of lead
1	Bunker Hill	Coeur d'Alene	Idaho	The Bunker Hill Co.	Lead-zinc ore.
2	United States & Lark.	West Mountain (Bingham).	Utah	United States Smelting, Refining and Mining Co.	Lead-zinc, gold-silver ore.
3	Federal	Southeastern Missouri.	Missouri	St. Joseph Lead Co.	Lead ore.
4	Lucky Friday	Coeur d'Alene	Idaho	Lucky Friday Silver-Lead Mines Co.	Do.
5	Viburnum	Southeastern Missouri.	Missouri	St. Joseph Lead Co.	Do.
6	Star and Morning Unit.	Coeur d'Alene	Idaho	The Bunker Hill Co. and Hecla Mining Co.	Lead-zinc ore.
7	Leadwood	Southeastern Missouri.	Missouri	St. Joseph Lead Co.	Lead ore.
8	Idarado	Upper San Miguel.	Colorado	Idarado Mining Co.	Copper-lead-zinc ore.
9	Indian Creek	Southeastern Missouri.	Missouri	St. Joseph Lead Co.	Lead ore.
10	Page	Coeur d'Alene	Idaho	American Smelting and Refining Company.	Lead-zinc ore.
11	Iron King	Big Bug	Arizona	Shattuck Denn Mining Corp.	Do.
12	United Park City	Blue Ledge	Utah	United Park City Mines Co.	Do.
13	Pend Oreille	Metaline	Washington	Pend Oreille Mines and Metals Co.	Do.
14	Badger State	Summit Valley	Montana	The Anaconda Company.	Zinc ore.
15	Austinville and Ivanhoe Mines.	Austinville	Virginia	The New Jersey Zinc Co.	Zinc-lead ore.
16	Eagle	Red Cliff (Battle Mountain).	Colorado	do	Lead-zinc, copper ore.
17	Ophir Unit	Ophir	Utah	United States Smelting, Refining and Mining Co.	Lead-zinc ore.
18	Sunshine	Coeur d'Alene	Idaho	Sunshine Mining Co.	Silver ore.
19	Emperius	Creede	Colorado	Emperius Mining Co.	Lead-zinc ore.
20	Deardorff Group	Upper Mississippi Valley.	Illinois	Ozark-Mahoning Co.	Fluorspar-lead-zinc ore.
21	Balmat	St. Lawrence County.	New York	St. Joseph Lead Company.	Zinc-lead ore.
22	Fairview-Blue Diggings.	Upper Mississippi Valley.	Illinois	Aluminum Company of America (Alcoa).	Fluorspar-lead-zinc ore.
23	Flux	Harshaw	Arizona	Nash & McFarland	Lead-zinc ore.
24	Camp Bird	Sneffels	Colorado	Camp Bird Colorado, Inc.	Do.
25	Blue Goose No. 1	Picher-Cardin	Oklahoma	The Eagle-Picher Co.	Zinc-lead ore.

Lead production of Utah was slightly less than in 1961 even though production continued uninterrupted. United States Smelting, Refining and Mining Co. started to reopen the Butterfield mine of Kennecott Copper Corp. Mine access was through the United States and Lark mine; it was expected that the ore body area would be reached during 1963. A new 400-ton-per-day differential flotation mill was built to treat ore from the Mayflower mine, owned by New Park Mining Co. and operated by Hecla Mining Co. Production was to begin soon from Burgin mine, Tintic Unit of Kennecott Copper Corp., where exploration proved 1.5 million tons of high grade ore. Lead output in Utah was about 7 percent less than that in 1961.

Output of lead from mines in Colorado decreased 2 percent. A development program for the Wellington mine was begun; a mill was being built and production was expected soon. The Emperius Mining Co. announced that its mine at Creede, Colorado would close indefinitely at yearend. Principal lead producing mines of Colorado were The Eagle mine of The New Jersey Zinc Co., San Miguel of Idarado Mining Co., and Creede mine of the Emperius Mining Co., the mines of Rico Argentine Mining Co., and the Camp Bird mine of Camp Bird Colorado, Inc.

Production from lead-producing mines in Washington continued to come mainly from the Metaline district from properties of Pend Oreille Mines and Metals Co. and American Zinc, Lead and Smelting Co. There was some exploration and development activity in Stevens County and on the Spokane Indian Reservation; and Clayloon Uranium Co. took action to boost production from operations on Gladstone Mountain. Washington mine output of lead dropped 25 percent.

The principal lead-producing mine in Arizona continued to be the Iron King of Shattuck Denn Mining Corp.

Montana mine production of lead was 132 percent over that for 1961. This increase was due largely to coproduct production from zinc mines and stockpiles of The Anaconda Company in Butte.

New Mexico lead production decreased 51 percent. Both the Linchburg mine and the Hanover mine of The New Jersey Zinc Co. closed indefinitely late in 1962.

SMELTER AND REFINERY PRODUCTION

Refined lead was produced at primary refineries from domestic and foreign source ore and base bullion, intermediate smelter products, and small quantities of scrap. Primary refineries produced some antimonial lead. The principal product of secondary refineries was antimonial lead, and the major source of secondary smelter feed was battery scrap. Refined pig lead, and antimonial lead plus lead-tin and other alloys, accounted for 27 and 73 percent, respectively, of total secondary lead recovery.

Three smelters, five combination smelter-refineries, and three refineries comprised the domestic primary lead production facilities. A list of major secondary smelting firms that reported to the Bureau of Mines was published in the Lead chapter of the 1961 Minerals Yearbook. All domestic primary smelters and refineries were as follows:

Smelters:

- **American Smelting and Refining Company**
  - **East Helena, Mont.**
  - **El Paso, Tex.**
- **International Smelting & Refining Co., Tooele, Utah**

Smelter-refineries:
- American Smelting and Refining Company
  - Selby, Calif.
  - Perth Amboy, New Jersey
- The Bunker Hill Co., Kellogg, Idaho
- St. Joseph Lead Co., Herculaneum, Mo.
- The Eagle-Picher Co., Galena, Kansas

Refineries:
- United States Smelting Lead Refinery, Inc., East Chicago, Ind.
- American Smelting and Refining Company, Omaha, Nebr.
- Schuylkill Products Co., Baton Rouge, La.

Refined Lead—Primary and Secondary.—Domestic primary lead smelters and refiners produced 377,900 tons of refined lead and 31,100 tons of lead in antimonial lead. The lead content of primary raw materials consumed for this production was 429,800 tons, and that of scrap material was 6,400 tons.

Domestic ores yielded 65 percent of the refined lead produced from primary sources compared with 64 percent in 1961. Foreign ores and bullion were the sources of the remainder.

Primary lead smelters also produced 1,842 tons of refined lead from scrap, but secondary smelters produced 91,600 tons. Refined lead, plus remelt lead produced from all sources, totaled 118,500 tons.

Antimonial Lead—Primary and Secondary.—Total antimonial lead production at both primary and secondary smelters was 273,100 tons with a lead content of 256,800 tons; 33,300 tons from primary smelters and 239,800 tons from secondary smelters. Scrap was the source of 11 percent of the primary smelter output; domestic ores furnished 49 percent and foreign ores, 40 percent. Battery scrap accounted for 65 percent of the total lead-base scrap melted. The major product from smelting scrap was antimonial lead.

TABLE 6.—Refined lead produced at primary refineries in the United States, by source material

(Short tons)

	1953–57 (average)	1958	1959	1960	1961	1962
Refined lead:						
From primary sources:						
Domestic ores and base bullion	333,655	269,082	225,270	228,899	288,078	245,645
Foreign ores and base bullion	168,265	201,074	115,661	153,537	161,487	130,418
Total	501,920	470,156	340,931	382,436	449,565	376,063
From secondary sources	4,138	2,338	1,194	4,776	1,569	1,842
Grand total	506,058	472,494	342,125	387,212	451,134	377,905
Average sales price per pound	$0.143	$0.117	$0.115	$0.117	$0.103	$0.093
Calculated value of primary refined lead (thousands)[1]	$143,549	$110,017	$78,414	$89,490	$92,610	$69,948

[1] Excludes value of refined lead produced from scrap at primary refineries.

Other Secondary Lead.—Lead-base, copper-base and tin-base scrap were source materials from which 444,200 tons of secondary lead was recovered. Secondary production decreased 2 percent. Secondary lead smelters recovered 92 percent of the total in 220 plants; primary smelters, 1 percent in 5 plants; and manufacturers, foundries, and secondary copper smelters, 7 percent.

TABLE 7.—Antimonial lead produced at primary lead refineries in the United States

Year	Production (short tons)	Antimony content: Short tons	Antimony content: Percent	Lead content by difference (short tons): From domestic ore	From foreign ore	From scrap	Total
1953–57 (average)	64,180	3,605	5.6	7,554	8,845	44,176	60,575
1958	50,246	2,803	5.6	8,256	8,190	30,997	47,443
1959	37,487	1,924	5.1	6,447	5,955	23,161	35,563
1960	30,230	1,575	5.2	1,216	1,169	26,270	28,655
1961	35,080	1,894	5.4	12,988	11,978	8,220	33,186
1962	33,325	2,249	6.7	14,838	12,545	3,693	31,076

TABLE 8.—Stocks and consumption of new and old lead scrap in the United States in 1962

(Short tons, gross weight)

Class of consumers and type of scrap	Stocks Jan. 1[1]	Receipts	Consumption: New scrap	Consumption: Old scrap	Consumption: Total	Stocks Dec. 31
Smelters and refiners:						
Soft lead	2,645	48,192		47,619	47,619	3,218
Hard lead	1,344	16,416		16,495	16,495	1,265
Cable lead	1,903	24,874		25,644	25,644	1,133
Battery-lead plates	16,118	384,583		377,324	377,324	23,377
Mixed common babbitt	375	3,107		3,249	3,249	233
Solder and tinny lead	230	8,446		8,386	8,386	290
Type metals	1,297	25,020		25,248	25,248	1,069
Drosses and residues	16,193	63,147	64,795		64,795	14,545
Total	40,105	573,785	64,795	503,965	568,760	45,130
Foundries and other manufacturers:						
Soft lead	106	325	94	205	299	132
Hard lead	203	170		96	96	277
Cable lead	102	1		72	72	31
Battery-lead plates	166	398		526	526	38
Mixed common babbitt	279	8,785		8,937	8,937	127
Solder and tinny lead	3	273	9	226	235	41
Type metals						
Drosses and residues	281		5		5	276
Total	1,140	9,952	108	10,062	10,170	922
Grand total:						
Soft lead	2,751	48,517	94	47,824	47,918	3,350
Hard lead	1,547	16,586		16,591	16,591	1,542
Cable lead	2,005	24,875		25,716	25,716	1,164
Battery-lead plates	16,284	384,981		377,850	377,850	23,415
Mixed common babbitt	654	11,892		12,186	12,186	360
Solder and tinny lead	233	8,719	9	8,612	8,621	331
Type metals	1,297	25,020		25,248	25,248	1,069
Drosses and residues	16,474	63,147	64,800		64,800	14,821
Total	41,245	583,737	64,903	514,027	578,930	46,052

[1] Revised figures.

TABLE 9.—Secondary metal recovered[1] from lead and tin scrap in the United States in 1962, by type of products

(Short tons, gross weight)

	Lead	Tin	Antimony	Other	Total
Refined pig lead	93,406				93,406
Remelt lead	25,062				25,062
Total	118,468				118,468
Refined pig tin		2,991			2,991
Remelt tin		343			343
Total		3,334			3,334
Lead and tin alloys:					
Antimonial lead	229,392	385	13,706	140	243,623
Common babbitt	17,074	905	1,520	74	19,573
Genuine babbitt	80	293	26	10	409
Solder	23,508	5,336	314	18	29,176
Type metals	30,055	1,742	3,610	10	35,417
Cable lead	16,295	6	165	3	16,469
Miscellaneous alloys	1,479	704	21	93	2,297
Total	317,883	9,371	19,362	348	346,964
Composition foil					
Tin content of chemical products		972			972
Grand total	436,351	13,677	19,362	348	469,738

[1] Most of the figures herein represent actual reported recovery of metal from scrap.

TABLE 10.—Secondary lead recovered in the United States

(Short tons)

	1953–57 (average)	1958	1959	1960	1961	1962
As refined metal:						
At primary plants	4,138	2,338	1,194	4,776	1,569	1,842
At other plants	122,835	113,719	124,185	143,443	139,100	116,626
Total	126,973	116,057	125,379	148,219	140,669	118,468
In antimonial lead:						
At primary plants	44,176	30,997	23,161	26,270	8,220	3,693
At other plants	198,990	151,956	181,185	179,217	197,349	225,699
Total	243,166	182,953	204,346	205,487	205,569	229,392
In other alloys	123,000	102,777	121,662	116,197	106,554	96,342
Grand total:						
Quantity	493,139	401,787	451,387	469,903	452,792	444,202
Value (thousands)	$141,590	$94,018	$103,819	$109,957	$93,275	$82,622

TABLE 11.—Lead recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

Kind of scrap	1961	1962	Form of recovery	1961	1962
New scrap:			As soft lead:		
Lead-base	56,808	44,803	At primary plants	1,569	1,842
Copper-base	4,981	5,586	At other plants	139,100	116,626
Tin-base	465	529	Total	140,669	118,468
Total	62,254	50,918	In antimonial lead [1]	205,569	229,392
Old scrap:			In other lead alloys	94,276	87,243
Battery-lead plates	240,896	252,593	In copper-base alloys	12,221	9,019
All other lead-base	132,495	124,277	In tin-base alloys	57	80
Copper-base	17,142	16,409	Total	312,123	325,734
Tin-base	5	5			
Total	390,538	393,284	Grand total	452,792	444,202
Grand total	452,792	444,202			

[1] Includes 8,220 tons of lead recovered in antimonial lead from secondary sources at primary plants in 1961 and 3,693 tons in 1962.

CONSUMPTION AND USES

Lead metal production at primary plants for the first quarter was 113,000 tons, about 8,000 tons less than average quarterly production in 1961, the second quarter dropped to 107,000 tons, the third quarter to 96,000 tons, and the fourth quarter to 93,000 tons.

Secondary lead production was at a slightly lower level than in 1961 amounting to 444,200 tons. Primary and secondary production totaled 847,600 tons compared with 927,300 tons in 1961. Producer stocks decreased moderately in the first two quarters, but in the third and fourth quarters these stocks dropped steadily and markedly to 196,700 tons from the record high yearend inventory of 262,100 tons in 1961. Consumer stocks also decreased but much more moderately. At yearend, producer and consumer stocks of metal (refined, in antimonial and other alloys) were reduced to 234,800 tons from 303,400 tons on January 1. Prices changed four times during 1962, reaching a low of 9.50 cents in February, then rising to 10.00 cents November 1 after consumption had exceeded supply for several months. Consumption increased for 20 of the 25 use classifications of Bureau of Mines statistics. Lead consumption increased in two of the three largest uses; in batteries, 14 percent and in red lead and litharge, 6 percent; but use decreased 1 percent in gasoline antiknock additives.

Soft lead, primary and secondary, accounted for 64 percent of the total consumed, 27 percent was lead in antimonial lead, 4 percent was in alloys, 1.3 percent was in copper-base scrap, 3.2 percent was in scrap that went directly into an end product, and 0.5 percent was recovered from ore in producing leaded zinc oxide and other pigments. Consumption ranged from a usual seasonal low in July of 79,600 tons to a high of 105,100 tons in October. The general consumption trend was downward for the first 7 months; in August it increased sharply and continued at a high level for the remainder of 1962 as battery and antiknock demand rose. Lead consumption was more than for any year since 1957.

Of the lead consumed during 1962, 72 percent was used in metal products; the major item was storage batteries which accounted for 38 percent of all lead consumed. Gasoline antiknock additives, 98 percent of the general classification chemicals, accounted for 15 percent of the total lead consumption. Lead pigments used 9 percent of the total lead, and 74 percent of that was for the manufacture of red lead and litharge. Two items of consumption related to the automobile industry, batteries and gasoline antiknock additives, represented 53 percent of total lead consumption.

The Association of Battery Manufacturers, Inc., reported the shipment of 30.5 million replacement battery units and total battery shipments of 38.9 million units, an increase of 8 percent and 11 percent, respectively. Battery shipments were at a record high.

Nine States accounted for 73 percent of the total lead consumed (excluding scrap) as follows: New Jersey, 14 percent; Louisiana and Texas together, 12 percent; Illinois, 11 percent; California, 10 percent; Indiana, 10 percent; Pennsylvania, 7 percent; New York, 5 percent; and Missouri, 4 percent.

TABLE 12.—Lead consumption in the United States, by products

(Short tons)

Product	1961	1962	Product	1961	1962
Metal products:			Pigments—Continued		
Ammunition	45,837	47,779	Pigment colors	11,273	11,660
Bearing metals	17,757	16,472	Other [1]	[2] 4,383	3,892
Brass and bronze	20,114	20,607			
Cable covering	57,458	56,676	Total	[2] 95,293	102,968
Calking lead	67,379	72,648			
Casting metals	6,873	7,355	Chemicals:		
Collapsible tubes	11,220	11,972	Gasoline antiknock additives	169,802	168,926
Foil	2,968	3,720	Miscellaneous chemicals	[2] 2,119	2,715
Pipes, traps, and bends	19,098	19,819			
Sheet lead	28,102	28,540	Total	[2] 171,921	171,641
Solder	54,838	66,873			
Storage batteries:			Miscellaneous uses:		
Antimonial lead	186,028	217,525	Annealing	5,066	5,306
Lead oxides	181,970	202,381	Galvanizing	1,444	1,146
Terne metal	965	1,402	Lead plating	243	236
Type metal	26,693	26,760	Weights and ballast	8,890	10,330
Total	727,300	800,529	Total	15,643	17,018
Pigments:			Other, unclassified uses	17,059	17,479
White lead	7,615	11,091			
Red lead and litharge	72,022	76,325	Grand total [3]	1,027,216	1,109,635

[1] Includes lead content of leaded zinc oxide and other pigments and chemicals.
[2] Revised figures.
[3] Includes lead which went directly from scrap to fabricated products.

TABLE 13.—Lead consumption in the United States, by months

(Short tons)

Month	1961	1962	Month	1961	1962
January	83,579	98,828	August	91,150	96,393
February	79,586	88,415	September	89,735	91,122
March	83,266	91,040	October	93,504	105,145
April	78,201	86,659	November	90,020	96,293
May	89,679	94,685	December	89,664	91,500
June	86,520	89,988			
July	72,312	79,567	Total [1]	1,027,216	1,109,635

[1] Includes lead content of leaded zinc oxide and other pigments and lead which went directly from scrap to fabricated products.

TABLE 14.—Lead consumption in the United States in 1962, by class of products and types of material

(Short tons)

Product	Soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
Metal products	211,315	76,034	43,582	14,929	345,860
Storage batteries	211,128	208,771	7		419,906
Pigments	99,184	142			99,326
Chemicals	171,641				171,641
Miscellaneous	9,931	7,076	11		17,018
Unclassified	11,890	3,816	739		16,445
Total	715,089	295,839	44,339	14,929	[1] 1,070,196

[1] Excludes 35,797 tons of lead that went directly from scrap to fabricated products and 3,642 tons of lead contained in leaded zinc oxide and other pigments and chemicals.

TABLE 15.—Lead consumption in 1962, by States [1]

(Short tons)

State	Refined soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
California	77,207	24,625	6,310	1,082	109,224
Colorado	1,879	2,190	118		4,187
Connecticut	12,928	10,087	50	977	24,042
District of Columbia	109				109
Florida	1,858	3,317			5,175
Illinois	72,488	38,189	7,053	1,559	119,289
Indiana	61,030	40,003	1,991	730	103,754
Kansas	8,358	11,517	4	360	20,239
Kentucky	42	2,675	2		2,719
Maryland	5,983	13,168	355		19,506
Massachusetts	5,892	3,640	196	247	9,975
Michigan	15,329	14,563	1,304	877	32,073
Missouri	39,134	2,988	91	1,018	43,231
Nebraska	4,927	850	4	292	6,073
New Jersey	119,271	18,610	9,741	759	148,381
New York	36,574	3,544	8,161	850	49,129
Ohio	13,496	7,745	3,058	1,216	25,515
Pennsylvania	45,500	30,121	938	2,269	78,828
Rhode Island	2,767	298			3,065
Tennessee	177	7,210	217	255	7,859
Virginia	2,387	924	464	777	4,552
Washington	7,804	3,554	127		11,485
West Virginia	16,332	5,477	1		21,810
Wisconsin	698	2,995	82	172	3,947
Alabama,[2] Georgia, Mississippi	33,299	12,008	1,731	714	47,752
Arkansas and Oklahoma	3,631	2,690	28		6,349
Hawaii and Oregon	584	2,760	4	217	3,565
Iowa and Minnesota	1,718	8,764	783	141	11,406
Louisiana and Texas	107,773	13,501	1,300	202	122,776
Montana and Idaho	11,146				11,146
New Hampshire, Maine, Delaware	3,681	2,826	222	213	6,942
North and South Carolina	646	3,761			4,407
Utah, Nevada, Arizona	112	557			669
Undistributed	329	682	4	2	1,017
Total	715,089	295,839	44,339	14,929	1,070,196

[1] Excludes 35,797 tons of lead which went directly from scrap to fabricated products and 3,642 tons of lead contained in leaded zinc oxide and other nonspecified pigments.
[2] These and following States are grouped to avoid disclosing individual company confidential data.

LEAD PIGMENTS[4]

Production of lead pigments increased slightly. Activity of industries consuming the largest amount of lead pigments varied as follows: Automobile and truck manufacture increased 24 percent, the value of public and private construction increased 6 percent, paint sales increased 5 percent, use in the production of natural and synthetic rubber increased 11 percent, and lead battery production rose 14 percent.

Production.—Lead consumed by manufacturers to produce lead pigments was 287,000 tons, compared with 270,300 tons in 1961.

All the white lead, red lead, and litharge pigments, as well as 161,000 tons of black oxide (battery oxides) were made from refined lead and represented 99 percent of the lead used for pigment purposes. The remaining 1 percent was consumed as lead ore to produce leaded zinc oxide. Production data for basic lead sulfate is withheld to avoid disclosing individual company confidential data. Lead silicate, a derivative of litharge, is included with litharge.

Consumption and Uses—*White Lead.*—Shipments of white lead decreased less than 1 percent. The paint industry used 74 percent of the white lead, and the ceramic industry used 1 percent. A substantial part of the remaining 25 percent also was used in the paint industry, and other uses for white lead included chemicals, greases, plasticizers, and stabilizers for plastics.

Basic Lead Sulfate.—Most lead sulfate was used in making leaded zinc oxide, but production figures were withheld to avoid disclosing individual company confidential data.

Red Lead.—Fifty-four percent of the red lead was consumed by the paint industry compared with 56 percent in 1961. Other use categories were colors, lubricants, petroleum, rubber, and miscellaneous small uses.

Orange Mineral.—No consumption was reported.

Litharge.—To avoid disclosing company confidential data, a large percentage of litharge shipped to industry was included in the group classification "Other." Within other uses, battery makers were the largest consuming group; chemicals, chrome pigments, driers, floor covering, friction material, ink, insecticides, and miscellaneous uses accounted for the remainder. Battery makers produced 161,000 tons of leaded litharge, known to the battery trade as black oxide or grey suboxide; this material was the basic ingredient of the lead paste filling of lead-acid battery plates.

Prices.—The quoted price of white lead was 16.5 cents per pound ($330 per ton) in carlots throughout 1962. The average value of shipments of dry white lead was $400 per ton; white lead in oil averaged $476 per ton. The quoted price of red lead ranged from 13.25 cents per pound to 14.00 cents, or $265 per ton to $280 per ton, in less than carlots; the average value of red lead shipments decreased $7 to $285 per ton. The quoted price of litharge ranged from 12.75 cents to 13.25 cents per pound, or $255 to $265 per ton, in less than carlots; averaged value of shipments decreased $10 to $231 per ton.

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[4] Prepared by Richard N. Spencer, commodity specialist, and Esther B. Miller, statistical assistant, Division of Minerals.

TABLE 16.—Production and shipments of lead pigments[1] and oxides in the United States

Pigment	1961 Production (short tons)	1961 Shipments Short tons	1961 Shipments Value[2] Total	1961 Shipments Value[2] Average per ton	1962 Production (short tons)	1962 Shipments Short tons	1962 Shipments Value[2] Total	1962 Shipments Value[2] Average per ton
White lead:								
Dry	10,354	10,523	$4,407,280	$419	10,161	10,597	$4,240,362	$400
In oil[3]	5,892	5,700	2,679,785	470	5,410	5,602	2,667,363	476
Total	16,246	16,223	7,087,065	--------	15,571	16,199	6,907,725	--------
Red lead	22,708	22,856	6,675,990	292	24,898	25,517	7,279,183	285
Litharge	98,817	98,950	23,841,808	241	102,908	103,397	23,860,746	231
Black oxide	147,136	--------	--------	--------	161,023	--------	--------	--------

[1] Except for basic lead sulfate, figures withheld to avoid disclosing individual company confidential data.
[2] At plant, exclusive of container.
[3] Weight of white lead only, but value of paste.

TABLE 17.—Lead content of lead and zinc pigments[1] and lead oxides produced by domestic manufacturers, by sources

(Short tons)

Pigment	1961 Lead in pigments produced from— Ore: Domestic	1961 Ore: Foreign	1961 Pig lead	1961 Total lead in pigments	1962 Lead in pigments produced from— Ore: Domestic	1962 Ore: Foreign	1962 Pig lead	1962 Total lead in pigments
White lead	--------	--------	12,997	12,997	--------	--------	12,457	12,457
Red lead	--------	--------	20,664	20,664	--------	--------	22,570	22,570
Litharge	--------	--------	91,900	91,900	--------	--------	95,704	95,704
Black oxide	--------	--------	140,973	140,973	--------	--------	153,819	153,819
Leaded zinc oxide	2,717	1,071	--------	3,788	1,727	760	--------	2,487
Total	2,717	1,071	266,534	270,322	1,727	760	284,550	287,037

[1] Excludes lead in basic lead sulfate; figures withheld to avoid disclosing individual company confidential data.

TABLE 18.—Distribution of white lead (dry and in oil) shipments,[1] by industries

(Short tons)

Industry	1953-57 (average)	1958	1959	1960	1961	1962
Paints	20,265	15,288	15,148	14,145	12,086	12,054
Ceramics	611	268	243	219	141	137
Other	4,451	[2]2,804	[2]3,833	[2]3,578	3,996	4,008
Total	25,327	18,360	19,224	17,942	16,223	16,199

[1] Excludes basic lead sulfate; figures withheld to avoid disclosing individual company confidential data.
[2] Figures for plasticizers and stabilizers withheld to avoid disclosing individual company confidential data.

TABLE 19.—Distribution of red lead shipments, by industries

(Short tons)

Industry	1953–57 (average)	1958	1959	1960	1961	1962
Paints	14,354	13,726	12,098	12,903	12,895	13,716
Storage batteries	(1)	(1)	(1)	(1)	(1)	(1)
Ceramics	(1)	(1)	(1)	328	(1)	637
Other	14,194	8,266	9,807	9,400	9,961	11,164
Total	28,548	21,992	21,905	22,631	22,856	25,517

[1] Included with "Other."

TABLE 20.—Distribution of litharge shipments, by industries

(Short tons)

Industry	1953–57 (average)	1958	1959	1960	1961	1962
Ceramics	20,018	(1)	15,340	15,753	14,393	17,752
Chrome pigments	5,339	3,731	4,682	(1)	(1)	(1)
Floor covering	(1)	(1)	(1)	(1)	(1)	(1)
Insecticides	(1)	(1)	(1)	(1)	(1)	(1)
Oil refining	3,771	2,598	3,096	2,371	2,147	2,404
Rubber	1,902	1,247	1,808	1,373	1,243	1,792
Storage batteries	(1)	(1)	(1)	(1)	(1)	(1)
Varnish	4,016	3,223	4,725	3,471	3,394	4,083
Other	101,198	81,366	76,362	75,672	77,773	77,366
Total	136,244	92,165	106,013	98,640	98,950	103,397

[1] Included with "Other."

Foreign Trade.—Imports of lead pigments and salts decreased 13 percent in value but increased 5 percent in quantity over imports during 1961. White lead imports increased 26 percent, red lead imports increased 21 percent, litharge imports increased 1 percent, and imports of other lead compounds increased 1 percent.

Exports of lead pigments decreased 22 percent in value and 17 percent in quantity, and exports of lead arsenate increased 36 percent in value and 53 percent in quantity.

TABLE 21.—U.S. imports for consumption of lead pigments and compounds

Kind	1961		1962	
	Short tons	Value (thousands)	Short tons	Value (thousands)
White lead	1,872	$535	2,361	$578
Red lead	457	88	555	83
Litharge	15,390	2,791	15,597	2,229
Other lead pigments			34	13
Other lead compounds	436	84	439	124
Total	18,155	3,498	18,986	3,027

Source: Bureau of the Census.

TABLE 22.—U.S. exports of lead pigments and compounds

Kind	1961		1962	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Lead pigments [1]	2,302	$764	1,919	$595
Lead arsenate	464	183	711	249
Total	2,766	947	2,630	844

[1] Includes white lead, red lead, and litharge.

Source: Bureau of the Census.

STOCKS

Stocks of refined lead at primary producing plants decreased throughout 1962, but from August 1 to yearend decreased 47,100 tons for an average monthly rate of 9,400 tons. Producer stocks of refined and antimonial lead decreased a total of 63,000 tons to a yearend inventory of 142,500 tons. Total yearend stocks, representing physical inventories at primary plants regardless of ownership, but not including material in process or in transit, were 196,700 tons compared with 262,100 tons at the close of 1961.

Stocks reported by the American Bureau of Metal Statistics showed an additional 17,700 tons of bullion was in process at, or in transit to, refineries, and about 18,600 tons of ore was in process at smelters, making a total of 233,000 tons of primary raw materials in stocks at these plants, 75,100 tons less than at yearend 1961.

Consumer and secondary smelter stocks of lead were 99,100 tons January 1, 104,300 tons March 31, 106,000 tons June 30, 92,000 tons September 30, and 93,500 tons December 31, 1962. Yearend stocks were 6 percent less than at the close of 1961.

On December 31 the total lead inventory in all Government stockpiles was 1,386,000 tons, comprised of 1,050,000 tons in the national (strategic) stockpile, and 336,000 tons in the Defense Production Administration (DPA), CCC, and Supplemental stockpiles. Government lead stockpile inventories on December 31 were 384.5 percent over maximum stockpile objectives.

TABLE 23.—Stocks of lead at primary smelters and refineries in the United States, Dec. 31

(Short tons)

Stocks	1953–57 (average)	1958	1959	1960	1961	1962
Refined pig lead	54,053	176,098	107,683	148,415	195,200	136,544
Lead in antimonial lead	11,714	11,811	11,361	10,483	10,354	5,975
Lead in base bullion	12,812	9,485	12,840	26,025	16,978	10,392
Lead in ore and matte	42,255	36,896	39,195	65,219	39,570	43,750
Total	120,834	234,290	171,079	250,142	262,102	196,661

TABLE 24.—Consumer stocks of lead in the United States, Dec. 31, by types of material

(Short tons, lead content)

Year	Refined soft lead	Anti-monial lead	Lead in alloys	Lead in copper-base scrap	Total
1958	76,924	37,511	7,056	1,409	122,900
1959	80,277	38,688	6,435	1,096	126,496
1960	49,725	39,230	7,216	1,097	97,268
1961	55,951	33,633	8,298	1,258	99,140
1962	51,121	34,389	6,817	1,169	93,496

PRICES

The quoted New York price for common lead was 10.25 cents on January 1 but on January 5 the price dropped to 10.00 cents. On February 1 the price dropped to 9.75 cents and on February 9 dropped again to 9.50 cents. This price remained in effect until November 1, when the price rose to 10.00 cents which continued for the remainder of 1962. The average quoted price of lead in the United States during 1962 was 9.63 cents.

Quotations on the London Metal Exchange ranged from a high of £62.25 per long ton on April 3 (equivalent to 7.82 cents per pound U.S. currency—computed on the average monthly rate of exchange) to a low of £50.00 (6.26 cents per pound) on August 24. The quotation on December 31 was £54.38 per long ton (6.81 cents per pound), and the 1962 average was £56.32 (7.06 cents per pound).

TABLE 25.—Average monthly and yearly quoted prices of lead at St. Louis, New York, and London [1]

(Cents per pound)

Month	1961			1962		
	St. Louis	New York	London [2]	St. Louis	New York	London [2]
January	10.80	11.00	7.99	9.83	10.03	7.42
February	10.80	11.00	8.17	9.38	9.58	7.37
March	10.80	11.00	8.24	9.30	9.50	7.62
April	10.80	11.00	8.38	9.30	9.50	7.60
May	10.80	11.00	8.31	9.30	9.50	7.51
June	10.80	11.00	8.06	9.30	9.50	7.24
July	10.80	11.00	8.07	9.30	9.50	6.74
August	10.80	11.00	8.09	9.30	9.50	6.39
September	10.80	11.00	8.03	9.30	9.50	6.49
October	10.80	11.00	7.87	9.30	9.50	6.62
November	10.01	10.21	7.59	9.79	9.99	6.79
December	10.05	10.25	7.58	9.80	10.00	6.94
Average	10.67	10.87	8.03	9.43	9.63	7.06

[1] St. Louis: Metal Statistics, 1963, p. 461. New York: Metal Statistics, 1963, p. 457. London: E&MJ Metal and Mineral Markets.
[2] Based on monthly rates of exchange by Federal Reserve Board.

FOREIGN TRADE

Imports.—General imports of lead were 2 percent less than in 1961. Imports for consumption were 398,200 tons, an increase of 2 percent. Import quotas were not entirely filled for either ore and concentrates or metal. Pigs and bars accounted for 65 percent of imports for consumption, ores and concentrates, 34 percent, and scrap and bullion, 1 percent. Australia, Mexico, Canada, Yugoslavia, Peru, and Spain, in descending order of quantity were the major suppliers of general imports of lead metal. The principal suppliers of ores and concentrates were the Republic of South Africa, Peru, Canada, Australia, Bolivia, and Honduras.

Exports.—Total lead exported was 7,500 tons, 36 percent less than that exported in 1961. All classes of exports decreased.

Tariff.—Import duties on pig lead and lead content of ores and concentrates remained unchanged at 1.0625 cents and 0.75 cent per pound, respectively. Duties on scrap were the same as on pig lead.

TABLE 26.—U.S. imports [1] of lead, by countries

(Short tons)

Country	1953-57 (average)	1958	1959	1960	1961	1962
Ore, flue dust, and matte (lead content):						
North America:						
Canada	33,762	22,270	32,226	26,473	34,361	27,728
Greenland		5,276				
Guatemala	5,831	5,019	153	1,809	9,817	2,135
Honduras	2,281	3,581	3,639	4,906	5,512	5,489
Mexico	3,102	1,786	489	1,249	1,166	1,180
Other	25	45	195			
Total	45,001	37,977	36,702	34,437	50,856	36,532
South America:						
Bolivia	16,648	14,715	11,221	9,021	11,370	8,242
Chile	815	367	113	1,283	610	
Colombia	519	851	570	705	722	439
Peru	45,346	70,757	36,777	36,300	28,970	32,750
Other	309	145	53	103		
Total	63,637	86,835	48,734	47,412	41,672	41,431
Europe	197	246	221	222	300	280
Asia:						
Philippines	2,156	1,169	310	228	238	57
Other	152	317	25	504		181
Total	2,308	1,486	335	732	238	238
Africa:						
Morocco [2]	527			5,238		
South Africa, Republic of [3]	38,997	49,215	27,879	39,352	34,089	33,881
Other	21	1				
Total	39,545	49,216	27,879	44,590	34,089	33,881
Oceania: Australia	28,226	25,839	24,963	18,299	20,031	26,544
Total ore, flue dust, and matte	178,914	201,599	138,834	145,692	147,186	138,906
Base bullion (lead content):						
North America	153	8	34	254	362	5
South America	52	452	46	39	60	[4] 2,080
Europe					(5)	
Asia	(5)					
Oceania						2,514
Total base bullion	205	460	80	293	422	[4] 4,599
Pigs and bars (lead content):						
North America:						
Canada	37,633	40,926	41,533	26,088	54,717	56,807
Mexico	96,572	122,864	86,827	69,930	81,328	65,892
Other	46		324	9	3	
Total	134,251	163,790	128,684	96,027	136,048	122,699

See footnotes at end of table.

TABLE 26.—U.S. imports[1] of lead, by countries—Continued

(Short tons)

Country	1953-57 (average)	1958	1959	1960	1961	1962
Pigs and bars (lead content)—Continued						
South America:						
Peru	33,062	42,473	29,311	25,197	26,195	22,115
Other	366	146				
Total	33,428	42,619	29,311	25,197	26,195	22,115
Europe:						
Belgium-Luxembourg	1,129	5,872	1,503	610		2,980
Germany, West	1,404	3,118	2,893	551	842	914
Spain	5,210	14,237	9,395	4,115	8,529	4,104
United Kingdom	1,272	8,836	988	7		335
Yugoslavia	41,022	36,789	32,731	30,027	30,347	31,909
Other	2,927	2,139	4,872	1,388		12
Total	52,964	70,991	52,382	36,698	39,718	40,254
Asia	41					
Africa: Morocco	[6] [7] 9,901	10,537	[6] 5,384	[6] 1,328		
Oceania: Australia	71,903	80,515	47,655	46,783	54,891	72,133
Total pigs and bars	302,488	368,452	263,416	206,033	256,852	257,201
Reclaimed, scrap, etc. (lead content):						
North America:						
Canada	3,890	1,908	2,251	4,059	1,441	1,279
Mexico	3,960	1,939	1,293	1,054	2,294	688
Other	1,051	420	245	160	45	186
Total	8,901	4,267	3,789	5,273	3,780	2,153
South America:						
Peru	140	48	(5)			
Venezuela	377					
Other	11		120			
Total	528	48	120			
Europe:						
Belgium-Luxembourg	179	7				
Denmark	276					
Germany, West	115		1	1		(5)
Netherlands	154					17
Other	307			4	2	
Total	1,031	7	1	5	2	17
Asia:						
Japan (including Nansei and Nanpo Islands)	8	19	18	5		2
Other	14					
Total	22	19	18	5		2
Africa	3					
Oceania:						
Australia	1,820	2,229	4,351	2,355	1,160	149
Other	20					
Total	1,840	2,229	4,351	2,355	1,160	149
Total reclaimed, scrap, etc	12,325	6,570	8,279	7,638	4,942	2,321
Grand total	493,932	577,081	410,609	359,656	409,402	403,027

[1] Data are general imports; that is, they include lead imported for immediate consumption plus material entering the country under bond.
[2] French Morocco before Jan. 1, 1957.
[3] Union of South Africa before Jan. 1, 1962.
[4] Adjusted by Bureau of Mines.
[5] Less than 1 ton.
[6] Includes 90 tons from Northern Rhodesia in 1953-57 (average) and from the Federation of Rhodesia and Nyasaland 1,052 tons in 1959, and 224 tons in 1960.
[7] Includes material classified by the Bureau of the Census as being from Algeria but believed by Bureau of Mines to be from French Morocco.

Source: Bureau of the Census.

TABLE 27.—U.S. imports for consumption [1] of lead, by countries

(Short tons)

Country	1953–57 (average)	1958	1959	1960	1961	1962
Ore, flue dust, and matte (lead content):						
North America:						
Canada	33,740	31,394	28,633	27,944	[2] 31,439	29,511
Greenland		5,276				
Guatemala	5,621	4,944	157	1,519	5,527	4,691
Honduras	2,238	3,577	3,649	4,457	4,803	7,007
Mexico	3,019	3,167	627	943	1,060	1,899
Other	3	12	8			
Total	44,621	48,370	33,074	34,863	[2] 42,829	43,108
South America:						
Bolivia	12,685	22,501	10,822	10,581	10,470	7,479
Chile	3,784	88	113	27	401	3
Colombia	495	850	370	628	514	480
Peru	40,813	92,027	38,872	33,571	32,318	32,078
Other	412	465	56	103		3
Total	58,189	115,931	50,233	44,910	43,703	40,043
Europe	144	21	107	(3)		220
Asia:						
Philippines	2,164	1,169	293	187	380	111
Other	155	311	25	427		
Total	2,319	1,480	318	614	380	111
Africa:						
Morocco [4]	526			5,238		
South Africa, Republic of [5]	37,808	37,993	28,939	30,784	29,736	29,756
Other	25	1	1,821			2
Total	38,359	37,994	30,760	36,022	29,736	29,758
Oceania:						
Australia	16,582	33,829	22,034	20,894	20,132	20,627
Other	8,873					
Total	25,455	33,829	22,034	20,894	20,132	20,627
Total ore, flue dust, and matte	169,087	237,625	136,526	137,303	136,780	133,867
Base bullion (lead content):						
North America	153	8	34	254	134	5
South America	15	408		39	102	[6] 2,078
Europe					(3)	
Asia						
Total base bullion	168	416	34	293	236	[6] 2,083
Pigs and bars (lead content):						
North America:						
Canada	37,633	40,926	41,478	26,154	54,902	56,807
Mexico	94,035	117,938	82,762	73,748	71,289	68,147
Other	46		261	29	6	
Total	131,714	158,864	124,501	99,931	126,197	124,954
South America:						
Peru	33,039	42,533	29,311	25,197	26,195	22,103
Other	366	146				
Total	33,405	42,679	29,311	25,197	26,195	22,103
Europe:						
Belgium-Luxembourg	1,129	4,604	1,569	1,733	41	1,685
Denmark	2,152	1,452	187	88		
Germany, West	1,404	3,008	2,613	654	911	614
Spain	5,210	9,505	11,270	6,056	8,775	3,958
United Kingdom	1,272	8,556	1,035	133	16	
Yugoslavia	41,022	36,789	32,376	30,159	[2] 30,230	32,240
Other	770	507	2,984	1,877		12
Total	52,959	64,421	52,034	40,700	[2] 39,973	38,509
Asia	41					

See footnotes at end of table.

TABLE 27.—U.S. imports for consumption [1] of lead, by countries—Continued

(Short tons)

Country	1953–57 (average)	1958	1959	1960	1961	1962
Pigs and bars (lead content)—Continued						
Africa:						
Morocco [4]	[7] 9,812	9,760	5,032	1,243	4	----------
Other	425	----------	703	460	113	----------
Total	10,237	9,760	5,735	1,703	117	----------
Oceania: Australia	71,903	76,035	51,051	45,816	54,945	72,300
Total pigs and bars	300,259	351,759	262,632	213,347	[2] 247,427	257,866
Reclaimed, scrap, etc. (lead content):						
North America:						
Canada	3,883	1,787	2,396	4,053	1,441	1,240
Mexico	4,325	2,433	1,350	1,189	2,291	612
Other	1,057	228	602	220	91	58
Total	9,265	4,448	4,348	5,462	3,823	1,910
South America:						
Peru	140	274	(3)	----------	----------	----------
Venezuela	377	----------	----------	----------	----------	----------
Other	11	34	120	----------	----------	----------
Total	528	308	120	----------	----------	----------
Europe:						
Belgium-Luxembourg	179	7	----------	----------	----------	----------
Denmark	276	----------	----------	----------	----------	----------
Germany, West	115	278	1	1	----------	(3)
Netherlands	154	----------	----------	----------	----------	17
Other	309	172	----------	15	2	----------
Total	1,033	457	1	16	2	17
Asia	22	19	17	5	1	2
Africa	3	----------	----------	----------	----------	----------
Oceania:						
Australia	691	3,387	3,411	115	68	149
Other	30	----------	----------	----------	----------	----------
Total	721	3,387	3,411	115	68	149
Total reclaimed, scrap, etc	11,572	8,619	7,897	5,598	3,894	2,078
Sheets, pipe, and shot:						
North America:						
Canada	185	252	452	213	114	49
Canal Zone	4	----------	----------	----------	----------	----------
Mexico	2,592	559	----------	----------	55	----------
Total	2,781	811	452	213	169	49
Europe	458	1,813	3,156	2,641	2,639	2,197
Asia	----------	1	(3)	1	37	30
Total sheets, pipe, and shot	3,239	2,625	3,608	2,855	2,845	2,276
Grand total	484,325	601,044	410,697	359,396	[2] 391,182	398,170

[1] Excludes imports for manufacture in bond and export, classified as "imports for consumption" by the Bureau of the Census.
[2] Revised figure.
[3] Less than 1 ton.
[4] French Morocco before Jan. 1, 1957.
[5] Union of South Africa before Jan. 1, 1962.
[6] Adjusted by Bureau of Mines.
[7] Includes material classified by the Bureau of the Census as being from Algeria but believed by Bureau of Mines to be from French Morocco.

Source: Bureau of the Census.

TABLE 28.—U.S. imports for consumption of lead, by classes [1] [2]

Year	Lead in ores, flue dust or fume, and mattes, n.s.p.f. (lead content)		Lead in base bullion (lead content)		Pigs and bars (lead content)		Sheets, pipe, and shot		Not otherwise specified value (thousands)	Total value (thousands)
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)		
1953-57 (average)	169,087	[3] $42,846	168	$65	300,259	[3] $79,920	3,239	$823	[3] $220	[3] $126,497
1958	237,625	50,772	416	136	351,759	71,404	2,625	596	446	124,795
1959	136,526	27,035	34	19	262,632	54,667	3,608	850	586	84,461
1960	137,303	27,816	293	[4] 62	213,346	45,065	2,855	696	710	75,383
1961	[5] 136,780	[5] 24,332	236	[4] 51	[5] 247,427	[5] 45,881	2,845	641	807	[5] 72,304
1962	133,867	21,137	[6] 2,083	710	257,866	41,570	2,276	474	978	65,138

[1] Excludes imports for consumption in bond and export, classified as "imports for consumption" by the Bureau of the Census.
[2] In addition to quantities shown (value included in total value), "reclaimed scrap, etc." imported as follows—1953-57 (average) 11,572 tons, [3] $2,623,005; 1958, 8,619 tons, $1,440,639; 1959, 7,897 tons, $1,304,107; 1960, 5,598 tons, $1,034,141; 1961, 3,894 tons, $591,971; 1962, 2,078 tons, $269,101.
[3] Data known to be not comparable with other years.
[4] Values for Peru in 1960 and Peru and Mexico in 1961 have been adjusted by the Bureau of Mines to reflect the value of lead.
[5] Revised figure.
[6] Adjusted by Bureau of Mines.

Source: Bureau of the Census.

TABLE 29.—U.S. imports for consumption of miscellaneous products containing lead

Year	Babbitt metal, solder, white metal and other combinations containing lead [1]			Type metal and antimonial lead [1]		
	Gross weight (short tons)	Lead content (short tons)	Value (thousands)	Gross weight (short tons)	Lead content (short tons)	Value (thousands)
1953-57 (average)	2,916	1,765	[2] $2,431	7,980	6,991	$2,368
1958	4,244	2,049	4,677	5,170	4,525	1,190
1959	11,840	3,751	16,820	5,612	5,020	1,204
1960	9,274	1,512	16,024	4,560	3,915	970
1961	[3] 7,930	1,409	14,207	6,430	5,765	1,340
1962	2,438	1,030	3,443	8,576	7,512	1,393

[1] 1960-62 data known to be not comparable with earlier years.
[2] Data known to be not comparable with other years.
[3] Revised figure.

Source: Bureau of the Census.

TABLE 30.—U.S. exports of lead, by countries[1]

(Short tons)

Destination	1953–57 (average)	1958	1959	1960	1961	1962
Ore, matte, base bullion (lead content):						
North America:						
Canada	226	----------	3	16	3	----------
Mexico	644	912	108	107	----------	----------
Total	870	912	111	123	3	----------
Europe	----------	30	----------	----------	77	7
Asia	17	70	113	1,174	4,357	2,891
Total ore, matte, base bullion	887	1,012	224	1,297	4,437	2,898
Pigs, bars, anodes:						
North America:						
Canada	73	19	11	24	80	39
Cuba	39	33	37	10	----------	----------
Mexico	16	4	28	60	24	25
Other	87	79	[2] 156	149	39	66
Total	215	135	[2] 232	243	143	130
South America	206	96	[2] 92	18	794	588
Europe	541	3	9	30	3	28
Asia:						
Japan	699	----------	5	----------	----------	----------
Philippines	265	427	[2] 472	34	227	81
Taiwan	49	566	1,916	1,536	874	950
Other	175	132	[2] 29	103	78	321
Total	1,188	1,125	[2] 2,422	1,673	1,179	1,352
Africa	3	----------	1	2	12	9
Oceania	----------	[3]	----------	1	2	1
Total pigs, bars, anodes	2,153	1,359	2,756	1,967	2,133	2,108
Scrap:						
North America	82	5	7	1,220	54	37
South America	[3]	----------	[3]	2	2	15
Europe:						
Belgium-Luxembourg	175	----------	----------	6	688	328
Germany, West	278	292	51	129	253	119
Italy	1	30	95	74	162	289
Netherlands	248	157	460	297	251	159
United Kingdom	924	382	513	851	1,167	786
Other	120	148	15	----------	----------	116
Total	1,746	1,009	1,134	1,357	2,521	1,797
Asia:						
Japan	693	----------	----------	----------	2,579	593
Other	----------	1	----------	[3]	7	19
Total	693	1	----------	[3]	2,586	612
Total scrap	2,521	1,015	1,141	2,579	5,163	2,461
Grand total	5,561	3,386	4,121	5,843	11,733	7,467

[1] In addition foreign lead was reexported as follows: Ore, matte, and base bullion 1953–57 (average) 3 tons: 1958–62, None. Pigs, bars, anodes, 1953–57 (average). 230 tons, 1958: 25 tons; 1959: 83 tons; 1960: None; 1961: 294 tons; 1962: None. Scrap: 1953–57 (average) 24 tons; 1958: None; 1959: 11 tons; 1960–62: None.
[2] Revised figure.
[3] Less than 1 ton.

Source: Bureau of the Census.

WORLD REVIEW [5]

World mine production increased 5 percent above that of 1961. Discussions continued in the Lead-Zinc Study Group in an effort to improve world statistics and understanding of the lead industry's economic problems. World smelter production was estimated to be 2.7 million short tons, the same as in 1961. According to the American Bureau of Metal Statistics (ABMS), free-world consumption was estimated at 2.2 million short tons.

The Lead-Zinc Study Group met in plenary session twice in Geneva, Switzerland during 1962, from March 15 to 21, the meeting suspended to reconvene May 28 to 31, and from October 24 to 26.

The International Lead-Zinc Study Group reported a 90,400-ton increase to 2,615,800 tons in world consumption of refined lead compared to the 1961 consumption of 2,525,400 tons. The Study Group also reported a reduction of 89,000 tons to 309,400 tons in world producer stocks of refined lead. It was evident that production and consumption of lead were more in balance than in several years. Increasing consumption combined with decreasing stocks improved the outlook for the lead industries and strengthened lead markets. Lead consumption increased in nearly every country in the world during 1962. Although the increase was only a modest 4 percent, it was encouraging. December 31 lead quotations on the London Metal Exchange declined 0.61 cent per pound from those of January to 6.81 cents per pound. The London lead quotation reached a high of 7.82 cents in April and a low of 6.26 cents in August.

TABLE 31.—World mine production of lead (content of ore) recoverable where indicated, by countries [1] [2]

(Short tons)

Country	1953–57 (average)	1958	1959	1960	1961	1962
North America:						
Canada	[3] 197,060	[3] 186,680	[3] 186,696	[3] 205,650	[4] 182,557	[4] 211,321
Cuba	60	[4] 70	----	----	----	----
Greenland	[5] 6,628	9,619	11,633	7,635	10,104	891
Guatemala [3]	7,397	8,788	6,381	9,433	9,458	[6] 2,135
Honduras	1,874	3,380	4,604	5,913	6,762	6,522
Mexico	234,455	222,582	210,188	210,177	199,877	213,074
United States [3]	339,426	267,377	255,586	246,669	261,921	236,956
Total	786,900	698,496	675,088	685,477	670,679	670,899
South America:						
Argentina	25,900	32,000	33,000	31,500	30,600	31,700
Bolivia (exports)	24,024	25,149	24,293	23,610	22,378	20,504
Brazil	[7] 3,610	[8] 5,300	[8] 6,600	[8] 12,000	[8] 15,000	[8] 17,500
Chile	4,286	2,815	2,560	2,694	2,252	1,830
Colombia (U.S. imports)	519	851	570	705	722	439
Ecuador	118	132	118	119	122	137
Peru	133,738	147,888	[3] 127,003	[3] 145,097	[3] 150,353	[3] 146,650
Total	192,195	214,135	194,144	215,725	221,427	218,760

See footnotes at end of table.

[5] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.

TABLE 31.—World mine production of lead (content of ore) recoverable where indicated, by countries [1] [2]—Continued

(Short tons)

Country	1953–57 (average)	1958	1959	1960	1961	1962
Europe:						
Austria [3]	5,529	6,012	5,906	5,758	6,051	5,855
Bulgaria [8]	57,500	77,900	88,700	92,374	88,000	89,900
Czechoslovakia [8]	4,700	6,600	7,000	7,200	7,200	14,900
Finland	1,112	2,482	2,126	1,755	3,439	3,161
France	11,882	14,727	18,335	20,451	20,834	15,100
Germany:						
East [8]	6,000	7,700	7,700	7,700	7,700	8,300
West	73,633	67,213	57,929	54,999	54,648	55,264
Greece	5,406	11,200	11,000	10,141	12,787	14,550
Ireland	2,016	412	1,476	1,480	279	----------
Italy	52,100	65,283	58,500	54,900	52,600	45,525
Norway	804	2,351	2,487	2,780	2,524	3,400
Poland	39,300	36,500	39,000	43,200	42,108	44,100
Portugal	1,660	994	35	34	28	----------
Rumania [7] [8]	12,300	13,200	13,200	13,200	13,200	13,800
Spain	65,747	76,710	77,271	80,353	87,863	78,284
Sweden	34,527	46,595	51,257	58,753	68,500	74,737
U.S.S.R. [8]	257,000	330,000	340,000	340,000	[7] 390,000	[7] 400,000
United Kingdom [3]	8,846	4,814	2,632	1,549	1,655	446
Yugoslavia	96,292	99,035	101,909	100,554	106,572	112,428
Total [8]	736,400	869,700	886,500	897,200	966,000	979,800
Asia:						
Burma	15,440	21,180	21,300	19,100	18,519	22,400
China [8]	31,000	55,000	75,000	90,000	100,000	100,000
India	2,903	4,356	5,292	4,991	4,478	5,065
Iran [8] [9]	15,900	18,700	16,500	16,500	16,500	11,000
Japan	29,380	40,448	39,844	43,577	51,015	58,679
Korea:						
North [8]	35,000	45,000	50,000	55,000	55,000	55,000
Republic of	724	1,343	256	1,012	1,014	1,554
Philippines	2,102	1,415	391	134	111	90
Thailand	4,612	1,032	1,455	2,028	2,437	2,600
Turkey	3,241	3,250	2,300	1,953	1,200	[8] 1,300
Total [8]	140,300	191,700	212,300	234,300	250,300	257,700
Africa:						
Algeria	11,022	11,095	12,173	11,529	10,141	9,965
Congo, Republic of	3,546	3,611	5,448	4,741	965	----------
Morocco	94,996	103,476	101,082	104,444	97,299	99,323
Nigeria	123	546	424	223	7	----------
Rhodesia and Nyasaland, Federation of: Northern Rhodesia [7]	16,315	14,608	16,128	16,160	16,956	16,343
South Africa, Republic of	686	36	168	136	102	7
South-West Africa [10]	84,200	[3] 83,796	[3] 77,551	71,500	70,000	82,688
Tanganyika (exports)	4,130	5,001	6,401	6,927	387	----------
Tunisia	27,518	25,920	19,997	19,676	18,698	14,936
Uganda (exports)	63	256	59	----------	----------	----------
United Arab Republic (Egypt)	223	330	770	88	40	2
Total	242,822	248,675	240,201	235,424	214,595	223,264
Oceania: Australia	326,697	366,652	354,249	345,143	302,019	413,560
World total (estimate)	2,430,000	2,590,000	2,560,000	2,615,000	2,625,000	2,765,000

1 Data derived in part from United Nations Statistical Yearbook, Yearbook of the American Bureau of Metal Statistics, and annual issues of the Statistical Summary of the Mineral Industry (Overseas Geological Surveys, London), and Metal Statistics (Metallgesellschaft) Germany.
2 This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
3 Recoverable.
4 Data for 1961 and 1962 not strictly comparable to previous years.
5 Average annual production 1956–57.
6 U.S. imports.
7 Smelter production.
8 Estimate.
9 Year ended March 21 of year following that stated.
10 Includes lead content of lead-vanadium concentrates.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

TABLE 32.—World smelter production of lead, by countries [1] [2]

(Short tons)

Country	1953-57 (average)	1958	1959	1960	1961	1962
North America:						
Canada	155,162	134,827	140,881	160,079	172,365	152,742
Guatemala	[3] 200			200	62	
Mexico	227,540	218,290	206,134	205,263	194,476	208,450
United States (refined) [4]	501,817	469,381	340,886	382,436	449,486	376,024
Total	884,719	822,498	687,901	747,978	816,389	737,216
South America:						
Argentina	23,656	36,200	34,200	28,300	31,000	27,000
Bolivia (exports) [5]	1,774	877	250	119		
Brazil	3,610	4,781	[3] 5,900	[3] 10,805	[3] 13,480	15,758
Chile	[6] 151	321	892	660	529	
Peru	67,800	71,045	62,619	81,726	84,253	76,654
Total	96,991	113,224	103,861	121,610	129,262	119,412
Europe:						
Austria [7]	12,906	13,756	13,610	13,717	13,605	13,417
Belgium [7]	95,360	105,685	97,489	102,190	110,110	102,681
Bulgaria	8,400	28,737	36,090	44,540	45,100	48,200
Czechoslovakia [3]	9,300	9,900	10,000	10,000	10,000	15,400
France	70,762	77,870	77,082	81,998	78,052	77,800
Germany:						
East [3] [7]	27,200	27,500	27,500	27,500	27,500	28,700
West	127,853	147,985	164,833	162,772	155,008	163,665
Greece	3,253	4,330	4,122	3,407	3,267	3,300
Italy	43,261	52,514	49,638	48,057	49,769	46,282
Poland	36,707	39,488	42,645	43,762	43,874	44,842
Portugal	1,204	743	877	998	1,663	2,173
Rumania [3]	12,100	13,200	13,200	13,200	13,200	13,800
Spain	65,343	77,729	75,497	78,464	85,678	79,666
Sweden	23,264	36,453	40,619	49,112	42,745	42,716
U.S.S.R. [3]	260,000	340,000	350,000	350,000	390,000	400,000
United Kingdom	7,542	4,156	1,580	1,224	1,178	205
Yugoslavia	80,998	92,904	94,132	98,263	99,650	107,945
Total [3]	885,500	1,073,000	1,098,900	1,129,200	1,170,400	1,190,800
Asia:						
Burma	17,397	19,150	21,768	18,499	17,376	19,164
China [3]	25,000	40,000	65,000	80,000	95,000	95,000
India	2,552	3,735	4,363	4,128	4,039	3,140
Iran [8]	1,042	1,047	[3] 1,000	1,280	1,437	440
Japan	34,347	42,412	67,152	76,465	83,476	98,752
Korea, North [3]	13,000	20,600	21,000	35,000	45,000	45,000
Turkey [3]	1,695	3,000	1,808	440	550	[3] 755
Total [3]	95,000	130,000	182,100	215,800	246,900	262,300
Africa:						
Morocco	30,902	36,513	31,361	33,871	26,994	26,935
Rhodesia and Nyasaland, Federation of: Northern Rhodesia	16,315	14,608	16,128	16,160	16,956	16,848
Tunisia [5]	28,437	27,718	24,039	21,894	20,339	17,447
Total	75,654	78,839	71,528	71,925	64,289	61,230
Oceania: Australia:						
Refined lead	212,246	214,451	208,102	212,687	181,736	212,941
Pb content of lead bullion (for export)	44,383	64,032	56,347	59,050	53,861	81,885
Total	256,629	278,483	264,449	271,737	235,597	294,826
World total (estimate)	2,295,000	2,495,000	2,410,000	2,560,000	2,665,000	2,665,000

[1] Data derived in part from United Nations Statistical Yearbook, Yearbook of the American Bureau of Metal Statistics, and annual issues of Statistical Summary of the Mineral Industry (Overseas Geological Surveys, London), and Metal Statistics (Metallgesellschaft) Germany.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Estimate.
[4] Figures cover lead refined from domestic and foreign ores; refined lead produced from foreign base bullion not included.
[5] Lead bars only; does not include lead contained in antimonial lead or in solders.
[6] Average annual production 1954-57.
[7] Includes scrap.
[8] Year ended March 21 of year following that stated.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

NORTH AMERICA

Canada.—Mine production of lead was 211,300 tons of recoverable lead. Refined lead production was 152,700 tons, 11 percent less than in 1961, and was from the only lead smelter in Canada, a unit of Consolidated Mining & Smelting Co. of Canada, Ltd. (Cominco), located at Trail, British Columbia. The smelter treated concentrates from the company-owned Sullivan, Bluebell, H. B., and Con mines, the Rycon Mines, Ltd. (a company subsidiary), and some purchased concentrate.

Progress was according to schedule in all phases of the Pine Point Mines, Ltd., project in Northwest Territories to bring those lead-zinc mines into production by late 1966. Pine Point Mines, Ltd., was a Cominco subsidiary. Also Cominco planned to bring a new lead-zinc mine into production at Duncan Lake, British Columbia, and to build a $6 million concentrator.

Other important lead ore and concentrate producers in British Columbia were Sheep Creek Mines, Ltd., from the Mineral King mine; Canadian Exploration, Ltd., from the Jersey mine; and Reeves MacDonald mines, Ltd., from the Reeves and the MacDonald mines. There were several lead producers in the Slocan district and in the south-central part of the Province.

The principal lead producers in the Yukon Territory were the Calumet, Elsa, and Hector mines of United Keno Hill Mines, Ltd. United Keno started production from its newly developed Keno mine.

The Chisel Lake mine of Hudson Bay Mining & Smelting Co., Ltd., was the principal lead producer of Manitoba and Saskatchewan.

Lead output of mines in Ontario remained small and was entirely from the zinc-copper-lead-silver mines of Geco Mines, Ltd., and Willroy Mines, Ltd. Lead production from Geco mines was about three times that produced in 1961.

Lead production from mines in Quebec increased over that during 1961 as a result of a larger output from the Coniagas mine of The Coniagas Mines, Ltd., and the Solbec mine of Solbec Copper Mines, Ltd. The Golden Manitou mine of Manitou-Barvue Mines, Ltd., and the New Calumet mine of New Calumet Mines, Ltd., were the principal lead producers of the Province. Considerable lead production was expected from mines of several companies operating in the Mattagami Lake district even though the principal metal product was zinc. Several of the mines were expected to be in production by late 1963.

Lead production in the Atlantic Provinces was largely from the Buchans mine of American Smelting and Refining Company. Magnet Cove Barium Corp., Ltd., and Heath Steele Mines, Ltd., contributed considerable lead output although operations of the Heath Steele Mines started at mid year. Brunswick Mining & Smelting Corp., Ltd., was progressing according to schedule, with mine development and construction, to place their properties in production, and were synchronizing the project with the related railway project of the Canadian government. Several other mining firms were engaged in mineral exploration of the Bathurst area. A new, large, low-grade lead discovery on Cape Breton Island, Nova Scotia, was announced. Several companies were exploring the area.

Mexico.—Lead mine production increased to 213,100 tons, 7 percent over that produced during 1961. Smelter output was 208,500 tons.

Consumption of lead increased 10,900 tons to 52,400 tons (ABMS), and again most of the increase was refined lead to process into lead oxides for export. A minimum of exploration was done during 1962.

Some mining companies complied with the mining law of 1960, requiring them to Mexicanize (51-percent-Mexican ownership). The Mexican Government passed a special resolution to enable Compania Minera ASARCO to comply with the provision of the mining law requiring 51 percent Mexican ownership. This resolution permitted ASARCO to deposit 51 percent of the company stock in escrow in a Mexican bank until such time as the Government of Mexico found a qualified buyer.

Compania Minera ASARCO continued operating without interruption. Operations were complicated, however, and placed in jeopardy by a Mexican Presidential decree nullifying titles to company-owned coal properties that furnished coal for making coke used in the smelters. If the new plan for Mexicanization became a reality, the company expected to proceed with several expansion projects for mines and plants.

Metalurgica Mexicana Penoles, S.A., (Metmex) 49 percent owned by American Metals Climax, Inc., operated at a reduced profit. Details of mine operations and lead output were unavailable to the Bureau of Mines. The 50-percent reduction in Mexican export and production taxes provided for in the new mining law was not yet implemented for Metmex, although it had been *Mexicanized* for nearly 2 years.

Minera Frisco, S.A., 49 percent owned by San Francisco Mines of Mexico, Ltd., since Mexicanization, milled a total of 928,700 tons of ore from the Frisco and Clarines mines producing 45,000 tons of lead in lead concentrates. The tonnage milled set a new record for the fourth consecutive year. Although Minera Frisco, S.A., was certified by the Department of National Patrimony, the company was unable to secure the tax rebates provided by law.

Compania Fresnillo, S.A., with affiliated Mexican companies and the Sombrerete Mining Co., produced 54,550 tons of lead in concentrates from 1,231,000 tons of ore. Of this total the Fresnillo-Plateros Unit produced 14,900 tons of lead; the Naica, 36,800 tons; the Zimapan, 1,650 tons; and the Sombrerete Mining Co., 1,200 tons.

SOUTH AMERICA

Argentina.—Cia. Minera Aguilar, S.A. (99.9 percent owned by St. Joseph Lead Co.) produced 33,100 tons of lead concentrate compared to 31,300 tons in 1961. Net earnings were appreciably higher than in 1961. Despite the political state of suspense in Argentina, the mine operated without interruption.[6] Cia. Minera Castano Viejo, S.A., an affiliated company of National Lead Co., produced most of the remaining lead from Argentine mines. Refined lead production in Argentina was 27,000 tons, 13 percent less than in 1961. All metal production was by four smelters from local sources and was all consumed in Argentina.

Bolivia.—Mine production of lead was 20,500 tons, and lead smelter production was again nil. Two small smelters, Fundicion Metabol,

[6] St. Joseph Lead Co. Annual Report. 1962, pp. 17–18.

a Government-owned company, and Campagnia Metalurgica, S.A. la Lima produced small tonnages of metallic lead. The latter company, mainly a tin producer, reported lead production as lead content of solder.

Brazil.—Mine production of lead was estimated at 17,500 tons. Total primary and secondary smelter-refinery output of lead was 15,800 tons. The most recent mine to come into production was Mineração Boquira, Ltda. An important lead deposit discovery was reported 24 miles from Cuiba in Mato Grosso. Cia. Brasileira de Chumbo (a smelting firm formed by the merger of Cia. Plumbum, S.A., and Cia. Accumulatores Prest-O-Lite), Institute de Pesquisas Tecnologicas, and Comercio e Industria de Matais "ARPA", S.A., produced lead metal from primary and secondary sources.

Peru.—Cerro de Pasco Corp. produced 74,900 tons of refined lead at its La Oroya smelter-refinery. This was 11 percent less than that produced during 1961. Purchased ores accounted for 59 percent of this output.[7] Cia. Minera Atacocha, S.A., was the largest producer of lead from a single mine, 20,700 tons. The Cerro de Pasco Corp. mine at Cerro de Pasco was the second in lead production, 17,300 tons, and the several mines of that company had a combined output of 35,700 tons.

Cia. Minerales Santander, Inc., a wholly owned subsidiary of St. Joseph Lead Co., produced 8,800 tons of lead concentrate, an increase of 13 percent over that produced in 1961.[8]

Other important lead producers were Northern Peru Mining Corp.; Mauricio Hochschild and Co.; Cia. de Minas Buena Ventura, S.A.; Minas de Cercapuquio, S.A.; Sindicato Minero Pacococha; Sindicato Minero Rio Pallanga, S.A.; and Volcan Mines Co. Part of the lead output from independent mines was smelted by Cerro de Pasco Corp. in Peru, and the remainder was exported to the United States, Europe, and Japan. Total recoverable lead mine output was 146,700 tons.

EUROPE

Bulgaria.—Lead mine production in 1962 was 89,900 tons.

Germany, West.—Mine production of lead was 55,300 tons and smelter output of metal was 163,700 tons. The secondary metal industry recovered 74,700 tons of lead. Several marginal mines were closed.

Sweden.—Mine production of lead was 74,700 tons, and smelter output of 42,700 tons was principally by the Boliden Mining Co. This production was an increase of 9 percent for mine output and the same as in 1961 for metal.

United Kingdom.—Mine output of lead was 450 tons, and combined primary and secondary refined lead production from ores, scrap, and imported bullion was 151,200 tons. United Kingdom consumption of domestically produced lead plus imports of refined lead was 304,600 tons. A total of 234,800 tons of lead was imported, and secondary lead plus mine production made up the remainder of supply; total consumption was 424,300 tons. Stocks at yearend were 66,800 tons, 7 percent less than on December 31, 1961.[9]

[7] Cerro Corp. Annual Report. 1962, p. 4.
[8] St. Joseph Lead Co. Annual Report. 1962, p. 18.
[9] British Bureau of Non-Ferrous Metal Statistics. World Non-Ferrous Metal Statistics. V. 16, No. 3, Bull. March 1963, p. 28.

Yugoslavia.—Lead-zinc-antimony mine production continued to increase and lead production was 112,400 tons. The new Srebrenica lead-zinc mine in Bosnia and Hercegovina, during the first phase of operation, was expected to produce about 7,500 tons of lead concentrate per year; production was to be increased as mine development proceeded. Development of the Sase lead-zinc mine in Macedonia was begun, and it was planned to produce 16,000 tons of lead per year. A considerable output of lead was expected from the lead-zinc deposits being developed in the Osogovska Planina range of Eastern Yugoslavia. To effect mineral industry economies, seven lead-zinc mining concerns, including the Trepca mines, planned to merge.

ASIA

Burma.—Refined lead production increased 10 percent from that of 1961 to 19,200 tons. Mine output increased to 22,400 tons of contained lead. The United Nations preliminary study of mineral resources was to be completed in 2 years, and estimates were that 5 million tons of lower grade lead-zinc ores could be mined profitably.

China.—Total refined lead output for China was estimated to be 95,000 tons. Surplus Chinese lead, exported to the U.S.S.R. as both concentrate and refined metal, was estimated to be more than 20,000 tons. Secondary lead recovery was estimated to have increased. The isolated smelterless mines of Sinkiang continued to be the principal lead mines exporting to the U.S.S.R. The important lead mining and smelting districts were Shenyana, Skao-Kuan, Hu-lu-tao, Shui-K'ou-shan, and T'ao-lin. Production capacities were estimated to be increasing slowly.

India.—The Zawar mine, the only operating lead-producing mine, produced 5,100 tons of lead in ores, an increase of 13 percent over that produced in 1961. Domestic production supplied only 9 percent of the domestic lead requirements. Metal Corporation of India, Ltd., operating the Zawar mine, smelted and refined the total mine output. A new 1,000-foot shaft was being sunk at the Zawar mine.[10]

An Indian Lead-Zinc information center was established in Calcutta by the Lead and Zinc Development Association of London.[11]

Iran.—Lead mine production was estimated at 11,000 tons, one-third less than in 1961.

Japan.—Mine production increased 15 percent compared with that of 1961. Smelter production was 98,800 tons of pig lead of which 42 percent was from imported ores and concentrates. Existing lead smelting capacity was to be expanded from 102,000 to 150,000 tons. Japanese lead consumption was estimated to be increasing annually by 14,000 tons, the increase was to be supplied mainly from imported concentrates, and imports of metal were expected to satisfy the balance of requirements. Construction of a 7,500-short-ton-per-year capacity tetraethyl lead plant, using a foreign process was abandoned in favor of a Japanese process.[12]

[10] Investors' Guardian (London). V. 178, No. 4569, June 22, 1962, p. 1448.
[11] Mining Journal (London). V. 260, No. 6646, Jan. 4, 1963, p. 15.
[12] Chemical Week. V. 90, No 12, Mar. 24, 1962, p. 72.

Korea, North.—Mine production was 55,000 tons, of which 45,000 tons was smelted domestically. The principal lead smelting center was Munpyong. Most of the lead output was exported to U.S.S.R.

AFRICA

Morocco.—Production of lead in ore and concentrate was 99,300 tons, an increase of 2 percent compared with that produced in 1961. Societe des Mines de Zellidja and Societe Nord-Africaine du Plomb were the principal lead mining firms. The Oued-el-Heimer smelter, owned jointly by Societe des Mines de Zellidja and Société Minère et Metallurgique de Penarroya, operated the only lead smelter. Newmont Mining Corp. and St. Joseph Lead Co. were part owners of these companies. Known reserves were nearly exhausted.[13]

Rhodesia and Nyasaland, Federation of.—The only lead-zinc metal producer continued to be Rhodesia Broken Hill Development Co., Ltd. Lead smelter production was 16,800 tons, virtually the same as in 1961. Ore processed during 1962 averaged 17.7 percent lead and 34.2 percent zinc. Measured and indicated reserves on December 31, were 5.9 million tons of ore averaging 13.5 percent lead and 26.9 percent zinc. Although lead smelting began in 1916 and several smelting methods have been used, overall recovery was always low (about 60 percent). The new Imperial Smelting unit that started producing in late January was expected to increase recoveries to 85-plus percent on mined ore and permit the smelting of stockpiled material previously untreatable.[14]

South-West Africa.—Tsumeb Corp., Ltd., mined and milled 715,000 tons of ore averaging 4.68 percent copper, 12.84 percent lead, and 3.72 percent zinc. During the fiscal year ending June 30, 1962, 64,700 tons of lead was sold and for the 6 months ending December 31, 39,400 tons. The Kombat Mine began producing in April, and milled 750 tons of ore per day. During the calendar year, the 102,651 tons of ore treated at the Kombat mill averaged 3.22 percent copper and 2.92 percent lead. The lead smelter, under construction, was scheduled to begin production during the latter half of 1963. Newmont Mining Corp. and American Metals Climax, Inc., each owned slightly more than 29 percent of Tsumeb Corp., Ltd.[15]

OCEANIA

Australia.—Mine production in the chief lead ore and concentrate producing country of the world increased to 413,600 short tons, 37 percent over that produced in 1961 after 4 consecutive years of decline. Refined lead production was 212,900 tons, and lead in bullion was 81,900 tons. The remaining lead was exported as concentrates for smelting and refining. The Broken Hill District continued as the outstanding lead-producing district. The new smelter at Cockle Creek operated satisfactorily during 1962.

Mount Isa Mines, Ltd., planned to contract for a 14,000-ton-per-day lead-zinc flotation plant at Mount Isa, Queensland, to be ready

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[13] Newmont Mining Corp. Annual Report. 1962, p. 16.
[14] Mining Journal (London). V. 106, No. 2, February 1962, pp. 70–71.
[15] Newmont Mining Corp. Annual Report. 1961, pp. 6–7.

for operation by June 30, 1965.[16] The company extended its exploration from North Queensland into New South Wales, and took an option on the mineral rights of Emu Creek Mining Co., Ltd.[17]

The Consolidated Zinc Corp., Ltd., and The Rio Tinto Co., Ltd., merged on March 30, to form The Rio Tinto-Zinc Corp., Ltd. The merged company operated mines, smelters, chemical plants, and other industries in Australia, North America, United Kingdom, Central and South Africa, and Europe. Its most valuable holdings were in uranium, 26.3 percent, and its second most valuable were in lead and zinc, 18.9 percent. The remaining company holdings, 54.8 percent, were in chemicals, copper, oil, other minerals, aluminum, construction materials, and other industries. Company operations in Australia comprised 38 percent of the total and were mainly lead and zinc.[18]

Mount Isa Mines, Ltd. (53.7 percent owned by American Smelting and Refining Company) produced 44,089 tons of lead bullion and 4,167 gross-weight tons of lead-copper dross from treating 705,500 tons of ore averaging 6.6 ounces of silver, 8.3 percent lead, and 6 percent zinc during the fiscal year ending June 30, 1962. This lead output was 26 percent less than that produced during fiscal year 1961. Most of the reduction was caused by a prolonged labor strike. Output was accelerated during the last half of the fiscal year and was further increased for the last 6 months of the calendar year 1962.[19]

E. Z. Industries, Ltd., produced 297,400 tons of complex gold, silver, zinc, copper, and lead ore from the Rosebery and Hercules mines during the fiscal year ending June 30, 1961; 8,100 tons of lead in lead concentrate and 3,950 tons of lead content in the copper concentrate were reported. Lead production increased 22 percent over that of fiscal year 1961.[20]

TECHNOLOGY

Advancement in lead technology, from reports of research investigations and developments, was made concerning lead-selenide single crystals for photoelectrics,[21] thermal expansion properties of normal and superconducting lead,[22] in low-temperature ranges effect of electron impact of vapors on systems of lead-selenium and lead-tellurim,[23] electropolishing of lead-telluride,[24] measurements of the effect of hydrostatis pressure and isotopic effect on superconducting lead,[25] dry

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[16] Mining World. V. 24, No. 2, February 1962, p. 41.
[17] Mining Journal (London). V. 258, No. 6605, Mar. 23, 1963, pp. 301–302.
[18] The Rio Tinto-Zinc Corp. Annual Report. 1962 pp. 4, 16, 17, 18, 19.
[19] Mount Isa Mines, Ltd. Annual Report. 1962, p. 26.
[20] E. Z. Industries, Ltd. Annual Report. 1962, pp. 14–16.
[21] Coats, D. G., W. D. Lawson, and A. C. Prior. Photoconductive Detectors in Lead Selenide. J. Electrochem. Soc., v. 108, No. 11, 1961, pp. 1038–1042.
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lubricants,[26] electrolysis of fused lead salts,[27] new applications for piezo electricity,[28] analysis methods,[29] developments in mineral dressing,[30] developments in extractive metallurgy,[31] fiber metal in alloys,[32] hardening techniques and improvement in cree-resistant qualities,[33] and fundamental studies of the properties of lead, its alloys, and compounds.[34]

The recent program of expanded research for lead and zinc, by Lead Industries Association and American Zinc Institute, advanced lead technology rapidly and stimulated research efforts by private organizations in lead technology. The Lead Development Association in England also made significant contributions to lead technology. The abstracting service, a joint project of Lead Industries Association and Lead Development Association, was valuable in affording reasearchers a world-wide coverage of new research developments in reports and patents classified as electrical cable sheathing, batteries, rolled and extruded lead, alloys, lead pigments and filler, lead chemicals, electronic applications, production, metallurgical and mechanical properties, corrosion, and physics, chemistry and analysis.[35] Un-

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der the expanded research program, Lead Industries Association and American Zinc Institute semiannually published the ERP Research Digest that gave abstracted progress reports of the projects comprising the metallurgy, the chemical and the electrochemical programs.[36]

The Geological Survey published a metallogenic map and descriptions of domestic lead occurrences.[37]

The Bureau of Mines issued a report evaluating a series of flotation collectors for the slime fraction of lead mill tailing.[38]

In addition to patents listed in Lead Abstracts, U.S. patents were issued relating to lead production,[39] lead chemicals,[40] nuclear fuel element,[41] alloys,[42] batteries,[43] lead powder shapes,[44] coating,[45] and analysis.[46]

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Lime

By C. Meade Patterson [1] and Rose L. Ballard [2]

MORE than 1 million tons of primary quicklime and hydrated lime was manufactured in Texas in 1962 for the first time in history. Other States that regularly produced over 1 million tons of lime per year were Ohio, Missouri, Michigan, and Pennsylvania, in descending order.

Open-market quicklime, hydrated lime, and dead-burned dolomite were 1 percent higher than in 1961 but 10 percent lower than in the record year 1956. Open-market lime tonnage of 1962 was surpassed by 5 other years (in descending order, 1956, 1955, 1957, 1959, and 1960). The substitution of cement, gypsum, and crushed limestone in some lime uses was partly responsible for the relatively stationary market. Inroads were made into the markets of primary lime by captive primary lime, captive regenerated lime, open-market regenerated lime, and open-market recovered lime slurry.

The average unit value of lime, sold or used, was forced upward by rising costs to a record high. Total U.S. primary open-market and captive lime production reached an alltime high of 13.8 million tons, 4 percent above the 1961 record. Regenerated lime output was 3.7 million tons.

LEGISLATION AND GOVERNMENT PROGRAMS

The Internal Revenue Service ruled that the depletion allowance could be applied to sales of limestone processed up to the point where it passed a No. 20 screen and at least 5 percent was retained on a No. 45 screen. The National Lime Association, Washington, D.C., and the National Limestone Institute, Inc., Washington, D.C., sponsored the revised ruling.[3]

An estimate of limestone reserves available to Lime Products, Inc., Union, Maine, was made by the Bureau of Mines for the Area Redevelopment Administration. An expansion project had been proposed by the company. There had not been any commercial lime production in Maine since 1958.

The specific tariff on hydrated lime under the Tariff Act of 1930 was 12 cents per 100 pounds ($2.40 per short ton) including the weight

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[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.
[3] Rock Products. Depletion Ruling Revised, Thanks to Lime Groups. V. 65, No. 2, February 1962, p. 44.

of the container. The tariff on lime "not specifically provided for," or any type of lime other than hydrated lime (quicklime, for example), was 10 cents per 100 pounds ($2 per ton) including the weight of the container. The rate was reduced for nations under General Agreement on Tariffs and Trade to 3 cents per 100 pounds (60 cents per ton) including the weight of the container for hydrated lime and to 2.5 cents per 100 pounds (50 cents per ton) including the weight of the container for lime "not specifically provided for" (quicklime). Practically all lime imported for consumption came from Canada under the lower rates of 3 and 2.5 cents per 100 pounds.

TABLE 1.—Salient lime statistics in the United States

(Thousand short tons and thousand dollars)

	1953–57 (average)	1958	1959	1960	1961	1962
Active plants	152	145	[1] 154	[1] 157	[1] 220	215
Sold or used by producers:						
Quicklime	5,697	5,538	[1] 7,746	8,271	[1] 8,998	9,509
Hydrated lime	2,105	2,014	2,766	2,715	[1] 2,269	2,386
Dead-burned dolomite	2,124	1,659	[1] 1,988	1,949	[1] 1,982	1,858
Total	9,927	9,211	[1] 12,500	12,935	[1] 13,249	13,753
Value [2]	$122,415	$121,193	[1] $163,909	[1] $172,733	[1] $177,463	$186,754
Average value, per ton	$12.33	$13.16	[1] $13.11	$13.35	[1] $13.39	$13.58
Open-market	8,349	7,388	[1] 8,396	[1] 8,189	[1] 8,072	8,145
Captive [3]	1,578	1,823	4,103	4,746	[1] 5,177	5,608
Imports for consumption	40	26	35	32	37	78
Exports	76	46	53	61	30	20

[1] Revised figure.
[2] Selling value, f.o.b. plant, excluding cost of containers.
[3] Incomplete figures; before 1961 the coverage of captive plants was only partial.

DOMESTIC PRODUCTION

The primary lime produced from limestone, dolomite, and shell was separated from the regenerated lime produced from calcium carbonate sludge, waste or byproduct calcium carbide lime, and calcium carbonate precipitated from water softening. The annual lime statistics for 1961 were revised to exclude the tonnage and value of the regenerated lime. New and revised tables have been introduced to show the tonnage and value of regenerated lime by States and uses.

The sulfate-process (kraft) and the soda-process paper industry produced most of the regenerated lime by calcining used calcium carbonate sludge to quicklime for captive use in on-site rotary kilns. Also, regenerated lime was produced at some calcium carbide-acetylene plants from waste or byproduct carbide lime for captive use as quicklime in manufacturing more calcium carbide and for sale to other consumers as hydrated lime or hydrated lime slurry. Municipal water-treatment plants in a few cities from California to Florida calcined the calcium carbonate sludge precipitated during water softening to quicklime in on-site rotary kilns and other kinds of calciners. Most of this regenerated lime was used in captive water-treatment operations, but excess lime was sold to other nearby municipal water-treatment plants.

Thirty-nine States reported primary lime production. Ohio, Missouri, and Michigan were the three leading States, in descending order of tonnage, and accounted for 39 percent of the total U.S. primary output of open-market and captive quicklime, hydrated lime, and dead-burned dolomite. The next five ranking States, in descending order also, were Pennsylvania, Texas, New York, Illinois, and Louisiana. Quicklime (including dead-burned dolomite) accounted for 83 percent of the total primary lime production, sold or used; and hydrated lime accounted for 17 percent of the primary production, sold or used. Open-market lime tonnage was 59 percent of the primary lime output, and captive tonnage constituted the remaining 41 percent.

Regenerated lime, totaling 3.7 million tons, was produced in 23 States, including 5 States that produced no primary lime (Georgia, Kentucky, Maine, North Carolina, and South Carolina). The three leading States among the 44 States that reported primary and/or regenerated lime production were Ohio, Michigan, and Missouri, in descending order. These three States accounted for 31 percent of the U.S. primary and regenerated lime. The next five States, on the basis of both primary and regenerated lime output, in descending order, were Texas, Pennsylvania, Louisiana, New York, and Alabama. Production of quicklime from calcium carbonate sludge and waste carbide lime amounted to 21 percent of the total U.S. primary and secondary lime in 1962.

Quicklime constituted 88 percent of the regenerated lime output, and hydrated lime constituted the remaining 12 percent. Most regenerated lime (92 percent) was captive and 8 percent was sold. Regenerated quicklime and regenerated hydrated lime were as suitable as primary quicklime and primary hydrated lime for a number of uses. When regenerated lime was continued in captive service, its secondary origin through regeneration remained evident. That proportion which was sold, however, lost its identity and became indistinguishable from primary lime. It served consumers as well as the primary product from stone or shell that it displaced.

Plans to build two identical $3 million lime plants at Bridgeport, Ala., were announced by Oolite Chemi-Lime, Inc., Nashville, Tenn. Daily capacity of each plant would be 700 short tons of lime, and the limestone feed would be quarried at Anderson, Tenn., and shipped by rail to Bridgeport.

Roberts Manufacturing Co., Cleburne, Tex., acquired the Batesville White Lime Co., Batesville, Ark., and its interest in the Texas Lime Co., Cleburne, Tex.

Kaiser Aluminum & Chemical Corp. mined dolomite and produced dolomitic quicklime and dead-burned dolomite at Natividad, Calif., 15 miles from Moss Landing, Calif., where periclase was produced from sea water. Basic refractories were produced by combining dolomitic quicklime or dead-burned dolomite and periclase. Kaiser Refractories Minerals Department was organized by Kaiser Refractories, Division of Kaiser Aluminum & Chemical Corp., Oakland, Calif., at its Natividad plant near Salinas, Calif., to produce and sell lime and other materials.

TABLE 2.—Lime, primary and regenerated, sold or used in the United States, by States

State	1961						1962					
	Primary lime			Primary and regenerated lime			Primary lime			Primary and regenerated lime		
	Active plants	Short tons	Value	Active plants	Short tons	Value	Active plants	Short tons	Value	Active plants	Short tons	Value
Alabama	8	579,311	$6,870,559	8	579,311	$6,870,559	7	521,636	$6,298,390	14	838,579	$11,033,545
Arizona	6	166,706	2,686,326	6	166,706	2,686,326	6	174,375	2,913,800	6	174,375	2,913,800
Arkansas	[4] 4	89,813	1,196,642	6	(1)	(1)	5	349,807	4,541,539	7	442,883	6,363,550
California	17	502,965	9,062,887	19	(1)	(1)	17	469,673	8,453,722	19	(1)	(1)
Colorado	14	74,955	1,318,572	14	74,955	1,318,572	15	92,511	1,518,464	15	92,511	1,518,464
Connecticut	1	32,987	589,165	1	32,987	589,165	1	35,180	634,730	1	35,180	634,730
Florida	3	(1)	(1)	5	213,155	3,554,686	3	(1)	(1)	10	(1)	(1)
Georgia [2]	---	---	---	---	---	---	---	---	---	6	263,101	4,886,505
Hawaii	2	14,306	354,428	2	14,306	354,428	2	15,243	385,724	2	15,243	385,724
Idaho	4	46,760	657,656	4	46,760	657,656	5	67,560	801,232	6	(1)	(1)
Illinois	5	(1)	(1)	5	(1)	(1)	5	(1)	(1)	5	(1)	(1)
Iowa	2	(1)	(1)	2	(1)	(1)	2	(1)	(1)	2	(1)	(1)
Kansas	1	15,494	192,900	1	15,494	192,900	1	4,775	59,449	1	4,775	59,449
Kentucky	---	---	---	2	(1)	(1)	---	---	---	2	(1)	(1)
Louisiana	5	635,943	6,291,603	10	926,542	11,893,039	5	624,121	6,518,862	10	915,615	12,131,386
Maine [2]	---	---	---	---	---	---	---	---	---	1	(1)	(1)
Maryland	3	(1)	(1)	4	96,127	1,301,871	3	(1)	(1)	4	(1)	(1)
Massachusetts	3	144,831	2,306,710	3	144,831	2,306,710	3	148,401	2,337,027	3	(1)	(1)
Michigan	11	1,190,491	15,665,012	13	(1)	(1)	10	1,152,620	15,371,402	13	(1)	(1)
Minnesota	5	(1)	(1)	5	(1)	(1)	5	(1)	(1)	5	(1)	(1)
Mississippi	[4] 1	(1)	(1)	3	(1)	(1)	1	(1)	(1)	3	(1)	(1)
Missouri	6	1,172,557	13,873,492	6	1,172,557	13,873,492	6	1,176,222	13,702,925	6	1,176,222	13,702,925
Montana	6	117,742	985,744	6	117,742	985,744	6	104,110	1,048,962	6	104,110	1,048,962
Nebraska	5	(1)	(1)	5	(1)	(1)	5	(1)	(1)	5	(1)	(1)
Nevada	4	(1)	(1)	4	(1)	(1)	3	(1)	(1)	3	(1)	(1)
New Jersey	1	(1)	(1)	1	(1)	(1)	1	(1)	(1)	1	(1)	(1)
New Mexico	1	25,210	350,419	1	25,210	350,419	1	28,969	402,669	1	28,969	402,669
New York	[4] 5	(1)	(1)	6	(1)	(1)	4	(1)	(1)	6	(1)	(1)
North Carolina [2]	---	---	---	---	---	---	---	---	---	4	306,844	4,444,900
Ohio	[4] 22	3,048,216	41,265,855	23	3,123,054	42,158,203	22	3,102,148	43,791,540	24	(1)	(1)
Oklahoma	1	(1)	(1)	1	(1)	(1)	1	(1)	(1)	1	(1)	(1)
Oregon	3	82,434	1,701,931	7	221,463	5,157,173	3	77,680	1,514,090	7	200,983	4,583,790
Pennsylvania	21	1,092,702	16,427,640	23	(1)	(1)	18	1,103,556	16,646,902	20	(1)	(1)
South Carolina [2]	---	---	---	---	---	---	---	---	---	3	262,465	2,686,649
South Dakota	2	(1)	(1)	2	(1)	(1)	2	(1)	(1)	2	(1)	(1)
Tennessee	3	(1)	(1)	3	(1)	(1)	3	(1)	(1)	7	(1)	(1)
Texas	[4] 11	789,538	8,702,422	12	(1)	(1)	11	1,046,256	11,990,799	12	(1)	(1)
Utah	7	142,430	2,625,919	7	142,430	2,625,919	7	163,359	2,759,143	7	163,359	2,759,143
Vermont	2	(1)	(1)	2	(1)	(1)	2	(1)	(1)	2	(1)	(1)

Virginia	10	656,767	7,374,734	11	(1)	(1)	10	614,513	7,668,303	11	(1)	(1)
Washington	2	(1)	(1)	9	349,247	8,480,877	2	(1)	(1)	10	(1)	(1)
West Virginia	3	(1)	(1)	3	(1)	(1)	3	(1)	(1)	3	(1)	(1)
Wisconsin	7	(1)	(1)	9	160,988	2,480,152	6	(1)	(1)	7	(1)	(1)
Wyoming	3	(1)	(1)	3	(1)	(1)	3	(1)	(1)	3	(1)	(1)
Undistributed	--------	[4] 2,628,657	[4] 36,961,964	--------	[4] 7,568,664	[4] 102,288,010	--------	2,677,090	37,383,706	--------	12,411,990	172,495,844
Total [3]	[4] 220	[4] 13,249,000	[4] 177,463,000	[4] 257	[4] 15,193,000	[4] 210,126,000	215	13,753,000	186,754.000	286	17,437,000	242,052,000
Puerto Rico	1	600	15,000	1	600	15,000	1	568	14,463	1	568	14,463

[1] Included with "Undistributed" to avoid disclosing individual company confidential data.

[2] Not canvassed before 1962.

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

[4] Revised figure.

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TABLE 3.—Lime sold or used by producers in the United States, by types and major uses

(Short tons)

Type and use	1961			1962		
	Sold	Used	Total	Sold	Used	Total
By type:						
Quicklime	[1] 6,124,380	[1] 4,856,614	[1] 10,980,994	6,066,740	5,298,508	11,365,248
Hydrated lime	[1] 1,948,229	[1] 321,612	[1] 2,269,821	2,076,839	307,718	2,384,557
Total lime [2]	[1] 8,072,000	[1] 5,177,000	[1] 13,249,000	8,145,000	5,608,000	13,753,000
By use:						
Agricultural:						
Quicklime	77,030		77,030	74,249		74,249
Hydrated lime	121,327		121,327	117,388		117,388
Total [2]	[1] 198,000		[1] 198,000	192,000		192,000
Construction:						
Quicklime	78,212	5,809	84,021	103,714	4,925	108,639
Hydrated lime	1,068,467	71,221	1,139,688	1,112,277	69,313	1,181,590
Total [2]	[1] 1,147,000	[1] 77,000	[1] 1,224,000	1,216,000	74,000	1,290,000
Chemical and other industrial:						
Quicklime	[1] 4,065,222	[1] 4,771,962	[1] 8,837,184	4,102,140	5,222,782	9,324,922
Hydrated lime	[1] 758,435	[1] 250,371	[1] 1,008,806	847,174	238,405	1,085,579
Total [2]	[1] 4,823,000	[1] 5,022,000	[1] 9,845,000	4,949,000	5,461,000	10,411,000
Refractory (dead-burned dolomite)	[1] 1,904,000	[1] 78,000	[1] 1,982,000	1,787,000	71,000	1,858,000

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

Carbon dioxide was the main product obtained from the calcination of limestone in a rotary kiln at West End Chemical Division, Stauffer Chemical Co., Westend, Calif. About 240 tons of limestone was calcined daily at 1,700° F in the 8- by 340-foot natural-gas-fired rotary kiln. The carbon dioxide from the limekiln was bubbled through Searles Lake brines to convert dissolved sodium carbonate to sodium bicarbonate that could be precipitated. The byproduct quicklime resulting from the dissociation of the limestone to produce carbon dioxide either was sold as pebble quicklime or was hydrated and sold as hydrated lime. In 1958 Stauffer Chemical Co. acquired West End Chemical Co., which had operated since 1926.

The Colorado Fuel and Iron Corp., Pueblo, Colo., began producing metallurgical quicklime in August at its new captive lime plant. The quicklime was used in The Colorado Fuel and Iron Corp. oxygen steelmaking plant.

Chemical Lime, Inc., Ocala, Fla., produced quicklime containing over 93 percent calcium oxide in its new fluid-bed calciner near Brooksville, Fla. The 200-ton-per-day plant shipped lime to chemical-processing and water-treatment plants.

Dixie Lime and Stone Co., Ocala, Fla., was formed by the consolidation of two Georgia and three Florida limestone companies, including Dixie Lime Products Co., a lime producer at Ocala, Fla.

TABLE 4.—Regenerated lime produced in the United States[1]

State	Quicklime		Hydrated lime		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1961:						
Arkansas	(2)	(2)			(2)	(2)
California	(2)	(2)			(2)	(2)
Florida	(2)	(2)			(2)	(2)
Idaho	(2)	(2)			(2)	(2)
Kentucky	(2)	(2)	(2)	(2)	(2)	(2)
Louisiana	(2)	(2)	(2)	(2)	(2)	(2)
Maryland	(2)	(2)			(2)	(2)
Michigan	(2)	(2)			(2)	(2)
Mississippi	(2)	(2)	(2)	(2)	(2)	(2)
New York	(2)	(2)			(2)	(2)
Ohio	74,838	$892,348			74,838	$892,348
Oregon	139,029	3,455,242			139,029	3,455,242
Pennsylvania	(2)	(2)			(2)	(2)
Texas	(2)	(2)			(2)	(2)
Virginia	(2)	(2)			(2)	(2)
Washington	(2)	(2)	(2)	(2)	349,247	8,480,877
Wisconsin	(2)	(2)	2,726	$59,592	(2)	(2)
Undistributed	1,364,131	24,950,776	360,990	3,305,363	1,378,600	19,834,854
Total	1,578,000	29,298,000	364,000	3,365,000	1,942,000	32,663,000
1962:						
Alabama	316,943	4,735,155			316,943	4,735,155
Arkansas	93,076	1,822,011			93,076	1,822,011
California	(2)	(2)			(2)	(2)
Florida	443,787	5,907,445			443,787	5,907,445
Georgia	263,101	4,886,505			263,101	4,886,505
Idaho	(2)	(2)			(2)	(2)
Kentucky	(2)	(2)	(2)	(2)	(2)	(2)
Louisiana	(2)	(2)	(2)	(2)	291,494	5,612,524
Maine	(2)	(2)			(2)	(2)
Maryland	(2)	(2)			(2)	(2)
Michigan	(2)	(2)	(2)	(2)	(2)	(2)
Mississippi	(2)	(2)	(2)	(2)	(2)	(2)
New York	(2)	(2)			(2)	(2)
North Carolina	306,194	4,435,700	650	9,200	306,844	4,444,900
Ohio	(2)	(2)			(2)	(2)
Oregon	123,303	3,069,700			123,303	3,069,700
Pennsylvania	(2)	(2)			(2)	(2)
South Carolina	262,465	2,686,649			262,465	2,686,649
Tennessee	(2)	(2)	(2)	(2)	151,611	1,948,043
Texas	(2)	(2)			(2)	(2)
Virginia	(2)	(2)			(2)	(2)
Washington	(2)	(2)	(2)	(2)	367,278	7,871,682
Wisconsin	(2)	(2)			(2)	(2)
Undistributed	1,442,835	24,175,764	435,045	3,572,526	1,067,497	12,316,041
Total	3,252,000	51,719,000	436,000	3,582,000	3,687,000	55,301,000

1 Mainly produced at pulpmills and to a lesser extent at calcium and municipal water treatment plants.
2 Included with "Undistributed" and "Total" to avoid disclosing confidential data.

An improved lime recovery system was based on a new 11- by 275-foot rotary limekiln at St. Marys Kraft Corp., St. Marys, Ga. The large kiln replaced two small rotary kilns and increased the capacity to produce captive quicklime for paper manufacture from 100 to 225 tons per day.

The Midwest Lime Co., Inc., Bonner Springs, Kans., shut down because of lack of sales. Last reported lime production was in July. The company began producing quicklime in February 1961, and much of the production was sold for municipal water treatment in Kansas City, Mo.

Crown Zellerbach Corp. planned to expand the pulping capacity of its Bogalusa, La., papermill by installing a 350-foot rotary limekiln that would be in operation by mid-1963.

TABLE 5.—Number and production of domestic lime plants by size of operation[1]

Annual production (short tons)	1961			1962		
	Plants	Production		Plants	Production	
		Short tons	Percent of total		Short tons	Percent of total
Less than 10,000	[2] 81	[2] 296,763	[2] 2	80	325,318	3
10,000 to less than 25,000	[2] 40	[2] 660,765	[2] 5	35	561,001	4
25,000 to less than 50,000	34	[2] 1,248,399	9	36	1,276,371	9
50,000 to less than 100,000	[2] 27	[2] 1,869,360	[2] 14	25	1,821,084	13
100,000 to less than 200,000	[2] 21	[2] 2,988,920	[2] 23	22	3,484,189	25
200,000 and over	17	6,187,208	[2] 47	17	6,281,842	46
Total [3]	[2] 220	[2] 13,249,000	[2] 100	215	13,753,000	100

[1] Includes captive tonnage.
[2] Revised figure.
[3] Data may not add to totals shown because of rounding.

The Sault Ste. Marie, Mich., plant of Union Carbide Olefins Co., Division of Union Carbide Corp., shut down one of two calcium carbide furnaces and expected to close completely by the end of 1963. This was the result of the decision of E. I. du Pont de Nemours & Co., Inc., to produce acetylene at its Montague, Mich., plant. Union Carbide Olefins Co. produced captive quicklime for calcium carbide manufacture at Sault Ste. Marie, Mich., Niagara Falls, N.Y., and Ashtabula, Ohio.

Southwest Lime Co., Neosho, Mo., discontinued lime production and sold its business to the Ash Grove Lime and Portland Cement Co., Kansas City, Mo. The plant was dismantled and its customers obtained lime from the Springfield, Mo., lime plant of Ash Grove Lime and Portland Cement Co.

Hydrated lime slurry was collected and distributed in tank trucks to consumers in the chemical and construction industries by Chemlime Corp., Elizabeth, N.J. The slurry was the byproduct of acetylene generation. Most of it was used in the neutralization of acidic wastes, but some was sold for tanning and soil stabilization. Chemlime Corp. had operations in 13 States: California, Illinois, Louisiana, Maryland, Massachusetts, New Jersey, New York, Ohio, Oregon, Pennsylvania, Texas, Virginia, and West Virginia. Data on this byproduct lime tonnage are not included in this chapter, but Chemlime Corp. was one of the Nation's largest dealers in hydrated lime.

Basic, Inc., Cleveland, Ohio, sold its quarry and lime plant at Gibsonburg, Ohio, to The Gibsonburg Lime Products Co., Gibsonburg, Ohio. All the patents, trademarks, and building lime business of Tiger Brands, Inc., Division of Basic, Inc., were also sold. The Gibsonburg Lime Products Co. continued the Tiger Brands Division, and Basic, Inc., continued the production of chemical and metallurgical lime and dead-burned dolomite. Also Basic, Inc., obtained a license from two Italian firms to produce and sell a large refractory block in the United States and Canada. The agreement was made with Dolomite Franchi S.P.A., Brescia, and Carlo Tassara S.P.A., Genoa. Vertical limekilns in Europe used the Italian refractory block.

The Gibsonburg Lime Products Co., Gibsonburg, Ohio, calcined dolomitic limestone in 2 rotary kilns and in a battery of 16 vertical kilns. Dolomitic quicklime for chemical and industrial purposes, such as glass manufacture and water treatment, was manufactured in the rotary kilns, and dolomitic quicklime to be hydrated for use in construction and agriculture was manufactured in the vertical kilns. One rotary kiln, measuring 8 by 208 feet, was fired with natural gas and produced 150 tons of quicklime daily. The other rotary kiln, which was 10.5 by 125 feet, was fired with pulverized coal and produced from 180 to 230 tons per day. The 16 coal-fired vertical kilns, each 11 feet in diameter and 54 feet high, calcined limestone at 2,300° F and had an average daily output of 12 tons of quicklime per kiln.

Grand River Lime Co., a subsidiary of Scioto Lime & Stone Co., Inc., Delaware, Ohio, was established at Grand River, Ohio, in 1959. It began producing open-market quicklime for metallurgical use in 1960 with an 8- by 170-foot rotary kiln fired by a mixture of bituminous coal and gas. Calcining temperature was 2,700° F. Installation of a second rotary kiln of identical size would be completed in 1963. Quicklime production from the first kiln was 180 tons per day, and the second kiln was expected to raise total output to 400 tons per day. The high-calcium limestone feed came from northern Michigan by boat.

Ohio Lime Co., Woodville, Ohio, produced dolomitic quicklime in 36 vertical kilns fired with low-sulfur and low-ash bituminous coal. The coal did not come in contact with the lime, and a very white quicklime was produced.

The captive lime plant of Pittsburgh Plate Glass Co., Chemical Division, Barberton, Ohio, obtained its kiln feed from the deepest underground limestone mine in the United States. Limestone was mined 2,250 feet beneath the surface.

Roberson-Rutherford Co., Cleveland, Ohio, expected to design and build complete lime-manufacturing facilities to supply lime for basic oxygen steelmaking.

The Woodville, Ohio, plant of Standard Lime & Cement Co., Division of Martin Marietta Corp., operated three automated, coal-fired rotary kilns. The limekiln had two diameters of 11 feet and 10 feet and was 350 feet long. Each of the two rotary kilns for calcining refractory material also had two diameters of 11 feet and 10 feet; these kilns were 320 feet long.

Three redesigned, high-capacity vertical kilns (50 feet high by 11 feet square) were operated at Ashtabula, Ohio, to produce captive quicklime for calcium carbide manufacture by Union Carbide Olefins Co., Division of Union Carbide Corp., New York, N.Y. The kilns had been built in 1946 to produce 100 tons of quicklime each per day, but patented improvements had raised individual kiln capacity to about 500 tons per day in 1957.[4] One kiln had produced 550 tons in a day. The capacity of these three kilns was three to six times that of most conventional vertical limekilns of comparable size; other high-capacity vertical kilns did not exceed an output of 300 tons per day.

[4] Erasmus, Hendrik de W., and Hans Leuenberger (assigned to Union Carbide Corp., New York). Lime Kiln. U.S. Pat. 2,933,297, Apr. 19, 1960.

Another division of Union Carbide Corp., Union Carbide Metals Co., began to offer this type of kiln to other lime producers and consumers in 1962. It was anticipated that such high-capacity kilns would be used elsewhere in the calcium carbide industry and for manufacturing captive quicklime in the alkali and steel industries. Union Carbide Metals Co. offered to operate such patented kilns for other lime consumers, to redesign and reconstruct existing vertical kilns on the same principles, to build and sell patented kilns, and to license their manufacture and use for a fee or for a royalty on every ton of quicklime produced during a specified initial operating period. Union Carbide Metals Co. licensed the largest calcium carbide producer in Japan to install this type of kiln, and negotiations were underway with another Japanese company and a French company. A public demonstration of the three patented kilns at Ashtabula, Ohio, was held on August 1.

Ash Grove Lime & Portland Cement Co., Kansas City, Mo., announced plans to build a $3.5 million, 250-ton-per-day lime plant at Portland, Oreg. Thirty acres of the Rivergate industrial district were purchased. This waterfront location was chosen because the limestone feed for the plant would be brought by barge from Blubber Bay, Texada Island, British Columbia. Construction was scheduled to begin early in 1963 and to be completed by the end of the year. Both quicklime and hydrated lime would be produced.

Mercer Lime & Stone Co., Branchton, Pa., calcined limestone from Rogers City, Mich., in five natural-gas-fired vertical kilns to produce lime that was sold mainly to the steel industry. Calcining the local limestone was abandoned in 1946, because the lime produced from it was chemically unsuitable for steel. The optimum size of the limestone kiln feed was 2.5 to 4 inches. Each of the four older kilns had a daily capacity of over 65 tons and required only 4.5 million Btu to produce a ton of quicklime. The fifth and newest kiln began producing in 1959; it had a 100-ton-per-day capacity, and even lower fuel requirements of 4.2 million Btu per ton of lime. Some of the quicklime was hydrated, and both hydrated lime and pebble quicklime were sold in bags and in bulk. Convenient, returnable steel containers that held 6 to 7 tons of lime were used in some bulk shipments.

Warner Co., Philadelphia, Pa., produced two kinds of quicklime and hydrated lime at two plants about 130 miles apart. High-calcium quicklime and hydrated lime were produced at Bellefonte, Pa., and dolomitic quicklime and hydrated lime were produced at Devault, Pa., in the Cedar Hollow plant. Warner Co. had pioneered in the introduction of the rotary limekiln, and calcining at both plants was by rotary kilns. Limestone was mined underground from three levels (the lowest being 960 feet deep) in the Bell mine at Bellefonte, and dolomite was quarried in an open pit at Cedar Hollow, Devault. After crushing, high-calcium quicklime was hydrated atmospherically, and dolomitic quicklime was pressure hydrated. Quicklime and hydrated lime of both kinds were sold in bags and in bulk. Warner Co. has been in business at least since 1799.

A $400,000, 120-ton-per-day, rotary-kiln lime plant was under construction at Rapid City, S. Dak. Pete Lien & Sons, Inc., would lease and operate the Rapid City Lime Co., which would be near the Pete

Lien & Sons limestone quarry. Production of quicklime from the 8.5- by 162-foot rotary kiln was expected to begin in September 1963, and some of the quicklime would be hydrated.

The South Dakota Cement Plant, a State-owned cement plant at Rapid City, S. Dak., considered adding a lime plant to its cement-manufacturing facilities. The cost of the 75,000-ton-per-year lime operation was estimated to be $1.8 million.

Another new waterfront lime plant in the Pacific Northwest also imported limestone feed by barge from Blubber Bay, Texada Island, British Columbia. A Canadian firm, Dominion Tar & Chemical Co., Ltd., and its subsidiary, Gypsum, Lime & Alabastine, Ltd., had organized Pacific Lime Co., Ltd. Its plant was built at Tacoma, Wash., to produce open-market lime. This $3 million, 250-ton-per-day lime producer had a grate-kiln system with a 6-foot 5-inch by 45-foot 8-inch traveling grate and a 10- by 110-foot rotary kiln. It was the second grate-kiln lime plant in the United States. This operation had an unloading dock, limestone and lime storage and recovery equipment units, a hydrating and bagging plant, and a service building. Lime production was scheduled to begin early in 1963.

The first census of transportation conducted by the Bureau of the Census revealed that the open-market lime manufactured by large companies in the Northeastern United States in 1959 and 1960 was shipped the following distances from the lime plant to the consumer or redistribution point: 26 percent of the total lime tonnage was shipped less than 100 miles; 47 percent, from 100 to 299 miles; 13 percent, from 300 to 499 miles; 13 percent, from 500 to 999 miles; and 1 percent, 1,000 miles and over.[5]

CONSUMPTION AND USES

Seventy-six percent of the U.S. primary lime production from limestone, dolomite, and shell was used chemically or industrially; 14 percent was used as refractory material; 9 percent was used in construction; and 1 percent was used in agriculture. Disregarding refractory lime or dead-burned dolomite in the consumption of primary lime, chemical and industrial uses accounted for 87 percent, construction for 11 percent, and agriculture for 2 percent. Combining primary and secondary (regenerated) lime output for an overall total of 17.5 million tons in 1962, chemical and industrial uses accounted for 81 percent, refractory uses for 11 percent, construction uses for 7 percent, and agricultural uses for 1 percent. Chemical and industrial uses accounted for over 99 percent of the regenerated lime, and construction and agricultural uses accounted for less than 1 percent.

Lack of significant change characterized most of the leading uses of lime. Noteworthy gains were reported for soil stabilization, nonferrous ore concentration and refining, and paint manufacture. Consumption of lime remained virtually unchanged in agriculture, finishing, masonry, sewage and trade-wastes treatment, water treatment, tanning, and in the manufacture of alkalies, calcium carbide, glass, petrochemicals, refractories, steel, and sugar. Less lime was

[5] Church, Donald E. New Market Data From Census of Transportation. Am. Marketing Assoc., 46th Nat. Conf., Washington, D.C., June 17–19, 1963, p. 5.

used in manufacturing precipitated calcium carbonate, insecticides, fungicides, and disinfectants, and in petroleum refining.

Not as much primary lime went into the manufacture of paper and pulp as in 1961, apparently because a higher proportion of the lime requirements of the paper industry was supplied by captive regenerated lime. The reported needs of the paper and pulp industry were supplied by 610,429 tons of primary open-market lime, 33,944 tons of primary captive lime, and 3,138,884 tons of captive regenerated lime for a total of 3,783,257 tons of lime from all sources in paper and pulp manufacture.

The 10 leading categories of uses of lime accounted for 84 percent of the total U.S. production of open-market and captive primary quicklime, hydrated lime, and dead-burned dolomite from limestone, dolomite, and shell. The uses were, in descending percentages of the total U.S. primary lime tonnage, alkali manufacture 23 percent, refractories 13 percent, steel 12 percent, ore concentration and refining 8 percent, calcium carbide 7 percent, water treatment 5 percent, paper and pulp 5 percent, sugar 4 percent, masonry 4 percent, and finishing 3 percent. All other lime uses accounted for the consumption of the remaining 16 percent of the production.

Adding regenerated captive quicklime and hydrated lime production from waste carbide lime, calcium carbonate sludge, and precipitated calcium carbonate to the primary open-market and captive quicklime and hydrated lime, the 10 leading uses of lime accounted for 85 percent of the total U.S. production of primary and regenerated lime. On this basis, lime consumption in paper and pulp led all other uses, which were, in descending percentages of the total, paper and pulp 22 percent, alkali manufacture 18 percent, refractories 11 percent, steel 9 percent, calcium carbide 6 percent, nonferrous ore concentration and refining 6 percent, water treatment 5 percent, sugar 3 percent, masonry 3 percent, and finishing 2 percent. All other uses accounted for the consumption of the remaining 15 percent of the combined primary and secondary U.S. lime production.

The universal need for lime was illustrated by producers' reports indicating apparent consumption in every State and the District of Columbia. All States consumed quicklime and hydrated lime, except Alaska and Hawaii, in which only hydrated lime consumption was reported. The leading lime-using States were also major lime-producing States, demonstrating the general rule that most lime is not shipped far from its origin and lime plants are established where lime needs exist. The 3 principal consuming States, that accounted for 28 percent of the apparent U.S. consumption, were, in descending order of lime tonnage consumed, Ohio, Michigan, and Pennsylvania. The next five ranking States, in descending order of quantities consumed, were Texas, New York, Louisiana, Florida, and Alabama. These States combined consumed 27 percent of the U.S. apparent consumption of primary and regenerated lime.

TABLE 6.—Lime sold or used by producers in the United States, by major uses

Use	1961			1962		
	Short tons	Value [1]		Short tons	Value [1]	
		Total	Average per ton		Total	Average per ton
Agricultural	198,357	$2,588,059	$13.05	191,637	$2,636,844	$13.76
Construction	1,223,709	21,042,725	17.20	1,290,229	21,980,560	17.04
Chemical and industrial uses	[2] 9,846,590	[2] 121,333,549	[2] 12.32	10,410,501	131,074,683	12.59
Refractory (dead-burned dolomite)	1,982,759	32,513,247	16.40	1,857,438	31,059,293	16.72
Total [3]	[2] 13,249,000	[2] 177,463,000	[2] 13.39	13,753,000	186,754,000	13.58

[1] Selling value, f.o.b. plant, excluding cost of container.
[2] Revised figure.
[3] Data may not add to totals shown because of rounding.

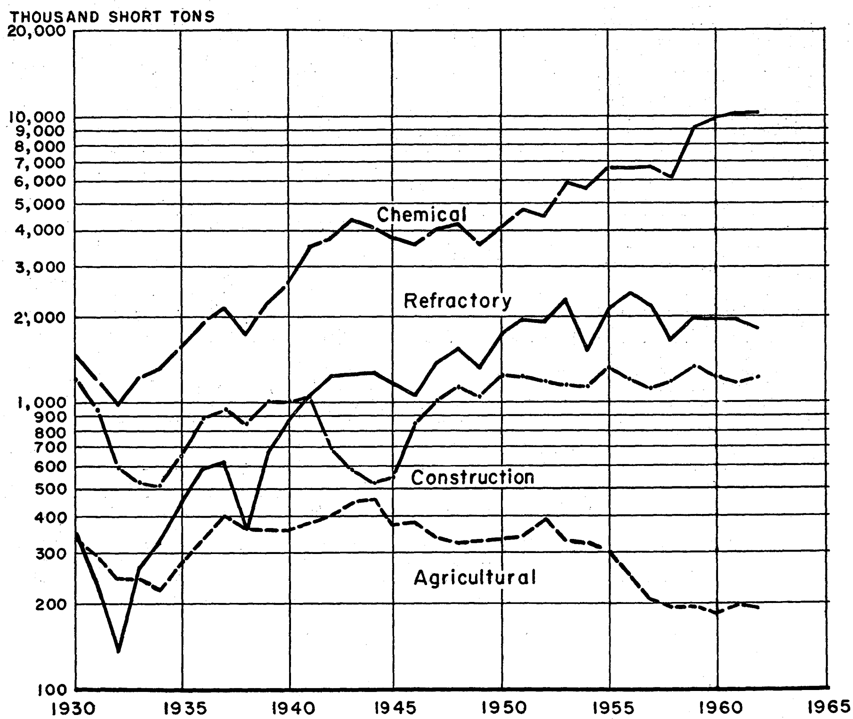

FIGURE 1.—Trends in major uses of lime, 1930–62.

TABLE 7.—Lime sold or used by producers in the United States, by uses

(Short tons)

Use	1961 Open-market	1961 Captive	1961 Total	1962 Open-market	1962 Captive	1962 Total
Agriculture	[1] 198,000		[1] 198,000	192,000		192,000
Construction:						
Finishing lime	427,129	4,641	431,770	446,204		446,204
Mason's lime	479,472	71,769	551,241	469,746	74,165	543,911
Soil stabilization	223,304	620	223,924	275,914	73	275,987
Other	16,774		16,774	24,127		24,127
Total [6]	[1] 1,147,000	[1] 77,000	[1] 1,224,000	1,216,000	74,000	1,290,000
Chemical and other industrial:						
Alkalies (ammonium, potassium, and sodium compounds)	7,058	2,978,053	2,985,111	26,693	3,068,236	3,094,929
Brick, sand-lime, and slag	10,249		10,249	8,856		8,856
Brick, silica	12,481		12,481	16,601		16,601
Calcium carbide	590,508	[1] 362,792	[1] 953,300	565,375	361,339	926,714
Calcium carbonate (precipitated)	(2)	(2)	43,403	(2)	(2)	39,152
Coke and gas (gas purification and plant byproducts)	12,007	3,007	15,014	12,970	2,905	15,875
Food and food byproducts	18,983		18,983	(2)	(2)	15,617
Glass	259,099		259,099	255,861		255,861
Insecticides, fungicides, and disinfectants	28,109	1,991	30,100	18,073	2,405	20,478
Metallurgy (other) [3]	112,150	24,733	136,883	20,988	35	21,023
Oil well drilling	1,757		1,757	4,982		4,982
Ore concentration [4]	166,146	600,007	766,153	236,325	819,139	1,055,464
Paint	(2)	(2)	9,366	(2)	(2)	40,826
Paper and pulp	681,703	[1] 13,678	[1] 695,381	610,429	33,944	644,373
Petrochemicals (glycol)	[1] 100,103	47,501	[1] 147,604	120,804	45,617	166,421
Petroleum refining	57,150		57,150	41,564		41,564
Rubber	855		855	1,176		1,176
Sewage and trade-wastes treatment	[1] 112,378	21,391	[1] 133,769	117,511	15,698	133,209
Steel (open-hearth, basic oxygen, and electric furnace flux)	1,491,543	95,208	1,586,751	1,574,867	74,536	1,649,403
Sugar	[1] 52,540	[1] 471,628	[1] 524,168	30,152	515,008	545,160
Tanneries	59,348		59,348	56,885		56,885
Water softening and purification	[1] 715,824	[1] 34,273	[1] 750,097	741,593	7,130	748,723
Wire drawing	9,140		9,140	11,295		11,295
Undistributed [5]	[1] 324,526	[1] 368,071	[1] 639,828	476,314	515,195	895,914
Total [6]	[1] 4,824,000	[1] 5,022,000	[1] 9,846,000	4,949,000	5,461,000	10,411,000
Refractory lime (dead-burned dolomite)	[1] 1,904,000	[1] 78,000	[1] 1,982,000	1,787,000	71,000	1,858,000
Grand total [6]	[1] 8,072,000	[1] 5,177,000	[1] 13,249,000	8,145,000	5,608,000	13,753,000

[1] Revised figure.
[2] Included with "Undistributed" and "Total" columns to avoid disclosing individual company confidential data.
[3] Includes various metallurgical uses.
[4] Includes flotation, cyanidation, bauxite purification, and magnesium manufacture.
[5] Includes alcohol, calcium carbonate (precipitated), medicine and drugs, explosives, paint, petrochemicals, salt, miscellaneous, and unspecified uses.
[6] Data may not add to totals shown because of rounding.

TABLE 8.—Regenerated lime sold or used by producers in the United States, by uses

(Short tons)

Use	1961			1962		
	Open-market	Captive	Total	Open-market	Captive	Total
Paper and pulp		1,555,192	1,555,192		3,138,884	3,138,884
Water softening and purification	16,411	33,463	49,874	8,163	72,364	80,527
Other [1]	224,368	112,280	336,648	292,664	175,324	467,988
Total [2]	241,000	1,701,000	1,942,000	301,000	3,387,000	3,687,000

[1] "Other" includes regenerated lime for agriculture, calcium carbide, construction, petrochemicals, sewage treatment, and steel. [2] Data may not add to totals shown because of rounding.

TABLE 9.—Apparent consumption of lime (primary and regenerated) sold and used in the United States, by States

(Short tons)

	1961			1962		
	Quicklime	Hydrated lime	Total	Quicklime	Hydrated lime	Total
Alabama	267,404	76,381	343,785	541,458	80,689	622,147
Alaska		137	137		250	250
Arizona	147,025	15,735	162,760	155,083	17,348	172,431
Arkansas	166,537	13,151	179,688	140,029	295,825	435,854
California	569,190	103,974	673,164	533,038	76,874	609,912
Colorado	87,626	14,024	101,650	117,524	21,446	138,970
Connecticut	40,802	24,837	65,639	44,358	24,565	68,923
Delaware	36,970	10,641	47,611	37,914	11,782	49,696
District of Columbia	93	8,225	8,318	20	7,321	7,341
Florida	301,212	61,977	363,189	610,876	57,742	668,618
Georgia	65,062	19,487	84,549	323,377	23,525	346,902
Hawaii		15,306	15,306		15,245	15,245
Idaho	48,714	11,430	60,144	66,530	13,398	79,928
Illinois	414,365	129,071	543,436	411,382	126,862	538,244
Indiana	542,131	38,815	580,946	555,796	39,988	595,784
Iowa	79,314	19,606	98,920	89,986	24,491	114,477
Kansas	40,269	20,216	60,485	44,746	18,512	63,258
Kentucky	542,544	34,052	576,596	560,022	40,798	600,820
Louisiana	845,443	131,837	977,280	854,400	98,146	952,546
Maine	38,777	10,060	48,837	71,529	11,518	83,047
Maryland	210,389	28,904	239,293	210,520	27,215	237,735
Massachusetts	35,994	44,320	80,314	32,552	46,491	79,043
Michigan	1,068,172	79,783	1,147,955	1,095,980	304,688	1,400,668
Minnesota	118,403	19,092	137,495	106,610	18,363	124,973
Mississippi	268,773	11,642	280,415	289,691	17,446	307,137
Missouri	118,656	50,763	169,419	113,978	53,861	167,839
Montana	115,535	5,923	121,458	106,077	4,079	110,156
Nebraska	37,667	8,742	46,409	29,729	9,899	39,628
Nevada	2,153	24,848	27,001	33,278	3,911	37,189
New Hampshire	4,737	3,697	8,434	5,573	3,932	9,505
New Jersey	52,770	96,025	148,795	52,888	99,721	152,609
New Mexico	6,020	42,044	48,064	31,113	22,379	53,492
New York	1,009,243	115,427	1,124,670	1,030,887	138,264	1,169,151
North Carolina	67,638	29,576	97,214	336,428	32,683	369,111
North Dakota	7,691	2,145	9,836	9,878	1,721	11,599
Ohio	1,941,099	149,330	2,090,429	2,026,622	135,367	2,161,989
Oklahoma	36,592	13,925	50,517	44,674	13,552	58,226
Oregon	230,618	9,730	240,348	207,460	13,144	220,604
Pennsylvania	1,023,402	184,904	1,208,306	966,261	254,068	1,220,329
Rhode Island	7,344	6,423	13,767	7,989	6,409	14,398
South Carolina	11,504	6,893	18,397	273,326	7,738	281,064
South Dakota	13,674	14,664	28,338	15,772	3,400	19,172
Tennessee	44,673	28,953	73,626	156,923	58,867	215,790
Texas	541,649	386,290	927,939	717,809	475,882	1,193,691
Utah	94,855	26,359	121,214	99,268	16,298	115,566
Vermont	1,700	1,716	3,416	294	2,705	2,999
Virginia	392,333	37,787	430,120	310,379	43,624	354,003
Washington	330,697	120,314	451,011	346,869	127,172	474,041
West Virginia	125,817	224,732	350,549	183,359	233,508	416,867
Wisconsin	95,401	51,344	146,745	111,367	56,231	167,598
Wyoming	23,901	5,489	29,390	16,826	4,030	20,856
Total [1]	[2] 12,273,000	[2] 2,591,000	14,863,000	14,128,000	3,243,000	17,371,000

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

PRICES

The average price of open-market and captive quicklime and hydrated lime, f.o.b. plant, excluding the cost of containers, increased from $13.39 per ton in 1961 to $13.58 per ton in 1962. The average price per ton had been reported as $13.83 for 1961, but when the tonnage and value of captive lime regenerated at pulpmills, at calcium carbide plants, and at municipal water-treatment plants was eliminated, the unit value changed to $13.39 per ton. Unchanged lime prices were reported throughout the year by Oil, Paint and Drug Reporter.[6] Bulk quicklime was $14.25 per ton, bagged hydrated lime was $17.25 per ton, and bagged hydrated spray lime was $18.25 per ton. These prices, which had been the same since April 21, 1958, were for 25-ton carlots from Eastern lime plants near New York City. Delivered wholesale New York City prices were $6.29 per ton higher when the freight charge from the nearest producing point was added.

Chemical & Engineering News quoted agricultural lime, at works, at $14.50 per ton; chemical, lump, and pebble quicklime, in bulk, at works, $9.50 to $25.10 per ton; hydrated lime in paper bags, at works, $10.00 to $17.50 per ton; and spray hydrated lime in paper bags, at works, $11.00 to $17.00 per ton.[7]

Chemstone Corp., Strasburg, Va., offered chemical pebble quicklime in bulk at $15.50 per ton and in 80-pound paper bags at $19.00 per ton; fluxing pebble quicklime in bulk at $14.50 per ton; chemical hydrated lime in bulk at $15.75 per ton and in 50-pound paper bags at $18.25 per ton; mason's hydrated lime in bulk at $14.00 per ton and in 50-pound paper bags at $16.50 per ton; agricultural hydrated lime in bulk at $14.00 per ton and in 50-pound paper bags at $16.50 per ton; spray hydrated lime in 50-pound paper bags at $18.25 per ton; and general purpose hydrated lime in 10-pound paper bags, loose, at $40.00 per ton and in 10-pound paper bags, baled, at $45.00 per ton. All prices were f.o.b. plant.

FOREIGN TRADE[8]

Imports.—Canadian quicklime, hydrated lime, and dead-burned dolomite or refractory lime accounted for 76,762 tons or 99 percent of the imported tonnage. Eight northern border States (Maine, New Hampshire, Vermont, New York, Michigan, Montana, Idaho, and Washington) and Connecticut received quicklime, hydrated lime, and dead-burned dolomite or refractory lime from Canada. Lime was transported by truck, train, and boat across the international boundary. Seventy-one percent of the lime from Canada (54,580 tons) entered New York; 22 percent (17,012 tons) entered Washington; 4 percent (3,019 tons) entered Michigan; 2 percent (1,110 tons) entered Idaho and Montana combined; 1 percent (869 tons) entered Vermont; and less than 1 percent (172 tons) entered Connecticut, Maine, and New Hampshire combined. Los Angeles, Calif., received refractory lime

[6] Oil, Paint and Drug Reporter. V. 181, Nos. 1–26; v. 182, Nos. 1–27; Jan. 1–Dec. 31, 1962.
[7] Chemical & Engineering News. V. 40, No. 44, Oct. 29, 1962, p. 65.
[8] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

from the United Kingdom and West Germany and hydrated lime from Japan in small quantities.

TABLE 10.—U.S. imports for consumption of lime

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
1953-57 (average)	1,159	$16,634	32,586	$568,061	6,149	$477,628	39,894	$1,062,323
1958	1,000	20,646	18,822	318,495	5,686	322,386	25,508	661,527
1959	530	9,346	26,374	442,330	8,468	495,952	35,372	947,628
1960	676	14,597	18,445	369,051	[3] 12,932	[3] 550,365	[3] 32,053	[3] 934,013
1961	950	21,710	31,418	491,352	4,256	233,271	36,624	746,333
1962	1,141	18,755	71,970	939,226	4,456	244,788	77,567	1,202,769

[1] Dead-burned basic refractory material consisting chiefly of magnesia and lime.
[2] Includes weight of immediate container.
[3] Adjusted by Bureau of Mines.

Source: Bureau of the Census.

Exports.—Lime was exported to 36 countries. Canada received 71 percent (13,799 tons) and Mexico 12 percent (2,295 tons). Together Canada, Mexico, Nicaragua (600 tons), Bermuda (479 tons), the Philippines (346 tons), and the Bahama Islands (268 tons) received 91 percent. The remaining 9 percent was shipped to 30 countries in North America, South America, Asia, Europe, Africa, and Oceania, in descending order of tonnage.

TABLE 11.—U.S. exports of lime

Year	Short tons	Value	Year	Short tons	Value
1953-57 (average)	76,715	$1,412,131	1960	61,056	$991,769
1958	45,844	1,047,310	1961	29,969	920,668
1959	52,780	1,000,337	1962	19,512	660,408

Source: Bureau of the Census.

WORLD REVIEW [9]

Table 12, reporting annual production of quicklime, hydrated lime, and dead-burned dolomite, sold or used, in short tons throughout the world during 1953–62, is presented for the first time. Incompleteness of data precludes statements of annual world production totals. More than likely, every industrialized and semi-industrialized nation produces quicklime and hydrates part of it. Some omissions in this table of countries known to produce lime are: (North America) Guatemala and Mexico; (Europe) Greece and Italy; (Asia) China, India, Iran, Israel, Japan, Pakistan, and Viet-Nam; and (Africa) Federation of Rhodesia and Nyassaland. On the basis of available information for 1961, U.S.S.R. led the world in lime production, followed in descending order by the United States, West Germany,

[9] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.

France, Czechoslovakia, Belgium, and Poland, all producing between 2 and 19 million tons annually. East Germany and the United Kingdom also belong in this group that annually produces 2 million tons of lime or more, but their 1961 lime production data were unavailable.

NORTH AMERICA

Barbados.—Several small kilns were operated, but lime production was not reported.[10]

Bermuda.—A small quantity of lime was produced in 1962, but the tonnage was unknown.[11]

Canada.[12]—Production of lime in 1962 decreased 2 percent below 1961 production, primarily because of the decline in the lime needs of the Ontario uranium industry. Production of quicklime constituted 81 percent and production of hydrated lime constituted 19 percent of the total in 1961. More than one-third of the lime production was captive. The 35 lime plants that operated in 1961 had 98 vertical kilns and 27 rotary kilns, affording a total daily capacity of 7,825 tons of primary quicklime. The number of rotary kilns reported in 1961 remained the same as in 1960. The decrease from 120 to 98 vertical kilns was the consequence of a decision not to count kilns that were not readily available for use. Two hydrated lime plants in Manitoba had no kilns and purchased quicklime.

The first traveling-grate rotary limekiln in Canada was installed at Dominion Tar & Chemical Co., Ltd., Joliette, Quebec. Quicklime capacity was raised from 200 to 500 tons per day. Dominion Magnesium, Ltd., Haley, Ontario, began to fire its limekilns with natural gas. High-calcium limestone from the quarry of Gypsum, Lime & Alabastine, Ltd., at Blubber Bay, Texada Island, British Columbia, would be exported by barge to feed the kilns of two new, northwestern U.S. commercial lime plants—Pacific Lime Co., Ltd., Tacoma, Wash., and Ash Grove Lime & Portland Cement Co., Portland, Oreg. Dominion Tar & Chemical Co., Ltd., and its subsidiary, Gypsum, Lime & Alabastine, Ltd., had organized and built Pacific Lime Co., Ltd., at Tacoma, Wash. It was unusual for Canadian interests to establish a lime plant in the United States. In 1961, Canada exported 30,355 tons of lime to the United States and imported 38,046 tons of lime from the United States. There were 950 employees in the Canadian lime industry in 1960.

Costa Rica.—Estimated lime production in 1962 was valued at $26,857.[13]

El Salvador.—Lime production in 1962 was valued at $12,000.[14]

[10] U.S. Consulate, Barbados, British West Indies. State Department Airgram A–95, Apr. 24, 1963, p. 1.

[11] U.S. Consulate, Hamilton, Bermuda. State Department Airgram A–121, Apr. 23, 1963, p. 1.

[12] Department of Mines and Technical Surveys, Mineral Resources Division (Ottawa, Canada). A Preliminary Survey of the Canadian Mineral Industry in 1962. Miner. Inf. Bull. MR 63, February 1963, p. 42.
Ross, J. S. Lime 1961. Canada Dept. Mines and Tech. Surveys, Miner. Res. Div. (Ottawa, Canada), May 1962, 6 pp.
Northern Miner (Toronto, Canada). V. 47, No. 47, Feb. 15, 1962, p. 5.

[13] U.S. Embassy, San Jose, Costa Rica. State Department Airgram A–651, May 8, 1963, p. 1.

[14] U.S. Embassy, San Salvador, El Salvador. State Department Airgram A–490, Mar. 15, 1963, p. 2.

Guatemala.—Lime was produced, but statistics were not compiled.[15]

Honduras.—The decline in lime production since 1959 was attributed to the installation of the first cement plant in Honduras that year.[16]

Nicaragua.—Output of lime in 1962 was valued at $608,374. The standard unit of weight was the 101-pound bag of lime valued at $1.07 per bag.[17]

Panama.—There was no record of quicklime production.[18]

Puerto Rico.—The lime plant of South Puerto Rico Sugar Corp., Ensenada, operated intermittently and produced 568 tons of quicklime valued at $14,463 in its coke-fired vertical kiln. The output was captive except for 5 tons sold to Caribe Nitrogen for chemical use. All the captive quicklime was used in sugar refining, except for 9 tons used in water treatment. Annual kiln capacity was 8,900 tons of quicklime. Other limekilns were idle, and 11,718 tons of imported hydrated lime supplied the needs of the sugar, chemical, and construction industries. Most of the hydrated lime (10,554 tons) was obtained from Alabama; also, 500 tons came from Maryland, 390 tons from Virginia, 188 tons from Colombia, and 86 tons from the Dominican Republic. Florida Lime Corp., Ocala, Fla., planned to erect a 100-ton-per-day lime plant near Ponce, Puerto Rico. The 8- by 150-foot rotary kiln was expected to produce open-market quicklime to be hydrated for the sugar industry.

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[15] U.S. Embassy, Guatemala, Guatemala. State Department Airgram A–691, May 9, 1963, p. 1.

[16] U.S. Embassy, Tegucigalpa, Honduras. State Department Airgram A–429, May 11, 1963, encl. 1, pp. 1–2.

[17] U.S. Embassy, Managua, Nicaragua. State Department Airgram A–365, May 14, 1963, encl. 1, p. 1.

[18] U.S. Embassy, Panama City, Panama. State Department Airgram A–496, May 8, 1963, p. 1.

TABLE 12.—World production of quicklime, hydrated lime, and dead-burned dolomite, sold or used

(Short tons)

Country	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962
North America:										
Canada	1,228,760	1,214,839	1,331,118	1,295,699	1,378,617	1,596,422	1,685,725	1,529,568	1,415,290	1,380,624
Costa Rica [1]	3,500	5,000	(2)	(2)	3,900	3,100	3,300	4,200	4,200	4,200
El Salvador	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	550	500
Honduras	(2)	(2)	(2)	(2)	12,400	12,600	13,700	11,900	11,500	(2)
Nicaragua	12,535	18,220	18,463	21,395	23,395	25,136	26,627	27,363	28,165	28,675
Puerto Rico	7,338	8,384	10,392	(3)	(3)	(3)	9,816	581	600	568
United States (sold or used by producers)	9,674,000	8,629,000	10,480,000	10,577,000	10,274,000	9,211,000	12,500,000	12,935,000	13,249,000	13,753,000
West Indies:										
British:										
Bahamas	(2)	(2)	(2)	3,840	3,120	3,970	4,120	2,960	3,120	2,480
Barbados	[1] 4,400	(2)	(2)	(2)	(2)	(2)	(2)	11,000	(2)	(2)
Bermuda	[1] 4,800	[1] 4,800	[1] 2,400	[1] 2,400	(2)	(2)	(2)	(2)	(2)	(2)
Dominican Republic	[1] 23,000	[1] 3,700	[1] 4,000	[1] 3,900	[1] 3,900	[1] 5,500	[1] 16,300	8,307	(2)	7,137
Guadeloupe	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	265
Haiti [1]	255,000	340,500	352,500	352,500	180,000	180,000	180,000	180,000	180,000	(2)
Netherlands Antilles (sales)	(2)	3,290	2,900	(2)	(2)	(2)	(2)	(2)	(2)	(2)
South America:										
Argentina	(2)	(2)	880,000	1,650,000	1,650,000	(2)	(2)	(2)	(2)	(2)
Brazil	(2)	884,240	829,929	931,832	932,517	1,098,892	1,223,879	1,177,523	(2)	(2)
Chile	984,405	(2)	984,405	1,058,077	(2)	(2)	(2)	(2)	(2)	(2)
Colombia	(2)	(2)	(2)	55,000	(2)	77,000	83,000	88,000	90,000	94,000
Ecuador	(2)	(2)	(2)	2,278	1,754	(2)	(2)	(2)	(2)	(2)
Paraguay	11,844	9,736	11,188	9,785	10,322	7,998	10,796	14,700	15,482	16,300
Peru	92,843	94,844	132,578	53,814	54,784	56,769	73,855	84,658	76,600	88,100
Uruguay	(2)	(2)	(2)	(2)	(2)	[1] 35,700	[1] 35,700	[1] 35,700	[1] 35,700	[1] 35,700
Venezuela	35,967	41,016	46,452	47,654	63,130	42,539	50,074	43,485	38,257	49,344
Europe:										
Austria	(2)	(2)	(2)	50,109	55,998	54,483	57,112	62,277	65,335	62,756
Belgium	1,651,075	1,721,818	1,997,397	2,042,033	2,099,590	1,944,634	1,955,723	2,129,663	2,126,356	2,250,547
Bulgaria	(2)	(2)	(2)	284,000	317,000	346,000	399,000	474,000	(2)	(2)
Czechoslovakia	(2)	(2)	1,695,000	1,850,000	1,930,000	2,033,000	2,263,000	2,543,000	2,598,000	2,611,000
Denmark	134,688	133,590	126,449	121,909	128,738	112,289	134,133	146,263	161,937	165,347
Finland	218,160	246,437	262,350	234,656	244,267	227,846	217,462	242,500	242,500	242,500
France	(2)	(2)	2,126,078	2,200,386	2,504,317	2,569,790	2,591,143	3,225,500	3.935,000	(2)
Germany:										
East	2,254,000	2,539,000	2,704,000	2,741,000	2,952,000	3,052,000	3,343,000	3,363,000	(2)	(2)
West	(2)	7,448,000	8,484,000	8,712,000	8,924,000	8,683,000	9,623,000	[4] 10,702,000	10,939,000	10,690,000
Hungary	492,346	507,458	562,677	451,000	517,000	506,108	589,983	643,372	675,515	(2)
Ireland	40,451	36,106	37,621	35,781	27,588	28,952	32,982	31,872	(2)	(2)
Luxembourg	35,290	39,145	47,917	58,997	54,037	51,423	47,119	(2)	12,839	(2)
Malta	49,050	45,909	45,225	46,602	16,182	33,930	(2)	43,650	43,725	45,000
Poland	(2)	(2)	1,479,000	1,552,000	1,976,000	2,079,000	2,025,000	2,040,000	2,047,000	(2)
Sweden	(2)	(2)	592,326	689,153	691,132	623,741	659,930	(2)	(2)	(2)
Switzerland	126,587	139,186	154,535	150,592	129,083	119,583	147,230	185,206	204,661	212,306

U.S.S.R	9,270,000	10,589,000	10,901,000	11,525,000	12,641,000	14,909,000	16,966,000	17,792,000	18,955,000	(2)
United Kingdom	2,091,000	2,196,000	2,393,000	2,483,000	2,464,000	1,609,000	2,240,000	(2)	(2)	(2)
Yugoslavia	360,579	361,936	440,702	494,527	600,556	624,310	680,769	776,748	799,707	790,751
Asia:										
Indonesia	(2)	(2)	120	179	137	111	93	119	(2)	(2)
Korea, Republic of	24,692	43,100	62,832	88,185	91,933	49,494	(2)	(2)	(2)	(2)
Lebanon	7,600	5,000	6,600	7,600	[1] 7,700	[1] 5,000	(2)	[1] 7,700	8,300	[1] 9,900
Philippines	(2)	(2)	(2)	11,296	39,172	56,108	43,085	21,111	27,869	(2)
Ryukyu Islands	(2)	(2)	(2)	(2)	(2)	(2)	1,610	866	3,296	820
Sarawak	2,393	396	1,300	353	283	118	34	17	116	132
Syrian Arab Republic	9,100	9,000	8,600	18,200	[1] 16,200	[1] 12,000	[1] 11,000	(2)	(2)	(2)
Taiwan	40,354	39,154	78,760	93,661	101,328	38,344	43,072	44,648	48,143	47,641
Africa:										
Algeria	19,109	21,765	23,276	9,526	12,830	13,804	9,046	15,200	(2)	(2)
Cape Verde Islands	2,066	8,566	(2)	(2)	(2)	(2)	3,060	1,433	2,013	(2)
Congo, Republic of the	103,983	93,581	107,470	107,070	110.738	(2)	(2)	(2)	(2)	(2)
Ethiopia	331	1,518	2,897	3,256	1,300	2,530	2,772	2,763	(2)	(2)
Libya	(2)	(2)	(2)	(2)	11,000	[1] 14,000	[1] 15,000	[1] 17,000	[1] 18,000	[1] 19,300
Morocco	7,700	8,300	8,192	401	(2)	(2)	(2)	(2)	(2)	(2)
Mozambique	3,563	3,663	5,663	6,511	8,164	4,774	(2)	11,590	(2)	(2)
Ruanda-Urundi	3,847	2,780	(2)	2,961	502	(2)	(2)	(2)	(2)	(2)
South Africa, Republic of (sales)	480,700	575,408	707,631	778,309	925,279	868,744	849,231	851,661	758,493	725,689
South-West Africa	----------	303	1,821	5,674	3,248	3,665	3,562	3,310	3,751	3,228
St. Thomas and Principe Islands	823	577	672	712	761	733	607	593	351	(2)
Tanganyika	7,256	5,710	6,553	5,828	4,509	4,632	4,067	4,071	3,833	2,559
Tunisia	100,107	101,205	93,374	87,435	77,104	79,763	99,389	138,760	133,000	141,920
Uganda	644	454	1,609	9,247	9,620	(2)	10,777	16,985	15,555	18,112
Oceania:										
Australia [5]	(2)	(2)	(2)	143,942	135,275	140,221	130,306	124,526	(2)	(2)
New Zealand	19,745	14,401	17,365	(2)	(2)	(2)	(2)	(2)	(2)	(2)

[1] Estimate.
[2] Data not available.
[3] Figure withheld to avoid disclosing individual company confidential data; included in U.S. figure prior to 1961.
[4] Including Saar, beginning 1960.
[5] Year ended June 30 of year stated.

Compiled by Liela S. Price, Foreign Statistics Unit, Division of Foreign Activities.

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SOUTH AMERICA

Paraguay.—Lime production was valued at $411,111 in 1962.[19]

Peru.—Output of lime in 1962 included 44,100 tons for construction, 16,500 tons for mineral concentration, 22,000 tons for agriculture, and 5,500 tons for chemical and industrial uses.[20]

EUROPE

Belgium.—Pebble quicklime, hydrated lime, and sintered refractory lime were produced in 1961. Dead-burned dolomite production was 330,296 tons.[21]

Czechoslovakia.—An automated lime plant at Cebin near Brno began producing quicklime from two vertical kilns. Later a rotary kiln was installed to calcine limestone too small for the vertical kilns.

Denmark.—Output of agricultural lime, including ground limestone, was 231,483 tons, output of industrial lime was 71,650 tons, and total quicklime output was 143,300 tons in 1961.[22]

Finland.—Quicklime production in 1962 was valued at $3 million.[23]

France.—A French company negotiated with Union Carbide Metals Co., New York, N.Y., to modify existing vertical limekilns to include the patented improvements of a new high-capacity vertical limekiln.[24]

Germany, West.—Agricultural lime sales totaled 532,000 tons in fiscal year 1961–62.[25]

Hungary.—Mixed-feed vertical kilns using coke were replaced by more economical producer-gas-fired vertical kilns that used inexpensive, low-grade brown coals and lignites. A lime plant with four vertical kilns fired by producer gas manufactured quicklime at Bélapátfalva. Each kiln had a daily capacity of 70 tons. Another producer-gas-fired lime plant at Dorog had two vertical kilns with a daily capacity of 70 tons of quicklime per kiln.[26]

Italy.—Dolomite Franchi S.P.A., Brescia, and Ing. Filippo and Carlo Tassara S.P.A., Genoa, licensed Basic, Inc., Cleveland, Ohio, to produce a large refractory block used in vertical limekilns and other furnaces in Europe.[27]

Malta.—Lime production in 1961 was valued at $86,206 and in 1962 was estimated at $89,600.[28]

Poland.—Polimex contracted for a $224,000 British Sturtevant-Knibbs continuous-hydration plant that would be manufactured and

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[19] U.S. Embassy, Asunción, Paraguay. State Department Airgram A–429, Apr. 21, 1963, p. 2.
[20] U.S. Embassy, Lima, Peru. State Department Airgram A–778, Apr. 30, 1963, p. 3.
[21] U.S. Embassy, Brussels, Belgium. State Department Dispatch 942, Apr. 19, 1962, encl. 1, p. 2.
[22] U.S. Embassy, Copenhagen, Denmark. State Department Dispatch 824, June 25, 1962, encl. 1, p. 1.
[23] U.S. Embassy, Helsinki, Finland. State Department Airgram A–860, May 8, 1963, p. 2.
[24] Chemical & Engineering News. Carbide Metals Cuts Lime Kiln Costs. V. 40, No. 32, Aug. 6, 1962, p. 28.
[25] Fertiliser and Feeding Stuffs Journal (London). Fertiliser and Lime. V. 57, No. 13, Dec. 26, 1962, p. 554.
[26] Madaras, J. G. A Modern Lime-Burning System. Cement, Lime and Gravel (London), v. 37, No. 5, May 1962, pp. 131–136.
[27] Pit and Quarry. V. 54, No. 7, January 1962, p. 213.
[28] U.S. Consulate, Valletta, Malta. State Department Airgram A–62, Mar. 12, 1963, pp. 2–3.

installed by Sturtevant Engineering Co. Ltd. Its anticipated output of 32 tons of hydrated lime per hour would be used in construction.[29]

Sweden.—Dolomitic quicklime production was 57,320 tons in 1961, and nonpulverized limestone production for lime manufacture totaled 429,456 tons.[30]

United Kingdom.—An oil-fired vertical limekiln was developed and patented by West's Gas Improvement Co. Ltd., Manchester, in collaboration with Catagas Ltd., Taylor Frith & Co. Ltd. (a lime producer), Doveholes, Buxton; and Petrofina Ltd., an oil company. The fuel oil was gasified in Catagas units around the kiln at the base of the calcining zone. The first commercial installation of a West's kiln was at Beswick's Lime Works Ltd., Hindlow, near Buxton, in 1961. This kiln was a cylindrical shaft 65 feet high, over 10 feet in outside diameter, 7.5 feet in inside diameter, and it had a daily capacity of 50 tons of quicklime.[31]

The lime plant of W. L. Hobbs, Ltd., Dyserth, North Wales, calcined Carboniferous limestone in two producer-gas-fired vertical kilns. The quicklime was mainly used in steel manufacture. Nearby at Abergele, North Wales, Limestone Products Ltd. calcined very pure Carboniferous limestone (99.6 percent calcium carbonate) in two producer-gas-fired Priest vertical kilns, each rated at 240 tons per week. Low-sulfur quicklime for steel manufacture was produced in one kiln, and high-sulfur quicklime for all other uses was produced in the other kiln. The sulfur was introduced into the lime from the local coal used to make the producer gas. Part of the production was hydrated. Lime for the steel industry was also manufactured near Kirkby Stephen by Sir Hedworth Williamson's Limeworks Ltd. Carboniferous limestone was calcined in four vertical kilns—two Priest kilns converted from gas firing to mixed-feed coke firing and two masonry kilns of oval cross section (30 feet long, 9 feet wide, and 35 feet deep). The pair of Priest kilns had a maximum combined output of 400 tons per week and consumed 450 pounds of coke per ton of quicklime produced. Hydrated lime was produced in a 4-ton-per-hour Knibbs-Sturtevant hydrator.[32]

Three heavy-oil, gas-fired vertical limekilns of Swedish design were installed at the Derbyshire Stone Ltd. Topley Pike quarry near Buxton, by Industrial Plant (Combustion) Ltd., Sheffield.[33]

Lime production was resumed at Barnetby quarry, Lincolnshire, after 31 years, by Singleton Birch & Co. Ltd. The kiln feed from the quarry was a hard chalk.[34]

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[29] Chemical Trade Journal and Chemical Engineer (London). Lime-Hydrating Plant for Poland. V. 150, No. 3895, Jan. 26, 1962, p. 176.

[30] U.S. Embassy, Stockholm, Sweden. State Department Airgram A–501, Dec. 4, 1962, encl. 1, p. 1.

[31] Cement, Lime and Gravel (London). A New Approach to Oil-Fired Lime Kilns. V. 37, No. 8, August 1962, p. 248; A New Type of Oil-Fired Lime Kiln, The Catagas System. V. 37, No. 11, November 1962, pp. 321–324.

Chemical Age (London). West's Develop New Oil-Fired Lime Kiln. V. 88, No. 2243, July 7, 1962, p. 22.

Steel & Coal (London). Oil-Fired Lime Kilns. V. 185, No. 4903, July 6, 1962, p. 42.

[32] Cement, Lime and Gravel (London). The Quarrying and Processing of Limestone. V. 37, No. 8, August 1962, pp. 223–232.

[33] Cement, Lime and Gravel (London). New Oil Gas-Fired Lime Kilns for Derbyshire Stone Ltd. V. 37, No. 4, April 1962, p. 125.

[34] Cement, Lime and Gravel (London). V. 37, No. 2, February 1962, p. 34.

Sales of agricultural lime and limestone in the fiscal year 1961–62 totaled 6.4 million tons.[35] The spreading of agricultural lime and limestone had increased eight times the annual tonnage spread before World War II as a result of the Government lime-spreading subsidies.[36] Liming subsidies started in 1937.

Soil Fertility Ltd., Beer, calcined lumps of chalk to captive quicklime in four masonry kilns (9 feet in diameter and 30 feet deep) that were fired with anthracite. The quicklime acted as a drying agent when it was mixed with damp chalk from the Beer quarry. The lime absorbed moisture from the chalk and became partially hydrated. The moisture content, which ranged from 8 to 22 percent in the chalk, was reduced to about 2 percent in the lime-chalk mixture that was crushed and sold as agricultural liming material.[37]

ASIA

Israel.—Production of quicklime and hydrated lime was 121,253 tons during the fiscal year 1961–62. Lime exports were 215 tons valued at $6,000 in 1961.[38] The Shfeya plant of Lime and Stone Production Co. Ltd. operated a 180-foot rotary kiln that produced 7 tons of quicklime per hour. The kiln had been manufactured by the British firm, Edgar Allen & Co., Ltd., Imperial Steel Works, Sheffield.[39]

Japan.—Denki Kagaku Kogyo, K.K., the largest calcium carbide producer in Japan, was licensed by Union Carbide Metals Co., New York, N.Y., to install a patented, high-capacity vertical kiln in a new 500-ton-per-day captive lime plant. The Japanese firm agreed to a down payment and royalty payments on the quicklime output during the first 10 years. Another Japanese company also negotiated for the use of this patented kiln.[40]

Lebanon.—Reported lime production in 1962 was valued at $118,421.[41] A modern lime plant equipped with Italian machinery was built at Fatri for $667,000. Its daily capacity of 100 tons could be doubled with some modifications. Consumption of lime in Lebanon was estimated to be about 200 tons per day, one-fourth of which was consumed in the sugar and steel industries. Small scattered pot kilns had supplied whatever lime was necessary before this first modern lime plant in Lebanon was built. The better quality lime from the Fatri plant was expected to bring a higher price of $17 per ton.

Pakistan.—Some construction lime was produced in West Pakistan, but statistics were unavailable.[42]

Ryukyu Islands.—Production of lime in 1962 was valued at $18,600.[43]

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[35] Fertiliser and Feeding Stuffs Journal (London). Fertiliser and Lime. V. 57, No. 13, Dec. 16, 1962, p. 554.
[36] Work cited in footnote 34.
[37] Cement, Lime and Gravel (London). Lime as Part of a Soil Fertility Service. V. 37, No. 5, May 1962, pp. 143–150.
[38] U.S. Embassy, Tel Aviv, Israel. State Department Airgram A–625, Apr. 5, 1963, pp. 6–7.
[39] Cement, Lime and Gravel (London). V. 37, No. 10, October 1962, p. 6a.
[40] Work cited in footnote 24.
[41] U.S. Embassy, Beirut, Lebanon. State Department Airgram A–1082, Apr. 30, 1963, p. 1.
[42] Qureshi, N. H. Industrial Minerals and Rocks of West Pakistan, Review of Mining Activities. Pres. at Cento Symposium on Industrial Rocks and Minerals, Lahore, West Pakistan, 1962, p. 7.
[43] U.S. Consulate, Naha, Ryukyu Islands. State Department Airgram A–11, Mar. 15, 1963, encl. 1, p. 1.

Sarawak.—Lime output was valued at $4,602 in 1961.[44]

Viet-Nam.—The leading industrial establishment in Thua Thiên Province was the Long Tho (long-lived dragon) Lime Plant located a few miles west of Huê. About 12 tons of quicklime was produced daily. Since local building contractors preferred cement to lime, the Government was concerned that lime consumption might diminish to the point where the plant would have to reduce production or shut down.[45]

AFRICA

Libya.—In 1962 output of lime was valued at $490,000.[46]

South Africa, Republic of.—Lime and limestone production was 7,481,944 tons in 1962. Local sales of lime and limestone were 6,568,080 tons valued at $11,758,187. Exports of lime and limestone amounted to 12,551 tons valued at $120,168.[47] In 1961 domestic sales of lump quicklime were 505,925 tons valued at $3,889,288 ($7.69 per ton) and of air-separated hydrated lime, 164,847 tons valued at $1,836,828 ($11.14 per ton).[48] To produce 2,677,400 tons of steel ingots, 108,300 tons of lime and limestone was consumed in 1961.[49] The Northern Lime Co., Ltd., which operated two major lime plants in the northwestern Cape Province at Taungs and Silver Streams, reported a 20-percent decline in profit, the result of lower demand for lime in uranium production. Demand for hydrated lime, manufactured at the Silver Streams plant, increased for use in construction because of its high quality and very high plasticity.[50]

South-West Africa.—In 1961 domestic sales amounted to 4,074 tons valued at $70,043.[51] Exports of lime in 1962 were 3,773 tons valued at $62,748.[52]

Tanganyika.—Lime production in 1962 was valued at $28,000.[53]

Uganda.—Lime production in 1962 was valued at $319,900.[54]

TECHNOLOGY

Calcination.—The second grate kiln in the United States for quicklime production was installed in 1962 at Pacific Lime Co., Ltd., Tacoma, Wash. The Dow Chemical Co. first applied the grate-kiln system to the calcination of limestone at Ludington, Mich., in 1960. This new system had the advantage of yielding uniformly calcined quicklime from mixed sizes of limestone feed, including the small sizes, at high capacity and low fuel requirements of less than 5 to 5.5

[44] U.S. Consulate, Singapore, Malaya. State Department Dispatch 327, Apr. 25, 1962, encl. 3, p. 1.
[45] U.S. Consulate, Huê, Viet-Nam. State Department Airgram A-5, Aug. 13, 1962, p. 3.
[46] U.S. Embassy, Benghazi, Libya. State Department Airgram A-274, Apr. 17, 1963, encl. 1, p. 1.
[47] U.S. Consulate, Johannesburg, Republic of South Africa. State Department Airgram A-362, Mar. 28, 1963, p. 3.
[48] Bureau of Mines. Mineral Trade Notes. V. 55, No. 2, August 1962, p. 45.
[49] U.S. Embassy, Pretoria, Republic of South Africa. State Department Airgram A-25, July 25, 1962, p. 3.
[50] Mining Magazine (London). Northern Lime Co. V. 107, No. 4, October 1962, p. 232.
[51] Work cited in footnote 48.
[52] U.S. Consulate, Johannesburg, Republic of South Africa. State Department Airgram A-334, Mar. 13, 1962, p. 2.
[53] U.S. Embassy, Dar es Salaam, Tanganyika, British East Africa. State Department Airgram A-465, Mar. 11, 1963, p. 2.
[54] U.S. Embassy, Kampala, Uganda. State Department Airgram A-531, May 4, 1963, encl. 1, p. 1.

million Btu per ton of quicklime. The grate kiln consisted of a traveling grate, a short rotary kiln, and a cooler. The traveling grate preheated mixed sizes of limestone feed with recovered exhaust heat, and small size limestone was calcined before it entered the rotary kiln. By virtue of its shorter-than-normal length, the rotary kiln suffered less heat loss by radiation from its shell. The cooler recovered heat for the system from the cooling quicklime and accelerated the rate of production. Efficient vertical kilns also produced quicklime at less than 5 or 5.5 million Btu per ton, but they usually required 5-inch stone. Vertical-kiln quicklime contained cores (uncalcined calcium carbonate), ordinarily more than 5 percent by weight and seldom less than 3 percent, and was contaminated by ash when a solid fuel had been mixed with the feed.[55]

The fluid-bed kiln possessed certain advantages: It consumed only 4 to 4.5 million Btu per ton of quicklime, it calcined the smallest size limestone, and it yielded quicklime that did not require grinding.[56] Fluid-bed kilns, however, required expensive preparation and predrying of limestone feed, and at times the small material lost totaled 10 percent or more of the limestone tonnage processed.[57]

Soft, well-calcined quicklime was produced at a moderate temperature and a low fuel rate in a well-insulated, coke-fired vertical kiln as long as the operation was continuous. A 1-day shutdown resulted in quicklime containing 18 percent residual carbon dioxide (42 percent calcium carbonate core) during the first week of resumed operation. An increased supply of coke before or after shutdown to eliminate residual carbon dioxide (or unburned core) caused overheating, scorification and destruction of refractory lining or backing brickwork, overburning or sintering of quicklime, and hanging of lime in the kiln. When dolomite was calcined in a vertical kiln for sintered or dead-burned dolomite following a shutdown, an underburned, useless material was produced.[58]

Most vertical kilns were unable to equal the rotary kiln in high-capacity quicklime production. The vertical kiln remained competitive, however, because it produced better quality quicklime, initially cost about 50 percent as much as a rotary kiln, produced less troublesome exhaust gases, and consumed only about 4 million Btu per ton of quicklime.[59]

The new, high-capacity, semiautomatic, vertical kiln of Union Carbide Metals Co. maintained and controlled its calcining temperature at 2,300° to 2,500° F by uniform distribution of fluid fuel and air throughout the calcining zone. Horizontal, water-cooled, hollow H-beams, each of which was partitioned into four chambers, extended across the calcining zone in two staggered tiers. The burner beams had oppositely disposed lateral ports along their lengths for delivering a mixture of fuel and air into the calcining zone for primary com-

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[55] Rock Products. New A–C System Obsoletes Other Lime-Kiln Processes. V. 65, No. 11, November 1962, p. 99.
[56] Priestley, R. J. Con: Vertical Kiln Advantages. Chem. Eng., v. 69, No. 23, Nov. 12, 1962, pp. 330, 332.
[57] Work cited in footnote 55.
[58] Eigen, Hans. (The Continuous Operation of Lime Shaft Kilns as a Prerequisite for Uniform Quality of Quicklime.) Zement-Kalk-Gips (Wiesbaden, West Germany), v. 51, No. 2, 1962, pp. 57–64.
[59] Chemical Week. New Kilns Make More Lime. V. 90, No. 1, Jan. 6, 1962, pp. 65–66.

bustion. The top tier had three burner beams and the bottom tier had two burner beams. Natural gas, furnace gas, producer gas, fuel oil, or any combination of these fuels could be used.

A 50-foot vertical kiln of this type, with an 11-foot-square internal cross section, had four zones with these vertical dimensions from top to bottom: 13-foot storage zone of 80-ton capacity for 3.5- by 5.5-inch limestone feed, 16-foot preheating zone, 9.5-foot calcining zone containing the two tiers of burner beams, and 11.5-foot cooling zone. A 65-foot by 11-foot-square vertical kiln had these zone dimensions: 13-foot storage zone of 80-ton capacity, 26-foot preheating zone, 12.5-foot calcining zone, and 13.5-foot cooling zone.

The average core content of the quicklime was as low as 2 percent calcium carbonate. Fuel consumption was 4.5 to 5 million Btu per ton of quicklime. For natural gas costing $0.572 per 1 million Btu, the cost of fuel per ton of quicklime (average 4.75 million Btu per ton) was $2.72. This was contrasted with $3.72 per ton for an efficient rotary kiln that required 6.5 million Btu per ton of quicklime and with as much as $5.72 per ton for an inefficient rotary kiln that required 10 million Btu per ton of quicklime. One vertical kiln of this type, measuring 65 feet by 11 feet in diameter, could produce 500 tons of quicklime per day and equal the output of two rotary kilns 10 feet in diameter and 200 feet long. Compared with two rotary kilns of combined equivalent capacity, capital investment was 50 to 67 percent lower, labor costs were 33 percent lower, maintenance costs were 40 percent lower, and production costs were 20 percent lower.[60]

Natural-gas firing replaced coke firing in the vertical kiln at the Nyssa, Oreg., plant of The Amalgamated Sugar Co. in 1960, and at the Carlton, Calif., plant of Holly Sugar Corp. in 1961. Coke was the conventional fuel for limekilns at beet-sugar plants. The installation of natural-gas firing at the Oregon beet-sugar plant cost more initially than continued coke firing, but fuel cost was only 80 cents per ton of limestone calcined with natural gas, contrasted with $2.50 per ton of limestone calcined using coke. These first two natural-gas-fired kilns in the beet-sugar industry consumed only 4 million Btu per ton of quicklime. Improved methods of gas distribution increased kiln capacity by as much as 70 percent without a corresponding increase in fuel consumption. One part of natural gas was mixed with 10 parts of air, the mixture was distributed uniformly throughout the charge, and gas combustion was complete. This was achieved by using higher gas velocity and more entry ports, by feeding some incoming air through gas ports, and by recirculating gases from the upper regions of the kiln.[61]

The new oil-fired vertical kiln developed and patented by West's Gas Improvement Co. Ltd., Manchester, England, with the assistance

[60] Chemical Engineering. Unique Burner Design Boosts Capacity of Lime Kiln. V. 69, No. 18, Sept. 3, 1962, pp. 74–75.
Chemical Week. Better Burning Boosts Lime Kiln Capacity. V. 91, No. 6, Aug. 11, 1962, pp. 57–58.
Nonmetallic Minerals Processing. At Ashtabula Plant: High Capacity Vertical Lime Kiln Developed by Union Carbide Metals. V. 3, No. 11, November 1962, pp. 24–25.
Pit and Quarry. Vertical Lime Kiln Design Displays Impressive Results. V. 55, No. 4, October 1962, pp. 92–93.
Union Carbide Metals Company. Revolutionary Vertical Lime Kilns. 1962, 6 pp.
Work cited in footnote 24.
[61] Work cited in footnote 59.

of Catagas Ltd., was of conventional gas-firing design but had Catagas oil units installed around the kiln at the base of the calcining zone. Inexpensive, heavy residual oil was flash-vaporized in the Catagas units, and the resulting hot gases passed directly into the charge undergoing calcination. Controlled admission of air and recirculated waste gases regulated the quality of the gas mixture. Air for combustion passed up through the cooling zone in sufficient volume to recover all the heat from the cooling quicklime and return it to the calcining zone. When in continuous operation at nominal capacity, this kiln produced 1 ton of quicklime per square foot of kiln cross section per day. The fuel required to produce 1 ton of quicklime during continuous operation was less than 5 million Btu and cost about $3.50.[62]

The first completely welded rotary kiln in the United States was built in 1933.[63] Automatic arc welding of rotary-kiln joints at the installation site was more economical than manual welding at the site in 1962, especially for the largest rotary kilns (up to 20 feet in diameter and 600 feet or more in length). Transportation limitations required that single kilns of the largest size be shipped from the factory to the plantsite in 17 or more sections. Hand welding in the field was practical only for small rotary kilns of relatively short length consisting of three or four sections. The shell sections with riding rings mounted were butt-joined by tack welding to establish kiln integrity and alinement. Then the girth gear was mounted and the auxiliary drive was installed to permit rotation. Two scaffolds on opposite sides of the field joint supported a beam that held the automatic welding head in a fixed position while the kiln rotated. Two gas torches 180° apart preheated the joint to 200° F. Then the joint was externally welded continuously as the kiln rotated at the slow peripheral speed of 1 foot per minute. Rotation was continued after the completion of the external weld until the temperature at the joint had fallen below 450° F. All joints were inspected to ascertain that the penetration of the external welding was satisfactory before welding began inside the kiln. An automatic welding machine was set inside the kiln so that the internal weld would penetrate the external weld and result in a complete, uniform mass of metal along the joint. Welding inside the kiln proceeded upslope, and the cables of the welding machine were drawn through central holes in the internal kiln bracing so they would not become entangled during rotation.[64]

Lead and zinc slugs in shotgun shells were fired from kiln guns to break up the objectionable clinker rings that formed in the calcining zones of rotary limekilns whenever overheated quicklime fused with the refractory lining. The less expensive lead slugs were satisfactory for smashing ordinary rings, and the zinc slugs were used for extra hard rings. The lower density of zinc permitted the slug made of it to be twice as large as the lead slug. By virtue of its larger size, the zinc slug penetrated deeper into the ring than the lead slug.[65]

Hydration.—To measure the susceptibility of dead-burned dolomite to hydration by atmospheric moisture during storage, tests were con-

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[62] Works cited in footnote 31.
[63] Rock Products. V. 65, No. 10, October 1962, p. 7.
[64] Nonmetallic Minerals Processing. Procedure for Field Welding of Large Rotary Kilns. V. 3, No. 11, November 1962, pp. 28–29.
[65] Rock Products. V. 65, No. 1, January 1962, p. 13.

ducted in a steam humidity cabinet in which temperature and humidity were controlled. The increase in minus 35-mesh particles under standard 24-hour test conditions of 160° F and 85 percent relative humidity correlated with the increase in hydration during long-term storage.[66] Pebble quicklime was fed into the inlet chamber of an improved hydrator and wetted by a horizontally directed stream of water. The hydrating lime fell through baffles into an intermediate mixing compartment and then into an outlet compartment. Movement through the baffles and chambers during hydration minimized the explosive hydration of larger quicklime pebbles.[67]

Granular dolomitic quicklime was hydrated without using liquid water and without yielding a powdered hydrated lime. A fluidized bed of dolomitic quicklime granules was subjected to heated gas in which the water vapor pressure was 60 millimeters of mercury and the calcium oxide became partially hydrated. Then the water vapor pressure was increased at an optimum rate to about 600 millimeters of mercury to complete the hydration of the calcium oxide and to hydrate the magnesium oxide.[68]

The 1962 Azbe Lime Award was presented to Dr. Rune Hedin, Royal Institute of Technology, Stockholm, Sweden, for his paper, "Processes of Diffusion, Solution, and Crystallization in the System $Ca(OH)_2$—H_2O." This hydration study was concerned with the diffusion constant, rate of solution, rate of precipitation, and rate of crystal growth of hydrated lime.[69]

Reuse.—The City of San Diego (Calif.) Water Department calculated the cost of its recovered quicklime after its new $535,000 rotary-kiln lime plant had operated for over a year. Average quicklime recovery during 6 months was 382 tons per month at an average availability of quicklime of 78.57 percent. On that actual availability basis, the operating costs were $8.27 per ton and maintenance cost was $4.12 per ton making a partial cost of $12.39 per ton. This subtotal was converted to the basis of 88-percent quicklime availability, or $13.88 per ton, and $9.17 per ton was added for recovery of capital investment over a 20-year period. The cost of $23.05 per ton of recovered quicklime was $5.00 below the delivered cost of commercial quicklime in San Diego, and, furthermore, an annual expenditure of $10,000 for sludge disposal had been eliminated.[70]

The new lime recovery system at St. Marys Kraft Corp., St. Marys, Ga., was based on an 11- by 275-foot rotary limekiln that replaced two small rotary limekilns. It was more advantageous to install one large-capacity kiln to handle the entire production of secondary quicklime than to add a third small-capacity kiln in raising the daily captive quicklime production from 100 to 225 tons. The single, large kiln

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[66] Hubble, D. H., and W. J. Lackey. Hydration Test for Dead-Burned Refractory Dolomite. Am. Ceram. Soc. Bull., v. 41, No. 7, July 1962, pp. 442–446.

[67] McKinley, Algene H., and David T. Underwood, Jr. (assigned one-third to Floyd W. Bischoff and Delmar F. Bischoff, jointly). Apparatus for Slaking Lime. U.S. Pat. 3,066,016, Nov. 27, 1962.

[68] Sable, Andre (assigned to Société d'Électro-Chimie, d'Électro-Métallurgie et des Aciéries Électriques d'Ugine, Paris, France). Process of Hydrating Granulated Alkaline Earth Metal Oxides. U.S. Pat. 3,044,857, July 17, 1962.

[69] Cement, Lime and Gravel (London). Swedish Scientist Wins Second Lime Award. V. 37, No. 11, November 1962, p. 347.

[70] Rock Products. Rotary Kiln Operating Costs Are Made Public. V. 65, No. 11, November 1962, p. 108.

saved fuel and labor, produced more uniform quicklime, and increased the yield of quicklime per ton of calcium carbonate slurry feed. Lime recovery was improved 7 percent, and lime production was increased 50 percent.

The new kiln could accommodate an increase of 25 percent in the lime requirements for paper manufacture. An average of 200 tons of quicklime, and as much as 235 tons of quicklime, was produced daily from calcium carbonate slurry by the new kiln. Maximum daily capacity was estimated to be 275 tons. The small kilns had recovered 85 to 87 percent of the available lime, but the new kiln recovered 92 to 94 percent of the available lime. More uniform heat distribution and better control by means of instrumentation and automation accounted for the higher rate of recovery. Each ton of quicklime produced in the new kiln required 8.5 million Btu, a significant reduction from the 13 million Btu that had been consumed per ton of quicklime produced in the two small, inefficient rotary kilns that had been replaced. The temperature was 400° F at the feed end of the new kiln and 1,800° F at the discharge end, and the calcium carbonate slurry was calcined for about 3 hours.

The hot dry quicklime discharged from the kiln was passed through a lump breaker and conveyed either to the primary slaker or to storage. In the slaker, the quicklime was slaked in an aqueous sodium carbonate solution (green liquor) yielding caustic soda for digesting wood chips and calcium carbonate sludge that was returned to the slurry tanks for recirculation through the centrifuges and the rotary kiln. The calcium carbonate slurry in the tanks was 65 percent water, but centrifuging reduced the water content to 38 percent in the slurry delivered to the kiln.

The daily loss of 12 to 14 tons of lime (6 to 8 percent of the lime in the continuous-cycle process) was offset by introducing makeup, centrifuged calcium carbonate sludge from the water-treatment system into the centrifuged calcium carbonate sludge from the slurry tanks before it entered the kiln. The lime that was replaced by the captive makeup lime had been lost to the circuit in scrubbers, stacks, and caustic plant rejects. In most papermills, the makeup lime was purchased from commercial lime producers, and it was unusual to employ captive makeup lime as produced and used at St. Marys Kraft Corp.[71]

[71] Levine, Sidney. Lime Recovery and Production Increased by New Kiln at St. Marys Kraft Corporation. Nonmetallic Miner. Proc., v. 3, No. 7, July 1962, pp. 25–27.

Lithium

By Arnold M. Lansche [1] and Victoria R. Schreck [2]

OUTPUT of lithium raw materials, which were produced in three States in the United States, declined moderately in 1962. A small quantity of lithium ore was mined in South Dakota. Imports of lithium minerals increased 14 percent.

DOMESTIC PRODUCTION

Domestic production of lithium raw materials declined 4 percent from 1961. North Carolina continued to be the primary source of lithium ore. Foote Mineral Co. produced spodumene concentrate from ore mined at its Kings Mountain, N.C., quarry, and American Potash & Chemical Corp. recovered coproduct lithium sodium phosphate from Searles Lake, Calif., brines. The Etta Mine in South Dakota was purchased from Maywood Chemical Works, Division of Stepan Chemical Co., and operated by Roy E. Chord of Edgemont and Walter S. Clifford of Custer, S. Dak.

Lithium Corporation of America expanded its lithium ore reserves in North Carolina to more than 20 million tons by acquisition of the Lincoln-National Concentration Corp. properties about 5 miles from Bessemer City.

Production of lithium hypochlorite powder bleach at competitive prices with other bleaching chemicals, was begun at Bessemer City, N.C.

Figures on shipments of lithium ores and compounds from domestic mines were withheld to avoid disclosing individual company confidential data.

CONSUMPTION AND USES

Domestically produced lithium minerals were consumed chiefly in manufacturing lithium chemicals and, to a lesser extent, in the production of ceramics and glass. Various lithium chemicals also were used in the ceramics and glass industries.

Dry lithium hypochlorite became available commercially for use as a bleach in laundries and for the chlorination of water in swimming pools. Lithium hydroxide was converted to stearate or other soap for use in multipurpose greases. The hydroxide also was used as an

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additive to the electrolyte of alkaline storage batteries. Lithium carbonate was used extensively in ceramics and glass. Lithium chloride and bromide were used in industrial air-conditioning systems, and the chloride and fluoride were used in welding and brazing compounds. Other lithium compounds served as polymerization catalysts and were used in the synthesis of organic chemicals.

Lithium metal was used as a degasifier and deoxidizer in metal production, as a constituent of various lightweight alloys, as a component in self-fluxing brazing alloys, and as a polymerization catalyst.

PRICES

Throughout 1962 the price of lithium metal, 99.5 percent pure, was quoted in E&MJ Metal and Mineral Markets at $9 to $11 per pound. The price of lithium carbonate declined moderately.

TABLE 1.—Range of prices on selected lithium compounds, in 1962

(Per pound)

Compound	January	December
Lithium bromide, national formulary, granular bags, works, freight equalized	$2.60	$2.60
Lithium carbonate, technical, drums, ton lots	.57	[1] .50
Drums, smaller lots [2]	.63	------------
Lithium chloride, technical, anhydrous, drums, carlots, truckloads, delivered or works, freight allowed	.87	.87
Less than carlots, same basis	.88-.92	.88-.92
Lithium hydride, powder, drums, 500-pound lots or more, works	9.50	9.50
Lithium hydroxide monohydrate, drums, carlots, truckloads, freight allowed	.54	.54
Less than carlots, same basis	.58	.58
Lithium nitrate, technical, drums, 100-pound lots	1.15-1.25	1.15-1.25
Lithium stearate, drums, carlots, works	.475	.475
Ton lots, works	.485	.485
Less than ton lots, works	.535	.535

[1] Price changed Feb. 12.
[2] Quotation "Technical, drums, 1,999 pounds or less" discontinued Apr. 23.

Source: Oil, Paint, and Drug Reporter.

FOREIGN TRADE [3]

Imports of lithium minerals—spodumene, lepidolite, petalite, and amblygonite—increased 14 percent. Southern Rhodesia continued to be the major supplier with imports from this source up 5 percent over 1961. Mozambique supplied lepidolite from the pegmatite area of the Zambezia district.

WORLD REVIEW

Based on figures that were partly estimated, production of lithium minerals in the free world declined in 1962. Production in the Federation of Rhodesia and Nyasaland—the leading supplier—was 18 percent lower than in 1961.

Australia.—Western Mining Corp., Ltd. exploratory drilling for lithium ore in the Mt. Marion pegmatites, southwest of Kalgoorlie, Western Australia, indicated an apparently large ore potential.[4] In

[3] Figures on imports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.
[4] Bureau of Mines. Mineral Trade Notes. V. 56, No. 2, February 1963, p. 42.

TABLE 2.—U.S. imports for consumption of lithium minerals by countries and U.S. customs districts

Country and U.S. customs district	1961		1962	
	Short tons	Value	Short tons	Value
North America: Canada: Michigan	2,115	$112,769	330	$16,500
Africa:				
Mozambique:				
Maryland			2,196	59,643
Philadelphia			1,149	43,769
South Carolina			2,316	55,928
Total			5,661	159,340
Rhodesia and Nyasaland, Federation of:				
Galveston	8,966	168,513		
Maryland	13,496	392,490	23,603	752,268
Total	22,462	561,003	23,603	752,268
South Africa, Republic of: [1]				
Maryland	2,252	102,806		
New York			1,115	77,929
Total	2,252	102,806	1,115	77,929
Total Africa	24,714	663,809	30,379	989,537
Grand total	26,829	776,578	30,709	1,006,037

[1] Effective Jan. 1, 1962; formerly Union of South Africa.

Source: Bureau of the Census.

one deposit the indicated reserve was reported to be 382,000 long tons containing 1.89 percent lithia. Pilot plant flotation tests produced a 6-percent-lithia concentrate suitable for commercial use.

Canada.—Quebec Lithium Corp. planned to increase production of lithium carbonate to 5 million pounds per year.[5] About 70 percent of the lithium carbonate output was exported to the United States and about 10 percent to the United Kingdom; the remainder was used in Canada. A new low-cost process was developed to produce lithium hydroxide monohydrate and an existing plant was modified to produce 2 million pounds per year. The company reported that its reserves of spodumene ore were virtually unlimited.

Surinam.—Amblygonite was recovered in Surinam in 1961 and 475 short tons was exported.[6]

United Kingdom.—The British Board of Trade considered imposing countervailing and antidumping duties on lithium hydroxide and lithium carbonate received from the United States. These duties would be levied if it were determined that production of these chemicals was being subsidized. Lithium carbonate imported from Canada had a temporary antidumping duty of 14 cents per pound imposed beginning November 30, 1962.[7] The complaining party was Associated Lead Manufacturers, Ltd., the only major United Kingdom producer of lithium chemicals.

[5] Northern Miner (Toronto). Outlook Improving for Quebec Lithium with Sales Rising. No. 39, Dec. 20, 1962, p. 7.
[6] U.S. Consulate, Paramaribo, Surinam. State Department Dispatch 149, June 18, 1962, p. 6.
[7] Chemical & Engineering News. V. 40, No. 50, Dec. 10, 1962, p. 17.

TABLE 3.—Free world production of lithium minerals, by countries

(Short tons)

Country	Mineral produced	1958	1959	1960	1961	1962
North America:						
Canada [1]	Spodumene	1,927	1,378	102	268	242
United States	Lithium minerals	(2)	(2)	(2)	(2)	(2)
South America:						
Argentina	Lithium minerals	175	187	(3)	(3)	(3)
Brazil	Spodumene (exports)	176	468	------	------	(3)
	Amblygonite (exports)	------	590	55	------	(3)
Surinam	Amblygonite	------	------	------	475	(3)
Europe: Spain	Amblygonite	------	------	28	19	(3)
Africa:						
Mozambique	Lepidolite	96	99	1	170	198
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	Eucryptite	398	[4] 57,901 (Eucryptite, Amblygonite, Lepidolite, Petalite, Spodumene combined)	1,334	1,879	866
	Amblygonite	1,835		------	86	35
	Lepidolite	64,699		15,485	24,037	21,243
	Petalite	13,166		63,336	27,698	21,705
	Spodumene	5,238		7,690	1,627	1,496
Ruanda-Urundi	Amblygonite	11	2,965	2,569	1,854	[5] 300
South Africa, Republic of	Lithium minerals	------	10	173	260	1,263
South-West Africa	Amblygonite	534	242	161	136	141
	Lepidolite	1,043	2,168	972	1,418	1,781
	Petalite	7,405	2,787	3,909	2,540	1,007
Uganda	Amblygonite	------	------	------	26	(3)
Oceania: Australia	Petalite	76	------	18	141	[5] 140
Free world total [2]	------	96,779	68,795	95,833	62,634	(3)

[1] Tons of lithia in spodumene concentrates.
[2] U.S. figure withheld to avoid disclosing individual company confidential data. No estimates included in total.
[3] Data not available.
[4] Exports.
[5] Estimate.

Compiled by Helen L. Hunt, Division of Foreign Activities.

TABLE 4.—Federation of Rhodesia and Nyasaland: Exports of lithium ores, by countries

Destination	1961		1962 [1]	
	Short tons	Value [2]	Short tons	Value [2]
Germany, West	1,154	$37,659	226	$3,173
Japan	1,368	28,885	------	------
Netherlands	5,253	106,545	------	------
South Africa, Republic of	165	2,824	------	------
United Kingdom	4,371	56,557	------	------
United States	20,232	305,611	------	------
Other countries	------	------	92	1,763
Total	32,543	538,081	318	4,936

[1] January through June, inclusive.
[2] Converted to U.S. currency at the rate of £1 equals US$2.8022 (1961) and US$2.8078 (1962).

Compiled from Customs Returns of the Federation of Rhodesia and Nyasaland, by Virginia G. Huguley and Corra A. Barry, Division of Foreign Activities.

TABLE 5.—South-West Africa: Exports of lithium ores, by countries

Year and destination	Amblygonite		Lepidolite		Petalite	
	Short tons	Value [1]	Short tons	Value [1]	Short tons	Value [1]
1961:						
Belgium					1,846	$43,727
Germany, West	47	$2,808				
Japan	12	586	628	$14,475	171	3,831
Netherlands			293	6,980	219	4,810
United Kingdom	17	938			121	2,652
Total	76	4,332	921	21,455	2,357	55,020
1962:						
Germany, West	146	8,092	148	1,399		
Japan			1,253	27,297		
Netherlands			75	2,594	233	5,483
United Kingdom					114	2,518
Total	146	8,092	1,476	31,290	347	8,001

[1] Converted to U.S. currency at the rate of one rand equals US $1.3957 (1961) and US $1.3987 (1962).

Compiled from Quarterly Information Circular on Minerals for the Republic of South Africa and the territory of South-West Africa, by Virginia G. Huguley and Corra A. Barry, Division of Foreign Activities.

TECHNOLOGY

The physical and optical properties and chemistry of eucryptite occurring in the Bikita pegmatites of Southern Rhodesia were discussed.[8] Eucryptite occurred in granular aggregates along with petalite and could be distinguished from quartz by its pink fluorescence under ultraviolet light. Crystals were determined to be hexagonal-rhombohedral in shape. Analysis of a transparent crystal of eucryptite gave the lithia content as 9.72 percent. The article compares Bikita eucryptite with synthetic material and with that obtained from Branchville, Conn., the Harding mine in New Mexico, and from Center Strafford, N.H.

Mining operations at the Foote Mineral Co. spodumene mine, Kings Mountain, N.C., were described.[9]

A method of producing lithium carbonate from decrepitated spodumene was patented.[10] Decrepitated spodumene was reacted with a gaseous mixture of sulfur trioxide, water vapor, and air at 335° to 450° C. Lithium sulfate was formed and solubilized in the process. Lithium carbonate was precipitated from the sulfate solution by sodium carbonate and recovered by filtration.

A mixed lithium-vanadium oxide, or lithium-vanadium bronze, was electrochemically produced by the reduction of vanadium pentoxide in a lithium chloride-potassium chloride eutectic melt.[11] The bronze was of practical interest because of its use as a cathode material in high-temperature batteries.

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[8] Hurlbut, Cornelius S., Jr. Eucryptite from Bikita, Southern Rhodesia. Am. Mineralogist, v. 47, Nos. 5–6, May–June 1962, pp. 557–561.

[9] Flow, Ralph C. Mode of Mining at Kings Mountain. Min. Eng., v. 14, No. 10, October 1962, pp. 45–48.

[10] Archambault, Maurice, James U. MacEwan, and Charles A. Olivier (assigned to Dept. of Mines, Quebec, Canada). Method of Producing Lithium Carbonate from Spodumene. U.S. Pat. 3,017,243, Jan. 16, 1962.

[11] Laitinen, H. A., and D. R. Rhodes. The Electrochemistry of V_2O_5 in LiCl-KCl Eutectic Melt. J. Electrochem. Soc., v. 109, No. 5, May 1962, pp. 413–419.

Demand for lithium chemicals was expected to increase, especially because of the characteristics of new compounds.[12] Lithium nitride, described as an ionic nitride, was investigated for applicability in addition reactions, displacements, and polymerization in organic reactions. Lithium perchlorate, suggested as a rocket propellant, can be stabilized against thermal decomposition by 15-mole-percent silver nitrate. Lithium-7 metaphosphate and pyrophosphate are valuable constituents in fused-salt nuclear breeder blankets because of their relatively high-thermal stability and low absorption of thermal neutrons by phosphorous compounds. Phenyllithium appears to be a good source for the introduction of the phenyl group into organic compounds; methyllithium can hinder steroid positioning in organic chemical reactions; and lithium methoxide is suggested for ester exchange in organic chemistry.

Lithium Corporation of America devised a vapor generator for volatilizing lithium salts and injecting the vapor into the atmosphere of hot mills or furnaces under controlled temperature and pressure to coat the metal walls with molten salt and to protect the walls against oxidation.[13]

A process was described for the manufacture of magnesium-lithium alloy castings by melting magnesium in an argon atmosphere and then adding lithium metal and other alloy components, usually aluminum, zinc, silver, and silicon, to the melt.[14]

Research progress was reported in the following areas of interest to producers and consumers of lithium: Phase equilibria of fused lithium, beryllium, and uranium fluorides,[15] luminescence of lithium compounds doped with copper,[16] the use of lithium hydroxide to protect boiler steels from corrosion,[17] and nonpyrophoric and nonexplosive acetylation with lithium acetylide-ethylene-diamine complex.[18] The lithium hydride electrode was discussed.[19] Electrical resistivity and microhardness were used to determine the solid solubility of lithium in aluminum.[20] Lithium chloride brine was used to freeze quicksand at a potash mine.[21]

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[12] Industrial and Engineering Chemistry. A Look at Lithium Compounds. V. 54, No. 6, June 1962, pp. 50–52.

[13] Metal Progress. How Lithium Brings Out the Best in Metals. V. 81, No. 6, June 1962. pp. 19A–19B.

[14] Saia, A., and R. E. Edelman. Producing Magnesium-Lithium Alloy Castings. Foundry, v. 90, No. 8, August 1962, pp. 38–41.

[15] Jones, L. V., D. E. Etter, C. R. Hudgens, A. A. Huffman, T. B. Rhinehammer, N. E. Rogers, P. A. Tucker, and L. J. Wittenberg. Phase Equilibria in the Ternary Fused-Salt System LiF-BeF_2-UF_4. J. Am. Ceram. Soc. and Ceram. Abs., v. 45, No. 2, February 1962, pp. 79–83.

[16] Wanmaker, W. L., and H. L. Spier. Luminescence of Copper-Activated Orthophosphates of the Type $ABPO_4$ (A=Ca, Sr, or Ba and B=Li, Na, or K). J. Electrochem. Soc., v. 109, No. 2, February 1962, pp. 109–114.

[17] Bloom, M. C., W. A. Fraser, and M. Krulfeld. The Corrosion of Steel Due to Concentration of Alkali in Steam Generating Systems (Lab. Studies on Conc. LiOH at 316° C). U.S. Naval Res. Lab. Rept. 5793, July 30, 1962, 9 pp.

Krulfeld, M., and M. C. Bloom. Corrosion Mechanisms (The Corrosion Products Obtained on Steel in Lithium Hydroxide Solutions at 600° F). NRL Progress Rept. PB181070, March 1962, pp. 35–36.

[18] Chemical & Engineering News. Complex Removes Hazard From Acetylation. V. 40, pt. 1, No. 36, Sept. 3, 1962, pp. 48–49.

[19] Indig, Maurice E., and Richard N. Snyder. The Lithium Hydride Electrode. J. Electrochem. Soc., v. 109, No. 9, September 1962, pp. 757–759.

[20] Costas, L. P., and R. P. Marshall. The Solubility of Lithium in Aluminum. AIME Trans. Met. Soc., v. 224, No. 5, October 1962, pp. 970–974.

[21] Thut, A. B. International Minerals Conquers High-Pressure Water and Quicksand to Sink Canadian Potash Shaft. Min. World, v. 24, No. 12, November 1962, pp. 20–24.

Magnesium

By H. B. Comstock[1] and Jeannette I. Baker[2]

AN INCREASE of 28,210 short tons in production of primary magnesium in the United States in 1962 accounted for most of the 26-percent rise in world production during the year. Domestic consumption of 45,951 short tons was the highest since 1956. The quantity of the primary metal used in structural products was 49 percent greater than in 1961. New alloys were developed, and new melting and finishing techniques were reported.

TABLE 1.—Salient magnesium statistics

(Short tons)

	1953-57 (average)	1958	1959	1960	1961	1962
United States:						
Production:						
Primary	74,710	30,096	31,033	40,070	40,745	68,955
Secondary	10,323	8,707	10,090	10,348	[1] 8,125	9,610
Imports for consumption	1,326	537	593	401	1,005	2,359
Exports	3,731	207	1,601	4,467	6,160	6,426
Consumption	46,115	35,352	41,551	37,100	45,533	45,951
Price per pound ....cents	31.40	35.25	35.25	35.25	35.25	35.25
World: Primary production	115,000	78,500	82,400	102,600	[1] 115,100	145,300

[1] Revised figure.

DOMESTIC PRODUCTION

Primary.—Production of primary magnesium in the United States rose 69 percent in 1962. The Dow Chemical Co. plant at Freeport, Tex., Alabama Metallurgical Corp. plant at Selma, Ala., and the Government-owned plant at Canaan, Conn., produced primary magnesium throughout the year. In January production began in Dow's 46,000-ton plant at Velasco, Tex. This brought active annual primary magnesium production capacity to 93,000 tons. Titanium Metals Corp. of America (TMCA) continued, throughout 1962, to recycle magnesium as an integrated operation of its production of titanium at Henderson, Nev.

Secondary.—Recovery of magnesium from new magnesium-base scrap was the highest since 1947. This was accounted for in part by disposal of approximately 1,700 tons of Government-owned new magnesium-base scrap to the highest bidders.

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[2] Research assistant, Division of Minerals.

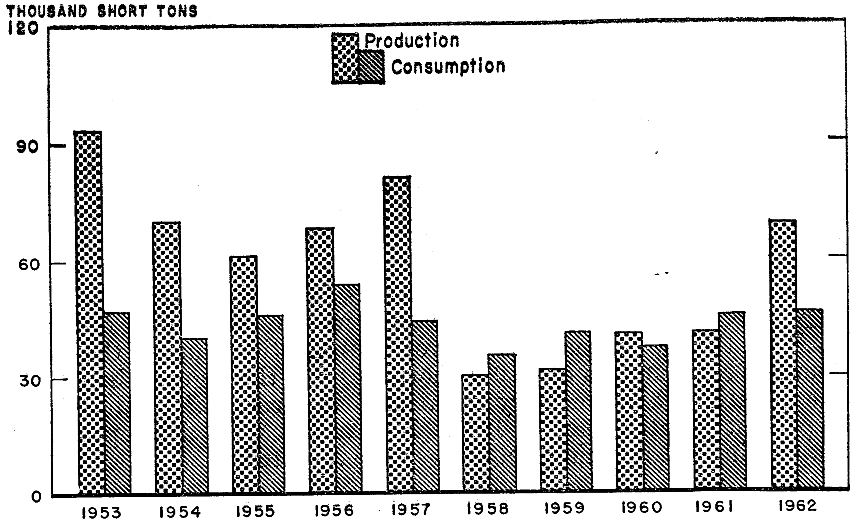

FIGURE 1.—Domestic production and consumption of primary magnesium, 1953–62.

TABLE 2.—Production and shipments of primary magnesium in the United States, by months

(Short tons)

Month	1953–57 (average)		1958		1959	
	Production	Shipments	Production	Shipments	Production	Shipments
January	7,035	7,058	5,272	3,367	1,877	2,976
February	6,420	6,504	3,526	2,060	1,725	3,671
March	7,115	6,135	3,235	2,260	1,925	3,681
April	6,225	5,860	2,772	3,043	1,808	4,176
May	6,690	5,241	2,469	2,415	2,668	3,995
June	6,210	5,613	1,784	2,844	2,778	4,271
July	5,055	4,264	1,799	2,645	2,850	4,559
August	5,675	4,788	1,845	2,610	2,967	4,367
September	5,990	5,224	1,791	2,942	2,846	3,026
October	6,195	4,732	1,927	3,151	3,018	3,556
November	6,020	5,793	1,814	2,911	3,042	4,718
December	6,080	3,693	1,862	3,908	3,529	4,536
Total	74,710	64,905	30,096	34,156	31,033	47,532

Month	1960		1961		1962	
	Production	Shipments	Production	Shipments	Production	Shipments
January	3,355	3,775	3,255	4,090	4,825	5,315
February	3,180	3,675	3,265	4,880	4,570	5,180
March	3,600	5,625	3,470	4,395	5,555	5,395
April	3,290	4,105	3,435	3,560	5,930	5,360
May	3,240	4,465	3,490	4,655	6,160	6,285
June	3,075	4,335	3,440	4,145	5,810	5,020
July	3,120	2,435	3,675	2,270	6,150	5,310
August	3,200	5,310	3,930	4,870	6,035	5,250
September	3,290	4,785	1,525	5,190	5,695	5,300
October	3,535	4,925	3,505	5,165	6,010	6,820
November	3,200	4,470	3,900	7,165	6,125	6,795
December	3,985	6,445	3,855	5,130	6,090	7,380
Total	40,070	54,350	40,745	55,515	68,955	69,410

TABLE 3.—Magnesium recovered from scrap processed in the United States, by kinds of scrap and forms of recovery

(Short tons)

	1953–57 (average)	1958	1959	1960	1961 [1]	1962
Kind of scrap:						
New scrap:						
Magnesium-base	3,484	2,280	3,073	3,179	1,905	4,700
Aluminum-base	1,986	1,653	2,105	2,825	1,500	1,770
Total	5,470	3,933	5,178	6,004	3,405	6,470
Old scrap:						
Magnesium-base	4,203	4,156	4,133	3,560	4,260	2,620
Aluminum-base	650	618	779	784	460	520
Total	4,853	4,774	4,912	4,344	4,720	3,140
Grand total	10,323	8,707	10,090	10,348	8,125	9,610
Form of recovery:						
Magnesium alloy ingot [2]	4,381	2,976	3,881	3,828	1,090	1,110
Magnesium alloy castings (gross weight)	252	78	219	103	360	650
Magnesium alloy shapes	3	3	2	3	350	195
Aluminum alloys	3,053	2,701	3,507	3,208	1,910	1,850
Zinc and other alloys	33	30	21	54	1,095	560
Chemical and other dissipative uses	26	53	600	255	1,350	260
Cathodic protection	2,575	2,866	1,860	2,897	1,970	4,985
Total	10,323	8,707	10,090	10,348	8,125	9,610

[1] Revised figures.
[2] Figures include secondary magnesium content of both secondary and primary magnesium alloy ingot.

TABLE 4.—Stocks and consumption of new and old magnesium scrap in the United States in 1962

(Short tons, gross weight)

Scrap item	Stocks, Jan. 1 [1]	Receipts	Consumption			Stocks, Dec. 31
			New scrap	Old scrap	Total	
Cast scrap	400	3,990	545	3,080	3,625	765
Solid wrought scrap	555	3,705	3,630		3,630	630
Borings, turnings, drosses, etc	180	1,150	1,050		1,050	280
Total	1,135	8,845	5,225	3,080	8,305	1,675

[1] Revised figures.

CONSUMPTION AND USES

A 49-percent increase in consumption of primary magnesium for structural products offset a decrease of 19 percent for distributive or sacrificial purposes. Increased use of magnesium parts in automotive equipment was reported.[3] Use of magnesium alloys in spacecraft was described.[4] A unique new use was developed when magnesium memory disks were installed in computer systems.[5] Magnesium tooling plate was chosen for the disks because of its light weight, low modulus of elasticity, and high damping capacity.

[3] Steel. Materials Battle in Auto Market Continues Unabated. V. 151, No. 21, Nov 19, 1962, pp. 131–132.
[4] Modern Metals. Mag Qualifies in Space. V. 18, No. 11, December 1962, p. 16.
[5] Light Metal Age. Magnesium Memory Discs. V. 20, Nos. 9–10, October 1962, p. 19.

TABLE 5.—Domestic consumption of primary magnesium (ingot equivalent and magnesium content of magnesium-base alloys), by uses

(Short tons)

Use	1953-57 (average)	1958	1959	1960	1961	1962
For structural products:						
Castings:						
Sand	8,655	5,698	4,770	2,561	2,408	3,464
Die	2,058	[1] 1,553	[1] 1,772	[1] 1,528	[1] 1,328	[1] 3,645
Permanent mold	875	889	981	745	464	901
Wrought products:						
Sheet and plate	5,062	4,061	6,128	4,112	4,434	6,352
Extrusions (structural shapes, tubing)	4,523	2,624	3,074	2,580	3,990	5,240
Forgings	184	141	1,913	893	767	415
Total	21,357	14,966	18,638	12,419	13,391	20,017
For distributive or sacrificial purposes:						
Powder	757	352	456	430	244	465
Aluminum alloys	10,814	10,746	14,780	12,511	19,754	18,265
Zinc alloys	(2)	(2)	(2)	(2)	[2] 27	[2] 100
Other alloys	314	446	840	421	1,017	896
Scavenger and deoxidizer	578	708	292	788	344	1,120
Chemical	188	148	351	276	297	405
Cathodic protection (anodes)	3,598	2,028	3,005	3,264	2,406	2,024
Reducing agent for titanium, zirconium, hafnium, uranium, and beryllium [3]	7,488	5,953	3,175	6,978	7,950	2,654
Other [4]	1,021	5	14	13	103	5
Total	24,758	20,386	22,913	24,681	32,142	25,934
Grand total	46,115	35,352	41,551	37,100	45,533	45,951

[1] Includes primary metal to produce small quantities of investment castings.
[2] Before 1961, included with "Other alloys."
[3] Before 1954, included with "Other." 1954, 6,386 tons; 1955, 8,056 tons; 1956, 13,303 tons; 1957, 9,695 tons.
[4] Includes primary metal for experimental purposes, debismuthizing lead, and producing nodular iron and secondary magnesium alloys.

STOCKS

On December 31, 1962, producer and consumer stocks were 7,070 tons of primary magnesium and 3,060 tons of primary magnesium alloy ingot—increases of 280 tons of primary magnesium and 1,110 tons of primary magnesium alloy ingot above stocks at the beginning of the year. At the end of the year the only Government stock of magnesium was 179,000 tons of primary metal in the national (strategic) stockpile.

PRICES

The base price of primary magnesium ingot in standard 42-pound pig form remained at 35.25 cents per pound, f.o.b. plants.

FOREIGN TRADE [6]

Imports of magnesium were more than twice the quantity imported in 1961 and nearly six times the quantity imported in 1960. More than 90 percent of the total 2,447 tons was scrap metal. These imports came from 21 countries: 1,009 tons from Japan, 893 tons from

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

Canada, 167 tons from West Germany, 87 tons from Taiwan, 69 tons from Sweden, 60 tons from the United Kingdom, 20 tons from Algeria, 18 tons from Belgium-Luxembourg, 17 tons from Hong Kong, 13 tons each from Norway and the Republic of South Africa, 12 tons from the Netherlands, 11 tons each from Denmark, Italy, and Morocco, and less than 10 tons each from Singapore, Aden, Tunisia, Australia, Nicaragua, and the Dominican Republic.

On July 1, 1962, the duty on magnesium metal decreased from 50 to 45 percent ad valorem. Duty on magnesium alloys (metallic magnesium content) decreased from 20 cents per pound plus 10 percent ad valorem to 18 cents per pound plus 9 percent ad valorem. For magnesium powder, ribbon, sheets, tubing, manufactures, and so forth, the duty decreased from 17 cents per pound plus 8.5 percent ad valorem to 15.5 cents per pound plus 7.5 percent ad valorem. Suspension of duty on metallic scrap was extended to June 30, 1964.

TABLE 6.—U.S. imports for consumption and exports of magnesium

Year	Imports					
	Metallic and scrap		Alloys (magnesium content)		Powder, sheets, tubing, ribbons, wire, and other forms (magnesium content)	
	Short tons	Value	Short tons	Value	Short tons	Value
1953-57 (average)	1,326	$606.517	15	$116,666	4	[1] $16,867
1958	537	280.316	9	38,096	16	97,194
1959	593	303.307	26	154,775	26	120,630
1960	401	202,087	28	287,916	4	60,623
1961	1,005	482,907	31	170,304	5	80,419
1962	[2] 2,359	[2] 1,079,819	[2] 53	106,242	35	83,399
	Exports					
	Metal and alloys in crude form, and scrap		Semifabricated forms, n.e.c.		Powder	
	Short tons	Value	Short tons	Value	Short tons	Value
1953-57 (average)	3,731	$2,280,570	[3] 293	[3] $712,170	29	$51,642
1958	[4] 207	[4] 225,522	[4] 834	[4] 1,053,844	11	16,147
1959	[4] 1,601	[4] 881.514	[4] 776	[4] 1,146,180	12	31,536
1960	[4] 4,467	[4] 2,658,480	[4] 658	[4] 1,037,325	7	23,048
1961	[4] 6,160	[4] 3,639,669	[4] 488	[4] 878,815	33	78,297
1962	[4] 6,426	[4] 3,656.316	[4] 594	[4] 1,002,977	21	62,980

[1] Owing to changes in tabulating procedures by the Bureau of the Census, data known to be not comparable with other years.
[2] Adjusted by Bureau of Mines.
[3] Owing to changes in items included in each classification 1954-57, data are not strictly comparable to earlier years.
[4] Effective Jan. 1, 1958, some material formerly included with "Metals and alloys in crude form, and scrap" included with "Semifabricated forms, not elsewhere classified."

Source: Bureau of the Census.

Although the rise in exports of magnesium from the United States was just above 5 percent, deliveries to Brazil, France, and Oceania were double the quantities exported to them in 1961.

TABLE 7.—U.S. exports of magnesium, by classes and countries

(Short tons)

Destination	1961			1962		
	Primary metal, alloys, and scrap	Semifabricated forms, n.e.c.	Powder	Primary metal, alloys, and scrap	Semifabricated forms, n.e.c.	Powder
North America:						
Canada	1,363	156	1	1,508	158	6
Mexico	387	53	----------	417	24	----------
Other	----------	9	----------	----------	5	----------
Total	1,750	218	1	1,925	187	6
South America:						
Brazil	169	----------	(1)	259	133	----------
Colombia	----------	8	----------	(1)	14	----------
Venezuela	4	44	----------	4	49	----------
Other	----------	42	----------	17	11	----------
Total	173	94	(1)	280	207	----------
Europe:						
Belgium-Luxembourg	2	10	1	----------	26	7
France	67	35	(1)	249	11	----------
Germany, West	2,297	20	(1)	2,505	53	----------
Italy	19	5	2	47	5	(1)
Netherlands	667	2	(1)	255	18	1
Spain	72	----------	----------	46	----------	1
Sweden	----------	6	4	11	8	3
Switzerland	----------	11	1	----------	9	----------
United Kingdom	616	7	1	620	15	2
Other	341	2	1	145	----------	----------
Total	4,081	98	10	3,878	145	14
Asia:						
India	41	----------	----------	52	----------	----------
Israel	9	21	1	4	9	1
Japan	----------	32	----------	----------	27	----------
Turkey	----------	----------	21	----------	4	----------
Other	6	15	----------	49	12	----------
Total	56	68	22	105	52	1
Africa	6	7	----------	44	2	----------
Oceania	94	3	----------	194	1	----------
Grand total	6,160	488	33	6,426	594	21

1 Less than 1 ton.

Source: Bureau of the Census.

WORLD REVIEW

Canada.—Production of magnesium increased 7 percent in 1962. The United Kingdom continued to receive the larger part of the magnesium exported.[7]

Japan.—The smaller of the two Japanese primary magnesium producers, Asahi Chemical Company, suspended production near the close of 1962.[8]

Norway.—The first stage of a three-phase expansion program at the Norsk Hydro plant at Herøya was completed. This brought annual production capacity to 19,000 tons.[9]

7 Northern Miner (Toronto). Dominion Magnesium Search for Markets Tougher in 1963. No. 44, Jan. 24, 1963, pp. 1, 5.

8 Metal Industry (London). Magnesium Production Suspended by Tokyo Chemical Company. V. 101, No. 24, Dec. 13, 1962, p. 451.

9 Metal Bulletin (London). Norsk Hydro Expansion. No. 4746, Nov. 13, 1962, pp. 22–23.

TABLE 8.—World production of primary magnesium, by countries [1]

(Short tons)

Country	1953-57 (average)	1958	1959	1960	1961	1962
Canada	[2] 7,800	6,796	6,102	7,288	7,635	8,200
China [2]	(3)	1,100	1,100	1,100	1,100	1,100
France	1,495	1,897	1,938	2,359	2,282	2,400
Germany, West	[4] 190	660	550	[2] 330	[2] 440	[2] 440
Italy	2,975	4,607	4,960	6,003	6,167	[2] 6,200
Japan	[4] 180	[5] 1,106	[5] 1,724	[5] 2,363	[5] 2,477	2,300
Norway	6,830	10,132	10,567	11,373	16,018	[2] 16,500
Switzerland	55	------	------	------	------	------
U.S.S.R. [2]	15,300	19,400	22,000	27,600	34,000	35,000
United Kingdom [6]	5,085	2,691	2,387	4,119	4,200	[2] 4,200
United States	74,710	30,096	31,033	40,070	40,745	68,955
World total (estimate) [1]	115,000	78,500	82,400	102,600	115,100	145,300

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[2] Estimate.
[3] Data not available; estimates by senior author included in total.
[4] Average annual production 1954–57.
[5] In addition, the following amounts of remelted magnesium were produced: 1958, 2,567 short tons; 1959, 2,694 short tons; 1960, 3,327 short tons; and 1961, 3,060 short tons.
[6] Primary metal and remelt alloys.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

United Kingdom.—Magnesium Elektron, Ltd., announced that erection of the 5,000-ton thermic magnesium plant, begun at Hampton, Derbyshire, early in the year, was nearing completion.[10]

TECHNOLOGY

Progress in research on magnesium was reported by industry and Government. New alloys were developed, and fabricating techniques were improved.

Continued studies of magnesium alloys, both cast and wrought, indicated need for more specific information on their damping capacity. The Bureau of Mines published a Report of Investigations on the damping capacity of a number of commercial and experimental magnesium alloys.[11] A correlation was established between damping capacity and composition.

Comparative tests of magnesium and aluminum alloys at various stress levels showed that some cast magnesium alloys had 10 to 20 times as much damping capacity as wrought aluminum alloys.[12]

A report was published covering studies of wrought magnesium alloys containing rare-earth elements.[13] Addition of vanadium and titanium dioxide did not increase the strength of magnesium-cerium alloys, but the tensile strength of the alloys was increased by addition of zirconium.

An improved magnesium-lithium alloy was developed.[14] Reduction of aluminum content enhanced workability with no sacrifice of me-

[10] Chemical Trade Journal and Chemical Engineer (London). More British Magnesium. V. 151, No. 3940, Dec. 7, 1962, p. 1147.
[11] Walsh, D. F., J. W. Jensen, and J. A. Rowland. Vibration Damping Capacity of Various Magnesium Alloys. BuMines Rept. of Inv. 6116, 1962, 16 pp.
[12] Kaufman, J. G. Damping of Light Metals. Mat. in Design Eng., v. 56, No. 2, August 1962, pp. 104–105.
[13] Crosby, R. L., and K. A. Fowler. Studies of Magnesium Alloys for Use at Moderate Temperatures. BuMines Rept. of Inv. 6078, 1962, 28 pp.
[14] Willner, Elliott. For Aerospace Applications: An Uultralight Magnesium Alloy. Mod. Metals, v. 18, No. 10, November 1962, pp. 38, 40, 43.

chanical properties. Tests in humid, salt spray, and marine environments indicated that corrosion resistance of the new alloy, designated as LA14XA and containing a maximum of 15 percent lithium and 1.25 percent aluminum, was comparable to that of the magnesium-thorium alloy system.

A new magnesium-rare earth alloy containing silver was developed that could be heat treated to increase its strength.[15]

An improved welding technique was developed for joining magnesium-thorium alloys.[16]

Improved foundry procedures for producing premium quality magnesium alloy castings were described.[17] The importance of control of composition of the metal was stressed, as well as careful melting practices.

A new metering system simplified cold-chamber diecasting.[18] The system was used in 1962 to produce automotive parts. An improved method of melting and pouring that protected the metal from the surrounding atmosphere was developed for magnesium-lithium alloys.[19] When the metal was poured into steel or graphite molds, the molds were capped and an argon atmosphere was maintained until the castings solidified.

An improved annealing process was developed for heat treating rolled magnesium alloys containing thorium.[20] Water vapor introduced into the atmosphere in the heat-treating furnace facilitated cleaning of the finished sheet and plate.

A new magnesium-thorium alloy, HM21A, was prepared in sheet and plate form for structural applications in areas requiring light weight combined with maximum strength and stiffness at temperatures reaching 800° F.[21]

The Department of Mines and Technical Surveys of Canada reported on studies of protection of molten magnesium with fluxes.[22]

A coating process combining anodizing, conversion coating, and sealing was developed in England to protect magnesium when used in corrosive environments.[23]

A new immersion treatment consisting of equal parts of tin and magnesium stannate was developed for coating magnesium alloys before painting.[24] The coating appeared to be particularly suitable for wrought or cast magnesium parts containing inserts and fasteners of dissimilar metals.

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[15] Payne, R. J. M., and Norman Bailey (assigned to Magnesium Elektron, Ltd.). Magnesium Base Alloys. U.S. Pat. 3,039,868, June 19, 1962.

[16] Metal Progress. Welding. V. 81, No. 4, April 1962, pp. 88–92.

[17] Flemings, M. C., and E. J. Poirier. Premium Quality Light Alloy Castings. Light Metal Age, v. 20, Nos. 9–10, October 1962, pp. 14–15.

[18] Light Metal Age. New Magnesium Metering System for Diecasting Automotive Parts. V. 20, Nos. 5–6, June 1962, p. 19.

[19] Saia, A., and R. E. Edelman. Producing Magnesium-Lithium Alloy Castings. Foundry, v. 90, No. 8, August 1962, pp. 38–41.

[20] Brackett, Guy F. (assigned to The Dow Chemical Co.). Anneal for Magnesium Alloys. U.S. Pat. 3,039,901, June 19, 1962.

[21] Materials in Design Engineering. Magnesium Alloy Sheet Tempered to High Strength. V. 55, No. 5, May 1962, pp. 206, 208.

[22] Webster, A. H., and N. F. H. Bright. The Effect of Various Factors on the Protection of Molten Magnesium Metal by Mixed Halide Fluxes. Canada Dept. Mines and Tech. Surveys, TB 35, May 1962, 25 pp.

[23] Miller, Myron. New Protection for Magnesium. Mat. in Design Eng., v. 56, No. 1, July 1962, pp. 90–91.

[24] Modern Metals. Stannate Immersion Treatment for Magnesium. V. 18, No. 2, March 1962, pp. 92–93.

A vitreous enamel in different colors and textures was developed for coating magnesium.[25]

A new chemical treatment for magnesium diecastings was announced.[26] Tests showed that cost of application of the chrome manganate solution after alkaline cleaning was about one-half the cost of the chrome pickle treatment presently in use.

Improvements were noted in uses of magnesium as a reducing agent to produce other metals. The Bureau of Mines conducted studies to produce zirconium with improved properties.[27] A mixture of magnesium and sodium proved to be superior to sodium, alone, for use as a reductant of zirconium tetrachloride. The zirconium produced with the reductant containing magnesium contained less oxygen and was not as hard as the metal prepared with sodium.

A method was developed for preparing high-purity ductile molybdenum by using primary magnesium to reduce molybdenum trioxide.[28]

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[25] Light Metals (London). Vitreous Enamel on Magnesium. V. 25, No. 288, May 1962, p. 117.

[26] American Metal Market. New Pickle Process Developed. V. 69, No. 14, Jan. 19, 1962, p. 24.

[27] Elger, Gerald W. Quality of Zirconium Prepared by Different Reductants. BuMines Rept. of Inv. 5933, 1962, 20 pp.

[28] Campbell, T. T., F. E. Block, and E. R. Andersen. Production of Molybdenum Metal by Magnesium Reduction of Molybdenum Oxides. BuMines Rept. of Inv. 5934, 1962, 22 pp.

Magnesium Compounds

By H. B. Comstock [1] and Jeannette I. Baker [2]

WORLD production of magnesite in 1962 was slightly below that of 1961. This was the first year since 1958 that production did not increase. Production of ore in the United States was the lowest since 1958. The decrease of U.S. exports of magnesite and magnesia was due mainly to expansion of magnesia production capacity in the United Kingdom. Development of improved properties of magnesium oxide was reflected in increased domestic consumption of caustic-calcined magnesia.

TABLE 1.—Salient magnesium compounds statistics

(Thousand short tons and thousand dollars)

	1953–57 (average)	1958	1959	1960	1961	1962
United States:						
Crude magnesite: Production:						
Quantity	538	493	594	499	604	492
Value [1]	$2,618	$2,409	$2,401	$2,051	$3,129	$2,287
Caustic-calcined magnesia:						
Sold or used by producers:						
Quantity	41	45	54	66	80	87
Value [2]	$2,795	$2,648	$3,533	$4,292	$5,004	$5,417
Imports for consumption: Value	$191	$115	$264	$213	$226	$395
Exports: Value	(3)	[4] $884	$667	$686	$535	$427
Refractory magnesia:						
Sold or used by producers:						
Quantity	401	415	518	506	599	576
Value	$20,440	$23,375	$31,458	$30,863	$35,408	$35,186
Imports: Value	$4,696	$5,095	$9,606	$7,576	$3,611	$5,520
Exports: Value	(3)	$2,838	$5,160	$5,988	$7,988	$6,363
Dead-burned dolomite:						
Sold or used by producers:						
Quantity	2,124	1,659	1,988	1,949	1,983	1,857
Value	$31,691	$27,378	$33,069	$32,468	$32,513	$31,059
Imports: Value	$478	$322	$496	$550	$233	$245
World: Crude magnesite: Production:						
Quantity	4,830	6,000	6,500	7,050	8,450	8,200

[1] Partly estimated: most of the crude is processed by mining companies, and very little enters the open market.
[2] Includes specialty magnesia of high unit value.
[3] Data not available.
[4] Corrected figure.

DOMESTIC PRODUCTION

Mines and plants producing magnesium compounds in the United States were listed in table 2 of the Magnesium Compounds chapter in the Minerals Yearbook, 1961. However, Philip Carey Manufac-

[1] Commodity specialist, Division of Minerals.
[2] Research assistant, Division of Minerals.

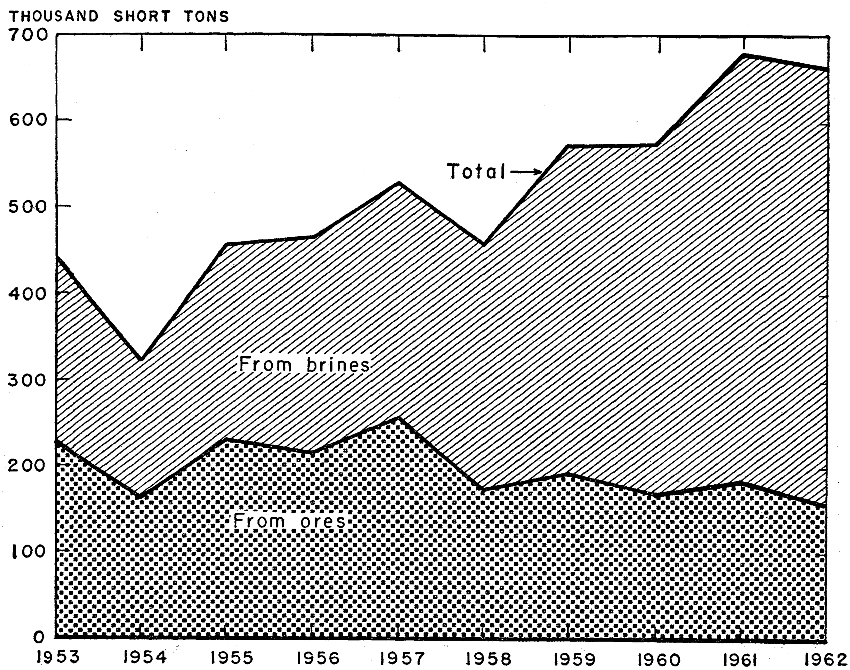

FIGURE 1.—Domestic production of magnesia from ores and brines, 1953–62.

turing Co. ceased production of magnesium carbonate and magnesium oxide at Plymouth Meeting, Pa., and closed the plant in 1962, and International Minerals & Chemical Corp. discontinued production of magnesium oxide at Carlsbad, N. Mex.

Production of crude magnesite decreased 18 percent below that of 1961. It came from Nevada and Washington. The quantity of crude olivine, mined in North Carolina and Washington, again was double that of the previous year. No brucite was mined in 1962.

Approximately 93 percent of the dead-burned dolomite came from Ohio, Illinois, Pennsylvania, Missouri, and West Virginia. Small quantities were produced in Mississippi, Utah, California, and Alabama. Some expansion of basic refractories production capacity was reported. Kaiser Aluminum & Chemical Corp. added facilities at its seawater magnesia plant at Moss Landing, Calif., to produce high-temperature basic refractory materials.[3]

Michigan led the six states, including California, Florida, Texas, New Jersey, and Mississippi, that produced magnesium oxide from sea water and brines. Output of magnesium trisilicate increased 40 percent above that of 1961, and production of magnesium sulfate increased 12 percent.

[3] American Metal Market. Kaiser's New Refractories Plant Starts Operation. V. 70, No. 45, Mar. 7, 1963, p. 16.

CONSUMPTION AND USES

Consumption of crude magnesite rose 11 percent, consumption of olivine increased 21 percent, and consumption of brucite was less than half that of 1961.

Consumption of caustic-calcined magnesia, magnesium chloride, magnesium sulfate and magnesium trisilicate increased considerably. Published reports showed increased use of magnesia and magnesium sulfate to produce paper.[4]

Use of specified magnesias decreased 23 percent, and consumption of refractory magnesia, dead-burned dolomite, precipitated magnesium carbonate, and magnesium hydroxide decreased less than 10 percent.

TABLE 2.—Magnesia sold or used by producers in the United States by kinds and sources

Year and kind	From magnesite, brucite, and dolomite		From well brines, raw sea water, and sea-water bitterns [1]		Total	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1961:						
Caustic-calcined	22,943	$1,069	57,129	$3,935	80,072	$5,004
Refractory	161,332	7,750	437,637	27,658	598,969	35,408
Total	184,275	8,819	494,766	31,593	679,041	40,412
1962:						
Caustic-calcined	21,440	1,001	65,369	4,416	86,809	5,417
Refractory	135,156	6,783	440,567	28,403	575,723	35,186
Total	156,596	7,784	505,936	32,819	662,532	40,603

[1] Magnesium made from a combination of dolomite and sea water is included with that from sea water.

TABLE 3.—Dead-burned dolomite sold in and imported into the United States

Year	Sales of domestic product		Imports [1]	
	Short tons	Value (thousands)	Short tons [2]	Value (thousands)
1953-57 (average)	2,123,993	$31,691	7,149	$478
1958	1,659,184	27,378	5,686	322
1959	1,987,767	33,069	8,468	496
1960	1,949,260	32,468	12,932	550
1961	1,982,759	32,513	4,256	233
1962	1,857,438	31,059	4,456	245

[1] Dead-burned basic refractory material comprising chiefly magnesium and lime.
[2] Includes weight of immediate container.

[4] Chemical Week. Bringing Out Bisulfite. V. 90, No. 26, June 30, 1962, p. 40.
American Metal Market. Paper Firm Uses Magnesia Base Pulping System. V. 69, No. 207, Oct. 26, 1962, p. 10.

TABLE 4.—Specified magnesium compounds produced, sold, and used by producers in the United States

Year and product [1]	Plants	Produced (short tons)	Sold: Short tons	Sold: Value (thousands)	Used (short tons)
1961:					
Specified magnesias (basis, 100 percent MgO), U.S.P. and technical:					
Extra-light and light	5	2,351	2,547	$1,497	----------
Heavy	3	22,963	23,544	2,901	----------
Total	[2] 6	25,314	26,091	4,398	----------
Precipitated magnesium carbonate	5	13,232	4,601	1,017	10,085
Magnesium hydroxide, U.S.P. and technical (basis, 100 percent $Mg(OH)_2$)	5	382,190	206,249	5,634	174,912
Magnesium chloride	7	164,477	12,150	745	[3] 148,000
1962:					
Specified magnesias (basis, 100 percent MgO), U.S.P. and technical:					
Extra-light and light	4	2,440	2,593	1,542	----------
Heavy	2	17,409	17,500	2,670	----------
Total	[2] 4	19,849	20,093	4,212	----------
Precipitated magnesium carbonate	5	13,809	5,218	1,161	8,552
Magnesium hydroxide, U.S.P. and technical (basis, 100 percent $Mg(OH)_2$)	6	357,597	197,386	5,589	157,259
Magnesium chloride	7	261,445	12,921	883	[3] 253,000

[1] In addition, magnesium phosphate, nitrate, sulfate, and trisilicate were produced.
[2] A plant producing more than 1 grade is counted only once in total.
[3] Greater part used for magnesium metal.

TABLE 5.—Domestic consumption of caustic-calcined magnesia by uses

(Percent)

Use	1958	1959	1960	1961	1962
Oxychloride and oxysulphate cement	50	49	47	33	19
Rayon	2	2	3	3	2
Fertilizer	(1)	(1)	1	(2)	(2)
85-percent-MgO insulation	10	4	3	8	1
Rubber	4	1	4	3	3
Fluxes	(1)	(1)	(1)	(2)	(2)
Refractories	(1)	1	9	27	47
Chemical processing	2	2	3	1	1
Uranium processing	6	9	7	5	3
Miscellaneous (including chemicals and paper industry)	26	32	23	20	24
Total	100	100	100	100	100

[1] Less than 1 percent.
[2] Less than 0.5 percent.

TABLE 6.—Domestic consumption of U.S.P. and technical-grade magnesias by uses

(Percent)

Use	1958	1959	1960	1961	1962
Rayon	18	17	21	17	25
Rubber (filler and catalyst)	12	11	9	8	27
Refractories	11	14	14	22	22
Medicinal	(1)	(1)	(1)	(2)	2
Uranium processing	5	1	(1)	(2)	1
Fertilizer	1	1	1	1	4
Electrical	21	14	16	17	----------
Neoprene compounds	2	----------	----------	----------	----------
Oxychloride and oxysulphate cement	----------	7	2	2	----------
Miscellaneous (including chemicals industry)	30	35	37	33	19
Total	100	100	100	100	100

[1] Less than 1 percent.
[2] Less than 0.5 percent.

PRICES

In October the price of magnesium carbonate, technical grade, increased from 11 to 12 cents per pound, and the U.S.P. grade from 13.5 to 14.5 cents per pound. Prices of other magnesium compounds remained unchanged throughout 1962.

FOREIGN TRADE [5]

Imports.—Increased imports of crude magnesite in 1962 were mainly the result of increased deliveries from Australia. Imports of caustic-calcined magnesia rose 74 percent above those of 1961, the largest increases being in the material from Austria and India. For the first time a small quantity was imported from Pakistan. Imports of refractory magnesia almost doubled in 1962, the largest increase being in imports from Austria. Imports of magnesium chloride and precipitated magnesium carbonate increased in 1962.

Exports.—While increases in U.S. exports of magnesite, magnesia, and manufactures (except refractories) to most countries were reported for 1962, the sharp reduction in shipments to Japan and the United Kingdom brought the total value to $5.8 million, a decrease of 32 percent below 1961.

Tariff.—In 1962 duty on crude magnesite remained at 0.234 cent per pound. Duty on dead-burned and grain magnesite and periclase remained at 0.383 cent per pound, and on caustic-calcined magnesia, 0.468 cent per pound.

On July 1, 1962, duty on magnesium oxide decreased from 2.5 to 2.25 cents per pound, and duty on dead-burned dolomite decreased from 15 percent ad valorem to 13.5 percent.

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

TABLE 7.—U.S. imports for consumption of crude and processed magnesite, by countries

Country	1961		1962	
	Short tons	Value	Short tons	Value
Crude magnesite:				
South America: Brazil	----------	----------	55	$1,067
Asia: India	----------	----------	6	267
Oceania: Australia	58	$2,124	1,611	22,528
Total	58	2,124	1,672	23,862
Lump or ground caustic-calcined magnesia:				
Europe:				
Austria	378	13,427	1,073	40,327
Greece	----------	----------	27	1,388
Netherlands	839	48,949	1,064	59,559
United Kingdom	8	2,158	35	2,354
Yugoslavia	331	11,813	226	7,942
Total	1,556	76,347	2,425	111,570
Asia:				
India	2,898	149,772	5,261	279,972
Pakistan	----------	----------	54	3,301
Total	2,898	149,772	5,315	283,273
Grand total	4,454	226,119	7,740	394,843
Dead-burned and grain magnesia and periclase:				
North America: Canada	685	255,515	----------	----------
Europe:				
Austria	23,494	1,636,183	54,816	3,115,572
Greece	12,117	873,829	18,783	1,198,514
Yugoslavia	15,713	845,536	24,158	1,205,880
Total	51,324	3,355,548	97,757	5,519,966
Grand total	52,009	3,611,063	97,757	5,519,966

Source: Bureau of the Census.

TABLE 8.—U.S. imports for consumption of magnesium compounds

Year	Oxide or calcined magnesia		Magnesium carbonate precipitated		Magnesium chloride (anhydrous and n.s.p.f.[1])		Magnesium sulfate (epsom salt)		Magnesium salts and compounds, n.s.p.f.[1] [2]		Manufactures of carbonate of magnesia	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1953-57 (average)	145	[3] $51.967	261	[3] $62,961	315	$9,032	9,934	$231,969	534	[3] $47,647	12	$2,427
1958	355	119,012	326	66,174	685	28,038	9,908	238,236	1,202	52,814	1	660
1959	273	71,498	351	93,721	949	28,141	12,350	302,036	1,925	66,096	1	830
1960	266	65,973	346	83.737	1,174	53,920	10,121	240,661	3,036	94,267	28	6,896
1961	248	61,208	342	73,602	1,012	31.375	10.031	231,022	3,796	117,393	6	3,155
1962	182	47,766	398	94,421	1,474	127,090	9,297	209.787	3,505	106,729	4	2,823

[1] Not specifically provided for.
[2] Includes magnesium silicofluoride or fluosilicate and calcined magnesia.
[3] Data known to be not comparable with other years.

Source: Bureau of the Census.

TABLE 9.—U.S. exports of magnesite and magnesia, by countries

Destination	Magnesite and magnesia, dead-burned				Magnesite and magnesia (except dead-burned) and manufactures, n.e.c.[1]	
	1961		1962		1961	1962
	Short tons	Value	Short tons	Value	Value	Value
North America:						
Canada	12,362	$1,153,317	14,361	$1,181,090	$184,080	$175,577
Honduras					942	396
Mexico	7,088	478,421	16,182	1,050,127	52,815	35,702
Other	5	709	5	650	12,646	6,154
Total	19,455	1,632,447	30,548	2,231,867	250,483	217,829
South America:						
Argentina	75	12,907	516	39,859		512
Brazil	10	6,063	7	4,155	20,467	6,807
Chile	218	15,570	261	18,530	81,335	13,704
Colombia			63	8,650	9,690	570
Peru	990	80,732	1,400	73,950	10,174	27,304
Venezuela			11	1,514	24,534	11,546
Other	1	616	1	270	3,532	3,095
Total	1,294	115,888	2,259	146,928	149,732	63,538
Europe:						
Denmark	51	21,861	255	67,197		
France	200	70,018	364	87,592	498	
Germany, West	6,434	439,587	8,018	655,267	15,002	370
Italy	97	29,952	128	43,961	1,093	2,237
Netherlands	377	24,333	1,199	92,458	416	587
Spain	5	2,280			5,768	81,191
Sweden	21	13,365	67	31,783	24,527	16,852
Switzerland	12	8,454	24	12,499	1,992	4,426
United Kingdom	41,989	2,559,739	367	185,251	36,974	9,309
Other	54	19,537	22	11,005	15,613	6,850
Total	49,240	3,189,126	10,444	1,187,013	101,883	121,822
Asia:						
Japan	52,258	2,927,261	27,816	1,582,926	2,454	450
Kuwait			160	14,742		730
Philippines			34	3,479	6,517	6,872
Other	4	1,286	52	4,430	17,661	8,027
Total	52,262	2,928,547	28,062	1,605,577	26,632	16,079
Africa:						
Liberia						7,370
South Africa, Republic of[2]	46	27,394	281	48,321	2,591	266
United Arab Republic (Egypt)					2,760	
Other			5	712	210	
Total	46	27,394	286	49,033	5,561	7,636
Oceania:						
Australia	325	80,072	235	120,460		250
New Zealand	19	14,230	32	22,047	460	
Total	344	94,302	267	142,507	460	250
Grand total	122,641	7,987,704	71,866	5,362,925	534,751	427,154

[1] Not elsewhere classified.
[2] Effective Jan. 1, 1962; formerly Union of South Africa.

Source: Bureau of the Census.

WORLD REVIEW

Although there were substantial increases in the output of crude magnesite in a number of countries in 1962, total world production fell 3 percent below that of 1961. The U.S.S.R. was the leading producer, followed in descending order by Austria, China, Czechoslovakia, the United States, and Yugoslavia.

EUROPE

Austria.—Both production of crude magnesite and exports of refractory magnesia decreased in 1962.

Greece.—A West German firm made a loan to the Hellenic Magnesite Co. for construction of a rotary kiln to produce dead-burned or calcined magnesia.[6]

Italy.—Sardomag, a company comprised of Italian, British, and German interests, began construction of a 55,000 short ton magnesium oxide plant at St. Antioco, in southeastern Sardinia.[7]

Sweden.—The world's first pulp mill to employ the magnesium bisulfite method, exclusively, began operating in southern Sweden.[8]

United Kingdom.—Steetley Co., Ltd., completed expansion of its magnesia facilities at Hartlepool to increase the annual plant capacity to 220,000 tons.[9]

TECHNOLOGY

Fundamental research on magnesium compounds emphasized improving the properties of magnesium oxide materials.

Studies of magnesium oxide single crystals continued.[10] Annealing at 2,000° C dissolved particles of impurities within the crystals and increased crystal strength.

Ceramic material prepared from magnesium oxide of 99.9 percent purity was developed for electrical insulation.[11] Tests showed that the material maintained superior insulation properties above 2,000° F.

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[6] Metal Bulletin (London). Loan for Hellenic Magnesite Co. No. 4755, Dec. 14, 1962, p. 31.
[7] Bureau of Mines. Mineral Trade Notes. V. 56, No. 3, March 1963, pp. 22–23.
[8] Chemical Age (London). Sweden Has World's First Magnesite Mill. V. 88, No. 2256, Oct. 6, 1962, p. 525.
[9] Refractories Journal (London). The Gossiping Refractory Gleaner. No. 1, January 1962, p. 33.
[10] Stokes, R. J. Dislocation Sources and the Strength of Magnesium Oxide Single Crystals. Trans. AIME, v. 224 (Met. Soc.), 1962, pp. 1227–1237.
[11] Ceramic Industry. New MgO Ceramic. V. 79, No. 2, August 1962, p. 28.

TABLE 10.—World production of magnesite by countries [1] [2]

(Short tons)

Country [1]	1953–57 (average)	1958	1959	1960	1961	1962
North America: United States	537,662	492,982	594,307	498,528	603,656	492,471
Total [1] [3]	860,000	740,000	890,000	810,000	900,000	820,000
South America: Brazil	[3] 11,000	53,116	53,378	69,793	84,549	[3] 83,000
Europe:						
Austria	1,080,244	1,346,133	1,324,106	1,791,701	1,982,704	1,771,863
Czechoslovakia	(4)	(4)	[3] 440,000	[3] 470,000	[3] 550,000	[3] 580,000
Greece	84,002	97,742	123,566	206,451	163,573	[3] 165,000
Italy	4,820	6,500	7,562	6,584	7,478	9,275
Norway	992					
Poland	24,509	15,432	18,188	23,920	29,873	[3] 30,000
Spain	29,274	38,442	44,569	53,239	91,702	[3] 88,000
U.S.S.R.	(4)	(4)	(4)	(4)	[3] 2,750,000	[3] 2,750,000
Yugoslavia	179,810	246,032	269,851	277,613	301,002	411,561
Total [1] [3]	3,300,000	3,750,000	3,900,000	4,500,000	5,900,000	5,800,000
Asia:						
China	(4)	(4)	(4)	(4)	[3] 1,100,000	[3] 1,000,000
India	89,906	114,900	174,129	172,326	231,203	239,201
Pakistan	[5] 24		443	486	180	[3] 180
Turkey	787	717		17	2,414	10,736
Total [1] [3]	560,000	1,270,000	1,530,000	1,530,000	1,390,000	1,310,000
Africa:						
Kenya	23	551	3,145	33	1,930	[3] 1,900
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	8,349			8,031	13,881	11,620
South Africa, Republic of	28,151	80,200	58,883	66,793	67,732	102,352
Tanganyika (exports)	215	337	118	126	46	
Total	36,738	81,088	62,146	74,983	83,589	115,872
Oceania:						
Australia	66,166	77,718	67,860	69,626	100,651	[3] 60,000
New Zealand	662	1,344		891	650	[3] 660
Total	66,828	79,062	67,860	70,517	101,301	[3] 60,660
World total (estimate) [1] [2]	4,830,000	6,000,000	6,500,000	7,050,000	8,450,000	8,200,000

[1] Quantities in this table represent crude magnesite mined. Magnesite is also produced in Bulgaria, Canada, Mexico and North Korea, but data on tonnage of output are not available; estimates by senior author of chapter included in total.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Estimate.
[4] Data not available; estimate by senior author of chapter included in total.
[5] One year only, as 1957 was first year of commercial production.

Compiled by Liela S. Price, Division of Foreign Activities.

TABLE 11.—Austria: Exports of magnesia and magnesite brick by countries [1]

(Short tons)

Destination	Magnesia				Magnesite brick	
	Caustic-calcined		Refractory			
	1961	1962	1961	1962	1961	1962
North America: United States	402	1,032	40,328	54,113	23	8
South America:						
Argentina	44	44	1,853	2,958	2,500	4,697
Brazil	29	45	61	33	1,470	949
Chile	5	-----	526	456	1,333	821
Venezuela	88	53	615	202	239	455
Europe:						
Belgium-Luxembourg	214	197	1,958	1,833	6,606	7,252
Bulgaria	-----	-----	43	119	548	1,649
Czechoslovakia	4,381	3,614	-----	1	98	1,219
Denmark	252	263	767	252	3,437	4,280
Finland	-----	-----	433	440	2,562	2,461
France	3,186	1,563	11,225	12,460	29,199	25,027
Germany, West	88,421	88,407	76,876	83,812	32,491	24,762
Greece	-----	-----	204	270	1,218	2,256
Hungary	1,753	2,441	13,584	10,389	20	-----
Italy	4,738	4,408	35,606	22,493	10,740	12,829
Netherlands	87	164	208	111	1,268	1,059
Norway	35	22	680	576	3,167	3,867
Poland	-----	-----	12,737	13	3,670	2,965
Portugal	19	19	1,731	360	3,541	2,990
Rumania	-----	-----	228	198	2,319	4,396
Spain	35	8	112	334	998	2,710
Sweden	164	754	1,351	1,657	10,257	10,054
Switzerland	2,998	3,385	675	716	1,814	2,156
United Kingdom	19	10	54,339	12,153	9,956	4,724
Asia:						
India	-----	-----	107	217	930	1,146
Israel	-----	-----	1,239	682	658	794
Japan	-----	-----	2,766	6	16	87
Turkey	-----	-----	80	62	1,499	1,019
Africa:						
Central African Republic	11	-----	128	187	4,128	4,796
South Africa, Republic of	-----	-----	41	5	646	1,147
United Arab Republic (Egypt)	-----	-----	5	223	73	736
Oceania: Australia	-----	-----	1,182	97	9,352	2,595
Other countries	72	54	533	890	4,583	3,251
Total	106,953	106,483	262,221	208,318	151,359	139,157

[1] This table incorporates some revisions.

Compiled from Customs Returns of Austria by Corra A. Barry, Division of Foreign Activities.

TABLE 12.—Greece: Exports of magnesite and calcined magnesia, by countries

(Short tons)

Destination	Crude magnesite		Calcined magnesia	
	1961	1962	1961	1962
Canada	-----	-----	3,411	2,205
France	3,307	5,451	2,147	5,209
Germany, West	876	508	13,005	13,649
Italy	9,713	14,248	-----	-----
Netherlands	2,370	2,146	31,999	30,928
Poland	772	331	-----	-----
United Kingdom	2,425	3,147	7,531	6,559
United States	-----	-----	21,803	25,172
Other countries	883	2	4,624	5,471
Total	20,346	25,833	84,520	89,193

Compiled from Customs Returns of Greece by Corra A. Barry, Division of Foreign Activities.

TABLE 13.—Netherlands: Exports of refractory magnesia, by countries [1]

(Short tons)

Destination	1961	1962
Belgium-Luxembourg	1,012	1,184
France	556	644
Germany, West	7,180	9,439
Italy	57	124
Other countries	18,010	22,321
Total	26,815	33,712

[1] This table incorporates some revisions.

Compiled from Customs Returns of the Netherlands by Corra A. Barry, Division of Foreign Activities.

Research by the U.S. Air Force to develop improved refractory ceramics included preparation of sinterable magnesium oxide.[12] Calcining high-purity basic magnesium carbonate at 1,100° F, resulted in a maximum density of 97 to 98 percent.

Studies of performance of refractories in glass plants provided new information for preparing basic brick and shapes to replace fireclay, alumina, and silica refractories.[13] The basic materials installed in heat exchange regenerators, port neck, and uptake applications had longer life and provided greater fuel efficiency than the materials they replaced.

Basic refractory producers and glass plant operators continued to test new basic materials and gather data in an effort to lengthen the life of refractories in the various environments of the regenerative systems.[14]

Improvements were developed in measuring the resistance of basic refractories to slags.[15]

Investigating materials for use in advanced infrared technology provided information on the desirable qualities of magnesium fluoride and the techniques for its preparation and formation into required sizes and shapes.[16] When high-purity magnesium fluoride was heated to 650° C and held under pressure of 30,000 pounds per square inch for 15 minutes, the material became as dense and transparent as the grown crystal.

At its Norris (Tenn.) Metallurgy Research Laboratory, the Bureau of Mines recovered spinel from dusting slags and determined its value as refractory material.[17] The spinel was recovered by acid leaching slags in the system $MgO \cdot Al_2O_3$–$2CaO \cdot SiO_2$. Small additions of magnesium fluoride and magnesium chloride were required for good bonding but the melting point remained above 1,970° C. Other work at the laboratory included the use of forsterite, stabilized dolomite, and chrome spinel to form lightweight basic refractories from bubbles.[18]

[12] Hyde, C., and W. H. Duckworth. Investigation of Sinterable Oxide Powders and Ceramics Made From Them. U.S. Dept. Commerce, Office of Tech. Serv., AD 266,735, June 1961, 20 pp.

[13] Van Dreser, M. L. Basic Refractories for the Glass Industry. Glass Industry, v. 43, No. 1, January 1962, pp. 18–21, 37, 41.

[14] Fischer, C. F. Basic Refractories in Glass Tank Regenerators. Ceram. Age, v. 78, No. 12, December 1962, pp. 55–58.

[15] Bachman, J. R. Basic Bricks in Open Hearth Roofs. Blast Furnace and Steel Plant, v. 50, No. 5, May 1962, pp. 415–419.

[16] Buckner, Dean A., Harold C. Hafner, and Norbert J. Kreidl. Hot-Pressing Magnesium Fluoride. J. Am. Ceram. Soc., v. 45, No. 9, September 1962, pp. 435–438.

[17] Tyrrell, M. E. Refractory Properties of Magnesia Spinel Recovered From Dusting Slags. BuMines Rept. of Inv. 5944, 1962, 8 pp.

[18] Tyrrell, M. E. Experimental Production of Lightweight Basic Refractories. BuMines Rept. of Inv. 6025, 1962, 16 pp.

The refractories were 35 percent lighter in weight than commercial brick and shapes and, per unit of weight, their tolerance was better for open-hearth slag.

Research was reported on development of tests for the properties of calcined dolomite.[19] A hydration test determined the effect of screen sizing, bulk density, and heat treatment of the calcined material.

Studies to improve the properties of olivine for use as foundry molding sand included air polishing and washing with water to remove fines and many impurities.[20] A test procedure was developed for calcining the cleaned sand in an oxygen-free atmosphere to determine moisture and gas content.

Techniques were described for using olivine sand to line pouring ladles in steel foundries.[21]

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[19] Hubble, D. H., and W. J. Lackey. Hydration Test for Dead-Burned Refractory Dolomite. Am. Ceram. Soc. Bull., v. 41, No. 7, July 1962, pp. 442–446.

[20] Ford, P. W. Olivine Sand Combined Moisture Study. Modern Castings, v. 42, No. 2, August 1962, pp. 58–63.

[21] Weber, T. L. Use of Olivine Sand for Ladle Linings. Foundry, v. 90, No. 2, February 1962, pp. 129, 131.

Manganese

By Gilbert L. DeHuff [1] and Teresa Fratta [2]

DOMESTIC production of manganese ore—ore, concentrates, and nodules containing 35 percent or more manganese—dropped to about 25,000 short tons in 1962, production being reported from California, Montana, and New Mexico only. Increased ore consumption, as well as lower imports accounted for a sizable drop in industrial ore stocks from 2.2 million tons at the beginning of the year to 1.8 million tons at yearend. Although ferromanganese imports were approximately half of those of 1961, those for commercial accounts were greater. Exports of high quality metallurgical ore began moving to Europe and to the United States from Gabon's important Moanda deposits which have been under development since 1959.

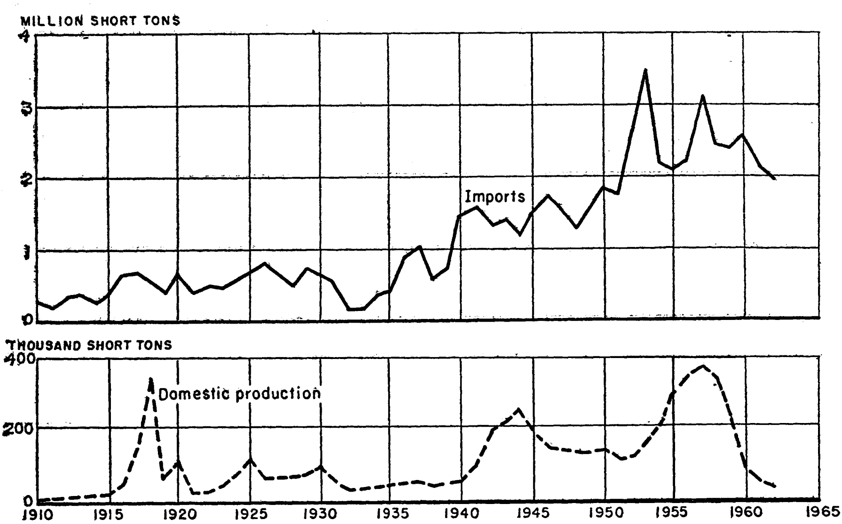

FIGURE 1.—General imports and domestic production (shipments) of manganese ore, 1910–62.

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[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

LEGISLATION AND GOVERNMENT PROGRAMS

The Office of Minerals Exploration (OME) continued to offer financial assistance for exploration of domestic manganese deposits to the extent of 50 percent of approved exploration costs.

Acquisition of both manganese ore and ferromanganese for the supplemental stockpile continued under Commodity Credit Corporation, U.S. Department of Agriculture, contracts for barter of surplus U.S. agricultural products.

In September, General Services Administration accepted an offer of The Anaconda Company to purchase 152,500 short dry tons of manganese carbonate ores that had been purchased by the Government under the Defense Production Act (domestic manganese purchase program) and stockpiled at Butte and Philipsburg, Mont., during 1951–58. The contract price for these ores, which were not of National Stockpile specification grade, was $1,089,864. In the course of the year, a contract was completed for conversion in the United States of Government-owned manganese ores, producing 1,381 tons of electrolytic manganese metal. This was the first conversion undertaken of manganese ores held in Government inventory. In other actions involving Government manganese stocks, 800 tons of ferromanganese fines and 4.5 tons of subspecification electrolytic manganese were sold.

TABLE 1.—Salient manganese statistics in the United States

	1953–57 (average)	1958	1959	1960	1961	1962
Manganese ore (35 percent or more Mn):						
Production (shipments):[1]						
Metallurgical____short tons__	262,480	327,309	223,164	70,905	39,246	19,007
Battery__________do____	9,906	(2)	6,011	9,116	6,832	5,729
Miscellaneous__________do____	12	----------	24	----------	10	22
Total[1]__________do____	272,398	327,309	229,199	80,021	46,088	24,758
Value__________thousands__	$21,132	$23,637	$17,904	$5,352	[3] $3,224	(4)
Imports, general_____short tons__	2,617,725	2,452,578	2,397,804	2,543,841	2,098,438	1,971,232
Consumption__________do____	2,134,326	1,497,574	1,605,507	1,946,389	1,717,805	1,872,564
Manganiferous ore (5 to 35 percent Mn):						
Production (shipments)[1]__do____	851,027	520,601	470,600	658,455	225,004	338,501
Value__________thousands__	$4,910	$3,532	$3,153	$4,466	$1,480	(4)
Ferromanganese:						
Production__________short tons__	876,611	636,736	629,307	842,818	732,813	781,112
Imports for consumption__do____	149,339	63,932	90,062	120,222	221,936	125,614
Exports__________do____	2,855	1,406	947	751	469	4,114
Consumption__________do____	892,739	674,495	755,229	800,430	778,003	805,441

[1] Shipments are used as the measure of manganese production for compiling U.S. mineral-production value. They are taken at the point at which the material is considered to be in marketable form for the consumer.

[2] Battery ore included in metallurgical.

[3] Revised figure.

[4] Combined value for total manganese ore and total manganiferous ores equals $4,268,000.

DOMESTIC PRODUCTION

Most of the manganese ore—ore, concentrates, and nodules, containing 35 percent or more manganese—produced in the United States in 1962 came from Montana. Taylor-Knapp Co. at Philipsburg, Mont., produced natural battery-grade concentrate, miscellaneous concentrate, and middlings from its own and purchased oxide ores. Metallurgical (oxide) nodules were produced in Montana from stocks of previously mined carbonate ore, including stocks that had been purchased by the Government under its 1951–58 depot (low-grade) domestic manganese purchase program. Metallurgical manganese ore or concentrate was produced in California and New Mexico. Production of synthetic battery ore and synthetic miscellaneous ore (high-purity manganese carbonate) from Cuyuna manganiferous materials by Manganese Chemicals Corp. at Riverton, Minn., ended in the first half of 1962.

Low-grade manganese ores containing 10 to 35 percent manganese were shipped from Georgia, Minnesota, Montana, and New Mexico; but Minnesota was the only State that reported shipments of manganiferous iron ore containing 5 to 10 percent manganese. As in 1961, all Minnesota manganiferous ores (ferruginous manganese and manganiferous iron) came from the Cuyuna range.

TABLE 2.—Metallurgical manganese ore,[1] ferruginous manganese ore,[2] and manganiferous iron ore,[3] shipped in the United States, by States

(Short tons, gross weight)

State	1961			1962		
	Metallurgical Manganese ore	Ferruginous Manganese ore	Manganiferous iron ore	Metallurgical Manganese ore	Ferruginous Manganese ore	Manganiferous iron ore
Arizona		(4 5)				
California				(4 6)		
Georgia		(4 7)			(4 7)	
Michigan			17,083			
Minnesota		91,560	90,275		147,203	145,576
Montana	10,673	2,236		19,007	2,264	
Nevada	28,573					
New Mexico		(4)		(4 6)	(4)	
Undistributed		23,850			6 43,458	
Total	39,246	117,646	107,358	19,007	192,925	145,576

1 Containing 35 percent or more manganese (natural).
2 Containing 10 to 35 percent manganese (natural).
3 Containing 5 to 10 percent manganese (natural).
4 Figure withheld to avoid disclosing individual company confidential data, included with "Undistributed."
5 Data are for manganese ore (concentrate) containing more than 35 percent manganese and produced from stocked tailings.
6 A relatively small quantity of metallurgical ore produced in California and in New Mexico is included in ferruginous manganese ore undistributed.
7 All miscellaneous.

TABLE 3.—Manganese and manganiferous ore shipped [1] in the United States in 1962, by States

Type and State	Short tons		Value (thousands)
	Gross weight	Manganese content	
Manganese ore: Montana [2]	24,758	13,056	(3)
Manganiferous ore:			
Ferruginous manganese ore: [4]			
Minnesota	147,203	18,551	(5)
Montana	2,264	528	$29
California, Georgia, New Mexico [6]	43,458	5,520	(5)
Total	192,925	24,599	(5)
Manganiferous iron ore: Minnesota [7]	145,576	9,016	(5)
Total manganiferous ore	338,501	33,615	(3)

[1] Shipments are used as the measure of manganese production for compiling U.S. mineral-production value. They are taken at the point at which the material is considered to be in marketable form for the consumer. Besides direct-shipping ore, they include, without duplication, concentrate and nodules made from domestic ores.
[2] Containing 35 percent or more manganese (natural). All metallurgical except 5,729 short tons of battery ore (concentrate) containing 2,297 tons of manganese and 22 short tons of miscellaneous ore (concentrate) containing 9 tons of manganese. Relatively small production (shipments) of metallurgical ore in California and New Mexico is included in the ferruginous manganese ore total in order to avoid disclosing confidential data.
[3] Combined value for total manganese ore and total manganiferous ores equals $4,267,793.
[4] Containing 10 to 35 percent manganese (natural).
[5] Included in total.
[6] All California and part of New Mexico data are for ore or concentrate containing 35 percent or more manganese (natural) reported as metallurgical. All Georgia ore was manganiferous and miscellaneous.
[7] Containing 5 to 10 percent manganese (natural).

CONSUMPTION, USES, AND STOCKS

Domestic consumption of manganese ore increased 9 percent over that of 1961, with domestic sources supplying only 1 percent of the total. Industrial ore stocks decreased 20 percent from the beginning of the year to 1.8 million tons at yearend.

In the production of steel ingots, consumption of manganese as ferroalloys, metal and direct-charged ore per short ton of open-hearth, bessemer, basic oxygen process, and electric steel produced was 13.7 pounds, compared with 13.4 pounds in 1961. Of the 13.7 pounds, 12.0 pounds was ferromanganese; 1.4 pound, silicomanganese; 0.1 pound, spiegeleisen; and 0.2 pound, manganese metal.

Electrolytic Manganese and Manganese Metal.—Consumption of manganese metal totaled 15,000 tons, compared with 16,000 tons in 1961. Virtually all was electrolytic manganese. American Potash & Chemical Corp. became the third U.S. producer of electrolytic manganese with the start of production at its new Aberdeen, Miss. plant early in May. Foote Mineral Co. at Knoxville, Tenn., and Union Carbide Metals Co. at Marietta, Ohio, were the other two producers.

Ferromanganese.—Ferromanganese was produced in 17 plants of 10 companies, as follows: The Anaconda Company, Anaconda, Mont.; Bethlehem Steel Co., Johnstown, Pa.; E. J. Lavino & Co., Reusens, Va., and Sheridan, Pa.; Montana Ferro-Alloys Co., Inc., Woodstock, Tenn.; Ohio Ferro-Alloys Corp., Philo, Ohio; Pittsburgh Metallurgical Co., Calvert City, Ky., and Niagara Falls, N.Y.; Tennessee Products & Chemical Corp, Rockwood, Tenn.; Tenn-Tex Alloy & Chemical Corp., Houston, Tex.; Union Carbide Metals Co., Alloy, W. Va., Ashtabula,

TABLE 4.—Consumption and stocks of manganese ore[1] in the United States

(Short tons, gross weight)

Use and ore source	Consumption 1961	Consumption 1962	Stocks Dec. 31, 1962[2] (including bonded warehouses)
Manganese alloys and manganese metal:			
Domestic ore	9,446	17,510	289
Foreign ore	1,577,519	1,720,184	1,712,450
Total	1,586,965	1,737,694	1,712,739
Steel ingots:			
Domestic ore			
Foreign ore	1,047	804	622
Total	1,047	804	622
Steel castings:			
Domestic ore			
Foreign ore	61	151	250
Total	61	151	250
Pig iron:			
Domestic ore			
Foreign ore	9,961	14,882	15,780
Total	9,961	14,882	15,780
Dry cells:			
Domestic ore	4,567	3,691	879
Foreign ore	23,734	29,934	5,571
Total	28,301	33,625	6,450
Chemicals and miscellaneous:			
Domestic ore	5,991	3,469	364
Foreign ore	85,479	81,939	35,708
Total	91,470	85,408	36,072
Grand total:			
Domestic ore	20,004	24,670	1,532
Foreign ore	1,697,801	1,847,894	1,770,381
Total	1,717,805	1,872,564	[3] 1,771,913

[1] Containing 35 percent or more manganese (natural).
[2] Excluding Government stocks.
[3] Excludes small tonnages of dealers' stocks.

Ohio, Marietta, Ohio, Portland, Oreg., and Sheffield, Ala.; and United States Steel Corp., Ensley, Ala., and Duquesne, Pa. The quantity of ferromanganese made in blast furnaces was twice that made in electric furnaces. Shipments of ferromanganese totaled 728,000 tons, valued at $134 million, compared with 757,000 tons, valued at $159 million in 1961. Largely because of competition from imports, E. J. Lavino & Co. closed its Virginia plant in June, except for making shipments from accumulated stocks.

Silicomanganese.—Production of silicomanganese in the United States was 136,000 short tons, compared with 120,000 tons in 1961. Shipments from furnaces totaled 130,00 tons ($25,429,000), compared with 121,000 tons ($25,238,000) in 1961. Plants that produced during the year were Interlake Iron Corp., Beverly, Ohio; Montana Ferro-Alloys Co., Inc., Woodstock, Tenn.; Ohio Ferro-Alloys Corp., Philo, Ohio; Pittsburgh Metallurgical Co., Calvert City, Ky., and Niagara Falls, N.Y.; Tennessee Products & Chemical Corp., Rockwood, Tenn.; Tenn-Tex Alloy & Chemical Corp., Houston, Tex.; Union Carbide

TABLE 5.—Consumption, by end uses, and stocks of manganese ferroalloys and metal in the United States in 1962

(Short tons, gross weight)

Use	Ferromanganese		Silico-manga-nese	Spiegel-eisen	Manga-nese metal [1]	Briquets
	High carbon	Medium and low carbon				
Steel ingots:						
Stainless steel	593	2,094	5,095	12	6,580	--------
Other alloy steel	110,957	10,418	30,658	6,699	996	10
Carbon steel	595,101	47,044	68,179	15,598	3,180	----------
Other	372	94	572	4	33	----------
Total	707,023	59,650	104,504	22,313	10,789	10
Steel castings:						
Stainless steel	257	238	409	1	77	----------
Other alloy steel	8,278	1,685	4,422	273	85	15
Carbon steel	6,131	1,855	7,271	963	10	113
Other	2,857	169	560	180	8	----------
Total	17,523	3,947	12,662	1,417	180	128
Steel mill rolls	797	188	545	516	----------	----------
Gray and malleable castings	6,013	690	3,476	11,823	----------	9,715
Alloys (includes welding rods)	7,509	966	974	80	3,705	----------
Other	1,123	12	181	----------	177	1
Grand total	739,988	65,453	122,342	36,149	14,851	9,854
Stocks, Dec. 31: [2]						
Consumer	140,315	7,527	12,868	4,684	1,50	920
Producer	(3)	(3)	(3)	32,302	(3)	----------

[1] Virtually all electrolytic.
[2] Including bonded warehouses. Excluding Government stocks.
[3] Producer stocks of ferromanganese, silicomanganese, and manganese metal totaled 209,882 short tons.

TABLE 6.—Manganese items in Government inventories as of December 31, 1962

(Thousand short dry tons)

Material	Total	National (strategic) stockpile	DPA inventory	CCC and supplemental stockpile
Stockpile grade:				
Battery:				
Natural ore	282	145	--------------	137
Synthetic dioxide	25	21	4	--------------
Chemical:				
Type A ore	147	29	--------------	118
Type B ore	101	2	--------------	99
Metallurgical ore	9,820	5,231	1,351	3,238
(Ferromanganese, standard high carbon) [1]	(833)	(143)	--------------	(690)
(Manganese metal, electrolytic) [1]	(11.0)	(1.7)	(5.3)	(4.0)
Nonstockpile grade: Metallurgical ore	2,327	621	1,706	--------------

[1] Figures in parentheses represent upgraded forms of manganese. They are included in the metallurgical ore figures and are not in addition to them.

Source: Office of Emergency Planning. Statistical Supplement, Stockpile Report to the Congress. OCDM-4, July-December 1962, pp. 29-31, 46.

Metals Co., Alloy, W. Va., Ashtabula, Ohio, Marietta, Ohio, Portland, Oreg., and Sheffield, Ala.; and Vanadium Corporation of America, Graham, W. Va. Consumption of silicomanganese was 15.2 percent that of ferromanganese, compared with 14.4 percent in 1961 and 12.3 percent in 1960.

Spiegeleisen.—The New Jersey Zinc Co., Palmerton, Pa., and Union Carbide Metals Co., Marietta, Ohio, produced spiegeleisen. The New Jersey Zinc Co. began converting its spiegeleisen production at Palmerton from blast furnace to electric furnace.

Manganiferous Pig Iron.—In producing pig-iron, furnaces used 573,000 short tons of manganese-bearing ores containing over 5 percent manganese (natural). Domestic sources supplied 439,000 tons and foreign sources 134,000 tons. The domestic ore included 304,000 tons containing 5 to 10 percent manganese (natural) and 135,000 tons containing 10 to 35 percent manganese. The foreign ore consisted of

TABLE 7.—Ferromanganese produced in the United States and metalliferous materials [1] consumed in its manufacture

Year	Ferromanganese produced			Materials consumed			Manganese ore used per ton of ferromanganese made (short tons)
	Gross weight (short tons)	Manganese content		Manganese ore (35 percent or more Mn natural)		Iron and manganiferous iron ores (short tons)	
		Percent	Short tons	Foreign (short tons)	Domestic (short tons)		
1953-57 (average)	876, 611	76.6	671, 899	[2] 1, 851, 685	[2] 50, 827	8, 469	[2] 2.2
1958	636, 736	77.7	494, 761	1, 228, 769	42, 061	1, 091	2.0
1959	629, 307	77.3	486, 549	1, 275, 138	3, 829	3, 935	2.0
1960	842, 818	77.7	654, 825	[2] 1, 801, 038	[2] 17, 819	1, 821	[2] 2.2
1961	732, 813	77.3	566, 432	[3] 1, 577, 519	[3] 9, 446	1, 685	[2] 2.1
1962	781, 112	77.2	602, 854	[2] 1, 673, 227	[2] 17, 417	96	[2] 2.2

[1] Excluding scrap.
[2] Includes ore used in producing silicomanganese, but only for 1955 in the 1953-57 period.
[3] Includes ore used in producing silicomanganese and metal.

TABLE 8.—Manganese ore used in producing ferromanganese and silicomanganese in the United States, by source of ore

Source	1961		1962	
	Gross weight (short tons)	Mn content, natural (percent)	Gross weight (short tons)	Mn content, natural (percent)
Domestic	9, 446	56.6	17, 417	56.5
Foreign:				
Africa	454, 189	46.0	525, 349	46.0
Brazil	448, 176	46.7	438, 355	46.6
British Guiana	70, 923	43.8	131, 172	42.5
Chile	16, 125	44.4	4, 509	44.3
Cuba	10, 774	45.8	12, 950	41.0
India	260, 796	44.8	260, 530	45.2
Mexico	212, 588	42.1	195, 737	43.1
Philippines	6, 400	44.2	3, 492	47.7
Other or unidentified [1]	97, 548	-----------	101, 133	-----------
Total	1, 586, 965	45.3	1, 690, 644	45.4

[1] For 1961, includes ore used in producing metal.

119,000 tons containing 5 to 10 percent manganese (natural) and 15,000 tons containing 35 percent or more manganese. Canada supplied all the foreign manganiferous iron ore.

Battery and Miscellaneous Industries.—Manufacturers of dry-cell batteries used 34,000 tons of manganese ore containing more than 35 percent manganese (natural), of which 3,700 tons was of domestic origin. Preparation of imported battery-grade ores for Union Carbide Consumer Products Co. manufacture of dry-cell batteries was transferred from Philadelphia, Pa., to a new facility at the Union Carbide Ore Co. ore-dressing and blending plant at Warwick (Newport News), Va., at the beginning of December. The new unit was capable of drying, crushing, and grinding approximately 20,000 tons of ore per year.

Chemicals and miscellaneous industries used 85,000 tons of manganese ore containing 35 percent or more manganese, 3,500 tons coming from domestic sources. The domestic ore and much of the foreign ore would not be able to meet National Stockpile Specification P–81–R for chemical-grade ore.

PRICES

Manganese Ore.—Commercial prices for spot purchases of Indian and South African manganese ore containing 46 to 48 percent manganese, as quoted by E&MJ Metal and Mineral Markets, opened the year at $0.87 to $0.90, nominal, per long-ton unit of manganese, c.i.f. U.S. ports, import duty extra. These quotations dropped in August to $0.80 to $0.85, nominal, and then remained unchanged. Brazilian ore containing 48 to 50 percent manganese was quoted by the same source on the same terms at $0.91, nominal, until August, after which the quotation was carried as simply nominal.

Manganese Alloys.—The average value, f.o.b. producers' furnaces for ferromanganese shipped was $184.62 per short ton, compared with $210.01 in 1961. Domestically produced standard ferromanganese containing 74 to 76 percent manganese, at eastern furnaces, carlots, continued to be quoted throughout 1962 at 9.5 cents per pound of alloy, or $190 per short ton, although some weakness in actual prices was indicated late in the year. Beginning in August, E&MJ Metal and Mineral Markets published a quotation for imported standard ferromanganese delivered at Pittsburgh. This remained unchanged at $158 per long ton. Effective January 2, the price of spiegeleisen containing 19 to 21 percent manganese was cut $7 to $93 per long ton, carlots, f.o.b. Palmerton, Pa.; effective November 12, the price was reduced to $90 per long ton, same basis.

Manganese Metal.—The first price change in more than a year for electrolytic manganese metal became effective in April with a reduction of 2.5 cents per pound in the price of the standard grade. Variations in price continued for different packing, quantities, and special grades. The new prices for leading items became 32 cents for carlots and 34.5 cents for ton lots packed in steel drums; 31.25 cents, carlots, and 33.75 cents, ton lots, for palletized or bulk shipments. Hydrogen-removed metal continued to command a 0.75 cent premium, but the premium for nitrided electrolytic manganese metal containing a minimum of 5.5 percent nitrogen became 4.75 cents per pound as the result of a price cut of only 1.25 cents. All the above prices held to the end of 1962.

FOREIGN TRADE[3]

Imports.—The average grade of imported manganese ore was 47.3 percent, compared with 47.0 percent for 1961. Brazil provided 42 percent of the total ore received in 1962; Ghana and the Republic of South Africa, each 10 percent; India, 9 percent; British Guiana and Mexico, each 7 percent; and Morocco, 6 percent. General imports of ore containing more than 10 percent and less than 35 percent manganese totaled 5,441 short tons, all of which came from Mexico; imports for consumption consisted of this Mexican ore plus 1,879 tons from Ghana.

Imports for consumption of ferromanganese totaled 125,614 short tons, approximately half of those reported for 1961; Government acquisitions were only a small part of the 1962 total. Imports for consumption classified as "manganese silicon (includes silicon manganese)" totaled 17,152 short tons (manganese content). Norway supplied 6,373 tons; Japan, 2,850 tons; Belgium-Luxembourg, 2,800 tons; Mexico, 2,647 tons; Spain, 1,558 tons; Yugoslavia, 787 tons; and Canada, 137 tons. Manganese metal imports for consumption were 1,989 short tons of which 1,013 tons came from Japan, 975 tons from the Republic of South Africa, and 1 ton (valued at $3,470) from France. No imports for consumption of spiegeleisen were reported.

Exports.—Ferromanganese exports totaled 4,114 short tons valued at $629,000, compared with 469 tons valued at $146,000 in 1961. Exports classified as "manganese metal and alloys in crude form and scrap," believed to be almost entirely electrolytic manganese metal, were 2,201 tons valued at $1,431,000, compared with 2,234 tons valued at $1,327,000 in 1961 and 2,430 tons valued at $1,501,000 in 1960. Spiegeleisen exports in 1962 were 715 tons valued at $59,000, all going to Canada. Exports classified as "manganese ore and concentrates containing 10 percent or more manganese" totaled 8,643 tons valued at $1,012,000. They were believed to be almost entirely imported manganese dioxide ore exported after grinding, blending, or otherwise classifying.

Tariff.—Duty on manganese ore from most countries continued at 0.25 cent per pound of contained manganese. Ore from the Philippines continued to be exempt from duty, and ore from the U.S.S.R. and certain associated countries was dutiable at 1 cent per pound of contained manganese. By Presidential Proclamation of February 7, imports into the United States from Cuba were prohibited.

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

TABLE 9.—U.S. imports of manganese ore (35 percent or more Mn), by countries

Country	General imports [1] (short tons)				Imports for consumption [2]					
					Short tons				Value	
	Gross weight		Mn content		Gross weight		Mn content			
	1961	1962	1961	1962	1961	1962	1961	1962	1961	1962
North America:										
Guatemala	----------	310	----------	170	----------	310	----------	170	----------	$15,516
Mexico	181,640	133,629	82,471	59,876	181,161	135,828	81,988	60,899	$5,233,654	3,897,010
Panama	1,109	----------	510	----------	1,109	----------	510	----------	40,481	----------
Total	182,749	133,939	82,981	60,046	182,270	136,138	82,498	61,069	5,274,135	3,912,526
South America:										
Brazil	744,896	823,714	361,096	398,129	793,890	887,441	387,783	428,036	29,065,210	31,504,474
British Guiana	135,410	145,188	55,537	61,087	6,096	43,490	2,665	18,805	185,783	945,390
Chile	12,786	4,970	5,745	2,203	12,786	4,970	5,745	2,203	348,063	127,935
Peru	----------	6,070	----------	2,553	----------	1,461	----------	643	----------	37,501
Total	893,092	979,942	422,378	463,972	812,772	937,362	396,193	449,687	29,599,056	32,615,300
Europe: Greece	21,796	2,873	10,478	1,379	57,818	1,565	27,917	750	3,109,257	85,817
Asia:										
India	174,221	178,900	79,519	81,751	257,800	209,972	120,689	97,058	7,765,112	5,314,804
Philippines	6,590	7,459	3,144	3,402	7,700	7,459	3,649	3,402	247,807	169,138
Turkey	3,168	6,970	1,492	3,298	----------	6,942	----------	3,300	----------	227,030
Total	183,979	193,329	84,155	88,451	265,500	224,373	124,338	103,760	8,012,919	5,710,972
Africa:										
Angola [3]	13,432	1,378	6,762	758	18,397	21,627	9,291	10,861	721,677	610,551
Congo, Republic of the, and Ruanda-Urundi	174,085	88,157	83,257	42,716	160,942	97,242	77,415	47,361	5,049,972	2,717,186
Ethiopia	6,630	6,936	3,432	3,468	6,630	6,936	3,432	3,468	245,550	255,581
Ghana	223,835	204,245	113,245	103,714	268,908	229,733	135,591	115,067	13,029,411	8,703,310
Morocco	117,036	125,003	62,737	66,275	108,286	121,974	57,877	64,670	5,954,722	6,496,493
Rhodesia and Nyasaland, Federation of	11,473	10,800	5,740	5,405	12,526	12,558	6,344	6,277	437,379	400,970
South Africa, Republic of [4]	260,212	195,804	106,042	81,496	219,475	168,338	93,718	71,513	5,511,156	3,879,551
United Arab Republic (Egypt)	----------	----------	----------	----------	21,480	13,160	10,752	6,380	805,917	555,111
Western Africa, n.e.c.[5]	10,096	11,019	4,740	5,069	10,096	----------	4,740	----------	311,506	----------
Western Equatorial Africa, n.e.c.[6]	----------	17,807	----------	8,727	----------	38	----------	20	----------	1,770
Total	816,799	661,149	385,955	317,628	826,740	671,606	399,160	325,617	32,067,290	23,620,523

Oceania:										
Australia	23		12		23	3,986	12	2,012	1,029	174,528
British Western Pacific Islands					2,069	1,591	944	764	80,798	29,741
Total	23		12		2,092	5,577	956	2,776	81,827	204,269
Grand total [7]	2,098,438	1,971,232	985,959	931,476	2,147,192	1,976,621	1,031,062	943,659	78,144,484	66,149,407

[1] Comprises ore received in the United States; part went into consumption during the year, and the remainder entered bonded warehouses.

[2] Comprises ore received during the year for immediate consumption and material withdrawn from bonded warehouses; excludes imports for manufacture in bond and export.

[3] 1962 data adjusted by Bureau of Mines to include material reported by the Bureau of the Census as from Belgium-Luxembourg.

[4] Effective Jan. 1, 1962; formerly Union of South Africa.

[5] Believed to be Ivory Coast.

[6] Believed to be Gabon.

[7] In 1962, general imports of ore classified as battery and chemical grades totaled, as reported, 64,413 short tons averaging 52.8 percent manganese. Of this quantity, 38,043 short tons came from Morocco, 11,883 short tons from Ghana, 9,078 short tons from India, 2,873 short tons from Greece, 1,378 short tons from the Republic of the Congo and Ruanda-Urundi, 1,120 short tons from the Federation of Rhodesia and Nyasaland, and 38 short tons from Western Equatorial Africa, n.e.c. It is believed that in the case of both general imports and imports for consumption the actual total for battery and chemical grades was approximately 100,000 short tons of which approximately 75,000 short tons was from Morocco. This does not change the total ore imports, but does decrease the quantity classified as metallurgical grade. Imports for consumption of battery and chemical grades in 1962 totaled, as reported, 63,315 short tons (averaging 52.9 percent manganese) valued at $3,668,230 or $57.94 per ton f.o.b. foreign ports. Of this total Morocco supplied 38,043 short tons ($2,016,827); Ghana, 11,883 short tons ($1,178,620); India, 9,078 short tons ($256,488); Republic of the Congo and Ruanda-Urundi, 2,708 short tons ($128,708); Greece, 1,565 short tons ($85,817); and Western Equatorial Africa, n.e.c., 38 short tons ($1,770). Note: It is believed that for 1961 actual total general imports of battery and chemical grades were approximately 120,000 short tons, and imports for consumption of these grades totaled approximately 160,000 short tons, of which Morocco supplied approximately 50,000 short tons in each case. These changes are at the expense of the reported respective metallurgical ore imports.

Source: Bureau of the Census.

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TABLE 10.—U.S. imports for consumption of ferromanganese, by countries

Country	1961			1962		
	Gross weight (short tons)	Mn content (short tons)	Value	Gross weight (short tons)	Mn content (short tons)	Value
North America:						
Canada	217	166	$36,255	180	135	$29,127
Mexico	2,009	1,513	235,955	1,549	1,236	196,815
Total	2,226	1,679	272,210	1,729	1,371	225,942
South America:						
Brazil				5,496	4,231	637,856
Chile	3,906	2,877	646,884	5,852	4,534	940,318
Total	3,906	2,877	646,884	11,348	8,765	1,578,174
Europe:						
Belgium-Luxembourg				3,825	2,923	465,946
France	40,859	31,391	5,745,190	46,035	35,403	5,759,434
Germany, West	21,672	16,816	2,572,525	23,044	17,671	2,658,997
Italy	441	363	97,119	263	217	52,693
Norway	2,220	1,710	245,000	1,175	894	127,486
Spain	1,347	1,058	163,858			
Sweden	1,120	844	126,000			
Yugoslavia	8,234	6,432	1,005,466	2,688	2,089	324,450
Total	75,893	58,614	9,955,158	77,030	59,197	9,389,006
Asia:						
India	96,958	73,058	17,290,849	7,538	5,702	1,166,690
Japan	15,747	12,463	3,104,794	11,946	9,707	2,426,943
Total	112,705	85,521	20,395,643	19,484	15,409	3,593,633
Africa: South Africa, Republic of	27,206	21,508	3,126,293	16,023	12,300	1,844,679
Grand total	221,936	170,199	34,396,188	125,614	97,042	16,631,434

Source: Bureau of the Census.

WORLD REVIEW

NORTH AMERICA

Canada.—For the first 6 months of 1962, Canada imported 33,000 tons of manganese ore, 4,700 tons of ferromanganese, and 1,700 tons of silicomanganese. Consumption statistics for the full years 1961 and 1960, respectively, were ferromanganese, 45,000 and 40,000 tons; silicomanganese, 9,500 and 8,100; spiegeleisen, 700 and 1,000; manganese metal 170 and 150;[4] metallurgical grade ore 77,000 and 71,000; and battery and chemical grade ore 2,000 and 2,400. Imports of manganese ore in 1961 totaled 76,000 tons; ferromanganese, 12,000 tons; and silicomanganese, 2,200 tons. Exports of ferromanganese in 1961 were 200 tons.[5]

[4] Schneider, V. B. Additive Materials. A Preliminary Survey of the Canadian Mineral Industry in 1962. Dept. of Mines and Tech. Surveys, Ottawa, Canada, Miner. Inf. Bull. MR 63. 1963, pp. 34, 36.
[5] Schneider, V. B. Manganese—1961. Dept. of Mines and Tech. Surveys, Ottawa, Canada, June 1962, 6 pp.

TABLE 11.—World production of manganese ore by countries[1] [2]

(Short tons)

Country [1]	Percent Mn [3]	1953–57 (average)	1958	1959	1960	1961	1962
North America:							
Cuba	36–50+	[4] 276,780	[4] 74,636	[4] 58,806	[5] 17,644	[3] [4] 46,000	[3] 83,000
Mexico	30+	207,300	[3] 187,400	[3] 181,900	[3] 171,400	[3] 155,900	[3] 184,900
Panama		[6] 2,154	4,489				
United States (shipments)	35+	272,398	327,309	229,199	80,021	46,088	24,758
Total		758,632	593,834	469,905	[3] 269,100	[3] 248,000	[3] 293,000
South America:							
Argentina	30–40	10,795	16,431	21,358	24,250	[3] 22,000	[3] 22,000
Bolivia (exports)						53	290
Brazil	38–50	404,609	972,413	1,138,649	1,101,387	1,101,699	[3] 900,000
British Guiana	40–42				137,454	216,203	303,636
Chile	40–50	52,284	42,061	42,744	50,594	35,012	51,800
Peru	40+	9,195	3,242	2,803	1,655	3,879	3,406
Venezuela	38+	[7] 21,624	9,039	3,955			
Total		498,507	1,043,186	1,209,509	1,315,340	1,378,846	[3] 1,281,000
Europe:							
Bulgaria	30+	60,558	31,300	28,700	27,600	40,800	[3] 44,000
Greece	35+	17,532	22,046	38,580	38,580	[3] 39,000	[3] 33,000
Hungary	30–	125,985	200,400	170,100	135,900	[3] 132,000	[3] 132,000
Italy	30–	53,083	48,588	57,138	51,749	52,302	49,100
Portugal	35+	7,695	5,484	7,703	8,197	12,492	[3] 12,000
Rumania	35	259,690	220,755	216,910	192,870	227,076	[3] 220,000
Spain	30+	41,135	40,267	44,924	24,586	17,092	13,825
U.S.S.R.[8]		5,304,100	5,915,000	6,080,300	6,472,800	6,583,000	[3] 7,000,000
Yugoslavia	30+	4,982	11,060	8,900	14,700	15,600	16,400
Total [1]		5,874,760	6,494,900	6,653,255	6,966,982	7,119,362	[3] 7,520,000
Asia:							
Burma	42+	3,180	1,405	606	324	196	213
China [3]	30+	410,000	935,000	1,100,000	1,380,000	1,100,000	1,100,000
Goa	32–50	163,528	86,078	83,584	118,195	[3] 110,000	96,732
India	35+	1,857,109	1,406,652	1,298,472	1,321,411	1,338,200	1,307,340
Indonesia	35–49	53,562	48,909	47,172	12,026	14,007	12,186
Iran [9]	30+	5,502	661	2,425	8,488	2,315	2,205
Japan	32–40	249,893	326,269	383,699	357,131	335,236	340,259
Korea, Republic of	30–48	2,929	287	496	1,521	1,518	1,105
Malaya	30+				3,222	7,130	341
Pakistan	42			32	327	379	
Philippines	35–51	17,077	24,590	38,365	19,159	20,986	13,160
Thailand	40+	[7] 416	1,102	452	582	588	3,194
Turkey	30–50	67,736	24,920	39,341	31,112	33,069	23,422
Total [3]		2,831,000	2,856,000	2,995,000	3,254,000	2,964,000	2,900,000
Africa:							
Angola	38–48	38,303	38,499	39,314	25,728	22,695	14,089
Bechuanaland	38+	[6] 243	14,213	20,138	25,032	31,737	15,075
Congo, Republic of the (formerly Belgian)	48+	387,989	372,741	425,694	412,154	348,595	348,547
Ethiopia	51			1,455	10,202	7,716	6,614
Gabon, Republic of	50–52						224,038
Ghana (exports) [10]	48	675,179	574,124	577,694	600,261	431,282	513,622
Ivory Coast	46+				68,343	109,526	117,906
Morocco	35–50	475,317	452,041	518,711	532,508	629,512	517,377
Rhodesia and Nyasaland, Federation of:							
Northern Rhodesia	30+	25,145	49,383	60,297	58,917	58,907	51,501
Southern Rhodesia	30+	789	2,512	2,126	1,676	205	7,977
South Africa, Republic of	40+	778,188	934,097	1,069,196	1,316,124	1,562,718	1,614,589
South-West Africa	45+	52,705	103,049	49,442	67,439	50,295	
Sudan [3]	36–44	[7] 8,300	6,600	440			
United Arab Republic (Egypt) [11]	38–58	6,474	48,730	67,318	22,046	2,272	[3] 2,200
Total		2,448,632	2,595,989	2,831,825	3,140,430	3,255,460	3,433,535

See footnotes at end of table.

TABLE 11.—World production of manganese ore by countries [1] [2] —Continued

(Short tons)

Country [1]	Percent Mn [3]	1953-57 (average)	1958	1959	1960	1961	1962
Oceania:							
Australia	45-48	54,837	66,845	100,768	67,921	98,587	[3] 84,000
Fiji	40+	19,390	20,503	14,566	13,073	3,869	1,202
New Caledonia	45+	[6] 1,232					
New Hebrides	52-55					5,060	76,754
New Zealand	48+	197	116	114	134		
Papua	46	17			54	2	
Total		75,673	87,464	115,448	81,182	107,518	161,956
World total (estimate) [1]		12,487,000	13,671,000	14,275,000	15,027,000	15,073,000	15,590,000

[1] Czechoslovakia and Sweden report production of manganese ore (approximately 13 to 17 percent manganese content); however, because the manganese content averages substantially less than 30 percent, the output is not included in this table. For the last 5 years, Czechoslovakia averages annually 165,000 tons, and Sweden averages approximately 11,000 tons.

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

[3] Estimate.

[4] Exports.

[5] U.S. imports.

[6] One year only because 1957 was the first year of commercial production.

[7] Average annual production 1956-57.

[8] Grade unstated. Source: The Industry of the U.S.S.R., Central Statistical Administration, Moscow.

[9] Year ending March 20 of year following that stated.

[10] Dry weight.

[11] In addition to high-grade ore shown in the table, Egypt produced the following tonnages of less than 30 percent manganese content: 1953-57 (average), 201,870; 1958, 74,300; 1959, 72,800; 1960, 282,200; and 1961, 304,700.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

SOUTH AMERICA

Argentina.—Import surcharges on manganese ore from the Latin America Free Trade Area were reduced from 150 percent to 100 percent in 1961, and ad valorem duties from 35 percent of the c.i.f. value to zero.[6] The largest producer of manganese ore, Minera Alumine, S.A., abandoned plans to move its concentrator from its manganese deposits in Rio Negro Province to those in Salta Province and converted the plant to fluorite production.[7]

Bolivia.—Late in 1962, it was reported that a mixed corporation (Government of Bolivia equity not less than 30 percent) was to be formed to develop and exploit the manganese and iron ore deposits of Mutun, near the Brazilian border.[8]

Brazil.—Exports of manganese ore by Indústria e Comércio de Minério S.A. (ICOMI) from Amapa totaled 735,000 tons in 1962, all destined for the United States.[9] Through prospecting, new ore bodies were reported (1961) in the Serra do Navio district. Diamond drilling in conjunction with mining provided significant information concerning bedrock and the carbonate and gondite protores, which occur as steeply dipping horizons in folded Pre-cambrian metasediments. Tropical weathering has altered the host rocks and produced residual oxide manganese ores of high quality, assaying up to 58 percent manganese. Locally, the oxide ores were found to have reached depths of 400 feet below the surface "following a former protore horizon to unweathered rocks." The principal ore minerals

[6] Bureau of Mines. Mineral Trade Notes. V. 55, No. 6, December 1962, p. 26.

[7] U.S. Embassy, Buenos Aires, Argentina. State Department Airgram A-318, Aug. 29, 1962, pp. 2-3.

[8] Bureau of Mines. Mineral Trade Notes. V. 56, No. 4, April 1963, p. 39.

[9] U.S. Consulate, Belem, Brazil. State Department Airgram A-47, Feb. 1, 1963, 1 p.

were cryptomelane and pyrolusite. The ore bodies occur along the flanks and crests of ridges for a distance of 6 miles along the strike, individual deposits attaining lengths up to 4,200 feet and widths to 600 feet. The ore was trucked from the open cuts to the washer where it was crushed, screened, and washed before being shipped by rail 120 miles to the port of Santana, near Macapá on the Amazon.[10] Exports of manganese ore from Bahia in 1962 totaled 32,000 tons with the grade of the shipments averaging from 38 to 46 percent manganese.[11]

Chile.—Ferromanganese exports in 1962 were 15,000 tons, all destined for the United States. The total manganese ore exports of 10,000 tons were divided as follows: The United States imported 6,500 tons; West Germany, 3,000 tons; and Japan, 500 tons.[12]

EUROPE

Belgium.—Société Européenne des Dérives du Manganese (SEDEMA) was formed in October 1962, capitalized at $1.62 million, with Manganese Chemicals Corp., Baltimore, Md. (an affiliate of Pickands Mather & Co.) having a one-third interest; the remainder of the interest was held by the Belgian companies of the Société Générale de Belgique group (Société Corbochimique; the Beceka-Manganese group; Société Commerciale des Mines, Minerais et Metaux; and S.A. d'Applications de Chimie Industrielle). A plant was to be built near the Carbochimique complex near Tertre, Hainaut province, to produce manganese chemicals, including manganese dioxide for dry-cell batteries, other manganese oxides, manganese carbonate, and manganese salts. These products have important electrical, electronic, agricultural, and chemical applications. Initial production was planned for late 1963.[13]

Italy.—Refined ferromanganese production in 1961 was 4,700 short tons; carbon ferromanganese, 32,000 tons; silicomanganese, 29,000 tons; spiegeleisen, 7,700 tons; and silicospiegeleisen, 1,500 tons. Import duties, effective September 1, set 2 percent carbon as the cutoff between refined and carbon ferromanganese. Manganese ore imports in 1961 were 153,000 tons, the same as in 1960. Principal suppliers for the 2 years with 1960 in parentheses were, respectively, Congo, 39,000 tons (25,000); Egypt, 30,000 (8,800); India, 23,000 (34,000); U.S.S.R., 16,000 (31,000); Ghana, 12,000 (2,500); Republic of South Africa, 5,100 (21,000); Morocco, 8,400 (3,900); and Iran, 7,500 (4,100).[14]

Netherlands.—Late in 1962, E. J. Lavino & Co., Philadelphia, Pa., and Algemeene Industrieele Mineraal en Ertsmaatschappij, Amsterdam, joined forces to form a company, A.I.M.E.-Lavino N. V. for the purpose of producing and marketing various manganese compounds

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[10] Nagell, R. H. Geology of the Serra do Navio Manganese District, Brazil. Econ. Geol., v. 57, No. 4, June–July 1962, pp. 481–498.
[11] U.S. Consulate, Salvador, Brazil. State Department Dispatches 47, A–4, A–31, and A–54, May 10, July 17, Oct. 16, 1962, and Jan. 16, 1963.
[12] U.S. Embassy, Santiago, Chile. State Department Airgrams A–14, A–131, A–470, and A–778, July 5, Aug. 8, Nov. 9, 1962, Feb. 25, 1963.
[13] American Metal Market. V. 69, Nos. 153 and 201, Aug. 9, 1962, p. 15, and Oct. 18, 1962, p. 23.
[14] Metalli Non Ferrosi e Ferroleghe—Statistiche 1961. (Non Ferrous Metals and Ferroalloys—Statistics 1961). AMMI (Rome—Milan—Cagliari), October 1962, pp. 124–129.

in Europe, especially manganous oxide for use in animal feeds and fertilizers. The manganese experience of the Dutch company dated from 1898, when its predecessor began mining manganese ore in Java.[15]

Spain.—Ferromanganese production in 1961 was 25,000 tons, and the grade of ore produced was 36.3 percent manganese.[16]

U.S.S.R.—Manganese ore deposits of the Dnepr littoral basin include the Nikopol, Great (Bolshoi or Veliki) Tokmak,[17] and Ingulets major "ore fields." The ores of the basin are all sedimentary, of Oligocene age, and change from oxide in the north to carbonate in the south. Depth below surface varies from 30 to 450 feet. The Nikopol deposit is composed mainly of manganese oxides of high quality, carbonate ores being found to a much lesser degree. The deposit commonly is composed of alternating streaks of ore and sandy clay and is essentially horizontal with ore varying from 0 to 15 feet in thickness, depending in large part upon the irregularity of the underlying Pre-cambrian basement. The ore, which varies in character and includes oolites and concretions, lies directly on Pre-cambrian granite or gneiss, or on Oligocene sands and clays; it has a cover of clays and sands. The deposit has been mined since 1886, and reserves were still described as "great." In the Great Tokmak deposit, carbonate ores (mangano-calcite) were reported to account for 90 percent of the total reserves and to be of higher quality than similar carbonate ores at Nikopol or Chiatura. The carbonate concentrates from Great Tokmak contained 27 to 28 percent manganese, and the oxide concentrates, 40 to 42 percent. It was estimated that "total reserves of manganese ore of the whole deposit should reach 1,400 million tons," but the grade was not given for this tonnage. On the other hand, of the 10 deposits of the Ingulets field, only the largest—with reserves of 1 million tons, at depths of 65 to 165 feet below the surface and with thicknesses of 5 to 6.5 feet,—"may be profitably exploited." The ore contains manganese oxides (and apparently carbonates also) with manganese contents from 10 to 35 percent. The 1959–65 plan for development of the national economy of the U.S.S.R. called for continued development of known deposits and prospecting for new ones in the Dnepr littoral basin. Before 1952, mining in the Nikopol field was entirely by underground methods, under the unfavorable conditions of wet and heavy ground with high timber and labor costs. The proportion of ore obtained by opencut operations increased to 41.5 percent by 1960 and was expected to reach 79 percent in 1965; "average overburden coefficient" was expected to be 11.5 cubic meters (15 cu. yds.) per ton in 1961 and 15.1 cubic meters (19.75 cu. yds.) per ton in 1965. Material benefits in productivity had already resulted.[18] As part of the program to-

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[15] American Metal Market. V. 69, No. 211, Nov. 1, 1962, p. 23.
[16] U.S. Embassy, Madrid Spain. State Department Airgram A–14, July 11, 1962, enclosure 1, pp. 2–3.
[17] Bureau of Mines. Minerals Yearbook. V. 1, 1961. Manganese chapter, pp. 877–878.
[18] Economic Geology. V. 57, No. 6, September–October 1962, p. 998.
Rudenko, F. A., V. K. Kulykovs'kyy, and others. (Minerals of the Ukraine.) (Kiev, U.S.S.R.) 1960. Joint Pub. Res. Service, Office Tech. Services, U.S. Dept. of Commerce, Transl. 13,009, Mar. 16, 1962, pp. 78–89.
Tarakhtiy, I. D. (Development of Manganese Ore Extraction in the Ukrainian S.S.R.), Metallurgicheskaya i Gornorudnaya Promyshelennost (U.S.S.R.). No. 1, January–February 1962, pp. 58–60. Joint Pub. Res. Service, Office Tech. Services, U.S. Dept. of Commerce, Transl 15,100, Sept. 5, 1962, pp. 5–8.

ward continuing to achieve markedly better ton-to-man ratios, a 200-foot high electrically operated, 10-bucket rotary excavator was designed and built to handle 3,900 cubic yards of earth per hour. It was equipped for traveling on crawler treads and for operating in conjunction with a belt conveyor system capable of transporting the excavated material 2.8 miles to the dump. Two of these machines were placed in operation at the Shevchenko opencut of the Nikopol Manganese Trust. By working jointly on two benches, it was claimed that a 260-foot thickness of overburden—reportedly consisting of both earth and rock—could be removed in one pass. Machines were planned that would have 12 buckets and be capable of handling 9,400 cubic yards of "solid ground" per hour. These buckets were expected to have a capacity of 3.4 cubic yards compared with the 2.1 cubic yards of the present machines.[19] Both sections of the Grushevka mill were commissioned January 1, 1962. The mill was near the town of Manganese in the Dnepropetrovsk District of the Ukraine and had a rated annual output of more than 1 million tons of the highest grades of manganese concentrates.[20] Construction of a large electrometallurgical ferroalloy plant, the Nikopol Ferroalloy Plant, was started. It was expected to produce manganese metal, ferromanganese, silicomanganese, and other ferroalloys.[21] Ferromanganese was made recently from Nikopol ore at Zaporozh'ye, and from Chiatura ore at Zestafoni.[22] Despite increases in production of manganese ore, difficulties were experienced in supplying furnaces and steel plants with sufficient "phosphorus-free raw material." Nikopol basin manganese slags, containing up to 20 percent manganese, had accumulated in large dumps or were being dumped into the sea. In the Chiatura basin, slags containing up to 18 percent manganese were being dumped into the Kvirila River. The "Mekhanobrchermet" Institute of Krivoy Rog and the Chemical-Technological Institute of Dnepropetrovsk investigated sulfur dioxide and dithionate methods of extracting manganese from slags containing 10 to 12 percent manganese and obtained good quality products by both methods. Preliminary calculations were stated to place the cost of manganese by such chemical processing as approximately equal to that obtained by normal concentration of ore.[23]

Contracts were signed with Japanese ferroalloy manufacturers for the Soviet Union to deliver in 1962, 4,000 tons of high grade ore (46 to 48 percent manganese); 9,500 tons of medium grade ore (45 percent manganese); and 29,500 tons of low-grade ore (35 percent manganese).[24] A new trade agreement with Sweden called for the U.S.S.R. to supply 25,000 tons of manganese ore annually through 1964.[25]

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[19] Mining Journal (London). V. 258, No. 6618, June 22, 1962, pp. 649, 651.
[20] Ekonomicheskaya Gazeta (Moscow, U.S.S.R.). Jan. 8, 1962. p. 12.
[21] Sukhorukov, A. (Nikopol Ferroalloy Plant Under Construction). Ekonomicheskaya Gazeta (Moscow, U.S.S.R.). No. 17(38), Apr. 23, 1962, p. 36. Joint Pub. Res. Service, Office Tech. Services, U.S. Dept. of Commerce, Soviet Ferrous Metallurgy, No. 56, Aug. 1, 1962, pp. 6–7.
[22] Soviet Geography. Am. Geographical Society, New York, May 1962, p. 71.
[23] Samoylov, I. (Valuable Manganese Slag Being Dumped Into the Water), Ekonomicheskaya Gazeta, (Moscow, U.S.S.R.). No. 17(38), Apr. 23, 1962, p. 35. Joint Pub. Res. Service, Office Tech. Services, U.S. Dept. of Commerce, Soviet Ferrous Metallurgy, No. 56, Aug. 1, 1962, pp. 4–6.
[24] Mining Journal (London). V. 258, No. 6597, Jan. 26, 1962, p. 101.
[25] Mining Journal (London). V. 258, No. 6604, Mar. 16, 1962, p. 264.

ASIA

China.—More than half of China's production of manganese ore in 1961 was low-grade material having a manganese content of not much more than 30 percent manganese, but with a high iron content. Most of this ferruginous ore came from the northern part of the country and was used in China for iron and steel production. Chinese ore offered on world markets in 1961 was reported to have been of inferior quality.[26]

Goa.—All manganese and iron ore mining in Goa, formerly part of Portuguese India, was by opencut operations, and the mining and export of these ores was the most important economic activity. Most of the deposits occur within a radius of 30 miles of the port of Mormugao and none is more than 50 miles away. The ore that was mined occurred at the surface or in the subsoil beneath a laterite crust. The leading mine owners used some mechanized equipment, but most operations relied on manual labor, using explosives to blast out the ore, then barging or trucking it to Mormugao, where limited facilities were inadequate for the volume of exports. Rail transportation was not available to the mine areas. The manganese portion of the business has trended downward since 1956, whereas the iron ore portion increased, until the output of manganese represented only about 2 percent and that of iron ore 98 percent in 1961–62. Indian tax laws and regulations for industry and labor did not apply to Goa in 1962.[27] Combined exports of manganese ore and ferruginous manganese ore totaled 133,000 tons, an increase of 17 percent over 1961. West Germany received 103,000 tons of the 1962 exports; Japan, 22,000 tons; and the Netherlands, 7,500 tons.[28] Floor prices for Goa were established by the Indian Government for manganese ore in June 1962, and for ferruginous manganese ore and for manganiferous iron ore ("blue dust" or "black iron ore") in August. These floor prices were rescinded in January 1963, allowing exporters to negotiate prices freely.[29] Several hundred small mine operators and approximately six large owner-exporters were engaged in manganese and/or iron-ore mining.

India.—On November 6, 1962, royalty rates for manganese, based on weight in tons instead of on value as formerly, were announced: Manganese dioxide, 15 rupees ($3.15); manganese ore, 45 percent manganese and above, 6 rupees ($1.26); manganese ore, 35 to 45 percent manganese, 3 rupees (63 cents); and manganese ore, below 35 percent manganese, 2 rupees (42 cents).[30] By acquiring equipment, including diesels to replace steam locomotives, doubling track, and shipping coal by trainloads instead of carloads, the capacity of the railways to move ore improved considerably by the end of 1962.[31] The Balaghat mine of Central Provinces Manganese Ore Co. (CPMO) is

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[26] Wei, Anton W. T. Minerals in China in 1961–III. Min. J. (London), v. 258, No. 6610, Apr. 27, 1962, p. 409.
[27] U.S. Consulate, Bombay, India. State Department Airgram A–115, Oct. 18, 1962, 5 pp.
[28] Bureau of Mines. Mineral Trade Notes. V. 56, No. 6, June 1963, p. 26.
[29] U.S. Consulate, Bombay, India. State Department Airgram A–226, Feb. 15, 1963, p. 2 and enclosure 1, p. 2.
[30] Bureau of Mines. Mineral Trade Notes. V. 56, No. 5, May 1963, pp. 41–44.
[31] U.S. Embassy, New Delhi, India. State Department Airgram A–845, Feb. 1, 1963, p. 18.

at the Bharweli manganese deposit, one of the largest in India. This deposit in the Balaghat District, Madhya Pradesh, is near the eastern end of an arcuate, 130-mile long, 16-mile wide belt of important manganese deposits folded in the Archaean metamorphic complex of Madhya Pradesh and Maharashtra. Mining at Bharweli was continuous since 1902. The ore body was 9,000 feet long, had a width of 8 to 45 feet, dipped 50 to 60 degrees northwest, and has been mined by an opencut as well as underground at three levels. Its enclosing rocks are sericite schists, garnetiferous mica schists, feldspathic quartzite, and phyllite; the ore contains thick and thin bands of quartzite and chert. Braunite and hollandite are the most abundant manganese minerals; cryptomelane and pyrolusite occur as alteration products.[32] Manganese Ore (India) Ltd. was formed in mid-1962 with 51 percent interest held by the public sector and 49 percent by CPMO. The new company was to take over the expired and expiring leases of CPMO in Madhya Pradesh and Maharashtra.[33] Manganese ore exports in 1961 were 1,117,000 tons, of which 324,000 tons contained 48 percent and more manganese; 610,000 tons, between 35 and 48 percent; 178,000, 35 percent or less; and 4,700 tons, peroxide ore and other. Japan received 362,000 tons (of which 317,000 tons was less than 48 percent manganese);[34] the United States, 205,000; the United Kingdom, 146,000; France, 74,000; Belgium, 69,000; Italy, 57,000; Netherlands, 48,000; Czechoslovakia, 37,000; West Germany, 31,000; Yugoslavia, 23,000; Norway, 22,000; Poland, 18,000; and other countries, 25,000. Manganese ore was produced from 573 mines employing 57,000 men. Domestic demand was supplied by 439,000 tons. A reduction in railway freight rates of up to 50 percent for manganese ores from mines located "very distant from the coast" was for 1 year from January 1, 1962. The new rate had the effect of creating a uniform rate of approximately 14–15 rupees ($2.94–$3.15) per ton regardless of the distance from the ports.[35] Ferromanganese exports in 1961 totaled 73,000 tons. The United States imported all of it except for 550 tons to the United Kingdom and 10 tons to Italy.[36]

Philippines.—Philippine Manganese Inc., the only producer of battery-grade manganese ore, produced 300 tons of this grade in 1962, all of which was consumed by domestic battery manufacturers.[37]

Thailand.—Exports of manganese ore were 440 tons,[38] compared with 130 tons in 1961 and 70 tons in 1960.

Turkey.—The Cayirli mine near Ankara, and the Eregli Manganese Co. on the Black Sea, were the principal manganese ore producers in 1961. Cayirli sold approximately 11,000 tons containing 49 per-

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[32] Roy, Supriya. Study of the Metamorphic Manganese Ores of Bharwell Mine Area, Madhya Pradesh, India, and Their Genesis. Econ. Geol., v. 57, No. 2, March–April 1962, pp. 195–208.

[33] Chemical Trade Journal and Chemical Engineer (London). V. 151, No. 3922, Aug. 3, 1962, p. 238.
Metal Industry (London). V. 100, No. 25, June 22, 1962, p. 499.
U.S. Embassy, New Delhi, India. State Department Airgram A–58, July 18, 1962, p. 10.

[34] U.S. Embassy, New Delhi, India. State Department Dispatch 1104, June 29, 1962, pp. 22–25.

[35] Metal Bulletin (London). No. 4760, Jan. 4, 1963, p. 21.

[36] Bureau of Mines. Mineral Trade Notes. V. 55, No. 6. December 1962, pp. 10–11.

[37] U.S. Embassy, Manila, Philippine Islands. State Department Dispatches 887 and A–261, June 20 and Sept. 21, 1962, p. 1.

[38] U.S. Embassy, Bangkok, Thailand. State Department Airgram A–824, Apr. 29, 1963, 2 pp.

cent manganese to the Karabuk steel plant, and exported 6,000 tons of fines to Spain. Most of the Eregli production was exported.[39]

AFRICA

Bechuanaland.—Manganese ore exports in 1961 were 25,000 tons. The Kwagkwe mine, south of Kanye, supplied 70 percent of the annual output and the remainder came from the Ootsi mine, an open-pit operation 12 miles north of Lobatsi and within 2 miles of the railroad. The manganese content of its ore product in 1961 ranged from 40 to 47 percent and averaged about 44 percent. Operated under different ownership from 1957 to September 1960, it was reopened by Bamelete Manganese (Pty.) Ltd. in July 1961, although not officially until June 1962 after the installation of a new screening plant. Plans called for an output of 5,000 tons of hand-picked ore per month. Its most important source of ore in 1961 was a series of "eluvial and rubble deposits" grading into highly manganiferous chert breccia or solid replacement bodies. The Kwagkwe mine of Marble Lime and Associated Industries was also an open-pit operation, although underground mining methods were used formerly. It had a heavy-medium separation plant, and analyses of its shipping grades were, in percent: High grade, 57.9 manganese and 1.5 iron; medium grade, 46.2 manganese and 6.9 iron; and low grade, 43.3 manganese and 8.9 iron. The geology of all the manganese deposits in Bechuanaland is similar, the manganese ore occurring as pods and lenses of manganese oxide (principally psilomelane) in sedimentary rocks.[40]

Gabon.—On October 2 and 3, 1962, the operations (mine, aerial tram, railway, and port facilities, representing a total investment of $98 million) of Cie. Minière de l'Ogooué (COMILOG) were officially inaugurated by ceremonies held in Gabon and in the Republic of Congo. The first shipment of ore, approximately 15,000 tons destined for West Germany, left the port of Point Noire the end of September. Mining was by opencut methods, in which two draglines with 122-foot booms and 6-cubic-yard buckets were used to remove overburden and ore. Each machine had a capacity of 240 cubic yards per hour and delivered to ore heaps from which 29-cubic-yard trucks were outloaded by two power shovels. The ore was crushed, washed, and screened, material under ¼-inch being rejected as tailing. These fines constituted approximately 30 to 40 percent of the washer feed. The marketable product, plus ¼-inch, had a typical analysis of 50 to 52 percent manganese, 3 to 4 percent ferric oxide, 2 to 3.5 percent silica, 6 to 7 percent alumina, and 0.10 to 0.13 percent phosphorus. The 47-mile aerial tramway, the second longest in the world, is a monocable system using buckets of 1-short ton capacity, spaced 59 yards apart. From the end of the cableway at M'blinda, the ore is carried by rail to Point Noire over 184 miles of new construction and 124 miles of the existing railroad, Chemin de Fer Congo-Ocean, which runs from Point Noire to Brazzaville.[41]

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[39] Bureau of Mines. Mineral Trade Notes. V. 55, No. 5, November 1962, p. 30.
[40] Bureau of Mines. Mineral Trade Notes. V. 55, No. 5, November 1962, p. 29.
South African Min. and Eng. J. (Johannesburg, Republic of South Africa.) Bechuanaland Manganese Plant Started Up. V. 73, pt. 1, No. 3620, June 22, 1962, p. 1357.
[41] Mining Journal (London). Moanda Manganese Mine in Production. V. 259, No. 6642, Dec. 7, 1962, pp. 538–539, 541.
International Commerce (U.S. Department of Commerce). New Congo Railway Carries Gabon's Manganese to Sea. V. 68, No. 25, Dec. 3, 1962, pp. 32–33.

Ivory Coast.—Newly discovered deposits were estimated to contain 3 to 6 million tons of high-grade manganese ore. They were investigated by trenching, geophysical methods, and drilling, by the Société pour le Développement Minier de la Côte d'Ivoire (SODEMI), a public corporation which was the official exploration agency of the Ivory Coast. Located in the northwest corner of the country in the Ziémougoula area near the town of Odienné, these deposits are in savannah country of moderate relief and were accessible by all-weather roads. One of the deposits, the Couture Hill, here was described as an elongated body rising 100 feet above the surrounding plain, and containing 500,000 tons of oxide ore which grades into carbonate and silicate protores at a depth of 165 feet. It was reported that the principal oxides are pryolusite and a battery-grade dioxide of the Nsuta (Ghana) type.[42] Exports of manganese ore from the Ivory Coast in 1961 were 114,000 tons of an average grade of 46 to 47 percent manganese,[43] coming from the coastal (Grand Lahou) deposit of Cie. Mokta el Hadid.[44]

Morocco.—Exports of chemical-grade ore in 1961 totaled 127,000 tons, of which the United States imported 103,000 tons; France, 14,000; the Netherlands, 3,400; Germany, 2,800; Czechoslovakia, 1,700; the United Kingdom, 1,350; and less than 100 tons each to Denmark, Poland, Italy, and Belgium. Metallurgical-grade ore exports totaled 245,000 tons, distributed as follows: France, 159,000; Norway, 20,000; Germany, 19,000; the United States, 11,000; Poland, 11,000; Yugoslavia 9,600; Spain, 6,200; Italy, 6,000; Sweden, 3,000; and small quantities to Denmark, Belgium, Switzerland, and the United Kingdom. Exports of sinter (33–56 percent manganese) were 177,000 tons, of which 91 percent went to France and the remainder to the United States.[45]

South Africa, Republic of.—The chairman of General Mining and Finance Corp., Ltd. reported at the annual meeting, June 1962, concerning two subsidiaries, as follows: The plant of Electrolytic Metal Corp. (Pty.) Ltd. was doubled in size, and production of battery-grade manganese dioxide was begun by General Manganese Products (Pty.) Ltd. early in June.[46] A 10-year contract was signed between General Mining and Finance Corp., Ltd., and its subsidiary, West Rand Consolidated Mines Ltd., on the one hand, and Province Mines Ltd. and Orient Manganese Co., on the other, for mining by the latter parties of battery-grade manganese ores in the Tarlton District of the Transvaal for processing in the new plant of General Manganese Products. The contract required that 2,500 tons of ore per month be delivered to obtain 1,250 tons of plant product,[47] prepared by grind-

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[42] South African Mining and Engineering Journal (Johannesburg). V. 74, pt. 1, No. 3651, Jan. 25, 1963, pp. 191–192.
[43] U.S. Embassy, Abidjan, Ivory Coast. State Department Dispatch 189, May 8, 1962, enclosure 1, p. 1.
[44] U.S. Embassy, Abidjan, Ivory Coast. State Department Airgram A–120, Sept. 18, 1962, p. 15.
[45] Bureau of Mines. Mineral Trade Notes. V. 56, No. 1, January 1963, pp. 27–28.
[46] Investor's Guardian (London). V. 178, No. 4570, June 29, 1962, p. 1527.
[47] Bureau of Mines. Mineral Trade Notes. V. 55, No. 5, November 1962, p. 30.

ing and leaching out impurities.[48] The plant, located at the West Rand Consolidated gold mine, Krugersdorp, was expected eventually to have surplus output for export. A small quantity of untreated battery-grade manganese ore or concentrate has been produced by Marble Lime & Associated Industries, Ltd. Production and local sales of South African manganese ore in 1961 were, respectively, in tons: 40 percent manganese and below, 787,000 and 395,000; 40 to 45 percent, 416,000 and 105,000; 45 to 48 percent, 242,000 and 60,000; and above 48 percent, 118,000 and 20,000. Manganese ore exports in 1961 and 1960 were 832,000, and 895,000 short tons, respectively. Distribution was as follows (1960 exports in parentheses): The United States, 225,000 (216,000); France, 164,000 (177,000); Germany, 124,000 (101,000); the United Kingdom, 110,000 (156,000); the Netherlands, 50,000 (50,000); Belgium, 43,000 (85,000); Japan, 36,000 (2,700); Sweden, 32,000 (21,000); Norway, 25,000 (44,000); Luxembourg, 19,000 (16,000); Denmark, 2,000 (3,300); Italy, 1,000 (22,000); Switzerland, 1,000 (none); and Poland, none (1,600). Work was started on doubling capacity of the Cato Ridge, Natal, plant of Ferroalloys Ltd. to 100,000 tons per year of ferromanganese, by adding two new electric furnaces to be completed by late 1963. The ferromanganese product has been exported to Europe and to the United States.[49]

South-West Africa.—The 1961 exports of manganese ore, totaling 66,000 tons (64,000 tons in 1960), were distributed as follows (1960 in parentheses): Spain, 31,000 (21,000); United States, 14,000 (33,000); Belgium, 11,000 (10,000); and Norway, 10,000 (none).[50] Exports in 1962 were 1,500 tons, averaging 46 percent manganese.[51]

OCEANIA

Australia.—Production of ferromanganese started in March 1962 at the new Bell Bay, Tasmania, plant of Tasmanian Electro-Metallurgical Co., Pty. Ltd., a subsidiary of Broken Hill Pty. Co., Ltd.[52] Capacity of the plant was 29,000 tons of high-carbon ferromanganese per year.[53] Production of manganese ore other than metallurgical for the 5 years, 1957–61, was as follows:[54]

Type	1957	1958	1959	1960	1961 (prelim.)
Battery:					
Short tons	860	1,100	1,600	950	1,300
Percent MnO_2	74.4	72.5	75.2	73.6	71.5
Other:					
Short tons	1,200	3,600	2,200	1,700	450
Percent MnO_2	64.9	66.6	70.5	65.9	66.5

New Hebrides.—The first shipment of manganese ore was made in January 1962 from the Forari deposits of Cie. Francaise des Phosphates de l'Oceanie (CFPO), on the island of Vate.[55] Total exports in

[48] U.S. Consulate General, Johannesburg, Republic of South Africa. State Department Dispatch 494, June 21, 1962, p. 21.
[49] Bureau of Mines. Mineral Trade Notes. V. 55, No. 3, September 1962, pp. 49–50.
[50] Bureau of Mines. Mineral Trade Notes. V. 55, No. 4, October 1962, pp. 24–25.
[51] U.S. Consulate General, Johannesburg, Republic of South Africa. State Department Airgram A-334, Mar. 13, 1963, p. 2.
[52] Bureau of Mines. Mineral Trade Notes. V. 55, No. 1, July 1962, p. 18.
[53] U.S. Embassy, Canberra, Australia. State Department Airgram A-572, Jan. 25, 1963, p. 1.
[54] The Australian Mineral Industry, Commonwealth of Australia (Australia). V. 15, pt. 2, No. 1, September 1962, p. 7.
[55] Bureau of Mines. Mineral Trade Notes. V. 55, No. 1, July 1962, p. 33.

1962 were 16,000 tons, all destined for Japan. The range of 6 analyses covering these shipments was, in percent: Manganese, 52.18 to 55.53; iron, 3.70 to 4.34; silica, 5.07 to 6.92; alumina, 2.51 to 7.26; and phosphorus, 0.062 to 0.081.[56] The deposit is a nearly horizontal bed, 2 feet thick with a 6½-foot cover of barren clay. The ore occurs as impure manganese oxides at the top of rhyolitic pumiceous tuff. Mining was by opencut with washer and agglomeration plant located several miles distant at the wharf at Metensa Bay on the east side of the island.[57]

TECHNOLOGY

In laboratory beneficiation tests at Salt Lake City, Utah, the Bureau of Mines used high-intensity magnetic separation to obtain rhodonite concentrates, containing 28 to 33 percent manganese, from San Juan Mountains (Colo.) raw materials with manganese contents varying from 7 to 28 percent. Recoveries ranged from 65 to 90 percent.[58] Using such a concentrate containing 29 percent manganese obtained from Silver Queen vein material, a silicomanganese containing 76.6 percent manganese, 17.3 percent silicon, and 1.8 percent carbon was made with a manganese recovery of 89 percent. The principal minerals in the concentrate were rhodonite (35 percent), rhodochrosite (30 percent), and quartz and chalcedony (together 25 percent); iron content of the concentrate was 2 percent, and silica content was 41 percent. Limestone was used for flux and coal for reductant.[59]

A reconnaissance resource study indicated a large quantity of manganiferous schist in the Kings Mountain district of North and South Carolina. Continuous mineralization, averaging 6.4 percent manganese as oxide and 7.4 percent iron, was suggested by scattered sampling over a 3-mile portion of a 12½-mile segment in South Carolina. The manganese oxide was believed to result from the weathering of the manganese garnet, spessartite, and there are possibilities for significant tonnages expressed as a submarginal oxide resource, a submarginal silicate resource, and possibly a submarginal mixed oxide-silicate resource. Laboratory agitation-leaching studies of three selected samples at the Bureau of Mines, Tuscaloosa, Ala., showed that the manganese oxides could be readily leached with sulfur dioxide to yield manganese extractions of 90 percent or more during leach periods of 30 minutes to 4 hours. However, manganese-to-iron ratios of the resulting liquors were too low for recovery of pure manganese sulfate by evaporation and crystallization, and the method was not applicable to the recovery of manganese occurring as a silicate.[60]

In laboratory-scale batch differential sulfatization tests at Tuscaloosa, Ala., the Bureau of Mines converted to manganese sulfate 60 to

[56] U.S. Consulate, Suva, Fiji. State Department Airgram A-202. Apr. 25, 1963, enclosure 1.

[57] U.S. Consulate, Suva, Fiji. State Department Dispatch 100, Feb. 27, 1962, enelosure 1, 1 p.

[58] Agey, W. W., C. H. Schack, and J. B. Clemmer. Metallurgical Studies of Rhodonite Ores, Silverton District, Colorado. 1. Beneficiation Tests to Produce Manganese Concentrates. BuMines Rept. of Inv. 6055, 1962, 16 pp.

[59] Fuller, H. C., and V. E. Edlund. Metallurgical Studies of Rhodonite Ores, Silverton District, Colorado. 2. Producing Silicomanganese by Electric Furnace Smelting. BuMines Rept. of Inv. 6062, 1962, 12 pp.

[60] O'Neill, J. F., and R. B. Bauder. Resource Investigation and Leaching Study of Manganiferous Schists, Kings Mountain District, North and South Carolina. BuMines Rept. of Inv. 6069, 1962, 12 pp.

99 percent of the managanese contained in a Georgia umber sample which, after drying, analyzed 45 percent iron and 5 percent manganese. Manganese extraction depended on temperature, contact time, and quantity and concentration of sulfur dioxide in the sulfur dioxide-air mixture used. Leaching with water, followed by evaporation, produced manganese sulfate that yielded a 58-percent manganese product with a manganese-to-iron ratio of 190 upon being fired at 1,150° C. The sulfatization tests were conducted in a small rotating drum that was fired indirectly, and optimum sulfatizing occurred in the range 670° to 730° C.[61]

Bench-scale flotation tests, using the standard oil-emulsion procedure employed in amenablity testing at time of purchase, were made by the Bureau of Mines, Salt Lake City, on three composite samples representing low-grade and offgrade manganese ore stockpiled by the Government at Deming, N. Mex., and Wenden, Ariz., during the domestic purchase program of 1951–55. The three composites (one for each depot and one for the depots combined) yielded concentrates analyzing, in percent: Manganese, 38.5 to 39.0; insoluble, 10 to 12; calcium oxide, 5; iron, 3 to 5; and combined lead, zinc, and copper, 1.3 to 1.7. Manganese recoveries were 88 to 90 percent. Proper conditioning of the pulp with the emulsion before flotation was a critical factor. Further studies indicated that sintering these concentrates above 1,000° C, with the addition of sodium or calcium chloride for removal of lead and zinc, would produce material meeting National Stockpile specifications for metallurgical manganese. Pyrolusite was the principal manganese mineral in the sample representing both depots, and minor quantities of ramsdellite were determined by X-ray diffraction. Major gangue constituents were quartz, chalcedony, bentonite, feldspar, and sericite. Discrete lead and zinc minerals were not found.[62]

More siliceous, lower grade, sintered flotation concentrate (Maggie Canyon) and still poorer log-washed ore (McGregor) from the Artillery Mountains area of Arizona were smelted separately by the Bureau of Mines in a 50-kilovolt-ampere single-phase electric-arc furnace at Boulder City, Nev., producing standard ferromanganese in each instance. Manganese recoveries from the sintered concentrate ranged from 85 to 89 percent; from the log-washed ore 73 to 80 percent. Tests run with this same furnace on metallurgical-grade nodules were compared with the operating data of a large commercial furnace on the same feed. Recoveries and product analyses were virtually the same; because of the greater surface to volume ratio, power consumption and electrode consumption were appreciably higher for the small furnace.[63] Details were reported of other sintering and electric smelting investigations producing standard ferromanganese, using flotation concentrate and high-grade dithionate pilot-plant precipitate, each

[61] LeVan, H. P., and R. B. Bauder. Differential Sulfatization of a Georgia Manganiferous Iron Ore. BuMines Rept. of Inv. 6046, 1962, 9 pp.

[62] Agey, W. W., and V. E. Edlund. Flotation and Sintering Studies on Manganese Ores Stockpiled at Deming, N. Mex., and Wenden, Ariz. BuMines Rept. of Inv. 6103, 1962, 13 pp.

[63] Petermann, F. B., and R. S. Lang. Electric Furnace Smelting of Offgrade Domestic Manganese Ores and Concentrates. BuMines Rept. of Inv. 6120, 1962, 21 pp.

of which was made from the same 10-percent-manganese Maggie Canyon ore.[64]

Application by the Bureau of Mines, Albany, Oreg., of the Dean-Leute ammonium carbamate process to three samples of low-grade dolomitic maganese carbonate ore from Philipsburg, Mont., obtained manganese extractions ranging from 42 to 84 percent. Manganese content of the head samples ranged from 4.26 to 12.8 percent; primary mineral constituents were rhodochrosite, dolomite, ankerite, and calcite, which were liberated essentially in the minus 100 mesh fraction. Part of the dolomite contained manganese and iron substituting for calcium and magnesium; the rhodochrosite contained magnesium, calcium, and iron substituting for manganese. The studies were statistically designed and evaluated.[65]

The Bureau of Mines, Boulder City, Nev., reported results of preliminary experiments in bacterial leaching manganese from low-grade Nevada and other manganiferous materials. In large-scale agitation-leaching tests in tanks, using 450 pounds from the Three Kids deposit and 800 pounds from the Boulder City deposit, results were respectively: Manganese recoveries, 72 and 92 percent; products, 48 and 54 percent manganese; leaching times, 100 and 51 days; head samples, 9.5 and 2.0 percent manganese.[66]

Studies of the $MnO-SiO_2$ system [67] and of the application of ultrasonics to the electrolytic deposition of manganese dioxide and manganese metal [68] were reported. From other studies, it was concluded that titanium would not be a practical substitute for manganese in the commercial production of steel.[69]

The first of a three-part series of publications was issued, reviewing briefly the principal processes which have been under consideration for recovering manganese from low-grade or offgrade domestic resources.[70] Manganese ore mining and washing operations in the Batesville district, Ark.,[71] were described, and the cataloging of the numerous manganese deposits of Arizona [72] and New Mexico was completed.[73]

More than 50 magnetic anomalies were mapped in the Westford Hill-Daggett Hill area, Hodgdon Township, in the southern district of Aroostook County, Maine. Chemical analysis of cores from nine drill holes indicated that the deposits, which are largely covered by glacial drift, averaged less than 7 percent manganese with iron con-

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[64] Edlund, V. E., and R. S. Lang. Sintering and Smelting Manganese Concentrates From Maggie Canyon Ore, Artillery Mountains Area, Ariz. BuMines Rept. of Inv. 5939, 1962, 27 pp.

[65] Sullivan, G. V., L. L. Brown, and R. G. Peterson. Extraction of Manganese From Low-Grade Dolomitic Materials by a Roast-Leach Process. BuMines Rept. of Inv. 6121, 1962, 24 pp.

[66] Perkins, E. C., and Frank Novielli. Bacterial Leaching of Manganese Ores. BuMines Rept. of Inv. 6102, 1962, 11 pp.

[67] Singleton, E. L., L. Carpenter, and R. V. Lundquist. Studies of the $MnO-SiO_2$ Binary System. BuMines Rept. of Inv. 5938, 1962, 31 pp.

[68] Kenahan, Charles B., and David Schlain. Effects of Ultrasonics on Electrolytic Deposition of Manganese and Manganese Dioxide From Sulfate Electrolytes. BuMines Rept. of Inv. 6073, 1962, 26 pp.

[69] Barnard, P. G., D. F. Walsh, and J. A. Rowland. Problems in Substituting Titanium for Manganese in Steel. BuMines Rept. of Inv. 6030, 1962, 27 pp.

[70] Norman, Lindsay D., and Ralph C. Kirby. Review of Major Proposed Processes for Recovering Manganese From United States Resources. 1. Pyrometallurgical Processes. BuMines Inf. Circ. 8138, 1962, 30 pp.

[71] Kline, H. D. Methods and Costs of Mining and Washing Manganese Ore, Batesville District, Arkansas. BuMines Inf. Circ. 8095, 1962, 22 pp.

[72] Farnham, L. L., L. A. Stewart, and C. W. DeLong. Manganese Deposits of Eastern Arizona. BuMines Inf. Circ. 7990, 1961, 178 pp.

[73] Farnham, Lloyd L. Manganese Deposits of New Mexico. BuMines Inf. Circ. 8030, 1961, 176 pp.

tent about twice as much. The minerals are extremely fine grained, and the manganese occurs as carbonates. Several other magnetic anomalies, including three significant ones, were outlined on the Stewart prospects in Linneus Township.[74]

Correlation between internal structure, internal friction (damping capacity), and magnetic susceptibility was demonstrated for 70 percent manganese—30 percent copper alloy in experiments at the Bureau of Mines, Rolla, Mo.[75]

Papers were published on the manganese oxide minerals,[76] and observations were made on the widespread occurrence of nsutite, a natural gamma-MnO_2 mineral. Named after the type locality Nsuta, Ghana, it occurred abundantly in the battery ores there.

An extensive bibliography of ocean-floor manganese deposits was appended to a published review of the literature and recent investigations of this subject.[77]

A process was patented, together with its associated apparatus, for the production by fused salt electrolysis of low-carbon, low-silicon manganese, or of a low-carbon, low-silicon manganese alloy. The fused electrolytic bath was specified to contain at least 50 percent by weight of calcium fluoride.[78]

Electrolytic manganese in lump form was marketed in December. Its low surface to weight ratio and high density were claimed for certain applications, particularly nonferrous castings, to provide better utilization and costs when compared with the use of master alloys or of electrolytic manganese in normal chip form.

In 1960–61, one of the blast furnaces at the Zaporozhstal plant in the Ukraine was converted to the production of ferromanganese, using a burden composed of 60 percent Nikopol grade I manganese ore and 40 percent agglomerate obtained from grade II ore. Average manganese content of the ore burden was 40 to 41 percent. By injecting air at a pressure of 4.5 atmospheres to the central part of the furnace, productivity was 109 percent, productivity without an "intensifier" being 100 percent. Injecting oxygen at 8.0 to 8.5 atmospheres, productivity was increased to 115.6 percent on the same basis.[79]

See also World Review section on U.S.S.R. in this chapter for additional technical information.

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[74] Earl, Kenneth M., and N. A. Eilertsen. Investigation of Manganese Deposits, Hodgdon and Linneus Townships, Southern District, Aroostook County, Maine. BuMines Rept. of Inv. 6119, 1962, 47 pp.

[75] Schwaneke, A. E., and J. W. Jensen. Magnetic Susceptibility and Internal Friction of Tetragonal Manganese-Copper Alloys Containing 70 Percent Manganese. J. Appl. Phys., v. 33, No. 3, March 1962, pp. 1350–1351.

[76] Fleischer, Michael, W. E. Richmond, and Howard T. Evans, Jr. Studies of the Manganese Oxides. V. Ramsdellite, MnO_2, An Orthorhombic Dimorph of Pyrolusite. Am. Mineral., v. 47, Nos. 1–2, January–February 1962, pp. 47–58.

Larson, Lawrence T. Zinc—Bearing Todorokite From Philipsburg, Montana. Am. Mineral., v. 47. Nos. 1–2. January–February 1962, pp. 59–66.

Levinson, A. A. Birnessite From Mexico. Am. Mineral., v. 47, Nos. 5–6, May–June 1962, pp. 790–791.

Mouat, M. M. Manganese Oxides From the Artillery Mountains Area, Arizona. Am. Mineral., v. 47, Nos. 5–6, May–June 1962, pp. 744–757.

Prinz, William C. Manganese Oxide Minerals at Philipsburg, Montana. Geological Survey Research 1961. U.S. Geol. Survey Prof. Paper 424–B, pp. B–296–297.

Zwicker, W. K., W. O. J. Groeneveld Meijer, and H. W. Jaffee. Nsutite—A Widespread Manganese Oxide Mineral. Am. Mineral., v. 47, Nos. 3–4, March–April 1962, pp. 246–266.

[77] Mero, John L. Ocean-Floor Manganese Nodules. Econ. Geol., v. 57, No. 5, August 1962, pp. 747–767.

[78] Welsh, Jay Y., Marlyn W. Milberg, and Harold R. Peterson (assigned to Manganese Chemicals Corp.). Producing Manganese by Fused Salt Electrolysis and Apparatus Therefor. U.S. Patent 3,018,233, Jan. 23, 1962.

[79] Balon, I. D., V. I. Litvinenko, T. A. Tuluevskaya, and N. T. Romanenko. Smelting Ferromanganese at the Plant "Zaporozhstal." Metallurgist, No. 12, December 1961.

Mercury

By John E. Shelton [1] and Gertrude N. Greenspoon [2]

RECORD mercury consumption, increased imports, and the lowest domestic mine production since 1956 marked the mercury industry in 1962. Prices were unchanged for most of the year; the annual average price was $191.21 per flask, 3 percent less than in 1961 and the lowest since 1950. Stocks were the smallest since 1959.

Mine production declined 17 percent as lower outputs were recorded in all principal mercury-producing States. Mercury consumption of 65,300 flasks exceeded that of 1961 by 17 percent. The increase was due to installation of new chlorine and caustic soda facilities using mercury cells and to increased demands by other principal users. Although consumption was at a record rate while domestic production decreased, a threefold increase of imports for consumption coupled with a 15-percent decrease in stocks resulted in an adequate supply to meet requirements.

Mercury continued to be eligible for Government assistance in exploration of deposits through the Office of Minerals Exploration. In August mercury was removed from the list of commodities eligible for barter transactions by the Commodity Credit Corporation.

World output of mercury totaled 244,000 flasks, 2 percent above 1961. Production gains were recorded in Mexico, Peru, and Yugoslavia, whereas output declined in the United States and was little changed in Italy and Spain.

TABLE 1.—Salient mercury statistics

	1953-57 (average)	1958	1959	1960	1961	1962
United States:						
Producing mines	97	101	71	75	69	56
Production flasks [1]	22,127	38,067	31,256	33,223	31,662	26,277
Value thousands	$5,602	$8,720	$7,110	$7,002	$6,257	$5,024
Imports:						
For consumption flasks	51,605	30,196	30,141	19,488	[2] 12,326	31,652
General do	53,901	30,973	30,260	19,515	[2] 12,527	31,666
Exports do	977	320	640	357	285	224
Reexports do	1,584	934	553	317	180	257
Stocks Dec. 31 do	21,447	11,274	13,580	19,761	17,533	14,924
Consumption do	51,854	52,617	54,895	51,167	55,763	65,301
Price: New York, average per flask	$250.93	$229.06	$227.48	$210.76	$197.61	$191.21
World: Production flasks	196,000	246,000	223,000	242,000	240,000	244,000
Price: London, average per flask	$239.82	$214.98	$208.61	$197.86	$181.87	$172.79

[1] Flasks as used in this chapter refers to a 76-pound flask.
[2] Revised figure.

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

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LEGISLATION AND GOVERNMENT PROGRAMS

Through the Office of Minerals Exploration (OME), the Government participated to the extent of 50 percent of the financial risk with private industry in exploratory ventures judged capable of increasing the Nation's resources for selected mineral commodities. In 1962, four new contracts were made to explore for mercury ores.

Company:	*Location*	*Total cost*
Alaska Mines & Minerals, Inc	Aniak district, Alaska	$324, 100
J. Selby & Wm. Dawson (assigned to San Simeon Keystone, Inc.)	San Luis Obispo County, Calif.	52, 730
T. R. Baugh	Valley County, Idaho	18, 510
Pacific Minerals & Chemicals Co., Inc.	Crook County, Oreg	69, 720

The U.S. Tariff Commission held a public hearing on February 20 following its investigation of the mercury industry in 1961. Members of mercury mining, selling, and consuming industries were present. The Commission report of November 1958 was updated, and results were published in "Report to the Congress on Investigation No. 332–32 (Supplemental)," TC 57, May 1962.

On August 23 mercury was removed from the list of items eligible for acquisition in exchange for surplus agricultural products under the barter program administered by the U.S. Department of Agriculture, Commodity Credit Corporation (CCC).

DOMESTIC PRODUCTION

Annual production of primary mercury in the United States declined for the second consecutive year; output was 17 percent less than in 1961 and the lowest since 1956. All principal mercury-producing States had lower outputs, and there was no production in Idaho for the first time since 1950. The number of producing mines dropped to 56, the smallest since 1953. The quantity of ore treated dropped 44 percent, and mercury recovered declined 17 percent, but the average grade treated rose 4.4 pounds per ton to 13.6 pounds. The increase in recovery was due primarily to the processing of substantial quantities of newly discovered high-grade ore at the New Idria mine, San Benito County, Calif. The average grade of ore treated in California rose from 11.7 pounds per ton in 1961 to 14.4 pounds. Production of secondary mercury declined 31 percent.

Despite a 15-percent drop in mercury output, California remained the leading mercury-producing State and supplied 61 percent of the domestic total. The four principal producers—New Idria, Buena Vista, New Almaden, and Mount Jackson (including Great Eastern) accounted for 94 percent of the State total, compared with 87 percent in 1961.

Nevada remained in second place, furnishing 25 percent of the domestic total. Production was 12 percent less than in 1961 and the lowest since 1957. The Cordero mine in Humboldt County, the leading producer in the State, ranked second in the United States. Its production, however, was 3 percent less than in 1961.

Output in Alaska was 10 percent less than in 1961 and represented 14 percent of the total domestic production. Most of the output came from the Red Devil mine, Kuskokwim River region.

The remainder of the 1962 production, less than 1 percent, came from Arizona and Oregon.

Four properties (each producing 1,000 flasks or more) supplied 90 percent of the total domestic output. The leading producers were as follows:

State:	*County*	*Mine*
Alaska	Aniak district	Red Devil.
California	San Benito	New Idria.
	San Luis Obispo	Buena Vista.
Nevada	Humboldt	Cordero.

In addition to the foregoing mines, the following mercury operations produced 100 flasks or more:

State:	*County*	*Mine*
California	Santa Clara	New Almaden.
	Sonoma	Culver-Baer.
		Mount Jackson (including Great Eastern).
	Yolo	Reed.

These 8 mines produced 97 percent of the domestic mercury output.

Producers reports on furnace capacity indicated that 3 multiple-hearth furnaces and 13 rotary furnaces could treat 180 and 730 tons of ore per day, respectively. In addition, 26 retorts (including multiple pipe, the D-type, and inclined pipes) were operated. Capacity ranged from 100 pounds of ore per day in inclined-pipe retorts to 6,000 tons per day in multiple-pipe retorts. Total reported capacity of retorts was more than 10,000 pounds per day.

TABLE 2.—Mercury produced in the United States, by States

Year and State	Producing mines	Flasks	Value [1]	Year and State	Producing mines	Flasks	Value [1]
1961:							
Alaska	2	4,129	$815,932	1962:			
Arizona	4	148	29,246	Alaska	2	3,719	$711,110
California	36	18,688	3,692,936	California	37	15,951	3.049,991
Idaho	1	1,073	212,036	Nevada	14	6,573	1,256,823
Nevada	21	7,486	1,479,308	Arizona and Oregon	3	34	6,501
Oregon	5	138	27,270	Total	56	26,277	5,024,425
Total	69	31,662	6,256,728				

[1] Value calculated at average New York price.

TABLE 3.—Mercury ore treated and mercury produced in the United States [1]

Year	Ore treated (short tons)	Mercury produced		Year	Ore treated (short tons)	Mercury produced	
		Flasks	Pounds per ton of ore			Flasks	Pounds per ton of ore
1953-57 (average)[2]	217,739	21,954	7.6	1960	258,071	33,106	9.7
1958	328,155	37,209	8.6	1961	262,108	31,633	9.2
1959	275,903	31,109	8.6	1962	146,523	26,228	13.6

[1] Excludes mercury produced from placer operations and from cleanup activity at furnaces and other plants.
[2] Until 1954, excludes some material from old dumps.

Production of mercury from secondary sources was 31 percent below 1961. Mercury was reclaimed from dental amalgam, oxide and acetate sludges, and battery scrap.

TABLE 4.—Production of secondary mercury in the United States

Year:	*Flasks*
1958	5,400
1959	4,950
1960	5,350
1961	8,360
1962	5,800

CONSUMPTION AND USES

Industrial consumption of mercury rose 17 percent to 65,301 flasks, an alltime record. Installation of two mercury-cell chlorine and caustic soda plants and expansion at another such plant, coupled with increased demands by some of the principal users, caused the record-breaking consumption.

Two new chlorine and caustic soda plants began producing at Monsanto, Ill., and Charleston, Tenn., and capacity was expanded at a plant at Brunswick, Ga. Mercury required to replace losses in manufacturing chlorine and caustic soda rose 21 percent.

The mercury-cell process gradually was replacing the older electrolytic diaphragm-cell method. In 1946 about 87 percent of domestic chlorine production was from diaphragm-cell plants, 4 percent from mercury-cell plants, and 9 percent from plants using other methods. In 1960 mercury cells accounted for 18 percent of the output, diaphragm cells 75 percent, and other 7 percent, and in 1961 the breakdown was 20, 74, and 6 percent, respectively.

The principal reason for the changeover to mercury cells is the lower chloride content in caustic soda produced by this method. The higher purity material is required by the rayon industry, the largest user of caustic soda.[3]

[3] Currey, John E., and Clifford A. Hampel. Report of the Chlor-Alkali Committee of the Industrial Electrolytic Division for the Year 1961. Electrochem. Tech., v. 1, No. 1–2, January–February 1963, pp. 56–60.
Chemical Week. Fast Push To Fill Chlorine Needs. V. 91, No. 1, July 7, 1962, pp. 75–76, 79.

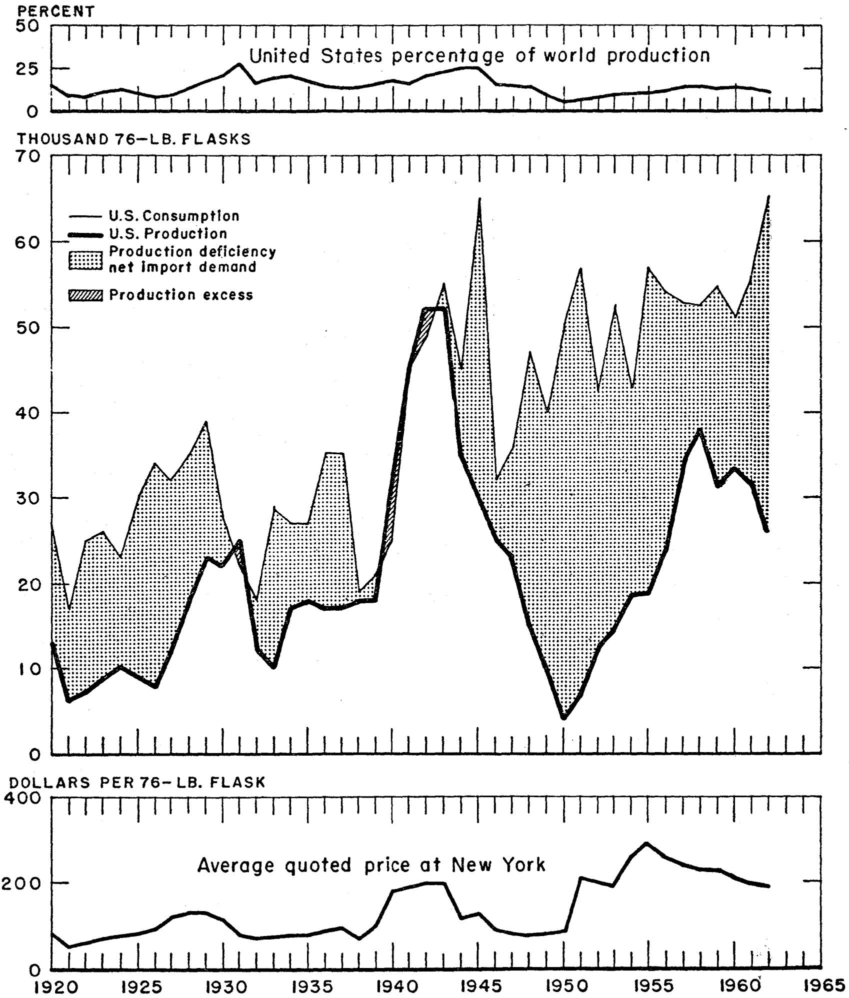

FIGURE 1.—Trends in production, consumption, and price of mercury, 1920–62.

Other uses that consumed more mercury were agriculture, 67 percent; pharmaceuticals, 34 percent; and electrical apparatus, 13 percent. Use of mercury in slime-control compounds for paper and pulp manufacture declined for the third consecutive year; consumption was 16 percent below 1961. Mildew proofing paint took 12 percent less mercury, industrial and control instruments took 8 percent less, and dental preparations used 6 percent less.

TABLE 5.—Mercury consumed in the United States by uses

(Flasks)

Use	1953-57 (average)	1958	1959	1960	1961	1962
Agriculture (includes fungicides, and bactericides for industrial purposes)	7,650	6,270	3,202	2,974	2,557	4,266
Amalgamation	221	248	265	255	278	299
Catalysts	776	816	965	1,018	707	874
Dental preparations [1]	1,280	1,741	1,828	1,783	2,154	2,033
Electrical apparatus [1]	9,729	9,335	8,905	9,268	10,255	11,564
Electrolytic preparation of chlorine and caustic soda	3,000	4,547	5,828	6,211	6,056	7,314
General laboratory use	1,045	968	1,110	1,302	1,484	1,752
Industrial and control instruments [1]	5,700	6,054	6,164	6,525	5,627	5,186
Paint:						
Antifouling	594	749	993	1,360	915	124
Mildew proofing	(2)	(2)	2,521	2,861	5,146	4,554
Paper and pulp manufacture	(3)	(3)	4,360	3,481	3,094	2,600
Pharmaceuticals	1,727	1,430	1,717	1,729	2,515	3,378
Redistilled [1]	9,167	9,448	9,331	9,678	9,013	8,987
Other	10,965	11,011	7,706	2,722	5,962	12,370
Total	51,854	52,617	54,895	51,167	55,763	65,301

[1] A breakdown of the "redistilled" classification showed ranges of 47 to 38 percent for instruments, 13 to 7 percent for dental preparations, 44 to 28 percent for electrical apparatus, and 18 to 8 percent for miscellaneous uses in 1953-61, compared with 41 percent for instruments, 14 percent for dental preparations, 28 percent for electrical apparatus, and 17 percent for miscellaneous uses in 1962.
[2] Data not available.
[3] Included with agriculture.

STOCKS

Consumers and dealers stocks of mercury were 12 percent less than those at the end of 1961. Withdrawal of metal from inventories for installation of two new chlorine and caustic soda plants and for expansion at an existing plant was largely responsible for the drop.

Stocks held by producers are usually small in relation to total industry inventories and in 1962 furnished only 8 percent of the total.

In addition to the stocks shown in table 6, 146,000 flasks, of which 16,000 flasks was in the supplemental stockpile, were in Government stockpiles at the end of 1962.

Mercury withdrawn from inventory for installation and expansion of chlorine and caustic soda plants and mercury-power boilers, together with other nondissipative uses, actually constitutes a reserve of metal. In the event these plants are dismantled or more urgent demands for mercury develop, this mercury can be reclaimed and used. At the end of 1962, 126,000 flasks of mercury was in use at chlorine and caustic soda plants and in boilers. The quantity in use at each type of installation may not be revealed.

TABLE 6.—Stocks of mercury, December 31

(Flasks)

Year	Producer	Consumer and dealer	Total
1953-57 (average)	1,407	20,040	21,447
1958	674	10,600	11,274
1959	1,880	11,700	13,580
1960	2,561	17,200	19,761
1961	2,033	15,500	17,533
1962	1,224	13,700	14,924

PRICES

The average price for mercury in the United States was $191.21 per flask, more than $6.00 below 1961 and the lowest since 1950. Prices ranged from $190–$193 per flask at the beginning to $186–$189 at the end of 1962. The high of $192–$195, reached the third week in February, was unchanged until the second week in November, when the quotation dropped to $190–$193 per flask.

In London, mercury was quoted at £59 ($165.20) per flask at the beginning of 1962. Slight increases starting in mid-January brought the price to £62 10s. ($175.00) in the third week of March, which held until the last week in May. The quotation of £61 10s. ($172.20) effective the week ending May 31 remained unchanged at yearend. The annual average price was £61 10s. 9d. ($172.79), 5 percent below that of 1961.

TABLE 7.—Average monthly prices of mercury at New York and London
(Per flask)

Month	1961		1962	
	New York [1]	London [2]	New York [1]	London [2]
January	$209.00	$193.99	$190.00	$167.25
February	208.06	193.19	191.50	172.39
March	206.00	193.03	192.00	174.83
April	205.90	189.57	192.00	175.88
May	203.00	187.20	192.00	175.19
June	200.46	186.36	192.00	172.71
July	194.80	182.57	192.00	172.61
August	188.17	177.14	192.00	172.43
September	188.00	175.06	192.00	172.26
October	188.62	172.44	192.00	172.28
November	189.25	167.21	190.40	172.32
December	190.00	165.77	186.60	172.40
Average	197.61	181.87	191.21	172.79

[1] Engineering and Mining Journal, New York.
[2] Mining Journal (London) prices in terms of pounds sterling were converted to U.S. dollars by using average rates of exchange recorded by Federal Reserve Board.

FOREIGN TRADE [4]

Imports.—Imports of mercury for consumption were almost triple the quantity received in 1961 and were the largest since 1957. Of the 31,700 flasks received in 1962, Italy supplied 33 percent, Spain 31 percent, Mexico 24 percent, and Yugoslavia 10 percent. Canada, Chile, Sweden, and the United Kingdom furnished the remainder. The Canadian metal was scrap mercury received duty free. Receipts from Yugoslavia were the largest since 1955.

Imports of various mercury compounds and preparations totaled 46,368 pounds, slightly more than half the 1961 quantity. Of the total, 29,071 pounds came from Yugoslavia, 12,023 from Spain, 4,508 from United Kingdom, 441 from the Netherlands, 325 from West Germany, and less than 1 pound each from Canada and Israel.

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

TABLE 8.—U.S. imports for consumption[1] of mercury, by countries

Country	1953–57 (average)		1958		1959		1960		1961		1962	
	Flasks	Value (thousands)	Flasks	Value (thousands)	Flasks	Value (thousands)	Flasks	Value (thousands)	Flasks	Value (thousands)	Flasks	Value (thousands)
North America:												
Canada	109	$27	50	$7	125	$23	20	$5	24	$4	61	$10
Mexico	9,851	1,999	8,251	1,506	3,516	646	2,419	382	[2] 3,023	445	7,718	1,076
Total	9,960	2,026	8,301	1,513	3,641	669	2,439	387	[2] 3,047	449	7,779	1,086
South America:												
Bolivia	----	----	9	2	11	2	----	----	----	----	----	----
Chile	5	1	514	102	813	164	139	26	82	15	200	31
Colombia	3	(3)	80	12	----	----	30	6	25	4	----	----
Peru	142	34	345	61	589	112	49	8	----	----	----	----
Total	150	35	948	177	1,413	278	218	40	107	19	200	31
Europe:												
Italy	16,759	3,063	1,133	221	6,146	1,256	3,420	627	2,073	365	10,501	1,800
Netherlands	14	3	----	----	----	----	----	----	----	----	----	----
Spain	20,876	4,014	18,494	3,729	17,111	3,400	12,464	2,278	6,544	1,118	9,826	1,638
Sweden	----	----	----	----	----	----	----	----	----	----	70	10
United Kingdom	571	128	(4)	(3)	235	48	----	----	(4)	(3)	(4)	(3)
Yugoslavia	3,253	695	220	46	954	198	900	170	355	62	3,276	537
Total	41,473	7,903	19,847	3,996	24,446	4,902	16,784	3,075	8,972	1,545	23,673	3,985
Asia:												
India	5	1	----	----	----	----	----	----	----	----	----	----
Japan	5	1	----	----	----	----	----	----	----	----	----	----
Philippines	----	----	1,100	236	400	81	----	----	----	----	----	----
Turkey	12	3	----	----	100	36	----	----	200	35	----	----
Total	22	5	1,100	236	500	117	----	----	200	35	----	----
Oceania:												
Australia	----	----	----	----	126	23	----	----	----	----	----	----
New Zealand	----	----	----	----	15	3	47	8	----	----	----	----
Total	----	----	----	----	141	26	47	8	----	----	----	----
Grand total	51,605	[5] 9,969	30,196	5,922	30,141	5,992	19,488	3,510	[2] 12,326	2,048	31,652	5,102

[1] Data include mercury imported for immediate consumption plus material withdrawn from bonded warehouses.
[2] Revised figure.
[3] Less than $1,000.
[4] Less than 1 flask.
[5] 1954 data known to be not comparable with other years.
Source: Bureau of the Census.

TABLE 9.—U.S. imports[1] of mercury, by countries

Country	1953–57 (average)	1958	1959	1960	1961	1962
North America:						
Canada	109	50	125	20	24	61
Mexico	10,363	8,350	3,631	2,459	[2] 3,205	7,660
Total	10,472	8,400	3,756	2,479	[2] 3,229	7,721
South America:						
Bolivia	---	9	11	---	---	---
Chile	25	1,160	400	139	82	200
Colombia	3	80	30	---	115	---
Peru	142	345	599	49	---	---
Total	170	1,594	1,040	188	197	200
Europe:						
Italy	17,413	1,015	6,175	3,447	2,002	10,548
Netherlands	14	---	---	---	---	---
Spain	21,557	18,644	17,509	12,444	6,544	9,826
Sweden	---	---	---	---	---	70
United Kingdom	613	(3)	185	---	(3)	(3)
Yugoslavia	3,634	220	954	910	355	3,301
Total	43,231	19,879	24,823	16,801	8,901	23,745
Asia:						
Japan	5	---	---	---	---	---
Philippines	---	1,100	400	---	---	---
Turkey	23	---	100	---	200	---
Total	28	1,100	500	---	200	---
Oceania:						
Australia	---	---	126	---	---	---
New Zealand	---	---	15	47	---	---
Total	---	---	141	47	---	---
Grand total	53,901	30,973	30,260	19,515	[2] 12,527	31,666

[1] Data are "general" imports; that is, they include mercury imported for immediate consumption plus material entering the country under bond.
[2] Revised figure.
[3] Less than 1 flask.

Source: Bureau of the Census.

Exports.—Exports of mercury, usually small, decreased 21 percent to 224 flasks (285 in 1961). Of the total, 53 (13) went to Colombia, 27 (56) to Japan, 24 (5) to Dominican Republic, 21 (61) to Canada, 17 (23) to Venezuela, 16 (7) to Mexico, 14 (14) to the Philippines, 11 (0.5) to Taiwan, 10 (8) to Netherlands Antilles, and the remainder in lots of less than 10 flasks each to 16 other countries.

Reexports.—Reexports totaled 257 flasks compared with 180 in 1961. Of the total, 95 (none) went to Japan, 85 (166) to Canada, 52 (none) to Mexico, 20 (none) to Colombia, and 5 (none) to Panama.

Tariff.—The duty of 25 cents per pound ($19 per flask) on imports of mercury, in effect since 1922, was continued.

TABLE 10.—U.S. exports of mercury

Year	Flasks	Value	Year	Flasks	Value
1953–57 (average)	977	$242,627	1960	357	$82,957
1958	320	95,003	1961	285	70,622
1959	640	92,255	1962	224	64,024

Source: Bureau of the Census.

TABLE 11.—U.S. reexports of mercury

Year	Flasks	Value	Year	Flasks	Value
1953-57 (average)	1,584	$346,371	1960	317	$62,015
1958	934	198,501	1961	180	33,067
1959	553	119,038	1962	257	42,549

Source: Bureau of the Census.

WORLD REVIEW

World output of mercury rose slightly above that of 1961 to 244,000 flasks. Production increases in Mexico, Peru, and Yugoslavia of 4, 23, and 2 percent, respectively, more than offset a 17-percent reduction in output in the United States. Production in Italy and Spain was virtually unchanged from 1961.

TABLE 12.—World production of mercury by countries [1]

(Flasks)[2]

Country	1953–57 (average)	1958	1959	1960	1961	1962
North America:						
Mexico	19,375	22,556	16,420	20,114	18,101	18,855
United States	22,127	38,067	31,256	33,223	31,662	26,277
South America:						
Chile	424	3,343	2,007	2,876	1,509	[3] 1,800
Colombia	[4] 45	203	95	149	191	[3] 190
Peru	194	1,983	2,526	3,034	3,001	[5] 3,684
Europe:						
Austria	15					
Czechoslovakia [6]	725	725	725	725	725	870
Italy	57,036	58,712	45,833	55,492	55,434	54,680
Rumania	396	353	387	413	350	[3] 350
Spain	45,185	55,382	51,680	53,369	51,202	[3] 50,000
U.S.S.R.[3]	16,800	25,000	25,000	25,000	25,000	35,000
Yugoslavia	13,773	12,270	13,344	14,069	15,954	16,273
Asia:						
China [3]	12,000	17,000	23,000	23,000	26,000	26,000
Japan	4,576	5,720	5,988	5,791	5,437	[3] 5,400
Philippines	[4] 2,338	3,321	3,539	3,041	3,167	3,108
Turkey	580	1,486	[5] 1,321	1,339	1,864	[3] 1,800
Africa: Tunisia	[4] 63	39	198	166	54	
World total (estimate)	196,000	246,000	223,000	242,000	240,000	244,000

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[2] 76-pound flasks.
[3] Estimate.
[4] Average annual production 1955–57.
[5] Exports.
[6] Estimate according to the 49th Annual issue of Metal Statistics (Metallgesellschaft), except Czechoslovakia 1962.

Compiled by Liela S. Price, Division of Foreign Activities.

China.—The better known mercury deposits [5] are located in adjoining areas of T'ung-jen in Kweichow and Fenghuang in Hunan. Most of the Chinese output has come from these mines, which are known to have large reserves. In late 1961, after many years, Chinese mercury reappeared on the London market.

[5] Wei, Anton, W. T. Minerals in China in 1961. Min. J. (London). V. 258, No. 6607, Apr. 6, 1962, pp. 334–335 and 337; No. 6608, Apr. 13, 1962, pp. 361–362; Apr. 27, 1962, pp. 409–411.

Italy.—Production in Italy, the leading world producer for the third consecutive year, was virtually unchanged from 1961. In July 1961, a Pacific Foundry furnace was installed to treat higher grade ore mined at the Societá Anonima Mineraria Monte Amiata Del Morone mine, Grosseto Province.[6]

In late 1962, it was announced that Mercurio Italiano, established in 1958 to market production of the Monte Amiata and Siele mines, would be dissolved January 1, 1963. Because of anti-monopoly rules of the European Common Market, the two companies were to operate separately thereafter.

TABLE 13.—Italy: Exports of mercury by countries [1]

(Flasks)

Destination	1961	1962	Destination	1961	1962
Austria	49	490	Norway	267	73
Belgium-Luxembourg	249		Pakistan	1,729	35
Czechoslovakia	870		Sweden	84	1,584
Denmark	200		Switzerland		464
France	4,009	7,530	United Kingdom	6,504	3,011
Germany, West	10,710	7,177	United States	5,587	6,504
India	980	1,920	Other countries	1,442	1,082
Iran		548			
Japan		4,435	Total	32,680	35,726
Netherlands		873			

[1] This table incorporates some revisions.

Compiled from Customs Returns of Italy by Bertha M. Duggan, Division of Foreign Activities.

Japan.—A report published [7] in 1958 stated that mercury production in Japan changed substantially with the discovery of Itomuka mine in 1936. Production began in 1939 and rose rapidly through 1944 when 5,700 flasks—80 percent of Japan's output—was produced. From 1945 through 1951, operations were considerably reduced; but they turned upward in 1952, and peak output (7,500 flasks) was attained in 1954. From 1939 through 1957 the Itomuka mine produced 61,000 flasks. In 1950, one 6-hearth, 5-meter-diameter Herreshoff furnace was installed, and in 1952 another Herreshoff furnace (6-hearth, 3-meter-diameter) was added. Two of the furnaces were in operation in 1958. (See Minerals Yearbook, 1954, for description of previously installed equipment.)

The Yamato mine, one of the oldest developed in Japan, was inactive from 1946 to 1951. In 1955, Yamato Metal Mining Co., Ltd., was formed and mercury was recovered in a 23-flask-per-month retort. A 25-ton-per-day Gould rotary furnace was installed in 1957 and output increased to 44 flasks per month. Production, including that from imported ore, totaled 14,100 flasks from 1929 to 1957.

Consumption of mercury by uses is shown in table 14.

[6] Metal Bulletin (London). No. 4694, May 8, 1962, p. 25.

[7] Yajima, Sumisaku. Mercury Mining in Japan and Outline of Nomura Mining Co., Ltd. August 1958, 15 pp.

TABLE 14.—Japan: Consumption of mercury, by uses

(Flasks)

Use	1952	1953	1954	1955	1956
Agriculture	290	1,277	2,234	1,102	1,189
Antifouling paint	1,015	928	1,189	1,160	1,306
Chlorine and caustic soda	1,885	3,481	5,947	4,873	11,197
Fulminate	1,015	319	667	638	870
Industrial and control instruments	870	1,189	1,276	1,422	1,799
Inorganic chemicals	830	696	2,089	2,263	4,003
Organic synthetic industry	870	1,422	1,508	3,394	6,933
Pharmaceuticals and dental preparations	58	348	493	290	203
Other	102	319	290	174	203
Total	6,935	9,979	15,693	15,316	27,703
	1957	1958	1959	1960	1961
Agriculture	3,133	4,264	2,959	5,076	4,786
Antifouling paint	464	377	377	493	464
Chlorine and caustic soda	11,487	3,046	7,107	15,084	13,054
Fulminate	1,015	899	754	551	406
Industrial and control instruments	2,060	1,741	1,653	1,741	1,538
Inorganic chemicals	8,413	5,338	6,382	7,049	7,252
Organic synthetic industry	7,890	8,528	6,904	6,817	8,586
Pharmaceuticals and dental preparations	116	87	87	87	87
Other	116	87	377	377	435
Total	34,694	24,367	26,600	37,275	36,608

TABLE 15.—Mexico: Exports of mercury by countries[1]

(Flasks)

Destination	1960	1961	Destination	1960	1961
Canada	239	197	United Kingdom	3,212	2,165
France	109	321	United States	5,790	5,266
Germany	347	236	Other countries	180	851
Japan	12,603	8,613			
Netherlands	162	1,599	Total	22,642	19,248

[1] This table incorporates some revisions.

Compiled from Customs Returns of Mexico by Bertha M. Duggan, Division of Foreign Activities.

TABLE 16.—Spain: Exports of mercury, by countries[1]

(Flasks)

Destination	1960	1961	Destination	1960	1961
Australia	268	192	Netherlands	3,046	3,221
Austria	505	174	Norway	55	300
Belgium-Luxembourg	549	245	Portugal	171	364
Brazil	753	813	Sweden	1,001	1,716
Canada	1,251	1,601	Switzerland	1,511	914
Czechoslovakia	1,201	----------	United Arab Republic (Egypt)	2,279	----------
Denmark	----------	1,651	United Kingdom	8,191	7,221
Finland	581	445	United States	12,322	9,394
France	6,609	7,728	Other countries	204	334
Germany, West	10,910	11,432			
Hungary	500	----------	Total	52,618	48,086
India	378	341			
Korea	333	----------			

[1] This table incorporates some revisions.

Compiled from Customs Returns of Spain by Bertha M. Duggan, Foreign Statistics, Division of Foreign Activities.

Turkey.—Most of Turkey's output has come from mines near Izmir on the Karaburun Peninsula. About 1956 Göksu Maden ve Sanayi, A.S. Istanbul, acquired mercury deposits near Şeyhşaban, Kastamonu Province, 12.5 miles from Abana.[8] Production totaled 345 and 195 flasks, respectively, in 1959 and 1960.

United Kingdom.—Foreign-trade data for the United Kingdom indicated that consumption of mercury decreased 20 percent in 1962. Imports of metal dropped 23 percent and reexports 31 percent. The new supply of mercury available for consumption totaled 14,900 flasks.

	1953-57 (average)	1958	1959	1960	1961	1962
Imports	20,300	19,200	25,700	25,300	27,000	20,700
Reexports	6,340	5,100	5,000	4,300	8,400	5,800
Apparent consumption	13,960	14,100	20,700	21,000	18,600	14,900

Imports of mercury by countries are shown in table 17.

TABLE 17.—United Kingdom: Imports of mercury by countries

(Flasks)

Country	1961	1962	Country	1961	1962
China	1,517	6,505	Turkey	1,462	2,230
Italy	6,553	3,027	U.S.S.R.	6,437	1,546
Mexico	2,953	1,129	United States	100	------
Netherlands	275	4	Yugoslavia	527	100
Peru	------	42	Other countries	21	22
Spain	7,202	6,120			
			Total	27,047	20,725

Reexports of mercury in flasks were as follows:

Destinations:	*1961*	*1962*
Australia	488	312
Belgium	184	227
Ceylon	170	86
Denmark	273	256
Finland	17	649
France	1,910	282
Germany, West	784	216
Hungary	(1)	233
India	610	570
Ireland	46	125
Netherlands	17	182
Pakistan	406	287
Poland	2,032	1,082
Rhodesia and Nyasaland, Federation of	42	84
South Africa, Republic of	343	512
Sweden	427	150
Other countries	639	521
Total	8,388	5,774

[1] Less than 1 flask.

[8] Bureau of Mines. Mineral Trade Notes. V. 55, No. 5, November 1962, pp. 30–32. Lathram, L. Wade (counselor of Embassy for Economic Affairs). Mercury Deposits of Göksu Maden ve Sanayi A.S. in Kastamonu Province. State Department Dispatch 597, Ankara, June 7, 1962, 4 pp.

Yugoslavia.—Virtually all the mercury produced in Yugoslavia came as usual from the Idria mine, and output rose 2 percent to 16,300 flasks in 1962. A 20-year development program approved for the Idria mine provided for installation of a new rotary furnace, increased mine production, and improved research facilities.[9]

TABLE 18.—Yugoslavia: Exports of mercury by countries[1]

(Flasks)

Destination	1960	1961
Austria	1,015	2,025
Czechoslovakia	----------	300
Finland	----------	145
France	305	872
Germany, West	400	550
India	----------	1,100
Israel	100	----------
Norway	25	130
Poland	----------	900
Sweden	30	750
U.S.S.R.	3,208	----------
United Kingdom	300	400
United States	1,151	2,501
Uruguay	300	----------
Other countries	20	10
Total	6,854	9,683

[1] This table incorporates some revisions.

Compiled from Customs Returns of Yugoslavia by Bertha M. Duggan, Division of Foreign Activities.

TECHNOLOGY

A new occurrence of cinnabar, the ore mineral of mercury, in west-central Alaska was announced by the U.S. Geological Survey. A map showing the occurrences of mercury in the United States was published.[10] Mercury deposits in Alaska were described.[11]

A mercury prospect in the Kuskokwim River Basin, Alaska was examined, and samples were taken for evaluation.[12] The geologic relationship of the mecury-bearing silica carbonate dikes was found to be similar to other mecury deposits in the Kuskokwim Basin.

The operations and comparative production costs from 1944 to 1958 at the Abbott mine, Lake County, Calif., were described.[13]

Results of studies on the caustic leaching of cinnabar concentrates and low-grade mercury ore and recovery of mercury from the leach solutions were published.[14] Tests showed that 95 percent of the cinnabar in flotation concentrates and 60 to 90 percent of the cinnabar in low-grade ore could be dissolved by solutions of sodium sulfide. Mercury in the leach solution could be recovered by precipitation with aluminum or by electrodeposition. Studies were made to determine the heat capacity and entropy at 298.15° K of red mercuric sulfide.[15]

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[9] Metal Bulletin (London). Yugoslav Quicksilver Growth. No. 4703, June 8, 1962, p. 23.
[10] Bailey, E. H. Mercury in the United States. Geol. Survey Map MR30, 1962.
[11] Malone, Kevin. Mercury Occurrences in Alaska. BuMines Inf. Circ. 8131, 1962, 57 pp.
[12] Maloney, Raymond P. Trenching and Sampling of the Rhyolite Mercury Prospect, Kuskokwim River Basin, Alaska. BuMines Rept. of Inv. 6141, 1962, 43 pp.
[13] Johnson, A. C., and F. D. Hanson. Mining and Furnacing Methods and Costs, Abbott Mine, COG Minerals Corp., Lake County, Calif. BuMines Inf. Circ. 8109, 1962, 35 pp.
[14] Stickney, W. A., and J. W. Town. Caustic Sulfide Treatment of Mercury Sulfides. AIME Trans. (Met. Soc.), v. 224, No. 2, April 1962, pp. 306–308.
Town, J. W., R. F. Link, and W. A. Stickney. Precipitation and Electrodeposition of Mercury in Caustic Solutions. BuMines Rept. of Inv. 5960, 1962, 19 pp.
[15] King, E. G., and W. W. Weller. Low-Temperature Heat Capacity and Entropy at 298.15° K of Red Mercuric Sulfide. BuMines Rept. of Inv. 6001, 1962, 4 pp.

Applications of mercury electrodes in quantitative analysis were listed.[16] Impurities were removed from the presence of an element to be determined during analytical procedures. A patent was granted for a vertical mercury electrode.[17]

A mercury ionic engine was tested in a laboratory to determine its potential in powering space vehicles.[18] An ionic engine utilizing mercury or cesium may be tested in space flight before 1970.

A liquid-metal flywheel was developed for stabilizing space vehicles in flight.[19] The circulation of mercury in closed loops was said to control pitch and roll of the vehicle.

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[16] Page, J. A., J. A. Maxwell, and R. P. Graham. Analytical Applications of the Mercury Electrode. The Analyst (Cambridge, England), v. 87, No. 1033, April 1962, pp. 245–272.

[17] Sullivan, P. M., and D. H. Chambers (assigned to the U.S. Department of the Interior). Electrolytic Cell with Vertical Mercury Electrode: U.S. Pat. 3,046,215, July 24, 1962.

[18] American Metal Market. Practical Cesium or Mercury Space Engines Face Numerous Problems. V. 69, No. 18, Jan. 25, 1962, p. 14.

[19] General Electric Company. Press release Nov. 19, 1962.

Mica

By Milford L. Skow[1] and Gertrude E. Tucker[2]

DOMESTIC sheet and scrap mica sold or used by producers reached a record high tonnage despite sharply reduced sales of sheet mica. Discontinuation of the Government purchasing program for domestic mica in early June caused a drop in sales of sheet mica, larger than punch and circle, to the lowest quantity recorded since 1952. Most of this mica went into Government inventories, and industry continued to depend largely on imports. Consumption of total sheet mica (block, film, and splittings) increased sharply, and sales of scrap and ground mica were moderately higher than in 1961. Increases in imports of all major categories of mica were sufficient to raise the total 44 percent higher than in 1961. Exports of mica and mica products were up 6 percent.

TABLE 1.—Salient mica statistics

	1953-57 (average)	1958	1959	1960	1961	1962
United States:						
Domestic, sold or used by producers:						
Sheet mica....thousand pounds..	748	661	706	[1] 587	[1] 526	361
Value..............thousands..	$2,633	$2,844	$3,419	[1] $3,108	[1] $3,386	$1,277
Scrap and flake mica thousand short tons..	86	93	102	98	99	108
Value..............thousands..	$1,915	$2,065	$2,665	$2,698	$2,417	$2,369
Ground mica [2] thousand short tons..	89	98	107	98	103	114
Value..............thousands..	$5,588	$5,560	$5,646	$5,193	$5,468	$6,489
Consumption, block and film thousand pounds..	[3] 3,621	2,856	2,868	2,776	2,536	2,811
Value..............thousands..	[3] $5,077	$3,632	$4,449	$3,988	$3,630	$3,490
Consumption, splittings thousand pounds..	8,555	5,329	7,223	6,227	5,514	6,728
Value..............thousands..	$4,975	$2,720	$3,464	$2,875	$2,266	$2,813
Imports for consumption thousand short tons..	12	10	11	11	7	10
Exports..............do....	4	5	5	4	4	4
Consumption, apparent,[4] sheet thousand pounds..	12,399	11,616	12,675	[1] 9,219	[1] 8,356	11,577
World: Production..............do....	300,000	315,000	350,000	365,000	365,000	400,000

[1] Revised figure.
[2] Domestic and some imported scrap mica.
[3] Average for 1954–57.
[4] Sheet mica sold or used, plus imports of unmanufactured and manufactured sheet mica, minus exports of sheet mica.

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

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LEGISLATION AND GOVERNMENT PROGRAMS

Purchasing programs for mica were continued by various Government agencies under authority delegated by the Office of Emergency Planning.

Defense Materials Service.—In February the General Services Administration (GSA) placed in operation a procedure providing for orderly termination of the purchasing program for domestic mica. All participants were given an equal opportunity to sell mica of qualified specifications so long as purchase quotas remained unfilled, and the Government was protected from exceeding the maximum quantity limitation of the program. The final day for Government purchases under the program was June 7, when the quota of 25,000 short tons of hand-cobbed mica or its equivalent in trimmed mica was acquired.

Government mica purchases at the three mica-purchasing depots of GSA yielded 101,065 pounds of full-trimmed muscovite block mica (over 0.007 inch thick) in 1962. Mica purchased under this program since its beginning in 1952 had been processed into 2,203,434 pounds of full-trimmed block and film, 1,207,715 pounds of punch, 211,803 pounds of other sheet, and 17,584,751 pounds of scrap. The full-trimmed block was 79 percent ruby mica. The Spruce Pine, N.C., depot furnished 65 percent of the total yield of ruby block mica and 84 percent of the nonruby.

TABLE 2.—Yield of full-trimmed muscovite ruby and nonruby block mica from domestic purchases by GSA in 1962, by grades, qualities, and depots

(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	59	28	103	190	76	9	15	100
3	168	90	278	536	233	39	39	311
4	464	171	620	1,255	401	49	94	544
5	2,283	1,154	3,619	7,056	1,359	293	607	2,259
5½	1,527	753	1,905	4,185	646	141	328	1,115
6	5,952	4,563	10,152	20,667	2,433	903	1,540	4,876
Total	10,453	6,759	[1] 16,677	33,889	5,148	1,434	[2] 2,623	9,205
Franklin, N.H.:								
2 and larger	9	32	16	57	44	34	5	83
3	42	113	44	199	117	98	14	229
4	118	321	158	597	222	218	45	485
5	822	2,276	983	4,081	1,087	1,217	247	2,551
5½	679	2,563	1,135	4,377	554	857	202	1,613
6	3,466	13,350	6,559	23,375	1,884	3,570	861	6,315
Total	5,136	18,655	8,895	32,686	3,908	5,994	1,374	11,276
Custer, S. Dak.:								
2 and larger	35	313	76	424	2	(3)	-------	2
3	32	342	110	484	2	1	(3)	3
4	70	589	152	811	3	3	1	7
5	434	2,422	926	3,782	34	47	13	94
5½	145	1,030	357	1,532	16	27	8	51
6	671	4,163	1,876	6,710	30	56	23	109
Total	1,387	8,859	3,497	13,743	87	134	45	266
Grand total	16,976	34,273	29,069	80,318	9,143	7,562	4,042	20,747

[1] Includes 14,338 pounds of Stained "B" quality.
[2] Includes 2,191 pounds of Stained "B" quality.
[3] Less than 1 pound.

TABLE 3.—Yield of byproducts from domestic purchases of ruby and nonruby mica by GSA in 1962, by depots

(Pounds)

Depot	Ruby			Nonruby		
	Miscellaneous [1]	Punch	Scrap	Miscellaneous [1]	Punch	Scrap
Spruce Pine, N.C.	1,100	9,160	325,736	315	838	82,746
Franklin, N.H.	4,442	13,785	192,602	704	842	18,313
Custer, S. Dak.	507	3,797	91,530			
Total	6,049	26,742	609,868	1,019	1,680	101,059

[1] Includes some full-trimmed thins and block of lower than Heavy Stained qualities.

Commodity Credit Corporation.—Muscovite block and film and phlogopite splittings were received during the year under carryover contracts for surplus agricultural commodities, but muscovite splittings and phlogopite block were not obtained by this barter program. Although it remained on the eligible list, mica was not considered for new contracts.

Office of Minerals Exploration.—No exploration contracts for mica were in force at the beginning of 1962, and none were executed during the year.

DOMESTIC PRODUCTION

Sheet Mica.—The quantity of sheet mica sold or used by producers declined 31 percent to the lowest total since 1949. Sales of sheet mica larger than punch and circle were 62 percent lower in quantity than in 1961, but the average value per pound was virtually unchanged. Most of this larger sheet mica was sold to the Government at above-market prices under the domestic mica purchasing program, and the midyear termination of this program resulted in the abrupt decline in sales. North Carolina continued to lead the States in production and increased its portion of the total quantity of reported sheet mica to 89 percent from 74 percent in 1961. New Hampshire was the only other State to furnish more than 1 percent of the 1962 total.

Scrap and Flake Mica.—Demand for scrap and flake mica sold or used by grinders increased 9 percent to the highest tonnage on record. The value, also 9 percent higher than in 1961, had been surpassed in 1959 and 1960. North Carolina again was the principal producing State with 58 percent of the tonnage. Alabama, Georgia, and South Carolina also furnished substantial quantities.

Ground Mica.—Sales of ground mica increased 11 percent in tonnage and 19 percent in value. Dry-ground mica constituted 88 percent of the tonnage and wet-ground mica the remaining 12 percent. Production was reported by 29 grinders in 26 dry-grinding and 8 wet-grinding plants. Carolina-Southern Mining Co., Inc., produced dry-ground mica at the Erwin, Tenn. mill that Harris Clay Co. operated in 1961. C. O. Fiedler, Inc., a producer of dry-ground mica at Ogilby, Calif., in 1960 and 1961, did not operate in 1962. Western Non-Metallics appeared on the list of mica grinders for the first time since 1956 with a dry-grinding operation at Ogilby, Calif., and Mineral Industrial Commodities of America, Inc., was a newcomer to the list with production of dry-ground mica at Pojoaque, N. Mex.

TABLE 4.—Mica sold or used by producers in the United States

Year and State	Sheet mica						Scrap and flake mica [2]		Total	
	Uncut punch and circle mica		Uncut mica larger than punch and circle [1]		Total sheet mica					
	Pounds	Value	Pounds	Value	Pounds	Value	Short tons	Value	Short tons	Value
1953–57 (average) [3]	504,021	$55,900	243,623	$2,577,411	747,644	$2,633,311	85,702	$1,914,937	86,076	$4,548,248
1958	376,005	31,044	285,339	2,813,425	661,344	2,844,469	93,347	2,064,632	93,675	4,909,101
1959	383,529	36,653	322,866	3,382,837	706,395	3,419,490	101,541	2,665,337	101,893	6,084,827
1960	330,246	21,628	[4] 257,155	[4] 3,086,343	[5] 587,401	[5] 3,107,971	97,912	2,697,510	[4] 98,204	[4] 5,805,481
1961	265,444	21,774	[4] 260,563	[4] 3,363,986	[6] 526,007	[6] 3,385,760	99,044	2,416,819	[4] 99,306	[4] 5,802,579
1962:										
Colorado	------	------	------	------	------	------	142	2,378	142	2,378
Georgia	------	------	60	657	60	657	(7)	(7)	(7)	(7)
Maine	------	------	2,017	15,539	2,017	15,539	15	450	16	15,989
New Hampshire	4,300	640	31,150	373,054	35,450	373,694	411	11,144	429	384,838
New Mexico	------	------	(7)	(7)	(7)	(7)	5,731	139,620	5,731	(7)
North Carolina	258,823	22,810	61,482	843,821	320,305	866,631	61,983	1,384,280	62,143	2,250,911
South Dakota	------	------	2,085	12,060	2,085	12,060	210	5,710	211	17,770
Undistributed [8]	------	------	1,041	8,259	1,041	8,259	39,210	1,095,715	39,210	1,244,251
Total	263,123	23,450	97,835	1,253,390	360,958	1,276,840	107,702	2,639,297	107,882	3,916,137

[1] Includes full-trimmed mica equivalent of hand-cobbed mica, 1952–62.
[2] Includes finely divided mica recovered from mica and sericite schist and mica that is a byproduct of feldspar and kaolin beneficiation.
[3] Includes small quantities of splittings in 1953.
[4] Revised figure.
[5] Quantity of sheet mica revised for the following States: Maine, 28,860 pounds from 26,842 pounds; North Carolina, 436,579 pounds from 430,193 pounds. Quantity and value of sheet mica in New Hampshire revised to 80,077 pounds valued at $1,026,400 from 72,188 pounds valued at $1,101,458.
[6] Quantity of sheet mica in Maine revised to 9,680 pounds from 7,373 pounds. Total quantity and value of sheet mica in New Hampshire revised to 105,943 pounds valued at $1,008,558 from 62,737 pounds valued at $931,158.
[7] Included with "Undistributed" to avoid disclosing individual company confidential data.
[8] Figures include Alabama, Arizona, California, Connecticut, Idaho, Montana, New Mexico, Pennsylvania, South Carolina, and States indicated by footnote 7.

TABLE 5.—Ground mica sold by producers in the United States, by methods of grinding [1]

Year	Dry-ground		Wet-ground		Total	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1953–57 (average)	76,026	$3,656	13,360	$1,932	89,386	$5,588
1958	85,106	3,715	12,423	1,845	97,529	5,560
1959	93,121	3,516	14,059	2,130	107,180	5,646
1960	86,225	3,422	12,121	1,771	98,346	5,193
1961	90,519	3,747	12,176	1,721	102,695	5,468
1962	99,936	4,351	13,851	2,138	113,787	6,489

[1] Partly estimated.

CONSUMPTION AND USES

Sheet Mica.—Consumption of sheet mica (block, film, and splittings) in the United States increased 18 percent to 9.5 million pounds from 8 million pounds in 1961.

Domestic fabrication of muscovite block and film mica increased 10 percent to return to the 1960 level of slightly less than 2.8 million pounds. This quantity comprised 5 percent Good Stained or better qualities, 39 percent Stained, and 56 percent lower than Stained. Electronic applications, principally tubes, consumed 61 percent of all qualities and 96 percent of the Stained or better qualities. Fabrication of muscovite block and film mica was reported by 20 companies in 10 States. New Jersey had the most plants and reported 3 percent less fabrication than in 1961. About 51 percent of the domestically fabricated block and film mica came from 12 companies in 3 States—New Jersey (5), New York (3), and North Carolina (4).

Consumption of mica splittings rose sharply from the 1961 level with a 22 percent gain in quantity and a 24 percent gain in value. Muscovite splittings from India continued to constitute the bulk of the consumption (95 percent by weight); the remainder was principally phlogopite splittings from the Malagasy Republic. Mica splittings were fabricated by 11 companies at 12 plants in 9 States. Operations at four plants—two in New York, one in New Hampshire, and one in Massachusetts—required 4.4 million pounds of splittings, 65 percent of the total consumed.

Built-Up Mica.—Domestic fabricators of splittings produced various forms of built-up mica for use principally as electrical insulation. Tape was the form in greatest demand (27 percent of the total built-up mica), followed closely by segment plate (26 percent), and molding plate (23 percent). Total consumption of built-up mica was 27 percent larger than in 1961 and had a 25 percent higher value.

Reconstituted Mica.—This sheet material, which is formed by papermaking procedures from specially delaminated natural mica scrap, continued to displace built-up mica in many applications and also served as the dielectric material in special capacitors. General Electric Co. at Schenectady, N.Y. (formerly at Coshocton, Ohio), and Samica Corp. (subsidiary of Minnesota Mining & Manufacturing Co.) at Rutland, Vt., continued to be the only producers. Total output increased substantially over that in 1961 to again reach a record high.

Synthetic Mica.—Commercial production of synthetic mica flake, principally for use in glass-bonded mica ceramic materials, was continued by Molecular Dielectrics, Inc., Clifton, N.J., and Synthetic Mica Co., Division of Mycalex Corporation of America, West Caldwell, N.J. High-quality crystals of synthetic mica, 1 square inch or larger, continued to be recovered by Molecular Dielectrics from its crude product. These crystals were split and punched for commercial use in special electronic tubes and other applications.

Other Substitutes for Sheet Mica.—Farnam Manufacturing Co., Inc., Asheville, N.C., continued to manufacture a heat-resistant electrical-insulation product from finely divided natural mica bonded with water-soluble aluminum phosphate. The material was produced as rigid sheets and also in various shapes.

Ground Mica.—Total demand for ground mica was 11 percent greater than in 1961 as sales increased 10 percent for dry-ground mica and 14 percent for wet-ground mica. Roofing materials, joint cement, and paint continued to lead in consumption of ground mica. End uses that took larger proportions of the total ground mica than in 1961 were roofing materials, joint cement, plastics, and welding rods.

TABLE 6.—Fabrication of muscovite ruby and nonruby block and film mica and phlogopite block mica, by qualities and end-product uses in the United States in 1962

(Pounds)

Variety, form, and quality	Electronic uses				Nonelectric uses			Grand total
	Capacitors	Tubes	Other	Total	Gage glass and diaphragms	Other	Total	
Muscovite:								
Block:								
Good Stained or better	421	32,786	4,218	37,425	6,007	132	6,139	43,564
Stained	6,415	1,036,777	8,992	1,052,184	2,561	38,341	40,902	1,093,086
Lower than Stained [1]	2,528	482,094	40,802	525,424	623	1,036,912	1,037,535	1,562,959
Total	9,364	1,551,657	54,012	1,615,033	9,191	1,075,385	1,084,576	2,699,609
Film:								
First quality	5,954			5,954				5,954
Second quality	75,774			75,774		45	45	75,819
Other quality	2,500			2,500				2,500
Total	84,228			84,228		45	45	84,273
Block and film:								
Good Stained or better [2]	82,149	32,786	4,218	119,153	6,007	177	6,184	125,337
Stained [3]	8,915	1,036,777	8,992	1,054,684	2,561	38,341	40,902	1,095,586
Lower than Stained	2,528	482,094	40,802	525,424	623	1,036,912	1,037,535	1,562,959
Total	93,592	1,551,657	54,012	1,699,261	9,191	1,075,430	1,084,621	2,783,882
Phlogopite: Block (all qualities)			904	904		26,378	26,378	27,282

[1] Includes punch mica.
[2] Includes First- and Second-quality film.
[3] Includes other-quality film.

TABLE 7.—Fabrication of muscovite ruby and nonruby block and film mica in the United States in 1962, by qualities and grades

(Pounds)

Form, variety, and quality	Grade					
	No. 4 and larger	No. 5	No. 5½	No. 6	Other [1]	Total
Block:						
Ruby:						
Good Stained or better	4,903	2,106	1,720	21,663	200	30,592
Stained	11,182	27,523	75,487	882,036	64,446	1,060,674
Lower than Stained	130,171	152,777	58,388	428,393	536,892	1,306,621
Total	146,256	182,406	135,595	1,332,092	601,538	2,397,887
Nonruby:						
Good Stained or better	1,868	99		11,005		12,972
Stained	950	4,534	4,813	22,115		32,412
Lower than Stained	36,650	67,624	4,693	870	146,501	256,338
Total	39,468	72,257	9,506	33,990	146,501	301,722
Films:						
Ruby:						
First quality	1,559	1,170	800	875		4,404
Second quality	28,125	29,978	14,386	2,675		75,164
Other quality					2,500	2,500
Total	29,684	31,148	15,186	3,550	2,500	82,068
Nonruby:						
First			900	650		1,550
Second	160	45	450			655
Other						
Total	160	45	1,350	650		2,205

[1] Figures for block mica include "all smaller than No. 6" grade and "punch" mica.

TABLE 8.—Consumption and stocks of mica splittings in the United States, by sources

(Thousand pounds and thousand dollars)

	Indian		Malagasy		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
Consumption:						
1953–57 (average)	7,867	$4,472	[1] 688	[1] $503	8,555	$4,975
1958	4,982	2,437	[2] 347	[2] 283	5,329	2,720
1959	6,726	3,098	[2] 497	[2] 366	7,223	3,464
1960	5,915	2,642	312	233	6,227	2,875
1961	5,274	2,077	240	189	5,514	2,266
1962	6,382	2,559	346	254	6,728	2,813
Stocks Dec. 31:						
1953–57 (average)	5,621	3,809	[3] 372	[3] 293	5,993	4,102
1958	3,392	1,801	[2] 316	[2] 258	3,708	2,059
1959	3,057	1,387	347	244	3,404	1,631
1960	2,839	1,270	316	212	3,155	1,482
1961	2,546	1,212	[4] 258	167	[4] 2,804	1,379
1962	3,588	([5])	143	([5])	3,731	([5])

[1] Includes Canadian, 1953–55.
[2] Includes Canadian.
[3] Includes Canadian, 1953–56.
[4] Revised figure.
[5] Data not available.

TABLE 9.—Built-up mica [1] sold or used in the United States, by products

(Thousand pounds and thousand dollars)

Product	1961		1962	
	Quantity	Value	Quantity	Value
Molding plate	737	$2,089	1,105	$2,639
Segment plate	1,177	2,521	1,253	2,951
Heater plate	(2)	(2)	506	1,532
Flexible (cold)	489	1,578	573	1,812
Tape	892	4,522	1,293	5,992
Other	517	1,677	94	523
Total	3,812	12,387	4,824	15,449

[1] Consists of alternate layers of binder and irregularly arranged and partly overlapped splittings.
[2] Included with "Other" to avoid disclosing individual company confidential data.

TABLE 10.—Ground mica sold by producers in the United States, by uses

Use	1961		1962	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Roofing	32,696	$917	38,767	$1,199
Wallpaper	675	97	783	118
Rubber	6,987	655	7,081	803
Paint	22,559	1,765	20,801	1,806
Plastics	486	57	3,624	198
Welding rods	1,029	61	1,447	78
Joint cement	17,994	1,225	21,778	1,524
Well drilling	13,981	412	12,895	420
Other uses [1]	6,288	279	6,611	343
Total	102,695	5,468	113,787	6,489

[1] Includes mica used for molded electric insulation, house insulation, Christmas-tree snow, annealing, and other purposes.

PRICES AND SPECIFICATIONS

The Government continued its purchases of domestically produced sheet mica until the program was terminated early in June. The prices paid by the Government for full-trimmed and half-trimmed block and film mica had been established in May 1956; prices for hand-cobbed mica had not changed since 1954, but purchasing procedures had varied.

Prices offered by mica fabricators for domestic clear sheet mica (roughly trimmed), as reported in E&MJ Metal and Mineral Markets, were unchanged from 1961 and ranged from 7 to 12 cents per pound for the smallest size (punch) to $4 to $8 per pound for 6- by 8-inch sheets. Stained or electric mica was quoted 10 to 20 percent lower.

North Carolina scrap mica was quoted throughout most of the year at $20 to $30 per short ton, depending on quality. In E&MJ Metal and Mineral Markets of December 31, the price quotation was raised to $30 to $40.

Prices listed for dry- and wet-ground mica remained unchanged since March 1956.

TABLE 11.—Price of dry- and wet-ground mica in the United States in 1962 [1]

(Cents per pound)

Mica	Value	Mica	Value
Dry-ground:		Wet-ground [2]—Continued	
Paint, 100 mesh	4	Rubber	8
Plastic, 100 mesh	4	Rubber, less than carlots [3]	8¾
Roofing, 20 to 80 mesh	3	Wallpaper	8¾
Wet-ground: [2]		Wallpaper, less than carlots [3]	9
Biotite	6½	White, 5 to 10 microns	8¼
Biotite, less than carlots [3]	7¼	White, 5 to 10 microns, less than carlots [3]	9
Paint or lacquer, 325 mesh	8¼		
Paint or lacquer, 325 mesh, less than carlots [3]	9		

[1] In bags at works, carlots, unless otherwise noted.
[2] Freight allowed east of the Mississippi River, one-half cent higher west of the Mississippi River, 1 cent higher west of the Rockies.
[3] Exwarehouse or freight allowed east of the Mississippi River.

Source: Oil, Paint and Drug Reporter.

Tentative specifications were adopted for the most significant physical properties of commercially available natural muscovite mica splittings.[3] Specifications for muscovite block and film mica based on visual quality were advanced from tentative to standard without revision.[4] Methods for sampling and testing untreated mica paper for electrical insulation were adopted without substantive change from the tentative standards first issued in 1960.[5]

[3] American Society for Testing and Materials. Tentative Specifications for Natural Muscovite Mica Splittings. D2131–62T, Supplement to Book of ASTM Standards Including Tentatives, pt. 11, 1962, pp. 299–302.
[4] American Society for Testing and Materials. Standard Specifications for Natural Muscovite Mica Based on Visual Quality. D351–62, Supplement to Book of ASTM Standards Including Tentatives, pt. 11, 1962, index ref to pt. 11, 1961, pp. 1042–1050.
[5] American Society for Testing and Materials. Standard Methods for Sampling and Testing Untreated Mica Paper Used for Electrical Insulation. D1677–62, Supplement to Book of ASTM Standards Including Tentatives, pt. 11, 1962, index ref. to pt. 11, 1961, pp. 1361–1362.

FOREIGN TRADE [6]

Imports.—Total quantity of mica imported for consumption was 44 percent larger than in 1961 and increases were registered for all major categories. However, the gain in total value was only 22 percent, principally because of the lower unit values for imports of manufactured mica and uncut sheet and punch.

Exports.—Total exports of mica and mica products were 6 percent higher than in 1961. Ground-mica exports, which again comprised most of the total, were up 5 percent, and exports of unmanufactured mica rose 29 percent. Despite an increase of almost 4 percent, exports of other manufactured mica remained below 200,000 pounds for the second consecutive year.

TABLE 12.—U.S. imports and exports of mica

Year	Imports for consumption								Exports	
	Uncut sheet and punch		Scrap		Manufactured		Total		All classes	
	Pounds	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands	Short tons	Value (thousands)
1953-57 (average)	1,995,264	[1] $3,584	6,087	[1] $78	5,292	[1] $8,026	12,377	[1] $11,688	3,859	$1,519
1958	2,181,056	5,092	4,064	48	5,053	8,800	10,208	13,940	4,741	1,217
1959	3,220,412	7,305	4,644	57	5,042	7,443	11,296	14,805	5,102	1,239
1960	1,088,021	2,081	6,240	86	4,266	6,139	11,050	8,306	4,012	1,311
1961	852,648	1,841	3,024	41	[2] 3,763	[2] 6,115	[2] 7,213	[2] 7,997	3,799	1,227
1962	1,107,929	1,789	4,458	55	5,403	7,922	10,415	9,766	4,028	1,363

[1] Data known to be not comparable with other years.
[2] Revised figure.

Source: Bureau of the Census.

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

TABLE 13.—U.S. imports for consumption of mica, by kinds and countries[1]

Year and country	Unmanufactured									
	Waste and scrap, valued not more than 5 cents per pound				Untrimmed phlogopite mica from which no rectangular piece exceeding 2 inches in size may be cut		Other			
	Phlogopite		Other				Valued not above 15 cents per pound, n.e.s.		Valued above 15 cents per pound	
	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value
1953-57 (average)	478,221	$5,437	11,697,297	$73,077	58,372	$11,235	166,102	$13,383	1,770,790	[2] $3,558,879
1958			8,128,613	48,169			10,317	1,182	2,170,739	5,090,800
1959			9,287,998	56,825			132,420	7,872	3,087,992	7,297,452
1960			12,480,715	86,272			118,980	8,600	969,041	2,071,509
1961	96,138	1,212	5,951,448	40,053			[3] 68,619	[3] 4,085	[3] 784,029	[3] 1,837,127
1962:										
North America: Mexico									99	368
South America:										
Argentina							27,558	2,288	226,409	113,221
Brazil			99,207	2,025			27,778	2,553	520,936	821,182
Europe: United Kingdom									1,168	2,686
Asia:										
India			8,382,654	49,475					245,357	717,499
Indonesia			322,560	2,169						
Africa:										
Angola									3,603	5,360
British East Africa									13,940	66,426
Malagasy Republic									40,941	55,714
Rhodesia and Nyasaland, Federation of			112,000	1,481					50	605
South Africa, Republic of									90	678
Total			8,916,421	55,150			55,336	4,841	1,052,593	1,783,739

See footnotes at end of table.

TABLE 13.—Imports for consumption of mica, by kinds and countries[1]—Continued

Year and country	Manufactured-films and splittings: Not cut or stamped to dimensions: Not above 12/10,000 of an inch in thickness		Not cut or stamped to dimensions: Over 12/10,000 of an inch in thickness		Cut or stamped to dimensions		Total films and splittings	
	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value
1953-57 (average)	7,963,920	[2] $2,975,427	2,290,273	[2] $3,571,010	57,151	[2] $991,677	10,311,344	[2] $7,538,114
1958	7,628,263	4,551,191	2,268,139	3,135,871	40,884	646,800	9,937,286	8,333,862
1959	7,059,064	2,806,063	2,726,667	2,643,361	80,696	1,261,977	9,866,427	6,711,401
1960	7,184,944	3,035,162	989,099	1,220,861	82,487	1,122,087	8,256,530	5,378,110
1961	[4] 5,800,568	[4] 2,572,106	[4] 1,469,972	[4] 1,812,709	[4] 67,116	[4] 1,140,572	[4] 7,337,656	[4] 5,525,387
1962:								
North America:								
Jamaica			5,542	8,112	4,055	15,878	9,597	23,990
Mexico	872	2,774			13,758	317,722	14,630	320,496
South America: Brazil	1,874	1,160	808,305	758,108	11,530	21,414	821,709	780,682
Europe:								
France					6	398	6	398
Germany, West					367	3,254	367	3,254
United Kingdom	2,000	1,548			14,980	343,994	16,980	345,542
Asia:								
Hong Kong					192	5,052	192	5,052
India	8,062,528	2,333,126	921,044	1,777,079	37,834	503,071	9,021,406	4,613,276
Japan	6,450	941			15,923	475,781	22,373	476,722
Africa:								
British East Africa			6,521	4,842			6,521	4,842
Malagasy Republic	541,847	475,202	4,409	3,902			546,256	479,104
Sudan			400	2,524			400	2,524
Total	8,615,571	2,814,751	1,746,221	2,554,567	98,645	1,686,564	10,460,437	7,055,882

Year and country	Manufactured-cut or stamped to dimensions, shape, or form		Manufactured-other: Mica plates and built-up mica		Manufactured-other: All mica manufactures of which mica is the component material of chief value		Manufactured-other: Ground or pulverized	
	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value
1953-57 (average)	40,375	$60,973	49,412	$198,829	55,318	$220,578	127,000	$7,611
1958	2,711	4,328	21,561	24,796	96,456	434,259	48,238	2,863
1959	5,310	9,144	30,403	29,065	135,326	690,088	46,049	2,965
1960	6,742	8,801	72,384	65,451	152,867	683,793	46,000	2,760
1961	793	1,617	57,609	49,966	105,777	537,270	23,000	1,380
1962:								
North America:								
Canada					9,500	13,581	69,000	3,935
Jamaica					7,608	10,463		
Mexico	1,432	2,679			15,955	70,720		
South America: Brazil					63,866	297,656		
Europe:								
Belgium-Luxembourg			141,739	104,872				
France					1,751	56,598		
Germany, West					30	328		
Ireland					59	1,594		
Italy					91	1,607		
Netherlands					1,108	28,799		
Switzerland					273	2,010		
United Kingdom	105	4,903			19,411	189,219		
Asia:								
India					10,907	56,880		
Japan					2,361	19,047		
Total	1,537	7,582	141,739	104,872	132,920	748,502	69,000	3,935

[1] Changes in Minerals Yearbook 1961, p. 912 should read as follows: Not above 12/10,000 of an inch in thickness—Brazil, revised to none, total all countries 5,800,568 pounds ($2,572,106); Over 12/10,000 of an inch in thickness—Brazil 713,527 pounds ($775,421), total all countries 1,469,972 pounds ($1,812,709); Cut or stamped to dimensions—Mexico 13,680 pounds ($206,382), total all countries 67,116 pounds ($1,140,572); total films and splittings—Brazil 715,687 pounds ($785,647), Mexico, 14,040 pounds ($207,985), total all countries 7,337,656 pounds ($5,525,387).

[2] Data known to be not comparable with other years.

[3] Adjusted by the Bureau of Mines.

[4] Revised figure.

Source: Bureau of the Census.

TABLE 14.—U.S. exports of mica and manufactures of mica, by countries

Year and destination	Unmanufactured		Manufactured			
			Ground or pulverized		Other	
	Pounds	Value	Pounds	Value	Pounds	Value
1953-57 (average)	453,747	$56,182	6,917,003	$384,389	346,985	$1,079,300
1958	1,030,540	90,565	8,198,367	430,820	254,198	695,626
1959	1,072,894	126,492	8,915,109	459,425	216,040	652,863
1960	701,926	113,101	7,077,245	370,217	243,354	828,461
1961	334,211	141,730	7,074,850	395,563	190,320	689,238
1962:						
North America:						
British Honduras	----------	----------	19,980	680	----------	----------
Canada	94,110	54,529	2,545,542	122,469	127,134	484,831
Canal Zone	----------	----------	----------	----------	128	214
Costa Rica	----------	----------	22,100	1,716	----------	----------
Dominican Republic	----------	----------	44,000	3,814	----------	----------
Guatemala	----------	----------	8,800	640	224	984
Haiti	----------	----------	----------	----------	190	1,126
Jamaica	8,725	2,520	26,000	1,078	520	1,320
Mexico	70,503	40,269	214,900	12,193	10,887	42,085
Netherlands Antilles	1,130	294	----------	----------	119	350
Nicaragua	----------	----------	----------	----------	152	1,203
Trinidad and Tobago	----------	----------	77,500	6,900	----------	----------
South America:						
Argentina			19,926	1,446	6,894	17,909
Brazil	----------	----------	----------	----------	688	1,744
Chile	----------	----------	----------	----------	1,569	10,083
Colombia	377	870	115,861	6,792	1,656	6,134
Ecuador	240	274	34,000	2,226	----------	----------
Peru	----------	----------	150,354	7,423	6,190	6,702
Uruguay	----------	----------	----------	----------	804	4,495
Venezuela	5,463	2,432	544,150	31,753	1,841	3,942
Europe:						
Belgium-Luxembourg	----------	----------	416,569	27,179	976	4,395
Denmark	----------	----------	37,240	1,660	----------	----------
France	25,400	12,600	805,850	63,101	2,161	7,034
Germany, West	17,449	20,347	1,084,051	60,112	2,849	15,486
Greece	----------	----------	4,480	384	----------	----------
Iceland	----------	----------	16,600	1,191	----------	----------
Italy	61,209	5,807	427,300	26,409	7,114	44,896
Netherlands	----------	----------	205,345	9,719	----------	----------
Norway	----------	----------	----------	----------	1,304	3,636
Portugal	----------	----------	16,203	875	----------	----------
Spain	----------	----------	62,000	3,753	7,360	27,924
Sweden	----------	----------	----------	----------	3,180	27,456
Switzerland	----------	----------	45,498	3,469	----------	----------
United Kingdom	5,510	5,896	57,000	4,881	668	3,170
Asia:						
Hong Kong	----------	----------	----------	----------	588	1,629
India	----------	----------	66,500	5,263	3,336	5,937
Indonesia	----------	----------	----------	----------	202	1,448
Iran	----------	----------	12,000	1,061	----------	----------
Israel	4,400	418	20,000	1,675	----------	----------
Japan	116,340	18,108	50,000	2,380	696	1,679
Korea	----------	----------	----------	----------	52	280
Kuwait	----------	----------	----------	----------	38	204
Philippines	16,000	1,524	36,000	2,827	1,291	6,056
Taiwan	4,000	380	----------	----------	----------	----------
Africa:						
Congo, Republic of the, and Ruanda-Urundi	----------	----------	----------	----------	802	4,323
Libya	----------	----------	15,000	1,313	----------	----------
Morocco	----------	----------	2,800	224	----------	----------
Rhodesia and Nyasaland, Federation of	----------	----------	13,000	1,076	----------	----------
South Africa, Republic of	----------	----------	140,700	9,572	836	5,034
United Arab Republic (Egypt)	----------	----------	9,000	788	----------	----------
Oceania:						
Australia	----------	----------	61,171	3,971	4,922	20,970
New Zealand	----------	----------	----------	----------	70	326
Total	430,856	166,268	7,427,420	432,013	197,441	765,005

Source: Bureau of the Census.

WORLD REVIEW [7]

World production of mica was estimated at 400 million pounds. Most of the 35-million-pound increase over the 1961 total resulted from increased production of marketable scrap by the United States and India.

[7] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.

TABLE 15.—World production of mica by countries [1] [2]

(Thousand pounds)

Country [1]	1953–57 (average)	1958	1959	1960	1961	1962
North America:						
Canada (shipments):						
Block	119	90	49	176		
Splittings	7	----------	----------	----------		
Ground	990	1,380	591	791	1,817	1,526
Scrap	631	35	174	734		
United States (sold or used by producers):						
Sheet	748	661	706	587	526	361
Scrap	171,404	186,694	203,082	195,824	198,088	215,404
South America:						
Argentina:						
Sheet	697	[3] 192	[3] 403	[3] 397	[3] 728	[3] [4] 485
Scrap	29					
Brazil	3,510	2,829	2,553	4,440	11,307	[4] 11,000
Europe:						
Austria [5]	----------	134	216	317	194	33
France	302	459	670	686	[4] 660	[4] 660
Norway, including scrap	3,523	4,519	12,059	6,393	7,716	2,205
Spain	24	20	11	(6)	----------	----------
Sweden:						
Block	2	----------	----------	----------	----------	----------
Ground	388	421	220	441	----------	----------
Yugoslavia	[7] 29	4	4	4	9	22
Asia:						
Ceylon	2	----------	----------	----------	----------	----------
India (exports):						
Block	5,818	5,243	6,305	5,216	4,592	4,396
Splittings	14,220	14,264	15,988	17,469	18,208	18,838
Scrap	23,371	24,001	29,242	42,829	35,355	45,523
Taiwan, including scrap	26	(6)	(6)	----------	----------	----------
Africa:						
Angola:						
Sheet	40	46	20	26	4	----------
Scrap and splittings	542	716	384	721	51	----------
Kenya	----------	15	22	2	(6)	2
Malagasy Republic (phlogopite):						
Block	99	234	269	256	223	181
Splittings	1,274	2,154	1,922	1,973	2,002	2,780
Morocco:						
Sheet	2	----------	----------	----------	----------	----------
Scrap	9	----------	----------	----------	----------	----------
Mozambique, including scrap	26	4	13	2	2	2
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia, Sheet	7	2	1	(6)	----------	----------
Southern Rhodesia:						
Block	132	108	106	90	64	33
Crude and scrap	40	----------	----------	754	101	174
South Africa, Republic of:						
Sheet	7	2	(6)	2	2	2
Scrap	5,095	4,255	3,761	6,711	5,441	4,901
South-West Africa	----------	----------	234	----------	----------	150
Sudan:						
Block	[8] 13	225	882	----------		----------
Scrap		154				
Tanganyika (exports):						
Sheet	154	108	117	179	196	218
Scrap	214	24	190	----------	----------	----------
Oceania: Australia:						
Block	55	31	33	9	----------	----------
Scrap	29	84	187	648	185	[4] 220
Damourite	1,127	1,080	1,100	1,252	1,138	[4] 1,100
World total (estimate) [1] [2]	300,000	315,000	350,000	365,000	365,000	400,000

[1] Mica was also produced in China, Rumania, and U.S.S.R., but production data were not available; estimates for these countries are included in the total.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Exports.
[4] Estimate.
[5] Including reclaimed from dumps, 1961 and 1962 from dumps only.
[6] Less than 500 pounds.
[7] Average annual production 1956–57.
[8] One year only, as 1957 was first year of commercial production.

Compiled by Liela S. Price, Division of Foreign Activities.

Argentina.—Mica exports in 1961 were 370 tons valued at $171,000, compared with 198 tons valued at $103,000 in 1960.[8]

Canada.—Test drilling of a muscovite schist in east central British Columbia indicated reserves of 200,000 tons containing 85 to 90 percent mica. The schist was being mined by Georgian Minerals Industries, Ltd., and partly processed in a plant at Cedarside; fine grinding and classification of the material took place at the plant of Magnet Cove Barium Corp., Ltd., at Rosalind, Alberta.[9]

India.—Exports of unmanufactured mica, 34,000 tons valued at $20 million, were 5,000 tons greater in quantity but $0.5 million less in value than in 1961. Exports of splittings, which have increased each year since 1958, accounted for a small part of the gain in tonnage; the remaining gain was in exports of scrap. Both splittings and scrap had a lower unit value than in 1961.[10]

A mica grinding plant with a capacity of 20 tons per 8-hour shift was being set up at Jaipur by India Mica Grinders (Pvt.), Ltd. Waste from the mines in Rajasthan was to be ground to a fine-mesh powder for export.[11]

At the annual meeting of the Mica Export Promotion Council in Calcutta in September, the participants expressed their views on the need for improving the mica export trade. The Chief Minister of Bihar urged that standards and floor prices for mica be fixed and fabrication facilities be established. He advocated that mica producers and exporters unite, take advantage of the preshipment inspection facilities provided by the Council, adopt the standards established by the Indian Standards Institution, and find new uses for mica.[12]

Rhodesia and Nyasaland, Federation of.—Sheet mica production, all in Southern Rhodesia, dropped to half that in 1961, but its unit value of almost $1 per pound was one-third higher. Mica exports, which comprised only sheet, totaled 33,327 pounds valued at $33,163.

Early in 1962 the Government, through the Department of Mines, encouraged formation of Mineral Development (Pvt.), Ltd., a company to find outlets for Rhodesian mica in various parts of the world. Previously F. F. Chrestien & Co., Miami, a subsidiary of the British firm, Associated Electrical Industries, was the only buyer of Rhodesian mica. At the end of 1962, Ketelby & Gelletich (Rhodesia), (Pvt.), Ltd., a subsidiary of an established company in Johannesburg, was formed to produce wet-ground mica from waste dumps in the Sinoia area.[13]

South Africa, Republic of.—Exports of scrap mica were the lowest in several years—159 tons valued at $4,357 compared with 894 tons valued at $27,300 in 1961. However, exports of ground mica increased from

[8] U.S. Embassy, Buenos Aires, Argentina. State Department Airgram A-318. Aug. 29, 1962, encl. 1, p. 1.

[9] Reeves, J. E. Mica. Canada Dept. Mines and Tech. Surveys, Miner. Processing Division (Ottawa), 1961, prelim. Rept., May 1962, p. 1.

[10] U.S. Embassy, New Delhi, India. State Department Airgram A-1309. Apr. 29, 1963, encl. 1, p. 2.

Bureau of Mines. Mineral Trade Notes. V. 55, December 1962, p. 29.

[11] Mining Journal (London). V. 258, Feb. 2, 1962, p. 121.

[12] U.S. Consulate, Calcutta, India. State Department Airgram A-90, Sept. 21, 1962, pp. 1-2.

[13] U.S. Consulate, Johannesburg, Republic of South Africa. State Department Airgram A-402. May 9, 1963, pp. 15-16, encl. 1, p. 1; encl. 2, p. 1; encl. 3, p. 1.

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566 tons valued at $68,400 in 1961 to 718 tons valued at $86,680 in 1962. No sheet mica was exported.[14]

Tanganyika.—A large part of the mica again was produced by the two African mica mining cooperative societies in the Uluguru mountains. Their production was almost 45 tons or about 41 percent of the total for Tanganyika. Exports of sheet mica were 218,000 pounds valued at $258,000, compared with 196,000 pounds valued at $246,000 in 1961.[15]

TECHNOLOGY

Natural Mica.—The geology of Virginia deposits of mica and several other minerals occurring chiefly in pegmatites was discussed; descriptions of individual deposits included a summary of previously reported information and more recently observed data.[16] Two reports described the geology of a region in western North Carolina where mica was one of the principal economic minerals.[17] Exploration of a productive mica deposit in northeastern Georgia indicated that other large pegmatite bodies may exist in this area, previously considered to contain only small shallow pegmatite deposits.[18] Evaluation of a Canadian nepheline-corundum deposit indicated the possibility of recovering mica as a byproduct.[19]

The pegmatites of Tanganyika were described, detailed geological and mineralogical data were reported for the various mica-producing fields, and the mica industry was traced from its beginning.[20] Information on many mica deposits in the Miami mica field of Southern Rhodesia was included in a report which described the general geology of the region and discussed characteristics of the mica and methods of mining it.[21]

The theoretical basis underlying methods for giving the unit cell dimensions of micas and related minerals in terms of composition was studied, and new formulas relating these properties were proposed.[22] Studies of the crystal structure of phlogopite were reported,[23] and the

[14] U.S. Consulate, Johannesburg, Republic of South Africa. State Department Airgram A–362. Mar. 28, 1963, p. 3.
Bureau of Mines. Mineral Trade Notes. V. 55, August 1962, p. 51.

[15] U.S. Embassy, Dar es Salaam, British East Africa. State Department Airgram A–608. May 13, 1963, encl. 1, p. 5.
Mining Journal (London). Mining in Tanganyika. V. 260, Apr. 19, 1963, p. 365.

[16] Brown, W. R. Mica and Feldspar in Virginia. Virginia Division of Min. Res., Min. Res. Rept. 3, 1962, 195 pp.

[17] Brobst, D. A. Geology of the Spruce Pine District, Avery, Mitchell, and Yancey Counties, North Carolina. Geol. Survey Bull. 1122(a), 1962, 26 pp.
Bryant, B. Geology of the Linville Quadrangle, North Carolina-Tennessee—A Preliminary Report. Geol. Survey Bull. 1121(d), 1962, 30 pp.

[18] Lesure, F. G. Geology of the Taylor Mica Mine, Hart County, Georgia. Georgia Geol. Survey Miner. News Letter, v. 25, Spring-Summer 1962, pp. 9–14.

[19] Moyd, L., P. Moyd, and H. L. Noblitt. The Monteagle Nepheline-Corundum-Mica Deposit, Hastings County, Ontario. Canadian Min. and Met. Bull. (Montreal), v. 55, August 1962, pp. 563–570.

[20] Harris, J. F. Summary of the Geology of Tanganyika. Tanganyika Geol. Survey Memoir No. 1, pt. 4, Econ. Geol., 1961, pp. 29–31, 103–107.

[21] Wiles, J. W. The Geology of the Miami Mica Field (Urungwe District). Southern Rhodesia Geol. Survey Bull. 51, Salisbury, 1961, 235 pp.

[22] Radoslovich, E. W., and K. Norrish. The Cell Dimensions and Symmetry of Layer-Lattice Silicates, I. Some Structural Considerations. Am. Miner., v. 47, May–June 1962, pp. 599–616.
Radoslovich, E. W. The Cell Dimensions and Symmetry of Layer-Lattice Silicates, II. Regression Relations. Am. Miner., v. 47, May–June 1962, pp. 617–636.

[23] Steinfink, H. Crystal Structure of a Trioctahedral Mica: Phlogopite. Am. Miner., v. 47, July–August 1962, pp. 886–896.
Zvyagin, B. B., and K. S. Mishchenko. (Electron-Diffraction Data on the Structure of Phlogopite-Biotite), Krystallograf., v. 7, No. 4, 1962, pp. 623–627.

mechanism of plastic deformation in mica was correlated with distortions in the crystal structure.[24]

Weathering of muscovite and paragonite in two soil samples was reported to be similar in type and rate.[25] A helpful technique was described for use in studying the artificial weathering of mica.[26] Studies of the surface properties of micas in contact with polar solvents included the consideration of weathering processes.[27]

The capacitance and dielectric losses of muscovite were measured under reduced pressure to determine their dependence on temperature and pressure. The possible structural changes in mica leading to these dielectric effects were discussed.[28] Similar investigations on phlogopite were reported.[29] The effect of radiation on the dielectric properties of muscovite over a range of temperatures and frequencies was studied.[30]

Results of an investigation into objective tests and test methods for evaluating sheet mica were summarized.[31] The Mica Industry Association, Inc., began a testing program to verify existing data and obtain additional information on the properties of sheet mica. The tests were being conducted at the laboratories of The Macallen Co., Inc.

The automatic processing of mica films for assembly into capacitors was described.[32] Mica was used for sealing gaskets in the internal parts of high-temperature fuel cells [33] and for windows in capsules designed for irradiation applications.[34]

Finely divided muscovite in mixtures commonly found in silt and waste deposits was recovered by magnetic separation after the mixture had been heated under reducing conditions.[35] Additions to the technology of recovering mica by froth flotation were the combination of the usual amine collectors with auxiliary reagents chosen from a group of substituted naphthalene and organosulfide compounds [36] and the use of monomeric substituted phenols as collectors.[37]

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[24] Shvaykovskaya, Ye. O., A. I. Nikolayeva, and T. D. Shalyt. (X-Ray Diffraction Study of Deformed Mica Substances). Referat. Zhur., Fiz., No. 6, 1962, p. 20; abs. Zap. Leningr. gorn. in-ta, v. 37, No. 3, 1961, pp. 105–108.

[25] Cork, M. G., and C. I. Rich. Weathering of Sodium-Potassium Mica in Soils of Virginia Piedmont. Soil Sci. Soc. of Am. Proc., v. 26, November–December 1962, pp. 591–595.

[26] Brown, C. G., G. W. Bailey, and J. L. White. Removal of Reaction Products from Muscovite-Treated with Molten Lithium Nitrate. Am. Miner., v. 47, July–August 1962, pp. 998–1000.

[27] Marshall, C. E. Reactions of Feldspars and Micas with Aqueous Solutions. Econ. Geol., v. 57, December 1962, pp. 1219–1227.

McDowell, L. L., and C. E. Marshall. Ionic Properties of Mica Surfaces. Soil Sci. of Am. Proc., v. 26, November–December 1962, pp. 547–551.

[28] Vorozhtsova, I. G., (On the Nature of Dielectric Losses in Mica). Izvest. Vysshikh Uchebnykh Zavedeniy, Fiz., No. 1, 1962, pp. 25–31.

[29] Afanas'yev, N. V., and M. S. Metsik. (The Nature of Dielectric Loss in Crystals of Phlogopite Mica). Izvest. Vysshikh Uchebnykh Zavedeniy, Fiz., No. 6, 1961, pp. 132–140.

[30] Vodop'yanov, K. A., and I. G. Vorozhtsova. (Effect of Gamma Irradiation on the Dielectric Losses in Mica). Izvest. Vysshikh Uchebnykh Zavedeniy, Fiz., No. 1, 1962, pp. 48–51.

[31] Pollak, E. E. Research and Development on Standardization of Objective Tests for Mica and Mica-Like Materials Suitable for Electron Tube Spacers. New York Naval Shipyard Material Lab. Final Rept. Lab. Project 5032-B-14.2, 9 pp. (ASTIA AD282259.)

[32] Campaigne, R. N., and D. A. Estabrooks. Silvering Mica Films Automatically for Bell System Capacitors. Western Elec. Eng., v. 6, October 1962, pp. 23–29.

[33] Reid, W. T., and A. P. Edson. Fuel Cells: Tomorrow's Power Plant. Battelle Tech. Rev., v. 11, June 1962, pp. 2–7.

[34] Chemical & Engineering News. V. 40, May 17, 1962, p. 41.

[35] Adam, H. W. (assigned to International Minerals & Chemical Corp., Skokie, Ill.). Method of Beneficiating Mica. U.S. Pat. 3,016,139, Jan. 9, 1962.

[36] Wilson, M. (assigned to U.S. Borax & Chemical Corp., Los Angeles, Calif.). Method and Means for Beneficiating Ores. U.S. Pat. 3,059,774, Oct. 23, 1962.

[37] De Groote, M., and K. T. Shen (assigned to Petrolite Corp., New York). Froth Flotation Process Employing Polyaminomethyl Phenols. U.S. Pat. 3,056,498, Oct. 12, 1962.

An apparatus was described for grinding mica by forcing a slurry to flow at high velocity through a restricted opening and impinge on an impact surface.[38]

The role of mica in the expansion of a fired clay by moisture was explained.[39] Studies of factors affecting the fired strength of insulating brick made from mica were reported.[40]

In basic research on mechanisms of friction and wear for lamellar solid lubricants, the energy required to separate mica laminae was measured.[41] A composition to protect metal surfaces from oxidation and prevent threaded and other contacting elements from seizing contained mica powder as a major constituent.[42] Ground mica also was used as a filler in high-temperature coatings,[43] an ingredient in an adhesive composition,[44] and a plugging agent in fracturing fluids.[45] Laboratory studies indicated that wet-ground mica used as part of all of the extender pigment in water-thinable oil paints decreased original gloss, cracking tendencies, speed of erosion, and moisture sensitivity of the films, and improved their cleansing, tint-retention, and durability.[46]

Synthetic Mica.—Research on synthetic mica continued at the Bureau of Mines, Norris Metallurgy Research Laboratory, Norris, Tenn. Principal efforts were directed toward growing large single crystals, obtaining basic information on nucleation and the liquid state of fluorphlogopite, reconstituting improved inorganic paper from water-swelling compounds, and preparing machinable dielectrics by devitrifying synthetic mica glasses. The melting temperature of fluorphlogopite was determined on clear single crystals by a technique which prevented loss by volatilization and was found to be 1,383° C.[47] Synthesis of fluorphlogopite from inexpensive and abundant olivine, clay, feldspar, and sand plus potassium silicofluoride and alumina was found to be feasible, but the product was below the quality needed for electrical and electronic applications.[48] Chemical, physical, optical, and X-ray data were reported for an unusual fluormica synthesized during studies of isomorphous substitution in synthetic mica.[49]

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[38] Cohn, M. I., and R. D. Perdue (assigned to Mineral Industries Corp. of America, Boston, Mass.). Method and Apparatus for Reducing Particle Size. U.S. Pat. 3,039,703, June 19, 1962.

[39] Cole, W. F. Moisture-Expansion Characteristics of a Fired Kaolinite-Hydrous Mica-Quartz Clay. J. Am. Ceram. Soc., v. 45, September 1962, pp. 428–434.

[40] Roy, S. B., and S. K. Som. Factors Affecting the Properties of Heat Insulating Mica Brick: I. Indian Ceram. Soc. Trans., v. 21, February 1962, pp. 55–60.

[41] Bryant, P. Lubrication Studies with Lamellar Solids. Aeronautical Systems Division, Wright-Patterson AFB, Ohio, Rept. ASD–TDR–62–55 (Final), January 1962, 23 pp. (ASTIA AD274817.)

[42] Pfefferkorn, O. T. (assigned to North American Aviation, Inc., El Segundo, Calif.). Anti-Seize and Sealing Composition and Method. U.S. Pat. 3,041,277, June 26, 1962.

[43] Labino, D., and L. V. Gagin (assigned to Johns-Manville Fiber Glass, Inc., Cleveland, Ohio). High-Temperature Resistant Siliceous Compositions and Method of Producing. U.S. Pat. 3,017,318, Jan. 16, 1962.

[44] Janota, R. B., and R. T. Gavin (assigned to Swift & Co., Chicago, Ill.). Insulation Adhesive Composition with Acrylate Polymer and Alkali Metal Siliconate. U.S. Pat. 3,025,256, Mar. 13, 1962.

[45] Phansalkar, A. K., A. H. Roebuck, and J. B. Scott (assigned to Continental Oil Co., Ponca City, Okla.). Low Fluid Loss Fracturing Composition. U.S. Pat. 3,046,222, July 24, 1962.

[46] Wet-Ground Mica Association, Inc. Wet-Ground Mica in Water Thinnable Linseed-Oil Paints. Press Release, Oct. 3, 1962, 2 pp.

[47] Alley, John K., and H. R. Shell. Melting Temperatures of Fluormicas and Related Compounds. BuMines Rept. of Inv. 5981, 1962, 32 pp.

[48] Shell, H. R., and Wilbur Warwick. Synthetic Mica from Low-Cost Raw Materials. BuMines Rept. of Inv. 6077, 1962, 19 pp.

[49] Miller, J. L., and R. C. Johnson. The Synthesis and Properties of a Fluormica, Intermediate Between Fluortaeniolite and Fluorhectorite. Am Miner., v. 47, September-October 1962, pp. 1049–1054.

Muscovite and phlogopite, containing boron in the lattice, were synthesized hydrothermally.[50] Etch patterns on synthetic fluorphlogopite were compared with those on natural phlogopite and interpreted in terms of the crystal structure.[51]

A method was proposed for producing large crystals of synthetic mica by slow cooling under controlled pressure.[52]

Soviet scientists continued research on synthetic mica and reported growing mica crystals from melts.[53]

Built-Up and Reconstituted Products from Natural and Synthetic Mica.— Samples of several different types of micanite from each of six manufacturers in India and three in other countries were evaluated with respect to a number of properties. Results showed that the quality of Indian micanites was comparable to the products of other countries, except for variations in thhickness and bond content.[54] A built-up mica with a specified resinous binder was claimed to be an extremely flexible and strong material that could be applied to various electrical members and heat treated to produce a tight, compact, high-voltage insulation with outstanding electrical properties.[55] Insulated high-voltage conductors were fabricated by wrapping an electrical conductor with two or more layers of tape composed of binder-free, overlapping mica flakes, backing this with longitudinal glass fiber threads wound over only a small portion of the tape surface, impregnating with a liquid resinous composition, and bonding the assemblage into a solid member.[56] Studies on reinforcing plastic composite insulation with flake materials included tests to determine the effectiveness of mica additions.[57]

Electrical insulation was formed by electrostatically depositing mica flakes in layers from a suspension of the flakes in a solvent that contained a binder and optionally a wetting agent.[58]

Vitreous micaceous material with superior electrical and thermal insulating properties was produced by heating a powdered mixture of lead borate frit and the raw materials for fluorphlogopite mica above 800°C and gradually cooling the product.[59] In a related process, the

[50] Stubican, V., and R. Roy. Boron Substitution in Synthetic Micas and Clays. Am. Miner., v. 47, September-October 1962, pp. 1166–1173.

[51] Patel, A. R., and S. Ramanathan. Etching of Synthetic Fluorphlogopite. Am. Miner., v. 47, September–October 1962, pp. 1195–1201.

[52] Slayter, G. (assigned to Owens-Corning Fiberglass Corp., Toledo, Ohio). Control of Crystal Growth in Mica Materials. U.S. Pat. 3,056,653. Oct. 2, 1962.

[53] Shternberg, A. A. (Growing Single Crystals from Melts by Controlled Heat Elimination). Refer. Zhur. Khim., No. 9, abs. 9B238, 1962, pp. 39–40.

———. (An Experiment in the Growing of Crystals by Elimination of Heat). Refer. Zhur. Khim., No. 16, abs. 16B179, 1962, p. 30.

[54] Dhar, R. N., S. S. Mandal, and S. B. Roy. Micanite and Its Properties. Central Glass & Ceram. Res. Inst. Bull. (Calcutta), v. 9, April–June 1962, pp. 67–78.

[55] Rogers, D. A., Jr., and R. J. Hillen (assigned to Westinghouse Electric Corp., East Pittsburgh, Pa.). Composite Mica Insulation and Electrical Conductors Insulated Therewith. U.S. Pat. 3,026,222, Mar. 20, 1962.

[56] Andersson, A. R., and P. T. Agren (assigned to Allmanna Svenska Elektriska Aktiebolaget, Vasteras, Sweden). Insulated Electrical Conductors and Process for Producing Same. U.S. Pat. 3,019,286, Jan. 30, 1962.

[57] Narmco Research & Development Division, Telecomputing Corp. Establishment of the Potential of Flake-Reinforced Laminates as Engineering Structural Materials. Final Rept. Contract NOw60-0305-C, March 1962, 52 pp. (ASTIA AD274332.)

[58] Flötgen, R., and K. Kalk (assigned to Licentia Patent-Verwaltungs-GmbH, Hohe Bleichen, Hamburg, West Germany). Method for Producing Mica Layers for Electrical Insulation. U.S. Pat. 3,043,735, July 10, 1962.

[59] Moore, R. E. (assigned to Mycalex Corp. of America, Clifton, N.J.). Method of Making Ceramoplastic Material. U.S. Pat. 3,057,741, Oct. 9, 1962.

powdered mixture comprised the raw materials for fluorphlogopite or other fluormica and the raw materials for lead borate glass.[60] Fluor-amphiboles were combined with synthetic fluormicas and hot pressed to produce strong, abrasion-resistant, machinable ceramic materials.[61]

Ground mica was the filler in an inorganic binder used to join sheets of glass fibers in an inorganic laminate having excellent stability and dielectric properties up to 2,500° F.[62]

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[60] Hessinger, P. S., and W. K. Haller (assigned to Mycalex Corp. of America, Clifton N.J.). Ceramoplastic Material. U.S. Pat. 3,024,118, Mar. 6, 1962.

[61] Shell, H. R. (assigned to the U.S. Department of the Interior). Fluormica-Fluoramphibole Ceramics and Processes of Making Same. U.S. Pat. 3,054,685, Sept. 18, 1962.

[62] Bozzacco, F. A. (assigned to Goodyear Aircraft Corp., Akron, Ohio). Inorganic Laminate. U.S. Pat. 3,047,442, July 31, 1962.

Molybdenum

By Horace T. Reno [1] and Mary J. Burke [2]

UNITED STATES produced 51 million pounds of molybdenum in 1962, 23 percent less than in 1961, as the Climax mine in Colorado, the principal producer, was closed part of the time by a strike. The strike began on July 19. The mine was reopened by the supervising staff on October 29 and then produced at approximately three-fourths of capacity for the remainder of the year. Despite the lessened output, end-use consumption of molybdenum was the highest since the Bureau of Mines started keeping records in 1956. Congress authorized the sale of 5 million pounds of molybdenum from the national stockpile in June, but no part of this reached the market in 1962.

TABLE 1.—Salient molybdenum statistics

(Thousand pounds of contained molybdenum and thousand dollars)

	1953-57 (average)	1958	1959	1960	1961	1962
United States:						
Concentrate:						
Production	59,180	41,069	50,956	68,237	66,563	51,244
Shipments	59,364	42,328	51,603	69,941	66,753	50,506
Value [1]	$62,971	$50,371	$64,655	$87,406	$87,925	$69,333
Consumption	35,262	31,298	37,448	44,784	42,261	40,990
Imports for consumption	63	1	----	----	----	----
Stocks, Dec. 31: Mine and plant	5,877	5,643	4,074	3,481	2,815	3,490
Primary products:						
Production	34,258	30,915	36,294	43,427	41,050	40,074
Shipments	34,870	31,359	41,658	45,777	47,106	46,673
Consumption	[2] 31,757	24,231	32,350	31,837	32,621	35,674
Stocks, Dec. 31: Producer	3,816	8,081	5,958	8,157	5,074	3,068
World: Production	72,300	[3] 57,800	70,300	89,500	87,900	75,000

[1] Largely estimated by Bureau of Mines.
[2] 1956-57 only.
[3] Revised figure.

DOMESTIC PRODUCTION

Molybdenum Mines.—According to the American Metal Climax, Inc., annual report to its stockholders, the Climax mine produced 32,659,000 pounds of molybdenum in a molybdenite concentrate. The mine produced over 36,000 tons per day for the first half of the year, a new

[1] Assistant chief, Branch of Ferrous Metals.
[2] Statistical assistant.

record. Crude ore production for the year totaled 8,185,000 tons. The company continued development of the Ceresco Ridge ore zone at a reduced rate throughout the strike; nevertheless, it still planned to bring this area into production in 1965 at the rate of 5,000 tons of ore per day. In its annual report, the company conservatively estimated the Climax mine ore reserve at 455 million tons containing over 2 billion pounds of molybdenum.

The Molybdenum Corporation of America actively continued exploiting its Questa property in New Mexico, but did not produce molybdenum.

Nye Metal, Inc., of Black Hawk, Colo., obtained government assistance through the Office of Minerals Exploration, U.S. Department of the Interior, to explore a molybdenum property in Gilpin County, Colo.

Byproduct Sources.—Molybdenite was recovered as a byproduct from copper mining in Arizona, Nevada, New Mexico, and Utah. Molybdenum oxide was recovered from tungsten ores in California. Molybdenum mined as a byproduct was 36 percent of the total quantity produced in the United States. Most byproduct producers shipped molybdenite concentrate rather than converting it to the oxide before shipment. Duval Sulphur & Potash Co. began developing two new molybdenum byproduct mines, the Mark Draw potash mine in New Mexico, and Ithaca Peak copper mine in Arizona; when these are in full production, they will more than double the company's output of molybdenite. Kennecott Copper Corp. replaced the molybdenum recovery unit at its Chino Mines Division concentrator at Hurley, N.Mex. The new unit was not completed in time to operate in 1962.

CONSUMPTION AND USES

Domestic end-use consumption of molybdenum increased 9 percent compared with that of 1961. The quantity was the most molybdenum consumed by end uses since 1956, when the Bureau of Mines first compiled consumption data. The increased use was distributed through most of the categories reported to the Bureau of Mines, although its use in stainless steel decreased 10 percent. Molybdenum use in high-speed steel increased 31 percent and in hot-work steel, 33 percent. Its use in steel-mill rolls increased 64 percent and in gray and malleable castings, 26 percent. The use of pure molybdenum metal powder to make wire, rod, and sheet increased 52 percent. In contrast to previous years when metal powder was used principally in research, most of the powder was consumed for commercial use. Its use in research apparently was about the same as in 1961.

Climax Molybdenum Co., Fansteel Metallurgical Corp., General Electric Co., and Westinghouse Electric Corp. offered a wide variety of pure molybdenum sheets and bars for sale. Superior Tube Co. of Norristown, Pa., offered small-size tubing of molybdenum and molybdenum alloys for sale on an experimental basis.[3] The U.S. Air Force awarded a contract to Martin Marietta Corp. to develop honeycombed sandwich panels for spacecraft that would withstand a temperature of

[3] Metal Progress. V. 82, No. 1, July 1962, p. 29.

3,500° F. The first Air Force contract for scaling up a refractory metal coating process to a production level was awarded to Pfaudler Co., Division of Pfaudler Permutit, Inc., Rochester, N.Y. Electrical Contacts and Specialties Division of Fansteel Metallurgical Corp. developed a sintered molybdenum material for conductor backup wafers that was said to be less expensive to use than cut or punched disks because no scrap is generated in its use.

TABLE 2—Production, shipments, and stocks of molybdenum products in the United States

(Thousand pounds of contained molybdenum)

	Product					
	Molybdic oxide [1]		Metal powder		Ammonium molybdate	
	1961	1962	1961	1962	1961	1962
Received from other producers	2,750	3,948	34	11	177	484
Gross production during year	38,382	36,748	1,751	2,586	1,085	2,024
Used to make other products listed here	6,578	8,922	187	227	841	1,839
Net production	31,804	27,826	1,564	2,359	244	185
Shipments:						
Domestic consumers	27,151	29,264	1,585	2,302	370	659
Exports	8,314	3,519		4	2	18
Total	35,465	32,783	1,585	2,306	372	677
Producer stocks, Dec. 31	2,746	1,694	469	463	179	156

	Product—Continued				Total	
	Sodium molybdate		Other [2]			
	1961	1962	1961	1962	1961	1962
Received from other producers	12	4	5	279	2,978	4,726
Gross production during year	446	366	6,994	9,338	48,658	51,062
Used to make other products listed here	2				7,608	10,988
Net production	444	366	6,994	9,338	41,050	40,074
Shipments:						
Domestic consumers	453	433	8,800	10,008	38,359	42,666
Exports	1	2	430	464	8,747	4.007
Total	454	435	9,230	10,472	47,106	46,673
Producer stocks, Dec. 31	115	46	1,565	709	5,074	3,068

[1] Includes molybdic oxide briquets, molybdic acid, and molybdenum trioxide.
[2] Includes ferromolybdenum, calcium molybdate, phosphomolybdic acid, molybdenum disulfide pellets, molybdenum pentachloride, and molybdenum hexacarbonyl.

TABLE 3.—Consumption of molybdenum products by end uses in 1962

(Thousand pounds of contained molybdenum)

End use	Molybdic oxides [1]	Ferromolybdenum [2]	Molybdenum metal powder	Ammonium molybdate	Sodium molybdate	Other [3]	Total
Steel:							
High-speed	1,368	773				132	2,273
Hot-work tool	233	155				47	435
Other tool	175	107				1	283
Stainless	2,512	1,793				22	4,327
Other alloy [4]	14,866	1,718				132	16,716
Steel-mill rolls	1,494	70					1,564
Gray and malleable castings	460	2,760	8			20	3,248
Welding rods	3	236					239
High-temperature alloys	435	241	2			636	1,314
Molybdenum powder:							
Wire, rod, and sheet			1,079				1,079
Other			1,171				1,171
Chemicals:							
Inorganic pigments	449			8	14		471
Organic pigments	161			8	217	2	388
Catalysts	666			22	2		690
Miscellaneous [5]	85	660	31	29	6	665	1,476
Total	22,907	8,513	2,291	67	239	1,657	35,674
Stocks at consumer plants, Dec. 31	3,245	1,251	43	14	24	355	4,932

[1] Includes technical and purified oxides.
[2] Includes molybdenum silicide and calcium molybdate.
[3] Includes thermite molybdenum and molybdenum pellets, purified molybdenum disulfide, and molybdenite concentrate.
[4] Includes qualitities that were believed used in producing high-speed and stainless steels because some firms failed to specify individual uses.
[5] Includes magnets, other special alloys, friction material, lubricants, pesticides, refractories, and packings.

STOCKS

The national (strategic) stockpile contained 84,062,802 pounds of molybdenum on December 31, 1962. The industrial inventory in concentrate and compounds totaled 11,490,000 pounds, about 1 million pounds less than at the same time in 1961. Producer stocks accounted for all the decrease, 40 percent less than in 1961. Mine and consumer inventories were, respectively, 24 and 16 percent more.

PRICES

E&MJ Metal and Mineral Markets quoted molybdenite concentrate and primary products per pound of contained molybdenum, f.o.b. point of shipment, as follows: Concentrate, 95 percent molybdenum sulfide (MoS_2), $1.40; molybdic trioxide (MoO_3), in bags $1.59, and in cans $1.60. The same publication quoted molybdenum powder in wholesale lots, carbon-reduced, at $3.35 and hydrogen-reduced, at $3.55. Ferromolybdenum, per pound of contained molybdenum, 5,000 pounds or more, f.o.b. New York (58 to 64 percent molybdenum), powdered, packed, was quoted at $1.95; other sizes, packed, at $1.89.

FOREIGN TRADE[4]

Imports.—There were no imports for consumption of molybdenum ore and concentrate into the United States. Molybdenum-bearing scrap imports totaled 44,553 pounds, gross weight, valued at $81,115. Imports of molybdenum, or molybdenum carbide sheets, wire, and other forms not elsewhere provided for totaled 32,378 pounds, gross weight, valued at $303,395. There were some imports for consumption of molybdenum metal powder, calcium molybdate, and other compounds or alloys, but both the quantity and value reported were questionable.

Exports.—Exports of molybdenum in ore and concentrate were 56 percent less in quantity and 53 percent less in value than in 1961, the record year. The United Kingdom, the principal recipient with 27 percent of the total, received 46 percent less than in 1961; France, with 19 percent of the total, received 55 percent less; Japan, with 13 percent of the total, received 66 percent less; and West Germany, with 11 percent of the total, received 78 percent less. Apparently the large decrease in exports was due to lessened activity in the world's principal steel-producing countries, outside the Soviet bloc nations, and to the threat of a domestic molybdenum shortage in the last half of the year.

Ferromolybdenum valued at $305,126 was exported to 14 countries; Canada was by far the principal recipient. Molybdenum wire and bar exports, except welding rods and wire, were valued at $373,754; molybdenum powder exports were valued at $84,224; and molybdenum metal and alloys in crude forms and scrap exports were valued at $70,086. Exports of semifabricated forms of molybdenum were valued at $135,180.

TABLE 4.—Molybdenum reported by producers as shipments for export from the United States

(Thousand pounds of contained molybdenum)

Product	1961	1962
Molybdenite concentrate	24,165	10,112
Molybdic oxide	8,314	3,519
All other primary products	433	488

TABLE 5.—U.S. exports of molybdenum products

(Pounds, gross weight)

Product	1961	1962
Ferromolybdenum [1]	358,523	189,823
Metal and alloys in crude form and scrap	440,849	75,211
Wire	12,488	12,088
Powder	11,816	25,219
Semifabricated forms (mainly rods, sheets, and tubes)	7,362	8,961

[1] Ferromolybdenum contains about 60 to 65 percent molybdenum.

Source: Bureau of the Census.

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

Tariff.—There were no changes in the import duties on molybdenum ore and concentrate and primary molybdenum products. The duties imposed under various trade agreements to the Tariff Act of 1930 on imports from all countries, except the U.S.S.R. and other designated Communist countries and areas, were as follows: Molybdenum ore and concentrate, 30 cents per pound of contained molybdenum; ferromolybdenum, molybdenum metal and powder, calcium molybdate, and other compounds and alloys of molybdenum, 25 cents per pound of molybdenum plus 7.5 percent ad valorem; and sheets, wire, or other forms of molybdenum or molybdenum carbide, 25.5 percent ad valorem.

TABLE 6.—U.S. exports of molybdenum ore and concentrate (including roasted concentrate), by countries

Destination	1961		1962	
	Molybdenum content (pounds)	Value	Molybdenum content (pounds)	Value
North America:				
Canada	1,617,911	$1,763,866	777,560	$983,865
Mexico	5,404	7,726	5,977	7,223
Total	1,623,315	1,771,592	783,537	991,088
South America:				
Argentina	274	388	1,868	2,370
Brazil	1,651	2,526		
Chile	14,448	20,704	16,000	26,400
Total	16,373	23,618	17,868	28,770
Europe:				
Austria	1,577,872	2,458,195	1,370,777	2,237,578
Belgium-Luxembourg	357	438	1,268	1,820
Denmark			9,514	14,271
France	6,408,257	8,679,994	2,896,360	4,165,260
Germany, West	8,073,153	10,633,828	1,791,970	2,671,481
Italy	1,442,231	1,942,176	1,256,715	1,807,367
Netherlands	590,937	816,990	224,170	365,005
Poland and Danzig			76,496	144,830
Spain	3,588	5,387	4,075	6,221
Sweden	2,290,865	2,963,614	827,104	1,153,379
Switzerland			29,956	48,438
United Kingdom	7,683,030	10,365,238	4,165,884	5,992,140
Total	28,070,290	37,865,860	12,654,289	18,607,790
Asia:				
Hong Kong	490	780	1,829	2,798
Japan	5,922,628	9,057,572	2,022,258	3,148,998
Philippines	3,022	3,965	10,400	17,212
Taiwan			1,453	2,110
Total	5,926,140	9,062,317	2,035,940	3,171,118
Africa: South Africa, Republic of [1]	879	1,268	2,458	3,914
Oceania: Australia	24,004	33,802	60,570	97,898
Grand total	35,661,001	48,758,457	15,554,662	22,900,578

[1] Effective Jan. 1, 1962; formerly Union of South Africa.

Source: Bureau of the Census.

WORLD REVIEW

NORTH AMERICA

Canada.—*British Columbia.*—At the annual meeting of Friday Mines, Ltd., it was reported that preliminary work on the company's copper-molybdenite property in the Keremeos area indicated a mineralized zone approximately 1 mile long, ranging in width from 40 to 200 feet and containing 0.8 percent copper and 0.35 percent molybdenite.[5] Noranda Mines, Ltd., awarded a contract to Fry Company & Associates to drive a 5,600-foot cross tunnel at its Boss Mountain molybdenum property.[6] Endako Mines Co. completed seven drill holes on its block of 57 claims 3 miles southwest of Endako Station on the Canadian National Railway. Reportedly, the drilling indicated economic grades of molybdenite mineralization over an area sufficiently wide to be suitable for opencut mining. Three intersections in the main mineralized zone indicated an average grade of 0.51 percent molybdenite across a true width of 70 feet.[7]

TABLE 7.—World production of molybdenum in ores and concentrates by countries [1] [2]

(Thousand pounds)

Country [1]	1953-57 (average)	1958	1959	1960	1961	1962
Australia	2	4	(3)	----------	2	----------
Austria	4	----------	----------	----------	----------	----------
Canada	622	888	749	768	771	797
Chile	2,921	2,972	3,785	4,440	3,699	5,271
China [4]	1,800	2,200	3,300	3,300	3,300	3,300
Japan	483	692	842	840	807	[4] 810
Korea, Republic of	26	82	49	97	71	163
Mexico	55	57	57	132	7	128
Norway	359	483	498	542	531	[4] 530
Peru	2	2	----------	----------	----------	----------
Philippines	----------	----------	123	150	249	[4] 260
Portugal	9	----------	----------	----------	----------	----------
South Africa, Republic of	[5] 2	9	----------	----------	----------	----------
U.S.S.R. [4]	(6)	9,300	9,900	11,000	11,900	12,500
United States	59,180	41,069	50,956	68,237	66,563	51,244
Yugoslavia	7	4	[4] 4	----------	----------	----------
World Total (estimate) [1]	72,300	57,800	70,300	89,500	87,900	75,000

[1] Molybdenum is also produced in North Korea, Rumania, and Spain, but production is negligible.
[2] This table incorporates some revision. Data do not add exactly to totals shown because of rounding where estimated figures are included in detail.
[3] Less than 500 pounds.
[4] Estimate.
[5] One year only, because 1957 was the first year of commercial production.
[6] Data not available; estimate by senior author of chapter included in total.

Compiled by Kathleen W. McNulty and Pearl J. Thompson, Division of Foreign Activities.

New Brunswick.—At the Mount Pleasant Mines, Charlotte County property, 37 miles south of Fredericton, preliminary exploration indicated a mineralized zone 300 feet long, open at both ends, and averaging 0.40 percent molybdenite.[8]

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[5] Canadian Mining Journal (Gardenvale, Quebec). V. 83, No. 11, November 1962, p. 106.
[6] Canadian Mining Journal (Gardenvale, Quebec). V. 83, No. 4, April 1962, p. 145.
[7] Northern Miner (Toronto). Molybdenite Bet Showing Promise for Endako Mines. V. 48, No. 21, Aug. 16, 1962, pp. 1 (809), 11 (819).
[8] Northern Miner (Toronto). Surface Drill Holes Cut Molybdenite at Mount Pleasant. V. 48, No. 35, Nov. 22, 1962, p. 3 (1095).

Ontario.—Evenlode Mines, Ltd., began exploring on the Thompson vein at its High Lake molybdenite property west of Kenora, in northwestern Ontario, where previous drilling indicated 126,000 tons containing 0.68 percent molybdenite.[9]

Quebec.—Molybdenite Corporation of Canada, Ltd., was the only molybdenum producer in Canada, although some copper producers recovered byproduct molybdenite. At midyear Molybdenite Corp. reported a reserve estimate of 280,000 tons at its La Corne mine; this did not include full ore potential on the two bottom levels.[10] Molybdenite Corp. obtained options on a molybdenite prospect of 7,000 acres in Eastern Townships, from Copperstream-Frontenac Mines, Ltd.[11] Following direct exploration of mineralized zones on the 300-foot level and diamond drilling below at its property 15 miles north of Cadillac in Preissac Township, Anglo American Molybdenite Mining Corp. reported calculated ore reserves to a depth of 450 feet. The reserves were estimated at 2,004,000 tons, averaging 0.30 percent molybdenite and 0.061 percent bismuth.[12]

Gaspé Copper Mines, Ltd., reportedly was in transition from pilot plant recovery of molybdenum from copper concentrate to molybdenum production as a byproduct. The extent of production was expected to be substantial and profitable.[13]

SOUTH AMERICA

Chile.—Production of molybdenite concentrate totaled 4,822 short tons in 1962, compared with 3,446 tons in 1961. Chile Exploration Co. accounted for 1,814 tons; Andes Copper Mining Co., 1,304 tons; and Braden Copper Co., 1,704 tons of the 1962 total. Andes Copper Mining Co. was shut down for 39 days by a labor strike, and the Chile Exploration Co. molybdenite recovery circuit was operated intermittently because heating facilities were needed part of the time for other uses. Molybdenite concentrate exports from Chile totaled 4,932 short tons. West Germany received 40 percent of the total, the United Kingdom, 20 percent, Sweden, 18 percent, the Netherlands, 17 percent, and France, the remaining 5 percent.[14]

EUROPE

Denmark.—The Danish Parliament passed a bill on December 15, 1961, granting Arktish Minekompagni A/S (Arctic Mining Co., Ltd.) a concession to prospect and mine for molybdenum between 71°54′ and 72°05′ North latitude and 24°00′ and 24°30′ West longitude. The Arctic Mining Co. was owned jointly by Nordic Mining Co. and Ameri-

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[9] Northern Miner (Toronto). Cut Molybdenite at Evenlode Mines Add Second Drill. V. 48, No. 30, Oct. 18, 1962, p. 3 (995).
[10] Northern Miner. Molybdenite Corp., Picking Up as Higher Tonnage Cuts Costs. V. 48, No. 13, June 21, 1962, pp. 1–2.
[11] Engineering and Mining Journal Newsletter. V. 13, No. 5, October 1962, p. 1.
[12] Northern Miner (Toronto). See Return of Capital, Good Profit From Anglo American Molybdenite. V. 48, No. 34, Nov. 15, 1962, pp. 13 (1085), 18 (1090).
[13] Northern Miner (Toronto). Expect Gaspé To Retire Debts Pay First Dividend Next Year. V. 48, No. 37, Dec. 6, 1962, pp. 1 (1215), 11 (1225).
[14] U.S. Embassy, Santiago, Chile. State Department Dispatch A–314, Oct. 1, 1962, p. 2. U.S. Embassy, Santiago, Chile. State Department Dispatch 434, Nov. 2, 1962, p. 2.

can Metal Climax, Inc. The company reported the existence of about 50 million tons of granite averaging 0.26 percent molybdenite.[15]

Norway.—Exploration for molybdenum ore in the Drangedal district of Telemark indicated the existence of ore containing 0.5 percent molybdenum. The extent of the ore body was not determined.[16]

TECHNOLOGY

In a comprehensive research program to produce and evaluate high-purity refractory metals, Bureau of Mines metallurgists prepared molybdenum with 99.95 percent purity, but the metal proved harder than commercial grades and did not possess their desirable fabrication characteristics. The molybdenum was prepared by reducing the molybdenum dichloride, trichloride, and pentachlorides with hydrogen. Research during the year was designed to determine the optimum conditions for producing the pure chlorides in a fluidized-bed reactor. A report describing the Bureau's procedure for preparing high-purity molybdenum by magnesium reduction was published.[17]

Bureau of Mines metallurgists received a patent on a method for separating molybdenum from tungsten by electrolysis from a fused electrolyte bath.[18] The Bureau continued its study to determine the optimum electrolyte for electrowinning and electrorefining molybdenum. Among those tested, no one electrolyte was proved definitely superior for either purpose.

Bureau of Mines ore dressers investigated three methods for recovering molybdenite from copper sulfide flotation concentrates. In the first method, they dried the filtered concentrate at low tempeature and followed this by flotation with kerosine and potassium ferrocyanide. In the second method, they filtered and washed the bulk concentrate and then followed with flotation. In the third method, they treated a fresh copper-molybdenum pulp with oxidizing chemicals in an effort to destroy the contained flotation agents and then processed the pulp by flotation. The best results were obtained with the first method, which employed the drying procedure, but the work was not conclusive. To date, the researchers on this project had developed satisfactory methods for retarding flotation of copper minerals, but had not found a completely satisfactory reagent for floating the molybdenum minerals.

Researchers studying industrial applications for molybdenum explored its use in diecasting, extrusion dies, high-temperature heating elements, metal-to-glass seals, and lubricants. Investigators studying its possible applications in the aerospace industry again ranked molybdenum second to tungsten among the refractory metals.

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[15] Bureau of Mines. Mineral Trade Notes. V. 54, No. 3, March 1962, p. 23.
Bureau of Mines. Mineral Trade Notes. V. 55, No. 3, September 1962, p. 54.

[16] Mining Journal (London). V. 259, No. 6642, Dec. 7, 1962, p. 548.

[17] Campbell, T. T., F. E. Block, and E. R. Anderson. Production of Molybdenum Metal by Magnesium Reduction of Molybdenum Oxides. BuMines Rept. of Inv. 5934, 1962, 22 pp.

[18] Zadra, John B., and John M. Gomes assigned to the U.S. Dept. of the Interior. Method for Separating Molybdenum From Tungsten by Electrolysis From a Fused Electrolyte Bath. U.S. Pat. 3,075,900, Jan. 29, 1963.

Climax Molybdenum Co. developed a promising molybdenum-base alloy containing 0.5 percent titanium and 0.08 percent zirconium.[19] Commercially it was designated the TZM alloy and was reported to be an all-purpose alloy, exhibiting superior utility in forging, drawing, roll forming, machining, welding, and case hardening. It was proved a useful material for diecasting aluminum. In one series of tests the cores showed no evidence of pitting, erosion, or dimensional change after forming 100,000 aluminum shapes.

TZM was tested widely to determine its possible use in the aerospace industry. Westinghouse Electric Corp. reported that it was highly strain-rate sensitive and prone to stress-cracking unless the rate of reduction in working was carefully controlled. Martin Marietta Corp. found that the recrystallization behavior of thin-gage (8- to 12-mils) TZM alloy sheet restricts its use for long-term structural application in service at temperatures below 2,300° F. Armour Research Foundation demonstrated the feasibility of joining TZM by fiber-metal resistance brazing.[20]

Pressure Technology Corporation of America successfully worked TZM at room temperature by a newly developed fluid-extrusion process.[21] Fluid extrusion involves a change from the brittle to ductile state because the metal is subjected to extremely high pressure. In one test, a billet of TZM alloy 0.150 inch in diameter was reduced to 0.25 inch in diameter (a 30-percent reduction in area) by fluid extrusion at a pressure of 300,000 pounds per square inch. Among other achievements in forming molybdenum, Oregon Metallurgical Corp. successfully cast a 330-pound seamless ring of the metal by the vacuum, consumable-electrode melting method.[22]

Thermionic Products Co. developed a proprietary process for case-hardening molybdenum to a level two or three times that which could be obtained by previous known methods.[23] Researchers at Lockheed-California Co. described a high-energy-rate method of forging molybdenum in which unalloyed molybdenum can be forged at temperatures as low as 1,100° F without developing internal ruptures or external defects and without adversely affecting the structure of the forged material.[24]

Industrial and aerospace researchers continued their interest in coating and cladding as means of overcoming molybdenum's susceptibility to oxidation at temperatures above 1,000° F. Their work did not uncover significant new techniques or materials, but in oxidation tests at the Lawrence Radiation Laboratory and in the Department of Metallurgy, Battelle Memorial Institute, Nichrome-clad molybdenum sheets containing various size hole- and notch-type defects exhibited a profound ability to heal the defects during exposure in still air at

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[19] Gilbert, R. W., Jr., and J. V. Houston, Jr. TZM—New Alloy Broadens Applications for Molybdenum. Metal Prog., v. 82, No. 5, November 1962, pp. 106–110.
[20] Houck, J. A. Review of Recent Developments, Molybdenum and Molybdenum-Base Alloys. Defense Metals Information Center, Battelle Memorial Inst., Apr. 6, 1962, 2 pp.; Oct. 5, 1962, 2 pp.
[21] Journal of Metals. V. 14, No. 12, December 1962, p. 864.
[22] American Metal Market. Oregon Metallurgical Casts Large Ring of Molybdenum. V. 69, No. 218, Nov. 14, 1962, p. 20.
[23] Malloy, Thomas B., Jr. New Process Case Hardens Molybdenum. Mat. in Design Eng., v. 56, No. 3, September 1962, pp. 9–10.
[24] Petersen, Alfred H., and Fred C. Pipher. Forging Molybdenum by High-Energy-Rate Method. Metal Prog., v. 82, No. 2, August 1962, pp. 78–82.

1,100° and 1,200° C.[25] The data indicated that the critical size defect for self-healing is larger than 0.063 inch in diameter, which was the largest size defect tested.

Platronics, Inc., developed a technique for electroplating pure gold directly on molybdenum.[26] It was claimed that the plating process will greatly reduce manufacturing cost in the electronic industry by eliminating the loss in gold scrap that results from working mechanically clad disks.

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[25] Adkins, Earl F., and Robert I. Jaffee. Oxidation Studies of Clad Molybdenum Containing Intentional Defects. J. Less-Common Metals, v. 4, No. 3, June 19, 1962, pp. 266–274.
[26] Metal Progress. V. 81, No. 3, March 1962, p. 9.

Nickel

By Joseph H. Bilbrey, Jr.,[1] and Ethel R. Long[2]

DOMESTIC price of electrolytic nickel, which was raised to 81.25 cents per pound in June 1961, was reduced to 79 cents per pound in May 1962, by Falconbridge Nickel Mines, Ltd. Other producers of nickel announced a similar price.

The United States used 118,677 tons of nickel in 1962, about the same as in 1961, with domestic production providing 12 percent of consumption. Europe and other world markets used less nickel than in 1961. Deliveries of electrolytic nickel under contracts with the U.S. Government were completed, freeing nickel for commercial uses. The supply of nickel in 1962 continued to be plentiful.

To meet market requirements, The International Nickel Company of Canada, Ltd., with annual nickel plant capacity of over 200,000 tons, cut back production in the fourth quarter by 13 percent; Société le Nickel produced 40 percent less nickel in 1962. Major producers increased their efforts in nickel marketing and in research and development in an attempt to increase the demand for nickel.

LEGISLATION AND GOVERNMENT PROGRAMS

The National Stockpile and Naval Petroleum Reserves Subcommittee of the Committee on Armed Services, U.S. Senate, 87th Congress, with Senator Stuart Symington as Chairman, conducted hearings on strategic and critical material stockpiles of the United States. The testimony of these hearings was published in a number of volumes.[3] Parts 6 and 7 dealt with Hanna Nickel Smelting Co. nickel contracts DMP–49–50–51; part 8 dealt with Falconbridge Nickel Mines Ltd., contract DMP 60, The International Nickel Co., Inc., contract DMP 80, and National Lead Co., contract DMP 131.

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[1] Commodity specialist, assisted technically by Isaac E. Weber, Division of Minerals.
[2] Statistical assistant, Division of Minerals.
[3] U.S. Senate. Inquiry Into the Strategic and Critical Material Stockpiles of the United States. Hearings before the National Stockpile and Naval Petroleum Reserves Subcommittee of the Committee on Armed Services. 87th Cong., 2d sess., 1962.

TABLE 1.—Salient nickel statistics

(Short tons)

	1953-57 (average)	1958	1959	1960	1961	1962
United States:						
Mine production	5,344	13,490	13,374	14,079	13,133	13,110
Plant production:						
Primary [1]	4,406	11,740	11,606	[2] 14,303	11,176	11,217
Secondary	11,079	7,411	9,438	9,431	10,688	11,108
Imports for consumption	135,000	90,000	112,000	103,000	127,000	123,000
Exports	21,591	14,032	13,073	54,109	55,493	27,641
Consumption	112,112	79,017	112,661	108,159	118,515	118,677
Stocks Dec. 31: Consumer [3]	13,490	13,339	14,125	11,369	18,298	13,450
Price cents per pound	74	74	74	74	74-81¼	81¼-79
World: Production	264,500	247,000	314,000	359,000	[4] 394,000	401,000

[1] Comprises metal from domestic ore and nickel recovered as a byproduct of copper refining.
[2] Contains 1,773 tons of primary nickel produced from imported Cuban concentrate.
[3] Does not include scrap.
[4] Revised figure.

DOMESTIC PRODUCTION

Primary Nickel.—All domestic mine output of nickel was produced by Hanna Mining Co.—874,000 dry short tons of ore containing 13,110 tons of nickel. Hanna Nickel Smelting Co. at Riddle, Oreg., processed the ore into 19,910 tons of ferronickel, having a nickel content of 10,569 tons. In addition, refineries at Carteret and Perth Amboy, N.J., Laurel Hill, N.Y., El Paso, Tex., and Tacoma, Wash., recovered 648 tons of nickel in the form of sulfate as a byproduct of copper refining. Shipments from these refiners contained 649 tons of nickel. Refined nickel salts (chiefly nickel sulfate) containing 2,482 tons of nickel were produced in the United States in addition to the nickel sulfate recovered as a byproduct of copper refining. Total refined salts production was 3,130 tons (nickel content), and shipments to consumers contained 3,161 tons of nickel.

TABLE 2.—Nickel produced in the United States

(Short tons, nickel content)

	1953-57 (average)	1958	1959	1960	1961	1962
Primary:						
Byproduct of copper refining	561	502	493	623	625	648
Domestic ore	3,845	11,238	11,113	[1] 13,680	10,551	10,569
Secondary	11,079	7,411	9,438	9,431	10,688	11,108

[1] Contains 1,773 tons of primary nickel produced from imported Cuban concentrate.

Secondary Nickel.—In 1962, 11,100 tons of nickel was recovered from nonferrous scrap in the United States, an increase of 4 percent over 1961.

Nickel recovered from ferrous nickel-base scrap is not included in the secondary-nickel tables. Ferrous nickel-base alloys are those in which the metal of highest percentage is nickel, but which contain so much iron, chromium, cobalt, or other constituents of ferrous alloys that they must be classed as ferrous alloys. Examples are inconel and nichrome. Both nonferrous and ferrous nickel-base alloys may be used as alloying ingredients in ferrous alloys, but ferrous nickel-base alloys cannot be used to make nonferrous alloys.

Consumption of nonferrous nickel-base scrap decreased to 13,200 tons, 3 percent less than in 1961.

TABLE 3.—Nickel recovered from nonferrous scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

Kind of scrap	1961	1962	Form of recovery	1961	1962
New scrap:			As metal	1,210	1,252
Nickel-base	3,108	3,460	In nickel-base alloys	1,824	2,037
Copper-base	1,564	1,713	In copper-base alloys	2,640	2,552
Aluminum-base	510	558	In aluminum-base alloys	863	901
Total	5,182	5,731	In ferrous and high temperature alloys [1]	2,059	2,154
Old scrap:			In chemical compounds	2,092	2,212
Nickel-base	4,734	4,469	Grand total	10,688	11,108
Copper-base	433	548			
Aluminum-base	339	360			
Total	5,506	5,377			
Grand total	10,688	11,108			

[1] Includes only nonferrous nickel scrap added to ferrous and high-temperature alloys.

TABLE 4.—Stocks and consumption of new and old nickel scrap in the United States in 1962

(Gross weight, short tons)

Class of consumer and type of scrap	Stocks, beginning of year	Receipts	Consumption			Stocks, end of year
			New	Old	Total	
Smelters and refiners:						
Unalloyed nickel	250	880	704	260	964	166
Monel metal	323	1,692	483	1,166	1,649	366
Nickel silver [1]	760	3,785	345	3,559	3,904	641
Miscellaneous nickel alloys	9	4,132	2	4,130	4,132	9
Nickel residues	53	11	4	27	31	33
Total	635	6,715	1,193	5,583	6,776	574
Foundries and plants of other manufacturers:						
Unalloyed nickel	266	2,929	1,418	1,610	3,028	167
Monel metal	91	840	214	548	762	169
Nickel silver [1]	2,824	9,371	8,518	47	8,565	3,630
Miscellaneous nickel alloys	45	318	-------	340	340	23
Nickel residues	507	2,440	2,052	252	2,304	643
Total	909	6,527	3,684	2,750	6,434	1,002
Grand total:						
Unalloyed nickel	516	3,809	2,122	1,870	3,992	333
Monel metal	414	2,532	697	1,714	2,411	535
Nickel silver [1]	3,584	13,156	8,863	3,606	12,469	4,271
Miscellaneous nickel alloys	54	4,450	2	4,470	4,472	32
Nickel residues	560	2,451	2,056	279	2,335	676
Total	1,544	13,242	4,877	8,333	13,210	1,576

[1] Excluded from totals because it is copper-base scrap, although containing considerable nickel.

CONSUMPTION AND USES

Nickel consumption was 118,677 tons, about the same as in 1961. There were decreases for some leading uses of nickel—for stainless steels consumption dropped 13 percent; that for nonferrous alloys was 2 percent less. A 14 percent increase was reported in the consumption of nickel for high-temperature and electrical-resistance alloys, and an 8 percent gain was reported in the electroplating industry.

TABLE 5.—Nickel (exclusive of scrap) consumed in the United States, by forms

(Short tons)

Form	1953-57 (average)	1958	1959	1960	1961	1962
Metal	83,108	61,768	87,751	87,399	101,394	103,485
Oxide powder and oxide sinter	18,553	13,007	20,710	19,392	15,883	13,760
Matte	8,864	3,309	2,899	17	16	3
Salts [1]	1,587	933	1,301	1,351	1,222	1,429
Total	112,112	79,017	112,661	108,159	118,515	118,677

[1] Figures do not cover all consumers.

TABLE 6.—Nickel (exclusive of scrap) consumed in the United States, by uses

(Short tons)

Use	1953-57 (average)	1958	1959	1960	1961	1962
Ferrous:						
Stainless steels	25,812	23,039	32,249	30,086	34,213	29,711
Other steels	16,974	14,510	18,342	15,331	18,238	18,608
Cast irons	5,023	3,851	4,857	4,605	4,649	5,503
Nonferrous [1]	32,701	18,048	25,606	26,567	28,789	28,215
High-temperature and electrical-resistance alloys	8,939	7,435	10,518	10,095	11,294	12,862
Electroplating:						
Anodes [2]	16,134	7,693	14,644	15,847	15,737	16,953
Solutions [3]	1,171	734	883	970	770	904
Catalysts	1,684	1,165	1,712	1,545	1,519	1,566
Ceramics	351	354	373	365	366	439
Magnets	839	636	1,028	778	773	910
Other	2,484	1,552	2,449	1,970	2,167	3,006
Total	112,112	79,017	112,661	108,159	118,515	118,677

[1] Comprises copper-nickel alloys, nickel silver, brass, bronze, beryllium alloys, magnesium and aluminum alloys, Monel, Inconel, and malleable nickel.
[2] Figures represent quantity of nickel used for production of anodes, plus cathodes used as anodes in plating operations.
[3] Figures do not cover all consumers.

TABLE 7.—Nickel (exclusive of scrap) in consumer stocks in the United States, by forms

(Short tons)

Form	1953-57 (average)	1958	1959	1960	1961	1962
Metal	10,500	10,608	9,567	9,009	12,199	12,477
Oxide powder and oxide sinter	2,120	2,464	4,334	2,143	5,856	783
Matte	400	3	24	7	5	9
Salts	470	264	200	210	238	181
Total	13,490	13,339	14,125	11,369	18,298	13,450

STOCKS

In addition to the consumer stocks reported in table 7, 446,435,000 pounds of nickel was in Government stockpiles as of December 31,

1962. Of this quantity, 123,435,000 pounds, 38 percent more than the maximum stockpile objective, was declared surplus. The total quantity included 334,355,000 pounds in the national (strategic) stockpile, 183,000 pounds less than on December 31, 1961; this decrease was due to sales of nickel oxide powder. The Defense Production Act (DPA) inventory included in the total was 112,080,000 pounds, an increase of 7,916,000 pounds. The DPA inventory was reduced by sales of electrolytic nickel and Nicaro nickel sinter and by withdrawals under contract settlements; it was increased by receipts of electrolytic nickel from Falconbridge Nickel Mines Ltd.

PRICES

Effective May 24, Falconbridge Nickel Mines Ltd., reduced the price of electrolytic nickel by 2.25 cents (U.S.) to 79 cents per pound, f.o.b. Thorold, Ontario; other producers followed suit. The price of nickel sinter was lowered to 75.25 cents per pound of contained nickel plus cobalt. Nickel sulfate was quoted at 30 cents per pound in bags, carlots, delivered.

Nickel prices, including 1.25 cents U.S. import duty, were as follows:

	Cents
Inco, electrolytic, f.o.b. Port Colborne, Ontario	79
Falconbridge, electrolytic, f.o.b. Thorold, Ontario	79
Sherritt Gordon, briquets, f.o.b. Port Colborne, Ontario, or Fort Saskatchewan, Alberta	79
Sherritt Gordon, powder, Nigara Falls Ontario:	
Grades C and F	84
Grade S	79
Le Nickel, rondelles, at New York, and with freight equaled Pt. Colborne, Ontario	79
Hanna, nickel in ferronickel (no charge for 45 percent iron), Riddle, Oreg., with freight equaled oxide sinter	75.25
Nickel oxide sinter, at Buffalo, N.Y., or other established U.S. points of entry, on nickel plus cobalt content	75.25

FOREIGN TRADE [4]

Imports.—The United States imported 123,000 tons of nickel in ore, matte, metal, oxide, slurry, and scrap—3 percent less than in 1961. Canada provided 92 percent of the imports, and Norway, 6 percent; the latter originated in Canada. Imported from France were 330 tons of nickel metal and 120 tons of nickel in oxide; these were of New Caledonia origin.

Exports.—The total of 27,641 tons of nickel-bearing materials exported in 1962—half of that exported in 1961—consisted mainly of nickel and nickel-alloy metals in scrap. Shipments to Japan were 30 percent of the total; to Canada, 19 percent; to the United Kingdom, 16 percent; to Sweden, 12 percent; and to West Germany, 8 percent. No substantive change was made in the Positive List of nickel commodities requiring validated export licenses.

Tariff.—The duty of 1.25 cents per pound on refined nickel was unchanged; nickel ore, oxide powder and oxide sinter, matte, slurry, and residues continued to enter duty free.

[4] Figures on U.S. imports and exports (unless otherwise indicated) compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 8.—U.S. imports for consumption of nickel products, by classes

(Short tons)

Class	1953–57 (average)	1958	1959	1960	1961	1962
Ore and matte	12,765	4,574	4,071	184	(1)	14
Metal (pigs, ingots, shot, cathodes, etc.) [2]	99,541	62,793	82,888	79,662	115,985	115,947
Oxide powder and oxide sinter	33,409	29,622	[3] 30,062	[3] 24,584	14,613	8,661
Slurry [4]	(5)	260	839	4,477	258	406
Refinery residues [6]	552	211	-------	-------	-------	-------
Scrap [2]	652	271	619	135	278	601
Total: Gross weight	146,919	97,731	118,479	109,042	131,134	125,629
Nickel content (estimated)	135,000	90,000	112,000	103,000	127,000	123,000

[1] Less than 1 ton.
[2] Separation of metal from scrap on basis of unpublished tabulations.
[3] Adjusted by Bureau of Mines.
[4] Nickel-containing material in powders, slurry, or any form, derived from ore by chemical, physical, or any other means, and requiring further processing to recover nickel or other metals.
[5] Not provided for in import schedule before July 1, 1956.
[6] Reported to Bureau of Mines by importers.

Source: Bureau of the Census.

TABLE 9.—U.S. imports for consumption of new nickel products, by countries

(Short tons)

Country	Metal		Oxide powder and oxide sinter			
	1961	1962	1961		1962	
	Gross weight	Gross weight	Gross weight	Nickel content	Gross weight	Nickel content
North America: Canada	101,710	106,432	14,613	10,967	8,511	6,410
Europe:						
France	(1)	330	-------	-------	150	120
Germany, West	8	1,002	-------	-------	-------	-------
Netherlands	4	-------	-------	-------	-------	-------
Norway	13,889	7,555	-------	-------	-------	-------
Sweden	58	-------	-------	-------	-------	-------
United Kingdom	316	628	-------	-------	-------	-------
Total	14,275	9,515	-------	-------	150	120
Grand total	115,985	115,947	14,613	10,967	8,661	6,530

Country	Slurry and other[2]				Ore and matte			
	1961		1962		1961		1962	
	Gross weight	Nickel content	Gross weight	Nickel content	Gross weight	Nickel content	Gross weight	Nickel content
North America: Canada	258	66	406	119	(1)	(1)	14	8
Total	258	66	406	119	(1)	(1)	14	8

[1] Less than 1 ton.
[2] Nickel-containing material in powder, slurry, or any form, derived from ore by chemical, physical, or any other means, and requiring further processing to recover nickel or other metals.

Source: Bureau of the Census.

TABLE 10.—U.S. exports of nickel products, by classes

Class	1960		1961		1962	
	Short tons	Value	Short tons	Value	Short tons	Value
Ore, concentrates, and matte	1	$4,326	1,766	$495,254	45	$15,923
Nickel and nickel-alloy metals in ingots, bars, rods, sheets, plates, strips, and other crude forms	9,835	16,839,376	7,152	13,702,988	7,990	16,494,663
Nickel and nickel-alloy metal scrap	42,633	10,289,345	44,479	11,265,674	17,520	4,301,446
Nickel and nickel-alloy semifabricated forms, not elsewhere classified	644	2,321,654	1,037	3,980,160	803	3,462,592
Nickel-chrome electric-resistance wire except insulated	235	969,261	254	1,079,325	190	965,478
Nickel catalysts	761	1,240,236	805	1,455,809	1,093	1,963,293
Total	54,109	31,664,198	55,493	31,979,210	27,641	27,203,395

Source: Bureau of the Census.

WORLD REVIEW [5]

World output of nickel, a record 401,000 tons, was 2 percent more than in 1961. The free world production was 287,000 tons, 4 percent less than in 1961. Of this total, Canada produced 83 percent; New Caledonia, 11 percent; and the United States, 4 percent.

[5] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.

TABLE 11.—World production of nickel by countries [1]

(Short tons)

Country	1953–57 (average)	1958	1959	1960	1961	1962
North America:						
Canada [2]	169,275	139,559	186,555	214,506	232,991	237,044
Cuba:						
Content of oxide	16,367	19,782	19,658	[3] 12,547	[4] 8,000	[4] 16,400
Estimated content of sulfide	----------	----------	200	1,600		3,600
United States:						
Byproduct of copper refining	561	502	493	623	625	648
Recovered nickel in domestic ore refined	[5] 3,845	11,238	11,113	11,907	10,551	10,569
Total	190,048	171,081	218,019	241,183	252,167	268,261
South America:						
Brazil (content of ferronickel)	[4] 60	80	85	150	[4] 150	[4] 150
Venezula (content of ore)	[6] 16	42	29	14	----------	----------
Total	76	122	114	164	[4] 150	[4] 150
Europe:						
Albania (content of nickeliferous ore) [4]	----------	1,000	1,800	[7] 2,700	2,800	2,800
Finland:						
Content of nickel sulfate	157	125	92	126	177	110
Content of concentrates	----------	----------	324	2,369	2,200	2,200
Germany, East (content of ore) [4]	[6] 110	110	110	110	110	110
Greece (content of nickeliferous ore)	[8] 476	265	----------	----------	----------	----------
Poland (content of ore) [4]	[9] 1,152	1,488	1,405	1,382	1,453	1,400
U.S.S.R. (content of ore) [4]	49,000	58,000	60,000	64,000	83,000	90,000
Total [4]	50,900	61,000	63,700	70,700	89,700	96,600
Asia: Burma (content of speiss)	81	367	159	81	112	182
Africa:						
Morocco (content of cobalt ore)	139	204	266	280	284	316
Rhodesia and Nyasaland, Federation of: Southern Rhodesia (content of ore)	27	4	----------	24	64	86
South Africa, Republic of (content of matte and refined nickel)	2,957	[4] 2,200	[4] 2,900	[4] 3,200	[4] 2,900	[4] 2,700
Total	3,123	2,408	3,166	3,504	3,248	3,102
Oceania: New Caledonia (recoverable) [10]	20,386	12,345	28,810	43,325	48,600	32,400
World total (estimate)	264,500	247,000	314,000	359,000	394,000	401,000

[1] This table incorporates some revisions.
[2] Comprises refined nickel and nickel in oxide produced and recoverable nickel in matte exported.
[3] Exclusive of unknown tonnage produced and stored at Nicaro since September 20, 1960.
[4] Estimate.
[5] Average annual production 1953–57.
[6] Average annual production 1955–57.
[7] Planned production.
[8] Average annual production 1956–57.
[9] Average annual production 1954–57.
[10] Comprises nickel content of matte and ferronickel produced in New Caledonia plus estimate of recoverable nickel in ore exported. Mine production (nickel content of ore) was as follows: 1953–57 (average) 28,260 tons; 1958, 15,600 tons; 1959, 36,200 tons; 1960, 59,000 tons; and 1961, 63,000 tons, 1962 estimated 38,000 tons.

Compiled by Catherine M. Judge, Division of Foreign Activities.

NORTH AMERICA

Canada.—Canada set a new record with nickel production at 237,044 tons, compared with 232,991 tons in 1961. Nickel in refinery, rolling mill, and foundry products, and in salts and chemicals delivered to consumers by The International Nickel Company of Canada, Ltd. (Inco), was 148,930 tons, 8 percent less than in 1961. Inco also delivered 10,155 tons of nickel that was sold at the same prices at which it was acquired from the U.S. Government or its suppliers. Inco cut its fourth quarter nickel production 13 percent to 40,000 tons.

Ore production from the Inco Ontario and Manitoba mines was 13,794,000 tons, 21 percent less than in 1961; this decrease was due to a reduction made in autumn 1962 to meet market requirements. In the Sudbury district, Inco operated the Creighton, Frood-Stobie, Garson, Levack, and Murray underground mines. The Clarabelle open-pit mine reached its expected capacity of about 8,000 tons per day, and the Ellen open-pit mine was shut down. By yearend the 3,000-foot shaft at the Copper Cliff North mine had been sunk to a depth of 2,105 feet. Hydraulic sandfill stabilized with small additions of portland cement was tested successfully on a large scale at the Frood mine; it was expected to result in decreased use of timber, less dilution of ore, and improved mining. Use of mixtures of ammonium nitrate and fuel oil as a blasting agent, replacing conventional high explosives, was extended to all mining operations in the Sudbury district and resulted in important savings. The flotation section at Copper Cliff was being modernized to provide greater capacity for pyrrhotite recovery. At Thompson, Manitoba, a new shaft was scheduled to be sunk to the 2,400-foot level to prepare additional ore zones for future production. Inco's proven ore reserve on December 31, 1962, was 299,416,000 tons, containing 9,006,300 tons of nickel-copper.

The Thompson plant raised its annual capacity from 37,500 to over 45,000 tons of refined nickel per year. Inco's annual capacity at this and the Sudbury facilities was increased to over 200,000 tons. Inco began its plant expansion and modernization program at Huntington, W. Va.; the plant was to include a large rolling mill and forging press. A new nickel chloride plant was constructed at Clydach, Wales.

Inco spent $5.9 million on exploration—21 percent less than in 1961—mainly in the Sudbury and Thompson areas. Exploration also was conducted in Guatemala; the South Pacific, including the British Solomon Islands; Australia; New Zealand; Australian New Guinea and Indonesia; and Africa.[6]

Falconbridge Nickel Mines Ltd. delivered 30,531 tons of nickel, 7 percent less than in 1961. The reduced deliveries resulted from completion in August of a long-term U.S. Government contract. Ore milled was 2,354,000 tons, a decrease of 4 percent, but upgrading of smelter feed led to improved nickel recovery. More than half of the ore milled came from the north rim of the Sudbury basin. The ore reserve at yearend totaled 48,263,000 tons averaging 1.45 percent nickel. Sinking of the shaft at the Strathcona mine was completed at a depth of 3,205 feet and development levels were being driven. The drive under the East mine area uncovered a considerable length of ore. Falconbridge expanded exploration, research, and development in Canada and performed pilot-scale work in Norway and the Dominican Republic. A wholly owned subsidiary, Falconbridge of Africa Ltd., was incorporated to explore on the African continent. Marbridge Mines Ltd., the first nickel producer in the Province of Quebec, produced 100,000 tons of ore from the nickel mine in La Motte Township during the last 7 months of 1962. Canadian Malartic Gold Mines Ltd. concentrated the ore in its nearby mill. The concentrate to be smelted by Falconbridge averaged 10.5 percent nickel and 0.6 percent

[6] The International Nickel Company of Canada, Ltd. Annual Report 1962. Pp. 7–17.

copper. The reserve at the mine on December 31, 1962, was 217,000 tons, grading 2.29 percent nickel and 0.10 percent copper.[7]

Sherritt Gordon Mines Ltd. mined and milled 1,262,502 tons of ore from its Lynn Lake, Manitoba, property, an increase of 4 percent over that in 1961, but the grade of ore was unusually low. Underground exploration resulted in the location of a new ore body and a large area of mineralization on the 2,000-foot level. Overall grade was not good but the company said prospects of developing ore in the area were promising. Nickel produced from Lynn Lake ore and purchased feed at the Fort Saskatchewan, Alberta, refinery was 12,157 tons, 10 percent more than in 1961. Nickel sales were 16 percent less at 9,384 tons. A new briquetting furnace was developed and installed to raise the quality of nickel briquets and to reduce the sulfur content from 0.018 percent to 0.003 percent.[8] North Rankin Nickel Mines Ltd., which had supplied about 2,000 tons of nickel in concentrate annually to the Sherritt Gordon refinery for treatment on a custom basis, closed its mining operations at Rankin Inlet on the west coast of Hudson Bay.[9]

Giant Mascot Mines Ltd., in the fiscal year ended September 30, 1962, milled 282,159 dry short tons of ore with average nickel content of 0.85 percent from its mine near Hope, British Columbia, and produced 17,970 tons of concentrate containing 1,891 tons of nickel. Milling capacity was increased from 900 to 1,100 tons per day. More ore was developed than was milled and ore reserves increased to 1,066,000 tons, mainly in the Brunswick zone. Because of the improved ore position, Giant Mascot extended its firm sales contract with Sumitomo Shoji Canada Ltd. (Sumitomo Metal Mining Co.) for an additional 2 years to March 1966. In calendar year 1962, 18,700 dry tons of concentrate containing 1,961 tons of nickel was shipped to Japan.[10]

Nickel Mining and Smelting Corp., a new nickel producer, brought its 750-ton mill at Gordon Lake, 55 miles northwest of Kenora, Ontario, into production in September at a mill rate of about 500 tons per day. Concentrate, which contained about 12 percent nickel and 6 percent copper, was shipped to Sudbury for refining by Inco. Ore to the concentrator averaged about 1.4 percent nickel and 0.5 percent copper.[11]

Raglan Nickel Mines Ltd. continued to explore its Ungava, New Quebec, prospect, increasing its reserve to 6.4 million tons averaging 1.60 percent nickel and 0.80 percent copper. The drill-indicated tonnages were 4.4 million tons in the Cross Lake deposit and 2 million tons in the nearby C–2 zone.[12]

McIntyre Porcupine Mines Ltd., was drilling its copper-nickel discovery in the Belleterre area of northwestern Quebec near the boundary of Blondeau and Gaboury Townships, about 13 miles west and slightly south of Belleterre. The property adjoins the Consolidated

[7] Falconbridge Nickel Mines Ltd. Annual Report 1962. Pp. 8–11.
[8] Sherritt Gordon Mines Ltd. Annual Report 1962. Pp. 3–5.
[9] Canadian Mining and Metallurgical Bulletin (Canada). North Rankin Nickel Mines. V. 55, October 1962, p. 748.
[10] Giant Mascot Mines Ltd. Annual Report. Sept. 30, 1962, 12 pp.; letter to Bureau of Mines, March 11, 1963.
[11] Canadian Mining Journal (Quebec). New Nickel Mine Now in Production. V. 83, No. 12, December 1962, p. 93.
[12] Canadian Mining Journal (Quebec). Raglan Nickel Mines Has Heavy Program. V. 83, No. 10, October 1962, pp. 125–126.

Regcourt Mines deposit which was estimated several years ago to contain 2.2 million tons of ore with a grade of 1.4 percent combined nickel-copper.[13]

Cuba.—Production of nickel in 1962 was estimated at 20,000 tons. Exports were made to the U.S.S.R., Czechoslovakia, China, Rumania, and Hungary.[14]

Guatemala.—Izabal Exploration and Mining Co. owned principally by The International Nickel Co., Inc. with a minority participation by Hanna Mining Co., spent $2 million on developing nickel ore deposits in the Lake Izabal region.[15]

EUROPE

Czechoslovakia.—The new nickel refinery at Sered in west Slovakia, with an annual capacity of 2,000 tons of nickel, began operations, using ore imported from Albania.[16]

Finland.—Outokumpu Oy, the Finnish Government copper-mining corporation, produced 444,000 tons of nickel-copper ore. Concentrate amounted to 44,910 tons, containing 2,431 tons of nickel. Nickel sulfate production was 162 tons.

Greece.—Société le Nickel obtained Greek Government approval for the import of $1.5 million for its share of the corporation to be set up with Greek Chemical and Fertiliser Co. to jointly operate the Larymna nickel facilities. Le Nickel will also lend the new corporation $3 million. The Council of Mines of the Ministry of Industry recommended that the Larymna mines concession be renewed for 10 years from March 1963, provided that operations at Larymna be resumed within 2 years.[17]

Norway.—Falconbridge Nikkelverk, A/S, Kristiansand, a subsidiary of Falconbridge Nickel Mines Ltd., Canada, produced 32,000 tons of nickel at its refinery.

ASIA

Japan.—Nickel ore imports in 1962 were 744,000 short tons, 36 percent less than in 1961. They came mainly from New Caledonia. Japan produced 6,246 tons of pure nickel and 10,397 tons of nickel in ferronickel; 7 and 44 percent less respectively, than in 1961. Although stainless steel production improved in 1962 as against 1961, the use of nickel from inventory and nickel-containing scrap contributed largely to lessened consumption of domestic metal.

Indonesia.—In February 1962, Sulawesi Nickel Development Corp. (Sunideco), signed agreements with the Indonesian Government under which Sunideco will extend a credit of $1.35 million to finance mine development. All nickel ore produced in the Pomalaa area of southeastern Sulawesi was to be sold to Sunideco until the credit is

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[13] Northern Miner (Toronto). McIntyre Net Up. Belleterre Find Looks Important. V. 48, No. 31, Oct. 25, 1962, pp. 1–2.
[14] Mining Journal (London). Cuba Plans Nickel Boost. V. 260, No. 6659, Apr. 5, 1963, p. 320.
[15] U.S. Embassy, Guatemala. State Department Airgram A103, Aug. 21, 1962, p. 1.
[16] Metal Bulletin (London). Sered Starts Up. No. 4741, Oct. 26, 1962, p. 27.
[17] U.S. Embassy, Athens, Greece. State Department Airgram 675 (Quarterly Economic Summary, October–December 1962), p. 11.

repaid. Intial production rate was to be 11,000 tons of nickel ore per month.[18]

AFRICA

South Africa, Republic of.—Anglo-American Corporation of South Africa, Ltd., in conjunction with The International Nickel Co. of Canada, Ltd., and South African Minerals Corp. Ltd. announced the formation of a new company to exploit nickel deposits in an 80,000-acre area west of Pilansberg in the Russtenberg district of the Transvaal. South African Minerals was to mine some nickel ore on this property.[19]

OCEANIA

Australia.—Under the auspices of the Department of National Development, Bureau of Mineral Resources, Geology and Geophysics, a study was made of nickel mineral resources in Tasmania, South Australia, and Papua. Domestic production of nickel in the immediate future was unlikely, and metal requirements will continue to be imported.[20]

New Caledonia.—Nickel ore produced was 1,605,000 tons containing 38,000 tons of recoverable nickel. Société le Nickel closed some of its production facilities during a modernization campaign and produced 13,579 tons of nickel matte containing 10,733 tons of nickel. This was 19 percent less than in 1961. Ferronickel made was 22,910 tons, containing 6,065 tons of nickel, a decrease of 59 percent. New Caledonia exported 657,000 tons of ore, 41 percent less than in 1961. Société le Nickel exported 9,948 tons of nickel in matte, and 5,663 tons of nickel in ferronickel.

TECHNOLOGY

The Federal Bureau of Mines conducted research on the separation of nickel and cobalt and recovery of these metals from lateritic ores. Additional objectives were improved production of higher purity nickel through solvent extraction and the use of molten-salt electrolysis to separate nickel and cobalt. Recovery of nickel-cobalt alloys from refractory scrap by electrochemical methods and by chlorination was explored, as well as rapid analytical methods to help the development of improved processes. Published reports covered the following: A procedure for electrodepositing high-purity nickel from electrolytes purified by an ion-exchange resin;[21] investigation of conditions for recovery of nickel and copper from Funter Bay, Alaska, sulfide ore and nickel from nickel-silicate ore, Nickel Mountain, Riddle, Oregon;[22] determination of the feasibility of establishing a nickel industry in the Philippines, based on mineralogical studies, electric smelting of nickeliferous laterite and serpentine ores, upgrading of ferronickel,

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[18] Bureau of Mines. Mineral Trade Notes. V. 55, No. 1, July 1962, p. 37.
[19] Holz, P. South African Nickel Mine To Re-open. Min. Mag. (London), v. 107, No. 5, November 1962, pp. 282–284.
[20] Ward, J. Nickel. Mineral Resources of Australia. Summary Report 40. Commonwealth Government Printer, Canberra, 1962, 28 pp.
[21] Donaldson, J.G., K. K. Kershner, and W. L. Falke. Purification of Electrolytes for the Deposition of High-Purity Nickel. BuMines Rept. of Inv. 5993, 1962, 13 pp.
[22] Fursman, O. C. Recovery of Mineral Values in Cupriferous and Nickeliferous Pyrrhotite. BuMines Rept. of Inv. 6043, 1962, 24 pp.

production of crude iron and mild steel, and recovery of nickel and cobalt;[23] a study and evaluation of the estimated capital requirements and probable returns for a plant processing 2,000 tons of Philippine laterite and serpentine ores a day to produce steel ingot and ferronickel;[24] data on nickel scrap in a study of the nonferrous scrap industry in California;[25] and information on the origin, collection, movement, and consumption of high-temperature alloy scrap in California and Nevada in 1959–60.[26]

A comprehensive account of the mineralogy of nickel-copper ores of the Sudbury, Ontario, district was published that included a review of the geological problems involved and of the various classifications of the ore deposits (physical, chemical, and genetic).[27]

The American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc. (AIME), published a 50th Anniversary Volume on froth flotation that included descriptions of plant practices of various nickel producers;[28] easily portable and rapid field methods using dimethylglyoxime were described for measuring total and available nickel in soil, rock, and sediment.[29]

A preliminary report was issued on the nickel-iron resources of the 1914 Surigao iron ore reservation, in the Philippines.[30]

An account was given of the Norwegian Kristiansand nickel refinery of Falconbridge Nikkelverk, A/S, with an annual capacity of 35,000 tons of nickel.[31] The nickel-refining operations of the Clydach, Wales, works of The International Nickel Co. (Mond) Ltd. were described.[32] The extraction of nickel from Yugoslavian nickel-bearing oxide-silicate iron and other ores containing from 0.2 to 2 percent nickel was reported by the Department of Mining and Metallurgy of the Faculty of Natural Sciences and Technology of Ljubljana.[33]

The Defense Metals Information Center, Battelle Memorial Institute, Columbus, Ohio, published memoranda on a use for nickel-base alloys[34] and on the tensile properties of nickel-base superalloys and 18- to 25-percent nickel steels.[35]

Much interest was taken in maraging alloy steels, a series of tough, high-strength steels developed by The International Nickel Co., Inc.,

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[23] Banning, L. H., W. E. Anable, R. B. Quicho, H. D. Hess, and P. C. Good. Metallurgical Investigations of Philippine Nickeliferous Ores. BuMines Rept. of Inv. 6063, 1962, 71 pp.

[24] Katell, S., J. H. Faber, T. J. Joyce, and P. Wellman. Economic Analysis of the Production of Ferronickel and Steel From Philippine Nickeliferous Ores. BuMines Inf. Circ. 8116, 1962, 45 pp.

[25] Branner, G. C. Secondary Nonferrous Metals Industry in California, With Data on Nevada and Hawaii. BuMines Inf. Circ. 8143, 1962, 115 pp.

[26] Branner, G. C., and J. W. Padan. High-Temperature Alloy Scrap in California and Nevada. BuMines Open-File Rept., 1962, 24 pp.

[27] Hawley, J. E. The Sudbury Ores: Their Mineralogy and Origin. Mineralogical Association of Canada (Kingston, Ontario, Canada), 1962, 207 pp.

[28] Fuerstenau, D. W. (ed.). Froth Flotation, AIME, New York, 1962, pp. 399–402.

[29] Bloom, H. Field Methods for the Determination of Nickel Using Dimethylglyoxime. Econ. Geol., v. 57, No. 4, June–July 1962, pp. 595–604.

[30] Rigor, R. G. Preliminary Report on the Investigation of the Nickel-Iron Resources of the 1914 Surigao Iron Ore Reservation. Republic of the Philippines, Bur. Mines Rept. of Inv. 35, March 1962, 92 pp.

[31] Archibald, F. R. The Kristiansand Nickel Refinery. J. Metals, v. 14, No. 9, September 1962, pp. 648–652.

[32] Metal Industry. Nickel Refining at Clydach. V. 101, No. 12, Sept. 20, 1962, pp. 25–26.

[33] Cazafura, K., J. Wohinz, and J. Zakrajsek. Hydrometallurgical Production of Nickel From Nickel-Bearing Oxide-Silicate Iron Ores. Min. and Met. Quart., No. 1, 1962, pp. 7–20; OTS 62–19467–1.

[34] Lund, C. H. The Use of Nickel-Base Alloys in the Rotating Parts of Gas Turbines for Aerospace Applications. DMIC Memo. 145, Jan. 11, 1962, 20 pp.

[35] Campbell, J. E. Compilation of Tensile Properties of High-Strength Alloys. DMIC Memo. 150, Apr. 23, 1962, table 8, p. 20; table 12, pp. 29–33.

particularly in the 18-percent nickel alloys with yield strengths of 250,000 and 300,000 pounds per square inch. The high order of toughness and ultra-high-strength levels of these alloys were developed by a simple heat treatment. Maraging steels showed promise for aerospace and cryogenic applications, aircraft structural parts, pressure vessels, and many specialized tools and fixtures subject to severe service conditions. Many steel companies were offering maraging steels on a commercial basis.[36]

A new dispersion–strengthened nickel alloy, TD–Nickel, containing 2 volume–percent thoria and 98 volume–percent nickel was produced by E. I. du Pont de Nemours & Co., Inc. It was expected to fit in the 1,800° to 2,400° F range.[37]

Republic Steel Corp. announced a new class of high-strength, high-performance alloy steels available in bar-forging billet, plate, and sheet, containing 3.10 to 8.50 percent nickel.[38] The possibility that uranium may be employed to negate the effects of impurity elements harmful to hot ductility of nickel was indicated in a Canadian report.[39] Sherritt Gordon Mines Ltd. developed five new grades of coarse and fine spherical nickel powders for use in high-purity porous pressed parts such as battery- and fuel-cell electrodes, bearings, filters, and other powder metal parts.[40] Sherritt Gordon also developed nickel-phosphorus and nickel-graphite composite powders.[41]

The Boiler and Pressure Vessel Code Committee of the American Society of Mechanical Engineers, approved 9-percent nickel steel as a cryogenic structural material. The ruling eliminated the need to stress-relieve joints after welding in metal thicknesses not exceeding 1.25 inches.[42] An accelerated laboratory test for determining the behavior of copper-nickel alloys for feed-water tubes of powerplant boilers was devised.[43] An account of the rapidly growing market in rechargeable nickel-cadmium batteries for household and other cordless electrical equipment was given.[44]

Beryllium-nickel alloys containing 2 to 3 percent beryllium, balance nickel, suitable for casting molds for diecasting, glass molding, and extruding, were described.[45] Inco introduced SD-Nickel, a new type of electrolytically refined nickel containing a small amount of sulfur, to be used primarily as a nickel-plating material.[46]

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[36] Decker, R. F., J. T. Eash, and A. J. Goldman. 18 Percent Nickel Maraging Steel. Trans. ASM, v. 55, No. 1, March 1962, pp. 58–76.
Drennen, D. C., and D. B. Roach. Properties of Maraging Steels. DMIC Memo. 156, July 2, 1962, 51 pp.

[37] Anders, F. J., Jr., G. B. Alexander, and W. S. Wartel. A Dispersion-Strengthened Nickel Alloy. Metal Prog., v. 82, No. 6, December 1962, pp. 88–91.
Chemical Week. Tougher Metals for Hotter Jobs. V. 90, No. 26, June 30, 1962, pp. 49–50.

[38] Republic Steel Corp. Preliminary Technical Data on Republic Hi–Performance Steels. October 1962, 4 pp.

[39] Thomson, R., and J. O. Edwards. Uranium in Non-Ferrous Metals. Canada Dept. Mines and Tech. Surveys, Mines Branch Rept., R97, July 1962, 42 pp.

[40] American Metal Market. New Nickel Spheroids for Pressed Parts. V. 69, No. 219, Nov. 15, 1962, p. 18.

[41] Chemical Engineering. Nickel-Coated Powders. V. 69, No. 20, Oct. 1, 1962, p. 66.

[42] Chemical Week. Boost for Nine Nickel. V. 90, No. 18, May 5, 1962, p. 51.

[43] Hopkinson, B. E. Copper-Nickel Alloys for Feedwater Heater Service. The International Nickel Co., Inc., Tech. Paper 339, July 19, 1962, p. 33.

[44] Mogerman, W. D. The Saga of the Storage Battery. Inco Mag., v. 28, No. 4, Summer 1962, pp. 13–20.

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Nitrogen

By Richard W. Lewis[1] and Betty Ann Brett[2]

THE ANNUAL production capacity of domestic anhydrous ammonia on January 1 was estimated at 7 million short tons. Even though production only amounted to about 83 percent of the January 1 capacity, the production capabilities of the industry were increased about 800,000 tons. Nitrogen (gaseous and liquid) capacity of air-separation plants also was substantially increased and production was 51 percent above 1961.

For better conformity of data, several of the tables in this chapter have been revised. Salient statistics now are reported in nitrogen content, and the production of high-purity nitrogen gas is included for the first time.

TABLE 1.—Salient statistics of the nitrogen industry

(Thousand short tons of contained nitrogen)

	1953-57 (average)	1958	1959	1960	1961	1962
United States:						
Production as ammonia	2,742	3,347	3,871	4,118	4,429	4,898
Production as high-purity nitrogen gas	141	256	544	725	1,045	1,574
Imports for consumption of nitrogen compounds	323	261	288	279	325	383
Exports of nitrogen compounds	184	213	230	211	173	246
Consumption [1]	2,761	3,511	3,836	4,059	4,327	4,595
World: Production [1]	9,058	11,918	13,005	14,184	15,403	16,320

[1] Figures are estimated and exclude nitrogen gas.

DOMESTIC PRODUCTION

The domestic output of pure nitrogen gas had increased eight-fold since 1957, not including liquid nitrogen produced by the many small "make-it yourself" units in use throughout the United States.

Domestic production of ammonia again rose in 1962, and was 11 percent greater than in 1961. In spite of the apparent overproduction, more ammonia plants were being built and still others were in the planning stages. Facilities for increased production of nitrogen compounds and nitrogenous fertilizers were also expanded.

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

The following anhydrous ammonia (NH_3) plants expanded or planned to increase their production capacities by either modernizing existing facilities or adding new units:

Company	Plant location	Added NH_3 capacity (tons per year)	Completion date
American Cyanamid Co.	Fortier, La.	15,000	1962
Coastal Chemical Corp.	Pascagoula, Miss.	70,000	1962
Cooperative Farm Chemicals Assoc.	Lawrence, Kans.	55,000	(1)
Consumers Cooperative Assoc.	Hastings, Nebr.	70,000	(1)
John Deere Chemical Co.	Pryor, Okla.	35,000	Early 1963
Shell Chemical Co.	Ventura, Calif.	(1)	1962
Solar Nitrogen Chemicals, Inc.	Joplin, Mo.	32,000	1962
Southern Nitrogen Co., Inc.	Savannah, Ga.	50,000	1962
		30,000	Fall 1963
Spencer Chemical Co.	Henderson, Ky.	15,000	1962
St. Paul Ammonia Products Co.	Pine Bend, Minn.	45,000	(1)

[1] Unannounced.

New anhydrous ammonia facilities were on stream, under construction, or planned in 1962:

Company	Plant location	Added NH_3 capacity (tons per year)	Completion date
American Oil Co.	Texas City, Tex.	200,000	Mid-1963
Armour Agricultural Chemical Co.	Cherokee, Ala.	130,000	1962
California Chemical Co.	Fort Madison, Iowa	100,000	1962
Central Nitrogen, Inc.	Terre Haute, Ind.	125,000	Fall 1963
Columbia Nitrogen Corp.	Augusta, Ga.	100,000	(1)
Consumers Cooperative Assoc.	Hastings, Nebr.	70,000	1962
Diamond Alkali Co.	Deer Park, Tex.	36,500	1962
The Dow Chemical Co.	Plaquemine, La.	55,000	1962
E. I. du Pont de Nemours & Co., Inc.	Victoria, Tex.	100,000	1964
Farmers Chemical Assoc., Inc.	Chattanooga, Tenn.	65,000	1962
	Childersburg, Ala.	65,000	(1)
W. R. Grace & Co.	Big Springs, Tex.	70,000	1962
Hawkeye Chemical Corp.	Clinton, Iowa	140,000	1963
Monsanto Chemical Corp.	Muscatine, Iowa	70,000	1963
The New Jersey Zinc Co.	Palmerton, Pa.	35,000	Fall 1963
Nitrin Corp.	Cordova, Ill.	138,000	Mid-1963
Oregon Chemical Fertilizer Co.		36,500	(1)
Shamrock Oil & Gas Corp.	Dumas, Tex.	55,000	1962

[1] Unannounced.

The total indicated increase in domestic ammonia-producing capacity was about 2 million tons.

Olin Mathieson Chemical Corp. planned to close its Niagara Falls, N.Y., ammonia facility in January 1963. It was reported that this was the first major synthetic ammonia plant built in North America. Although a major plant in 1925, when it was constructed, its 20-ton-per-day capacity is considered small by today's standards.

Many companies included, with their new or expanded facilities, units to produce nitrogen compounds for fertilizer or chemical use. American Cyanamid Co. reportedly was planning to produce diammonium phosphate. Armour Agricultural Chemical Co. planned to produce daily 500 tons of ammonium phosphate, 250 tons of ammo-

TABLE 2.—Nitrogen production in the United States

(Short tons of contained nitrogen)

	1958	1959	1960	1961	1962 [1]
Anhydrous ammonia: Synthetic plants [2]	3,190,062	3,717,186	3,962,272	4,282,160	4,753,407
Ammonia compounds, coking plants:					
Ammonia liquor	12,256	12,098	12,241	10,990	11,184
Ammonium sulfate	135,890	131,613	134,034	125,951	126,170
Ammonium phosphates	8,702	9,946	9,769	10,111	6,902
Total	3,346,910	3,870,843	4,118,316	4,429,212	4,897,663
Nitrogen gas [2]	255,640	543,875	724,724	1,045,357	1,574,438

[1] Preliminary figures.
[2] Bureau of the Census Current Industrial Reports.

nium nitrate, 300 tons of nitric acid, 50 tons of urea, and 250 tons of nitrogen solutions. California Chemical Co. completed a 250-ton-per-day nitric acid unit and a 150-ton-per-day prilled ammonium nitrate plant. Central Nitrogen, Inc., was building units for daily production of 350 tons of nitric acid and 400 tons of ammonium nitrate. John Deere Chemical Co. increased the urea production capacity of its Pryor plant 25 percent. Hawkeye Chemical Corp. included units for ammonium nitrate and other nitrogenous fertilizers. Urea, ammonium nitrate, nitric acid, and other nitrogenous fertilizers were to be produced in 1963 by Nitrin Corp. Shell Chemical Corp. and Southern Nitrogen Co., Inc., were expanding their urea plants to 75,000- and 70,000-ton-per-year capacities, respectively. Solar Nitrogen Chemicals, Inc., put on stream a 150-ton-per-day plant at Joplin, Mo.

Several companies not involved in increasing anhydrous ammonia capacity were busy adding new fertilizer plants.

A group of Carolina fertilizer producers joined with W. R. Grace & Co. to establish Carolina Nitrogen Corp. The new company planned facilities at Wilmington, N.C., to manufacture ammonium nitrate, calcium ammonium nitrate, and other nitrogenous fertilizers, using anhydrous ammonia from the W. R. Grace & Co. new plant on Trinidad, British West Indies.

Hercules Powder Co. completed a new fertilizer complex at Louisiana, Mo., to produce ammonium nitrate-ammonia solutions and was adding facilities for manufacturing urea and prilled ammonium nitrate.

Mississippi Chemical Co., Yazoo City, Miss., increased production capacities of nitric acid and ammonium nitrate to 700 tons of each daily.

Premier Petrochemical Co., a new company, planned a 70,000-ton-per-year urea plant near Pasadena, Tex., to be operative early in 1964.

Tennessee Valley Authority planned new nitric acid units to replace the old World War I plant at Muscle Shoals, Ala.

TABLE 3.—Major nitrogen compounds produced in the United States

(Thousand short tons, gross weight)

Compounds	1961	1962
Ammonium chloride [2]	25	([3])
Ammonium nitrate [2]	3,235	3,449
Ammonium sulfate [2]	1,545	1,684
Ammonium phosphate [4]	1,235	1,590
Nitric acid [2]	3,380	3,641
Urea [5]	922	1,020

[1] Preliminary figures.
[2] Bureau of the Census Current Industrial Report M28A.
[3] Data not available.
[4] Estimated.
[5] U.S. Tariff Commission.

New air separation plants for producing oxygen and nitrogen gas or liquid were built, under construction, or planned during the year as follows:

Company	Plant location	Capacity (tons per day)
Air Products and Chemicals, Inc	Chicago, Ill	200
	Delaware City, Del	([1])
Air Reduction Sales Co	Albion, Mich	200
	Johnstown, Pa	([1])
	Beaumont, Tex	130
Atomic Energy Commission	Oak Ridge, Tenn	([1])
Linde Co	Deer Park, Tex. (planned)	200
	Essington, Pa	230
	Fontana, Calif	450
	Pearl River, Miss. (planned)	350
	Huntsville, Ala. (planned)	200
Industrial Air Products Co	Boise, Idaho	([1])

[1] Data not available.

The total liquid nitrogen and oxygen capacity of the many plants operated by Linde Co., including planned units, was reported to be over 5,000 tons daily.

CONSUMPTION AND USES

Demand increased again in 1962 for both nitrogen compounds and high-purity nitrogen.

Combined nitrogen consumption increased 6 percent; and was used chiefly in fertilizers. Nearly 3.4 million tons of fertilizer nitrogen was consumed for agricultural uses in the year ending June 30, 1962. The order of importance of the principal fertilizer materials consumed was anhydrous ammonia, ammonium nitrate, nitrogen solutions, urea, and ammonium sulfate.

Industrial consumption of high-purity nitrogen increased about 50 percent.

PRICES

Fertilizer-grade anhydrous ammonia, ammonium nitrate, ammonium sulfate, and urea dropped in price during the year. The price quotation for urea was changed on April 9 from f.o.b. to delivered. The prices for other major nitrogen compounds either remained unchanged or were increased slightly.

TABLE 4.—Price quotations for major nitrogen compounds in 1962

(Per short ton)

Compound	Jan. 8	Dec. 31	Effective date of change
Ammonium nitrate, fertilizer-grade, 33.5 percent N:			
Canadian, carlots, shipping point, freight equalized, bags	$70.00	[1] $67.00	Oct. 8.
Domestic, f.o.b. works, bags	70.00	[1] 67.00	Oct. 8.
Ammonium nitrate, domestic with dolomite, 20.5 percent N, bags, carlots, Hopewell, Va	44.00	48.00	Oct. 8.
Ammonium sulfate, granular, bulk, f.o.b. works, base	32.00	28.00	July 16.
Anhydrous ammonia, fertilizer, tanks, works, freight equalized east of Rockies	92.00	[2] 92.00	Oct. 8.
Cyanamide, fertilizer-mixing-grade, 21 percent N, granular, bags, Niagara Falls, Ontario	57.00	59.00	Oct. 1.
Sodium nitrate, domestic, crude, carlots, works, bulk	44.00	44.00	
Sodium nitrate, imported, crude, carlots, port warehouse, bulk	44.00	44.00	
Urea:			
Industrial, 46 percent N, bags, carlots, ton lots, f.o.b. plant	100.00	100.00	
Agricultural, 45 percent N, bags, carlots, f.o.b. plant [3]	96.00	93.25	Oct. 8.

[1] Quoted at $64 per ton from Aug. 6 to Oct. 8.
[2] Quoted at $84 per ton from Aug. 6 to Oct. 8.
[3] Quote changed from "f.o.b. plant" to "delivered" on April 9.

Source: Oil, Paint and Drug Reporter.

FOREIGN TRADE [3]

The gross weight of nitrogen compounds imported for consumption increased 10 percent over that in 1961. Shipments of urea, ammonium nitrate containing over 32 percent nitrogen, and ammonium nitrate mixtures increased 76, 38, and 33 percent, respectively. Imports of sodium nitrate dropped 12 percent.

Exports were more than double those of 1961, chiefly because of a 273-percent increase in shipments of fertilizer-grade ammonium sulfate.

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

TABLE 5.—U.S. imports for consumption and exports of major nitrogen compounds [1]

(Short tons)

Compounds	1961 Gross weight	1961 N content	1962 Gross weight	1962 N content
Imports:				
Industrial chemicals: Ammonium nitrate	106	37	442	155
Fertilizer materials:				
Ammonium nitrate containing over 32 percent nitrogen	[2] 156,650	52,478	216,153	72,411
Ammonium nitrate mixtures containing 32 percent and less nitrogen, including ammonium nitrate-calcium carbonate mixtures, except solutions	[2] 92,033	19,327	122,006	25,621
Ammonium phosphates	112,993	16,949	131,578	19,737
Ammonium sulfate	[2] 246,866	51,842	244,998	51,450
Calcium cyanamide	41,987	10,497	36,946	9,237
Calcium nitrate	73,737	11,429	58,167	9,016
Nitrogen solutions	[2] 64,269	22,494	68,645	24,026
Synthetic nitrogenous fertilizer materials, not elsewhere specified	47,280	9,456	58,600	11,720
Potassium nitrate, crude	1,962	235	4,437	532
Potassium-sodium nitrate mixtures, crude	13,801	2,070	29,505	4,426
Sodium nitrate	494,345	79,095	434,556	69,529
Urea, not elsewhere specified	107,018	48,693	188,040	85,558
Total	[2] 1,453,047	324,602	1,594,073	383,418
Exports:				
Industrial chemicals:				
Ammonium nitrate	1,554	544	690	242
Anhydrous ammonia and chemical-grade aqua (ammonium content)	9,513	7,820	4,717	3,877
Fertilizer materials:				
Ammonium nitrate	28,324	9,489	41,533	13,914
Ammonium phosphates and other nitrogenous phosphatic-type fertilizer materials	77,506	11,626	120,520	18,078
Ammonium sulfate	144,450	30,335	538,514	113,088
Anhydrous ammonia and aqua (ammonia content)	92,904	76,367	54,750	45,005
Nitrogeneous chemical materials, not elsewhere classified	18,145	3,629	62,677	12,535
Sodium nitrate	1,217	195	945	151
Urea	72,317	32,543	86,691	39,011
Total	445,930	172,548	911,037	245,901

[1] Detail revised to exclude imports of organic nitrogenous fertilizer materials, not elsewhere specified, and to include nitrogen content estimated by Bureau of Mines.
[2] Revised figure.

Source: Bureau of the Census.

WORLD REVIEW [4]

NORTH AMERICA

Canada.—Sherritt Gordon Mines Ltd., at Fort Saskatchewan, Alberta, completed a 35,000-ton-per-year urea plant and exported the product to farm markets in Washington and Oregon.[5] The Canadian production capacity for ammonia at the beginning of the year was estimated to be 601,000 tons with seven companies producing ammonia and/or ammonium compounds. Byproduct ammonia from the coke and gas industry accounted for 12,000 tons of the total capacity.[6]

[4] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.
[5] Northern Miner (Toronto). Sherritt Gordon Exports First Urea Shipment. No. 38, Dec. 13, 1962, p. 20.
[6] Birnie, A. W. The Fixed Nitrogen Industry and Its Future in Canada. Canadian Min. and Met. Bull. (Montreal), v. 55, No. 607, November 1962, pp. 811–815.

Costa Rica.—The Government of Costa Rica announced that an agreement was reached for Fertilizantes de Centro America, S.A., to establish a large nitrogenous fertilizer plant to produce nitric acid, ammonium nitrate, and nitrate-phosphate fertilizer. Liquid ammonia would be imported from Colombia.[7]

TABLE 6.—World production and consumption of nitrogen compounds, years ended June 30

(Thousand short tons of contained nitrogen)

Year	Production[1]	Consumption[1]	
		In agriculture	In industry
1957-58	11,397	9,295	1,793
1958-59	12,438	10,322	1,965
1959-60	13,572	[2] 11,317	[2] 2,207
1960-61 [2]	14,795	12,007	2,421
1961-62	16,011	13,227	2,640

[1] Estimate.
[2] Revised figure.

Source: British Sulphate of Ammonia Federation, Ltd.

Mexico.—A new anhydrous ammonia plant, built in Salamanca, Guanajuato, by The Lummus Co., Ltd., for Petroleos Mexicanos, went on stream. The plant, with a capacity of 220 tons per day, was the beginning of a growing petrochemical industry being built adjacent to the Petroleos Mexicanos Salamanca refinery.[8] Construction of a urea plant began near Salamanca. It was to be operated by Fertilizantes del Bajio, S.A.[9]

Netherlands Antilles.—Construction began on a $20 million group of fertilizer plants at Barcadera in Aruba. An ammonia plant with a capacity of 110,000 tons per year, scheduled for completion in January 1963, was to be operated by Antilles Chemical Co., an affiliate of Standard Oil Co. of New Jersey. The other plants of the group—sulfuric acid, nitric acid, urea, and fertilizer—were scheduled for completion about 3 months later and were to be operated by Aruba Chemical Industries, N.V.[10]

Trinidad.—Federation Chemicals Ltd., a subsidiary of W. R. Grace & Co., awarded contracts to construct a new ammonia plant in Point Lisas, Trinidad.[11] It was reported that the new facility would increase the company's annual capacity from 35,000 tons to 235,000 tons. Two 9,000-ton-capacity tankers were planned for transporting liquid ammonia from Point Lisas to Wilmington, N.C., for the production of nitrogenous fertilizers by Carolina Nitrogen Corp., a new firm jointly owned by W. R. Grace & Co. and other fertilizer producers.[12]

[7] Bureau of Mines. Mineral Trade Notes. V. 55, No. 4, October 1962, pp. 25–26.
[8] Commercial Fertilizer. V. 105, No. 1, July 1962, p. 45.
[9] Bureau of Mines. Mineral Trade Notes. V. 55, No. 3, September 1962, p. 59.
[10] Foreign Commerce Weekly. New Plants in Aruba. V. 67, No. 23, June 4, 1962, p. 1023.
[11] Commercial Fertilizer. V. 105, No. 3, September 1962, pp. 50, 51.
[12] Commercial Engineering. V. 69, No. 13, June 25, 1962, p. 53.

TABLE 7.—World production and consumption of nitrogen compounds, years ended June 30, by principal countries

(Thousand short tons of contained nitrogen)

Country	Production [1]			Consumption [1]		
	1959-60	1960-61	1961-62	1959-60	1960-61	1961-62
Australia	24	23	25	28	37	44
Austria	187	187	200	57	61	67
Belgium	349	323	304	112	155	129
Brazil	13	18	13	55	66	72
British West Indies	6	22	24	17	18	20
Bulgaria	69	93	97	136	110	128
Canada	355	406	446	94	99	110
Ceylon	---	---	---	34	31	33
Chile	204	160	192	15	22	25
China	309	386	408	661	672	694
Cuba	6	6	28	29	34	39
Czechoslovakia	158	154	174	191	203	243
Denmark	---	---	---	136	138	148
Finland	41	41	41	69	74	78
France	732	844	898	671	747	816
Germany:						
East	419	429	430	320	308	314
West	1,404	1,561	1,504	934	941	961
Greece	---	---	---	86	80	86
Hungary	61	69	82	96	99	110
India	105	121	154	265	260	314
Indonesia	---	---	---	50	28	116
Ireland	---	---	---	24	28	33
Israel	18	22	24	19	24	26
Italy	742	819	863	470	446	482
Japan	1,134	1,229	1,334	849	860	865
Korea:						
North	88	88	94	88	99	105
Republic of	---	---	11	179	220	231
Mexico	28	35	44	143	160	171
Netherlands	464	476	502	250	263	290
Norway	283	311	330	74	75	75
Pakistan	13	12	22	37	77	88
Peru	7	9	9	30	33	28
Philippines	13	15	20	55	56	58
Poland	298	320	358	293	309	353
Portugal	51	53	73	83	79	85
Rhodesia and Nyasaland, Federation of	---	---	---	31	33	39
South Africa, Republic of	69	88	99	89	99	105
Spain	95	129	146	265	298	320
Sweden	46	57	64	131	136	137
Switzerland	25	31	28	21	23	23
Taiwan	43	55	68	123	122	138
U.S.S.R.	981	1,113	1,268	1,025	1,135	1,235
United Arab Republic (Egypt)	43	72	132	160	209	226
United Kingdom	607	672	700	632	683	735
United States	3,803	4,141	4,414	3,913	4,205	4,450
Yugoslavia	9	18	33	110	110	132
World total [2]	13,319	14,642	15,699	13,509	14,422	15,551

[1] Estimated.
[2] Includes quantities for minor producing and consuming countries not listed above.

Source: Nitrogen. No. 21, January 1963, pp. 25-28.

SOUTH AMERICA

Argentina.—A proposal was approved by the Government for construction of a $26 million fertilizer plant near Zarate, Buenos Aires Province. The plant was designed to produce annually about 36,000 tons of ammonia and 56,000 tons of urea and was scheduled for completion by mid-1965.[13]

[13] Bureau of Mines. Mineral Trade Notes. V. 55, No. 1, July 1962, p. 39.

Brazil.—Carbocloro-Industrias Quimicas Ltda. began construction on facilities to produce daily about 45 tons of ammonia, a similar quantity of urea, and smaller quantities of other ammonia compounds. Also a new plant for the annual production of 80,000 tons of ammonia and 24,000 tons of urea was under construction for Petroleo Brasileiro, S.A., at Camacari, State of Bahia.[14]

Chile.—The Chilean Reconstruction Finance Corp. approved a $760,000 loan to sustain operations at the Victoria nitrate mine and plant at Tarapacá Province.[15] Exports of natural nitrates were 17 percent less in 1962 than in 1961 but were still 134,000 tons above those for 1960. The United States remained the best customer, receiving 47 percent of the total exports.

TABLE 8.—Chile: Exports o nitrate in 1962. by countries [1]

(Thousand short tons)

Destination	Quantity	Destination	Quantity
Argentina	11	Mexico	11
Australia and New Zealand	6	Middle East	3
Brazil	47	Netherlands	17
Canada	2	Peru	6
Denmark	19	Portugal	14
Ecuador	1	Spain	146
El Salvador	1	Sweden	4
France	60	United Kingdom	7
Germany, West	13	United States	469
Greece	2	Other countries [2]	3
India	22	In transit	81
Ireland	5		
Italy	18	Total	989
Japan	21		

[1] Includes 67,673 tons of potassium nitrate.
[2] Includes Belgium, Bolivia, Colombia, Costa Rica, Guatemala, Nicaragua, Panama, Uruguay, and Venezuela; each received less than 1,000 tons.

Colombia.—A new ammonia and nitric acid plant was under construction near Cartagena and scheduled for completion in October 1962. Amoniaco del Caribe, S.A., a subsidiary of International Petroleum (Colombia) Ltd., was to operate the plant, which was reported to have a daily production of 275 tons of ammonia and 138 tons of nitric acid. A fertilizer plant to be operated by Abonos Colombianos, S.A., for the production of urea and other fertilizers was being built on the same site.[16]

Ecuador.—Fertilizantes del Ecuador S.A. planned a $1.4 million fertilizer-producing facility in the Guayaquil area with U.S., West German, and domestic financing. The plant called for production of mixed fertilizers in 2 years, using ammonia from an affiliated plant in Colombia. Ammonia from natural gas was to be produced 3 years later.[17]

Peru.—Contracts were signed for a 68,000-ton-per-year ammonium nitrate plant to be constructed near Cuzco.[18]

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[14] Nitrogen. No. 20, November 1962, p. 43.
[15] Engineering and Mining Journal. V. 163, No. 10, October 1962, p. 156.
[16] Oil, Paint and Drug Reporter. Ammonia, Fertilizer Units Get Under Way in Colombia. V. 181, No. 13, Mar. 26, 1962, p. 59.
[17] Foreign Commerce Weekly. New Ecuadoran Plant To Make Fertilizers. V. 67, No. 23, June 4, 1962, p. 1024.
[18] Chemical Engineering. V. 69, No. 15, July 23, 1962, pp. 156, 159.

Venezuela.—The Moron plant of Venezuelan Petrochemical Institute started producing ammonia and fertilizers.[19]

EUROPE

A new international nitrogen cartel, Nitrex, A.G., with headquarters at Zurich, Switzerland, was organized and joined by the following: Badische Anilin und Sodafabrik A.G., Farbwerke Hoechst A.G., and Ruhr-Stickstoff A.G. (West Germany); Federation Belge des Producteurs d'Azote (Belgium); Centraal Stickstof Verkoopkantoor N.V. (Netherlands); Norsk Hydro-Elektrisk Kvaelstofaktieselskab (Norway); Oesterreichische Stickstoffwerke A.G. (Austria); Seifa Societa per lo Svilupo Consumi Fertilizzanti (Italy); Syndicate Professionnel de L'Industrie des Engrais, Azotes (France); and Lonza Elektrizitalswerke and Chemische Fabriken (Switzerland).[20]

Belgium.—Ammoniaque Synthetique et Derives started an expansion program of its ammonia and nitrogen fertilizer facilities at Willebrock. Annual capacity was to be increased from 35,000 to 110,000 tons of nitrogen.[21]

Denmark.—Dansk-Norsk Kvaelstoffabrik I/S employed Société Belge de l'Azote et des Produits Chimiques du Marly (S.B.A.) of Belgium to design and erect an ammonium nitrate plant at Grenaa.[22]

Greece.—A nitrogenous fertilizer plant was being built in the Ptolemais lignite area in northern Greece. Trial runs were expected in April 1963. The annual capacity of the plant was given as 344,000 short tons of products.[23] An ammonia plant and a refinery with petrochemical facilities were planned for northern Greece. These projects were to be a part of the Salonika Industrial Development Plan. It was reported that Standard Oil Co. of New Jersey would help finance and provide technical assistance and supervision for the construction of the units.[24]

Hungary.—Borsod Chemical Combine at Kazincbarcika, northeast Hungary, planned to double its output of nitrogenous fertilizer and reach a capacity of 215,000 tons per year by the end of 1962. The National Economic Committee endorsed a proposal to start a further expansion in 1963 aimed to again double production.[25]

Ireland.—A contract for designing and erecting a 150,000-ton-per-year nitrogenous fertilizer plant at Arklow, County Wicklow, was awarded to Lurgi, A. G. of Frankfurt, West Germany. Civil engineering work was to start in November and the plant was expected to be in operation by the end of the first quarter of 1965.[26]

Italy.—A new byproduct ammonium sulfate plant was being erected in conjunction with a new coke-oven plant at Taranto. The plant was

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19 Chemical Week. V. 91, No. 10, Sept. 8, 1962, p. 27.
20 Bureau of Mines. Mineral Trade Notes. V. 55, No. 4, October 1962, p. 26.
21 Nitorgen. No. 16, March 1962, p. 50.
22 Chemical Age (London). V. 87, No. 2217, Jan. 6, 1962, p. 14.
23 Bureau of Mines. Mineral Trade Notes. V. 55, No. 3, September 1962, pp. 57–58.
24 Chemical & Engineering News. V. 40, No. 50, Dec. 10, 1962, pp. 29, 30.
25 Chemical Age (London). Hungary Plans 400% Nitrogen Boost. V. 88, No. 2254, Sept. 22, 1962, p. 407.
26 Chemical Age (London). Lurgi Win £5 Million Contract for Irish Fertiliser Plant. V. 88, No. 2261, Nov. 10, 1962, p. 717.

designed to supply 50 tons of export-quality ammonium sulfate daily.[27]

Netherlands.—An ammonia plant which would use natural gas from the newly discovered Groningen field in northern Holland, was planned for erection at Delfzijl.[28]

Norway.—A West German firm was commissioned by Norsk Koksverk A/S to construct a synthetic ammonia plant in north Norway. The plant was to use coke-oven gas as a raw material and to have an annual capacity of 60,000 tons.[29]

Portugal.—A new plant with capacity to produce 170 tons of ammonia in addition to producing gas for use in the city of Lisbon was built for Soc. Portuguesa de Petroquimica Sarl of Lisbon. Part of the ammonia was used by the company for making fertilizers and part was sold to other companies for the same purpose.[30] A new nitrogenous fertilizer plant was under construction on the Tagus River with completion scheduled for the end of 1962. Uniao Fabril do Azoto, a Portuguese firm, was to operate the 180-ton-per-day ammonia plant and related facilities for production of urea, ammonium compounds, and nitric acid.[31]

Spain.—Organizadora de Fertilizantes de Iberia was formed by Banco de Bilbao and International Development & Investment Co., Ltd., of the Bahamas. The new firm planned to build an ammonia plant at La Coruña, having a daily capacity of about 330 tons, and two fertilizer plants, one at Huelva and the other at Levante.[32] Refineria de Petroleos de Escombreras, S.A. was building a second large fertilizer plant at Cartagena. Annual capacities were stated to be 200,000 tons of ammonium sulfate, 70,000 tons of urea, and 18,000 tons of other fertilizers.[33] Plans were approved for Amoniaco Español, S.A., a newly formed company owned by Esso Mediterranean Inc. and Spanish interests, to build a large nitrogen fertilizer plant at Malaga. The plant was scheduled for completion in the summer of 1964 and was being designed to use the new Imperial Chemical Industries, Ltd., high-pressure naphtha-reforming process for the production of anhydrous ammonia.[34]

Sweden.—Svenska Salpeterverken A.B. was building a new ammonia plant at Köping to replace a plant that had been producing ammonia from coke-oven gas. The new plant would use a process based on gasification of oil and have an annual capacity of 50,000 tons. The company also planned to build a new plant later at Kvarntorp to produce 10,000 tons per year of ammonium sulfate.[35]

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[27] Chemical Trade Journal and Chemical Engineer (London). V. 151, No. 3927, Sept. 7, 1962, p. 483.

[28] Oil, Paint and Drug Reporter. Ammonia Boost for Europe? That Is the Promise Being Given by Dutch Economic Minister. V. 182, No. 18, Oct. 29, 1962, pp. 7, 34.

[29] Chemical Trade Journal and Chemical Engineer (London). V. 150, No. 3910, May 11, 1962, p. 971.

[30] Chemical Trade Journal and Chemical Engineer (London). Nitrogen in Portugal. V. 150, No. 3914, June 8, 1962, p. 1159.

[31] Sulfur Institute News. V. 2, No. 9, September 1962, p. 3.

[32] Bureau of Mines. Mineral Trade Notes. V. 55, No. 1, July 1962, p. 44.

[33] Fertiliser and Feeding Stuffs Journal (London). Spain's New Fertiliser Plants. V. 57, No. 7, Oct. 3, 1962, p. 282.

[34] Chemical Fertilizer. V. 105, No. 6, December 1962, p. 54.

[35] Fertiliser and Feeding Stuffs Journal (London). Sweden's Expansion Scheme. V. 57, No. 6, Sept. 19, 1962, p. 231.

United Kingdom.—Fisons, Ltd., and Esso Petroleum Co., Ltd., abandoned their joint project of building an $11.2 million, 150,000-ton-per-year ammonia plant next to the Milford Haven refinery.[36] Fisons, Ltd., concluded a contract with Imperial Chemical Industries, Ltd. (ICI), whereby ICI would supply Fisons, Ltd., with ammonia for the production of nitrogenous fertilizers. Fisons, Ltd., was expected to erect two new nitrogenous fertilizer plants and to increase the phosphoric acid capacity at Immingham at an approximate cost of $25 million. These plants were to be completed in two stages, the first by 1964 and the second by 1966. ICI was to complete a new $14 to $16.8 million ammonia plant by 1966, at Immingham to meet the expanded requirements. Until the new plant could be put into operation, Fisons' ammonia needs were to be supplied from other ICI plants.[37] ICI also planned to increase the annual capacity of its Severnside ammonia plant, already under construction, by 180,000 tons.[38] The new 25,000-ton-per-year ammonia plant for Nitrogen Fertilisers Ltd. at Flixborough, Lincolnshire, was completed.[39] The first of four ammonia synthesis gas units being built at Billingham for ICI was operating in November. The other three units were scheduled to go on stream in succession during the first 3 months of 1963.[40] ICI, Billingham Division, closed two of its ammonia plants, one in Northumberland and the other in South Wales. Both plants used coke and both lacked direct access to ocean waterways. Together the two plants had produced about 5 percent of the total capacity of the company.[41] Richard Thomas and Baldwins Ltd. began operating its Spencer steelworks at Llanwern in South Wales. A by-product plant to produce 125,000 tons per year of ammonium sulfate from coke-oven gas was included in the facility.[42] Plans were established by Scottish Agricultural Industries Ltd. to build a new nitric acid plant next to its fertilizer works at the Leith docks. The plant was to be designed for the Kuhlman process with a 55,000-ton-per-year capacity.[43]

Yugoslavia.—A large ammonium nitrate fertilizer plant under construction at Panchevo began pilot operations. The plant was expected to be in full production, 400,000 tons per year, by mid-1963. Domestic needs would be satisfied with production from the Panchevo plant plus that from the recently opened 150,000-ton-per-year plant at Lukavats in Bosnia.[44]

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[36] Chemical Week. Ammonia Switch. V. 90, No. 7, Feb. 17, 1962, p. 43.

[37] Oil, Paint and Drug Reporter. Fisons and ICI Finally Get Together To Resolve an Old Ammonia Puzzler. V. 182, No. 13, Sept. 24, 1962, pp. 3, 52.

[38] Chemical Age (London). I.C.I.'s New 180,000 t.p.d. Severnside Ammonia Plant. V. 88, No. 2256, Oct. 6, 1962, p. 517.

[39] Chemical Age (London). Nitrogen Fertilisers Open New Synthesis Ammonia Plant at Flixborough. V. 88, No. 2267, Dec. 22, 1962, p. 947.

[40] Chemical Age (London). Billingham Synthesis Ammonia Unit on Stream. V. 88, No. 2264, Dec. 1, 1962, p. 833.

[41] Chemical Engineering. V. 69, No. 15, July 23, 1962, p. 156.

[42] Chemical Engineering. V. 69, No. 26, Dec. 24, 1962, p. 116.

[43] Chemical Age (London). S.A.I. To Have First U.K. Kuhlman Nitric Plant. V. 88, No. 2258, Oct. 20, 1962, p. 597.

[44] Engineering and Mining Journal. Yugoslavia Fertilizer Mill Begins Pilot Operations. V. 163, No. 9, September 1962, p. 124.

ASIA

Burma.—Three Soviet fertilizer experts completed a 6-month assignment in Burma for the United Nations Food and Agriculture Organization, after which they recommended construction of a 133,000-ton nitrogenous fertilizer plant in the Chauk natural gas field of Upper Burma.[45]

Ceylon.—The Government of Ceylon started planning the erection of an ammonium sulfate plant after receiving a report from Battelle Memorial Institute.[46]

Cyprus.—The Government of Cyprus planned a 100,000-ton-per-year plant to produce various chemical fertilizers to meet the island's requirements and have some surplus for export.[47]

India.—The capacity of the nitrogenous fertilizer industry in June 1962 was reported to be 273,000 tons of nitrogen equivalent with an additional 1,150,000 tons licensed.[48] The Rourkela fertilizer plant started making about 200 tons of synthesis ammonia per day, using coke-oven gas from the neighboring steel plant. The plant was expected to produce 600,000 tons of calcium ammonium nitrate annually when in full operation. East India Distilleries and Sugars Ltd. completed its new 52,000-ton-per-year ammonium phosphate plant at Ennore, near Madras. Plans were to double its output during the next 3 years. Work on the Trombay fertilizer plant proceeded according to schedule. The Fertilizer Corporation of India took over the building of the urea plant in Madhya Pradesh. Nitrogenous fertilizer plants were planned or underway at Durgapur, Visakhapatnam (Andhra Pradesh), Kothagudem, Nahorkativa (Assam), and Gorakhpur.[49]

Israel.—Fertilisers and Chemicals Ltd. started producing calcium ammonium nitrate in its new plant at Haifa. Local requirements for this fertilizer were expected to be met by the output of this plant.[50]

Japan.—Because of the loss of export markets, many Japanese ammonium sulfate producers were converting their plants to the production of other chemicals such as resins, foodstuffs, and medicines.[51]

Pakistan.—A proposal to build a 145,000-ton-per-year urea plant at Kashmor was examined by West Pakistan Industrial Development Corp.[52]

Philippines.—Marinduque Iron Mines Agents, Inc., began constructing a 485-ton-per-day ammonium sulfate plant in Iligan City.[53] Standard Oil Co. of New Jersey prepared plans for establishing a $30 million fertilizer facility to produce 300 tons per day of ammonia.

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[45] Chemical Age (London). F.A.O. Fertiliser Experts Plan Nitrogen Plant for Burma. V. 87, No. 2237, May 26, 1962, p. 866.
[46] Chemical Trade Journal and Chemical Engineer (London). Fertilisers in Ceylon. V. 151, No. 3939, Nov. 30, 1962, p. 1114.
[47] Oil, Paint and Drug Reporter. Cyprus Plans Construction of Major Fertilizer Facility. V. 181, No. 21, May 21, 1962, p. 36.
[48] Bureau of Mines. Mineral Trade Notes. V. 55, No. 6, December 1962, p. 30.
[49] Chemical Age (London). Indian Fertiliser Projects Speeded Up, 1 Million Tons Nitrogen by 1965–66. V. 88, No. 2258, Oct. 20, 1962, p. 612.
[50] Chemical Age (London). V. 88, No. 2246, July 28, 1962, p. 134.
[51] Oil, Paint and Drug Reporter. NH_4 Sulfate Loss Pushes Japanese Into Other Lines. V. 182, No. 23, Dec. 3, 1962, p. 7.
[52] Bureau of Mines. Mineral Trade Notes. V. 56, No. 2, February 1963, p. 47.
[53] Mining Journal (London). V. 258, No. 6614, May 5, 1962, p. 545.

Facilities for the production of urea, diammonium phosphate, and mixed fertilizers also were included.[54]

Syrian Arab Republic.—Work was started on a power station, the first step toward establishing a fertilizer factory for Syria. The entire project, scheduled for completion in 1969, was part of a Soviet-Syrian Technical and Economic Cooperation Agreement.[55]

Taiwan.—Ground was broken for the construction of an ammonia-urea plant for Mobile China Allied Industries Ltd. at Miaoli. Capacities were reported to be 110,000 tons of urea and 50,000 tons of ammonia.[56]

Thailand.—A new fertilizer plant with annual production capacities of 60,000 tons of ammonium sulfate and 30,000 tons of urea was under construction at Maemoh.[57]

AFRICA

South Africa, Republic of.—A contract was awarded to Simon-Carves, Ltd. (Africa), to build a nitrogenous fertilizer plant for South African Coal Oil & Gas Corp. Completion date was set for 1964.[58]

Tunisia.—A nitrogenous fertilizer plant with an annual capacity of 20,000 tons of ammonium phosphate and 270,000 tons of ammonium nitrate was planned.[59]

OCEANIA

Australia.—An order was placed by Imperial Chemical Industries of Australia and New Zealand Ltd. for an integrated ammonia and methanol synthesis plant to be completed at Botany by early 1964.[60]

TECHNOLOGY

Osterreichische Stickstoffwerke A.G., of Linz, Austria, developed and patented a new ammonia converter that consisted of packed catalyst sections alternated with zones where heat is exchanged with fresh gas mixture. With the new converter, the nitrogen-hydrogen mixture is preheated with hot reaction gases leaving the various successive catalyst sections.[61]

A new process was put into use at the Budapest Gas and Coke Works, Budapest, Hungary, for the recovery of ammonia from gas liquor without additional heat consumption.[62]

A new one-step naphtha reform process to produce ammonia synthesis gas was reported in operation in a demonstration plant.[63]

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54 Oil, Paint and Drug Reporter. Esso Fertilizer Plant To Rise in Philippines. V. 182, No. 24, Dec. 10, 1962, p. 5.
55 Commercial Fertilizer. V. 105, No. 1, July 1962, p. 46.
56 Chemical Engineering. V. 69, No. 25, Dec. 10, 1962, p. 198.
57 Sulfur Institute News. V. 2, No. 10, October 1962, p. 3.
58 Bureau of Mines. Mineral Trade Notes. V. 55, No. 6, December 1962, p. 30.
59 Chemical Trade Journal and Chemical Engineer (London). V. 150, No. 3912, May 25, 1962, p. 1067.
60 Chemical Age (London). ICIANZ Ammonia, Methanol Contract for Power-Gas. V. 88, No. 2259, Oct. 27, 1962, p. 635.
61 Hinrichs, H. and Dipl.-ing J. Niedetzky. A New Type of Converter for Ammonia Synthesis. Angew. Chem. (International Edition in English), v. 1, No. 4, April 1962, pp. 206–210.
62 Chemical Age (London). New Hungarian Process for Recovery of Ammonia. V. 87, No. 2222, Feb. 10, 1962, p. 246.
63 Chemistry and Industry (London). No. 50, Dec. 15, 1962, pp. 2094, 2095.

Friedrich Uhde G.m.b.H., a 75-percent-owned subsidiary of Farbwerke Hoechst A.G., Dortmund, West Germany, developed a process for making nitric acid by utilizing the heat from the ammonia oxidation reaction for the entire energy requirement. Three companies had plants either on stream or under construction using the process.[64]

The Tennessee Valley Authority evaluated bids for installation of a new nitric acid plant guaranteed to produce 65 to 68 percent acid. High-concentration acid was new in the United States, buts its production was common practice in Europe. The possibility of starting a trend that would end the construction of 60-percent-acid plants was reported.[65]

A thesis described how liquid nitrogen could be produced from atmospheric air by combining the refrigeration machine with an air-rectifying column. It was stated that 4 liters of 99.8- to 99.9-percent pure liquid nitrogen could be produced per hour.[66]

Canadian Industries Ltd. found that ammonia used as a modifier and alkalinity regulator in froth-flotation processes improved the product and reduced the reagent cost. The process (covered by Canadian patent 640,751) was tested at several Canadian mills with encouraging results.[67]

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[64] Forbath, Peter. New Design Recoups Heat in Nitric Acid Plant. Chem. Eng., v. 69, No. 26, Dec. 24, 1962, pp. 64–66.

[65] Chemical Week. TVA Lifts Nitric Concentration Ceiling. V. 91, No. 23, Dec. 8, 1962, pp. 53, 54.

[66] Van der Ster, J. The Production of Liquid Ammonia From Atmospheric Air Using a Gas Refrigerating Machine. Thesis, Delft, June 22, 1960; abs. 2854 in Philips Research Reports, v. 17, No. 2, April 1962, p. 198.

[67] Chemical Week. Floating With Ammonia. V. 91, No. 3, July 21, 1962, p. 138.

Perlite

By John W. Hartwell [1] and Victoria R. Schreck [2]

CRUDE PERLITE production in the United States in 1962 increased 3 percent over that of 1961. Output of expanded perlite was 1 percent less than 1961.

DOMESTIC PRODUCTION

Crude Perlite.—Crude perlite was produced by 15 companies from 16 mines, the same as in 1961. The quantity of crude perlite sold to expanders increased about 2,000 short tons over 1961, and that used in producer's plants increased about 8,000 tons.

New Mexico continued to be the leading crude perlite producing State with 76 percent of the domestic total. Other producing States, in descending order of output, were Nevada, California, Arizona, Colorado, Idaho, and Utah.

Expanded Perlite.—Perlite was expanded in 29 States by 74 companies at 78 plants, compared with 30 States, 68 companies, and 102 plants in 1961. The greatest number of expanders were in California, 12; Pennsylvania, 7; Texas, 6; Illinois and New York, 5 each; and New Jersey, 4.

TABLE 1.—Crude and expanded perlite produced and sold or used by producers in the United States

(Thousand short tons and thousand dollars)

Year	Crude perlite						Expanded perlite		
	Quantity mined	Sold		Used at own plant to make expanded material		Total quantity sold and used	Quantity produced	Sold	
		Quantity	Value	Quantity	Value			Quantity	Value
1953-57 (average)	316	179	$1,579	84	$540	263	226	225	$11,550
1958	372	197	1,624	95	840	292	241	239	12,373
1959	443	221	1,846	104	891	325	276	273	14,187
1960	385	214	1,847	98	818	312	248	244	13,046
1961	374	196	1,665	114	998	310	240	235	12,605
1962	408	198	1,611	122	1,052	320	238	234	12,374

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.

TABLE 2.—Expanded perlite produced and sold by producers in the United States

(Thousand short tons and thousand dollars)

State	1961				1962			
	Quantity produced	Sold			Quantity produced	Sold		
		Quantity	Value	Average value per ton		Quantity	Value	Average value per ton
California	22	22	$1,374	$63.77	24	24	$1,421	$58.93
Florida	7	7	452	61.00	8	8	516	65.63
Kansas	1	1	53	73.10	1	1	42	64.05
Michigan	4	4	237	56.09	4	4	225	60.18
New Jersey	10	10	626	62.08	9	9	568	62.80
New York	14	14	662	44.34	12	12	628	53.62
Pennsylvania	16	16	1,037	66.02	14	14	936	65.14
Texas	24	24	1,424	58.68	27	27	1,599	58.15
Other Eastern States [1]	79	77	4,408	57.07	75	73	4,101	55.99
Other Western States [2]	63	60	2,332	39.01	64	62	2,338	37.64
Total	240	235	12,605	53.59	238	234	12,374	52.80

[1] Includes Illinois, Indiana, Maryland, Massachusetts, New Hampshire, North Carolina, Ohio, Tennessee, Virginia, and Wisconsin.
[2] Includes Arizona, Colorado, Idaho, Iowa, Louisiana, Minnesota, Missouri, Nebraska, Nevada, New Mexico (1961), Oregon, and Utah.

Great Lakes Carbon Corp. plant at Florence, Ky., was under construction during 1962. It was to contain 120,000 square feet of floor space for the manufacture of insulation board by a new process requiring expanded perlite and fiber.

Perlite Producers, Inc., opened a new crushing and screening plant, having a capacity of 200 tons per day, at Marfa, Tex. Perlite was to be mined at Pinto Canyon, about 40 miles southwest of Marfa, where reserves were reported to be 12 million tons. The processed perlite was to be sold as a lightweight aggregate and a fertilizer additive.

A new perlite processing plant at Magdalena, N. Mex., was being erected that would have a crushing and screening capacity of 250 tons a day. The raw material was to be obtained from a perlite deposit 6 miles south of Magdalena.

CONSUMPTION AND USES

The following end-use percentages for expanded perlite were reported by producers: Building-plaster aggregates, 47; filter aids, 19; concrete aggregate, 16; oil-well cement, 6; insulation (loose fill), 3; insulation (other) and soil conditioning, 2 each; filler and wallboard, 1 each; and miscellaneous uses, 3. Compared with 1961, building-plaster uses decreased 3 percent and filter aids 2 percent. Use in oil-well cement increased 5 percent.

PRICES

The average value of crushed, cleaned, and sized perlite sold to expanders was $8.14 per short ton, f.o.b. producers' plants, compared with $8.49 in 1961. The average value of crude perlite expanded by prime producers was $8.59, compared with $8.75 in 1961. A weighted average price of these two categories of crude perlite was $8.31, 3 percent less than the 1961 price.

The average price of all expanded perlite sold in 1962 was $52.80 per ton, a decrease of $0.79 per ton below the average price in 1961.

FOREIGN TRADE

Crude perlite may be imported duty-free under paragraph 1719 of the Tariff Act of 1930. Expanded perlite had a duty of 15 percent ad valorem since Jan. 1, 1948. No crude or expanded perlite was imported during 1962. Only crude perlite was exported during 1962; it was grouped with other exported mineral commodities, and the data were not available separately.

WORLD REVIEW [3]

Canada.—All crude perlite used during 1961 was imported from the United States. About 92,000 cubic yards of expanded perlite valued at Can$740,000 was produced from the imported material. This was a 12-percent decrease in volume and an 11-percent decrease in value from that of 1960. Eight plants were in operation in Alberta, British Columbia, Manitoba, Ontario, and Quebec, the same as in 1960.

In 1961, the use of expanded perlite for plaster aggregate was 91 percent of total production compared with 86 percent in 1960. Four percent was used in insulating concrete, compared with 1 percent in 1960. Horticulture, insulation, stucco, acoustic tile, and plaster uses were 5 percent, the same as in 1960.

Prices for expanded perlite were quoted at 25 to 35 cents per cubic foot in bags of 3 and 4 cubic feet. All prices were f.o.b. plant.[4]

Ecuador.—A report on industrial minerals showed that perlite was found near the Antisana volcano, but production was not mentioned.[5]

Greece.—Perlite production in 1962 was reported at 22,000 tons valued at $140,000.[6]

TECHNOLOGY

A review of the perlite industry since 1951, including an estimate of production to 1965 was published.[7]

Two Kern County, Calif. deposits of perlite, neither of which had been commercially developed, were described.[8]

Microscopic study of expanded perlite yielded information regarding the internal structure. Since specifications for expanded perlite, in a variety of uses, called for different physical properties that re-

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[3] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.

[4] Wilson, H. S. Lightweight Aggregates 1961 (Preliminary). Canada Dept. Mines and Tech. Surveys, Ottawa, May 1962, pp. 1–5.

[5] Stoll, W. C. Notes on the Mineral Resources of Ecuador. Econ. Geol., v. 57, No. 5, August 1962, pp. 799–808.

[6] U.S. Embassy, Athens, Greece. State Department Airgram A–1029, May 8, 1963, encl. 1.

[7] Plummer, David E. The Perlite Panorama. Rock Products, v. 65, No. 12, December 1962, pp. 85–86.

[8] Troxel, Bennie W., and Paul K. Morton. Mines and Mineral Resources of Kern County, Calif. California Div. of Mines and Geol., County Rept. 1, 1962, p. 244.

quired various types of processing, this study was considered a useful aid in evaluating the product.[9]

Research workers at the University of Kosice in Czechoslovakia developed a perlite-expanding furnace, which they claimed produced a better end product. The furnace layout was illustrated, and the process was described.[10]

The water-repellent treatment of perlite materials using organo-silicon compounds was studied. Capillary action, frost and water resistance, and endurance during alternate wetting and drying were noted before and after treatment.[11]

Two new refractories, each made of expanded perlite with a ceramic bond, that can be used at 900° and 1,350° C were developed in Hungary. Claims were made that both varieties had heat-resistant properties and greater strength than any similar refractory material.[12]

To improve mass moulding of perlite insulating board, suggestions were made that 0.1 to 1.0 percent of a compound such as sulfonated carbohydrate might be added. With the addition of this compound, the percentage of perlite used in making the board could be increased by 40 to 65 percent.[13]

The use of Bulgarian perlite as a component of container glass was studied. The physical and chemical properties of glass compositions determined the quantity of perlite that could be substituted for feldspar. The substitution of perlite was estimated to save the industry 10 to 20 percent in the cost of raw material.[14]

A method of mining perlite using a sonic wave apparatus,[15] and a method of processing expanded perlite to make it resistant to dimensional changes caused by absorption of water were described.[16]

Several processes for materials using perlite as one of the ingredients were patented. These included compositions for insulating board,[17] thermal and acoustical insulation products,[18] fireproof insulation that was applied to metal surfaces,[19] a metal alloy for lightweight castings,[20] and for a gypsum-lime plaster.[21]

A method of making a lightweight clay brick, using perlite as a sub-

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[9] Bailey, D. A., and F. L. Kadey, Jr. Petrographic Thin-Section Study of the Internal Structure of Expanded Perlite. Trans. Soc. of Min. Eng., v. 223, No. 1, March 1962, pp. 37–40.

[10] Mine and Quarry Engineering (London). Fountain Furnace for Perlite. V. 28, No. 10, October 1962, p. 466.

[11] Lasskaya, E. A., and M. G. Voronkov. Use of Organosilicon Compounds for Water-Repellant Treatment of Heat-Insulating Materials Made From Expanded Perlite. J. Am. Ceram. Soc. (Ceram. Abs.), v. 45, No. 11, November 1962, p. 260.

[12] South African Mining and Engineering Journal (Johannesburg). New Refractory Material. V. 23, pt. 1, No. 3603, Feb. 23, 1962, p. 407.

[13] Albert, Janos. (A Method of Manufacturing Heat Resistant and Heat Insulating Ceramic Products.) Referativnyi Zhur. Khim., No. 21, 1962, p. 337.

[14] Stoycheva, V. Possibilities for the Utilization of Perlite in the Glass Industry. J. Am. Ceram. Soc. (Ceram. Abs.), v. 45, No. 6, June 1962, p. 138.

[15] Bodine, A. G. Sonic Method and Apparatus for Surface Mining Mineral Beds or the Like. U.S. Pat. 3,033,543, May 8, 1962.

[16] Larson, K. R. (assigned to U.S. Gypsum Co., Chicago, Ill.). Dimensionally Stable Expanded Perlite and Method for Making the Same. U.S. Pat. 3,062,752, Nov. 6, 1962.

[17] Kingsbury, J. C. Insulating Composition. U.S. Pat. 3,015,626, Jan. 2, 1962.

[18] Denning, P. S. (assigned to Johns-Manville Perlite Corp.). Insulating Product and Its Manufacture. U.S. Pat. 3,042,578, July 3, 1962.

[19] Sefton, R. C. (assigned to Steel City Industries, Inc.). Insulating Coating Comprising Polyvinyl Alcohol, Asbestos, Cement, and Aggregate. U.S. Pat. 3,042,681, July 3, 1962.

[20] Kreigh, J. R., and J. K. Gibson. Metal-Aggregate Product. U.S. Pat. 3,055,763, Sept. 25, 1962.

[21] Cunningham, K. G., and A. G. Baillie (assigned to Imperial Chemical Industries, Ltd., London). Wall Plasters and Their Preparation. U.S. Pat. 3,057,742, Sept. 9, 1962.

stitute for vermiculite, was suggested in a patent.[22] Another suggestion described a well-cementing composition.[23]

Canadian patents, not previously issued in the United States, were granted for a method of expanding perlite[24] and a composition for moulded thermal insulation products.[25]

Other foreign patents granted on uses of perlite were for insulation in a cryogenic storage tank;[26] an insulated casing for protecting pipes, tanks, and processing equipment;[27] a building stone;[28] and an improved method of producing expanded perlite.[29]

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[22] Robinson, G. C. (assigned to Zonolite Co., Chicago, Ill.). Method of Making Refractory Clay Product. U.S. Pat. 3,030,218, Apr. 17, 1962.
[23] Mayhew, E. J. (assigned to Halliburton Co.). Oil and Gas Well Cementing Compositions. U.S. Pat. 3,036,633, May 29, 1962.
[24] Carpenter, G. (assigned to British & Overseas Minerals Ltd.). Canadian Pat. 651,046, Oct. 23, 1962.
[25] Denning, P. S. (assigned to Johns-Manville Perlite Corp.). Canadian Pat. 646,160, Aug. 7, 1962.
[26] Wissmiller, I. L. (assigned to Chicago Bridge & Iron Co.). Australian Pat. 235,188, Aug. 28, 1961.
[27] Insul-Fil Co., Inc. British Pat. 908,492, Oct. 17, 1962.
[28] Evorenko, G. I. Russian Pat. 139,973, Dec. 16, 1960.
[29] Skusnov, L. I. Russian Pat. 147,521, Aug. 31, 1961.

Phosphate Rock

By Richard W. Lewis [1] and Gertrude E. Tucker [2]

PRODUCTION of marketable phosphate rock increased again in 1962 and was 4 percent greater than in 1961. Also a new world production record of 46 million tons was established. This was an increase of 5 percent over that of 1961. Marketable rock sold or used by producers continued its upward trend gaining 7 percent. Most of the gain was absorbed domestically because U.S. exports were only slightly higher than in 1961.

TABLE 1.—Salient phosphate rock statistics

(Thousand long tons and thousand dollars)

	1953–57 (average)	1958	1959	1960	1961	1962
United States:						
Mine production	44,611	46,459	49,249	54,338	60,535	56,746
P_2O_5 content [1]	5,662	7,237	7,692	8,282	9,026	8,823
Marketable production	13,663	14,879	15,869	17,516	18,559	19,382
P_2O_5 content	4,310	4,668	4,939	5,443	5,804	6,004
Value	$84,858	$93,693	$98,758	$117,041	$130,535	$134,304
Average per ton	$6.21	$6.30	$6.22	$6.68	$7.03	$6.93
Sold or used by producers	13,491	14,757	16,065	17,202	17,842	19,060
P_2O_5 content	4,255	4,616	5,014	5,352	5,551	5,927
Value	$84,392	$92,842	$99,657	$115,363	$125,593	$134,222
Average per ton	$6.26	$6.29	$6.20	$6.71	$7.04	$7.04
Imports for consumption [2]	112	108	140	129	134	134
Value	$2,809	$2,944	$3,421	$3,754	$3,629	$3,551
Average per ton	$25.08	$27.21	$24.45	$29.04	$27.08	$26.57
Exports [3]	2,444	2,694	3,048	3,994	3,918	3,934
P_2O_5 content	801	887	956	1,290	1,261	1,269
Value	$15,643	$18,060	$20,466	$26,632	$26,924	$27,567
Average per ton	$6.40	$6.70	$6.71	$6.67	$6.87	$7.01
Consumption, apparent [4]	11,159	12,171	13,157	13,337	14,058	15,260
World: Production	30,430	35,110	37,700	40,670	43,670	46,040

[1] P_2O_5 (phosphorus pentoxide) content estimated. Figures revised for 1957–61.
[2] Data on P_2O_5 content not available.
[3] As reported to the Bureau of Mines by domestic producers.
[4] Measured by sold or used plus imports minus exports.

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

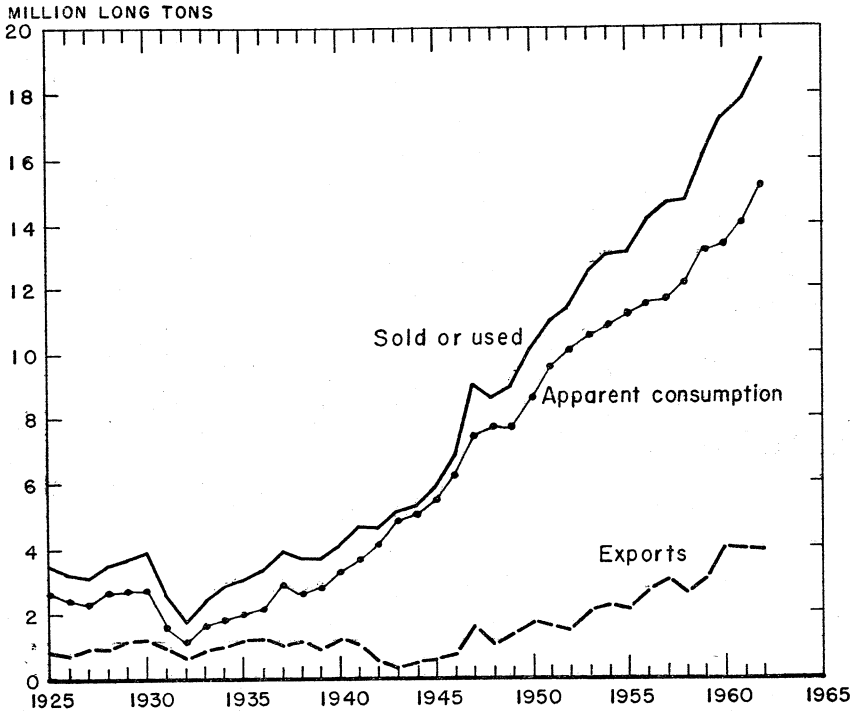

FIGURE 1.—Phosphate rock (sold or used), apparent consumption, and exports, 1925–62.

DOMESTIC PRODUCTION

The most significant increase in production of marketable phosphate rock occurred in the Western States and was 19 percent above that of 1961. Tennessee and Florida increased production 8 and 1 percent, respectively. Of the total domestic output of marketable rock 72 percent was from Florida, 16 percent from the Western States, and 12 percent from Tennessee.

The domestic phosphate industry was again quite active in 1962; new companies were formed, established companies expanded their facilities and/or built new plants, some mergers and reorganizations occurred, and new ore deposits were explored.

Des Plaines Chemical Co., a new company reportedly a joint venture of Swift & Co. and Stauffer Chemical Co., built a 150-ton-per-day wet-process phosphoric acid plant at Morris, Ill.

The largest superphosphate plant west of the Mississippi was put on stream by AFC Inc. at Bena, Calif. Production capacity of 50 tons per hour was claimed. Units for producing diammonium phosphate and ammonium sulfate were included. Armour Agricultural Chemical Co. began producing triple superphosphate at a new plant at Fort Meade, Fla. Central Farmers Fertilizer Co. started manufacturing triple superphosphate in the $400,000 addition to its Georgetown, Idaho, plant. A new plant, capable of producing 40 tons of superphosphate per hour, was opened by Central Farmers Cooperative, at Demopolis, Ala. FMC Corp. completed a $30 million renovation of its elemental phosphorus plant at Pocatello, Idaho. The Achan phosphate washing plant of International Minerals & Chemical Corp. (IMC) at Bartow, Fla., was relocated 2.5 miles south of its previous site and resumed operation with additional capacity. Kaiser Aluminum & Chemical Corp. planned the construction of a plant at Gramercy, La., to produce phosphoric acid employing the hydrochloric acid process developed and patented by Israel Mining Industries, Haifa, Israel. Northwest Cooperative Mills, Inc., St. Paul, Minn., began operating its $4 million phosphoric acid plant at Pine Bend, Minn. The plant was expected eventually to produce ammonium phosphate at the rate of 100,000 tons per year. Rocky Mountain Phosphates, Inc., began constructing a new $3 million phosphate processing plant at Garrison, Mont. The plant was scheduled for completion in December, when the company would move its operations from the leased plant at Butte, Mont. Tennessee Valley Authority (TVA) was constructing a 25,000-kilowatt, $3 million rotating electric phosphorus furnace at its Muscle Shoals, Ala., facilities. The new furnace with a capacity of about 16,500 tons per year was to replace older less efficient equipment without increasing the plant's total capacity. Swift & Co. prepared to open a new phosphate mine at the old abandoned town of Silver City, near Agricola, Fla. The new open-pit mine was to replace production lost when the Varn mine east of Fort Meade was shut down late in the year because ore reserves were depleted. A new 150,000-ton-per-year diammonium phosphate plant was built by Swift & Co. adjacent to its facilities at Harvey, La.

TABLE 2.—Mine production of phosphate-rock ore in the United States, by States

(Thousand long tons)

Year	Florida		Tennessee [1]		Western States [2]		Total United States	
	Rock	P_2O_5 content [3]	Rock	P_5O_2 content	Rock	P_2O_5 content	Rock	P_2O_5 content [3]
1953–57 (average)	39,906	4,565	2,658	548	2,047	549	44,611	5,662
1958	41,084	5,988	3,003	625	2,372	624	46,459	7,237
1959	43,365	6,323	2,709	556	3,175	813	49,249	7,692
1960	48,007	6,753	2,931	636	3,400	893	54,338	8,282
1961	54,403	7,552	3,321	734	2,811	740	60,535	9,026
1962	49,600	7,093	3,812	855	3,334	875	56,746	8,823

[1] Includes brown rock, white rock in 1953–58, and blue rock in 1954–58.
[2] Includes Idaho, Montana, Utah, and Wyoming.
[3] Estimate. Figures revised for 1957–61.

IMC sold a half interest in the mineral rights of three sections of Polk County, Fla., to Gibson Industries, Inc. This was a three-way $2 million transaction that also involved a Chicago bank. It was reported that IMC was bound by the agreement to produce and process at least 450,000 tons of phosphate rock annually from the tract. Cities Service Co. negotiated a merger with Tennessee Corp. by which they were to acquire the business and assets of the latter. The merger was subject to stockholders' approval early in 1963. Virginia-Carolina Chemical Corp. traded about 1,000 acres of land in Hillsborough County, Fla., to Exchange National Bank of Tampa for two tracts of land near Fort Meade, Fla. It was expected that the Hillsborough County tract would eventually be sold to American Cyanamid Co., operators of the nearby Sydney mine.

Collier Carbon & Chemical Corp. hired Global Marine Exploration Co. to dredge samples from the ocean floor about 40 miles west of San Diego, Calif. The area of 30,000 acres contains phosphorus-rich pebbles and boulders and might become a major new source of phosphates. A $6 million phosphate-rock mining development was planned for the Douglas property, 75 miles southeast of Missoula, Mont., by the Montana Phosphate Products Co., a subsidary of Consolidated Mining & Smelting Co., of Canada, Ltd. The project, including underground development of adits to reach the deposits and the construction of a floatation mill and mine service buildings, was scheduled to begin early in 1963 and to be in operation in 1964. The American Agricultural Chemical Co. and Kennecott Copper Corp. jointly formed a new company, Pamlico Mining and Chemical Corp. to explore and possibly develop a large phosphate deposit in North Carolina. The new company acquired the Bear Creek Mining Co. interests in Beaufort County. Magnet Cove Barium Corp. and Texas Gulf Sulphur Co. also planned to explore for phosphate deposits in the same general area. Both companies completed contracts with the State of North Carolina for leases on areas of river bottoms. Magnet Cove was to pay the State 3.7 percent of the gross sales of marketable phosphate rock removed from the bottom of the Pungo River, Beaufort County, and Texas Gulf was to pay 12.5 percent of the gross values of phosphates taken from the Pamlico River bottom. The leases contained stringent provisions to guard against stream pollution. Susquehanna-Western, Inc., was granted phosphate prospecting permits on 4,024 acres of Federal land southeast of Lander, Wyo., by the Bureau of Land Management. An application for 640 more acres in the same area was under consideration.

The residents of Mount Pleasant, Tenn., voted in favor of issuing up to $5 million in industrial revenue bonds to build a new elemental phosphorus plant for Virginia-Carolina Chemical Corp. The company was expected to invest about $3 million in the project, and construction was to begin early in 1963.

TABLE 3.—Marketable production of phosphate rock in the United States, by States

(Thousand long tons)

Year	Florida [1]		Tennessee [2]		Western States [3] [4]		Total United States	
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content
1953-57 (average)	10,106	3,357	1,623	423	1,934	530	13,663	4,310
1958	10,851	3,593	1,903	495	2,125	580	14,879	4,668
1959	11,564	3,794	1,755	458	2,550	687	15,869	4,939
1960	12,321	4,052	1,939	506	3,256	885	17,516	5,443
1961	13,789	4,531	2,235	575	2,535	698	18,559	5,804
1962	13,949	4,543	2,418	638	3,015	823	19,382	6,004

[1] Salable products from washers and concentrators of land pebble and hard rock, and drier production of soft rock (colloidal clay).
[2] Salable products from washers and concentrators of brown rock, brown-rock ore (matrix) used directly, blue rock in 1954-58, and white rock in 1953-58.
[3] Mine production of ore (rock), plus a quantity of washer and drier production.
[4] Includes Idaho, Montana, Utah, and Wyoming.

CONSUMPTION AND USES

The trend to greater consumption continued in 1962 with an increase of 9 percent above that of 1961. The U.S. Department of Agriculture reported a total of 2,761,294 short tons of available phosphorous pentoxide (P_2O_5 content) consumed as fertilizer during the year ending June 30, 1962. This was a 4 percent increase over the preceding fiscal year.

Producers reported to the Bureau of Mines that 5,927,000 long tons (P_2O_5 content) of phosphate rock was sold or used. Of the total, 58 percent was used in agriculture, 20 percent in chemical uses, and the remainder was exported.

TABLE 4.—Phosphate rock sold or used by producers and apparent consumption in the United States

(Thousand long tons and thousand dollars)

Year	Sold or used		Apparent consumption
	Quantity	Value	Quantity
1953-57 (average)	13,491	$84,392	11,159
1958	14,757	92,842	12,171
1959	16,065	99,657	13,157
1960	17,202	115,363	13,337
1961	17,842	125,593	14,058
1962	19,060	134,222	15,260

TABLE 5.—Florida phosphate rock sold or used by producers, by kinds

(Thousand long tons and thousand dollars)

Year	Hard rock				Soft rock [1]			
	Rock	P_2O_5 content	Value		Rock	P_2O_5 content	Value	
			Total	Average per ton			Total	Average per ton
1953-57 (average)	86	30	$705	$8.20	71	15	$453	$6.38
1958	76	27	639	8.40	51	10	405	7.94
1959	76	27	649	8.54	56	11	443	7.91
1960	74	26	639	8.64	45	9	372	8.33
1961	73	26	672	9.16	39	8	303	7.87
1962	70	25	659	9.34	33	6	275	8.39
	Land pebble				**Total**			
	Rock	P_2O_5 content	Value		Rock	P_2O_5 content	Value	
			Total	Average per ton			Total	Average per ton
1953-57 (average)	9,770	3,252	$60,516	$6.19	9,927	3,297	$61,674	$6.21
1958	10,446	3,463	66,309	6.35	10,573	3,500	67,353	6.37
1959	11,628	3,837	71,771	6.17	11,760	3,875	72,863	6.20
1960	12,132	3,984	80,905	6.67	12,251	4,019	81,916	6.69
1961	12,667	4,168	88,395	6.98	12,779	4,202	89,370	6.99
1962	13,624	4,460	93,669	6.88	13,727	4,491	94,603	6.89

[1] Includes material from waste-pond operations.

TABLE 6.—Tennessee phosphate rock[1] sold or used by producers

(Thousand long tons and thousand dollars)

Year	Rock	P_2O_5 content	Value: Total	Value: Average per ton	Year	Rock	P_2O_5 content	Value: Total	Value: Average per ton
1953-57 (average)	1,692	441	$12,298	$7.27	1960	1,927	502	$15,319	$7.95
1958	1,923	501	13,160	6.84	1961	2,291	592	19,099	8.34
1959	1,775	462	13,266	7.47	1962	2,476	654	20,173	8.15

[1] Includes small quantity of Tennessee blue rock in 1954-58 and white rock in 1953-58.

TABLE 7.—Western States phosphate rock sold or used by producers

(Thousand long tons and thousand dollars)

Year	Idaho				Montana[1]				Total			
	Rock	P_2O_5 content	Value: Total	Value: Average per ton	Rock	P_2O_5 content	Value: Total	Value: Average per ton	Rock	P_2O_5 content	Value: Total	Value: Average per ton
1953-57 (average)	1,139	300	$5,315	$4.67	[2] 733	[2] 217	[2] $5,105	$6.96	1,872	517	$10,420	$5.57
1958	1,436	370	6,370	4.44	825	245	5,959	7.22	2,261	615	12,329	5.45
1959	1,590	400	6,625	4.17	940	277	6,903	7.34	2,530	677	13,528	5.35
1960	1,973	520	10,269	5.21	1,051	311	7,859	7.47	3,024	831	18,128	5.99
1961	1,687	434	8,913	5.28	1,085	323	8,211	7.57	2,772	757	17,124	6.18
1962	1,744	444	10,164	5.83	1,113	338	9,282	8.35	2,857	782	19,446	6.81

[1] Montana includes Utah in 1953-55 and 1961-62, and Wyoming in 1953-62.
[2] Wyoming data published previously in Phosphate Rock chapters included as follows: 1953-57 (average): 36,400 long tons of rock, 11,600 tons of P_2O_5, valued at $239,400, for 1957 data only.

TABLE 8.—Phosphate rock sold or used by producers in the United States, by grades and States

(Thousand long tons)

Year and grade—B.P.L.[1] content (percent)	Florida: Quantity	Florida: Percent of total	Tennessee: Quantity	Tennessee: Percent of total	Western States: Quantity	Western States: Percent of total	Total United States: Quantity	Total United States: Percent of total
1961:								
Below 60	83	1	2,034	89	1,561	56	3,678	21
60 to 66	125	1	} 257	} 11	} 733	} 27	378	2
66 to 68	2,767	22					3,430	19
68 to 70	2,073	16			[2] 478	[2] 17	[3] 2,625	[3] 15
70 to 72	1,831	14	-------	-------	(²)	(²)	1,831	10
72 to 75	4,484	35	-------	-------	(²)	(²)	4,484	25
75 to 77	1,416	11	-------	-------	-------	-------	1,416	8
Total	12,779	100	2,291	100	2,772	100	17,842	100
1962:								
Below 60	69	1	1,984	80	1,609	56	3,662	19
60 to 66	} 2,820	} 20	[2] 459	[2] 19	} [2] 1,248	} [2] 44	704	4
66 to 68			33	1			2,541	13
68 to 70	1,509	11	(²)	(²)			2,779	15
70 to 72	3,103	23	(²)	(²)	-------	-------	[3] 3,148	[3] 17
72 to 75	4,047	29	-------	-------	(²)	(²)	4,047	21
75 to 77	[4] 2,179	[4] 16	-------	-------	-------	-------	2,179	11
Total	13,727	100	2,476	100	2,857	100	19,060	100

[1] Bone phosphate of lime, $Ca_3(PO_4)_2$.
[2] Figures combined to avoid disclosing individual company confidential data.
[3] Includes 72 to 75 grade rock in Western States.
[4] Includes some higher grade rock.

TABLE 9.—Phosphate rock sold or used by producers in the United States, by uses and States

(Thousand long tons)

Year and use	Florida		Tennessee		Western States		Total United States	
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_5O_2 content	Rock	P_2O_5 content
1961:								
Domestic:								
Agricultural:								
Ordinary superphosphate	4,316	1,454	(1)	(1)	(1)	(1)	4,462	1,501
Triple superphosphate [2]	3,924	1,296	[1] 72	[1] 23	[1] 644	[1] 201	4,494	1,473
Direct application to soil	471	144	75	23	(3)	(3)	546	167
Stock and poultry feed	} 295	} 96	------	------	(3)	(3)	295	96
Other [4]			1	(5)	20	6	21	6
Total	9,006	2,990	148	46	664	207	9,818	3,243
Industrial:								
Electric furnace manufacture of phosphorus and ferrophosphorus	377	114	2,135	544	1,586	387	4,098	1,045
Other [6]	------	------	8	2	------	------	8	2
Total	377	114	2,143	546	1,586	387	4,106	1,047
Exports [7]	3,396	1,098	------	------	522	163	3,918	1,261
Grand total	12,779	4,202	2,291	592	2,772	757	17,842	5,551
1962:								
Domestic:								
Agricultural:								
Ordinary superphosphate	4,963	1,652	(1)	(1)	(1)	(1)	4,963	1,652
Triple superphosphate [2]	4,089	1,341	------	------	[1] 686	[1] 215	[8] 4,810	[8] 1,567
Direct application to soil	} 694	} 217	} [1] 103	} [1] 32	(1)	(1)	493	153
Stock and poultry feed					(1)	(1)	266	84
Other [4]	------	------	(1)	(1)	(1)	(1)	3	1
Total	9,746	3,210	103	32	686	215	10,535	3,457
Industrial:								
Electric furnace manufacture of phosphorus and ferrophosphorus	592	183	2,366	620	1,626	396	4,584	1,199
Other [6]	------	------	7	2	------	------	7	2
Total	592	183	2,373	622	1,626	396	4,591	1,201
Exports [7]	3,389	1,098	------	------	545	171	3,934	1,269
Grand total	13,727	4,491	2,476	654	2,857	782	19,060	5,927

[1] Figures are combined to avoid disclosing individual company confidential data.
[2] Includes rock for phosphoric acid (wet process).
[3] Included with "Other" agricultural.
[4] Includes phosphate rock used in calcium metaphosphate, fused tricalcium phosphate, nitraphosphate, fertilizer filler, and other applications.
[5] Less than 1,000 tons.
[6] Includes phosphate rock used in pig iron blast furnaces, parting compounds, research, defluorinated phosphate rock, refractories, and other applications.
[7] As reported to the Bureau of Mines by domestic producers.
[8] Includes ordinary superphosphate in Tennessee and the Western States.

STOCKS

Producers' yearend stocks were 7 percent higher than at the end of 1961.

TABLE 10.—Producer stocks of phosphate rock, December 31[1]

(Thousand long tons)

Source	1961		1962	
	Rock	P_2O_5 content	Rock	P_2O_5 content
Florida	3,494	[2] 1,148	3,716	1,200
Tennessee [3]	202	57	144	41
Western States	[2] 755	[2] 205	913	246
Total	[2] 4,451	1,410	4,773	1,487

[1] As reported to the Bureau of Mines by domestic producers.
[2] Revised figure.
[3] Includes a quantity of washer-grade ore (matrix).

PRICES

Prices for Florida land-pebble phosphate rock, based on fuel oil at $2.52 per barrel and labor at $1.72 per hour, remained steady through April, according to quotations by Oil, Paint and Drug Reporter. Based on a drop in the price of fuel oil to $2.35 per barrel, on May 21, 1962, phosphate-rock prices decreased and remained steady through December.

TABLE 11.—Prices of Florida land pebble, unground, washed, and dried phosphate rock, in bulk, carlots, at mine, in 1962

(Per short ton)

Grade (percent B.P.L.)	January 1	December 31
66 to 68	$5.22	$5.135
68 to 70	6.08	5.995
70 to 72	6.66	6.575
74 to 75	7.57	7.475
76 to 77	8.45	8.365

Source: Oil, Paint and Drug Reporter.

FOREIGN TRADE[3]

Imports.—There was no significant difference in the quantity of imported crude phosphates from that of 1961. However, the amount of superphosphates imported for consumption was 18 times as much as that for 1961, and ammonium phosphate imports were higher by 43 percent.

TABLE 12.—U.S. imports for consumption of phosphate rock and phosphatic fertilizers

Fertilizer	1961		1962	
	Long tons	Value	Long tons	Value
Phosphates, crude, not elsewhere specified	134,004	$3,628,897	133,628	$3,550,900
Superphosphates (acid phosphate):				
Normal (standard)	1,151	24,797	13,860	325,260
Concentrated (treble)	1,946	135,522	44,352	2,692,284
Ammoniated	140	10,188	954	48,455
Total superphosphates	3,237	170,507	59,166	3,065,999
Ammonium phosphates, used as fertilizer	100,887	7,471,148	144,722	9,642,213
Bone dust, or animal carbon and bone ash, fit only for fertilizer	9,673	786,542	9,577	578,166
Guano	9,362	977,754	3,946	395,724
Slag, basic, ground or unground	46	1,281	2,012	156,516
Dicalcium phosphate (precipitated bone phosphate) all grades	10,149	516,673	9,193	433,720

Source: Bureau of the Census.

Exports.—According to the Bureau of the Census the quantity of phosphate rock exported in 1962 was less than 3 percent greater than in 1961. The value of exported rock, however, was 5 percent higher. Japan remained the major consumer, receiving 28 percent of the total tonnage. During the past 2 years, exports to Japan have been decreasing. A greater demand for superphosphates in foreign countries was reflected in the total tonnage exported, which increased 19 percent over 1961. The quantity of superphosphate shipped to the Republic of Korea more than doubled that shipped in 1961, so that country became the leading customer for U.S. superphosphate fertilizer.

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

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TABLE 13.—U.S. exports of phosphate rock, by grades and countries

Grade and destination	1961 Long tons	1961 Value	1962 Long tons	1962 Value
Florida phosphate rock:				
North America:				
Canada	378,216	$3,532,409	457,901	$4,412,134
Costa Rica	295	3,147	397	4,628
El Salvador	171	2,121		
Haiti	28	290		
Mexico	62,998	465,764	124,757	1,007,446
South America:				
Brazil	44,332	495,219	60,059	627,027
Chile	1,922	28,362	202	3,312
Colombia	3,124	38,190	4,418	59,789
Peru	11,991	112,638	15,890	152,003
Uruguay	12,890	147,688	737	17,948
Venezuela	627	8,999	855	16,138
Europe:				
Belgium-Luxembourg	3,029	31,798	2,484	22,977
Denmark	52,638	477,099	17,082	164,674
France	11,106	111,279	23,510	223,283
Finland	26,169	246,547		
Germany, West	298,248	2,468,450	364,616	3,065,579
Greece	20,871	187,839		
Italy	682,722	5,683,487	724,568	6,013,433
Netherlands	160,479	1,496,525	135,574	1,311,839
Norway	7,838	74,458		
Spain	30,072	270,548	157,099	1,458,299
Sweden	43,649	450,834	49,361	485,343
Switzerland	3,968	41,092	2,184	22,386
United Kingdom	266,206	2,289,819	280,924	2,318,557
Asia:				
India	1,005	6,241		
Israel	39	872		
Japan	1,316,373	10,638,961	1,200,036	9,752,186
Pakistan	62	526		
Philippines	34,508	304,443	18,833	182,010
Singapore			904	21,000
Taiwan	36,874	344,551	19,397	178,943
Viet-Nam	743	13,137	14,216	261,892
Africa:				
British East Africa			300	4,583
South Africa, Republic of [1]	877	6,225		
Total	3,514,070	29,979,558	3,676,304	31,787,409
Other phosphate rock: [2]				
North America:				
Bahamas			27	638
British Honduras	29	400	63	587
Canada	583,915	6,656,144	543,220	6,805,295
Mexico	51	754		
South America:				
Brazil			5,503	51,839
Uruguay	11,058	114,517		
Venezuela	5,876	62,092	567	7,260
Europe:				
Belgium-Luxembourg			1,500	19,125
Germany, West			63	533
Italy	208	12,227	9,845	90,027
United Kingdom	249	2,802	16	254
Asia:				
Taiwan	5,717	53,670		
Viet-Nam	1,559	27,490	1,950	69,140
Africa: South Africa, Republic of			62	636
Total	608,662	6,930,096	562,816	7,045,334
Grand total	4,122,732	36,909,654	4,239,120	38,832,743

[1] Effective Jan. 1, 1962, formerly Union of South Africa.
[2] Includes colloidal matrix, sintered matrix, soft phosphate rock, and Tennessee, Idaho, and Montana rock.

Source: Bureau of the Census.

TABLE 14.—U.S. exports of superphosphates (acid phosphates), by countries

Destination	1961		1962	
	Long tons	Value	Long tons	Value
North America:				
Bahamas	397	$16,211	467	$19,613
British Honduras			94	7,160
Canada	167,316	5,347,166	138,292	4,294,965
Costa Rica	1,817	108,753	2,390	145,669
Dominican Republic	4,730	329,193	4,340	257,449
El Salvador	835	41,009		
Guatemala	357	22,357	13	1,440
Honduras	27	2,201	193	13,416
Jamaica	93	6,529	30	2,125
Mexico	35,805	2,382,159	5,210	382,972
Nicaragua	45	1,275	45	1,200
Panama	277	17,988	93	5,417
Other	69	4,507	4	280
South America:				
Argentina	1,477	43,587	1,313	71,879
Brazil	58,205	2,965,214	40,227	1,937,807
Chile	46,797	2,902,751	70,149	4,109,446
Colombia	1,525	102,160	12,800	744,744
Ecuador	329	22,425	596	40,945
Peru	53	5,655	149	12,893
Venezuela	7,620	485,488	6,995	310,274
Other	29	938	4	316
Europe:				
Belgium-Luxembourg			8,911	81,333
Denmark	40	1,000	33	700
Germany, West	344	18,662		
Netherlands	12,587	644,926	39,871	1,719,500
Sweden			201	4,150
United Kingdom	8	684	46	987
Asia:				
India	1,476	96,960		
Indonesia	37,822	2,125,982	21,221	1,497,608
Korea, Republic of	88,586	5,966,056	198,171	11,618,869
Nansei and Nanpo Islands			3,750	254,282
Philippines	491	31,000	34	2,211
Viet-Nam			2,416	142,130
Other	40	2,654	41	2,982
Africa: Ghana			67	3,650
Oceania: Australia			22	1,547
Total	469,197	23,695,490	558,188	27,689,959

Source: Bureau of the Census.

WORLD REVIEW

NORTH AMERICA

Canada.—Cyanamid of Canada, Ltd., began production in a new plant at Welland, Ontario. The new Can$3 million facility became eastern Canada's first producer of diammonium phosphate, ammonium phosphate, and triple superphosphate.[4] Consolidated Mining & Smelting Co. of Canada, Ltd. (Cominco), planned a Can$11 million expansion project which would double its phosphate fertilizer capacity at Kimberley, British Columbia, raising it to 170,000 tons per year. Construction was scheduled for completion in 1964.[5]

Mexico.—Fertilizantes del Istmo, S.A., was constructing a fertilizer plant at Minatitlan, Veracruz. The new facility, part of a large installation already producing nitrogenous fertilizers, included a 50 ton-per-day phosphoric acid plant which was expected to use Florida pebble phosphate.[6]

[4] Commercial Fertilizer. V. 105, No. 6, December 1962, pp. 52, 53.
[5] Chemical Week. Doubling in Phosphate. V. 90, No. 19, May 12, 1962, p. 22.
[6] Phosphorus & Potassium (London). Mexico's Phosphate Fertilizer Position. No. 4, December 1962, p. 7.

TABLE 15.—World production of phosphate rock by countries [1] [2]

(Thousand long tons)

Country [1]	1953–57 (average)	1958	1959	1960	1961	1962
North America:						
United States	13,663	14,879	15,869	17,516	18,559	19,382
Netherlands Antilles (exports)	107	85	97	113	150	[3] 130
Total [1]	13,770	14,964	15,966	17,629	18,709	19,510
South America:						
Brazil:						
Apatite	} 102	111	131	200	240	[3] 240
Phosphate rock		524	860	666	402	[3] 400
Chile:						
Apatite	49	19	19	17	14	12
Guano	37	31	21	[3] 21	17	16
Peru (guano)	289	164	125	155	156	157
Venezuela	[4] 35	------	------	------	------	------
Total	512	849	1,156	1,059	829	[3] 825
Europe:						
Belgium	25	18	13	8	14	[3] 14
France	97	102	76	57	40	[3] 40
Poland	37	70	40	40	46	55
Spain	15	------	------	3	------	------
Sweden (apatite)	2	------	------	------	------	------
U.S.S.R.:						
Apatite [3]	3,390	3,940	3,940	4,230	4,530	5,120
Sedimentary rock [3]	1,450	1,970	1,970	2,260	3,050	3,450
Total [3]	5,020	6,100	5,040	6,600	7,680	8,680
Asia:						
China [3]	160	300	500	600	500	600
Christmas Island (Indian Ocean) (exports)	340	374	494	503	694	513
India (apatite)	6	15	14	15	20	29
Indonesia	2	2	10	7	9	2
Israel	83	206	201	221	222	226
Jordan	147	289	332	356	416	450
Korea, North	(5)	(5)	(5)	(5)	[3] 50	[3] 50
Philippines:						
Guano	3	7	(6)	10	(6)	(6)
Phosphate rock	------	1	------	(6)	------	4
Viet-Nam, North:						
Apatite	(5)	133	256	482	568	[3] 600
Phosphate rock	(5)	32	50	50	[3] 50	[3] 50
Total [1] [3]	820	1,390	1,890	2,280	2,530	2,520
Africa:						
Algeria	663	552	563	554	419	384
Malagasy Republic	3	5	7	5	------	------
Morocco	5,038	6,236	7,050	7,354	7,824	8,033
Mozambique (guano)	[7] 1	(6)	(6)	(6)	(6)	(6)
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	------	------	2	3	(6)	------
Senegal:						
Aluminum phosphate	78	103	94	104	137	139
Calcium phosphate	10	------	------	106	401	[3] 490
Seychelles Islands (guano)	6	17	6	7	8	[3] 8
South Africa, Republic of	125	213	228	263	292	302
South-West Africa (guano)	1	------	1	------	1	1
Togo	------	------	------	------	278	[3] 360
Tunisia	1,946	2,243	2,150	2,063	1,950	2,064
Uganda	4	2	3	4	(6)	1
United Arab Republic (Egypt)	564	549	668	558	617	[3] 620
Total [1]	8,439	9,920	10,772	11,021	11,927	12,402

See footnotes at end of table.

TABLE 15.—World production of phosphate rock by countries [1] [2]—Continued

(Thousand long tons)

Country [1]	1953–57 (average)	1958	1959	1960	1961	1962
Oceania:						
Angaur Island (exports)	74					
Australia	7	7	5	2	5	[3] 4
Makatea Island (French Oceania)	257	320	362	407	404	[3] 322
Nauru Island (exports)	1,235	1,234	1,192	1,351	1,282	1,516
Ocean Island (exports)	295	324	314	320	301	257
Total	1,868	1,885	1,873	2,080	1,992	2,099
World total (estimate) [1] [2]	30,430	35,110	37,700	40,670	43,670	46,040

[1] A negligible amount of phosphate rock is produced in Jamaica, Japan, Sarawak, Somalia Republic, and Tanganyika.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Estimate.
[4] Average annual production 1956–57.
[5] Data not available; estimate by senior author of chapter included in the total.
[6] Less than 500 tons.
[7] Average annual production 1955–57.
[8] Exports.

Compiled by Liela S. Price, Division of Foreign Activities.

SOUTH AMERICA

Argentina.—Villa Aufricht & Cia. put into operation a thermal-process phosphoric acid plant. Imported phosphorus was used as raw material, but production of phosphorus in southern Argentina was planned.[7]

Brazil.—Three new superphosphate plants were planned for construction and operation by the end of 1963 at Saõ Paulo. Each of two plants was to have an annual capacity of 120,000 tons and the third one, 60,000 tons.[8]

Peru.—Midepsa Industries, Ltd., of Montreal, Canada, owners of 93.6 percent of Minerales Industriales del Peru, S.A., completed an agreement with Homestake Mining Co. of San Francisco, Calif., to develop its large phosphate property in Peru. Homestake was to spend from US$200,000 to US$1 million for technical and marketing studies before June 30, 1963. At any time before this date, Homestake had an option to invest up to US$21 million in production and marketing facilities. In return, Homestake was to receive a 46-percent interest in the properties and assume operating control.[9]

Venezuela.—A pilot plant was erected close to a large newly discovered phosphate deposit near Lobatera, Tachira. A processing plant was planned.[10] The Instituto Venezolano de Petroquimica estimated the phosphorite reserves in the Riecito mines at 12.4 million tons.[11]

[7] Oil, Paint and Drug Reporter. Phosphoric Acid Plant Completed in Argentina. V. 181, No. 11, Mar. 12, 1962, p. 5.
[8] Foreign Trade (Ottawa). V. 118, No. 3, Aug. 11, 1962, p. 20.
[9] Mining World. What's Going On in the Mining World. V. 24, No. 12, November 1962, p. 19.
[10] Rock Products. V. 65, No. 3, March 1962, p. 65.
[11] Fertiliser and Feeding Stuffs Journal (London). Phosphorite in Venezuela. V. 57, No. 6, Sept. 19, 1962, p. 238.

EUROPE

France.—The phosphatic fertilizer industry began a major expansion phase with plans for at least four new wet-process phosphoric acid plants.[12]

Germany, West.—A new 50,000-kilowatt, 22,000-ton-per-year phosphorus furnace was planned by Knapsack-Griesheim, A. G., a subsidiary of Hoechst, A. G., for its plant at Knapsack. The new unit was scheduled for operation early in 1964.[13]

Hungary.—A new superphosphate plant with an estimated capacity of 200,000 tons per year was scheduled to start operating at Szolnok by the end of the year.[14]

Greece.—An agreement between Commercial and Ionian-Popular Banks of Greece and the French firm Compagnie pour l'Étude de Développement des Eschanges Commerciaux (COMPADEC) was made, whereby a 250,000-ton-per-year phosphatic fertilizer plant would be constructed at Nea Karvali in eastern Macedonia. COMPADEC was to furnish 80 percent of the estimated US$33 million cost.[15]

Netherlands.—Eerste Nederlandse Co-operatieve Kunstmestfabriek planned to start during 1963 a second phosphoric acid plant which would double the firm's capacity.[16]

Poland.—The capacity of the new superphosphate plant at Lubon, Posen, was increased to 380,000 tons per year after only a few months of operation. The original plant was designed to produce 200,000 tons annually.[17] A new superphosphate plant at Tarnobrzeg began operating early in 1962 and by December attained an annual production rate of 100,000 tons.[18]

Rumania.—A 10,000-ton-per-day phosphoric acid plant and sodium tripolyphosphate facility was planned. Union Chimique Belge, S.A., was to supply the engineering services, supervise the construction and initial operation, and train the operating personnel.[19]

Spain.—A new company was being organized by Instituto Nacional de Industria to exploit phosphate-rock deposits in Sahara Province.[20]

Turkey.—As a result of Turkish-U.S. cooperation, some high-grade phosphate-rock deposits were located in the Gaziantep and Adiyaman area, southeastern Anatolia.[21]

United Kingdom.—A 150,000-ton (P_2O_5 equivalent) phosphoric acid plant for Immingham was included in the expansion plans of Fisons Ltd.[22]

A new phosphoric acid plant was installed at Saxilby, Lincolnshire, for Lindsey and Kesteven Fertiliser, Ltd. The plant was capable of producing 25 tons of acid per day initially.[23]

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[12] Phosphorus & Potassium (London). Phosphate Rock Supplies to the E.E.C. No. 2, June 1962, pp. 1–6.
[13] Phosphorus & Potassium (London). No. 3, September 1962, p. 49.
[14] Sulphur Institute News. V. 2, No. 9, September 1962, p. 3.
[15] Bureau of Mines. Mineral Trade Notes. V. 56, No. 1, January 1963, p. 31.
[16] Chemical Trade Journal and Chemical Engineer (London). Fertilisers in Holland, V. 151, No. 3940, Dec. 7, 1962, p. 1163.
[17] Sulphur Institute News. V. 2, No. 10, October 1962, pp. 2, 3.
[18] Chemical Age (London). Polish Superphosphate Plant Produces First 100,000 Tons. V. 88, Nos. 2267/8, Dec. 22/29, 1962, p. 959.
[19] Engineering and Mining Journal. V. 163, No. 5, May 1962, p. 138.
[20] Commercial Fertilizer. V. 104, No. 4, April 1962, p. 43.
[21] Bureau of Mines. Mineral Trade Notes. V. 55, No. 6, December 1962, pp. 32–33. Bureau of Mines. Mineral Trade Notes. V. 56, No. 1, January 1962, pp. 34–35.
[22] Sulphur Institute News. V. 2, No. 10, October 1962, p. 2.
[23] Chemical Trade Journal and Chemical Engineer (London). New Phosphoric Acid Plant. V. 150, No. 3900, Mar. 2, 1962, p. 436.

ASIA

India.—The new 50,000-ton-per-year superphosphate plant of Blue Mountain Estates and Industries, Ltd., at Ennore, near Madras, began production in August. Granulated superphosphate was manufactured for the first time in India. Phosphate rock and sulfur were imported from Egypt, Jordan, and Morocco.[24] An estimated US$50 million fertilizer facility near Koyli, Gujarat, was planned. Units to produce annually 90,000 tons of urea, 1,250,000 tons of ammonium phosphate, and 200,000 tons of ammonium sulfate were included in the project.[25]

Indonesia.—A 100,000-ton-per-year triple superphosphate plant was being constructed with U.S.S.R technical and financial aid at Tjilatjap, central Java. The plant was scheduled for production in late 1964 or early 1965.[26]

Israel.—Proved reserves of phosphate at Oron were revised upward to 70 million tons as reported by Barclays Bank D.C.O. The revised estimate was the result of a recent geological survey of the area.[27] Israel-American Phosphates Co. (IAP) established reserves of over 25 million tons of phosphate, containing 27 to 28 percent P_2O_5 most of which was south of Beersheva. Plans were made by IAP to begin prospecting at Ein Yahav, where higher grade phosphates had been reported.[28] A merger of Negev Phosphates Co., Ltd., and Fertilizers and Chemicals, Ltd., was approved by the Israeli Cabinet. Israel Investors Corp (New York) was to be offered a 50-percent share in the merged company.[29] Plans were made to establish a mining and chemical industry at Oron within 3 years. Four units were to be built, a phosphate calcining plant, a triple superphosphate plant, a defluorination plant, and a soda ash plant.[30]

Japan.—The 3,600-ton-per-year phosphoric acid plant of Toyo Soda Manufacturing Co. began production using Israel Mining Industries' hydrochloric acid process. Initial production of 89-percent acid employed waste hydrochloric acid from the adjacent plant of Nippon Polyurethane Co.[31]

Jordan.—Bids were opened for planning the exploitation of phosphate deposits in southern Khass province. It was estimated that by 1965 phosphate could be produced at the rate of 1.5 million tons per year.[32] The Jordan Development Board signed a contract with Ralph M. Parsons Co. of Los Angeles, Calif., on August 30, to act as engineering consultants in developing the Al Hasa phosphate deposits. The contract included geological surveys, engineering, and supervision of construction.[33]

Lebanon.—Plans were made to develop phosphate-rock deposits near Hasbaya in the south Beka'a Valley as a possible source of raw material for superphosphate manufacture.[34]

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[24] Fertiliser and Feeding Stuffs Journal (London). V. 57, No. 7, Oct. 3, 1962, p. 292.
[25] Chemical Engineering. V. 69, No. 8, Apr. 16, 1962, p. 211.
[26] Phosphorus & Potassium (London). No. 1, April 1962, p. 14.
[27] Mining Journal (London). V. 259, No. 6636, October 1962, p. 390.
[28] Bureau of Mines. Mineral Trade Notes. V. 54, No. 4, April 1962, p. 20.
[29] Chemical Week. V. 91, No. 3, July 21, 1962, p. 50.
[30] Foreign Trade (Ottawa, Canada). V. 118, No. 11, Dec. 1, 1962, p. 26.
[31] Phosphorus & Potassium (London). No. 3, September 1962, p. 14.
[32] Chemical Week. V. 90, No. 22, June 2, 1962, p. 34.
[33] Bureau of Mines. Mineral Trade Notes. V. 55, No. 5, November 1962, pp. 36, 37.
[34] Bureau of Mines. Mineral Trade Notes. V. 55, No. 3, September 1962, pp. 61, 62.

Viet-Nam, North.—Construction was started on North Viet-Nam's first chemical fertilizer plant, which was to have a capacity of 100,000 tons of superphosphate per year.[35]

AFRICA

Algeria.—A new company, Société du Djebel Onk, was organized to exploit the Djebel Onk phosphate deposits in eastern Algeria. The benefication plant under construction was scheduled to begin operating in 1963 at the rate of 600,000 tons annually.[36]

Morocco.—Construction of the Safi Chemical complex, which began in April, was scheduled for completion in 32 months. Several Moroccan companies were furnishing about 40 percent of the estimated cost of US$25 million. The contract for building the superphosphate plant was held by the French firm, Krebs. Lurgi, of West Germany, was to erect the sulfuric acid plant. Blaw-Knox Chemical Engineering Co. (United States) was awarded a contract for the general engineering and supervision of the entire project. Annual capacities expected were triple superphosphate, 200,000 tons; phosphoric acid, 150,000 tons; and sulfuric acid, 500,000 tons.[37] The managing director of Office Chérifien des Phosphates, the Moroccan state phosphate agency, acquired an 8-percent holding in Compagnie des Phosphates de Constantine, and became a member of the board of this Algerian phosphate company.[38]

Rhodesia and Nyasaland, Federation of.—Plans for establishing a phosphate mining plant at Dorowafi in Sabi Valley, Southern Rhodesia, were postponed indefinitely by African Explosives & Chemical Industries, Ltd. The postponement followed the Federal Government's denial of the company's application for a protective import duty on all phosphatic fertilizers.[39]

Senegal.—International Minerals & Chemical Corp. (IMC), Skokie, Ill., became a partner in the high-grade phosphate mine operation near Dakar. IMC signed the agreement with the director-general of the Bank de Paris et des Pays Bas, representative of the French interests who, with the Senegalese government, owned the Compagnie Sénégalaise de Phosphates de Taiba. Other major partners in the company included Sociéte Pierrefitte, a French chemical and fertilizer producer; Compagnie Financière pour l'Outre Mer, a French investment firm; and Péchiney, Compagnie de Produits Chimiques et Electrometallurgiques, Compagnie de Saint-Gobain S.A., the leading French aluminum producer and a major chemical company.[40]

South Africa, Republic of.—Phosphate Development Corp., Ltd. at Phalaborwa, expected to produce phosphate concentrate at the annual rate of 360,000 tons by the end of 1962. The Committee of Enquiry Into the Fertilizer Industry in the Republic of South Africa proposed that a third inland superphosphate plant be established at Pha-

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[35] Sulphur Institute News. V. 2, No. 10, October 1962, p. 2.
[36] Bureau of Mines. Mineral Trade Notes. V. 55, No. 2, August 1962, p. 54.
[37] Bureau of Mines. Mineral Trade Notes. V. 55, No. 1, July 1962, p. 46.
[38] Chemical Age (London). Morocco Takes Interest in Algerian Phosphates. V. 88, No. 2261, Nov. 10, 1962, p. 728.
[39] Mining Journal (London). Phosphate Plans Postponed. V. 258, No. 6613, May 18, 1962, p. 512.
[40] Mining World and Engineering Record (London). International Minerals in African Phosphate Deal. V. 178, No. 4560, March 1962, p. 73.

TABLE 16.—Selected African countries: Exports of phosphate rock in 1962, by countries

(Long tons)

Destination	Algeria	Morocco	Senegal	Togo	Tunisia	Total
North America:						
Canada		11,811				11,811
United States				11,860		11,860
South America:						
Brazil		30,011		13,915		43,926
Chile			5,905			5,905
Uruguay			24,015		23,572	47,587
Europe:						
Austria		153,165				153,165
Belgium		783,909		787		784,696
Bulgaria		23,737			61,147	84,884
Czechoslovakia		116,370			64,771	181,141
Denmark		211,567	6,201		18,789	236,557
Finland		79,611				79,611
France	145,961	1,199,370	94,602	21,899	488,953	1,950,785
Germany, West	7,390	719,593	87,095	13,238	63,564	890,880
Greece		90,790		3,760	61,300	155,850
Hungary		40,448				40,448
Ireland	4,668	209,020				213,688
Italy	48,238	290,410		39,319	392,299	770,266
Netherlands		368,677	32,775	9,190	40,292	450,934
Norway		54,289			5,019	59,308
Poland		506,509			53,842	560,351
Portugal		230,442				230,442
Spain	174,599	654,521	5,238		31,303	865,661
Sweden		270,210	16,951		24,115	311,276
Switzerland		25,089			3,081	28,170
United Kingdom	2,362	866,733		8,866	38,382	916,343
Yugoslavia		1,817		20,334	141,337	163,488
Asia:						
China		126,350				126,350
India		85,208			127,754	212,962
Indonesia	12,303					12,303
Japan		212,755	53,674	38,434	36,110	340,973
Taiwan		46,264		3,248		49,512
Turkey		26,406			18,798	45,204
Africa:						
Canary Islands		8,532				8,532
Rhodesia and Nyasaland, Federation of		56,604				56,604
South Africa, Republic of		329,074	10,088	11,449	70,099	420,710
Oceania: New Zealand	5,039					5,039
Total	400,560	7,829,292	336,544	196,299	1,764,527	10,527,222

Compiled from Customs Returns by Virginia G. Huguley and Corra A. Barry, Division of Foreign Activities.

laborwa as a consortium project shared by Federale Volksbeleggings (National Investment Corp.) farmer's cooperatives, and other fertilizer interests. The superphosphate plant already operated by Fisons, Ltd., at Sasolburg was expanded, and a second plant was under construction by African Explosives & Chemical Industries, Ltd., at Modderfontein.[41]

Tunisia.—A new Tunisian company, NPK Engrais S.A.T., planned to construct and operate a triple superphosphate plant at the Port of Sfax. International Finance Corp. (IFC), Aktiebolaget Forenade Superfosfatfabriker (Sweden), and Freeport International, Inc., a subsidiary of Freeport Sulphur Co., agreed to finance the project. The plant was planned for operation in 1965 with a capacity of 150,000 tons.[42]

[41] Bureau of Mines. Mineral Trade Notes. V. 56, No. 2, February 1963, pp. 47, 48.
[42] International Commerce (U.S. Department of Commerce). U.S. Firm Joins in IFC Loan to Tunisian Phosphate Plant. V. 68, No. 25, Dec. 3, 1962, p. 35.

TABLE 17.—United Arab Republic (Egypt): Exports of phosphate rock by countries

(Long tons)

Destination	1960	1961 [1]
Ceylon	57,746	48,198
Czechoslovakia	4,444	27,853
India	91,649	100,621
Italy	4,941	----------
Japan	89,531	75,520
Spain	28,616	----------
Yugoslavia	19,910	----------
Other countries	65	7,780
Total	296,902	259,972

[1] January through September, inclusive.

Source: Customs Returns of United Arab Republic (Egypt).

Compiled by Virginia G. Huguley and Corra A. Barry, Division of Foreign Activities.

United Arab Republic (Egypt).—A contract for building a superphosphate plant at Assiut was awarded to a West German firm. Initial production was expected by July 1964.[43]

OCEANIA

Australia.—An announcement was made that the first phosphoric acid plant in Australia would be built at Port Kembla for Australian Fertilisers, Ltd. The plant was to have a nominal capacity equivalent to 100 tons P_2O_5 per day.[44] Exploration continued in the newly discovered phosphate occurrences near Rum Jungle, Northern Territory. The discovery was made by the Bureau of Mineral Resources while prospecting for uranium. Four deposits were found within a distance of about 2 miles, and more were believed to exist under the soil cover.[45] The increasing domestic need for phosphatic fertilizers stimulated the search for new sources of supply.[46]

TECHNOLOGY

In an investigation of several sedimentary phosphate samples of different origin the uranium content increased with increasing P_2O_5 content and with decreasing sulfate content.[47]

A new evaporation technique using radiofrequency was investigated for concentrating phosphoric acid. This novel method of concentrating aqueous solutions had been tested previously by Universal Foods, Inc., Lakeland, Fla., to produce orange juice concentrate with higher solids content.[48]

Froth flotation of Tennessee and Florida phosphate slime material using a carrier technique was studied. Although the results were far from being commercially feasible, this was the first flotation

[43] Mining Journal (London). V. 259, No. 6624, Aug. 3, 1962, p. 109.
[44] Chemical Trade Journal and Chemical Engineer (London). Phosphoric Acid in Australia. V. 151, No. 3928, Sept. 14, 1962, p. 522.
[45] Commercial Fertilizer. V. 105, No. 6, December 1962, p. 39.
[46] Mining Magazine (London). V. 107, No. 2, August 1962, p. 94.
[47] Habashi, Fathi. Correlation Between the Uranium Content of Marine Phosphates and Other Rock Constituents. Econ. Geol., v. 57, No. 7, November 1962, pp. 1081–1084.
[48] Chemical Engineer. V. 69, No. 8, Apr. 16, 1962, pp. 73, 76.

concentrate obtained from the slimes. Further improvement appeared possible. Test results on Tennessee slime were superior to those obtained on the Florida material, producing about a 55-percent B.P.L. (bone phosphate of lime) recovery of 59-percent B.P.L. concentrates compared with 22.4-percent B.P.L. recovery of 49.2-percent B.P.L. concentrates.[49]

Uncalcined phosphates were used satisfactorily in phosphorus-furnace tests with different phosphate charges. The operating characteristics of the furnace were improved and the electrical energy requirements were reduced, however, when calcined phosphate was used. The tendency for segregation to occur inside the furnace was decreased and furnace performance was improved by using a uniformly sized charge of phosphates, carbon, and silica.[50]

A method of extracting carbonates from phosphorite ore was based on dissolution of sparingly soluble carbonates with aques salt solutions (sodium and magnesium chlorides and sodium, potassium, ammonium, and magnesium sulfates) at 25° C and carbon dioxide pressures from 1 to 3 atmospheres. The solubility of the carbonates was highest with potassium and magnesium sulfates. The solubility of the carbonates increased with an increase of carbon dioxide partial pressure and a decrease of temperature.[51]

Nordac, Ltd. (United Kingdom) developed a new process for producing concentrated phosphoric acid, 70- to 74-percent P_2O_5 equivalent, from wet-process acid of about 55-percent P_2O_5 equivalent. The wet-process acid was concentrated by submerged combustion in stages until no free water remained. The method was similar to the submerged-combustion method developed by Tennessee Valley Authority (TVA), but was the first such process developed in England.[52]

Western Phosphates, Inc., Salt Lake City, Utah, began using its new vacuum process commercially for concentrating 54 percent wet-process phosphoric acid to superphosphoric acid of 68 to 72 percent P_2O_5. The process was claimed to be superior to the TVA submerged-combustion method in lower capital investment and operating costs and in higher product quality.[53]

A small semiindustrial scale phosphoric acid demonstration plant was constructed at Haifa, Isreal, with a nominal production of 80 percent phosphoric acid equivalent to 1 ton of P_2O_5 per day. The purpose of the plant was to demonstrate a process to the Isreali for making high-grade phosphoric acid from phosphate rock. The plant consisted of three units, each capable of being operated for a limited time independently of the other two. The first unit included feed tanks, dissolution of the phosphate rock in hydrocloric acid, and separation of the solids from the liquor. The second unit extracted the acids with solvent, and purified the solvent extract from calcium chloride and other minor compounds. The last unit included evaporation and distillation operations necessary for the recovery of dis-

[49] Greene, Ernest W., and James B. Duke. Selective Froth Flotation of Ultrafine Minerals or Slimes. Min. Eng., v. 14, No. 10, October 1962, pp. 50–55.
[50] Barber, J. C., and E. C. Marks. Phosphorus Furnace Operations. J. Metals, v. 14, No. 12, December 1962, pp. 902–906.
[51] Shternina, E. B., and E. V. Frolova. (Extraction of Ballast Carbonates From Kara-Tau Phosphate Ore.) Zhurnal Prikladnoi Khimii (U.S.S.R.), v. 35, No. 4, April 1962, pp. 751–756.
[52] Sulphur Institute News. V. 2, No. 9, September 1962, p. 1
[53] Chemical Engineering. V. 69, No. 13, June 25, 1962, p. 53.

solved solvent and for the separation and concentration of the product.[54]

TVA developed a new fertilizer product, ammonium polyphosphate, a high-grade soluble granular material that should be useful in making liquid-mixed fertilizers. During pilot plant tests products varying in grade were made but the grade expected to be most suitable for large-scale production was 15–61–0 (15 percent nitrogen, 61 percent phosphorous pentoxide, and no potash).[55]

Increased demand for special-lined tank cars in 1962 was attributed to use in transporting phosphoric acid. In 1961, one rubber company lined 127 cars, 69 of which were for phosphoric acid. In the first quarter of 1962, 50 of 60 cars ordered were for phosphoric acid. Polyvinyl chloride linings for phosphoric acid and alum cost about $2,000 and last about 5 years.[56]

A modern bucket-wheel excavator was being assembled in Morocco to mine the phosphate deposits near Casablanca. The excavator, designed by a West German firm, was described as having a 70-foot excavator boom, a 66-foot loading boom, and a 12-foot-diameter bucket wheel with 8 buckets. The theoretical capacity of the machine was 700 tons per hour. Only one man was required to operate the electric-powered plant.[57]

International Minerals & Chemical Corp. reduced phosphate-rock handling cost at its Polk County, Fla., plant by using wider and higher than standard bulldozer blades. The special blades carried more of the relatively light phosphate mineral per pass. This resulted in a reduction in wet-storage handling cost.[58]

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[54] Baniel, A. The I.M.I. Phosphoric Acids Process. Chem. Eng. Prog., v. 58, No. 11, November 1962, pp. 100–104.
[55] Slack, A. V. Ammonium Polyphosphate. Farm Chemicals, v. 125, No. 11, November 1962, pp. 16, 18, 20.
[56] Chemical Week. Upturn in Tank-Car Lining. V. 90, No. 10, Mar. 10, 1962, pp. 41, 42.
[57] Fertiliser and Feeding Stuffs Journal (London). Latest Phosphate Excavator. V. 56, No. 7, April 4, 1962, p. 299.
[58] Mining World. V. 24, No. 7, June 1962, pp. 42, 43.

Platinum-Group Metals

By J. P. Ryan [1] and Ethel M. Tucker [2]

SUSTAINED industrial demand and continued price stability characterized the U.S. platinum metals industry in 1962. Domestic consumption of platinum-group metals increased slightly, but imports declined about 19 percent compared with 1961. Mine production and refinery output of new metals dropped sharply from the high levels of 1961, but recovery of secondary metals was substantially higher.

World output of platinum-group metals was estimated to have decreased slightly from that of 1961. Production increased in Canada and the U.S.S.R., however, these increases did not offset decreases in output in the Republic of South Africa, the United States, and Colombia. The International Nickel Company of Canada, Ltd., reported increased production of platinum-bearing ores but moderately lower deliveries of platinum-group metals. Rustenburg Platinum Mines, Ltd., (Republic of South Africa) the other large producer of these metals in the free world, indicated that for the fiscal year ending August 31, 1962, its production was reduced and metal sales were somewhat lower than in fiscal year 1961.

TABLE 1.—Salient platinum-group metals statistics

(Troy ounces)

	1953–57 (average)	1958	1959	1960	1961	1962
United States:						
Mine production [1]	22,681	14,359	15,485	23,609	43,248	28,742
Value	$1,763,079	$740,583	$913,736	$1,485,439	$2,256,432	$1,591,463
Refinery production:						
New metal	56,879	48,195	49,321	51,243	79,453	54,775
Secondary metal	77,739	81,514	135,996	76,857	85,971	132,102
Imports for consumption	793,272	670,431	1,010,333	680,646	884,463	720,352
Exports (except manufactures)	33,121	47,368	31,405	65,149	61,845	60,59
Stocks Dec. 31: Refiner, importer, dealer	470,407	493,426	495,851	515,750	555,445	598,102
Consumption	713,798	689,693	896,403	775,214	823,226	866,459
World: Production	1,070,000	890,000	[2] 1,055,000	[2] 1,275,000	[2] 1,205,000	1,190,000

[1] From crude platinum placers and byproduct platinum-group metals recovered largely from domestic gold and copper ores.
[2] Revised figure.

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

LEGISLATION AND GOVERNMENT PROGRAMS

The regulations that were established under the Defense Materials System by Business and Defense Services Administration of the U.S. Department of Commerce and that govern the flow of raw materials to defense agencies remained in effect with respect to platinum-group metals. Purchase orders for materials needed in national defense work continued to have priority over unrated commercial business orders.

All platinum-group metals, through the semifabricated stage, required a validated license for export to Soviet-bloc countries. The export of all commodities to North Korea, Communist China, and Viet-Nam was prohibited.

Platinum-group metals continued to be included in the list of commodities eligible for government financial assistance under the program administered by the Office of Minerals Exploration; however, no projects were active in 1962.

DOMESTIC PRODUCTION

Platinum-group metals recovered from placer deposits in Alaska and as byproducts of copper and gold refining decreased 34 percent to 28,700 ounces. Output of both placer platinum and byproduct platinum metals declined sharply.

As in preceding years, nearly all the placer platinum was produced by Goodnews Bay Mining Co., the only company that produced platinum as a primary product in the United States. Most of the byproduct platinum-group metals were recovered by American Metal Climax, Inc., from the treatment of sludges and residues of electrolytic refining of copper. In addition, small quantities of byproduct platinum-group metals were recovered from the treatment of copper residues by American Smelting and Refining Company and International Smelting & Refining Co. Yuba Consolidated Industries, Inc., recovered a small quantity of crude platinum from gold placer operations.

New platinum-group metals recovered by refiners from both domestic and foreign crude materials dropped 31 percent to 54,800 ounces; output of all metals of the group declined. About half of the total new metals recovered came from domestic sources.

Secondary plantinum-group metals recovered by refiners chiefly from scrap, sweeps, sludges, and other industrial residues aggregated 132,100 ounces, a marked increase over the quantity recovered in 1961. The gain in output extended to all metals of the group. In addition, refiners recovered and returned to industrial consumers for reuse more than 885,000 ounces of platinum-group metals refined on toll, compared with about 700,000 ounces in 1961. These refined metals were received as worn out or otherwise depleted materials such as catalysts, spinnerets, extrusion dies, laboratory ware, and other used equipment. Four refiners, Engelhard Industries, Inc.; J. Bishop & Co.; American Metal Climax, Inc.; and Metals and Controls Division, Texas Instruments, Inc., accounted for nearly all of the toll refining.

Domestic ores and secondary materials furnished about 19 percent of the domestic requirements for platinum-group metals in 1962, compared with 16 percent in 1961.

TABLE 2.—New platinum-group metals recovered by refiners in the United States, by sources

(Troy ounces)

Year and source	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1953–57 (average)	46,804	5,099	2,671	989	658	658	56,879
1958	35,409	5,913	3,146	1,014	1,229	1,484	48,195
1959	37,296	7,525	1,700	491	930	1,379	49,321
1960	35,131	9,636	2,675	1,003	2,457	341	51,243
1961:							
From domestic sources: Crude platinum; Gold and copper refining	17,155	22,668	1,284	147	932	306	42,492
From foreign crude platinum	28,958	6,320	619	1	1,061	2	36,961
Total	46,113	28,988	1,903	148	1,993	308	79,453
1962:							
From domestic sources: Crude platinum; Gold and copper refining	14,244	14,141	739	95	439	146	29,804
From foreign crude platinum	22,218	2,003	166	5	577	2	24,971
Total	36,462	16,144	905	100	1,016	148	54,775

TABLE 3.—Secondary platinum-group metals recovered in the United States

(Troy ounces)

Year	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1953–57 (average)	40,743	31,375	1,249	311	2,045	2,016	77,739
1958	36,426	38,883	1,223	335	2,639	2,008	81,514
1959	58,945	68,279	1,188	361	5,631	1,592	135,996
1960	38,861	35,465	914	279	953	385	76,857
1961	51,218	32,451	193	6	1,836	267	85,971
1962	71,817	56,273	767	99	2,570	576	132,102

CONSUMPTION AND USES

Domestic consumption of platinum-group metals, as indicated by sales to consuming industries, aggregated 866,500 ounces, about 5 percent more than in 1961 and only 3 percent less than the record sales of 1959. Gains in the quantity of metals consumed by chemical, glass, dental and medical, and miscellaneous uses more than offset declines in consumption for electrical, petroleum, and jewelry uses. Consumers in the United States acquired nearly three-fourths of the world production of platinum-group metals in 1962.

The gain in sales of platinum-group metals included each metal of the group. Platinum sales were up 7 percent above 1961, reflecting increased demand from all consuming industries except petroleum refining and jewelry manufacturing. The quantity of platinum sold to petroleum refiners declined sharply, but the chemical, petroleum, and glass industries together continued to account for nearly half of the total platinum sold; electrical and electronic industries obtained nearly one-third of the total; jewelry and decorative uses took 9 percent of the total; and dental and medical, and miscellaneous uses, 9 percent.

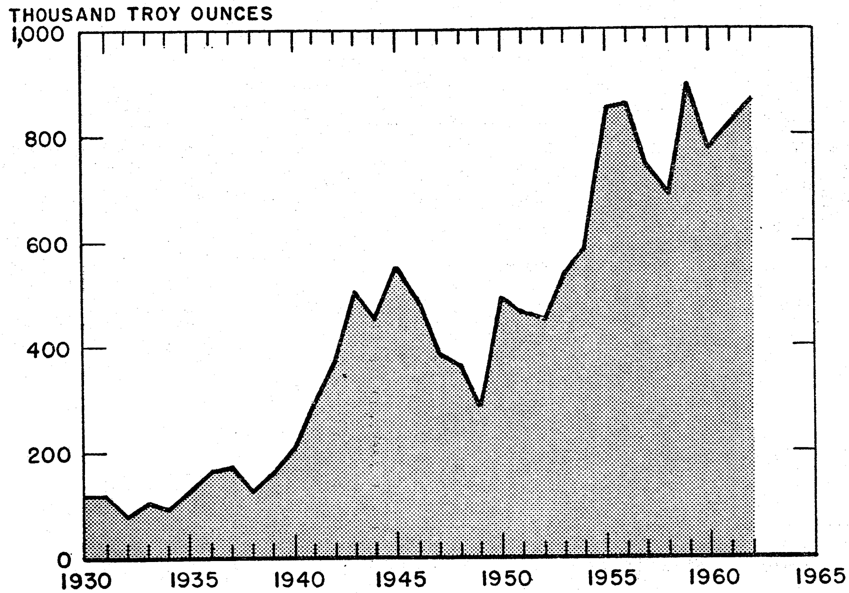

FIGURE 1.—Consumption of platinum-group metals in the United States, 1930–62.

TABLE 4.—Platinum-group metals sold to consuming industries in the United States

(Troy ounces)

Year and industry	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total	Percent of total
1953-57	368,497	317,001	5,018	1,118	16,157	6,007	713,798	100
1958	263,681	395,100	6,942	701	18,581	4,688	689,693	100
1959	363,490	488,071	7,508	779	30,813	5,742	896,403	100
1960	324,583	414,225	6,168	788	24,615	4,835	775,214	100
1961:								
Chemical	72,016	90,533	1,120	656	6,880	1,210	172,415	21
Petroleum	37,742	449	----------	----------	550	1	38,742	5
Glass	35,234	5	5	----------	2,481	----------	37,725	4
Electrical	87,419	353,010	1,800	28	3,004	1,092	446,353	54
Dental and medical	16,487	47,228	674	----------	16	1,056	65,461	8
Jewelry and decorative	30,187	14,354	2,806	4	5,593	597	53,541	7
Miscellaneous	4,003	2,461	142	117	650	1,616	8,989	1
Total	283,088	508,040	6,547	805	19,174	5,572	823,226	100
1962:								
Chemical	87,822	110,518	1,973	774	8,276	903	210,266	24
Petroleum	13,160	961	----------	----------	152	----------	14,273	2
Glass	45,530	124	----------	----------	5,111	----------	50,765	6
Electrical	100,569	327,788	3,468	174	5,265	1,875	439,139	51
Dental and medical	22,601	54,899	263	----------	44	966	78,773	9
Jewelry and decorative	28,573	12,975	3,123	----------	6,546	546	51,763	6
Miscellaneous	6,017	12,595	424	177	669	1,598	21,480	2
Total	304,272	519,860	9,251	1,125	26,063	5,888	866,459	100

Palladium sales gained 2 percent because of increased demand for chemical, dental and medical, and miscellaneous uses, which amounted to about one-third of total sales, thereby offsetting the decline in demand for electrical, jewelry, and decorative uses. Electrical industries consumed somewhat less than two-thirds of the total palladium sold.

Aggregate sales of minor platinum-group metals, iridium, osmium, rhodium, and ruthenium, increased 32 percent to 42,300 ounces. As in 1961, about 40 percent of the total metals sold went to the chemical and glass industries; 25 percent, to electrical industries; 24 percent for jewelry and decorative uses; and 9 percent for dental, medical, and miscellaneous uses. Rhodium comprised about 62 percent of the total sales of these metals.

The principal industrial uses of the platinum-group metals were based essentially on their high resistance to oxidation and corrosion especially at elevated temperature, superior catalytic activity, good electrical conductivity, stable thermoelectric behavior, and other thermal and refractory characteristics. In the electrical industry, which received more than half of the total metals sold, platinum-group metals, particularly palladium, were used principally for a wide variety of contacts which must transmit reliable electrical impulses that control equipment operation, such as telephone relays and electronic components for aerospace vehicles. The metals were used in this equipment in either pure or alloyed form, and as solid, clad, or electroplated metals. Platinum-group metals were used in many other specialized applications where freedom from tarnish and corrosion at high temperature, and resistance to spark erosion and mechanical

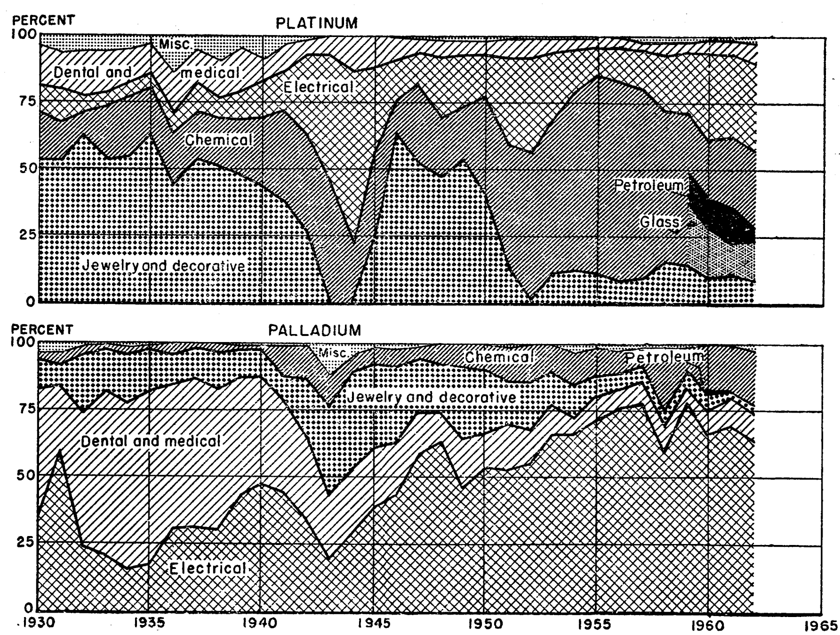

FIGURE 2.—Sales of platinum and palladium to various consuming industries in the United States, 1930–62, as percent of total.

wear were essential. Platinum and palladium catalysts continued to be used extensively in many chemical processes including ammonia oxidation, production of nitric acid, production of hydrogen peroxide, and hydrocarbon synthesis. Platinum-group-metal catalysts continued to be used extensively in petroleum refining for the production of high-octane gasoline, which involved such reforming processes as cracking, isomerization, hydrogenation, dehydrogenation, and sulfur removal. Large quantities of platinum-group-metal catalysts were used in the pharmaceutical industry for producing various drugs.

Substantial quantities of platinum and platinum alloys continued to be used in such specialized equipment as laboratory apparatus, equipment for melting special glass and extruding glass fiber, spinnerets for extruding synthetic fiber, spark plug electrodes, thermocouples, resistance thermometers, and electric heating elements in furnaces, and in many other applications involving service at high temperature or in a corrosive environment.

The minor platinum-group metals—iridium, rhodium, osmium, and ruthenium—were used principally as alloying elements with the more abundant platinum and palladium to produce alloys having increased hardness, tensile strength, and resistance to heat and corrosion. Rhodium, the most abundant of the minor platinum-group metals, was widely used as electroplate in jewelry, sliding contacts, and reflectors, and in other applications requiring a bright, tarnish-resistant surface.

Palladium brazing alloys were used to a greater extent in joining materials for high-temperature service. Using palladium to plate tungsten parts before joining insured strong bonds and raised the temperature range at which tungsten could operate.

Several new applications of platinum-group metals were noted that might lead to wider industrial use. Irradiated iridium was used in a modified radioisotope technique developed by United States Graphite Co. for measuring wear in carbon-graphite parts. Iridium-rhodium thermocouples were employed by Leeds and Northrup Co. to measure furnace temperatures up to 3,600° C in oxygen steelmaking. Iridium spark plugs for aircraft engines withstood chemical attack by lead compounds in high-octane aviation fuel better than conventional tungsten-platinum alloy plugs. Platinum frames held the sapphire-covered solar cells of the *Telstar I* satellite. Platinum and sapphire have similar coefficients of expansion and resisted corrosion by micrometeorites. Thus, the solar cells were protected from space radiation, and the satellite could be operated for several years.[3]

Other applications of platinum-cobalt-alloy permanent magnets, first used in electric wrist watches, included magnets for miniature relays, field buckling magnets, denture magnets, and focusing magnets for X-band helix traveling-wave tubes.

An increasing number of fuel-cell designs under investigation employed platinum, or another platinum-group element dispersed on or within the structure of the electrode, in conjunction with a variety of fuels. In the field of immersion pyrometry, new sensors of high-purity platinum were developed that were capable of withstanding

[3] Missiles and Rockets. Telstar I To Be First Active ComSat. V. 11, No. 2, July 9, 1962, pp. 14–15.

the extreme thermal shock of immersion in liquid nitrogen or rapid heating to 750° C without a change in measuring accuracy of more than one-tenth of a degree at 0° C.

A continuous series of platinum junctions connected alumina plates in a ceramic thermoelectric generator developed by Minneapolis-Honeywell Regulator Co. The generator was capable of a 100-volt output at 1,300° C.

Palladium alloy diffusion cells were used to produce ultra-pure hydrogen from a number of industrial gases. The principal purposes of these cells were, 1) to raise commercial-grade hydrogen to ultra-high purity for specialized applications in the metallurgical and chemical industries, 2) to obtain pure hydrogen from low-grade hydrogen-containing gas from industrial processes, and 3) to purify process gases by removing unwanted hydrogen.

The use of platinum metals in photographic emulsions and the application of palladium alloy diffusion cells were described.[4]

Other new platinum metal products marketed for the first time in 1962 included a 2-thermocouple system, Platinel, which incorporated fine wires of platinum, palladium, and gold for jet-propeller engine control systems, and a differential thermocouple voltmeter designed to simplify calibration.

Platinum combined with a cancer drug formed a complex reported to be more effective against certain tumors in animals. The platinum complex, with 6-mercaptopurine was said to be extremely active against carcinoma-755 and sarcoma-180.[5]

STOCKS

Domestic refiners and dealers reported total working stocks of platinum-group metals on hand, in process, or in transit at yearend of 598,100 ounces, about 8 percent more than at the end of 1961. Stocks of individual metals of the group, except osmium and ruthenium, increased. No platinum-group metals were acquired in 1962 for government stockpiles, but 849 ounces of subgrade rhodium was sold from the strategic stockpile. Government stockpiles contained 1,542,000 ounces of these metals at yearend.

TABLE 5.—Government inventory of platinum-group metals, December 31, 1962

(Thousand troy ounces)

Metal	National (strategic) stockpile	DPA[1] inventory	CCC[2] and supplemental stockpile	Total
Iridium	14			14
Palladium	90	8	648	746
Platinum	[3] 716		50	766
Rhodium	1			1
Ruthenium			15	15
Total	821	8	713	1,542

[1] Defense Production Act.
[2] Commodity Credit Corporation.
[3] Revised figure.

[4] Platinum Metals Review. V. 6, June 1962, p. 27; v. 6, October 1962, pp. 130–135.
[5] Chemistry. Metal Complexes To Fight Cancer. V. 35, No. 8, April 1962, p. 20.

TABLE 6.—Refiner, importer, and dealer stocks of platinum-group metals in the United States, December 31

(Troy ounces)

Year	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1958	295,274	151,572	10,548	4,241	20,883	10,908	493,426
1959	290,691	158,706	11,127	4,218	20,720	10,389	495,851
1960	260,916	204,345	11.473	4,225	26,547	8,244	515,750
1961	255,654	244,910	12,250	3,058	29,258	10,315	555,445
1962	256,755	285,173	13,871	2,762	30,692	8,849	598,102

PRICES

The relatively stable demand for platinum-group metals was balanced by an adequate supply and prices quoted by the principal refiners remained virtually unchanged. Owing to competitive conditions, however, some large sales were made at prices below the so-called official prices. Such prices per troy ounce quoted by E&MJ Metal and Mineral Markets were as follows: Platinum, $80 to $85; palladium, $24 to $26; iridium, $70 to $75; osmium, $60 to $70; rhodium, $137 to $140; and ruthenium, $55 to $60. As in 1961, lack of speculative interest and continued price stability resulted in virtually no trading in platinum futures on the New York Mercantile Exchange and no contracts were executed.

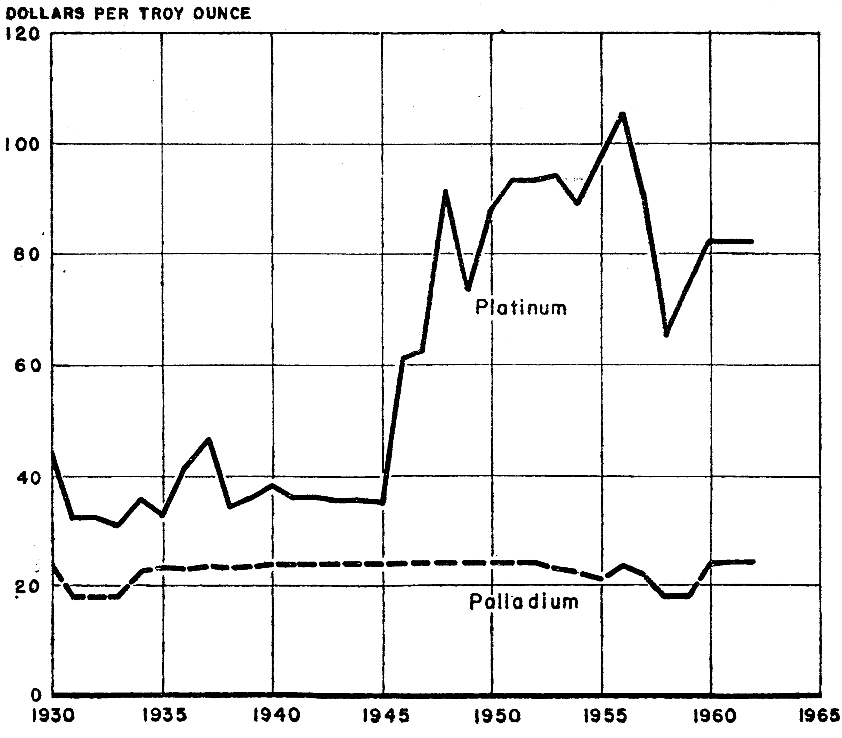

FIGURE 3.—Average price per troy ounce of platinum and palladium, 1930–62.

FOREIGN TRADE [6]

Imports.—More than 80 percent of domestic requirements for platinum-group metals continued to be supplied by foreign countries. U.S. imports of these metals aggregated nearly 720,400 ounces, about 19 percent less than in 1961. Imports of platinum, both refined and unrefined, dropped 14 percent. Palladium imports declined 24 percent and ruthenium imports were down slightly. Imports of iridium, osmium, and rhodium rose sharply above 1961.

Imports of platinum-group metals from Canada and Switzerland increased substantially, but imports from the U.S.S.R., the United Kingdom, Colombia, and the Netherlands declined sharply.

Exports.—Exports of platinum-group metals declined slightly to 60,600 ounces. More than two-thirds of the total exports went to the United Kingdom.

TABLE 7.—U.S. imports for consumption of platinum-group metals

Year	Troy ounces	Value (thousands)	Year	Troy ounces	Value (thousands)
1953-57 (average)	793,272	[1] $43,287	1960	680,646	$34,131
1958	670,431	24,972	1961	884,463	36,840
1959	1,010,333	36,912	1962	720,352	32,699

[1] Data known to be not comparable with other years.

Source: Bureau of the Census.

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

TABLE 8.—U.S. imports for consumption of platinum-group metals (unmanufactured), by countries[1]

(Troy ounces)

Year and country	Unrefined material[2]				Refined metals						Total
	Ores and concentrates of platinum metals	Platinum grain and nuggets (including crude, dust and residues)	Platinum sponge and scrap	Osmiridium	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	
1961:											
North America:											
Canada	9	8			79,070	62,824	2,279		7,600	3,151	154,941
Guatemala	24										24
Mexico			394								394
Panama		66									66
Total	33	74	394		79,070	62,824	2,279		7,600	3,151	155,425
South America: Colombia	535	[3] 29,844	[3] 1,348		1,211						32,938
Europe:											
Czechoslovakia					1,760						1,760
France						8,941					8,941
Germany, West					300	1,501	37				1,838
Italy			1,650								1,650
Netherlands					13,360	72,648					86,008
Norway		900			2,970	3,200					7,070
Switzerland					10,857	39,718			1,292		51,867
U.S.S.R.					24,301	202,350			981		227,632
United Kingdom		796		2,595	103,030	180,215	2,050	466	7,021	5,818	301,991
Total		1,696	1,650	2,595	156,578	508,573	2,087	466	9,294	5,818	688,757
Asia:											
Japan			5,631			296					5,927
Lebanon			456								456
Total			6,087			296					6,383
Africa: Union of South Africa									500		500
Oceania: Australia			454	6							460

Grand total:											
Troy ounces	568	[3] 31,614	[3] 9,933	2,601	236,859	571,693	4,366	466	17,394	8,969	884,463
Value	$39,124	[3] $2,287,687	[3] $581,750	$65,757	$18,164,919	$12,672,492	$286,356	$26,107	$2,327,883	$388,415	$36,840,490
1962:											
North America:											
Canada		14			80,365	85,249	5,325		10,145	2,250	183,348
Mexico			173			4,721					4,894
Total		14	173		80,365	89,970	5,325		10,145	2,250	188,242
South America:											
Colombia		22,052	616		975						23,643
Venezuela					312						312
Total		22,052	616		1,287						23,955
Europe:											
Austria						3,215					3,215
France			3		913	5,976					6,892
Germany, West					2,200		209				2,409
Italy			2,212		775						2,987
Netherlands					1,172	46,447					47,619
Norway		1,300			4,420	5,990					11,710
Switzerland					8,212	122,422					130,634
U.S.S.R.					14,378	91,245			8,366		113,989
United Kingdom				24	96,498	66,559	3,467	1,062	11,492	6,249	185,351
Total		1,300	2,215	24	128,568	341,854	3,676	1,062	19,858	6,249	504,806
Asia:											
Japan			2,213								2,213
Taiwan						48					48
Total			2,213			48					2,261
Oceania: Australia			968						120		1,088
Grand total:											
Troy ounces		23,366	6,185	24	210,220	431,872	9,001	1,062	30,123	8,499	720,352
Value		$1,610,406	$683,952	$1,455	$16,097,273	$9,369,755	$577,761	$54,937	$3,965,449	$338,500	$32,699,488

[1] On the basis of detailed information received by the Bureau of Mines from importers, certain items recorded by the Bureau of the Census as "sponge and scrap" have been reclassified and included with "platinum refined metal" in this table.

[2] Bureau of the Census categories are in terms of metal content. It is believed, however, that in many instances gross weight is actually reported.

[3] Revised figure.

Source: Bureau of the Census.

TABLE 9.—U.S. exports of platinum-group metals, by countries [1]

Year and destination	Platinum (ore, concentrates, ingots, bars, sheets, wire, sponge, and other forms, including scrap)		Palladium, rhodium, iridium, osmiridium, ruthenium, and osmium (metal and alloys including scrap)		Platinum group manufactures, except jewelry (value)
	Troy ounces	Value	Troy ounces	Value	
1953–57 (average) [2]	15,531	$1,295,411	17,590	$471,327	$1,788,756
1958	35,075	1,233,350	12,293	379,375	2,102,566
1959	18,560	1,146,795	12,845	389,988	2,305,855
1960	49,497	3,211,538	15,652	503,914	2,978,436
1961:					
North America:					
Canada	570	69,049	3,956	178,296	1,461,510
Guatemala					98,155
Mexico	810	85,721	2,256	77,186	262,299
Other	(3)	224			2,623
Total	1,380	154,994	6,212	255,482	1,824,587
South America:					
Argentina	289	38,346	2	402	10,622
Brazil	4,799	52,707	569	15,856	5,078
Chile	37	4,590			3,319
Colombia	487	38,934	772	20,038	1,774
Venezuela	8	1,095	122	3,769	5,744
Other	10	260			4,761
Total	5,630	135,932	1,465	40,065	31,298
Europe:					
Belgium-Luxenbourg	729	18,670	428	10,800	29,699
France	1,218	94,519	440	40,595	125,035
Germany, West	2,777	225,915	1,660	93,302	136,094
Italy	4,387	348,615	112	4,437	11,348
Spain			457	14,483	37,705
Switzerland	2,259	216,242	2,972	142,769	630,393
United Kingdom	22,458	854,113	2,098	64,353	33,177
Other	35	4,131			5,867
Total	33,863	1,762,205	8,167	370,739	1,009,318
Asia:					
India	370	23,396	320	10,291	35,491
Japan	14	1,683	4,267	141,533	12,901
Philippines	29	648			2,729
Other	38	4,290	29	1,772	12,616
Total	451	30,017	4,616	153,596	63,737
Africa	13	1,281			51,162
Oceania	48	4,324			3,345
Grand total	41,385	2,088,753	20,460	819,882	2,983,447
1962:					
North America:					
Canada	392	60,952	2,002	71,701	2,274,242
Mexico	177	34,076	3,119	83,274	313,453
Other			185	4,594	6,550
Total	569	95,028	5,306	159,569	2,594,245
South America:					
Argentina	19	8,545			17,949
Brazil	389	50,620	365	10,566	8,511
Chile	2	1,122	206	7,911	3,911
Colombia	1	512	900	22,530	87,541
Venezuela	18	3,582	60	1,440	99,154
Other			503	16,943	5,722
Total	429	64,381	2,034	59,390	222,788

See footnotes at end of table.

TABLE 9.—U.S. exports of platinum-group metals, by countries[1]—Continued

Year and destination	Platinum (ore, concentrates, ingots, bars, sheets, wire, sponge, and other forms, including scrap)		Palladium, rhodium, iridium, osmiridium, ruthenium, and osmium (metal and alloys including scrap)		Platinum group manufactures, except jewelry (value)
	Troy ounces	Value	Troy ounces	Value	
1962—Continued					
Europe:					
Belgium-Luxembourg	449	$14,650	224	$7,100	$28,197
France	406	10,317	326	41,107	25,149
Germany, West	377	28,925	1,502	128,247	122,403
Italy	135	7,758	96	4,042	84,787
Switzerland	2,953	169,149	100	8,000	35,482
United Kingdom	43,044	1,052,577	357	17,342	197,438
Other	29	4,443	60	1,748	2,572
Total	47,393	1,287,819	2,665	207,586	496,028
Asia:					
Japan	1,211	61,735	935	32,379	4,732
Other	40	4,669			124,955
Total	1,251	66,404	935	32,379	129,687
Africa					54,069
Oceania	9	450			608,917
Grand total	49,651	1,514,082	10,940	458,924	4,105,734

[1] Quantities are gross weight.
[2] Owing to changes in classification, data not strictly comparable with years before 1955.
[3] Less than 1 troy ounce.

Source: Bureau of the Census.

WORLD REVIEW

World production of platinum-group metals was estimated at 1.19 million ounces, only slightly less than in 1961. Increased output was reported in Canada and output in the U.S.S.R. was estimated to be higher than in 1961, but these increases did not counteract declines in the Republic of South Africa, the United States, and Colombia.

Demand for platinum catalysts continued at a high level outside the United States. The number of reforming plants using platinum in Western European oil refineries had grown to 63 in the early part of the year. About two-thirds of the oil refineries in Western Europe had catalytic reforming units. Engelhard Industries, Inc., reported increased sales of spinnerets and electrical contacts by its subsidiary companies in Switzerland and Australia, respectively, and expansion of its chemical catalysts facilities and refining operations in the United Kingdom.

Canada.—Output of platinum-group metals increased 8 percent in 1962 to 453,500 ounces valued at Can$28.1 million. Virtually all production of platinum-group metals was recovered as a byproduct of the treatment of nickel-copper ores, chiefly from the Sudbury district of Ontario but partly from nickel-copper ores from the Thompson mine in Manitoba which began production in 1961. Two nickel-copper mining companies—Marbridge Mines, Ltd., in La Motte Township, Quebec, and Nickel Mining and Smelting Corp., near Kenora, Ontario—began production of platinum-group metals in 1962. Platinum-bearing concentrates from Marbridge were smelted by Falconbridge Nickel Mines, Ltd., in the Sudbury area, but the recovery of platinum metals was not disclosed. Platinum-bearing nickel-copper concentrates from the Nickel Mining and Smelting Corp. mine were shipped to the International Nickel Company of Canada, Ltd., (INCO) at Copper Cliff, Ontario, for smelting. The precious metal content, chiefly platinum, was estimated at Can$3.00 per ton.

The bulk of the Canadian production of platinum-group metals continued to come from seven mines near Sudbury, Ontario, and the new one at Thompson, Manitoba, that were operated by Inco which

TABLE 10.—World production of platinum-group metals [1]

(Troy ounces)

Country	1953-57 (average)	1958	1959	1960	1961	1962
North America:						
Canada:						
Platinum: Placer and from refining nickel-copper matte	162,663	146,092	150,382	483,604	418,278	453,526
Other platinum-group metals: From refining nickel-copper matte	189,931	154,366	177,713			
United States: Placer platinum and from domestic gold and copper refining	22,681	14,359	15,485	23,609	43,248	28,742
Total	375,275	314,817	343,580	507,213	461,526	482,268
South America: Colombia: Placer platinum (U.S. imports)	35,604	19,619	31,498	28,855	29,844	22,052
Europe: U.S.S.R.: Placer platinum and rom refining nickel-copper ores [2]	230,000	250,000	300,000	330,000	350,000	375,000
Asia:						
Japan:						
Palladium from refineries	198	240	341	563	1,550	1,372
Platinum from refineries	760	442	470	1,396	2,247	1,872
Iridium from refineries	[3] 648	643				
Philippines:						
Platinum from refining nickel-platinum concentrates					177	172
Palladium from refining nickel-platinum concentrates					215	141
Total	1,606	1,325	811	1,959	4,189	3,557
Africa:						
Congo, Republic of the (formerly Belgian): Palladium from refineries [4]	132	161				
Ethiopia: Placer platinum	231	180	68	189	180	180
South Africa, Republic of:						
Platinum-group metals from platinum ores	421,470	[2] 300,000	[2] 375,000	[2] 400,000	[2] 350,000	[2] 300,000
Osmiridium from gold ores	6,462	[5] 4,873	5,352	[5] 6,334	[2] 7,000	[2] 6,000
Total	428,295	305,214	380,420	406,523	357,180	306,180
Oceania:						
Australia:						
Placer platinum	13	22		4	2	
Placer osmiridium	38	42	3			
New Guinea	9	28	18	4	5	7
Total	60	92	21	8	7	7
World total (estimate) [1]	1,070,000	890,000	1,055,000	1,275,000	1,205,000	1,190,000

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[2] Estimate.
[3] Annual average production, 1955-57.
[4] Includes platinum.
[5] Sales.

Compiled by Pearl J. Thompson, Division of Foreign Activites.

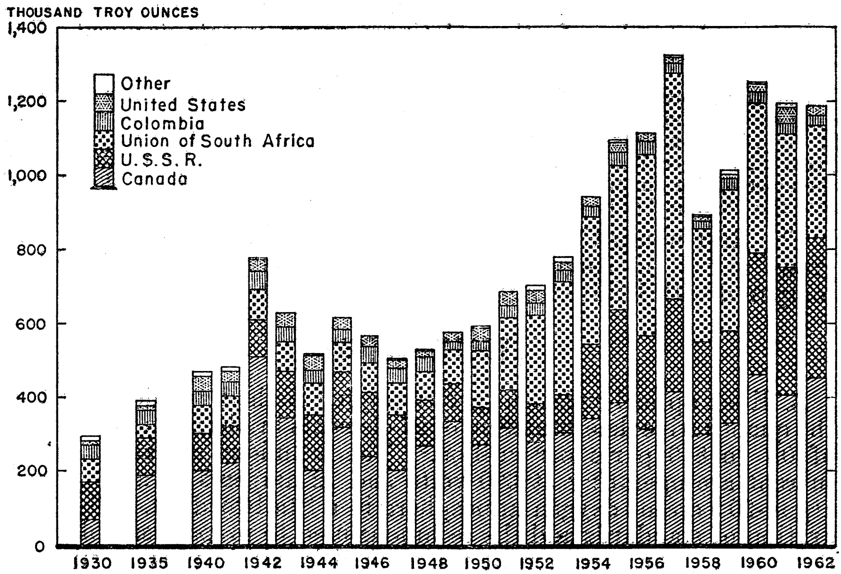

FIGURE 4.—World production of platinum-group metals, 1930, 1935, 1940–62.

increased production of platinum-bearing nickel-copper ore by 3.7 million tons to 17.5 million tons but delivered less platinum-group metals and gold than in 1961. The company also reported an ore reserve at yearend of 299.4 million tons, compared with 297.4 million tons at the end of 1961. A cutback of 13 percent in nickel production in the fourth quarter did not affect recovery of platinum-group metals in 1962.

Falconbridge Nickel Mines, Ltd., operated five mines in the Sudbury district and continued developing its Strathcona mine. Exploration of a platinum-bearing nickel-copper deposit near Belleterre, Quebec, was continued.

Colombia.—Output of platinum-group metals in Colombia dropped 16 percent.

South American Gold & Platinum Co., the leading producer, reported a 20-percent drop in the output of platinum to 13,000 ounces, resulting from a lower grade of gravel washed. The company contributed more than half of the total Colombian output. Five dredges were operated throughout 1962, and handled 21.1 million cubic yards, somewhat less than in 1961. Four dredges were in the Choco district and one was in Narino. Gravel reserves increased substantially to 87.9 million cubic yards having an average combined gold and platinum value of 16.2 cents per cubic yard, compared with 64.2 million cubic yards averaging 17.4 cents per cubic yard in 1961.[7]

South Africa, Republic of.—Output of platinum-group metals in South Africa decreased 14 percent based on the lower production reported by Rustenburg Platinum Mines, Ltd., the leading producer. The company also reported in its anual report for the fiscal year end-

[7] South American Gold & Platinum Co. Forty-sixth Annual Report, 1962. P. 17.

ing August 31, 1962, that sales of platinum were about the same as last year, but sales of other platinum-group metals declined. The report stated:

Due to the lower rate of mine production which has prevailed since the beginning of the calendar year 1962, there will be a further reduction in the quantity of byproduct metals available in refined form for sale during the current year. . . . There has been no improvement in the market for platinum since the close of the financial year and present world trading conditions do not indicate the likelihood of an increase in demand at this stage.

The Rustenburg Company reported that its inventory of platinum-group metals on August 31, 1962, was valued at US$10.1 million, compared with US$10.4 million on the same date in 1961.

TECHNOLOGY

A direct optical emission spectrographic method was developed for the quantitative determination of 27 elements in platinum in the range of 0.1 to 800 parts per million.[8] The technique utilized a direct-current arc operating at 300 volts and 12 amperes in a 70 percent argon-30 percent oxygen atmosphere in a Stallwood jet. The preparation of standards and the technique used to prepare samples were described. The precision of the method is within plus or minus 10 percent.

A patent[9] was issued for a process of separating and recovering platinum and platinum compounds from finely divided ore by treatment with a gaseous mixture of nitrosyl chloride and chlorine produced from agua regia, at a temperature high enough to form volatile platinum compounds and to separate them from the residue of the ore.

The new thermocouple combination, Platinel, was developed[10] by Engelhard Industries, Inc., for jet engines, gas turbines, nuclear reactors, and other applications where operating temperatures have restricted the life of base-metal thermocouples. Initial tests indicated a drift of only two degrees in electromotive-force output after a 2,500-hour test at 1,300° C. A thermocouple wire of platinum, gold, and palladium was used for the positive leg and an alloy of gold and palladium for the negative leg.

An economic process of depositing thin tarnish-resistant coatings of palladium by immersion plating[11] was developed for use in printed circuits. The electrolytic process combined the low cost of palladium (compared with gold and platinum) with the most economic method of obtaining the desired coating. A complex dinitrito-sulfate-palladous bath (DNS) was used.

Aqueous solutions of rhodium salts, as stereo-specific catalysts developed by U.S. Rubber Co., were considered for the large scale production of cis-polybutadiene by the commonly used technique of

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[8] Lincoln, A. J., and J. C. Kohler. Direct Spectrographic Determination of Trace Impurities in High Purity Platinum. Engelhard Industries Tech. Bull., v. 3, No. 2, September 1962, pp. 53–60.

[9] Wolcott, E. R. Process for Recovering Valuable Rare Metals by Volatilization. U.S. Pat. 3,049,422, Aug. 14, 1962.

[10] American Metal Market. New Thermocouple Metal Developed. V. 68, No. 3, June 12, 1961, p. 14.

[11] Philpott, J. E. Immersion Plating of Palladium. Platinum Metals Rev., v. 6, No. 4, October 1962, pp. 144–146.

emulsion-polymerization.[12] Researchers at Shell Development Co. laboratories demonstrated that a much broader steric control over such polymerizations was possible with other ions and complex compounds of the platinum-group metals. For example, almost complete trans-1, 4 polymerization additions were obtained using rhodium trichloride, cycol-octadiene rhodium chloride, and iridium trichloride as catalysts. Palladium chloride or ammonium chlorpalladate gave high proportions of 1, 2 polymerizations, but the polymers had low molecular weight.

Research on precious-metal electrode catalysts for fuel cells disclosed that platinum and palladium were the most effective catalysts for the oxygen electrode.[13] The cells were intended to operate at ordinary or moderately elevated temperatures using an acid electrolyte in the place of liquid organic fuels that would ultimately be used. Platinum and palladium also were found to be the most efficient catalysts for direct oxidation of methanol in acid media. Several articles of general interest on the technology of platinum-group metals were published.[14]

Palladium brazing alloys, developed for joining materials for high-temperature service, also proved advantageous in joining alloys which formed refractory oxide skins. Several standard alloy systems containing palladium were developed and their physical and mechanical properties evaluated.[15]

Approximately 270 patents were issued in the United States involving the use or application of platinum-group metals in various industrial processes and fabricated products. Nearly two-thirds of the patents involved the preparation, use, reactivation, and recovery of platinum-metal catalysts in petroleum refining, chemical and petrochemical processes, and in the manufacture of pharmaceuticals. These processes included reforming, hydrogenation, dehydrogenation, isomerization, oxidation, reduction, and purification. Several patents also were issued on the use of platinum metals in electrodes, as protective coatings, in electronic devices, thermoelectric components, and chemical equipment.[16]

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[12] Platinum Metals Review (London). Rhodium as a Polymerization Catalyst. V. 6, No. 4, October 1962, p. 135.

[13] Magistrate, L. A. Recent Highlights at Engelhard Industries, Inc. Engelhard Industries, Inc., Tech. Bull., v. 3, No. 1, June 1962, p. 5.

[14] Clements, F. S. Twenty-Five Years' Progress in Platinum Metals Refining. Industrial Chemist, v. 38, July 1962, pp. 345–354.

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Platinum Metals Review (London). Platinum Catalysts in Fuel Cells. V. 6, No. 1, January 1962, p. 8.

Rylander, Paul N., and Duane R. Steele. Hydrogenation of Certain Aromatics With Platinum Metal Catalysts. Engelhard Ind., Inc., Tech. Bull., v. 3, No. 1, June 1962, pp. 19–22.

[15] Rhys, D. W., and R. D. Berry. The Development of Palladium Brazing Alloys. Metallurgia, v. 66, December 1962, pp. 255–263.

[16] Engelhard Industries, Inc. Tech. Bull., v. 3, Nos. 1–3, 1962, pp. 37–47, 71–80, 107–118; No. 4, 1963, pp. 143–155.

Potash

By Richard W. Lewis [1] and Gertrude E. Tucker [2]

THE DOMESTIC market for potassium salts, principally for fertilizers, recovered in 1962 with sales by producers 5 percent above the record year of 1960. Production of marketable potassium salts in the United States was below that of 1961.

American Potash Institute, Inc., Washington, D.C., organized a Foundation for International Potash Research to supervise a campaign to expand the knowledge of and encourage the use of additional U.S. potash in areas outside the United States.

TABLE 1.—Salient potash statistics

(Thousand short tons and thousand dollars)

	1953–57 (average)	1958	1959	1960	1961	1962
United States:						
Production of potassium salts (marketable) .... quantity..	3,524	3,640	4,033	4,472	4,629	4,167
Approximate equivalent K_2O quantity..	2,073	2,147	2,383	2,638	2,732	2,452
Value [1]	$78,060	$75,000	$80,393	$89,676	$104,464	$94,859
Sales of potassium salts by producers quantity..	3,368	3,954	4,191	4,412	4,226	4,615
Approximate equivalent K_2O quantity..	1,979	2,336	2,476	2,602	2,487	2,722
Value at plant	$74,559	$81,577	$83,903	$88,417	$95,388	$105,608
Average value per ton	$22.14	$20.64	$20.02	$20.04	$22.57	$22.89
Imports for consumption of potash materials .... quantity..	296	366	432	415	465	620
Approximate equivalent K_2O quantity..	159	199	234	226	262	342
Value	$10,790	$12,874	$15,737	$15,370	[2] $17,315	$21,864
Exports of potash materials..quantity..	260	507	572	833	[2] 803	861
Approximate equivalent K_2O quantity..	141	254	337	491	[2] 473	508
Value	$10,209	$18,276	$18,496	$25,926	[2] $32,477	$30,808
Apparent consumption of potassium salts [3] .... quantity..	3,404	3,813	4,051	3,994	[2] 3,888	4,374
Approximate equivalent K_2O quantity..	1,997	2,281	2,373	2,337	[2] 2,276	2,556
World: Production (marketable):						
Approximate equivalent K_2O...do....	7,800	8,800	9,400	10,000	10,700	10,700

[1] Derived from reported value of "Sold or used."
[2] Revised figure.
[3] Measured by sold or used plus imports minus exports.

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

DOMESTIC PRODUCTION

Production of marketable potassium salts in the United States for 1962 was 10 percent less than in 1961, chiefly because of a 58-day labor strike in the Carlsbad, N. Mex., potash mines. The calculated average grade of crude salts mined in New Mexico was 18.55 percent K_2O equivalent, compared with 18.74 percent in 1961.

The principal producing States remained as in the preceding year, with New Mexico furnishing 90 percent of the domestic output. California and Utah supplied the bulk of the remainder with Maryland and Michigan again contributing a small percentage.

Estimated from available data,[3] approximately 11,000 short tons of manure salts containing 2,500 tons K_2O equivalent, was produced.

Mining and refining facilities of established producers continued to expand, and annual production capacity increased to 2.85 million short tons by the end of the year. No new companies started production.

TABLE 2.—Production and sales of marketable potassium salts in the United States, in 1962, by product

(Thousand short tons and thousand dollars)

Product	Production			Sales		
	Gross weight	K_2O equivalent	Value [1]	Gross weight	K_2O equivalent	Value
Muriate of potash, 60-percent-K_2O minimum:						
Standard	2,031	1,244	$43,724	2,196	1,345	$47,324
Coarse	1,310	800	30,712	1,503	919	35,460
Granular	294	178	7,002	364	220	8,883
Total	3,635	2,222	81,438	4,063	2,484	91,667
Other potassium salts [2] [3]	532	230	13,421	552	238	13,941
Grand total	4,167	2,452	94,859	4,615	2,722	105,608

[1] Derived from reported value of "Sold or used."
[2] Figures for refined muriate and manure salts are included with potassium sulfate and potassium-magnesium sulfate to avoid disclosing individual company confidential data.
[3] Includes the sulfate manufactured from captive production of muriate.

Texas Gulf Sulphur Co. dropped slightly behind schedule in its potash development 9 miles southwest of Moab, Utah. The company reported in December that the mine shaft was 80 percent completed and that potash was expected to be on the market by early fall of 1963. Approximately $32 million will have been invested in the enterprise by the end of 1963. The annual production capacity of the installation when completed was stated to be 693,000 tons K_2O equivalent.

Activity in the Moab potash area was reported by three other companies. Richfield Oil Corp. expanded its holdings of 2,880 acres by acquiring several thousand additional acres of leased land. Superior Oil Co. converted 10 potash prospecting permits to leases, which committed them to develop more than 12,000 acres of potash lands. Continental Oil Co. remained active by drilling exploratory holes on its 8,000-acre site.

[3] American Potash Institute, Inc. North American Deliveries of Potash Salts. E-168, Mar. 21, 1963, p. 2.

TABLE 3.—Production and sales of potassium salts in New Mexico

(Thousand short tons and thousand dollars)

Year	Crude salts [1]		Marketable potassium salts					
	Mine production		Production			Sales		
	Gross weight	K_2O equivalent	Gross weight	K_2O equivalent	Value [2]	Gross weight	K_2O equivalent	Value
1953–57 (average)	10,973	2,158	3,216	1,892	$70,760	3,074	1,807	$67,626
1958	12,224	2,309	3,355	1,978	69,106	3,650	2,157	75,343
1959	13,932	2,588	3,707	2,189	74,117	3,821	2,258	76,725
1960	15,071	2,841	4,138	2,440	82,645	4,092	2,412	81,653
1961	15,653	2,934	4,281	2,523	96,380	3,882	2,281	87,415
1962	14,115	2,619	3,758	2,208	85,124	4,206	2,476	95,851

[1] Sylvite and langbeinite.
[2] Derived from reported value of "Sold or used."

At Wendover, Utah, Bonneville, Ltd., acquired an additional 24,700 acres of Federal potash leases adjacent to its existing properties. At the end of the year Bonneville was considering a merger with either Standard Magnesium Co. or Kern County Land Co.

In Nevada, Leprechaun Mining & Chemical Co., Inc., continued its development of the Clayton Valley saline project.

American Potash & Chemical Corp., Trona, Calif., completed an expansion program, begun in 1961, which increased the potash plant capacity 25 percent.

Considerable activity took place in the Carlsbad, N. Mex., potash region. International Minerals & Chemical Corp. (IMC) completed a $500,000 installation for increasing production capacity of the double sulfate of magnesium and potassium which is extracted from langbeinite. Duval Sulphur & Potash Co. planned an $8 million expenditure to develop its extensive deposit of langbeinite ore. The project called for two new mine shafts, approximately 900 feet deep, and milling facilities for langbeinite ore. The opening of a major sylvite ore body also was included in the plans. Potash Company of America converted its flotation plant to use amine flotation reagents for the recovery of potash. Use of the new process was expected to extend the company's reserves to 16 to 18 years, compared with only 10 to 12 years when using the old process. The approximate cost of the conversion was $5 million.[4] Kermac Potash Co. announced that a contract to build a 1,500-ton-per-day potash plant near Carlsbad, N. Mex., had been awarded to Western-Knapp Engineering Co. for completion early in 1964. The capital investment in the mine and mill facilities was expected to approximate $20 million. The company's potash reserves were estimated at 90 million tons of ore averaging 17 percent K_2O.[5]

[4] Mining World. V. 24, No. 11, October 1962, p. 44.
[5] Mining World. Progress Reported in Joint New Mexico Potash Project. V. 73, No. 47, Nov. 22, 1962, p. 1.

CONSUMPTION AND USES

The apparent consumption of potassium salts in the United States began to climb again after a 2-year decline and was 8 percent above the peak year of 1959.

Illinois continued to be the leading State for deliveries of agricultural potash; Indiana, Ohio, Georgia, and Florida followed in order. Deliveries do not necessarily correspond to consumption since much of that delivered is used in mixed fertilizers and resold. The deliveries of potassium salts for chemical use increased nearly 10 percent.

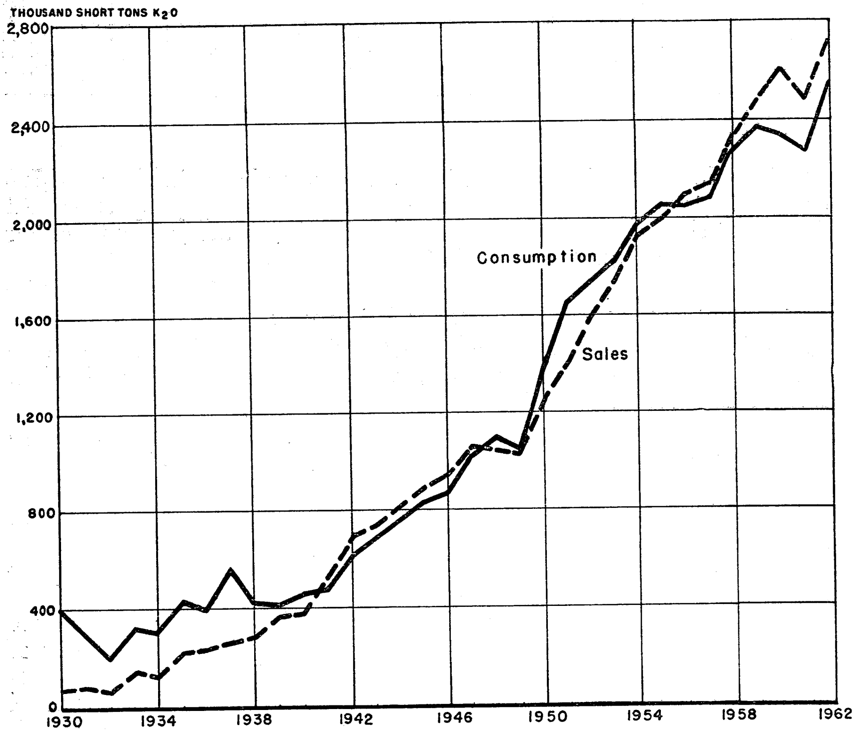

FIGURE 1.—Comparison of apparent domestic consumption of potash (K_2O) and sales by domestic producers of potash in the United States, 1930–62.

TABLE 4.—Deliveries of potash salts in 1962, by States of destination

(Short tons of K_2O)

State	Agricultural potash	Chemical potash	State	Agricultural potash	Chemical potash
Alabama	83,271	22,606	Nevada	----------	1,388
Arizona	1,109	132	New Hampshire	12	20
Arkansas	56,369	198	New Jersey	39,817	2,248
California	22,631	8,425	New Mexico	185	50
Colorado	1,244	24	New York	46,602	72,180
Connecticut	4,970	269	North Carolina	104,064	376
Delaware	9,561	548	North Dakota	2,710	----------
District of Columbia	456	----------	Ohio	178,471	5,521
Florida	150,442	1,258	Oklahoma	9,452	531
Georgia	167,319	289	Oregon	6,390	315
Idaho	1,094	----------	Pennsylvania	37,088	3,099
Illinois	236,863	3,246	Rhode Island	1,793	277
Indiana	195,038	3,154	South Carolina	64,013	1
Iowa	88,922	222	South Dakota	660	----------
Kansas	3,371	981	Tennessee	100,078	----------
Kentucky	53,705	6,814	Texas	78,169	6,031
Louisiana	21,717	487	Utah	137	206
Maine	16,425	25	Vermont	2,942	----------
Maryland	78,847	772	Virginia	130,424	459
Massachusetts	15,836	112	Washington	9,843	971
Michigan	76,650	885	West Virginia	1,551	13,350
Minnesota	68,941	----------	Wisconsin	72,035	74
Mississippi	56,881	----------	Wyoming	61	----------
Missouri	66,638	1,296			
Montana	125	1	Total	2,368,653	158,841
Nebraska	3,731	----------			

Source: American Potash Institute, Inc.

STOCKS

Stocks held by producers were reduced drastically because of decreased production coupled with high sales volume. Stocks on hand at yearend include material sold for delivery in the 1963 spring planting season.

TABLE 5.—Stocks of potassium salts in the United States

(Thousand short tons)

Year	Number of producers	Stocks, Dec. 31	
		Potassium salts	Equivalent potash (K_2O)
1953–57 (average)	10	662	393
1958	11	625	372
1959	11	464	277
1960	11	521	311
1961	11	[1] 927	[1] 558
1962	11	479	288

[1] Revised figure.

PRICES

The 1962–63 bulk prices for muriate of potash were only slightly different from prices of the preceding fertilizer year. Price lists were published by producers for shipments during the months indicated against contracts made before July 1, 1962. For contracts made after July 1, 1962, an additional 2 cents per unit was charged by some companies, and, by others, the price was increased 5 percent. All producers reserved the right to adjust prices to meet the competition. Freight was equalized on the basis of 62 percent K_2O on bulk shipments of muriate of potash.

Carlsbad, N. Mex., producers were forced to equalize freight to North Dakota, South Dakota, Minnesota, Wisconsin, and northern Iowa to meet the competition of incoming shipments of potash from the Canadian operations in Saskatchewan.[6]

TABLE 6.—Bulk prices for New Mexico potash[1]
(Cents per unit K_2O)

Product	1962			1963	
	July-Aug.	Sept.-Oct.	Nov.-Dec.	Jan.	Feb.-June
Standard muriate, 60-percent-K_2O minimum	35	36	37	37	40
Coarse, 60-percent-K_2O minimum	36	37	38.5	38.5	41.5
Granular, 60-percent-K_2O minimum	37	38.5	40	40	43
Sulfate of potash, 50-percent-K_2O minimum	67	67-72	72	75	75
Manure salts (run of mine), 20-percent-K_2O minimum	17.65	17.65	17.65	17.65	17.65

[1] Quoted by producers, f.o.b. Carlsbad, in minimum 40-ton carlots.

TABLE 7.—Bulk prices for California potash[1]
(Cents per unit K_2O)

Product	1962			1963	
	July-Aug.	Sept.-Oct.	Nov.-Dec.	Jan.	Feb.-June
Standard muriate, 60-percent-K_2O minimum	44	45	46	46	48.5
Granular muriate, 60-percent-K_2O minimum	45	46	47	47	49.5
Sulfate of potash, 50-percent-K_2O minimum	77.5	77.5-82.5	82.5	85.5	85.5

[1] Quoted by American Potash & Chemical Corp., carlots, f.o.b., Trona, Calif.

FOREIGN TRADE[7]

Imports.—Total imports of muriate of potash were nearly 32 percent higher than in 1961, chiefly due to the restoration of Canadian potash production. Canada's share of the 109,545-ton increase amounted to 70 percent. Shipments from France, West Germany, and Spain increased 11, 13, and 8 percent, respectively. Imports from the U.S.S.R., however, decreased 37 percent.

Exports.—Total exports of potash fertilizers increased nearly 10 percent but the value per ton was only $33.46, compared with $38.12 in 1961. Japan continued as the outstanding customer, receiving 47 percent of the exports. Deliveries to Japan, however, had been decreasing since 1960, and in 1962 they were 2 percent less than in 1961.

Exports of chemical potash decreased 56 percent. Canada was the major importer, receiving 45 percent of the total.

[6] Chemical Week. V. 91, No. 24, Dec. 15, 1962, pp. 127–128.
[7] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census, and American Potash Institute, Inc.

TABLE 8.—U.S. imports for consumption of potash materials

Material	Approximate equivalent as potash (K_2O) (percent)	1961				1962			
		Short tons	Approximate equivalent as potash (K_2O)		Value	Short tons	Approximate equivalent as potash (K_2O)		Value
			Short tons	Percent of total			Short tons	Percent of total	
Used chiefly in fertilizers:									
Muriate (chloride)[1]	60	347,023	208,361	79.5	$10,582,032	456,568	272,993	79.9	$13,012,264
Potassium nitrate, crude	40	1,962	785	.3	142,285	4,437	1,775	.5	192,920
Potassium-sodium nitrate mixtures, crude	14	13,801	1,932	.8	583,679	29,505	4,131	1.2	1,224,517
Potassium sulfate, crude[1]	50	93,540	46,723	17.8	3,641,471	114,471	57,466	16.8	4,408,189
Other potash fertilizer materials	6	46	3	(2)	2,150	4,576	275	.1	171,633
Total	----------	456,372	257,804	98.4	14,951,617	609,557	336,640	98.5	19,009,523
Used chiefly in chemical industries:									
Bicarbonate	46	233	107		28,683	681	313		79,514
Bitartrate:									
Argols	20	261	52		34,479	----------	----------		----------
Cream of tartar	25	880	220		453,108	1,420	355		669,657
Carbonate	61	178	109		24,466	116	71		14,935
Caustic	80	958	766		176,239	1,260	1,008		233,641
Chlorate and perchlorate	36	439	158		101,994	673	242		140,925
Chromate and dichromate	40	5	2	1.6	1,801	5	2	1.5	1,727
Cyanide	70	763	534		417,870	1,058	741		515,854
Ferricyanide	42	[3] 308	[3] 129		[3] 179,293	382	160		233,098
Ferrocyanide	44	[3] 492	[3] 216		[3] 187,066	723	318		261,881
Nitrate	46	2,475	1,139		325,111	3,136	1,443		365,392
Permanganate	29	20	6		9,686	29	8		13,849
Rochelle salts	22	194	43		83,464	211	46		83,497
All other	50	[3] 1,429	[3] 715		[3] 339,850	[4] 985	493		[4] 240,263
Total	----------	[3] 8,635	[3] 4,196	1.6	[3] 2,363,110	10,679	5,200	1.5	2,854,233
Grand total	----------	[3] 465,007	[3] 262,000	100.0	[3] 17,314,727	620,236	341,840	100.0	21,863,756

[1] Quantities furnished by American Potash Institute, Inc., except 1962 imports of muriate from Canada. Value adjusted by Bureau of Mines, except muriate from Canada.
[2] Less than 0.05 percent.
[3] Revised figure.
[4] Adjusted by Bureau of Mines.

TABLE 9.—U.S. imports for consumption of potash materials, by countries

(Short tons)

Year and country	Bitartrate: Argols or wine lees [1] (20)	Bitartrate: Cream of tartar [1] (25)	Caustic (hydroxide) [1] (80)	Chlorate and perchlorate [1] (36)	Cyanide [1] (70)	Muriate (chloride) [2] [1] (60)	Potassium nitrate, crude [1] (40)	Potassium sodium nitrate mixtures, crude [1] (14)	Potassium nitrate (saltpeter), refined [1] (46)	Potassium sulfate, crude [2] [1] (50)	All others [3]	Total: Quantity	Total: Value
1961:													
Chile								13,741				13,741	$576,847
France			29		118	156,940	218			44,102	238	201,645	7,042,207
Germany:													
East									419		75	494	90,982
West		2	736	21	439	133,416	1,694	60	1,382	31,680	643	170,073	5,811,540
Italy		326							674	17,758	150	18,908	1,070,776
Spain		227				43,342					40	43,609	1,332,805
Sweden			193	279							1	473	144,480
U.S.S.R.						13,325					18	13,343	405,137
United Kingdom		325			191						[4] 615	[4] 1,131	[4] 376,310
Other countries	261			139	15		50				1,125	1,590	463,643
Total	261	880	958	439	763	347,023	1,962	13,801	2,475	93,540	[4] 2,905	[4] 465,007	[4] 17,314,727
1962:													
Belgium-Luxembourg											213	213	131,789
Canada			71		149	76,395	1,250	2			[5] 162	[5] 78,029	[5] 1,686,708
Chile							2,204	29,473				31,677	1,310,708
France			21	22	234	173,972	227			37,567	3,052	215,095	7,431,300
Germany:													
East				22					487		57	566	84,337
West			884	27	475	150,810	756	30	1,641	37,472	1,537	193,632	6,509,354
Italy		303			16				874	31,793	1,198	34,184	1,611,024
Spain		233		133		46,958			122	7,639	49	55,134	1,716,005
Sweden			283	356								639	188,700
U.S.S.R.						8,433					6	8,439	257,276
United Kingdom		884			134						530	1,548	580,868
Other countries			1	113	50				12		904	1,080	355,687
Total		1,420	1,260	673	1,058	456,568	4,437	29,505	3,136	114,471	7,708	620,236	21,863,756

[1] Figures in parentheses indicate, in percent, approximate equivalent as potash (K_2O).
[2] Quantities furnished by American Potash Institute, Inc., except 1962 imports of muriate from Canada. Values adjusted by Bureau of Mines, except muriate from Canada.
[3] Approximate equivalent as potash (K_2O): 1961–62, 38 percent.
[4] Revised figure.
[5] Adjusted by Bureau of Mines.

Source: Bureau of the Census.

TABLE 10.—U.S. exports of potash materials, by countries

Destination	Fertilizer				Chemical			
	1961		1962		1961		1962	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
North America:								
Canada	107,058	$4,256,709	90,163	$3,685,855	6,448	$1,148,384	5,942	$1,101,612
Costa Rica	524	23,055	333	15,500	20	3,022	3	1,224
Dominican Republic	4,869	172,132	3,612	141,130	1	292	6	2,286
Mexico	17,305	452,438	27,444	746,064	907	168,431	950	184,966
Other	408	17,868	3,389	144,564	48	12,494	78	12,141
Total	130,164	4,922,202	124,941	4,733,113	7,424	1,332,623	6,979	1,302,229
South America:								
Argentina	1,225	40,290	110	3,757	300	93,613	118	38,912
Brazil	42,996	1,482,976	32,740	1,014,068	256	63,988	733	155,224
Chile	4,222	127,704	7,036	226,530	27	11,539	63	15,526
Colombia	550	24,150	5,700	205,416	143	34,983	97	25,682
Ecuador	600	31,760	198	10,170	68	12,810	10	2,886
Peru	-------	-------	105	5,187	42	11,359	70	17,654
Uruguay	-------	-------	1,652	65,200	46	10,521	10	4,266
Venezuela	-------	-------	3,425	102,494	319	79,457	178	48,582
Other	67	3,185	110	4,928	73	14,008	86	12,789
Total	49,660	1,710,065	51,076	1,637,750	1,274	332,278	1,365	321,521
Europe:								
Belgium-Luxembourg	-------	-------	2,352	74,296	40	16,680	17	9,386
Germany, West	-------	-------	-------	-------	327	138,608	236	99,747
Ireland	-------	-------	15,120	441,335	2	1,080	99	10,815
Italy	16,240	495,705	44,847	1,234,585	227	39,173	226	35,008
Netherlands	624	26,222	1,120	31,360	32	13,373	242	100,915
Sweden	-------	-------	2,205	61,791	523	53,707	807	43,608
United Kingdom	4,475	123,054	3,877	124,860	82	13,246	433	111,848
Other	-------	-------	-------	-------	497	242,976	120	38,277
Total	21,339	644,981	69,521	1,968,227	1,730	518,843	2,180	449,604
Asia:								
India	-------	-------	-------	-------	158	35,730	231	35,656
Japan	[1]405,665	[1]16,382,692	397,567	13,474,694	106	26,220	92	18,206
Korea, Republic of	18,998	690,086	40,019	1,317,943	1	920	-------	-------
Pakistan	11,593	475,860	-------	-------	13	2,818	50	13,887
Philippines	7,467	236,047	21,365	661,229	68	20,508	118	27,564
Taiwan	25,388	907,258	16,926	465,756	11,034	301,137	8	2,496
Viet-Nam	9,194	402,498	11,767	550,878	30	8,341	31	8,033
Other	-------	-------	91	3,305	267	49,682	201	33,578
Total	[1]478,305	[1]19,094,441	487,735	16,473,805	11,677	445,356	731	139,420
Africa:								
South Africa, Republic of	18,602	621,515	15,521	446,406	59	11,760	89	31,294
Other	5	224	-------	-------	66	34,522	98	18,939
Total	18,607	621,739	15,521	446,406	125	46,282	187	50,233
Oceania:								
Australia	29,489	939,346	41,145	1,277,213	7,492	316,204	1,695	164,892
New Zealand	45,833	1,548,175	58,010	1,836,583	18	3,719	34	6,950
Other	13	494	-------	-------	-------	-------	-------	-------
Total	75,335	2,488,015	99,155	3,113,796	7,510	319,923	1,729	171,842
Grand total	[1]773,410	[1]29,481,443	847,949	28,373,097	29,740	2,995,305	13,171	2,434,849

[1] Revised figure.

Source: Bureau of the Census.

WORLD REVIEW [8]

Brazil.—Compañhía Comércio e Navegação announced plans to extract 5,000 tons of potassium chloride annually during the processing of salt from its mine at Macau, Rio Grande do norte.[9]

Canada.—Potash was produced and marketed for the first time since Potash Company of America was forced to close operations in 1959 because of water seepage in the mine shaft. International Minerals & Chemical Corp. (Canada), Ltd. (IMC), reached the potash deposit at 3,132 feet on June 8, 1962, in its Esterhazy, Saskatchewan, mine. IMC first began shaft-sinking operations in 1957 and by the end of 1962 had invested $40 million in its mine and milling facilities. The facilities were expected to be operating at full capacity in 1963, employing about 400 Canadians and producing over 1.2 million tons of product.[10]

Potash Company of America continued the repair work on its mine shaft near Saskatoon, Saskatchewan, completing the cement grouting of the shaft to prevent water seepage from the Blairmore formation. The company stated that a minimum of 18 months and

TABLE 11.—World production of potash (marketable, unless otherwise stated), by countries [1]

(Short tons, K_2O equivalent)

Country	1953–57 (average)	1958	1959	1960	1961	1962
North America:						
Canada			46,500			[2] 150,000
United States	2,073,077	2,147,671	2,383,259	2,638,574	2,732,602	2,452,921
Crude (including brines) [3]	2,338,384	2,478,725	2,781,960	3,039,309	3,143,569	2,863,335
South America: Chile (nitrate)	9,796	9,811	15,482	[2] 16,500	15,504	19,541
Europe:						
France	1,301,590	1,628,146	1,611,466	1,688,635	1,887,499	1,898,178
Crude [3]	1,475,695	1,835,033	1,828,804	1,909,791	2,098,603	[2] 2,110,000
Germany:						
East [2]	1,560,000	1,700,000	1,764,000	1,836,000	1,846,000	1,900,000
Crude [2 3]	1,800,000	1,960,000	2,028,000	2,110,340	2,121,840	2,183,900
West	1,759,935	1,886,052	2,026,046	2,180,369	2,253,122	2,136,277
Crude [3]	2,091,000	2,225,600	2,363,353	2,552,950	2,645,500	2,495,600
Italy	(4)	9,022	11,575	51.162	130.163	148,745
Spain	240,679	262,672	269,790	291,356	289.037	259,629
U.S.S.R.[2]	794,000	1,100,000	1,160,000	1,212,500	1,455,000	1,650,000
Asia:						
Israel	[2] 20,950	[5] 69,900	[5] 76,000	[5] 91,300	[5] 93,600	[5] 100,200
Japan:						
Alunite [2]	430	500	210	190	130	130
Carbonate [2]	[6] 1,175	1,380	2,120	2,570	2,540	2,540
Africa: Eritrea		450				
World total (marketable) (estimate) [1]	7,800,000	8,800,000	9,400,000	10,000,000	10,700,000	10,700,000

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[2] Estimate.
[3] To avoid duplication of figures, data on crude potash are not included in the total.
[4] Data not available, estimate included in total.
[5] Year ended Mar. 31 of year following that stated.
[6] Average for 1 year only as 1957 was first year of commercial production.

Compiled by Helen L. Hunt, Division of Foreign Activities.

[8] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.
[9] Bureau of Mines. Mineral Trade Notes. V. 55, No. 3, September 1962, p. 62.
[10] Western Miner and Oil Review. Esterhazy Potash Project Now in Production. V. 35, No. 10, October 1962, pp. 76–81.

$6.5 million would be required to make the necessary repairs and modifications for renewed production. Annual capacity of the facilities was reported to be 600,000 tons of potash (360,000 tons K_2O).[11]

Tombill Mines, Ltd., leased an additional 4,617 acres of potash land in the western part of Manitoba between St. Lazare and Binscarth and the Saskatchewan border. The company already had about 4,000 acres leased in the same area.[12] Also Tombill Mines entered into an agreement with Steep Rock Iron Mines, Ltd., and Premium Iron Ores, Ltd., which might lead to future development of the Tombill potash property. Technical and marketing studies were initiated and Steep Rock Iron Mines was named to manage the potash operations.[13]

Continental Potash Corp. reported that its mine shaft near Unity, Saskatchewan, had been reconditioned to the top of a cement plug at 1,707 feet. The shaft had been seriously damaged in the summer of 1961 by water and mud seepage. Negotiations were underway for new financing to continue development of the property.[14]

Consolidated Morrison Explorations, Ltd., continued to drill test holes on its potash properties about 35 miles east of Saskatoon, Saskatchewan.[15]

United States Borax & Chemical Corp. and its partner, Homestake Mining Co., renewed their interest in Canadian potash. Feasibility studies were completed and the project was reported to show consider-

TABLE 12.—France: Exports of potash materials[1] by countries

(Short tons)

Destination	1960	1961	Destination	1960	1961
North America:			Europe—Continued		
Canada	21,783	33,013	United Kingdom	245,832	281,252
Cuba	12,603	3,333	Asia:		
Martinique	10,975	8,284	Ceylon	33,655	37,404
United States	158,783	177,888	India	9,277	6,025
South America:			Japan	224,636	173,706
Brazil	46,519	8,773	Philippines	4,555	14,240
Chile	2,205	6,714	Taiwan	11,023	11,023
Colombia	6,090	7,330	Africa:		
Venezuela	6,654	5,657	Algeria	18,798	13,491
Europe:			Ivory Coast	4,631	6,693
Austria	39,759	21,367	Morocco: Southern Zone	7,077	12,423
Belgium-Luxembourg	149,346	171,344	Rhodesia and Nyasaland,		
Denmark	35,612	52,751	Federation of	11,678	20,441
Finland	10,830	8,789	Senegal	661	5,864
Germany, West	18,767	31,307	South Africa, Republic of	19,518	19,276
Greece	6,366	5,465	Tunisia	3,858	1,102
Ireland	38,928	79,254	Oceania:		
Italy	61,762	64,629	Australia	23,486	16,429
Netherlands	141,149	121,125	New Zealand	25,574	61,592
Norway	16,465	17,471	Other countries	43,801	46,184
Sweden	51,110	45,986			
Switzerland	73,902	79,879	Total	1,597,668	1,677,504

[1] Figures include salts, carbonate, chloride, and nitrate of potash.

Compiled from Customs Returns of France by Bertha M. Duggan, Division of Foreign Activities.

[11] Oil, Paint and Drug Reporter. Potash Sad Story Gets Happy Ending. V. 182, No. 6, Aug. 6, 1962, p. 5.
[12] Precambrian-Mining in Canada (Winnipeg). Potash Lease-Area Is Now Doubled. V. 35, No. 11, Nov. 1962, p. 35.
[13] Canadian Mining Journal (Gardenvale, Quebec). V. 83, No. 11, Nov. 1962, p. 108.
[14] Canadian Mining Journal (Gardenvale, Quebec). V. 83, No. 9, Sept. 1962, pp. 130, 132.
[15] Canadian Mining Journal (Gardenvale, Quebec). V. 83, No. 6, June 1962, p. 116.

able promise. Development would require an investment of about $55 million.[16]

Duval Sulphur & Potash Co., Southwest Potash Corp., and Standard Chemical, Ltd., examined possibilities for solution mining. Also, Imperial Oil Ltd., Shell Oil Co. of Canada, Ltd., and Sifto Salt, Ltd. took out permits in areas of deep potash deposits which suggested interest in solution mining.[17]

Alwinsal Potash of Canada Ltd.; Canberra Oil Company Ltd., subsidiary of Superior Oil Co.; Kerr-McGee Oil Industries, Inc.; National Potash Co.; and Northwest Company, Ltd., subsidiary of Imperal Oil, Itd. also held potash land rights in Saskatchewan at the beginning of the year.

Israel.—Dead Sea Works, Ltd., awarded a $25 million contract to 3 U.S. firms for the construction of a 25-mile dike system to form evaporation ponds in the Dead Sea area. It was reported that the project when completed in 1965 would increase annual production of potash from 165,000 tons to nearly 660,000 tons.[18] Also, construction of a $15 million, 440,000-ton-per-year potash plant near Sodom was begun with completion scheduled for April 1964.[19]

Italy.—A plant to produce potash and rock salt was planned for the Racalmuto district between Canicatti and Caltanisetta in Sicily. Plans called for an initial annual capacity of 370,000 tons of kainite.[20]

TABLE 13.—West Germany: Exports of potash materials[1] by countries[2]

(Short tons)

Destination	1961	1962
North America:		
Canada	34,311	26,291
Puerto Rico	11,839	--------
United States	192,263	177,497
South America:		
Brazil	43,104	30,774
Chile	9.183	6,239
Colombia	5,731	7,140
Uruguay	1,791	3,913
Venezuela	3,034	--------
Europe:		
Austria	62,341	52,926
Belgium-Luxembourg	155,788	153,880
Denmark	246,086	188,536
Finland	10,208	12,716
France	26,979	110,906
Greece	8,288	11,310
Ireland	15,426	49,378
Italy	35,966	27.516
Netherlands	149,525	151,825
Norway	11,483	4,830
Rumania	8,270	89
Sweden	27,786	37,793
Europe—Continued		
Switzerland	34,613	27,703
United Kingdom	252,141	222,432
Asia:		
Ceylon	16,306	5,453
India	12,663	15,010
Indonesia	6.981	747
Japan	239,637	31,878
Malaya	11,738	8,439
Pakistan	16,547	--------
Philippines	14,247	2,909
Taiwan	22,849	11,321
Africa:		
Morocco	2,205	4,409
Rhodesia and Nyasaland, Federation of	9,205	10,938
South Africa, Republic of	26,640	40,801
Oceania:		
Australia	20,706	13,366
New Zealand	59,667	25.576
Other countries	42,519	30,334
Total	1,848,066	1,504,875

[1] Data include crude salts, chloride, sulfate, magnesium sulfate, and beet ash.
[2] This table incorporates some revisions.

Source: Compiled from Customs Returns of West Germany by Bertha M. Duggan, Division of Foreign Activities.

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[16] Mining World. Homestake Considers Launching Canadian Potash Operations. V. 73, No. 21, May 24, 1962, p. 1.

[17] Engineering and Mining Journal. Saskatchewan Potash Attracts Many, Solution Mining Stirs Interest. V. 163, No. 7, July 1962, pp. 98, 122–123.

[18] Oil, Paint and Drug Reporter. Potash Dike for Israel. V. 182, No. 3, July 16, 1962, pp. 7, 37.

[19] Chemical Engineering. V. 69, No. 7, Apr. 2, 1962, p. 148.

[20] Fertilizer and Feeding Stuffs Journal. Potash in Sicily. V. 56, No. 1, Jan. 10, 1962, p. 28.

Jordan.—Arab Potash Co., Ltd., planned to build a 275,000-ton potash plant on the shore of the Dead Sea at Safi. Western-Knapp Engineering Co. contracted to design the plant and supervise its construction.[21]

United Kingdom.—Armour Chemicals Industries Ltd. applied for permission to exploit potash deposits in the Whitby area. The public inquiry, required before permission can be granted, was postponed indefinitely.[22]

TABLE 14.—Spain: Exports of potash materials, by countries

(Short tons)

Destination	1961	1962	Destination	1961	1962
North America: United States	34,021	53,324	Europe—Continued		
South America: Chile	----------	3,307	Norway	57,176	61,070
Europe:			Portugal	17,240	13,324
Belgium-Luxembourg	32,300	22,219	United Kingdom	50,371	60,852
Denmark	12,762	6,630	Asia: Japan	78,868	----------
Greece	----------	1,378	Other countries	----------	91
Italy	21,065	9,504	Total	322,950	247,286
Netherlands	19,147	15,587			

Compiled from Customs Returns of Spain and U.S. Embassy, Madrid, State Department Airgram 796, Apr. 19, 1963, by Bertha M. Duggan, Division of Foreign Activities.

TECHNOLOGY

A fully automatic mine-car loading process was developed and placed into use by International Minerals & Chemical Corp. at its Carlsbad potash mine. Photoelectric control was substituted for an older hydraulic control system to give such operational reliability that no attendant was required.[23]

Magnesium ammonium phosphate, precipitated during the process of converting sea water into a potable water supply, was said to be a valuable long-lasting fertilizer.[24]

Central Salt and Marine Chemical Research Institute at Bhavnagai, India, developed three processes for the recovery of potassium from marine bitterns. One of these was patented, and the State Trading Corp. agreed to finance a commercial plant at Tuticorin based on the process.[25]

Several temporary potash storage facilities were put into use by United States Borax & Chemical Corp. An area of cleared level land slightly larger than 50 by 100 feet was covered with a polyethylene sheet. Approximately 21,000 tons of potash was piled 25 to 30 feet high on the sheet and covered with reinforced polyethylene. A weathertight seal was made by stapling the cover to the bottom sheet. These protective coverings provided satisfactory additional storage

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[21] Chemical & Engineering News. Arab Potash Plans Dead Sea Project. V. 40, No. 43. Oct. 22, 1962, p. 91.

[22] Chemical Trade Journal and Chemical Engineer (London). V. 151, No. 3942, Dec. 21, 1962, p. 1250.

[23] Mining Engineering. Photoelectric Control for Mine Car Loading Developed at Carlsbad. V. 14, No. 9, September 1962, pp. 63–65.

[24] Science News Letter. Fertilizer By-Product From Ocean Water. V. 82, No. 17, Oct. 27, 1962, p. 273.

[25] Chemical Trade Journal and Chemical Engineer (London). Potash in India. V. 151, No. 3930, Sept. 28, 1962, p. 635.

at far less cost than would have been required if permanent warehouses had been built.[26]

General Motors Research Laboratories studied the possibility of using potassium nitrate for computer and amplifier elements.[27]

The use of potassium vapor as a metallic working fluid for driving reactor-powered turbines appeared promising. Interest in potassium for this use was stimulated by its low vapor pressure at high temperatures, a property especially important in space vehicles.[28]

Patents were issued on mining [29] and beneficiation [30] of potash ores and the processing of potash products.[31]

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[26] Pit and Quarry. Potash Piles Protected With Plasticized Covers. V. 55, No. 2, August 1962, pp. 127, 130.

[27] Chemistry. Potassium Nitrate for Computer Elements. V. 36, No. 3, November 1962, p. 30.

[28] Iron Age. Potassium Vapor Turbine? V. 190, No. 5, Aug. 2, 1962, p. 51.

[29] Legatski, H. R. (assigned to Phillips Petroleum Co., Bartlesville, Okla.). Mining and Extraction of Ores. U.S. Pat. 3,034,773, May 15, 1962.

[30] Adams, A., and S. E. Tschappler (assigned to International Minerals & Chemical Corp., Skokie, Ill.). Beneficiation of Potash Ore. U.S. Pat. 3,063,562, Nov. 13, 1962.

Jackson, F. L., B. M. Fisher, and G. L. Jordan (assigned to National Potash Co., New York, N.Y.). Beneficiating Potash Ores. U.S. Pat. 3,037, 624, June 5, 1962.

Keen, J. L., and J. K. Opie (assigned to General Mills, Inc., Minneapolis, Minn.). Flotation Concentration of Halite. U.S. Pat. 3,032,198, May 1, 1962.

Le Baron, I. M., and D. H. Fenske (assigned to International Minerals & Chemical Corp., Skokie, Ill.). Process of Beneficiating Langbeinite Ores. U.S. Pat. 3,016,138, Jan. 9, 1962.

Marullo, G., and G. Perri (assigned to Montecatini Soc. Generale per l'Industria Mineraria e Chimica, Milan, Italy). Process for Separation of Schoenite From Sodium Chloride by Means of Flotation. U.S. Pat. 3,049,233, Aug. 14, 1962.

Marullo, G., G. Perri, and G. Tubiello (assigned to Montecatini Soc. Generale per l'Industria Mineraria e Chimica, Milan, Italy). Process for Concentrating Kainite by Means of Flotation. U.S. Pat. 3,059,773, Oct. 23, 1962.

Schoeld, E. A. (assigned to Potash Company of America, Carlsbad, N. Mex.). Amine Flotation Reagent. U.S. Pat. 3,034,985, May 15, 1962.

Snow, R. E. (assigned to International Mineral & Chemical Corp., Skokie, Ill.). Process for Beneficiation of Sylvinite Ore. U.S. Pat. 3,052,349, Sept. 4, 1962.

Trachta, J. E., and C. O. Rodriquez (assigned to International Minerals & Chemical Corp., Skokie, Ill.). Flotation of Granular Ores. U.S. Pat. 3,016,143, Jan. 9, 1962.

Wilson, W. P. (assigned to United States Borax & Chemical Corp., Los Angeles, Calif.). Process for Treating Ores Containing Clays. U.S. Pat. 3,051,548, Aug. 28, 1962.

[31] Daman, A. C. (assigned to Denver Equipment Co., Denver, Colo.). Apparatus for Comminuting Ores or the Like. U.S. Pat. 3,064,906, Nov. 20, 1962.

Dancy, W. B. (assigned to International Minerals & Chemical Corp., Skokie, Ill.). Dust Control in Potash Products. U.S. Pat. 3,063,800, Nov. 13, 1962.

Ebner, K. (assigned to Metallgesellschaft, A.G., Frankfort on the Main, West Germany). Method of Preparing Potassium Sulfate From Kainite. U.S. Pat. 3,058,806, Oct. 16, 1962.

MacPherson, A. R., and R. R. Turner (assigned to Aerofall Mills, Inc., Columbus, Ohio). Air Classification System. U.S. Pat. 3,017,993, Jan. 23, 1962.

Smith, M. L., and R. E. Witman (assigned to Duval Sulphur & Potash Co., Houston, Tex.). Potash Treating Process. U.S. Pat. 3,026,194, Mar. 20, 1962.

Smith, R. E. (assigned to Potash Company of America, Carlsbad, N. Mex.). Method and Means for Filtration of Slurries. U.S. Pat. 3,064,813, Jan. 20, 1962.

Pumice

By John W. Hartwell [1]

DOMESTIC pumice and pumiceous materials sold or used by pro ducers in 1962 decreased 9 percent in quantity and 8 percent in value from 1961 sales.

DOMESTIC PRODUCTION

Fifteen States reported pumice production by 98 companies, individuals, railroads, or highway departments at 104 operations.

Total output was nearly 2.25 milllion short tons valued at $6.3 million. Arizona, with 8 mines and 34 percent of the U.S. production, was the leading State, followed by California, with 25 percent from 30 mines; New Mexico, with 14 percent from 13 mines; and Hawaii, with 10 percent from 19 mines. American Samoa reported production for the first time of 50,000 short tons of volcanic cinder valued at $108,000.

TABLE 1.—Pumice sold or used by producers in the United States

(Thousand short tons and thousand dollars)

Year	Pumice and pumicite		Volcanic cinder		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1953–57 (average)	884	$2,643	738	$1,006	1,622	$3,649
1958	925	3,091	1,048	2,196	1,973	5,287
1959	784	3,267	1,492	2,596	2,276	5,863
1960	601	2,767	1,609	2,802	2,210	5,569
1961	936	4,203	1,527	2,596	2,463	6,799
1962	509	3,167	1,738	3,095	2,247	6,262

TABLE 2.—Pumice sold or used by producers in the United States

(Thousand short tons and thousand dollars)

State	1961		1962	
	Quantity	Value	Quantity	Value
Arizona	745	$1,893	756	$1,640
California	610	2,202	573	2,615
Colorado	44	60	76	82
Hawaii	324	626	232	380
Idaho	60	95	43	64
New Mexico	339	879	308	741
Utah	60	95	28	46
Wyoming	20	20	42	41
Other States [1]	261	929	189	653
Total	2,463	6,799	2,247	6,262
American Samoa	---	---	50	108

[1] Includes Kansas, Nebraska, Nevada, Oklahoma, Oregon, Texas, and Washington.

[1] Commodity specialist, Division of Minerals.

CONSUMPTION AND USES

Consumption and use of volcanic cinders increased 14 percent over 1961. The largest uses for domestic pumice and pumiceous materials were for concrete admixtures and aggregates (44 percent), railroad ballast (30 percent), and road construction (21 percent).

TABLE 3.—Pumice sold or used by producers in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1961		1962[1]	
	Quantity	Value	Quantity	Value
Abrasive: Cleaning and scouring compounds	13	$221	35	$1,201
Concrete admixture and concrete aggregate	1,047	3,518	1,006	3,057
Railroad ballast	603	563	698	623
Road construction[2]	558	1,083	482	803
Other uses[3]	242	1,414	76	686
Total	2,463	6,799	2,297	6,370

[1] Includes American Samoa.
[2] Includes surfacing, ice control, and maintenance.
[3] Includes abrasive uses (miscellaneous), absorbents, acoustic plaster, brick manufacture, filtration, insecticides, insulation, soil conditioners, and miscellaneous uses.

PRICES

Nominal price quotations of domestic and imported prepared pumice were carried regularly in trade publications. The Oil, Paint and Drug Reporter quoted the following prices per pound, bagged, in ton lots: Domestic, coarse to fine, $0.03625 to $0.04250; imported, Italian, silk-screened, coarse, $0.0650, fine, $0.040. Imported, Italian, sun-dried, coarse pumice was quoted at $60 per ton.

E&MJ Metal and Mineral Markets quoted nominal yearend prices per pound, f.o.b. New York or Chicago, in barrels as follows: Powdered, 3 to 5 cents; lump, 6 to 8 cents.

The values per ton of pumice in various use categories were: Cleaning and scouring compounds and other abrasive uses, $34.48; concrete admixtures and aggregate, $3.04; insulation, $9.94; railroad ballast, $0.89; road construction, $1.67; and other and unclassified uses, $2.65.

FOREIGN TRADE[2]

Imports.—Pumice stone imported for use in the manufacture of concrete masonry products, such as building block, brick, and tile, from Greece, Italy, and the French West Indies was 76,184 tons valued at $147,672, compared with 24,652 tons valued at $84,314 in 1961. Imported crude pumice, valued at less than $15 per ton, had an average value of $8.24, compared with $8.95 in 1961; crude pumice valued at more than $15 per ton averaged $18.18, compared with $17.66 in 1961; and wholly or partly manufactured pumice averaged $27.99, compared with $28.48 in 1961.

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

Exports.—Pumice exports were grouped with other mineral commodities and were not available separately.

Tariff.—Pumice stone used in the manufacture of concrete masonry products was imported duty free. Duty for crude pumice valued at $15 a ton and under was 0.045 cent per pound; crude valued over $15 a ton, 0.12 cent per pound; and wholly or partly manufactured, 0.45 cent per pound. These rates were in effect throughout the year.

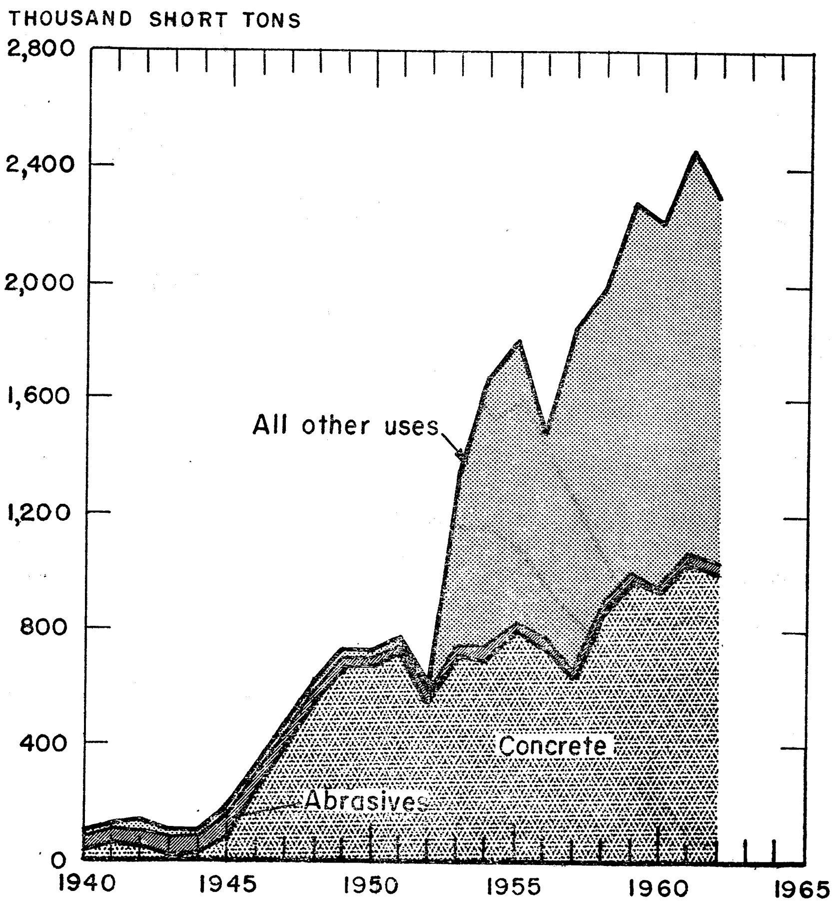

FIGURE 1.—Trends in pumice by uses, 1940–62.

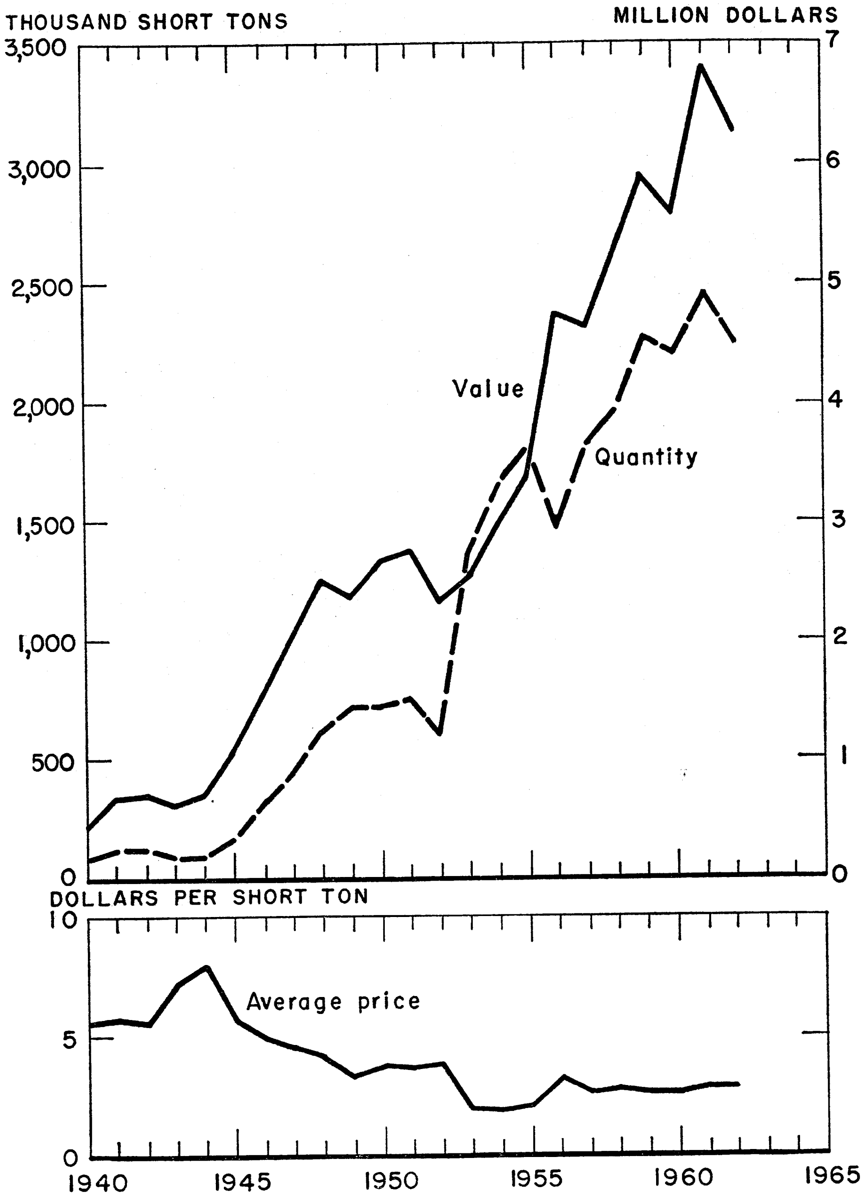

FIGURE 2.—Total value, quantity, and price per ton of pumice, 1940–62.

TABLE 4.—U.S. imports for consumption of pumice, by countries

Country	Crude or unmanufactured				Wholly or partly manufactured				Pumice [1]				Manufactured, n.s.p.f.	
	1961		1962		1961		1962		1961		1962		1961	1962
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Value	
Greece	-----	-----	20	$434	-----	-----	-----	-----	11,278	$56,490	54,003	$103,216	-----	-----
Italy	6,907	$68,830	7,116	69,375	4,063	$115,704	3,184	$89,111	13,374	27,824	22,166	42,705	-----	-----
Other	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	15	1,751	$19,457	$22,499
Total	6,907	68,830	7,136	69,809	4,063	115,704	3,184	89,111	24,652	84,314	76,184	147,672	19,457	22,499

[1] Imported to be used in the manufacture of concrete masonry products.

Source: Bureau of the Census.

WORLD REVIEW

Greece.—Santorin earth occurred at Thera in the Cyclades Islands, according to an officially compiled list of mines and minerals in Greece.[3]

TABLE 5.—World production of pumice by countries [1] [2]

(Short tons)

Country [1]	1953–57 (average)	1958	1959	1960	1961	1962
Argentina [3]	[4] 17,119	22,307	19,842	[5] 20,000	[5] 20,000	[5] 20,000
Austria: Trass	43,669	29,784	34,885	38,581	40,846	30,696
Canary Islands	753	----------	1,836	1,614	1,585	[5] 1,650
Cape Verde Islands: Pozzolan	----------	----------	10,033	7,094	7,361	[5] 7,700
France:						
Pumice	11,171	7,051	2,064	995	[5] 1,100	[5] 1,100
Pozzolan	354,605	396,975	482,683	475,484	462,970	[5] 462,000
Germany, West (marketable)	3,008,277	3,255,121	4,039,966	4,742,138	5,898,461	6,289,781
Greece:						
Pumice	56,124	49,614	71,650	88,185	77,162	[5] 88,000
Santorin earth	66,028	94,428	93,696	198,416	209,439	[5] 220,000
Iceland	[6] 12,125	[5] 11,000	[5] 10,000	[5] 9,000	[5] 9,000	[5] 7,200
Italy:						
Pumice	194,978	145,413	258,254	345,390	[5] 3,970,000	[5] 3,970,000
Pumicite	29,944	137,899	146,717	124,671		
Pozzolan	2,030,120	2,992,880	3,055,978	3,494,273		
Japan	(7)	120,000	(7)	(7)	(7)	(7)
Kenya	[8] 2,076	821	2,515	2,711	779	1,243
New Zealand	9,272	25,851	31,803	49,204	36,637	36,425
United Arab Republic (Egypt)	671	1,185	2,756	3,307	4,335	4,299
United States (sold or used by producers):						
Pumice and pumicite	884,151	925,026	783,873	601,315	936,039	[9] 559,716
Volcanic cinder	737,692	1,047,930	1,402,247	1,609,050	1,526,546	1,737,587
World total (estimate) [1] [2]	7,530,000	9,300,000	10,700,000	11,900,000	13,300,000	13,600,000

[1] Pumice is also produced in Canada, Mexico and U.S.S.R., but data on production are not available; no estimates are included in total, but it is believed that U.S.S.R. produces a sizable quantity.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Includes volcanic ash and cinders, and pozzolan.
[4] Average annual production 1955–57.
[5] Estimate.
[6] Average annual production 1954–57.
[7] Data not available; estimate by senior author of chapter included in total.
[8] Average annual production 1956–57.
[9] Includes American Samoa.

Compiled by Helen L. Hunt, Division of Foreign Activities.

West Indies.—Some islands were reported to be rich sources of lightweight aggregates and pozzolans. The Dominican Republic; Martinique, French West Indies; and St. Eustatius, Netherlands Antilles; had large deposits of pumiceous material. A preliminary study of the deposits was made, but a more detailed investigation was contemplated before considering commercial production.[4]

TECHNOLOGY

Pumice deposits in Kern County, Calif., were described. Nearly 150,000 tons of pumice and pumicite valued at about $1 million had been mined at a few localities in the El Paso Mountains. Two principal deposits were described, and the name of the deposit, location,

[3] U.S. Embassy, Athens, Greece. State Department Dispatch A–105. Aug. 1, 1962, encl. 1, p. 4.
[4] Eckel, Edwin B. Probe West Indies for Volcanic Raw Materials. Rock Products, v. 65, No. 2, February 1962, pp. 108–113.

name of owner, geology, remarks, and references were given for six others.[5]

Volcanic ash from 6 of the more than 100 deposits in Kansas was tested for commercial possibilities especially in the bloated form. Data on the physical and chemical properties of the ash, its bloating characteristics, and product tests were available. Free samples were available for companies wishing to conduct their own tests.[6]

The pozzolanic properties of volcanic ash near Linton, N. Dak., were investigated. The pozzolanic activity index of raw and calcined ash with lime and portland cement was determined. Additional data were obtained on unconfined compressive strength and freeze-thaw resistance of mixes of lime-ash-soil and cement-ash-soil.[7]

Studies of volcanic ash deposits in South Texas were conducted for inclusion in an inventory of mineral resources in a specified trade area. Published and unpublished data were checked and supplemented by field investigations.[8]

The results of tests on a series of volcanic tuffs from various Italian deposits were reported and discussed.[9]

Pumice of different origins and chemical compositions, for the production of lightweight concrete, were investigated as to strength, porosity, and insulating properties.[10]

A method of manufacturing artificial pumice stone from acidic slags obtained during the refining of certain types of iron ore was suggested.[11]

A decorative, moisture-resistant coating for concrete, wood, or clay structural material consisted of a mixture, containing ground pumice. It was applied over a liquid primer.[12]

A foreign patent, not previously issued in the United States, covered a method of manufacturing nucleated hydraulic cement from a mixture containing pumice and 1 percent of either potassium or sodium hydroxide.[13]

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[5] Troxel, Bennie W., and Paul K. Morton. Mines and Mineral Resources of Kern County, Calif. California Division Mines and Geology, County Rept. No. 1, 1962, pp. 261–265.

[6] Bauleke, Maynard P. What's New in Volcanic Ash for Industry? Kansas State Geol. Survey, Bull. 157, pt. 3, 1962, 19 pp.

[7] Manz, Oscar E. Investigation of Pazzolanic Properties of the Cretaceous Volcanic Ash Deposits Near Linton, North Dakota. North Dakota Geol. Survey Rept. of Inv. 38, 1962, 42 pp.

[8] Maxwell, Ross A. Mineral Resources of South Texas. Univ. Texas, Bureau Econ. Geol., Austin, Tex., Rept. of Inv. 43, 1962, pp. 131–134.

[9] Sersale, R. Research on the Constitution, Origin, and Chemical Behavior of Volcanic Tuff. Building Sci. Abs. (London), v. 35, No. 5, May 1962, pp. 133–134.

[10] Kayser, Walter. Investigation to Determine the Characteristics of Pumice. J. Am. Ceram. Soc. (Ceram. Abs.), v. 45, No. 11, November 1962, p. 259.

[11] New Scientist (London). West Germany Artificial Pumice. V. 14, No. 291, June 14, 1962, p. 586.

[12] Proux, J. L. Process for Coating Brickwork, Masonry, Concrete and Wood and Compositions Therefor. U.S. Pat. 3,051,590, Aug. 28, 1962.

[13] Duriez, M. J. J., and R. E. A. Lezy. French Addition Pat. 75,052, June 9, 1961.

Quartz Crystal

Electronic-Grade

By Benjamin Petkof[1] and Gertrude E. Tucker[2]

CONSUMPTION of electronic-grade quartz crystal in the United States increased 35 percent over that of 1961. Production of finished crystal units was 20 percent greater in 1962. The trend toward manufacture of a larger number of miniaturized units continued.

TABLE 1.—Salient electronic- and optical-grade quartz crystal statistics

	1953-57 (average)	1958	1959	1960	1961	1962
Imports of electronic- and optical-grade quartz crystal [1] ... thousand pounds	678	274	[2] 367	[2] 676	854	325
Value ... thousands	$1,398	$341	[2] $638	[2] $504	$762	$731
Consumption of raw electronic-grade quartz crystal [3] ... thousand pounds	208	158	210	230	216	291
Production, piezoelectric units, number [4] ... thousands	5,322	5,510	6,820	8,712	9,822	11,787

[1] Imports are mostly Brazilian pebble valued at $0.35 or more per pound.
[2] Excludes quartz crystal imported from Brazil and accepted under Government agricultural barter contracts.
[3] For 1954 and subsequent years, data include some reworked scrap quartz crystal.
[4] For 1957-62, includes finished crystal units produced from reprocessed blanks, from raw quartz previously reported as consumption, and from imported blanks.

DOMESTIC PRODUCTION

As in previous years, there was no reported production of natural electronic-grade quartz in the United States. At yearend P. R. Hoffman Co., Carlisle, Pa.; Sawyer Research Products, Inc., Eastlake, Ohio; Thermo-Kinetic Corp., Tucson, Ariz.; Transcom Electronics, Inc., Newport, R.I.; and Western Electric Co., North Andover, Mass., were producing manufactured quartz. Sawyer Research reported sales of 13,000 pounds to both foreign and domestic users. Western Electric continued to produce quartz for its own use and the use of affiliated companies. P. R. Hoffman Co., which had been growing quartz experimentally, began regular production in July 1962.

Total production capacity for manufactured quartz was estimated at more than 60,000 pounds per year as of December 1962.

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

CONSUMPTION AND USES

Consumption of raw quartz crystal for the production of piezoelectric units was 291,000 pounds, 75,000 pounds more than in 1961. Consumption of 19,500 pounds of domestically produced manufactured quartz crystal was almost three times the 1961 consumption. Approximately 11,128,000 finished crystal units were produced from raw quartz crystal consumed in 1962, and an additional 659,000 units were obtained from stocks of blanks carried over from prior years and from some imported blanks. The average yield per pound of raw quartz crystal consumed was 38.2 finished crystal units, compared with 43.4 units in 1961. The yield of finished crystals from manufactured quartz crystal was reported to be 2 to 10 times greater than the yield from natural quartz crystal.

A total of 33 quartz-crystal cutters, representing 34 consumers in 15 States, reported to the Bureau of Mines in 1962. Thirty-one of the consumers produced piezoelectric units, and three produced semifinished blanks only. About 90 percent of the raw quartz crystal used was reported by 19 consumers in 6 States. Pennsylvania, with 40 percent of the total consumption, was the leading State, followed by Illinois, Missouri, Kansas, and Massachusetts.

Piezoelectric units were made by 46 producers in 19 States. One producer had plants in two States. Fifteen of the 46 producers did not consume raw quartz crystal but manufactured finished crystal units from partly processed blanks. About 90 percent of the output of finished crystal units came from 24 plants in 9 States. Pennsylvania, Missouri, Illinois, Kansas, and Massachusetts produced the largest quantities of finished crystal units. Oscillator plates comprised 86 percent of the total production of piezoelectric units; the remaining 14 percent consisted of filter plates, telephone resonator plates, transducer crystals, and miscellaneous items. Production of filter and telephone resonator plates increased substantially.

PRICES

Prices for natural electronic-grade quartz crystal sold to domestic users showed no significant change from 1961 prices. Approximate prices for the different weight classes follow:

Weight class (grams):	*Price per pound*
100–200	$2.00–$3.50
201–300	4.00–12.50
301–500	8.00–14.00
501–700	12.00–20.00
701–1,000	18.00–24.00
1,001–2,000	24.00–35.00

The price of manufactured quartz crystal remained unchanged from previous years and ranged from $27.50 to $35 per pound, depending on quantity commitments.

Lasca, used for manufacturing clear fused quartz and as feed material for manufactured quartz crystal, sold for about $0.50 per pound for first-quality material. The price of second-quality lasca was about $0.25 per pound.

FOREIGN TRADE [3]

Imports of electronic- and optical-grade quartz crystal valued at more than $0.35 per pound were 62 percent lower than in 1961. However, the declared valuation decreased only 4 percent. Brazil, still the major supplier, furnished 320,600 pounds, or almost 99 percent of the total. Japan, the United Kingdom, Argentina, and West Germany supplied the remaining 4,000 pounds.

Quartz crystal imports valued at less than $0.35 per pound totaled 611,321 pounds and were valued at $111,612. This was an increase of more than 90 percent in quantity and 200 percent in value over imports in 1961. This material, usually referred to as lasca, was used principally for the manufacture of fused quartz and as feed material for the production of manufactured quartz crystal.

Exports of raw quartz crystal declined 14 percent in value from $518,400 in 1961 to $448,200. Principal countries of destination were Japan, Canada, the United Kingdom, and France. Data on the quantity of quartz crystal exported were not available. Reexports were valued at $90,420, compared with $75,350 in 1961.

Exports of quartz crystal manufactures, both natural and synthetic, declined slightly in value, from $790,400 in 1961 to $714,378. However, the value of reexports of this item increased more than ninefold, from $7,424 in 1961 to $76,826. Data on the quantities involved were not available.

WORLD REVIEW [4]

Brazil.—Exports of electronic- and fusing-grade quartz crystal in 1962 totaled 3,498,700 pounds, valued at approximately $1,477,340,[5] a decrease of 25 percent in quantity and an increase of 12 percent in value compared with the 1961 figures. Breakdown was not available by grade, but a substantial quantity of the material was lasca.

Malagasy Republic.—Exports of electronic-grade quartz crystal in 1962 totaled 18,739 pounds valued at approximately $148,873; fusing-grade quartz totaled 13,007 pounds valued at approximately $1,169; and ornamental-grade quartz totaled 23,589 pounds valued at approximately $19,373. Production data were not available for the year.

TECHNOLOGY

The rate of growth of high-quality manufactured quartz crystal was increased significantly by the addition of small quantities of lithium salts. Growth rates increased from 0.012 to 0.015 inch per day to at least 0.040 to 0.050 inch per day. Also, crystals grown from "lithium-doped" solutions showed fewer defects than crystals grown in solutions without lithium salts. This technique will significantly lower the production cost of high-quality manufactured quartz.[6]

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

[4] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.

[5] U.S. Embassy, Rio de Janeiro, Brazil. State Department Dispatch A-1240, May 9, 1963, encl. 1, p. 4(a).

[6] Bell Laboratories Record. Low Cost, High Quality Quartz Grown by New Lithium-Doping Process. V. 40, No. 5, May 1963, p. 180.

A thermoelectric heating and cooling system, based on the Peltier effect, was developed to maintain a quartz crystal at 25° C plus or minus 1° C while the external temperature varies from minus 40° to plus 60° C. The quartz crystal and associated thermoelectric system were placed within a small thermal-insulating Dewar flask which minimized heating and cooling requirements for maintaining the crystal temperture at 25° C. Operation at room temperature reduced the aging rate of the crystal and improved the temperature frequency stability.[7]

Early in 1962 the U.S. Army Signal Corps granted a renewal contract to the Clevite Research Center of Clevite Corp. for the continued study of methods to improve the quality of manufactured quartz. When this contract was initially awarded in 1946, it called for investigation of the factors limiting the Q factor of manufactured quartz. The new contract emphasized the development of techniques to make internal imperfections visible and to study their causes.[8]

An experimental method was reported for maintaining a quartz crystal at a given frequency over a wide temperature range. Temperature-sensitive bimetallic arms, located at the proper axial orientation to control frequency changes, were used to exert a changing pressure on the edge of a quartz crystal. Experimental data showed a frequency variation of less than 1.5 parts per million over a temperature range of minus 30° to plus 65° C.[9]

Modification of the quartz crystal geometry from a rectangular or circular shape to that of an equilateral triangle caused the crystal oscillation to occur at a frequency of no less than 10 megacycles. The oscillation occurred at its fundamental frequency with a sharp peak response and with almost complete rejection of spurious harmonics near the fundamental frequency.[10]

Improved frequency stability over a wide temperature range was obtained by providing a ridged mount at or near the nodal point of the quartz crystal and avoiding the use of solder for electrical connections or support.[11]

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[7] Merritts, T. D., and J. C. Taylor. Thermoelectric Temperature Control. Proc. 16th Ann. Symp. on Frequency Control, U.S. Army Signal Res. and Devel. Lab., Fort Monmouth, N.J., Apr. 25–27, 1962, pp. 422–437.

[8] Electronic News. Pact Renewed for Synthetic Quartz Study. V. 7, No. 304, Feb. 26, 1962, p. 48.

[9] Munn, R. J. Temperature Compensated Quartz Crystal Units. Proc. 16th Ann. Symp. on Frequency Control, U.S. Army Signal Res. and Devel. Lab., Fort Monmouth, N.J., Apr. 25–27, 1962, pp. 170–186.

[10] Bechmann, Rudolf (assigned to the U.S. Army). Piezoelectric Crystal. U.S. Pat. 3,020,424, Feb. 6, 1962.

[11] Wolfskill, John M. (assigned to Bliley Electric Company, Erie, Pa.). Method of Producing Piezoelectric Crystal Devices. U.S. Pat 3,037,263, June 5, 1962.

Rare-Earth Minerals and Metals

By John G. Parker [1]

DOMESTIC mine shipments of rare-earth minerals in 1962 were almost 50 percent greater than in 1961, primarily because the shipments of California bastnaesite doubled. The quantity of monazite concentrate imported from the Republic of South Africa, Australia, Malaya, and an unidentified country was about 2.5 times that for 1961.

Government financial aid of up to 50 percent of the approved cost of exploration for monazite and other rare-earth minerals was available from the Office of Minerals Exploration (OME).

DOMESTIC PRODUCTION

Concentrate.—Although operations continued at one-third capacity, the Molybdenum Corporation of America mine and mill at Mountain Pass, Calif. expanded production of high-grade bastnaesite concentrate through improving efficiency.[2] Shipments of monazite concentrate, obtained as a byproduct in the processing of northeastern Florida beach sands by Titanium Alloy Manufacturing Division, National Lead Co., increased slightly.

Metals and Compounds.—Processors of rare-earth concentrates and producers of separated and refined compounds and metals were American Potash & Chemical Corp., West Chicago, Ill.; American Scandium Corp., Newtown, Ohio; W. R. Grace & Co., Davison Chemical Division, Pompton Plains, N.J.; Kleber Laboratories, Inc., Burbank, Calif.; Lunex Co., Pleasant Valley, Iowa; Michigan Chemical Corp., St. Louis, Mich.; Molybdenum Corporation of America, Washington, Pa.; Research Chemicals Division, Nuclear Corporation of America, Phoenix, Ariz.; and Vitro Chemical Co., Chattanooga, Tenn.

Cerium and other rare-earth metals and alloys, misch metal, and ferrocerium (including lighter flints) were produced by American Metallurgical Products Co., Inc., New Castle, Pa.; Castalloy, Inc., Natick, Mass.; Mallinckrodt Chemical Works, St. Louis, Mo.; Ronson Metals Corp., Newark, N.J.; and Union Carbide Metals Co., Alloy, W. Va.

Kleber Laboratories, established in 1961 as a producer of high-purity compounds and metals, went out of business in November.

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[1] Commodity specialist, Division of Minerals.
[2] Molybdenum Corporation of America. Annual Report, 1962, 11 pp.

Semi-Elements, Inc., Saxonburg, Pa., doped laser materials, including crystals, glass rods, and liquids with rare-earth elements. Vitro Laboratories, Division of Vitro Corporation of America, announced construction of a pilot plant to be completed in March 1963 at West Orange, N.J. The plant would develop processes on nuclear fuels and high-temperature materials, including rare-earth-yttrium silicides.[3]

Requirements for high-purity rare-earth metals were met by production and shipments of several hundred pounds of refined material, which was used mainly for research purposes. Dresser Products, Inc., Great Barrington, Mass., shipped about 5 pounds of purified rare-earth metals, chiefly ytterbium and gadolinium, which had been fabricated into undesignated forms.

CONSUMPTION AND USES

Apparent consumption of rare-earth elements increased approximately 10 percent to 2,386 short tons of rare-earth oxides.

The large processors of rare-earth concentrates continued to offer commercial-grade rare-earth compounds. These large companies and several smaller refiners produced and sold high-purity rare-earth material.

In the spring a great deal of interest was aroused by the potential large scale use of rare-earth chlorides as a component of a petroleum cracking catalyst. Evaluation of the process and of the material needed, however, was precluded by its proprietary nature.

A substantial portion of rare-earth production was consumed for glass polishing compounds (mostly oxides). However, hopes for extending this consumption to the polishing of flat glass were lessened because of the comparatively high cost of the compounds and the announcement that the Pilkington float process for manufacturing flat glass shortly would be introduced into the United States. This process essentially eliminated the need for final polishing of the glass. As components of glass mixtures, rare-earth elements serve as decolorizers and colorants. They are valued also for contributing high-refractive indices and true-color definition to advanced lens systems such as those used in certain expensive cameras.

The carbon arc electrode industry continued to be an important consumer at a level somewhat lower than that of the polishing compound producers. Rare-earth oxides and fluorides were used as basic raw materials.

Although a substantial quantity of the misch metal produced was used in lighter flints, other metallurgical applications were investigated. Addition of misch metal or a ferrosilicon-magnesium-rare-earth alloy to nodular iron was reported to control detrimental elements such as sulfur and oxygen. Certain properties and textural qualities of some grades of steel were improved by adding rare-earth elements in misch metal and oxide form. Aluminum and magnesium alloys inoculated with the light rare-earth elements were reported to

[3] American Metal Market. V. 69, No. 230, Dec. 3, 1962, p. 17.

have improved creep, fatigue, and corrosion resistance at elevated temperatures.

The increased use in laser materials and in other microwave applications, resulting from intensive Government-sponsored research and development, required increasingly larger quantities of such rare-earth elements as neodymium and samarium as activators in crystals and glass rods.

The superior neutron absorption (high-thermal neutron cross section) of certain rare-earth elements, such as europium, made their use attractive in dispersions and in alloys tested for nuclear reactor control rods.

STOCKS

Rare-earth ore-mineral stocks, chiefly in the form of monazite concentrate, were lower at the end of the year than at the close of 1961. This situation existed despite expanded imports which were about 2.5 times greater than during 1961. Stocks of bastnaesite in chemical processing company inventories were small, but those held by the primary domestic producer of the mineral increased. At the 1962 rate of consumption, it appeared at yearend that the stores of the intermediate material, rare-earth sodium sulfate, would be sufficient for several years. The national (strategic), U.S. Department of Agriculture Commodity Credit Corporation (CCC), and supplemental stockpiles totaled 15,025 tons of rare-earth materials on December 31, 1962.

PRICES

Nominal quotations of monazite prices by E&MJ Metal and Mineral Markets remained the same as in 1961. Imported monazite concentrates, per pound, c.i.f., U.S. ports, were quoted as follows: Massive, 55 percent total rare-earth oxides including thoria, 14 cents; sand, 55 percent at 10 to 15 cents, 66 percent at 18 cents, and 68 percent at 20 cents. Processors of monazite purchased large quantities of concentrates at prices well below the quoted prices. No price was quoted for domestic bastnaesite.

American Metal Market quotations on small lots of 99.9 percent-pure rare-earth metals remained unchanged from 1961. Ronson Metals Corp. offered higher purity metals, such as lanthanum and cerium, at no increase in prices. New price lists on purified oxides, salts, and metals were published by Kleber Laboratories, Inc., Lunex Co., and Vitro Chemical Co.

Prices for misch metal were about the same as in 1961, except for one company that made large shipments at considerably lower prices.

FOREIGN TRADE [4]

Imports.—A total of 109 pounds of cerium valued at $1,339 was received from West Germany and the United Kingdom. West Ger-

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

many shipped practically all of the metal. Cerium alloys, including ferrocerium, were imported from Austria, France, Japan, the United Kingdom, and West Germany and totaled 20,608 pounds valued at $60,421. Austria supplied over 75 percent of the total. Monazite concentrate imported from Australia, Federation of Malaya, Republic of South Africa, and an unidentified country totaled 7,650 tons valued at $1,115,000. The Republic of South Africa contributed 83 percent of this quantity. Canada shipped 70,000 pounds of cerite and cerium ore valued at $11,463 to the United States.

Exports.—Of the 3,708 pounds of cerium ores, metals, and alloys valued at $16,249 that were exported, 43 percent was shipped to the United Kingdom; 27 percent, to Canada; 22 percent, to West Germany; and 8 percent, to France. Exported ferrocerium (lighter flints) totaled 38,501 pounds valued at $172,518. About 57 percent of these shipments were to the United Kingdom; 19 percent, to Canada; and the remainder, to 15 other countries, including Japan, Venezuela, Australia, and Mexico.

WORLD REVIEW [5]

Production of monazite concentrate throughout the free world since 1948 is shown in table 1. Publishable data on South African production was unavailable before 1962.

Australia.—This country produced concentrate containing about 95 percent monazite, valued at approximately $64 per ton.

Brazil.—Monazite production was based on 60-percent concentrate.

Malagasy Republic.—Exports of monazite totaled 637 tons, valued at about $238 per ton.[6]

Malaya, Federation of.—Exports of monazite decreased about 10 percent from 1961, and were priced at about $84 per ton.

Nigeria.—The Federal Ministry of Mines and Power reported that the value of monazite produced was a little over $1,800.[7]

South Africa, Republic of.—Mining was resumed in the spring at the large Steenkampskraal vein monazite deposit near Vanrhynsdorp after a hiatus of several years. Monazite exports were 8,944 tons valued at $1,486,485.[8]

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[5] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.

[6] U.S. Embassy, Tananarive, Malagasy Republic. State Department Dispatch A-333, May 25, 1963, p. 1 (encl.).

[7] U.S. Embassy, Lagos, Nigeria. State Department Dispatch A-595, Mar. 28, 1963, p. 1.

[8] U.S. Consulate General, Johannesburg, Republic of South Africa. State Department Dispatch A-362, Mar. 28, 1963, p. 4.

TABLE 1.—World production of monazite concentrates by countries[1]

(Short tons)

Country[1]	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962
North America: United States	[2] 40	([3])	767	1,497	2,229	1,232	1,971	1,219	([3])	[2] 2,006	[2] 722	[2] 770	([3])	([3])	([3])
South America:															
Argentina	----	----	----	----	----	----	----	----	1	----	----	----	----	----	----
Brazil	[4] 1,968	[4] 2,387	([5])	([5])	([5])	([5])	2,976	([5])	([5])	([5])	1,162	1,222	1,153	[6] 930	[6] 930
Asia:															
Ceylon	----	----	----	----	16	56	51	67	58	150	124	94	370	239	----
India	([5])	([5])	([5])	530	([5])	([5])	([5])	([5])	([5])	([5])	4,122	([5])	([5])	([5])	([5])
Indonesia	----	----	----	----	----	314	11	122	([5])	([5])	([5])	([5])	([5])	111	153
Korea, Republic of[7]	----	----	----	----	903	845	1,108	560	203	392	355	65	11	854	([5])
Malaya, Federation of (exports)	----	----	----	84	63	208	391	279	707	549	479	264	47	780	702
Thailand	----	----	----	----	----	----	----	----	18	64	1	([5])	([5])	([5])	([5])
Africa:															
Congo, Republic of the	----	----	----	41	15	12	4	5	1	----	----	----	----	----	----
Malagasy Republic	----	----	----	----	----	----	----	72	168	331	----	----	471	503	702
Mozambique	----	----	----	----	----	----	----	----	----	([8])	([8])	----	1	([8])	([5])
Nigeria	----	----	----	([5])	6	----	----	----	86	104	64	15	13	8	10
South Africa, Republic of	----	----	----	----	[6] 300	[6] 5,000	[6] 9,000	[6] 9,000	[6] 9,000	9,314	8,112	2,402	----	----	5,326
United Arab Republic (Egypt)	7	3	80	1	7	7	9	1	7	([5])	([5])	[6] 165	([5])	([5])	([5])
Oceania: Australia[9]	942	1,510	1,337	1,864	129	283	199	216	268	496	508	401	405	1,839	1,091
Total (items listed only)[1]	2,957	3,900	2,184	4,017	3,668	7,957	15,720	11,541	10,517	13,406	15,649	5,398	2,471	5,264	8,914

[1] Monazite is also produced in USSR but no data is available.
[2] Shipments.
[3] Figure withheld to avoid disclosing individual company confidential data.
[4] Exports.
[5] Data not available.
[6] Estimate.
[7] Reported as concentrates containing 45–55 percent of R_2O_3; also reported as 30 percent Ce, which may be high.
[8] Less than 0.5 ton.
[9] The data listed represent the total for the three classes: High-grade, low-grade concentrate, and concentrate.

Compiled by Helen L. Hunt, Division of Foreign Activities, Bureau of Mines.

TECHNOLOGY

A rare-earth pegmatite in the Adirondack Mountains, N.Y., contained extremely large crystals of allanite, a complex rare-earth silicate. Fergusonite, a metaniobate of rare-earth elements, yttrium, and uranium, was one of the minerals at this locality. Its discovery marked the first known occurrence in New York.[9]

A metamict mineral, discovered in alkalic rocks in Central Kazakhstan, was named pravdite. It was said to differ in chemical and physical properties from other known rare-earth minerals. Heating affects this calcium rare-earth aluminosilicate somewhat as it does ferrihuttonite, an iron-bearing thorium silicate, but the physical properties differ.[10]

The Bureau of Mines published reports on the separation of rare-earth elements by solvent extraction and ion exchange, electrowinning and solid-state electrorefining of rare-earth metals, thermal decomposition of certain rare-earth salts, thermochemical investigations of rare-earth oxides, chlorides, and cerium metal, spectrographic and instrumental analytical methods, phase equilibrium study of a binary system, a bibliography of rare-earth usage in refractories, and a comprehensive study of rare-earth metal and thorium deposits in several Western States.[11]

Research on beneficiation led to developing a separation method having industrial potentialities. Bastnaesite was reacted with a kerosine solution of alkylphosphoric acids. The reaction products were leached successively by water, an alkali solution, and nitric acid.[12]

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[9] Rowley, Elmer B. Rare Earth Pegmatite Discovered in Adirondack Mountains Area, Essex County, N.Y. Rocks and Minerals, v. 37, Nos. 7–8, July–August 1962, pp. 341–347.

[10] Nurl'baev, A. N. Pravdite. A New Rare-Earth Mineral. Doklady Akad. Nauk S.S.S.R., v. 147, No. 3, 1962, pp. 689–691. (Trans. by Michael Fleischer, U.S. Geological Survey, Jan. 25, 1963).

[11] Boles, Sara Jane. Rare-Earth Compounds as High-Temperature Refractories: A Bibliography. BuMines Inf. Circ. 8082, 1962, 70 pp.

Copeland, M. I., M. Krug, C. E. Armantrout, and H. Kato. Iron-Gadolinium Phase Diagram. BuMines Rept. of Inv. 5925, 1962, 16 pp.

Domingues, L. P., Roy L. Wilfong, and LeRoy R. Furlong. Pyrolysis of Five Salts of Yttrium, Lanthanum, and Cerium. BuMines Rept. of Inv. 6029, 1962, 19 pp.

Kelly, Francis J. Technological and Economic Problems of Rare-Earth-Metal and Thorium Resources in Colorado, New Mexico, and Wyoming. BuMines Inf. Circ. 8124, 1962, 38 pp.

Lindstrom, R. E., and J. O. Winget. Hydrogen as a Retaining Ion for Rare-Earth Separation by Ion Exchange with EDTA and DCTA. BuMines Rept. of Inv. 6131, 1962, 18 pp.

Marchant, J. D., E. S. Shedd, and T. A. Henrie. Solid-State Electrorefining of Rare-Earth Metals. Rare-Earth Research, Gordon and Breach Science Publishers, Inc., New York, 1962, pp. 143–150.

Montgomery, R. L. Heat of Solution of Cerium Metal in Hydrochloric Acid, BuMines Rept. of Inv. 6146, 1962, 9 pp.

Morrice, E., C. Wyche, and T. A. Henrie. Electrowinning Molten Lanthanum From Lanthanum Oxide. BuMines Rept. of Inv. 6075, 1962, 9 pp.

Pankratz, L. B., E. G. King, and K. K. Kelley. High-Temperature Heat Contents and Entropies of Sesquioxides of Europium, Gadolinium, Neodymium, Samarium, and Yttrium. BuMines Rept. of Inv. 6033, 1962, 18 pp.

Rice, A. C., and C. A. Stone. Amines in Liquid-Liquid Extraction of Rare-Earth Elements. BuMines Rept. of Inv. 5923, 1962, 15 pp.

Seim, H. J., Joseph L. Johnson, K. R. Stever, and Howard H. Heady. Ion Exchange Separation and Instrumental Analysis of Impurities in Rare-Earth Metals. BuMines Rept. of Inv. 6097, 1962, 19 pp.

Walden, G. E., and Donald F. Smith. High-Temperature Heat Contents and Entropies of Bismuth Chloride and Cerous Chloride. BuMines Rept. of Inv. 5859, 1961, 4 pp.

Whitehead, A. B., and Howard H. Heady. Spectrographic Analysis of Cerium by a Carrier Distillation Technique. BuMines Rept. of Inv. 6091, 1962, 24 pp.

Wilfong, Roy L., Louis P. Domingues, and LeRoy R. Furlong. Thermal Decomposition of Five Salts of Praseodymium, Neodymium, and Samarium. BuMines Rept. of Inv. 6060, 1962, 18 pp.

[12] Maneval, David R. Beneficiation of Bastnaesite Rare Earth Ore. Pennsylvania State Univ., Coll. of Miner. Ind., v. 31, No. 8, May 1962, pp. 1, 3–5, 8.

A British ion-exchange method consisted of loading a cation column with a mixture of ammonium and mixed rare-earth cations and eluting with nitrilotriacetic acid in aqueous ammonia.[13] A hydrogen form of a cation-exchange resin containing sulfonic acid groups absorbed rare-earth metal values from an aqueous solution. This procedure was followed by elution with diethylenetriamine pentaacetic acid to separate yttrium and gadolinium.[14] New elution methods used various complexing agents to collect successive fractions, each containing mainly ions of yttrium or a single rare-earth element.[15] Russian research on rare-earth chemistry was summarized. Basic types of rare-earth deposits and new trends in rare-earth element production were discussed. Particular stress was laid on the possibility of automated ion exchange and the need to develop oxidation methods. This would permit certain rare-earth elements with normal and abnormal valence states to be separated more easily.[16] Control of pH permitted simple and rapid separation of rare-earth elements from thorium and scandium. Higher pH was needed to remove the rare-earth elements from a silica gel column.[17] Cerium was separated from cesium, zirconium, and uranium in a conductive aqueous solution by electrodialysis through ion exchange membranes followed by oxidation of the cerium ions. Quadrivalent cerium was removed from the cation exchange membrane.[18]

Thorium and rare-earth elements were determined in oxalate precipitates in the analysis of monazite sand concentrate.[19] The development of a pulsed-arc-discharge light source giving self-reversed spectral lines was reported. Interpretation of the spectra of neutral and singly ionized rare-earth elements was simplified, and the nature of the ground state of the atom was revealed.[20]

Quantities of rare-earth elements and yttrium between 0.01 and 0.1 percent in cast steels were determined by a relatively simple spectrophotometric method. The constituents were coprecipitated with thorium from a solution containing ammonium fluoride. Thorium was removed by anion exchange, and the color-forming reagent, arsenazo, was used to determine yttrium or rare-earth elements spectrophotometrically.[21] Lanthanum, samarium, and europium in manganese nodules were determined by neutron activation. The sensitivity of the

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[13] Topp, Norman Eric, and David Douglas Young. An Improved Method for Obtaining Rare Earth Concentrates. Brit. Pat. 880,561, Oct. 25, 1961. Chem. Trade J. and Chem. Eng. (London), v. 150, No. 3899, Feb. 23, 1962, pp. 412, 417.

[14] Hansen, Robert D. (assigned to The Dow Chemical Co., Midland, Mich.). Method of Separating Rare Earth Metal Ions. U.S. Pat. 3,033,646, May 8, 1962.

[15] Krumholz, Pawel. Process for Separating Ions by Ion Exchange. U.S. Pat. 3,037,841, June 5, 1962.

Krumholz, Pawel, and Kasimierz Josef Bril. Process for Separating Rare Earths and Yttrium by Ion Exchange. U.S. Pat. 3,054,655, Sept. 18, 1962.

[16] Vagina, N. S. (Second All-Union Conference on the Chemistry, Preparation, and Analysis of Rare Earth Elements). Zhurnal Neorganicheskoy Khimii, v. 7, No. 8, August 1962, pp. 2025–26; JPRS 16,240, Nov. 19, 1962, available from Off. Tech. Services, U.S. Dept. Commerce.

[17] Kuteynikov, A. F., and V. M. Brodskaya. Zhur. Anal. Khim., v. 17, No. 3, May–June 1962, pp. 305–310: Current Rev. of the Soviet Tech. Press, Aug. 24, 1962, p. 1(770).

[18] Webb, William H., and Jerry D. Vie (assigned to the U.S. Atomic Energy Commission). Separations by Electrodialysis. U.S. Pat. 3,038,844, June 12, 1962.

[19] Habashi, Fathi. Chemical Analysis of Monazite Sand. Metallurgia (Manchester, England), v. 65, No. 391, May 1962, pp. 255–256.

[20] Sugar, Jack. Light Source for Producing Self-Reversed Spectral Lines. J. Res. NBS. V. 66A, No. 4, July–August 1962, pp. 321–324.

[21] Bornong, Bernard J., and John L. Moriarty. Spectrophotometric Determination of Yttrium and Rare Earths in Cast Steels. Anal. Chem., v. 34, No. 7, June 1962, pp. 871–873.

method was 1, 0.02, and 0.01 micrograms for the three rare-earth elements, respectively.[22]

The binary system, praseodymium-neodymium, was shown to have complete liquid and solid solubility in low- and high-temperature phases.[23] Diagrams were constructed representing the results of equilibria studies of binary systems of zirconia with various rare-earth oxides in quantities from 1 to 10 mole-percent.[24] Thermochemical investigations included measurements of specific heat, at constant pressure, of cerium, neodymium, and samarium and of gadolinium nitrate between 1.3° and 220° K.[25]

Lattice contractions, changes of energy levels and of valency, and the normal gamma- to alpha-cerium transformation were noted in thorium-cerium alloys. The mean valency of the cerium atoms was increased by about 10 percent to minimize the compressive forces exerted by the solvent thorium with a concurrent decrease in the effective atomic radius.[26]

Development of high-temperature thermoelectric materials was promising as a result of work performed on neodymium, gadolinium, and cerium selenides and tellurides. These semiconducting materials have good thermal stability at least up to 1,000° C. A thermoelectric figure of merit of one or larger was thought to be obtainable after additional research, thus allowing the use of these materials in thermoelectric energy conversion systems.[27]

Lanthanum diiodide, which was formed by melting lanthanum triiodide with an excess of lanthanum, conducted electricity equally as well as did lanthanum metal. This was attributed to the presence of free electrons in both the solid and liquid states. These free electrons gave rise to reactivity that made the material a strong reducing agent that could only be handled under an inert atmosphere or in a vacuum.[28] Cerium monosulfide was prepared by reducing cerium sesquisulfide electrolytically in a mixture of chlorides of sodium, potassium, and cerium.[29] The first preparation of single crystals of rare-earth tellurides by the vapor transport method was reported. Tetragonal crystals of rare-earth tellurides (MTe_2 where M signifies

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[22] Kawashima, T., M. Osawa, T. Mochizuki, and H. Hamaguchi. Determination of Lanthanum, Samarium and Europium in Manganese Nodules by Neutron Activation. Bull. Chem. Soc. Japan, v. 34, No. 5, 1961, pp. 701–705; Anal. Abs. (Cambridge, England), v. 9, No. 3, March 1962, abs. 1050.

[23] Yamamoto, Albert S., Charles E. Lundin, and Joseph F. Nachman. A Fundamental Investigation of the Alloying Behavior of the Rare Earths and Related Metals. Semiann. Prog. Rept. Univ. of Denver, Denver Res. Inst., No. 5, May 1962, 17 pp. (Contract AF 33 (616), 6787, ASTIA, AD 275747.)

[24] Collongues, R., M. Perez y Jorba, and J. Lefevre. On the Equilibrium Diagrams of the Systems Zirconia-Rare Earths. Bull. Soc. Chim. France, NL, v. 28, 1961, pp. 70–74; (Henry Brutcher Transl. No. 5260, 10 pp.) Battelle Tech. Rev., v. 11, No. 5, May 1962, p. 184a.

[25] Arajs, Sigurds, and R. V. Colvin. Analysis of Specific Heats of Cerium, Neodymium, and Samarium at High Temperatures. J. Less-Common Metals (Amsterdam, Netherlands), v. 4, No. 2, April 1962, pp. 159–168.

Hellwege, K. H., W. Pfeffer, and H. J. Thiel. (Specific Heat of Gd $(NO_3)_3$–6 H_2O in a Range of Temperature Between 1.3 K and 220 K.) Ztschr. Physik, v. 168, No. 5, 1962, pp. 474–477; Battelle Tech. Rev., v. 11, No. 11, November 1962, p. 455a.

[26] Evans, D. S., and G. V. Raynor. The Electronic State of Cerium in Thorium-Cerium Alloys. J. Less-Common Metals (Amsterdam, Netherlands), v. 4, No. 2, April 1962, pp. 181–190.

[27] Battelle Technical Review. Rare Earths in Electronics. V. 11, No. 11, November 1962, p. 13.

[28] Molten Salts Show Their Nature. Chemical and Engineering News. V. 40, No. 30, July 23, 1962, pp. 38–39.

[29] Didchenko, R., and L. M. Litz. Preparation of Lanthanide and Actinide Monosulfides by Fused Salt Electrolysis. J. Electrochem. Soc., v. 109, No. 3, March 1962, pp. 247–250.

lanthanum, cerium, praseodymium, or neodymium) up to 4 by 2 by 1 millimeter were grown.[30] Reproducible surfaces necessary for electrical measurements of these compounds were prepared by chemical polishing, because mechanical polishing generated a strained surface.[31]

The intermediate temperature forms of samarium and europium sesquioxides were thought to have face-centered cubic structures, and the stable high-temperature forms to be noncubic, as were sintered compacts subjected to the action of boiling water at atmospheric pressure.[32] A new compound, europium tungstate, was prepared by heating mixed europium oxide and tungstic acid at 1,000° C, cooling slowly, and then reheating at 1,150° C under a 30° C temperature oscillation. Its strong fluorescence occurred within a relatively narrow spectral range, the strongest emission being between 5,800 and 6,300 Angstrom units.[33]

Ingots of soft, pure samarium and europium metals without detectable protoxides were obtained from less pure metal. Europium metal was sublimed and the condensate remelted in place. Pure metal crystals were obtained by remelting and slowly cooling samarium ingots in a tantalum crucible in an inert atmosphere.[34] In magnesium alloys, the maximum solid solution of neodymium was found to be 3.20 weight-percent at 540° C and of cerium, 0.66 weight-percent at 580° C. This confirmed the belief that the better mechanical properties of magnesium-neodymium alloys, compared with those of magnesium-cerium, are caused by the higher solubility of neodymium in magnesium.[35] Rare-earth elements or titanium additives were used in a new process for hardening molybdenum so that metal might be considered for bearings, valve parts and extrusion dies. The hardening mechanism was not well understood, but it was considered to be similar to the nitriding of ferrous metals.[36]

Laser research included doping crystals, glass, and liquids with various rare-earth elements. Continuous, coherent infrared radiation was emitted by calcium fluoride crystals doped with dysprosium and calcium tungstate crystals doped with neodymium. The new, pulsed lasers required only a small fraction of the power that was needed for operating previous devices.[37] Glass, an isotropic substance, constituted an ideal laser material; it readily dissolved neodymium and other rare-earth elements, had a wide range of formulations, and was shaped easily.[38] Terbium-doped liquid lasers emitted coherent green light which was reported to be capable of penetrating ocean depths.[39] Magnetically modulated laser systems with lower power thresholds and

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[30] Bro, P. The Preparation of Single Crystals of Some Rare-Earth Tellurides. J. Electrochem. Soc., v. 109, No. 11, November 1962, p. 1110.

[31] Bro, P. The Chemical Polishing of Rare Earth Tellurides. J. Electrochem. Soc., v. 109, No. 8, August 1962, p. 750.

[32] Shears, E. C. Samarium and Europium Oxalates, Oxides, and Their Hydrates. Brit. Ceram. Soc. Trans., v. 61, No. 5, May 1962, pp. 225–245.

[33] Chemical & Engineering News. V. 40, No. 29, July 16, 1962, p. 33.

[34] La Blanchetais, (Mlle) Charlotte Henry. (Purification Conditions for Samarium and Europium Metals.) Compt. rendus, v. 254, No. 15, 1962, pp. 2785–2787. J. Inst. Metals, Metal. abs. (London), v. 30, pt. 2, October 1962, p. 138.

[35] Rokhin, L. L., Izvest. Akad. nauk SSSR. Otdel. tekh. nauk. Metall. toplivo, No. 2, March–April 1962, pp. 126–130: Current Rev. Soviet Tech. Press, Aug. 24, 1962, p. 5(769).

[36] Industrial and Engineering Chemistry. V. 54, No. 10, October 1962, p. 9.

[37] Missiles and Rockets. V. 10, No. 19, May 7, 1962, p. 35; Chemical Week, v. 90, No. 5, Feb. 3, 1962, p. 57.

[38] American Metal Market. V. 69, No. 194, Oct. 8, 1962, p. 16.

[39] American Metal Market. V. 69, No. 125, June 29, 1962, p. 12.

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higher outputs were thought possible through the use of a new ferromagnetic glass doped with neodymium.[40]

Soda-silica glass, to which divalent europium or trivalent cerium had been added, absorbed energy in the region of solar emission. This was attributed to the absorption of sunlight by absorption bands characteristic of the rare-earth additives, and the apparent transfer of photoelectrons to nearby traps forming color centers that absorbed light in the visible spectrum. Upon removing the activating light, these centers decayed almost instantaneously and the glass regained its transparency.[41]

Royal Dutch/Shell Group announced that it would license use of a copper catalyst containing one or more rare-earth chlorides. This was expected to permit commercial recovery of chlorine from byproduct hydrochloric acid.[42]

Metals of the light rare-earth subgroup were added to pig iron at a Russian tractor plant and produced nodular iron that was used in casting engine crankshafts and distributing shafts.[43]

Rare-earth additions as misch metal to a molten aluminizing bath substantially increased corrosion resistance and impact toughness of aluminized sheet. In order to prevent the misch metal from settling to the bottom of the bath as a separate metallic phase, it was added as an aluminum-rare-earth master alloy.[44]

Inverse segregation in bearing metals was prevented by adding certain rare-earth metals. By this means, lead was uniformly distributed throughout the cast structure, thereby affording smooth, homogeneous castings.[45]

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[40] American Metal Market. V. 69, No. 180, Sept. 18, 1962, p. 16.

[41] Cohen, Alvin J., and Herbert L. Smith. Variable Transmission Silicate Glasses Sensitive to Sunlight. Sci., v. 137, No. 3534, Sept. 21, 1962, p. 981.

[42] Chemical Age (London). V. 87, No. 2239, June 9, 1962, p. 933.

[43] Terekhova, V. F., and I. V. Burov. (Use of Rare Earth Metals in Metallurgy). Byulleten' Tekhniko-Ekonomicheskoy Informatsii, No. 7, July 1962, pp. 3–6; JPRS 16,143, Nov. 13, 1962, available from Office of Technical Services, U.S. Dept. of Commerce, Washington, D.C.

[44] Iron Age. Rare Earths Enrich Aluminizing. V. 189, No. 22, May 31, 1962, pp. 132–133.

[45] Knight, R. J. How Rare Earth Metals Affect Lead Distribution in Lead Bronzes. Foundry, v. 90, No. 12, October 1962, pp. 46–47.

Salt

By Robert T. MacMillan [1]

AN INCREASE in salt output of 3 million tons established a new production record for the United States. Greater tonnages in all types of salt contributed to a 12-percent gain for the industry.

LEGISLATION AND GOVERNMENT PROGRAMS

A ground of three major rock salt producers were acquitted of conspiracy to fix rock salt prices.[2] The decision, handed down in a Federal Court in Minneapolis, Minn., resulted from a 5-week trial in which the Government emphasized identical bids as evidence of collusion. The defendants successfully contended that identical bids were the result of keen competition and not of collusion.[3]

A salt company in Texas was convicted in Federal District Court in Houston of shipping sea salt accompanied by literature containing false and misleading statements relative to therapeutic values of the salt. The Food and Drug Administration charged that the company made false claims relative to the beneficial effects of mineral substances in the salt thwarting cancer and other ailments.[4]

TABLE 1.—Salient salt statistics

(Thousand short tons and thousand dollars)

	1953–57 (average)	1958	1959	1960	1961	1962
United States:						
Sold or used by producers	22,444	21,910	25,160	[1] 25,479	25,707	28,807
Value [2]	$118,476	$141,486	$155,839	$161,214	$160,223	$174,841
Imports for consumption	301	611	1,025	1,057	1,050	1,374
Value	$1,678	$3,368	$5,438	$4,484	$3,755	$5,097
Exports	354	363	424	420	642	665
Value	$2,698	$2,273	$2,660	$2,548	$3,876	$3,616
Consumption, apparent	22,391	22,158	25,761	26,118	26,115	29,516
World: Production	71,600	82,500	87,600	93,200	94,100	100,500

[1] Revised figure.
[2] Valuer are f.o.b. mine or refinery and do not include cost of cooperage or containers.

DOMESTIC PRODUCTION

Texas was the leading salt producing State with 19 percent of the total output; Louisiana was second with 18 percent. New York,

[1] Commodity specialist, Division of Minerals.
[2] Oil, Paint & Drug Reporter. Rock Salt Producers Win Price Fixing Case Decision. V. 181, No. 24, June 11, 1962, p. 3.
[3] Chemical & Engineering News. Federal Jury Acquits Rock Salt Producers. V. 40. No. 25, June 18, 1962, p. 36.
[4] Chemistry. Sea Salt. V. 36, No. 1, September 1962, pp. 3, 5.

Michigan, and Ohio each produced about 15 percent of the total, and California 6 percent. These 6 States supplied 88 percent of the total U.S. output. The remaining 12 percent was produced in 11 other States.

Salt was produced at 93 plants by 56 companies. Five companies, operating 25 plants, produced 59 percent of the total production; 5 other companies with 14 plants provided 26 percent. The remaining plants supplied 15 percent of the output.

Over 1 million tons of salt was produced at each of 9 plants; 9 plants reported production between 500,000 and 1 million tons, and 32 plants produced between 100,000 to 500,000 tons each. Of the remaining plants, 20 produced less than 10,000 tons.

TABLE 2.—Salt sold or used by producers in the United States

(Thousand short tons and thousand dollars)

State	1961		1962	
	Quantity	Value	Quantity	Value
California	1,601	(1)	1,643	(1)
Kansas [2]	913	$11,409	944	$11,654
Louisiana	4,722	23,357	5,248	27,407
Michigan	3,885	31,284	4,274	33,343
New Mexico	33	284	43	334
New York	4,149	30,761	4,456	32,236
Ohio	3,465	25,037	4,187	28,706
Oklahoma	3	19	5	25
Texas	4,695	17,682	5,553	19,485
Utah	249	3,187	311	3,349
West Virginia	899	3,510	1,042	4,635
Other States [3]	1,093	13,693	1,101	13,667
Total	25,707	160,223	28,807	174,841

[1] Included with "Other States" to avoid disclosing individual company confidential data.
[2] Quantity and value of brine included with "Other States."
[3] Includes States indicated by footnote 1, and Alabama, Colorado, Hawaii, Kansas (brine only), Nevada, North Dakota, Virginia.

TABLE 3.—Salt sold or used by producers in the United States, by methods of recovery

(Thousand short tons and thousand dollars)

Method of recovery	1961		1962	
	Quantity	Value	Quantity	Value
Evaporated:				
Bulk:				
Open pans or grainers	315	$8,465	316	$8,434
Vacuum pans	2,183	45,398	2,305	49,667
Solar	1,532	8,738	1,656	8,940
Pressed blocks	357	7,866	366	8,034
Total	4,387	70,467	4,643	75,075
Rock:				
Bulk	6,376	41,289	7,665	45,298
Pressed blocks	63	1,661	61	1,576
Total	6,439	42,950	7,726	46,874
Salt in brine (sold or used as such)	14,881	46,806	16,438	52,892
Grand total	25,707	160,223	28,807	174,841

TABLE 4.—Evaporated salt sold or used by producers in the United States

(Thousand short tons and thousand dollars)

State	1961		1962	
	Quantity	Value	Quantity	Value
Kansas	411	$9,180	432	$9,446
Louisiana	196	4,430	246	6,298
Michigan	875	17,420	904	18,274
Oklahoma	1	14	1	15
Texas	101	2,761	(1)	(1)
Other States [2]	2,803	36,662	3,060	41,042
Total	4,387	70,467	4,643	75,075

[1] Included with "Other States" to avoid disclosing individual company confidential data.
[2] Includes California, Hawaii, Nevada, New Mexico, New York, North Dakota, Ohio, Utah, and West Virginia.

TABLE 5.—Rock salt sold by producers in the United States

(Thousand short tons and thousand dollars)

Year	Quantity	Value	Year	Quantity	Value
1953–57 (average)	5,112	$31,301	1960	6,466	$44,983
1958	5,407	37,125	1961	6,439	42,950
1959	6,160	41,119	1962	7,726	46,874

TABLE 6.—Pressed-salt blocks sold by original producers of salt in the United States

(Thousand short tons and thousand dollars)

Year	From evaporated salt		From rock salt		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1953–57 (average)	284	$5,127	57	$1,045	341	$6,172
1958	280	6,413	53	1,372	333	7,785
1959	288	6,763	55	1,406	343	8,169
1960	330	7,575	60	1,526	390	9,101
1961	357	7,866	63	1,661	420	9,527
1962	366	8,034	61	1,576	427	9,610

Salt production capacities continued to expand in Ohio, New York, and Louisiana. Rock salt production began at the new mine of the International Salt Co., near Cleveland. Evaporated-salt production capacity at Watkins Glen, N.Y., was expanded. In Louisiana, Cargill, Inc., completed a 1,250-foot shaft to a salt dome at Belle Island. Freezing methods were used to stabilize the earth to a depth of 250 feet in order for the shaft to be completed.

A large solar salt facility was planned for the Bahama Islands by Diamond Crystal Salt Co. An island 200 miles southeast of Nassau was chosen for the project which was to cover 10,000 acres. Production was expected to begin in 1965; the output would be distributed to municipal and industrial users along the eastern seaboard of the United States.

CONSUMPTION AND USES

Production of chlorine and its coproduct, caustic soda, continued to expand as the chief market for salt. More than 10.8 million tons, 38 percent of the total salt output, was consumed by the chlorine caustic industry. The second largest consumption of salt was in manufacturing soda ash, which took 6.5 million tons or 22 percent of the total. The manufacture of all chemicals including chlorine, caustic, and soda ash consumed 65 percent of the total salt production.

Salt used for highway ice and snow removal and road stabilization increased 43 percent, consuming about 12 percent of the total production in 1962. This use is shown as "States, counties, and other political subdivisions (except Federal)" in table 7.

TABLE 7.—Salt sold or used by producers in the United States, by classes and consumers or uses

(Thousand short tons)

Consumer or use	1961				1962			
	Evaporated	Rock	Brine	Total	Evaporated	Rock	Brine	Total
Chlorine	([1])	([1])	8,357	9,971	([1])	([1])	9,163	10,860
Soda ash	--------	([1])	([1])	5,740	--------	([1])	([1])	6,480
Soap (including detergents)	29	7	--------	36	([1])	8	([1])	133
All other chemicals	209	524	617	1,350	233	656	511	1,400
Textile and dyeing	79	120	--------	199	92	123	--------	215
Meatpackers, tanners, and casing manufacturers	346	426	--------	772	338	414	--------	752
Fishing	23	8	--------	31	([1])	([1])	--------	24
Dairy	82	9	--------	91	66	8	--------	74
Canning	193	52	--------	245	193	54	--------	247
Baking	([1])	([1])	--------	109	([1])	([1])	--------	116
Flour processors (including cereal)	43	6	--------	49	([1])	([1])	--------	54
Other food processing	87	10	--------	97	97	13	--------	110
Ice manufacturers and cold-storage companies	30	30	--------	60	20	29	--------	49
Feed dealers	610	365	--------	975	626	411	--------	1,037
Feed mixers	243	90	--------	333	271	107	--------	378
Metals	66	62	--------	128	57	63	--------	120
Ceramics (including glass)	([1])	7	([1])	14	11	9	--------	20
Rubber	([1])	([1])	84	118	8	26	80	114
Oil	38	66	33	137	45	65	42	152
Paper and pulp	([1])	88	([1])	131	11	101	--------	112
Water-softener manufacturers and service companies	198	([1])	([1])	423	209	([1])	([1])	442
Grocery stores	566	221	--------	787	561	259	--------	820
Railroads	9	33	--------	42	12	42	--------	54
Bus and transit companies	([1])	([1])	--------	51	([1])	([1])	--------	74
States, counties, and other political subdivisions (except Federal)	([1])	2,127	([1])	2,266	([1])	3,060	([1])	3,241
U.S. Government	24	36	--------	60	22	118	--------	140
Miscellaneous	996	480	16	1,492	1,048	([1])	([1])	1,589
Undistributed [2]	516	1,672	5,774	--------	723	2,160	6,642	--------
Total	4,387	6,439	14,881	25,707	4,643	7,726	16,438	28,807

[1] Included with "Undistributed" to avoid disclosing individual company confidential data.
[2] Includes some exports and consumption in Territories, oversea areas administered by the United States, and Puerto Rico.

TABLE 8.—Distribution (shipments) of evaporated and rock salt produced in the United States,[1] by destination

(Thousand short tons)

Destination	1961		1962	
	Evaporated	Rock	Evaporated	Rock
Alabama	26	216	28	242
Alaska	3		3	
Arizona	12	9	17	11
Arkansas	14	56	15	61
California	699	64	742	45
Colorado	81	27	86	23
Connecticut	13	53	14	36
Delaware	7	7	7	10
District of Columbia	5	9	5	15
Florida	21	69	22	81
Georgia	41	70	42	73
Hawaii	4		4	
Idaho	28	2	30	2
Illinois	240	434	241	514
Indiana	135	166	134	264
Iowa	135	152	139	175
Kansas	60	173	66	178
Kentucky	38	180	41	197
Louisiana	28	178	30	156
Maine	9	145	10	147
Maryland	43	137	42	152
Massachusetts	75	215	43	241
Michigan	159	188	202	401
Minnesota	116	100	128	136
Mississippi	17	72	18	69
Missouri	84	172	81	170
Montana	23	2	32	1
Nebraska	72	78	78	83
Nevada	25	159	23	158
New Hampshire	5	183	5	157
New Jersey	131	287	143	287
New Mexico	13	42	11	49
New York	208	1,130	229	1,382
North Carolina	82	116	95	125
North Dakota	60	5	26	4
Ohio	233	393	246	596
Oklahoma	31	45	28	49
Oregon	24		54	
Pennsylvania	160	312	161	402
Rhode Island	9	21	9	23
South Carolina	23	20	25	25
South Dakota	26	18	33	21
Tennessee	81	91	113	182
Texas	85	222	92	244
Utah	55	(2)	58	(2)
Vermont	6	57	6	81
Virginia	73	93	74	111
Washington	124		175	
West Virginia	22	53	24	59
Wisconsin	139	165	132	221
Wyoming	14	1	15	2
Other[1]	570	52	566	65
Total	4,387	6,439	4,643	7,726

[1] Includes shipments to Territories, oversea areas administered by the United States, and Puerto Rico, exports, and some shipments to unspecified destinations.
[2] Included with "Other" to avoid disclosing individual company confidential data.

PRICES

Quotations for salt by Oil, Paint and Drug Reporter in 1962 continued at the same level where they had remained since 1958. Quoted prices and value data were as follows:

Quoted prices:
- Rock salt, paper bags, carlots, f.o.b. New York .... per 100 pounds .. $1.09
- Salt, vacuum, common fine, carlots, f.o.b. New York .... do 1.34

Average value, bulk salt:
Evaporated, vacuum, grainer, and pressed blocks____________per ton__ $22.15
Solar evaporated____do____ 5.40
Rock____do____ 6.07
Salt in brine (sold or used as such) per ton contained salt______________ 3.22

FOREIGN TRADE [5]

Salt imports, the highest on record, were 31 percent greater than those of 1961. About 49 percent of the total imports came from Canada, 30 percent from Mexico, and 15 percent from the Bahamas. The remaining tonnage was received from other Caribbean islands and Spain. Imports were equal to nearly 5 percent of U. S. salt output.

Exports of salt increased 4 percent, establishing a new tonnage record. Japan, receiving 75 percent, and Canada, receiving 18 percent, were the leading customers. About 2 percent of the domestic production was exported.

TABLE 9.—Salt shipped to the Commonwealth of Puerto Rico and oversea areas administered by the United States

Territory	1961		1962	
	Short tons	Value	Short tons	Value
American Samoa	99	$3,321	161	$5,745
Guam	85	8,607	104	8,695
Puerto Rico	9,852	764,037	10,984	795,607
Virgin Islands	127	17,332	98	12,652
Wake Island	1	155	(1)	13

1 Less than 1 ton.

Source: Bureau of the Census.

TABLE 10.—U.S. imports for consumption of salt, by countries

Country	1961		1962	
	Short tons	Value	Short tons	Value
North America:				
Bahamas	190,738	$736,771	203,041	$784,217
Canada	381,894	2,166,879	677,880	3,557,593
Dominican Republic	64,763	288,049	29,269	87,760
Jamaica	6,810	18,240	11,359	30,426
Mexico	386,828	483,742	407,273	511,317
Total	1,031,033	3,693,681	1,328,822	4,971,313
Europe:				
Spain	19,051	60,963	45,397	125,695
United Kingdom			(1)	251
Total	19,051	60,963	45,397	125,946
Asia: Japan			(1)	127
Grand total	1,050,084	3,754,644	1,374,219	5,097,386

1 Less than 1 ton.

Source: Bureau of the Census.

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

TABLE 11.—U.S. imports for consumption of salt, by classes

Year	In bags, sacks, barrels, or other packages (dutiable)		Bulk (dutiable)	
	Short tons	Value	Short tons	Value
1953-57 (average)	14,272	[1] $188,794	286,285	[1] $1,489,081
1958	43,864	558,902	567,179	2,809,557
1959	37,726	531,151	986,903	4,906,490
1960	17,693	267,634	1,039,335	4,216,080
1961	9,259	144,210	1,040,825	3,610,434
1962	15,234	253,963	1,358,985	4,843,423

[1] Data known to be not comparable with other years.

Source: Bureau of the Census.

TABLE 12.—U.S. imports for consumption of salt, by customs districts

Customs district	1961		1962	
	Short tons	Value	Short tons	Value
Buffalo	4,651	$49,340	37,096	$200,389
Chicago	16,576	77,742	38,088	155,672
Connecticut	33,521	150,171	33,329	196,138
Duluth and Superior	48,564	263,633	45,460	236,683
Georgia	133,219	510,996	148,222	568,745
Hawaii			40	1,316
Los Angeles			36,477	46,600
Maine and New Hampshire	9,606	55,963	38,755	226,578
Maryland	11,226	40,092		
Massachusetts	37,461	133,312	48,925	155,165
Michigan	176,810	985,774	353,155	1,812,364
New York	54,657	251,513	29,269	87,760
Ohio	79,296	462,011	61,458	335,513
Oregon	116,544	145,787	80,405	100,502
Puerto Rico	6,100	30,500	6,073	30,365
Rochester			10,000	51,430
San Diego	13	130	25	265
Vermont	256	1,721	5,135	31,486
Virginia	43,025	161,495	48,746	185,107
Washington	270,272	337,825	290,366	363,950
Wisconsin	8,287	96,639	63,195	311,358
Total	1,050,084	3,754,644	1,374,219	5,097,386

Source: Bureau of the Census.

TABLE 13.—U.S. exports of salt, by countries

Destination	1961		1962	
	Short tons	Value	Short tons	Value
North America:				
Bermuda	137	$2, 430	105	$2, 466
Canada	95, 848	770, 163	119, 855	921, 458
Central America:				
British Honduras	19	410	20	818
Canal Zone	----------	----------	102	1, 212
Costa Rica	1, 115	13, 945	280	8, 213
El Salvador	94	2, 134	75	1, 957
Guatemala	530	9, 781	612	7, 747
Honduras	309	8, 700	188	5, 740
Nicaragua	565	13, 924	600	14, 211
Panama	438	9, 092	181	4, 552
Mexico	3, 426	111, 079	7, 765	159, 877
West Indies:				
Bahamas	1, 280	17, 334	192	15, 665
Cuba	600	23, 180	----------	----------
Dominican Republic	180	2, 479	488	3, 622
Haiti	54	2, 822	105	7, 298
Netherlands Antilles	428	25, 708	798	42, 330
Other	184	4, 173	181	3, 613
Total	105, 207	1, 017, 354	131, 547	1, 200, 779
South America:				
Chile	302	2, 807	1, 019	9, 968
Ecuador	180	4, 882	369	9, 667
Peru	248	5, 086	328	4, 670
Venezuela	1, 890	16, 946	3, 180	23, 357
Other	350	3, 680	331	5, 478
Total	2, 970	33, 401	5, 227	53, 140
Europe:				
France	75	1, 402	361	5, 636
Germany, West	394	4, 102	1, 005	10, 238
Italy	1, 027	9, 476	1, 996	17, 131
Netherlands	1, 383	13, 860	2, 052	18, 480
Spain	648	6, 600	1, 844	13, 200
United Kingdom	1, 849	17, 376	2, 226	17, 283
Other	519	6, 444	1, 343	9, 956
Total	5, 895	59, 260	10, 827	91, 924
Asia:				
Hong Kong	490	3, 920	349	3, 251
Japan	516, 498	2, 647, 168	501, 143	2, 125, 173
Lebanon	234	3, 748	157	6, 326
Philippines	643	10, 466	972	8, 639
Saudi Arabia	816	36, 861	496	14, 101
Other	667	14, 241	1, 228	19, 464
Total	519, 348	2, 716, 404	504, 345	2, 176, 954
Africa:				
Angola	585	2, 340	585	2, 340
Congo, Republic of the, and Ruanda-Urundi	1, 593	6, 370	820	7, 468
Ghana	750	3, 000	----------	----------
Nigeria	350	1, 800	790	4, 246
South Africa, Republic of	2, 156	10, 448	3, 406	16, 287
Other	16	1, 550	418	2, 286
Total	5, 450	25, 508	6, 019	32, 627
Oceania:				
Australia	2, 307	9, 227	3, 943	39, 733
New Zealand	514	2, 244	3, 214	12, 854
Other	275	12, 609	80	7, 604
Total	3, 096	24, 080	7, 237	60, 191
Grand Total	641, 966	3, 876, 007	665, 202	3, 615, 615

Source: Bureau of the Census.

A new tariff bill, referred to as the Trade Classification Act, was passed but its effective date was delayed. According to the new bill, the duties on salt remained unchanged as follows:

Trade Classification Act item number	*Type of salt*	*Duty*
420.92	In brine	10 percent ad valorem.
420.94	In bulk	$0.017 per 100 pounds.
420.96	Other (packaged)	$0.035 per 100 pounds.

Salt in brine, formerly an unenumerated article in paragraph 1558 of the Tariff Act of 1930, was assigned a special classification number under the bill.

WORLD REVIEW

Salt production increased worldwide, totaling 100.5 million tons compared with 94.1 million tons in 1961. U.S. production was 29 percent of the world total.

Aden.—Aden Salt Works, largest in the nation, suspended operations in December 1961, pending the arrival of new machinery. The company contracted to dredge the shallow canal connecting the salt works with the harbor during the shutdown.[6]

Australia.—Lacking deposits of rock salt, Australia depended largely on solar evaporation of brines for supplies of salt. At Dry Creek near Osborne, 5,000 acres of swampland was converted to evaporating and crystallizing ponds, which produced 400,000 tons of salt from sea water in 1962. The salt was harvested by specially designed machines and transported to the stockpile by a conveyor belt system.[7]

TABLE 14.—World production of salt, by countries[1 2]

(Thousand short tons)

Country[1]	1953–57 (average)	1958	1959	1960	1961	1962
North America:						
Canada	1,310	2,361	3,317	3,311	3,304	3,665
Costa Rica	13	[3] 33	14	[3] 14	[3] 13	[3] 10
El Salvador	47	12	14	15	17	20
Guatemala	17	18	18	17	25	24
Honduras	[3] 12	[3] 11	[3] 11	[3] 11	17	17
Mexico	257	400	573	[3] 573	[3] 660	[3] 660
Nicaragua	13	11	12	12	13	10
Panama	8	7	9	8	9	11
United States (including Puerto Rico):						
Rock salt	5,108	5,407	6,160	6,466	6,439	7,728
Other salt	17,338	16,504	19,003	19,015	19,268	21,081
West Indies:						
British:						
Bahamas	144	112	233	231	230	222
Leeward Islands (exports)	3	3	2	(4)	(4)	(4)
Turks and Caicos Islands	12	22	35	28	33	[3] 33
Cuba	67	65	89	65	(4)	(4)
Dominican Republic:						
Rock salt	31	49	71	73	84	[3] 55
Other salt	14	18	22	22	22	
Haiti	32	[3] 11	11	[3] 11	[3] 11	[3] 11
Netherlands Antilles	2	[3] 1	[3] 1	(5)	(5)	(5)
Total	24,428	25,045	29,595	29,872	[3] 30,200	[3] 33,600

See footnotes at end of table.

[6] Bureau of Mines. Mineral Trade Notes. V. 55, No. 1, July 1962, p. 48.
[7] Chemical Trade Journal and Chemical Engineer (London). Harvesting Salt. V. 151, No. 3931, Oct. 5, 1962, p. 688.

TABLE 14.—World production of salt, by countries [1] [2]—Continued

(Thousand short tons)

Country [1]	1953–57 (average)	1958	1959	1960	1961	1962
South America:						
Argentina:						
Rock salt	2	(5)	(5)	(5)	(5)	(5)
Other salt	437	632	572	605	[3] 640	[3] 640
Brazil	797	1,053	941	1,017	980	1,284
Chile	49	19	39	47	51	[3] 53
Colombia:						
Rock salt	197	243	235	259	294	293
Other salt	55	78	63	75	77	44
Ecuador	33	23	24	33	35	[3] 35
Peru	103	116	116	117	96	103
Venezuela	75	97	86	87	162	[3] 154
Total [1] [3]	1,765	2,280	2,095	2,260	2,350	2,625
Europe:						
Austria:						
Rock salt	1	1	1	2	3	6
Other salt	450	567	443	530	474	540
Bulgaria	74	123	98	96	139	[3] 139
Czechoslovakia	169	179	177	185	207	[3] 207
France:						
Rock salt and salt from springs	2,926	3,059	2,971	3,306	3,260	[3] 4,200
Other salt	651	925	869	812	979	
Germany:						
East	1,756	1,960	1,858	1,968	2,204	[3] 2,200
West (marketable):						
Rock salt	3,366	3,556	3,659	4,001	4,783	5,047
Brine salt	354	370	363	374	376	381
Greece	91	106	108	107	131	[3] 132
Italy:						
Rock salt and brine salt	1,105	1,135	1,412	1,743	1,744	1,904
Other salt	870	1,053	780	1,123	[3] 1,100	[3] 1,100
Malta	2	2	2	1	2	2
Netherlands	639	876	1,087	1,208	1,228	1,391
Poland:						
Rock salt	1,360	432	560	574	670	671
Other salt		1,344	1,455	1,571	1,591	1,616
Portugal	293	343	236	236	294	[3] 294
Rumania	720	807	926	1,152	1,466	[3] 1,470
Spain:						
Rock salt	487	617	616	592	677	[3] 1,760
Other salt	925	983	873	941	1,086	
Switzerland	132	138	151	164	173	185
U.S.S.R.[3]	7,100	7,200	7,200	8,300	9,000	9,000
United Kingdom:						
Rock salt	78	130	160	168	320	535
Other salt	5,153	5,397	5,956	6,371	6,031	6,169
Yugoslavia	152	190	150	166	177	[3] 185
Total [1] [3]	28,890	31,530	32,140	35,720	38,150	39,170
Asia:						
Aden	262	174	196	143	86	86
Afghanistan:						
Rock salt	34	29	29	29	24	[3] 24
Other salt		[3] 37	[3] 44	[3] 55	73	[3] 72
Burma	101	123	123	163	138	172
Cambodia	46	71	55	41	60	[3] 60
Ceylon	75	20	34	60	39	52
China [3]	6,900	11,500	12,600	14,200	12,700	13,200
Cyprus	4	6	6	---	2	7
India:						
Rock salt	6	6	4	4	4	[3] 4
Other salt	3,479	4,661	3,499	3,782	3,816	4,243
Indonesia	198	259	347	218	491	335
Iran [6]	290	82	88	143	160	160
Iraq [6]	24	29	41	40	41	42
Israel	29	37	37	41	49	[3] 49
Japan	643	1,166	1,285	977	913	944
Jordan	10	12	18	13	21	21
Korea:						
North	[3] 165	484	[3] 485	357	432	[3] 440
Republic of	285	481	430	440	134	428
Lebanon	14	13	14	6	11	11
Pakistan:						
Rock salt	168	198	176	203	222	223
Other salt	269	197	141	272	207	276
Philippines	77	154	193	105	103	106

TABLE 14.—World production of salt, by countries [1] [2]—Continued

(Thousand short tons)

Country [1]	1953-57 (average)	1958	1959	1960	1961	1962
Portuguese India	13	6	4	8	[3] 8	11
Ryukyu Islands	4	3	3	3	4	(5)
Syrian Arab Republic	24	19	9	11	8	20
Taiwan	380	489	474	499	476	656
Thailand	300	471	506	369	276	[3] 220
Turkey:						
Rock salt	26	40	39	34	33	31
Other salt	444	498	503	456	262	444
Viet-Nam, South	95	68	172	159	110	213
Yemen	94	----------	110	110	132	[3] 132
Total [3]	14,460	21,335	21,665	22,940	21,035	22,680
Africa:						
Algeria	108	150	144	[3] 158	144	[3] 144
Angola	67	76	76	64	74	66
Canary Islands	20	17	14	13	15	[3] 15
Cape Verde Islands	21	9	22	26	26	[3] 26
Chad, Republic of (Natron)	6	----------	[3] 3	[3] 7	[3] 13	[3] 28
Congo, Republic of the (formerly Belgian)	1	(5)	1	1	1	1
Ethiopia (including Eritrea)	204	183	155	173	166	191
French Somliland	32	----------	----------	----------	----------	----------
Ghana	[3] 24	[3] 24	[3] 24	13	20	21
Kenya	24	21	22	24	25	21
Libya	16	14	16	14	11	16
Malagasy Republic	19	19	[3] 19	[3] 19	[3] 19	[3] 19
Mauritius	3	3	4	4	4	4
Morocco	64	67	37	33	23	31
Mozambique	15	24	21	44	44	[3] 44
Senegal, Republic of (including Mauritania)	67	78	77	55	49	53
Somali Republic	4	4	4	[3] 8	2	[3] 2
South Africa, Republic of	163	241	261	279	229	310
South-West Africa:						
Rock salt	6	7	6	4	4	4
Other salt	58	89	50	76	56	78
Sudan	60	60	60	60	58	[3] 55
Tanganyika	26	40	41	39	36	33
Tunisia	162	187	101	183	177	175
Uganda	10	11	10	6	8	3
United Arab Republic (Egypt)	481	444	422	575	570	[3] 570
Total [1] [3]	1,661	1,768	1,590	1,878	1,774	1,910
Oceania:						
Australia	424	481	524	519	554	[3] 550
New Zealand	6	23	23	19	6	[3] 6
Total	430	504	547	538	560	[3] 556
World total (estimate) [1] [2]	71,600	82,500	87,600	93,200	94,100	100,500

[1] Salt is produced in Albania, Bolivia, and Nigeria, but figures of production are not available. Estimates for these countries are included in the total.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Estimate.
[4] Data not available; estimate by senior author of chapter included in total.
[5] Less than 500 tons.
[6] Year ended March 31 of year following that stated.

Compiled by Liela S. Price, Division of Foreign Activities.

Canada.—Shaft sinking and mining operations at three Canadian rock salt mines were described. Mining methods and handling facilities were similar to the most up-to-date U.S. salt-mining practices and equipment.[8] A detailed report of the large salt deposits of On-

[8] Jarman, H. G. Mining Rock Salt in Canada. Min. Mag. (London), v. 106, No. 3, March 1962, pp. 142–146.

tario was published. Reserves were estimated at more than 2 million million tons.[9]

Lebanon.—A salt refinery was established at Tripoli on the northern coast. It was expected to supply 6,000 to 7,000 tons annually for domestic table salt needs.[10]

Rumania.—A new salt pit capable of producing 150,000 tons annually began production at Ocna Dej, a well-known saltworks. The salt reserves of Rumania were reported to be among the world's largest.[11]

United Kingdom.—Extensive modernization of the Meadowbank rock salt mine near Winsford, Cheshire, was completed. A detailed report of the underground mining and the surface treatment plant was published.[12] Mining, handling, and treatment methods were similar to those used by U.S. rock salt producers.

TECHNOLOGY

A salt symposium sponsored by the Northern Ohio Geological Society was held in Cleveland May 3 to 5. Papers were presented on geology of salt formations, mining evaporated salt, and solution mining of salt. The most advanced mining techniques were described including hydraulic fracturing, a means of interconnecting adjacent wells drilled into a salt formation. The formation was fractured by water at high pressure, and the pressure was maintained until channels had been dissolved through the salt between the wells. Although the direction of the fracture was not readily controllable, the system had many advantages over older brining procedures. Sonar electronic gear was used successfully in defining solution cavities.

A recrystallizing process transformed waste rock salt into high-purity evaporated salt.[13] A double-effect salt recrystallizer was developed to utilize excessively fine salt, which may exceed 20 percent of the total output of a mine. Finely crushed salt was required as feed rather than brine because the process had no net water evaporation capacity.

The underlying principle of operation was that between 160° and 226° F. sodium chloride solubility increases with increasing temperature, whereas the solubility of calcium sulfate, the chief impurity in rock salt, decreases as the temperature rises. By dissolving the impure rock salt in hot brine nearly saturated with calcium sulfate, most of this impurity was rejected and was filtered off with the other insolubles. Pure salt was crystallized from the clarified liquor by flashing to a lower temperature in a vacuum chamber. Both the evaporating and cooling effects contributed to the crystallization of the salt; however, the cooling effect prevented crystallization of calcium sulfate because of its inverse temperature-solubility relationship. The result is a crystalline salt product that was more than 99.99 percent sodium chloride. By washing adhering mother liquor from the crystals on the

[9] Hewitt, D. F. Salt in Ontario. Ontario Dept. of Mines (Toronto, Canada), Ind. Miner. Rept. 6, 1962, 38 pp.
[10] Foreign Trade (Ottawa, Canada). Salt. V. 118, No. 4, Aug. 25, 1962, p. 27.
[11] Chemical Trade Journal and Chemical Engineer (London). Salt Rich Rumania. V. 150, No. 3901, Mar. 9, 1962, p. 506.
[12] Mine and Quarry Engineering (London). Modernization at the Meadowbank Rock Salt Mine. V. 28, No. 2, February 1962, pp. 50–59; No. 3, March 1962, pp. 98–106.
[13] Thielgard, L. J. The Recrystallizer Process. Chem. Eng. Prog., v. 58, No. 8, August 1962, pp. 68–71.

filter, the impurities may be further reduced to 5 parts per million.

Steam required to produce 1 ton of pure salt was about 2,100 pounds in the double-effect machine. This compared favorably with 2,200 pounds per ton used by forced-circulation quadruple-effect evaporators of conventional design.

Another salt crystallizer of improved design was described.[14] By using an evaporator with a conispherical shape, which was a sphere on top of a cone, the maximum ratio of vapor-release area to evaporator volume was achieved. The geometry of the unit also has the least surface area per unit of volume, thus minimizing buildup of crystals at local cool spots. Structural stability and smooth contours also contributed to the improved design.

Mining operations at the Retsof mine of International Salt Co. were discussed.[15] The mine, 35 miles south of Rochester, N.Y., was reported to be the largest in the world and encompassed nearly 2,700 acres of a salt vein about 1,200 feet below ground level.

Since production first started 77 years ago, hand labor has been largely replaced by efficient mechanization. The room-and-pillar system of mining was used. After the face was prepared by shearing and undercutting, about 400 tons of salt was blasted with each shot. Between 200 and 210 pounds of AN/FO (ammonium nitrate and fuel oil mixture) was used in place of dynamite. The broken salt was mechanically loaded into cars and hauled to the foot of the shaft by rail. Development of a new area by using pneumatic-tired vehicles and a trackless system of haulage was planned.

A standing cavity more than 110 feet in diameter resulted from Project Gnome, a 3-kiloton experimental nuclear blast detonated 1,200 feet below the surface in a bedded salt deposit near Carlsbad, N. Mex.[16] Five months after the blast when the cavity was entered and examined, the radioactivity level was low and the cavity was half filled with crushed salt, much of which was 2 to 3 mesh in size.

Several reports covering various aspects of the Project Gnome nuclear detonation were released by the Atomic Energy Commission. It was stated in one report that the pressure of the explosion spread the layers of salt apart and thrust wedges of salt from the cavity into the spaces. This effect was not noted in comparable test explosions in tuff.[17]

A symposium on the effects of deicing chemicals on highway structures—particularly concrete bridge decks—was held by the Highway Research Board, an agency of the National Research Council of the National Academy of Sciences. Progressively severe deterioration of concrete surfaces where deicing chemicals were used was noted by State, county, and municipal maintenance forces in many areas. Spalling, scaling, and pitting of the concrete was most severe on bridge decks where circulating cold air beneath the structure was thought to be a contributing factor. The proper use of air entrain-

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[14] Chemical Engineering News. New Salt Crystallizer Cuts Salt Build-Up. V. 39, No. 16, Apr. 17, 1961, p. 62.

[15] Skillings Mining Review. International Salt's Retsof Mine. V. 51, No. 16, Apr. 21, 1962, pp. 1, 4.

[16] Hoy, R. B. Application of Nuclear Explosives in Mining. Min. Eng., v. 14, No. 9, September 1962, pp. 48–56.

[17] U.S. Atomic Energy Commission. Earth Deformation From a Nuclear Detonation in Salt. U.S. Dept. of Commerce, Office of Tech. Serv., PNE 109 F, 1962, 60 pp.

ment techniques when laying the concrete was helpful in preventing deterioration, although improper techniques were valueless. Surface additives were sometimes helpful, but the most effective means of controlling the deterioration was through close control and inspection while emplacing the concrete.[18]

Explosives, having characteristic impedances closely matching those of a particular type of rock, generate higher peak-strain amplitudes in the rock, transmit higher percentages of explosive energy to the rock, and cause more rock breakage per blast.[19] These and other conclusions resulted from tests conducted in a Louisiana salt mine. Records were made of the particle velocity, the crushed volume, and the strain produced by various types of explosives detonated in rock salt.

A small quantity of salt is necessary for the normal body functions of human beings and animals; however, an excessive quantity in the system is toxic, causing a condition called salt or sodium poisoning. These facts were tragically emphasized when 6 of 14 infants died after having been accidentally fed large doses of salt in their daily formulas. A treatment technique known as peritoneal dialysis was credited with saving the lives of three of the survivors.

The principal of ion exchange was the fundamental factor in removing the excess salt from the babies' bloodstreams. A solution of sugar and water was injected into the abdominal cavities and allowed to remain several hours. By ion exchange through body membranes, sugar and salt were interchanged between the blood and the injected solution, which was periodically withdrawn and replaced with fresh solution until the salt level in the blood was restored to normal.[20]

Patents were issued for several processes of salt mining and manufacturing. These processes included (1) a method for coating granular salt with a combination of an anticaking substance, such as sodium silicate, and an antimalarial agent;[21] (2) a water-soluble iron cyanide coating for salt particles to prevent caking;[22] (3) a process for recovering various salts from sea water by a combination of solar evaporation, precipitation, and thermal evaporation,[23] (4) a downflow type of solid-salt dissolver capable of producing saturated brine free of air bubbles;[24] (5) a method of hydraulic fracturing underground beds including salt so that a horizontal opening in the strata was made which may form a channel connecting another well in the field;[25] and (6) an apparatus for recovering salt produced by solar evaporation from the bottom of crystallizing ponds.[26]

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[18] Highway Research Board. Effects of De-Icing Chemicals on Structures—A Symposium. Nat. Acad. Sci., Nat. Res. Council, Bull. 323, 1962, 96 pp.
[19] Nicholls, H. R., and V. E. Hooker. Comparative Studies of Explosives in Salt. BuMines Rept. of Inv. 6041, 1962, 46 pp.
[20] Science Newsletter. Salt Poisoning Treatment. V. 82, No. 24, Dec. 15, 1962, p. 380.
[21] Baugh, C. Salt Composition and Process for Making Same. U.S. Pat. 3,048,525, Aug. 7, 1962.
[22] Kaufman, D. W. (assigned to International Salt Co., Inc., Clarks Summit, Pa.). Treatment of Bulk Salt. U.S. Pat. 3,036,884, May 29, 1962.
[23] Pomykala, E. S. Process for Separating Sea Salts. U.S. Pat. 3,055,734, Sept. 25, 1962.
[24] MacKinnon, C. E. (assigned to International Salt Co., Inc., Clarks Summit, Pa.). Salt Dissolver. U.S. Pat. 3,036,896, May 29, 1962.
[25] Redlinger, J. F. (assigned to FMC Corp., New York). Method of Hydraulic Fracturing in Underground Formations. U.S. Pat. 3,018,095, Jan. 23, 1962.
[26] Carello, M. Self Moving Plant Comprising a Mechanical Continuously Working Salt Gathering Machine in Artificial Salt Marshes. U.S. Pat. 3,061,953, Nov. 6, 1962.

Sand and Gravel

By Perry G. Cotter [1] and Jewel B. Mallory [2]

AS A RESULT of increases in nearly all types of construction, output of sand and gravel was greater than in any previous year. The total value of new construction put-in-place increased 6 percent over that of 1961, the number of new private housing units increased 13 percent, and 7 percent more highway construction was completed.

LEGISLATION AND GOVERNMENT PROGRAMS

Appropriations for the Interstate Highway System for Fiscal Year 1964 were $2.6 billion. The 1962 Highway Act authorized expenditure of $950 million for primary and secondary roads during Fiscal Year 1964 and $975 million for Fiscal Year 1965. The Act also provided for relocation advisory assistance to families displaced by highway construction and increased the funds for research and planning.[3] In December, 70 percent of the Interstate Highway System was either open to traffic, under construction, or in the planning stage.[4]

DOMESTIC PRODUCTION

Output of 777 million tons of sand and gravel valued at $795 million was an increase of 3 percent in tonnage and 6 percent in value over that in 1961. California, which far surpassed the other States in production, was followed by Michigan, Ohio, Illinois, Wisconsin, Texas, New York, Minnesota, Indiana, and Utah. The 338 million tons produced by these 10 States accounted for 50 percent of the total United States production.

Commercial Production.—Commercial operations supplied 73 percent of the total production of sand and gravel. The average price for commercially produced material was $1.12 per ton. More extensive use of automatic controls and improvements in procedures for digging and processing sand and gravel assisted producers in keeping costs low.

Government-and-Contractor Production.—The quantity of sand and gravel reported by Government-and-Contractor operations was 1 per-

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.
[3] Fallon, Hon. George H. Rapid Progress Is Important. Am. Road Builder, v. 40, No. 5, May 1963, pp. 8–10.
[4] Whitton, Rex M. Progress in the Interstate Highway System. Am. Highways, v. 42, No. 2, April 1963, pp. 1–10.

cent less than in 1961. Value was $159 million, an average of $0.76 per ton. The entire production of a private producer must be under contract to some Governmental agency to be classified under the Government-and-Contractor category. If any part of the production is sold commercially, the entire output is designated as commercial.

Degree of Preparation.—Washing, screening, or other means of beneficiation was required for 90 percent of the commercial production. Of the total output, 86 percent was beneficiated compared with 84 percent in 1961. This may have indicated some depletion of high-grade deposits in areas of greatest demand and insistence on compliance with more rigid specifications.

TABLE 1.—Sand and gravel sold or used by producers in the United States, by classes of operations and uses

(Thousand short tons and thousand dollars)

Class of operation and use	1961		1962	
	Quantity	Value	Quantity	Value
Contruction:				
Building:				
Sand	125,290	$132,000	134,249	$140,507
Gravel	111,378	146,188	111,712	145,257
Paving:				
Sand	108,788	95,866	111,110	100,410
Gravel	311,714	271,704	318,972	289,701
Fill:				
Sand	26,924	12,824	28,022	14,616
Gravel	30,119	15,094	30,601	15,402
Railroad ballast:				
Sand	517	354	825	880
Gravel	3,232	2,570	3,625	2,718
Other:				
Sand	3,770	3,512	5,435	4,907
Gravel	6,875	7,202	6,528	7,472
Total construction	728,607	687,314	751,079	721,870
Industrial sand:				
Unground:				
Glass	6,682	21,943	7,199	23,847
Molding	5,815	15,808	6,232	16,998
Grinding and polishing	1,094	2,388	987	1,843
Blast sand	635	2,814	802	3,295
Fire or furnace	622	1,285	396	945
Engine	754	1,477	777	1,588
Ferrosilicon	47	126	81	246
Filtration	210	547	176	457
Oil (hydrafrac)	258	1,677	266	1,844
Other	1,011	2,864	1,132	3,367
Total unground	17,128	50,929	18,048	54,430
Ground [1]	919	8,064	2,068	12,813
Total industrial	18,047	58,993	20,116	67,243
Miscellaneous gravel	5,130	4,994	5,506	5,612
Grand total	751,784	751,301	776,701	794,725
Commercial:				
Sand	240,346	275,099	259,086	300,211
Gravel	299,209	324,185	307,893	335,209
Government-and-contractor: [2]				
Sand	42,990	28,450	40,671	28,352
Gravel	169,239	123,567	169,051	130,953

[1] See table 11 for use breakdown.
[2] Approximate figures for operations by States, counties, municipalities, and other Government agencies under lease.

Size of Plants.—Sixty percent of the total production was supplied by 2,243 plants producing between 50,000 and 500,000 tons per year. The number of smaller plants, producing less than 25,000 tons, increased by 245 units. Seven more plants reported production of more than 1 million tons. In 1952 only 27 plants had an output of over 1 million tons compared to 60 so reporting in 1962.

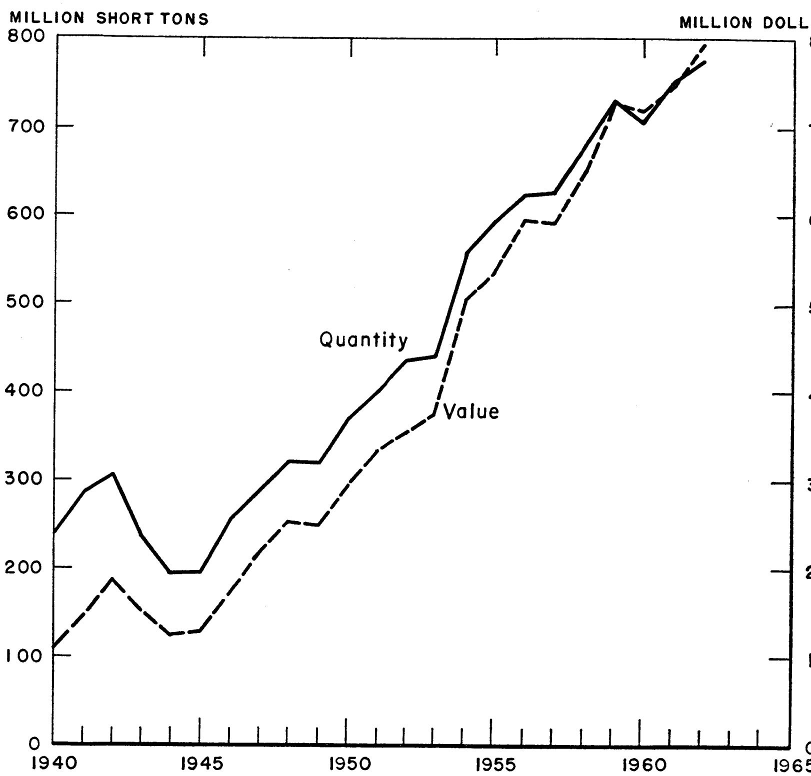

FIGURE 1.—Production and value of sand and gravel in the United States, 1940–62.

TABLE 2.—Sand and gravel sold or used by producers in the United States[1]

(Thousand short tons and thousand dollars)

Year	Sand		Gravel		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1953–57 (average)	209,575	$214,610	359,993	$307,611	569,568	$522,221
1958	241,658	251,071	442,840	401,718	684,498	652,789
1959	269,185	288,531	461,020	440,181	730,205	728,712
1960	265,656	293,599	444,136	426,833	709,792	720,432
1961	283,336	303,549	468,448	447,752	751,784	751,301
1962	299,757	328,563	476,944	466,162	776,701	794,725

[1] Includes possessions and other areas administered by the United States (1953–56).

TABLE 3.—Sand and gravel sold or used by producers in the United States, by States, and classes of operations

(Thousand short tons and thousand dollars)

State	1961						1962					
	Commercial		Government-and-contractor		Total		Commercial		Government-and-contractor		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	4,919	$5,621	881	$831	5,800	$6,452	4,399	$4,418	256	$68	4,655	$4,486
Alaska	629	1,177	4,612	3,008	5,241	4,185	533	965	5,198	4,390	5,731	5,355
Arizona	10,283	9,699	[1] 7,405	[1] 6,476	[1] 17,688	[1] 16,175	7,897	8,640	7,682	8,764	15,579	17,404
Arkansas	5,933	6,892	3,456	2,182	9,389	9,074	6,717	7,946	4,130	2,060	10,847	10,006
California	86,046	107,153	24,135	16,958	110,181	124,111	88,572	107,523	19,088	17,399	107,660	124,922
Colorado	9,383	9,720	8,977	7,226	18,360	16,946	10,650	11,785	8,663	7,141	19,313	18,926
Connecticut	5,669	5,732	1,830	901	7,499	6,633	7,902	8,283	2,306	961	10,208	9,244
Delaware	961	970	----	----	961	970	1,755	1,445	----	----	1,755	1,445
Florida	5,944	5,072	586	505	6,530	5,577	5,745	5,045	179	134	5,924	5,179
Georgia	3,150	3,049	----	----	3,150	3,049	3,429	3,365	----	----	3,429	3,365
Hawaii	336	667	80	91	416	758	354	801	346	321	700	1,122
Idaho	2,198	2,417	5,107	4,376	7,305	6,793	2,686	2,756	11,635	10,273	14,321	13,029
Illinois	30,516	34,578	837	520	31,353	35,098	32,861	38,231	1,261	750	34,122	38,981
Indiana	19,109	16,660	468	238	19,577	16,898	20,838	18,466	423	226	21,261	18,692
Iowa	10,154	9,665	3,237	1,986	13,391	11,651	11,108	11,033	2,689	1,441	13,797	12,474
Kansas	8,975	6,722	2,391	1,059	11,366	7,781	9,274	6,953	2,278	1,086	11,552	8,039
Kentucky	5,349	5,287	233	253	5,582	5,540	6,029	5,316	108	62	6,137	5,378
Louisiana	11,783	14,729	259	104	12,042	14,833	11,701	14,682	339	135	12,040	14,817
Maine	2,275	1,513	6,646	2,283	8,921	3,796	1,860	1,269	8,154	2,744	10,014	4,013
Maryland	12,230	16,833	174	61	12,404	16,894	12,604	16,753	158	63	12,762	16,816
Massachusetts	12,614	12,603	5,447	2,355	18,061	14,958	13,274	13,302	4,292	1,724	17,566	15,026
Michigan	39,667	36,348	14,936	11,442	54,603	47,790	35,547	34,299	12,016	7,730	47,563	42,029
Minnesota	19,109	17,644	11,581	6,499	30,690	24,143	19,090	16,701	10,309	5,955	29,399	22,656
Mississippi	5,536	5,314	384	589	5,920	5,903	6,394	6,336	607	926	7,001	7,262
Missouri	8,744	10,266	627	422	9,371	10,688	9,445	10,927	859	645	10,304	11,572
Montana	2,122	2,269	12,580	11,237	14,702	13,506	2,124	2,407	16,349	15,235	18,473	17,642
Nebraska	9,099	7,476	995	774	10,094	8,250	10,938	8,609	1,915	1,188	12,853	9,797
Nevada	2,635	3,356	4,460	4,087	7,095	7,443	3,048	4,857	4,802	4,798	7,850	9,655
New Hampshire	1,924	1,588	5,777	2,039	7,701	3,627	2,394	2,294	5,866	1,825	8,260	4,119
New Jersey	12,246	20,890	11	5	12,257	20,895	13,697	21,218	31	12	13,728	21,230
New Mexico	4,111	4,913	8,412	5,136	12,523	10,049	3,590	4,384	3,299	3,637	6,889	8,021
New York	25,329	29,112	2,714	1,359	28,043	30,471	27,538	30,827	1,909	519	29,447	31,346
North Carolina	6,314	6,391	3,465	2,076	9,779	8,467	8,889	9,205	3,627	2,252	12,516	11,457
North Dakota	1,719	1,654	7,676	5,853	9,395	7,507	2,593	2,224	7,022	4,898	9,615	7,122

Ohio	32,536	40,177	1,152	1,095	33,688	41,272	34,626	42,815	578	518	35,204	43,333
Oklahoma	4,029	4,515	1,281	998	5,310	5,513	3,802	4,355	634	381	4,436	4,736
Oregon	6,477	7,583	5,822	6,097	12,299	13,680	9,629	10,378	5,240	4,178	14,869	14,556
Pennsylvania	12,594	19,766	----------	----------	12,594	19,766	14,419	23,587	----------	----------	14,419	23,587
Rhode Island	1,686	1,628	40	38	1,726	1,666	2,141	1,754	205	136	2,346	1,890
South Carolina	2,867	3,050	37	17	2,904	3,067	3,273	3,648	45	22	3,318	3,670
South Dakota	4,126	3,040	7,198	4,296	11,324	7,336	3,832	2,698	11,539	6,509	15,371	9,207
Tennessee	5,576	7,507	656	539	6,232	8,046	5,621	7,717	454	301	6,075	8,018
Texas	23,272	27,975	4,126	2,716	27,398	30,691	25,619	29,948	4,457	3,149	30,076	33,097
Utah	7,920	4,798	[1] 10,405	[1] 12,181	[1] 18,325	[1] 16,979	5,270	4,929	14,671	16,025	19,941	20,954
Vermont	920	1,001	1,312	566	2,232	1,567	677	676	753	400	1,430	1,076
Virginia	9,568	14,516	271	181	9,839	14,697	9,620	16,295	125	80	9,745	16,375
Washington	11,526	10,007	7,468	6,138	18,994	16,145	12,786	12,628	6,794	5,517	19,580	18,145
West Virginia	4,882	10,152	----------	----------	4,882	10,152	5,202	10,942	----------	----------	5,202	10,942
Wisconsin	22,496	17,465	17,482	10,992	39,978	28,457	22,476	17,833	11,173	6,575	33,649	24,408
Wyoming	2,069	2,124	4,600	3,232	6,669	5,356	2,511	1,952	5,258	6,152	7,769	8,104
Total	539,555	599,284	212,229	152,017	751,784	751,301	566,979	635,420	209,722	159,305	776,701	794,725
American Samoa	----------	----------	----------	----------	----------	----------	----------	----------	3	4	3	4
Guam	----------	----------	38	49	38	49	----------	----------	----------	----------	----------	----------
Johnston Island	----------	----------	1	1	1	1	----------	----------	----------	----------	----------	----------
Panama Canal Zone	75	73	----------	----------	75	73	70	77	----------	----------	70	77
Puerto Rico	6,682	9,072	4,688	1,313	11,370	10,385	6,631	9,161	747	632	7,378	9,793

[1] Revised figure.

TABLE 4.—Sand and gravel sold or used by producers in the United States in 1962, by States, uses, and classes of operations

(Commercial unless otherwise indicated)

State	Sand, construction							
	Building				Paving			
	Commercial		Government-and-contractor		Commercial		Government-and-contractor	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Alabama	1,212,956	$959,626	---	---	532,183	$418,999	31,302	$8,347
Alaska	80,722	274,228	30,739	$204,429	210	683	109,328	148,817
Arizona	1,555,800	2,046,600	150,900	150,700	636,400	655,100	2,028,300	3,694,000
Arkansas	1,346,148	1,433,507	2,200	3,300	946,052	890,513	1,836,955	895,447
California	23,076,756	27,023,807	59,410	77,086	11,139,674	11,777,717	7,614,829	6,680,396
Colorado	1,944,800	2,150,400	37,100	39,600	375,300	294,000	175,400	92,500
Connecticut	2,537,070	2,670,376	---	---	1,969,256	1,880,813	86,975	33,950
Delaware	174,244	182,909	---	---	(1)	(1)	---	---
Florida	4,604,726	3,603,225	---	---	80,594	68,806	98,820	93,904
Georgia	2,172,816	1,590,185	---	---	470,560	340,612	---	---
Hawaii	275,375	643,661	---	---	(1)	(1)	430	1,387
Idaho	321,467	556,629	---	---	65,990	82,947	350,910	211,978
Illinois	5,124,485	4,570,072	7,040	4,613	7,148,506	6,558,437	243,971	122,026
Indiana	3,720,271	3,019,535	---	---	3,624,636	2,864,047	11,075	4,984
Iowa	2,340,142	2,095,422	---	---	1,524,481	1,309,804	38,733	20,545
Kansas	3,220,911	2,363,425	---	---	3,263,767	2,494,775	1,166,721	509,232
Kentucky	2,114,812	1,944,217	---	---	1,471,122	1,207,565	121	181
Louisiana	2,064,521	1,931,921	---	---	1,801,538	1,680,227	---	---
Maine	230,128	152,544	---	---	301,191	242,059	1,673,224	559,326
Maryland	3,365,534	4,120,147	60	135	2,347,304	3,192,555	990	2,145
Massachusetts	2,910,098	2,952,482	100	100	1,561,304	1,517,043	125,500	54,160
Michigan	4,715,328	3,706,032	---	---	4,166,548	3,912,475	2,056,313	1,047,670
Minnesota	3,800,413	2,940,899	---	---	1,824,079	1,350,418	2,616,312	1,407,079
Mississippi	847,134	659,951	---	---	1,113,101	921,814	299,222	303,097
Missouri	3,306,537	2,908,604	---	---	1,142,513	943,391	57,175	57,175
Montana	352,364	552,948	19,933	53,531	63,438	77,291	52,791	47,095
Nebraska	3,112,900	2,701,000	17,900	43,400	1,048,200	821,500	389,800	197,900
Nevada	690,095	1,317,312	8	27	(1)	(1)	101,219	125,396
New Hampshire	469,624	336,340	---	---	380,896	303,194	1,122,017	397,957
New Jersey	4,465,146	4,464,927	---	---	2,534,038	1,999,556	3,049	1,067
New Mexico	770,100	854,200	21,500	66,900	382,800	460,600	130,100	221,300
New York	9,451,002	11,230,656	41,850	15,500	5,846,173	6,027,672	31,623	18,808
North Carolina	2,134,329	1,686,935	---	---	790,715	567,563	2,182,716	1,188,097

North Dakota	398,700	468,500	100,100	50,100	17,100	19,800	346,400	335,400
Ohio	5,775,049	6,415,695	41	60	7,152,096	7,257,533	281,101	223,360
Oklahoma	1,667,516	1,420,525			869,543	748,561	390,512	185,308
Oregon	959,867	1,208,331	1,310	2,291	548,563	641,846	222,659	71,224
Pennsylvania	4,492,785	6,511,367			2,562,093	3,776,519		
Rhode Island	381,438	343,464			180,719	156,097	31,871	21,111
South Carolina	1,336,423	724,732			321,000	128,800	4,583	1,329
South Dakota	527,200	509,600			162,600	167,300	661,800	509,500
Tennessee	1,953,767	3,052,283			719,830	817,737		
Texas	7,396,127	6,735,379	5,972	7,985	3,770,917	3,913,739	271,208	117,617
Utah	998,700	1,114,800	1,216,100	2,507,600	401,800	399,800	224,100	121,200
Vermont	59,234	51,140			182,787	127,016	77,679	27,942
Virginia	1,546,599	2,251,096			1,945,967	2,476,029	52,645	5,937
Washington	1,908,428	2,334,360	34,820	54,477	686,513	660,573	191,626	217,021
West Virginia	1,441,748	1,834,155			654,527	995,956		
Wisconsin	3,021,546	2,417,752	12,000	5,400	1,887,532	1,524,564	2,685,240	1,414,138
Wyoming	116,100	181,600	100	100	117,600	82,800	85,900	47,100
Undistributed [1]					213,401	209,381		
Total	132,489,981	137,219,501	1,759,183	3,287,334	80,947,157	78,966,227	30,163,245	21,444,153
American Samoa			1,630	2,223			1,087	1,482
Panama Canal Zone	35,134	38,457			35,134	38,457		
Puerto Rico	1,746,000	2,711,675	4,500	6,750	1,614,500	1,599,725	182,500	177,750

[1] Figures withheld to avoid disclosing individual company confidential data; included with "Undistributed."

TABLE 4.—Sand and gravel sold or used by producers in the United States in 1962, by States, uses, and classes of operations—Continued

(Commercial unless otherwise indicated)

State	Sand, construction—Continued									
	Railroad ballast		Fill				Other [2]			
			Commercial		Government-and-contractor		Commercial		Government-and-contractor	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Alabama	(1)	(1)	45,510	$27,172	-	-	-	-	-	-
Alaska	-	-	33,470	30,150	-	-	379	$2,537	6,075	$6,750
Arizona	-	-	112,100	80,800	143,100	$48,100	93,500	120,500	-	-
Arkansas	-	-	246,931	134,598	-	-	30,693	18,616	-	-
California	8,241	$13,341	3,368,854	2,580,712	706,529	613,899	407,494	336,513	7,500	9,320
Colorado	-	-	24,600	13,500	78,000	51,600	16,100	13,200	-	-
Connecticut	-	-	394,614	248,926	1,400	490	124,644	104,415	24,534	12,952
Delaware	-	-	27,120	17,505	-	-	(1)	(1)	-	-
Florida	(1)	(1)	315,069	200,600	75,000	33,750	53,022	56,180	5,400	6,000
Georgia	76,168	75,941	47,992	35,588	-	-	(1)	(1)	-	-
Hawaii	-	-	14	28	-	-	-	-	-	-
Idaho	-	-	32,913	14,564	-	-	144	111	-	-
Illinois	128,900	142,035	1,431,975	748,132	505	177	124,593	160,621	-	-
Indiana	8,000	4,800	1,330,905	502,853	-	-	140,282	72,880	-	-
Iowa	(1)	(1)	460,911	248,539	9,264	4,632	75,426	66,465	12,568	5,788
Kansas	(1)	(1)	892,505	440,260	23,793	13,581	36,805	32,726	-	-
Kentucky	-	-	837,614	358,057	-	-	-	-	-	-
Louisiana	-	-	59,260	30,914	-	-	(1)	(1)	-	-
Maine	-	-	168,772	80,979	13,076	4,577	95,144	70,584	-	-
Maryland	(1)	(1)	320,791	396,939	-	-	448,178	718,343	-	-
Massachusetts	-	-	1,430,552	543,382	2,430,000	895,500	387,254	322,272	43,758	23,331
Michigan	-	-	1,721,701	679,655	1,386,368	473,845	42,379	24,387	85,921	34,968
Minnesota	(1)	(1)	407,995	264,747	83,214	27,731	63,122	49,350	56,644	20,544
Mississippi	-	-	(1)	(1)	270	108	-	-	-	-
Missouri	(1)	(1)	320,877	289,859	-	-	1,874	2,315	-	-
Montana	-	-	54,675	83,850	8,000	8,800	35,269	34,831	-	-
Nebraska	-	-	(1)	(1)	-	-	(1)	(1)	-	-
Nevada	-	-	25,217	23,342	13,048	50,581	-	-	-	-
New Hampshire	-	-	(1)	(1)	1,552,026	309,269	(1)	(1)	-	-
New Jersey	-	-	(1)	(1)	-	-	(1)	(1)	5,049	1,767
New Mexico	-	-	59,500	59,500	-	-	(1)	(1)	1,300	3,000

New York	-	-	725,483	376,467	83,975	6,350	694,648	640,541	319,645	136,887
North Carolina	127,435	109,572	45,286	30,121	379,800	235,500	(1)	(1)	490,962	249,738
North Dakota	-	-	(1)	(1)	-	-	(1)	(1)	-	-
Ohio	-	-	672,768	530,513	3,322	847	209,700	186,893	-	-
Oklahoma	-	-	485,812	219,629	-	-	8,775	3,510	400	200
Oregon	-	-	188,804	116,225	750	300	30,569	23,869	-	-
Pennsylvania	-	-	31,490	30,005			428,682	611,779	-	-
Rhode Island	-	-	213,500	115,950	-	-	(1)	(1)	-	-
South Carolina	(1)	(1)	104,610	42,541	-	-	-	-	40,798	21,113
South Dakota	-	-	10,700	5,200	9,900	8,700	9,500	10,600	-	-
Tennessee	-	-	-	-	-	-	(1)	(1)	-	-
Texas	(1)	(1)	389,624	164,738	10,000	4,000	36,203	17,380	-	-
Utah	200	200	252,200	227,400	6,800	3,400	21,900	18,700	-	-
Vermont	-	-	33,516	18,357			37,447	29,037	75,833	28,792
Virginia	(1)	(1)	618,840	247,978	-	-	51,166	54,901	22,266	8,906
Washington	5,270	2,945	640,929	324,230	42,654	72,468	21,939	33,542	4,375	7,249
West Virginia	-	-	2,431	5,827	-	-	502	602	-	-
Wisconsin	(1)	(1)	985,497	563,948	421,104	147,307	3,558	2,750	63,567	27,517
Wyoming	4,900	1,200	34,300	12,600	-	-	2,300	1,100	-	-
Undistributed[1]	465,807	529,841	931,605	433,263	-	-	435,186	460,071	-	-
Total	824,921	879,875	20,539,832	11,600,143	7,481,898	3,015,512	4,168,377	4,302,121	1,266,595	604,822
American Samoa	-	-	-	-	-	-	-	-	-	-
Panama Canal Zone	-	-	-	-	-	-	-	-	-	-
Puerto Rico	-	-	512,500	325,090	434,000	322,550	-	-	-	-

[1] Figures withheld to avoid disclosing individual company confidential data; included with "Undistributed." [2] Includes unspecified.

TABLE 4.—Sand and gravel sold or used by producers in the United States in 1962, by States, uses, and classes of operations—Continued

(Commercial unless otherwise indicated)

State	Sand, industrial									
	Glass		Molding		Grinding and polishing		Blast		Fire or furnace	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Alabama	-	-	([1])	([1])	-	-	-	-	-	-
Alaska	-	-	-	-	-	-	-	-	-	-
Arizona	-	-	-	-	-	-	800	$3,100	-	-
Arkansas	226,904	$628,524	57,000	$160,650	-	-	-	-	-	-
California	676,548	3,490,856	25,661	115,892	4,623	$73,968	211,665	767,537	([1])	([1])
Colorado	-	-	-	-	-	-	([1])	([1])	-	-
Connecticut	-	-	1,625	1,948	-	-	-	-	-	-
Delaware	-	-	-	-	-	-	-	-	-	-
Florida	([1])	([1])	763	7,303	-	-	34,242	147,071	-	-
Georgia	([1])	([1])	([1])	([1])	-	-	([1])	([1])	-	-
Hawaii	-	-	-	-	-	-	-	-	-	-
Idaho	-	-	([1])	([1])	-	-	909	7,729	-	-
Illinois	1,437,885	3,380,767	384,345	1,050,969	-	-	([1])	([1])	([1])	([1])
Indiana	27,225	93,725	([1])	([1])	-	-	([1])	([1])	-	-
Iowa	-	-	([1])	([1])	-	-	([1])	([1])	-	-
Kansas	-	-	-	-	-	-	([1])	([1])	-	-
Kentucky	17,085	64,100	-	-	-	-	-	-	-	-
Louisiana	-	-	-	-	-	-	1,679	2,965	-	-
Maine	-	-	([1])	([1])	-	-	-	-	-	-
Maryland	([1])	([1])	-	-	([1])	([1])	-	-	-	-
Massachusetts	109	300	([1])	([1])	-	-	([1])	([1])	-	-
Michigan	([1])	([1])	1,517,770	2,743,943	([1])	([1])	([1])	([1])	-	-
Minnesota	([1])	([1])	60,312	219,375	([1])	([1])	([1])	([1])	-	-
Mississippi	-	-	([1])	([1])	-	-	186	518	-	-
Missouri	418,798	1,064,221	77,864	216,879	203,928	374,395	([1])	([1])	-	-
Montana	-	-	-	-	-	-	-	-	-	-
Nebraska	-	-	-	-	-	-	-	-	-	-
Nevada	([1])	([1])	([1])	([1])	-	-	([1])	([1])	([1])	([1])
New Hampshire	-	-	-	-	-	-	-	-	-	-
New Jersey	683,396	2,595,360	1,509,080	4,788,055	18,879	54,356	107,406	549,899	8,013	$22,156
New Mexico	-	-	-	-	-	-	-	-	-	-
New York	-	-	159,758	624,303	-	-	-	-	-	-
North Carolina	-	-	-	-	-	-	([1])	([1])	-	-
North Dakota	-	-	-	-	-	-	-	-	-	-
Ohio	([1])	([1])	382,866	1,451,335	([1])	([1])	([1])	([1])	150,589	429,006

Oklahoma	(1)	(1)	(1)	(1)	610	610	10, 155	31, 586		
Oregon			683	122			2, 149	3, 719		
Pennsylvania	(1)	(1)	141, 027	405, 468	(1)	(1)	(1)	(1)	169, 475	385, 558
Rhode Island			(1)	(1)						
South Carolina	(1)	(1)	(1)	(1)			(1)	(1)	(1)	(1)
South Dakota			(1)	(1)			(1)	(1)		
Tennessee	(1)	(1)	225, 147	678, 046	(1)	(1)				
Texas	(1)	(1)	33, 927	80, 074			119, 122	665, 668	2, 700	9, 558
Utah			(1)	(1)			200	600		
Vermont										
Virginia	(1)	(1)	(1)	(1)						
Washington	30, 208	271, 876	1, 100	9, 744			(1)	(1)		
West Virginia	(1)	(1)	(1)	(1)			(1)	(1)	(1)	(1)
Wisconsin	(1)	(1)	559, 848	1, 543, 893			(1)	(1)		
Wyoming										
Undistributed [1]	3, 680, 446	12, 257, 442	1, 093, 595	2, 899, 953	759, 169	1, 339, 245	313, 271	1, 114, 048	65, 135	99, 072
Total	7, 198, 604	23, 847, 171	6, 232, 371	16, 997, 952	987, 209	1, 842, 574	801, 784	3, 294, 440	395, 912	945, 350
American Samoa										
Panama Canal Zone										
Puerto Rico										

[1] Figures withheld to avoid disclosing individual company confidential data; included with "Undistributed."

TABLE 4.—Sand and gravel sold or used by producers in the United States in 1962, by States, uses, and classes of operations—Continued

(Commercial unless otherwise indicated)

	Sand, industrial—Continued											
	Engine		Ferrosilicon		Filtration		Oil (hydrofrac)		Other		Ground sand	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Alabama	98,786	$98,759			(1)	(1)						
Alaska									13,620	$44,265		
Arizona							19,000	$206,100	32,100	57,700		
Arkansas											10,303	$195,260
California	55,189	177,898			9,537	$53,959	(1)	(1)	(1)	(1)	22,655	241,311
Colorado	(1)	(1)			(1)	(1)	(1)	(1)	(1)	(1)		
Connecticut					19,000	24,700						
Delaware	25,231	18,923										
Florida	(1)	(1)			(1)	(1)			(1)	(1)		
Georgia					(1)	(1)			(1)	(1)	(1)	(1)
Hawaii	(1)	(1)							3,438	6,876		
Idaho									(1)	(1)	4,374	37,176
Illinois	19,014	17,613			9,542	26,268	(1)	(1)	(1)	(1)	744,894	5,222,810
Indiana	(1)	(1)			(1)	(1)			(1)	(1)	(1)	(1)
Iowa	(1)	(1)			(1)	(1)			(1)	(1)		
Kansas	31,300	54,955			8,811	15,042			1,725	1,208		
Kentucky	(1)	(1)							(1)	(1)		
Louisiana					(1)	(1)						
Maine	(1)	(1)										
Maryland	(1)	(1)							(1)	(1)		
Massachusetts											(1)	(1)
Michigan	(1)	(1)							(1)	(1)	(1)	(1)
Minnesota	(1)	(1)					(1)	(1)			(1)	(1)
Mississippi					2,233	2,221					(1)	(1)
Missouri	(1)	(1)	(1)	(1)	233	326			21,720	55,997	109,223	1,031,688
Montana												
Nebraska	500	300										
Nevada									42,662	104,399	3,565	24,385
New Hampshire	(1)	(1)			(1)	(1)						
New Jersey	28,774	95,775			9,913	50,605			141,705	638,112	116,471	1,028,153
New Mexico	700	3,400										
New York	(1)	(1)			(1)	(1)			(1)	(1)		
North Carolina					(1)	(1)			(1)	(1)		
North Dakota												
Ohio	(1)	(1)	(1)	(1)	(1)	(1)			72,017	185,000	(1)	(1)
Oklahoma					631	3,417			(1)	(1)	(1)	(1)

Oregon	14,820	7,410										
Pennsylvania	(1)	(1)	(1)	(1)					(1)	(1)	(1)	(1)
Rhode Island												
South Carolina	24,366	73,646			(1)	(1)			41,276	62,389	(1)	(1)
South Dakota							(1)	(1)				
Tennessee	1,508	2,262							2,974	7,161		
Texas	21,155	20,033			(1)	(1)	72,380	479,980	(1)	(1)	(1)	(1)
Utah	(1)	(1)										
Vermont									1,500	1,889		
Virginia	50,392	108,503			(1)	(1)			(1)	(1)	(1)	(1)
Washington									(1)	(1)	546	2,800
West Virginia	(1)	(1)	(1)	(1)			(1)	(1)	(1)	(1)	(1)	(1)
Wisconsin	(1)	(1)			(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Wyoming												
Undistributed [1]	405,197	908,940	80,846	$246,176	115,752	280,458	174,794	1,158,142	757,375	2,202,385	1,055,715	5,028,935
Total	776,932	1,588,417	80,846	246,176	175,652	456,996	266,174	1,844,222	1,132,112	3,367,381	2,067,746	12,812,518
American Samoa											102,000	107,890
Panama Canal Zone												
Puerto Rico												

[1] Figures withheld to avoid disclosing individual company confidential data; included with "Undistributed."

TABLE 4.—Sand and gravel sold or used by producers in the United States in 1962, by States, uses, and classes of operations—Continued

(Commercial unless otherwise indicated)

State	Gravel, construction							
	Building				Paving			
	Commercial		Government-and-contractor		Commercial		Government-and-contractor	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Alabama	845,609	$952,913			1,182,695	$1,293,975	224,470	$59,858
Alaska	106,369	295,690	135,501	$467,330	25,505	52,830	2,371,952	2,420,611
Arizona	1,983,700	2,366,100	207,000	204,700	2,735,100	2,521,000	5,090,200	4,636,200
Arkansas	1,496,454	2,214,933			2,219,978	2,187,905	2,050,994	1,058,305
California	23,261,642	29,565,462	2,575,572	2,046,543	23,984,308	28,875,404	7,485,456	7,493,922
Colorado	3,362,700	4,434,600	227,000	198,300	4,519,600	4,327,000	7,860,400	6,549,800
Connecticut	1,245,535	1,854,671			1,039,840	1,096,014	2,189,573	912,109
Delaware	70,709	184,054			(1)	(1)		
Florida	256,276	320,673			170,037	340,074		
Georgia	(1)	(1)			(1)	(1)		
Hawaii	48,240	96,480			26,995	53,990	(1)	(1)
Idaho	450,176	622,962	25,105	23,850	1,690,900	1,357,131	10,989,208	9,926,327
Illinois	4,163,691	3,889,638			10,868,872	10,395,106	1,008,648	622,874
Indiana	2,851,678	3,217,888			6,435,202	6,525,469	357,967	203,367
Iowa	1,555,817	2,335,366			4,617,934	4,032,890	2,555,406	1,383,075
Kansas	270,236	222,975			1,355,889	1,149,652	1,087,239	563,384
Kentucky	630,130	835,591			919,093	877,168	108,287	61,851
Louisiana	3,381,780	4,749,262	245,261	98,104	4,163,200	6,028,000	93,431	37,373
Maine	131,315	143,088			600,481	441,720	6,467,885	2,179,845
Maryland	1,914,490	3,567,530	50	145	2,028,336	2,719,204	(1)	(1)
Massachusetts	3,146,537	4,326,601			1,823,644	1,929,862	1,282,340	605,720
Michigan	4,441,077	5,362,042	138,580	69,215	17,020,900	14,802,764	7,609,588	5,810,149
Minnesota	2,807,082	4,089,125	2,800	1,540	9,062,116	6,683,383	7,176,558	4,364,455
Mississippi	1,377,208	1,531,711			2,766,619	2,924,955	308,054	623,126
Missouri	1,908,399	2,203,020			1,701,827	1,439,741	801,875	587,690
Montana	596,399	820,254	37,421	93,336	535,364	460,762	16,104,137	14,930,954
Nebraska	1,043,100	850,800	4,000	3,000	5,054,500	3,751,600	692,100	540,100
Nevada	881,113	1,416,466	1,239	1,255	767,882	837,448	4,605,892	4,555,098
New Hampshire	436,024	609,407			641,072	812,133	3,189,234	1,116,791
New Jersey	1,898,959	2,997,404			1,254,263	1,400,988	22,299	9,255
New Mexico	784,900	1,035,100	10,400	30,300	1,289,400	1,515,700	3,128,700	3,303,200
New York	4,390,506	6,062,727	7,935	2,747	4,268,310	4,382,770	1,139,319	307,916

North Carolina	1,540,826	2,315,079	----	----	3,661,804	3,518,329	553,400	560,070
North Dakota	446,300	807,800	191,500	263,800	1,155,900	662,100	4,905,200	3,980,500
Ohio	5,628,091	6,964,942	153	532	11,044,967	13,535,189	(1)	(1)
Oklahoma	115,235	178,940	----	----	310,132	338,129	241,294	194,123
Oregon	1,879,108	2,194,337	152,071	163,730	4,448,504	5,190,756	4,769,043	3,882,484
Pennsylvania	2,509,708	3,432,776	----	----	2,747,678	4,069,831	----	----
Rhode Island	340,539	447,989	----	----	258,523	295,702	(1)	(1)
South Carolina	(1)	(1)	----	----	(1)	(1)	----	----
South Dakota	139,200	201,400	95,100	85,000	2,855,300	1,677,400	10,165,000	5,515,200
Tennessee	1,031,833	1,282,457	----	----	978,643	817,400	453,738	300,907
Texas	6,517,038	8,764,026	17,898	26,387	6,487,421	8,219,929	4,151,955	2,992,611
Utah	1,313,900	1,459,000	3,840,200	7,574,500	1,496,400	965,700	5,821,100	4,829,700
Vermont	47,701	80,514	46,101	16,135	221,055	289,581	371,486	263,790
Virginia	1,542,175	3,149,873	----	----	2,680,811	5,488,770	49,709	64,849
Washington	2,790,408	3,039,058	136,364	173,279	4,651,747	4,506,763	4,957,298	4,287,445
West Virginia	1,355,338	1,635,596	----	----	492,282	825,688	----	----
Wisconsin	3,124,087	2,635,752	400,402	210,828	11,481,666	7,935,749	7,211,409	4,608,133
Wyoming	239,700	325,500	127,800	115,000	1,779,200	1,254,700	4,990,400	5,967,400
Undistributed [1]	787,224	1,298,028	----	----	1,848,017	1,798,139	959,518	783,581
Total	103,086,262	133,387,600	8,625,453	11,869,556	173,369,912	176,606,493	145,601,762	113,094,148
American Samoa	----	----	----	----	----	----	----	----
Panama Canal Zone	----	----	----	----	----	----	----	----
Puerto Rico	1,195,000	2,212,850	5,500	8,250	989,100	1,851,790	20,500	33,750

[1] Figures withheld to avoid disclosing individual company confidential data; included with "Undistributed."

TABLE 4.—Sand and gravel sold or used by producers in the United States in 1962, by States, uses, and classes of operations—Continued

(Commercial unless otherwise indicated)

State	Gravel, construction—Continued										Gravel, miscellaneous	
	Railroad ballast		Fill				Other				Short tons	Value
			Commercial		Government-and-contractor		Commercial		Government-and-contractor			
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value		
Alabama	(1)	(1)	24,990	$29,112							361,783	$419,743
Alaska	35,100	$23,500	217,109	204,532	2,544,173	$1,142,105	8,183	$8,183			12,578	28,300
Arizona	(1)	(1)	458,000	321,900	17,500	5,300	141,900	104,500	44,500	$25,400	(1)	(1)
Arkansas	8,872	3,576	86,101	42,173	240,493	102,584	(1)	(1)			40,491	34,962
California	398,480	418,166	1,152,242	1,016,728	532,366	367,974	488,351	442,351	106,160	110,160	212,170	292,694
Colorado	(1)	(1)	107,100	82,400	285,100	209,100	(1)	(1)			184,000	178,800
Connecticut			414,692	274,004			22,363	16,688	3,523	1,233	133,764	110,417
Delaware			8,800	6,936							2,275	5,484
Florida												
Georgia												
Hawaii					900	1,500						
Idaho	(1)	(1)	37,296	29,971	269,136	110,669	(1)	(1)			1,850	579
Illinois	93,474	94,078	673,814	407,019	1,200	384	71,861	69,323			251,613	185,743
Indiana	134,140	68,516	1,854,765	955,568	30,598	9,209	(1)	(1)	23,115	8,090	44,230	30,822
Iowa	(1)	(1)	208,780	126,433	2,438	731	62,643	158,602	71,100	26,680	68,693	105,726
Kansas			69,263	75,960			7,414	8,224			99,622	80,177
Kentucky			31,212	25,039								
Louisiana	(1)	(1)	74,330	41,331			(1)	(1)			(1)	(1)
Maine	(1)	(1)	206,722	71,659			(1)	(1)			50,152	24,217
Maryland	(1)	(1)	702,615	354,167			(1)	(1)			391,954	292,779
Massachusetts	(1)	(1)	991,097	545,234	410,000	145,000	405,653	275,320	500	500	(1)	(1)
Michigan	186,699	193,103	374,027	228,150	563,995	225,697	134,853	162,097	175,265	68,147	79,202	96,274
Minnesota	489,029	297,084	294,154	150,502	341,407	118,134	7,299	9,538	32,023	15,896	105,543	64,142
Mississippi	(1)	(1)	(1)	(1)							119,664	100,536
Missouri	66,514	50,422	16,097	11,420							15,727	8,387
Montana	233,175	110,936	177,981	180,459	109,657	84,074	49,798	48,490	17,255	17,255	25,210	36,792
Nebraska			7,000	5,400	811,000	403,800	116,900	80,200			330,000	269,000
Nevada	(1)	(1)	450,032	461,390	55,628	40,400	998	1,942	25,000	25,000	(1)	(1)
New Hampshire			99,451	34,562			(1)	(1)	2,700	945	105,969	48,789
New Jersey			270,534	126,918			55,813	89,452			34,135	44,978
New Mexico	(1)	(1)	53,500	69,200			(1)	(1)	6,700	12,700	101,200	128,800
New York	(1)	(1)	1,306,685	714,034	284,299	30,878	(1)	(1)			372,806	384,050

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North Carolina	(1)	(1)	-----	-----	20,000	18,800	(1)	(1)	-----	-----	502,510	916,771
North Dakota	117,400	46,100	381,100	163,900	1,479,100	267,900	11,200	6,300	-----	-----	28,500	18,700
Ohio	(1)	(1)	1,035,356	676,589	353	124	1,732,008	2,704,648	7,510	2,002	240,460	249,260
Oklahoma	-----	-----	-----	-----	2,250	1,125	593	1,700	-----	-----	5,544	5,037
Oregon	71,770	93,839	1,197,553	592,074	49,931	24,927	169,706	175,086	43,976	32,666	116,793	131,146
Pennsylvania	(1)	(1)	130,357	82,988	-----	-----	60,141	76,666	-----	-----	(1)	(1)
Rhode Island	-----	-----	564,682	232,453	-----	-----	(1)	(1)	-----	-----	(1)	(1)
South Carolina	(1)	(1)	-----	-----	-----	-----	(1)	(1)	-----	-----	500	1,500
South Dakota	44,800	33,200	40,500	23,700	607,600	390,800	11,600	7,600	-----	-----	21,800	15,400
Tennessee	64,000	80,000	252,785	161,782	-----	-----	-----	-----	-----	-----	(1)	(1)
Texas	252,477	172,624	195,515	69,581	-----	-----	1,475	2,500	-----	-----	67,131	53,439
Utah	18,800	8,300	401,900	352,300	3,563,100	988,700	40,200	40,300	-----	-----	300,100	298,300
Vermont	-----	-----	52,419	32,783	171,899	60,165	(1)	(1)	10,348	3,657	(1)	(1)
Virginia	-----	-----	175,000	98,750	-----	-----	(1)	(1)	-----	-----	-----	-----
Washington	369,390	260,056	900,778	398,573	1,318,329	610,422	429,081	468,172	108,715	94,345	224,858	210,319
West Virginia	(1)	(1)	(1)	(1)	-----	-----	14,698	21,684	-----	-----	15,800	39,502
Wisconsin	303,222	151,010	691,030	332,468	379,110	162,137	104,099	94,699	-----	-----	109,932	83,078
Wyoming	151,400	31,100	9,300	7,000	33,700	12,600	7,100	8,400	19,700	9,700	49,300	46,100
Undistributed [1]	586,737	582,573	79,310	49,604	-----	-----	1,673,577	1,934,973	-----	-----	678,073	571,115
Total	3,625,479	2,718,183	16,475,974	9,866,746	14,125,262	5,535,239	5,829,507	7,017,538	698,090	454,376	5,505,932	5,611,858
American Samoa	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Panama Canal Zone	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Puerto Rico	-----	-----	305,000	196,950	100,000	83,000	166,900	154,960	-----	-----	-----	-----

[1] Figures withheld to avoid disclosing individual company confidential data; included with "Undistributed."

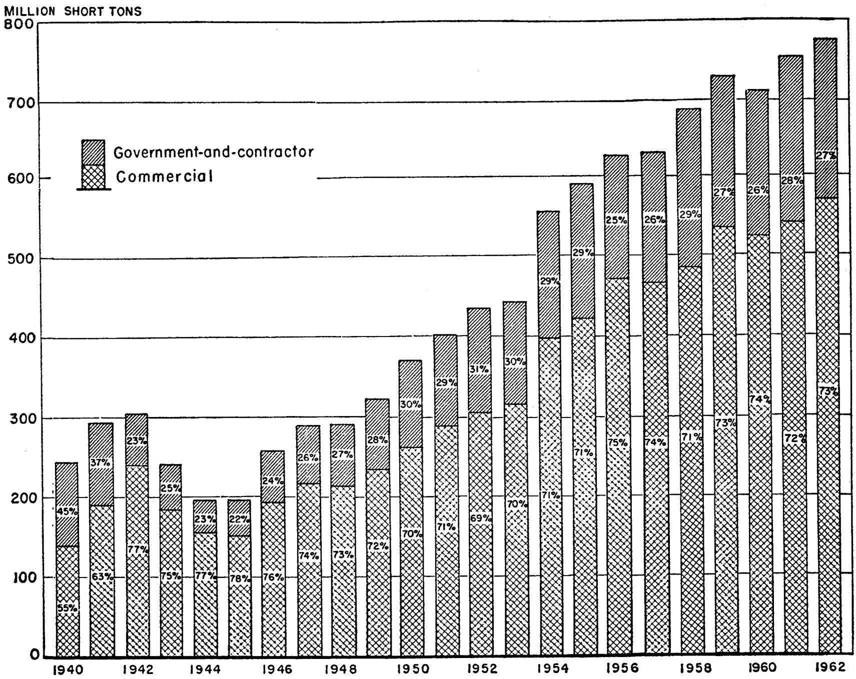

FIGURE 2.—Sand and gravel sold or used in the United States, 1940–62.

TABLE 5.—Sand and gravel sold or used by Government-and-contractor producers in the United States,[1] by uses

(Thousand short tons and thousand dollars)

Year	Sand							
	Building		Paving		Fill		Other	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1953–57 (average)	1,737	$1,686	19,386	$9,543	(2)	(2)	(2)	(2)
1958	1,584	1,807	28,496	15,151	(2)	(2)	(2)	(2)
1959	1,353	1,419	34,097	19,654	1,927	$899	254	$102
1960	962	1,374	26,042	18,500	3,785	2,122	728	338
1961	2,321	3,331	32,243	21,621	7,991	3,256	435	242
1962	1,759	3,287	30,163	21,444	7,482	3,016	1,267	605

Year	Gravel								Total Government-and-contractor sand and gravel	
	Building		Paving		Fill		Other			
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1953–57 (average)	9,669	$5,980	125,902	$71,978	(2)	(2)	(2)	(2)	156,694	$89,187
1958	3,814	4,116	161,310	106,432	(2)	(2)	(2)	(2)	195,204	127,506
1959	10,387	6,882	144,525	100,308	2,719	$789	20	$14	195,282	130,067
1960	7,320	6,417	130,323	93,859	17,106	7,890	631	522	186,897	131,022
1961	6,480	9,372	148,572	109,155	13,510	4,547	677	493	212,229	152,017
1962	8,626	11,870	145,602	113,094	14,125	5,535	698	454	209,722	159,305

[1] Includes possessions and other areas administered by the United States (1953–56).
[2] Data not available.

Production Trends.—In metropolitan centers the trend towards construction of multifamily units, which require less sand and gravel than single unit dwellings, was expected to reduce the demand locally for construction sand and gravel. The rapidly expanding increase in the use of gypsum board for partition walls in place of wet plastering was expected to decrease demand for plaster sand. The Pilkington process for manufacturing flat glass was likely to reduce demand for grinding and polishing sands.

TABLE 6.—Sand and gravel sold or used by Government-and-contractor producers in the United States,[1] by types of producer

(Thousand short tons and thousand dollars)

Type of producer	1953-57 (average)		1958		1959	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction and maintenance crews	47,840	$20,181	49,770	$26,314	49,800	$28,643
Contractors	108,854	69,006	145,434	101,192	145,482	101,424
Total	156,694	89,187	195,204	127,506	195,282	130,067
States	92,208	52,826	123,555	78,676	111,696	74,947
Counties	41,938	19,265	49,329	29,639	56,293	34,975
Municipalities	3,328	1,844	2,970	1,959	3,282	1,972
Federal agencies	19,220	15,252	19,350	17,232	24,011	18,173
Total	156,694	89,187	195,204	127,506	195,282	130,067
	1960		1961		1962	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction and maintenance crews	52,035	$31,212	54,030	$33,194	55,547	$31,216
Contractors	134,862	99,810	158,199	118,823	154,175	128,089
Total	186,897	131,022	212,229	152,017	209,722	159,305
States	110,157	78,227	127,004	94,111	129,314	95,787
Counties	48,563	31,654	46,932	30,334	49,590	29,656
Municipalities	2,897	1,755	6,357	3,335	3,236	2,679
Federal agencies	25,280	19,386	31,936	24,237	27,582	31,183
Total	186,897	131,022	212,229	152,017	209,722	159,305

[1] Includes possessions and other areas administered by the United States (1953-56).

TABLE 7.—Sand and gravel sold or used by producers in the United States, by classes of operation and degrees of preparation

(Thousand short tons and thousand dollars)

	1961		1962	
	Quantity	Value	Quantity	Value
Commercial operations:				
Prepared	483,344	$567,909	515,761	$604,703
Unprepared	56,211	31,375	51,218	30,717
Total	539,555	599,284	566,979	635,420
Government-and-contractor operations: [1]				
Prepared	146,244	124,189	152,739	134,000
Unprepared	65,985	27,828	56,983	25,305
Total	212,229	152,017	209,722	159,305
Grand total	751,784	751,301	776,701	794,725

[1] Includes operations by or for States, counties, municipalities, and Federal Government agencies as follows—1961: 1,775 operations; 1962: 1,753.

TABLE 8.—Number and production of domestic commercial sand and gravel plants by size of operation

Annual production (short tons)	1961				1962			
	Plants [1]		Production		Plants [1]		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	1,631	35.1	16,946	3.2	1,876	35.9	18,604	3.3
25,000 to 50,000	778	16.7	28,193	5.2	912	17.5	32,960	5.8
50,000 to 100,000	825	17.8	58,470	10.8	939	18.0	66,826	11.8
100,000 to 200,000	692	14.9	97,287	18.0	744	14.3	103,624	18.3
200,000 to 300,000	301	6.5	72,886	13.5	322	6.2	78,267	13.8
300,000 to 400,000	129	2.8	44,204	8.2	158	3.0	53,248	9.4
400,000 to 500,000	97	2.1	43,302	8.0	80	1.5	35,365	6.2
500,000 to 600,000	54	1.2	29,313	5.4	48	.9	24,743	4.4
600,000 to 700,000	34	.7	21,944	4.1	37	.7	22,364	4.0
700,000 to 800,000	21	.5	15,810	2.9	16	.3	12,001	2.1
800,000 to 900,000	16	.3	13,876	2.6	21	.4	17,730	3.1
900,000 to 1,000,000	15	.3	14,301	2.7	8	.2	7,537	1.3
1,000,000 and over	53	1.1	83,023	15.4	60	1.1	93,710	16.5
Total	4,646	100.0	539,555	100.0	5,221	100.0	566,979	100.0

[1] Includes a few companies operating more than 1 plant but not submitting separate returns for individual plants.

Methods of Transportation.—Eighty-eight percent of the total output of sand and gravel was moved by truck, compared with 74 percent in 1952. Rail shipments were 8 percent, the same as in 1961, but shipments by waterways increased 1 percent. Some zoning ordinances required surety bonds to pay for extraordinary costs of repairing highways used for hauling sand and gravel.

Employment and Productivity.—Inclement weather in many parts of the country reduced the average number of working days by 4 percent under 1961. However, employment of more workers for longer hours and improved equipment brought the average output up to 7.5 tons per man hour compared to 7.4 tons in 1961.

TABLE 9.—Sand and gravel sold or used in the United States, by classes of operation and method of transportation

	1961		1962	
	Thousand short tons	Percent of total	Thousand short tons	Percent of total
Commercial:				
Truck	460,131	61	476,664	61
Rail	56,184	8	60,734	8
Waterway	22,227	3	26,732	4
Unspecified	1,013	(1)	2,849	(1)
Total commerical	539,555	72	566,979	73
Government-and-contractor: Truck [2]	212,229	28	209,722	27
Grand total	751,784	100	776,701	100

[1] Less than 0.5 percent.
[2] Entire output of Government-and-contractor operations assumed to be moved by truck.

TABLE 10.—Employment in the commercial sand and gravel industry and average output per man in the United States in 1962, by States[1]

State	Employment					Production (short tons)	Average output per man	
	Average number of men	Time employed						
		Average number of days	Total man shifts	Man-hours				
				Average man per day	Total		Per shift	Per hour
Alabama	463	245	113, 660	8. 5	970, 452	4, 398, 834	38. 7	4. 5
Alaska	75	97	7, 307	8. 5	62, 455	533, 245	73. 0	8. 5
Arizona	716	235	168, 524	8. 0	1, 356, 151	7, 897, 100	46. 9	5. 8
Arkansas	832	200	166, 314	8. 8	1, 470, 393	6, 716, 677	40. 4	4. 6
California	4, 805	227	1, 092, 329	8. 1	8, 848, 453	88, 572, 297	81. 1	10. 0
Colorado	654	215	140, 615	8. 2	1, 150, 246	10, 650, 200	75. 7	9. 3
Connecticut	429	220	94, 397	8. 5	800, 958	7, 902, 403	83. 7	9. 9
Delaware	77	210	16, 136	8. 3	134, 262	1, 754, 631	108. 7	13. 1
Florida	350	257	90, 025	8. 8	789, 371	5, 744, 675	63. 8	7. 3
Georgia	330	237	78, 261	8. 7	683, 255	3, 429, 048	43. 8	5. 0
Hawaii	61	70	4, 253	8. 0	34, 018	354, 286	83. 3	10. 4
Idaho	300	132	39, 658	8. 1	320, 661	2, 686, 284	67. 7	8. 4
Illinois	2, 039	218	443, 765	8. 3	3, 696. 098	32, 860, 511	74. 0	8. 9
Indiana	1, 063	228	242, 061	8. 7	2, 108, 300	20, 837, 806	86. 1	9. 9
Iowa	894	176	156, 912	9. 3	1, 462, 229	11, 107, 632	70. 8	7. 6
Kansas	645	210	135, 452	8. 9	1, 207, 462	9, 274, 529	68. 5	7. 7
Kentucky	352	251	88, 416	10. 1	893, 095	6, 028, 950	68. 2	6. 8
Louisiana	1, 078	248	267, 611	8. 8	2, 356, 196	11, 701, 107	43. 7	5. 0
Maine	311	180	56, 006	8. 7	486, 017	1, 859, 317	33. 2	3. 8
Maryland	886	255	226, 148	8. 8	1, 984, 464	12, 603, 894	55. 7	6. 4
Massachusetts	921	207	190, 856	8. 2	1, 571, 742	13, 273, 636	69. 5	8. 4
Michigan	1, 866	215	400, 794	9. 1	3, 642, 997	35, 546, 751	88. 7	9. 8
Minnesota	1, 634	155	252, 874	9. 0	2, 264, 118	19, 090. 171	75. 5	8. 4
Mississippi	497	267	132, 933	8. 9	1, 187, 426	6, 393, 782	48. 1	5. 4
Missouri	681	236	160, 903	8. 5	1, 368, 247	9, 445, 036	58. 7	6. 9
Montana	208	130	27, 124	8. 2	222, 255	2, 123, 673	78. 3	9. 6
Nebraska	964	201	193, 668	9. 7	1, 882, 587	10, 938, 300	56. 5	5. 8
Nevada	292	169	49, 300	8. 0	394, 192	3, 048, 232	61. 8	7. 7
New Hampshire	185	158	29, 233	8. 7	254, 902	2, 394, 476	81. 9	9. 4
New Jersey	1, 192	241	287, 210	8. 2	2, 363, 387	13, 697, 342	47. 7	5. 8
New Mexico	329	196	64, 372	8. 2	527, 025	3, 590, 300	55. 8	6. 8
New York	1, 934	191	370, 332	8. 4	3, 098, 034	27, 538, 529	74. 4	8. 9
North Carolina	717	189	135, 221	9. 4	1, 271, 658	8, 888, 846	65. 7	7. 0
North Dakota	291	147	42, 712	8. 7	373, 152	2, 593, 000	60, 7	6. 9
Ohio	2, 336	223	521, 765	8. 3	4, 350, 643	34, 626, 280	66. 4	8. 0
Oklahoma	264	243	64, 281	8. 5	547, 895	3, 801, 597	59. 1	6. 9
Oregon	895	190	170, 088	8. 0	1, 360, 281	9, 628, 889	56. 6	7. 1
Pennsylvania	1, 423	212	301, 441	8. 8	2, 661, 056	14, 418, 522	47. 8	5. 4
Rhode Island	149	212	31, 617	8. 0	253, 836	2, 141, 265	67. 7	8. 4
South Carolina	285	264	75, 245	8. 6	643, 791	3, 272, 775	43. 5	5. 1
South Dakota	375	140	52, 555	9. 1	479, 953	3, 831, 800	72. 9	8. 0
Tennessee	525	235	123, 153	8. 5	1, 051, 996	5, 621, 447	45. 6	5. 3
Texas	2, 208	265	584, 341	8. 9	5, 176, 488	25, 619, 364	43. 8	4. 9
Utah	408	205	83, 689	8. 2	683, 574	5, 269, 500	63. 0	7. 7
Vermont	128	187	23, 908	8. 8	210, 626	677, 120	28. 3	3. 2
Virginia	739	237	174, 784	9. 0	1, 581, 352	9, 619, 983	55. 0	6. 1
Washington	926	172	159, 514	8. 0	1, 280, 986	12, 785, 704	80. 2	10. 0
West Virginia	728	162	118, 289	9. 3	1, 099, 777	5, 201, 604	44. 0	4. 7
Wisconsin	1, 635	180	293, 836	8. 9	2, 606, 738	22, 476, 126	76. 5	8. 6
Wyoming	220	141	30, 926	8. 1	249, 851	2, 511, 200	81. 2	10. 1
Total	41, 315	212	8, 774, 814	8. 6	75, 475, 101	566, 978, 676	64. 6	7. 5

[1] Excludes operations by or for States, counties, municipalities, and Federal Government agencies. All employment data are preliminary.

Compiled by the Branch of Accident Analysis, Division of Accident Prevention and Health.

CONSUMPTION AND USES

Construction Uses, Including Ballast.—Total new construction put-in-place reached a record high of $61 billion, an increase of 6 percent over that of 1961, and was responsible for the rise in production of sand and gravel. Sand used for railroad ballast increased 60 percent in volume and 149 percent in value.

Industrial Sands.—The combined output of ground and unground industrial sand increased 2,069,000 in tonnage and $8,250,000 in value over 1961. Production of ground sand showed an increase of 125 percent in tonnage.

TABLE 11.—Ground sand sold or used by producers in the United States,[1] by uses

	1961		1962	
	Short tons	Value	Short tons	Value
Abrasives	159,238	$1,561,176	278,355	$2,112,076
Chemicals	15,111	147,034	11,952	116,010
Enamel	15,874	166,025	14,263	148,837
Fillers	68,729	500,512	69,411	718,629
Foundry uses	162,782	1,045,838	942,356	2,972,051
Glass	47,807	412,193	76,216	587,647
Pottery, porcelain, and tile	208,443	1,965,591	180,313	1,829,964
Unspecified	241,108	2,265,580	494,880	4,327,304
Total	919,092	8,063,949	2,067,746	12,812,518

[1] Arkansas, California, Georgia, Idaho, Illinois, Indiana, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Nevada, New Jersey, Ohio, Oklahoma, Pennsylvania, South Carolina, Texas, Virginia Washington, West Virginia, and Wisconsin.

PRICES

The average value of total sand and gravel produced by both commercial and Government-and-Contractor operations was $1.02 per short ton, compared with $1.00 per ton in 1961. The average value for commercially produced sand and gravel was $1.12; that for Government-and-Contractor sand and gravel was $0.76. The average price for construction sand, as reported from 20 large cities in December, was $2.29 per ton, about the same as in 1961. Specific market prices, a more reliable criterion than average market prices, were reported to range from $1.25 per ton for construction sand in Philadelphia to $4.25 per ton in Seattle.[5]

The average price for 1½-inch gravel, reported from a survey conducted in 18 cities, was $2.70 per ton. Prices reported for the same size ranged from $1.95 per ton in Philadelphia to $4.25 per ton in St. Louis.[6]

FOREIGN TRADE[7]

Tonnage of construction sand and gravel entering foreign trade was small and limited to localities close to the Canadian and Mexican borders. Exports to Canada of sand for glass making, foundries,

[5] Engineering News-Record. V. 170, No. 2, Jan. 10, 1963, p. 65.
[6] Engineering News-Record. V. 169, No. 23, Dec. 6, 1962, p. 69.
[7] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

sandblasting and other special uses amounted to approximately 700,000 tons annually.

TABLE 12.—U.S. imports for consumption of sand and gravel, by classes

Year	Sand				Gravel		Total	
	Glass sand [1]		Sand, n.s.p.f., crude or manufactured					
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1953-57 (average)	3,470	[2] $278,791	304,960	[3] $380,853	21,230	[3] $6,768	329,660	[3] $666,412
1958	6,516	[2] 223,817	317,860	485,553	7,619	7,125	331,995	716,495
1959	101	[2] 91,414	348,331	463,589	102,878	92,967	451,310	647,970
1960	10,765	37,111	379,673	515,837	3,752	5,423	394,190	558,371
1961	2	[2] 1,602	335,005	440,759	43,287	44,009	378,294	486,370
1962	31,416	63,950	307,637	414,703	29,198	31,948	368,251	510,601

[1] Classification reads: "Sand containing 95 percent or more silica and not more than 0.6 percent oxide of iron and suitable for manufacturing glass."
[2] Consists mainly of synthetically prepared silica from West Germany for specialized uses and is not comparable in value to ordinary glass sand.
[3] Data known not to be comparable with other years.

Source: Bureau of the Census.

WORLD REVIEW

Canada.—Production of quartz and silica sand in 1961 was estimated to be 2,168,005 tons, valued at Can$2,828,198, a decline of 4 percent in tonnage and 13 percent in value from 1960. Imports of silica sand from the United States were 693,210 tons with an average value of Can$3.57 per ton. Export of quartzite to the United States of 26,774 tons was about double that of 1960.[8]

Peru.—Preliminary figures for production of sand and gravel in 1962 were 1 million tons, compared with 900,000 tons in 1961.[9]

TECHNOLOGY

General.—A report published by the Illinois Geological Survey outlined the shapes and distribution patterns of the Pennsylvanian sandstone deposits of Illinois.[10]

A tentative standard C 429–59T, which designated methods for sampling procedures and sieve testing of sand and other granular materials, was adopted by ASTM Committee C–14.[11]

Methods developed by the Geological Survey for the rapid analysis of silicate, carbonate, and phosphate rocks were published. Complete scheme of analysis was shown by a flow diagram; reagents used, procedures, and calculations were given in detail.[12]

A recent report stated that British methods of testing appeared to be inadequate in determining the effect of aggregates upon durability

[8] Collings, R. K. Silica Review (Preliminary), Canadian Mineral Industry 1961. Dept. of Mines and Tech. Surveys, Ottawa, July 1962, 8 pp.
[9] U.S. Embassy, Lima, Peru. State Department Airgram A–778, May 13, 1963, p. 5.
[10] Potter, Paul E. Shape and Distribution of Pennsylvanian Sand Bodies in Illinois. Illinois State Geol. Survey Circ. 339, 1962, 35 pp.
[11] Close, Paul. Problems in Sampling and Sieve Testing. Glass Industry, v. 43, No. 12, December 1962, pp. 655, 659, 696–697.
[12] Shapiro, L., and W. W. Brannock. Rapid Analysis of Silicate, Carbonate, and Phosphate Rocks. Geol. Survey Bull. 1144–A, 1962, 56 pp.

of concrete, either because tests were not standardized or because no accepted methods for testing existed. Further research was suggested to determine the harmful and harmless varieties of chalk, iron compounds, coal, lignite, and shales and other laminated particles. Methods for applying freezing and thawing tests were described in detail.[13]

Eighty-two potential deposits of industrial silica sand in the Pacific Northwest were sampled and evaluated. The samples were classified by chemical or spectographic analysis. Amenability to simple low-cost methods of beneficiation was determined. Thirty-seven deposits were of good quality but only 16 were considered to be extensive enough for commercial development.[14]

Papers presented informally at the 1962 Annual Operating Session of the National Sand and Gravel Association dealt with plant maintenance and housekeeping, product control, settling basins, storage problems, uses of special screens, and markets for sand and gravel.[15]

Results of a study on pipeline transportation of sand slurries were published. Data secured as a result of this investigation were to be used to design hydraulic transport systems.[16]

A comprehensive report was issued on the methods of mining and processing used at a Michigan sand and gravel plant that produced both foundry sand and construction sand and gravel. Details were given pertaining to the geology of the deposit, methods of prospecting, stripping, excavation and transportation, plant layout, and processing. Flowsheets and organizational charts were shown, and a table itemized plant costs per ton in percentages of total costs.[17]

A simple and rapid field method for mechanical analysis of sand was developed. The results obtained were stated to be comparable with more time-consuming laboratory procedures.[18]

Plant Equipment.—An 8-inch gravel pump mounted on a floating pontoon delivered sand and gravel from a Thames River deposit to a land-based processing plant.[19]

A comprehensive and well-illustrated series of articles described the various types of floating dredges used to extract sand and gravel in the Rhine Valley.[20]

A unitized floating grab, screening, washing, and loading plant used in winning sand and gravel from deposits in West Germany was described.[21]

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[13] Jordan, J. P. R. Problems Associated with Research on Aggregates. Cement, Lime and Gravel (London), v. 37, No. 3, March 1962, pp. 73–76.

[14] Carter, George J., H. J. Kelly, and E. W. Parsons. Industrial Silica Deposits of the Pacific Northwest. BuMines Inf. Circ. 8112, 1962, 57 pp.

[15] National Sand and Gravel Association. Engineering Problems of Sand and Gravel Production. NSGA Circ. No. 88, May 1962, 34 pp.

[16] Wayment, William R., G. L. Wilhelm, and J. D. Bardill. Factors Influencing the Design of Hydraulic Backfill Systems. Pt. 1, Friction-Head Losses of Sand Slurries During Pipeline Transport. BuMines Rept. of Inv. 6065, 1962, 43 pp.

[17] Beck, William A. Sand and Gravel Operations and Costs, Construction Aggregates Corp., Ferrysburg, Mich. BuMines Inf. Circ. 8092, 1962, 26 pp.

[18] Azmon, Emanuel. Field Method for Sieve Analysis of Sand. J. Sedimentary Petrol., v. 31, No. 4, December 1961, pp. 631–633.

[19] Mine and Quarry Engineering (London). New Gravel Pit at Staines. V. 28, No. 1, January 1962, pp. 14–18.

[20] Cement, Lime and Gravel (London). V. 37, No. 7, July 1962, pp. 193–195; No. 8, August 1962, pp. 243–247; No. 9, September 1962, pp. 261–266; No. 10, October 1962, pp. 303–308.

[21] Mine and Quarry Engineering (London). Grab Dredging for Sand and Gravel in West Germany. V. 28, No. 9, September 1962, pp. 382–391; No. 10, October 1962, pp. 426–433.

An article described the ways in which radial stackers for handling aggregates were more effective than fixed stackers.[22]

Processing Equipment.—A new producer of silica sand in the Pacific Northwest obtained a high-grade material from an impure deposit containing iron, clay, and heavy minerals by use of a combination of attrition cells and froth flotation.[23]

Pinched sluices, originally developed for recovering heavy minerals from Florida beach sands, were found to be very effective in recovering fine masonry sands from coarse sands containing clay balls.[24]

An Arizona producer developing a river deposit that contained a high percentage of minus-200 mesh fines produced high-grade masonry sand by installing a wet cyclone separator.[25]

Heavy-Medium Plants.—A comprehensive summary of research on the application of heavy-medium separation methods to Canadian gravels was published. Included were the historical background, description of deleterious constituents, and the steps followed in developing a heavy-medium process. Pilot plant equipment used at the Canadian Bureau of Mines Branch in Ottawa was illustrated and the flowsheet shown. Results of tests on Quebec, Michigan, and California gravels were tabulated.[26]

A heavy-medium separation plant installed at the El Rio, Calif., plant of the Southern Pacific Milling Co. removed undesirable rock from the Santa Clara river bed aggregate.[27]

Vertical Sand Drains.—More than 500,000 lineal feet of sand drains were driven by a contractor to dewater a New Jersey swamp lying in the way of a new highway interchange near the Jersey Meadows. A total of 7,700 drains, varying in depth from 50 to 110 feet, were required. An 11-foot blanket of sand and 18 feet of dirt fill raised the interchange embankment to grade.[28] The 1,500,000 cubic yards of sand and gravel required were transported 50 miles from Sussex County by rail.[29]

Patents.—In the cleaning of clay, soil, and other fine materials from quarried gravel which was to be used for concrete aggregate, the material was agitated with high-velocity air and then with another air stream to carry away the material loosened by the first blast.[30]

Blocking of screens was largely prevented by use of a multiple-bend screen installation which sized wet sand and gravel.[31]

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[22] Newton, H. W. Getting More From Radial Stackers. Western Construction, v. 37, No. 10–A, October 1962, pp. 63–64.

[23] Utley, Harry F. High-Quality Silica Sand for Northwest Industries. Pit and Quarry, v. 54, No. 8, February 1962, pp. 129–132.

[24] Charmbury, Dr. H. B. Pinched Sluice to the Rescue. Rock Products, v. 65, No. 2, February 1962, pp. 73–74.

[25] Bergstrom, John H. Wet Cyclone Solves Fines Problem. Rock Products, v. 65, No. 2, February 1962, pp. 95–96.

[26] Hanes, F. E., and R. A. Wyman. The Application of Heavy Media Separation to Concrete Aggregate. Can. Min. and Met. Bull. (Montreal), v. 55, No. 603, July 1962, pp. 489–496.

[27] Cement, Lime and Gravel (London). V. 37, No. 7, July 1962, pp. 193–195; No. 8, Summer 1962, pp. 6–7.

[28] Smith, Gordon R. Sand Drains Stabilize Swampy Highway Site. Construction Methods and Equipment, v. 44, No. 12, December 1962, pp. 74–76.

[29] Pit and Quarry. Base Material for Highway Over Marsh Supplied by High-Capacity Gravel Plant. V. 54, No. 7, January 1962, p. 150.

[30] Knibbs, N. V. S., and E. G. S. Thyer (assigned to Fawkham Developments Ltd. (Kent, England). Improvements in or Relating to the Cleaning of Small Stone and Other Hard Discrete Material. British Pat. 896,829, May 16, 1962.

[31] Fontein, F. J., H. H. Dreissen, and H. F. Jennekens (assigned to Stamicarbon N. V., Heerlen, Netherlands). U.S. Pat. 3,037,629, June 5, 1962.

The concrete aggregate properties of argillaceous carbonate or dolomitic type gravel or crushed stone were improved by treatment with gaseous methyl chlorosilane or other silicon halide gases.[32]

A flotation and skimming system was developed to remove cinders, lignite, organic matter, and other waste materials from concrete aggregate sand.[33]

Gaseous hydrogen chloride was used to remove iron impurities from silica sand. The purified sand was then washed with water and subjected to froth flotation using an anionic collector. Sand so treated was suitable for glass making.[34]

A patent was granted for a portable washing, sizing, and dewatering apparatus for treating concrete aggregate sand direct from the pit.[35]

A separatory cone was devised to recover very fine-grained sand from the wash water used in ordinary sand and gravel classifying and washing plants.[36]

Apparatus was designed for dewatering and classifying sand from a gravel-cleaning plant for use as concrete aggregate.[37]

The process and apparatus for preparing a concrete sand having a fineness modulus between 2.1 and 3.0 from fluvioglacial or Pleistocene sand benches were patented.[38]

Glass.—Pittsburgh Plate Glass Co. secured the rights to use the Pilkington process for making flat and plate glass. In this process a continuous ribbon of glass flows from the melting furnace over a bed of molten tin which gives a flawless surface to the glass sheet and eliminates the need for grinding and polishing.[39]

A standard sample for determining the viscosity of glass was developed at the National Bureau of Standards. The determination of the viscosity of glass assists in finding compositions that give optimum melting and fabricating properties.[40]

Glass beads of various sizes were used to shot-peen soft metals and alloys. Bright finishes were obtained with less abrasion loss than occurred when novaculite or aluminum oxide were used as abrasives.[41]

Research at Corning Glass Works developed a strengthening process for glass that increased flexural strength to 100,000 pounds per square inch as compared to 20,000 pounds per square inch for ordinary tempered glass.[42]

Foundry Sand.—The British Steel Casting Research Association investigated the use of a variety of nonsiliceous materials including mul-

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[32] Hiltrop, C. L., and J. Lemish (assigned to Iowa State College Research Foundation, Ames, Iowa). Aggregate Treatment. U.S. Pat. 3,042,535 July 3, 1962.

[33] Gish, H. J. (assigned to Stewart Sand & Material Co.). Sand Skimmer. U.S. Pat. 3,043,430, July 10, 1962.

[34] Segrove, H. D. (assigned to British Industrial Sand Ltd., Redhill, England). Purification of Sand Containing Colour-Imparting Impurities. U.S. Pat. 3,050,364, Sept. 21, 1962.

[35] Holmes, J. B. Combined Washer, Separator, and Grader for Loose Materials. U.S. Pat. 3,042,208, July 3, 1962.

[36] Koch, W. (assigned to Kleeman's Vereinigte Fabriken, Stuttgart-Oberturkheim, Germany). Apparatus for Separating Fine-Grained Sand. U.S. Pat. 3,035,697, May 22, 1962.

[37] Parker, F. W. Sand De-Watering and Classifying Plant. Canadian Pat. 642,083, June 5, 1962.

[38] De Koning, J. (assigned to Stamicarbon N. V., Heerlen, Netherlands). Process and Apparatus for the Separation of Sand. Canadian Pat. 640,969, May 8, 1962.

[39] Chemical Week. Pittsburgh Plate Glass Will Use the New Float-Glass Process. V. 91, No. 11, Sept. 15, 1962, p. 99.

[40] Technical News Bulletin. Viscosity Standard Sample of Glass. U.S. Department of Commerce. V. 46, No. 11, November 1962, p. 175.

[41] Iron Age. Glass Shot Shines Soft Alloys. V. 190, No. 18, Nov. 1, 1962, pp. 68–69.

[42] Iron Age. New Process Toughens Glass. V. 190, No. 13, Sept. 27, 1962, pp. 86–87.

lite, silicon carbide, magnesite, dolomite, olivine, zircon, fireclay grog, and chromite to determine their suitability for use in sand casting.[43]

A moisture monitoring system was developed to eliminate needlessly prolonged drying of foundry molds and cores.[44]

A fiber glass plastic-laminate hopper lining solved the problem of sand sticking in overhead molder's hoppers for a Pennsylvania foundry. The 1/16-inch linings which were installed by two men in about 4 hours, were nonrusting, abrasion-free, and eliminated the use of vibrators.[45]

The advantages of using olivine sand for linings in ladles used to pour austenitic manganese steel, low-alloy steels, and all grades of stainless steel were reported.[46]

The use of sand molds for large precision castings of aluminum was claimed to have resulted in savings of 50 percent over customary methods.[47]

A book containing the lectures on coremaking presented at the 1961 Technical and Operating Conference of the Steel Founders' Society of America was published. Subjects discussed were types of sands and additives for mixtures of core sand and included oil-bonded, shell, resin-bonded, and sodium silicate-bonded cores.[48]

An article specified the factors to be considered in evaluating the various methods of making cores. The advantages of new sand binders were discussed.[49]

A molten salt bath was used by a manufacturer of tractor castings to remove adhering sand, scale, and organic material from castings. The removal of sand by this method greatly increased the life of tools used in machining.[50]

The factors influencing the flow rate of metal into sand molds were discussed. These factors included temperature (680° to 1,630° C), pressure, sand roughness, dimensions, and surface finish of the molten metal, conducting system, surface tension, and viscosity of molten steel, white cast iron, mechanical cast iron, phosphorus cast iron, copper, bronze, cupro-aluminum, and brass.[51]

Procedures for reclaiming shell molding sand were described.[52] Results obtained by using hygroscopic and mineral additives to increase shakeout collapsibility of sand cores were reported.[53]

The performance of resin-coated sands used for making shell molds and cores was found to be critically affected by the surface area of

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[43] Metal Industry (London). Sands. V. 101, No. 17, Oct. 25, 1962, p. 190.
[44] Metal Industry (London). Economy in Foundry Sand Drying. V. 100, No. 6, Feb. 9, 1962, p. 108.
[45] Foundry. Plastic Hopper Lining Keeps Sand Flowing. V. 90, No. 5, May 1962, pp. 304, 306.
[46] Weber, T. L. Use of Olivine Sand for Ladle Linings. Foundry, v. 90, No. 2, February 1962, pp. 129, 131.
[47] Steel. Jumbo Aluminum Mold Precisely Cast in Sand. V. 150, No. 17, Apr. 23, 1962, p. 111.
[48] Foundry. Steel Founders Publish Lectures on Core Sands. V. 90, No. 4, April 1962, p. 104.
[49] Dorfmueller, Anton, Jr. How to Choose a Binder. Foundry, v. 90, No. 4, April 1962, pp. 54–59.
[50] Groothoff, Clarence. Chemical Cleaning of Ferrous Castings. Foundry, v. 90, No. 5, May 1962, pp. 312, 314.
[51] Jeanclos, M. G. C. de Lara, and H. Hanf. (Filling of Sand Foundry Molds and the Hydraulic Analogy.) Revue de Metallurgie (Paris), v. 59, No. 6, June 1962, pp. 531–546.
[52] Puryear, William H., and L. E. Wile. Reclamation of Shell Molding Sand. Foundry, v. 90, No. 9, September 1962, pp. 60–63.
[53] Sarker, A. D. Ways to Improve Collapsibility of Silicate-Bonded Sands. Foundry, v. 90, No. 8, August 1962, pp. 52–57.

the sand used, milling time, type and amount of lubricant used, errors in the amount of accelerator, and the amount of gas produced during decomposition.[54]

Special Silicas.—A paper presented during the 1962 Annual Meeting of ASTM reported results of research conducted to evaluate grading requirements for mortar sand.[55]

Fused silica units weighing over 4 tons were produced for use under corrosive conditions. The material was inactive to all acids except hydrofluoric and phosphoric, had high thermal shock resistance, good insulating properties, and was not porous.[56]

A method was patented for preparing organo-silicon hydrophobic powders having a pore volume of at least 3 cubic centimeters per gram.[57]

Details of the production methods used by an Arizona plant to produce closely sized oil-well fracturing sands for the Rocky Mountain and California oil fields were reported. The equipment was illustrated and the flowsheet shown.[58] Patents were granted for a method of making a silica-zirconia catalyst,[59] for a method for preparing a low-surface area silica,[60] and for the regeneration of silica gel.[61]

A comprehensive review of the technologies developed for the manufacture of silica bricks was published. Among the other aspects discussed were raw materals, mineralizers, binders, batch preparation, forming, firing, physical properties, and uses. An extensive bibliography was included.[62]

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[54] Less, Frank W. Factors in Production of Resin-Coated Sand. Foundry, v. 90, No. 2, February 1962, pp. 70–73.
[55] Bloem, Delmar L. Effects of Aggregate Grading on Properties of Masonry Mortar. ASTM Special Tech. Pub. 320, 1962, 25 pp.
[56] Chemical Engineering. Silica Fusion Process Reduces Cost of Thwarting Acid Attack. V. 69, No. 8, Apr. 16, 1962, p. 90.
[57] Tyler, Leslie J. (assigned to Dow Corning Corp., Midland, Mich.). Silica Powders. U.S. Pat. 3,015,645, Jan. 2, 1962.
[58] Rock Products. Unusual Sand—Unusual Market. V. 65, No. 3, March 1962, pp. 82–85.
[59] Plank, Charles J., E. J. Rosinski, and R. B. Smith (assigned to Socony Mobile Oil Company, Inc.). Manufacture of a Silica-Zirconia Catalyst for Conversion of Hydrocarbons. U.S. Pat. 3,015,620, Jan. 2, 1962.
[60] Winyall, Milton E. (assigned to W. R. Grace & Co., New York.) Process for Preparing Low Surface Area Silica. U.S. Pat. 3,070,426, Dec. 25, 1962.
[61] Walther, James E. (assigned to California Research Corp., San Francisco Calif.). Aqueous Regeneration of Silica Gel. U.S. Pat. 3,053,774, Sept. 11, 1962.
[62] Gupta, M. M., and D. N. Nandi. Silica Refractories-A Review. Central Glass & Ceramic Institute Bulletin (Calcutta, India). V. 9, No. 3, 1962, pp. 115–136.

Silicon

By Frank L. Fisher,[1] Gertrude C. Schwab,[2] and Hilda V. Heidrich[2]

OUTPUT of both polycrystal and monocrystal (single crystal) high-purity silicon increased in 1962 reversing a downward trend that began in 1961. Unit values had dropped each year since 1959. Stocks of polycrystal silicon decreased sharply during 1962 whereas stocks of monocrystal silicon decreased slightly.

A definite trend toward higher purity material was evident in 1962 and a record number of silicon electronic devices were produced. Competition continued between high-purity silicon and germanium. A greater proportion of the entertainment market (transistors and diodes for radios and television sets) used silicon instead of germanium. The share of this market increased from 8 percent to 12 percent. Silicon maintained its dominate position as the major material in the manufacture of rectifiers and solar cells.

Metallurgical silicon and silicon alloy production and shipments increased in 1962 after declining in 1961. Important gains in production and shipments were made by the 21 to 55 percent ferrosilicon and silicon metal.

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[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

TABLE 1.—Production, shipments, value, and stocks of high-purity silicon in the United States

Type and grade (resistivity, ohm/cm)	Stocks as of Dec. 31, 1960 (kilograms)	1961 [1]			Stocks as of Dec. 31, 1961 [2] (kilograms)	1962			Stocks as of Dec. 31, 1962 (kilograms)
		Production (kilograms)	Shipments			Production (kilograms)	Shipments		
			Quantity (kilograms)	Value (thousands)			Quantity (kilograms)	Value (thousands)	
Polycrystal, negative and positive:									
50 to over 100	4,170	17,411	14,185	$3,417	4,782	[4] 19,129	17,319	$2,967	2,550
25 to 49	2,709	2,952	3,611	681	1,197	2,940	3,937	503	(3)
5 to 24	1,386	(3)	2,832	433	720	8,917	9,366	978	(3)
Solar and other	834	(3)	5,496	830	453	5,916	6,424	474	1,609
Total	9,099	27,568	26,124	5,361	7,152	36,902	37,046	4,922	4,503
Single-crystal:									
Negative:									
Rods	1,669	[4] 4,587	[4] 4,015	[4] 5,031	(3)	5,932	5,139	5,288	(3)
Slices	83	[5] 1,204	[5] 1,195	[5] 2,875	(3)	[5] 2,117	[5] 2,104	4,008	(3)
Total	1,752	5,791	5,210	7,906	1,933	8,049	7,243	9,296	1,713
Positive:									
Rods	462	(3)	(3)	(3)	(3)	990	(3)	1,387	(3)
Slices	32	(3)	(3)	(3)	(3)	[5] 582	(3)	[5] 905	(3)
Total	494	1,638	1,404	2,454	665	1,572	1,600	2,292	659
Grand total	2,246	7,429	6,614	10,360	2,598	9,621	8,843	11,588	2,372

[1] Includes Puerto Rico. [2] Revised figures.
[3] Figure withheld to avoid disclosing individual company confidential data.
[4] Includes infrared shapes. [5] Includes epitaxial wafers.

DOMESTIC PRODUCTION

HIGH-PURITY SILICON

High-purity silicon producers made 36,902 kilograms of polycrystal silicon and 9,621 kilograms of monocrystal silicon, an increase of 34 and 30 percent respectively, over that of 1961. The trend to produce increasing quantities of higher purity silicon continued during 1962 with more than half the polycrystal high-purity silicon produced with over 50 ohms per centimeter resistance. A shift to more production by the Czochralski and floating-zone methods of refining to obtain these higher purities occurred.

Two companies dropped out of the electronic-grade silicon market: International Metalloids, Inc., subsidiary of W. R. Grace & Co., Toa Alta, Puerto Rico, and Sylvania Electric Products, Inc., Towanda, Pa. E. I. du Pont de Nemours & Co., Inc., the pioneer high-purity silicon producer, announced in December that it was discontinuing production of silicon and would halt operations early in 1963. Kemet Co., division of Union Carbide Corp., became a subsidiary of the Linde Co.'s New Products Department which is also owned by the U.C.C.

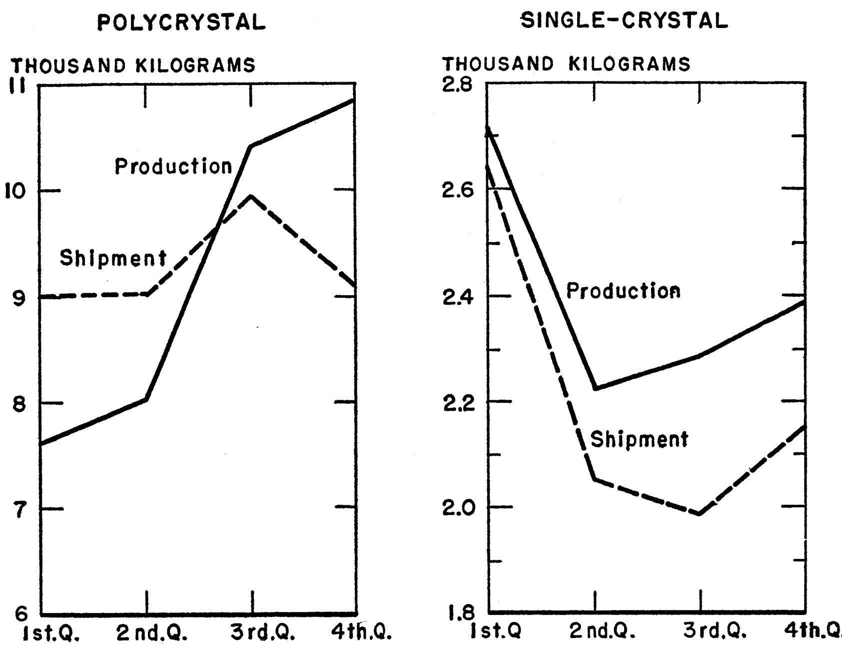

FIGURE 1.—Quarterly changes in production and shipments of high-purity silicon in the United States in 1962.

Monsanto Chemical Corp. expanded its facilities to produce epitaxial wafers and Czochralski monocrystals. Mallinckrodt Chemical Works announced it was discontinuing the sale of polycrystalline silicon but would continue to produce it for its own monocrystal manufacturing operations.

Producers of electronic-grade silicon and their plant location were as follows:

Company:	*Plant location*
Allegheny Electronic Chemicals Co	Lewis Run, Pa.
Dow Corning Corp	Hemlock, Mich.
E. I. du Pont de Nemours & Co., Inc	Brevard, N.C.
Kemet Co. (Linde Co.'s New Product Department)	Cleveland, Ohio.
Mallinckrodt Chemical Works	St. Louis, Mo.
Merck & Co., Inc	Danville, Pa.
Monsanto Chemical Corp	St. Charles, Mo.
Texas Instruments, Inc	Dallas, Tex.
Trancoa Chemical Corp	Reading, Mass.

Four companies produced electronic-grade monosilicon from purchased scrap, secondary, and polycrystal silicon for resale to the electronics industry. These silicon converters were as follows:

Company:	*Plant Location*
Futurecraft, Solid State Materials Division	South El Monte, Calif.
Knapic Electro-Physics, Inc	Palo Alto, Calif.
Kollstan Semiconductor Elements, Division of Kollsman Instrument Corp	Westbury, Long Island, N. Y.
Monosilicon, Inc	Gardena, Calif.

Stauffer Chemical Co. began constructing a plant at Niagara Falls, N.Y., to produce silicon terachloride, the intermediate raw material for electronic-grade silicon. The major suppliers of silicones, the silicon polymers that are finding widespread industrial applications, were Dow Corning Corp., Midland, Mich., General Electric Co., Silicone Products Department, Long Island City, N.Y., and Union Carbide Corp., Silicones Division, Waterford, N.Y.

METALLURGICAL SILICON AND SILICON ALLOYS

Metallurgical silicon was produced by 6 firms in 10 plants as follows:

Company:	*Plant location*
Keokuk Electro-Metals Co., division of Vanadium Corporation of America	Wenatchee, Wash.
National Metallurgical Corp., subsidiary of Apex Smelting Co	Springfield, Oreg.
Ohio Ferro-Alloys Corp	Brilliant, Ohio.
Do	Philo, Ohio.
Do	Powhatan Point, Ohio.
Do	Tacoma, Wash.
Pittsburgh Metallurgical Co	Charleston, S.C.
Do	Niagara Falls, N.Y.
Reynolds Metals Co	Sheffield, Ala.
Union Carbide Metals Co., Division of Union Carbide Corp	Alloy, W. Va.

Ferrosilicon was produced by most of these firms and by most of the ferroalloy industry. A more complete list of silvery pig iron and ferrosilicon producers is given in the "ferroalloys" chapter of this Minerals Yearbook. Net production was the gross production minus the quantity of alloy used to make other alloys within the reporting plant.

CONSUMPTION AND USES

HIGH-PURITY SILICON

Shipments of polycrystal silicon increased 42 percent compared with 1961 and had a total value of $4.9 million. Despite this sharp increase, the total value decreased. Monocrystal shipments increased 34 percent, and the value of the shipments totaled $11.6 million, a gain over that of 1961.

The electronic industry fabricated a record 17 million silicon transistors and 162 million silicon diodes and rectifiers valued at $78 million and $110 million, respectively. The unit value of these electronic devices dropped from that of 1961. The total value of the transistors was less than that of 1961, whereas the total value of diodes and transistors showed a 10 percent gain.

Refinements in processing techniques resulted in a quantity of high-purity silicon in each device in 1962 which was approximately one-half that used in 1960. Unit quantity of high-purity silicon per device in 1962 is as follows:

Device:	Estimated grams per unit device
Power rectifier	2.5
Rectifier	.02
Diode	.05
Transistor	15
Solar cell	1.5

Consumption of high-purity silicon was marked by a change to higher purity materials. The demand for p-type materials shifted to 300 ohms per centimeter (ohm/cm) resistance and up. Previously this was 50 ohm/cm and more than 100 ohm/cm resistance. N-type material increased from 15 to 30 ohm/cm to 30 to 100 ohm/cm resistance.

TABLE 2.—Net production, shipments, and stocks of silvery pig iron, ferrosilicon, and silicon metal in 1962

(Short tons, gross weight)

Alloy and percent of silicon contained	Net production	Shipments	Stocks as of Dec. 31, 1962
Silvery pig iron:			
Blast furnace: 5-13	80,322	85,004	22,013
Electric furnace: 14-20	133,652	137,862	19,272
Ferrosilicon:			
21-55	269,441	250,334	51,474
56-70	27,485	30,397	6,392
71-80	59,092	55,321	13,546
81-89	10,280	9,152	3,250
90-95	3,132	3,582	948
Silicon metal: 96-99	64,133	61,384	6,429
Ferrosilicon briquets: 40-50	42,741	43,275	3,495
Miscellaneous silicon alloys	12,090	12,217	4,507
Total	702,368	688,528	131,326

New uses for high-purity silicon included its use in strain gages and as a radiation detector. The latter use was considered the simplest device for accurately measuring high-intensity radiation.[3] The widespread interest in the successful launching of Telstar drew attention to its 3,600 silicon solar cells as its power source. Large scale research into various arrangements of silicon solar cells was undertaken in order to improve the power source in other spacecraft. In more conventional travel, the General Electric Co. delivered the first of 66 silicon-rectifier powered locomotives to the Pennsylvania Railroad. Using air-cooled silicon rectifiers for power conversion resulted in lower cost operation and considerable savings in space and weight.

METALLURGICAL SILICON

Most of the silicon metal was consumed in aluminum-base alloys (35,538 short tons). The major use of these alloys was in aluminum automobile engines. The miscellaneous uses for silicon metal included a significant quantity in the rapidly expanding silicone industry. The lower grade of silvery pig iron showed a decrease which was reflected in an increase in the higher grade silvery pig iron indicating a continuation of the trend toward higher purity ferroalloys.

[3] Bell Laboratories Record. Silicon Solar Cells Measure High Intensity Radiation, V. 40, No. 5, May 1962, p. 179.

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STOCKS

Stocks of polycrystal high-purity silicon at yearend were 37 percent less than the quantity on hand at the beginning of 1962. Stocks of high-purity monocrystal decreased slightly during the same period. Stocks of silvery pig iron dropped 36 percent, and stocks of 21 to 55 percent ferrosilicon increased 85 percent during the same period. The overall stock change for silicon alloys and silicon metal was an increase of 6 percent.

PRICES

The price of polycrystal electronic-grade silicon declined during 1962 from an average price of $139 per kilogram shipped in the first quarter to $129 per kilogram for polycrystal shipped in the second quarter. The price increased to an average of $133 per kilogram for material shipped in the fourth quarter. The average value of electronic-grade monocrystal was $1,334 per kilogram at the beginning of 1962. The price increased to an average value of $1,410 per kilogram for shipments in the first quarter, and then declined to an average value of $1,195 per kilogram for material shipped in the last quarter.

TABLE 3.—Consumption by major end uses and stocks of silicon alloys in the United States in 1962

(Short tons, gross weight)

Alloy and percent of silicon contained	Stainless steels	Other alloy steels [1]	Carbon steels	Tool steels	Steel mill rolls	Gray and malleable castings
Silvery pig iron:						
5-13	----------	933	1,297	----------	795	81,143
14-20	----------	5,901	16,703	----------	136	90,547
Ferrosilicon:						
21-55 [4]	6,471	46,042	76,968	845	698	64,560
56-70	795	9,415	14,960	----------	----------	568
71-80	7,720	15,378	5,304	417	132	10,264
81-89	52	915	1,798	----------	101	3,181
90-95	19	2,397	137	----------	37	175
Silicon metal: 96-99	15	48	40	15	----------	581
Ferrosilicon briquets: 40-50	----------	180	285	----------	19	23,977
Miscellaneous silicon alloys [8]	254	5,544	8,270	59	117	10,590
Total	15,326	86,753	125,762	1,336	2,035	285,586

Alloy and percent of silicon contained	Aluminum base alloys	High temperature alloys	Other nonferrous alloys [2]	Miscellaneous uses	Total consumption	Stocks as of December 31, 1962
Silvery pig iron:						
5-13	----------	----------	1	201	84,370	7,564
14-20	----------	----------	149	[3] 6,129	119,565	17,164
Ferrosilicon:						
21-55 [4]	42	195	2,228	[5] 11,218	209,267	20,863
56-70	----------	----------	----------	[5] 3,657	29,395	1,435
71-80	----------	14	29	[6] 5,705	44,963	4,753
81-89	----------	----------	33	3	6,083	675
90-95	2,773	27	38	51	5,654	579
Silicon metal: 96-99	35,538	577	628	[7] 7,417	44,859	2,320
Ferrosilicon briquets: 40-50	----------	----------	2	2	24,465	3,684
Miscellaneous silicon alloys [8]	131	57	37	3,298	28,357	1,959
Total	38,484	870	3,145	37,681	596,978	60,996

[1] Includes quantities of carbon steels because some firms failed to specify individual uses.
[2] Includes cutting and wear-resistant materials, welding rods, alloy hard-facing rods, permanent-magnet alloys, copper-base alloys, nickel-base alloys, electrical resistance alloys, anodes, and other nonferrous alloys.
[3] Mainly in high-silicon iron and to beneficiate iron ore.
[4] Mainly from 40 to 55 percent silicon.
[5] Mainly to produce ferronickel.
[6] Mainly in magnesium reduction, pig iron, etc.
[7] Mainly in silicones and other chemical compounds.
[8] Includes calcium-silicon, calcium-manganese-silicon, silicon-manganese-zirconium, ferrocarbon (including briquets), Alsifer, and other miscellaneous silicon alloys.

Purchase of electronic-grade silicon by consumers was generally on a negotiated basis because of the wide variety of specifications and special shapes desired by the electronic industry. Adherence to solid state physics criteria was more pronounced for electronic-grade monocrystal than for polycrystal. A representative price list for polycrystal at yearend was as follows:

TABLE 4.—Prices of polycrystal, high-purity silicon

Grade (resistivity minimum, ohm/cm)	Boron content (parts per billion)	Price per pound (quantity less than 100 pounds)	Price per pound (quantity more than 100 pounds)
25	0.9	$60	$55
50	.8	70	65
100	.7	80	75
150	.6	90	85
200	.5	100	95

The price of 50 percent grade ferrosilicon was $0.1450 per pound from January until August when it dropped to $0.1350. The regular grade, 98 percent silicon metal, 0.35 percent maximum iron, was unchanged at $0.2150 per pound.

FOREIGN TRADE [4]

Foreign trade in high-purity silicon continued to be active. The United States and Japan dominated export trading activity. A sharp drop in U.S. exports to Japan occurred during 1962, because the Japanese expanded domestic production.

Imports of ferrosilicon for consumption increased with most of the material originating in Canada. The quantity of silicon metal imported totaled 12 tons and it all came from Canada. Exports of ferrosilicon dropped sharply.

WORLD REVIEW

EUROPE

Belgium.—The new electronic-grade silicon plant of the Olen Chemicals Products Division of Société Générale Métallurgique de Hoboken began production on an industrial scale in 1962.

Norway.—Construction was started in 1962 on a 25,000-ton-per-year-capacity ferrosilicon plant (45 percent silicon) at Thambshavn, South Trondelag County, by Orkla Grube A/B.

The second furnace of the Norwegian Ferrosilicon Producers began operating in March bringing the annual capacity of the joint venture to 20,000 tons of 45 percent ferrosilicon.

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

TABLE 5.—U.S. imports for consumption of ferrosilicon, by grades and countries, and silicon metal, by countries

	1960			1961			1962		
	Short tons		Value	Short tons		Value	Short tons		Value
	Gross weight	Silicon content		Gross weight	Silicon content		Gross weight	Silicon content	
Ferrosilicon:									
8 percent and less than 30 percent silicon:									
Canada	12,685	1,940	$687,012	12,580	1,931	$616,024	15,172	2,359	$782,588
Germany, West	1,336	200	246,790	580	87	109,403	1,086	163	180,948
Total	14,021	2,140	933,802	13,160	2,018	725,427	16,258	2,522	963,536
30 percent and less than 60 percent silicon:									
Canada	413	200	56,911	514	248	67,788	-	-	-
Germany, West	1	1	281	-	-	-	-	-	-
Total	414	201	57,192	514	248	67,788	-	-	-
60 percent and less than 80 percent silicon:									
Canada	257	178	55,239	35	24	6,438	53	37	9,366
France	-	-	-	-	-	-	11	8	1,873
Japan	185	140	33,676	-	-	-	-	-	-
Norway	2,819	2,177	424,955	-	-	-	5	4	845
South Africa, Republic of[1]	54	41	8,937	21	17	3,630	2	2	272
Yugoslavia	66	52	9,541	-	-	-	-	-	-
Total	3,381	2,588	532,348	56	41	10,068	71	51	12,356
80 percent and less than 90 percent silicon: Japan	53	43	9,398	-	-	-	-	-	-
Grand total	17,869	4,972	1,532,740	13,730	2,307	803,283	16,329	2,573	975,892
Silicon metal:									
Canada	4	4	889	-	-	-	12	12	5,015
France	269	266	72,342	31	30	8,206	-	-	-
Italy	28	27	7,475	-	-	-	-	-	-
Total	301	297	80,706	31	30	8,206	12	12	5,015

[1] Effective Jan. 1, 1962; formerly Union of South Africa.

Source: Bureau of the Census.

TABLE 6.—U.S. exports of ferrosilicon

Year	Short tons	Value	Year	Short tons	Value
1953-57 (average)	2,046	$389,266	1960	5,501	$867,140
1958	2,177	391,621	1961	34,764	6,104,913
1959	10,558	980,658	1962	4,101	1,348,661

Source: Bureau of the Census.

A 10,000 ton-per-year ferrosilicon plant started operating at Troms, Northern Norway, in 1962. It was owned by K/S A/S Fesil Nord & Co.

Yugoslavia.—The annual capacity of the Electro-Bosna ferrosilicon plant at Jajne was increased to 9,000 tons in 1962. This brought total domestic capacity to 19,000 tons.

ASIA

India.—Mysore Iron and Steel Works, Bhadravati, began operating in July at an annual capacity of 5,000 tons of ferrosilicon. The plant was designed for a future annual capacity of 20,000 tons.

Japan.—The electronic-grade silicon industry had expanded rapidly since it started in 1959. It was second to the United States in both production and plant capacity in 1962. Production in 1962 was 6,300 kilograms. Japanese silicon producers are shown in table 7.

TABLE 7.—Japanese silicon producers

Company	Plant location	Production method	Operation started	Polycrystal production capacity (kilograms per year)
Tokai Electrode Manufacturing Co.	Chigasaki, Kanagawa	Hydrogen reduction of $SiHCl_3$.	1959	1,200
Osaka Titanium Co., Ltd	Amagasaki, Hyogo	do	1959	720
Nitchitsu Electronic Chemical Co.	Noda, Chiba	Zinc reduction of $SiCl_4$.	1959	5,000
Komatsu Electronic Metal Co.	Hiratsuke, Kanagawa	Thermal decomposition of SiH_4.	April 1960	4,800
Shin-Etsu Chemical Industry Co.	Isobe, Gunma	Hydrogen reduction of $SiHCl_3$.	August 1960	3,000
Nihon Electronic Metals Co.	Kodaira, Tokyo	do	March 1961	1,000
Kokusai Electric Manufacturing Co., Ltd.	Komae, Tokyo	Single-crystal only	1961	

TECHNOLOGY

Refinements in processing high-purity silicon resulted in an improved material that became available to consumers in 1962. This availability coincided with consumer demand for a higher quality product meeting more rigid solid state specifications. One major forward step was a better understanding of epitaxial deposition and the properties of silicon thin films.[5]

Improvements were made in doping techniques for both n- and p-type high-purity silicon. One manufacturer introduced doping pellets with the high-purity silicon. The number of pellets per unit weight of silicon was determined by a nomograph that was also supplied by the company.

Production of high-purity silicon was generally by the Czochralski method, float-zone refining, or epitaxial growth. All producers using those methods introduced modifications that were closely guarded

[5] Albert, M. P., and J. F. Combs. Thickness Measurement of Epitaxial Films by the Infrared Interference Method. J. Electrochem. Soc., v. 109, No. 8, August 1962, pp. 709–713.

Charig, J. M., and B. A. Joyce. Epitaxial Growth of Silicon by Hydrogen Reduction of $SiHCl_3$ Onto Silicon Substates. J. Electrochem. Soc., v. 109, No. 10, October 1962, pp. 957–962.

Deal, B. E. Epitaxial Deposition of Silicon in a Hot-Tube Furnace. J. Electrochem. Soc., v. 109, No. 6, June 1962, pp. 514–517.

Dermatis, S. N., and J. W. Faust, Jr. Growing Silicon Sheets. Metal Industry (London), v. 101, No. 20, Nov. 15, 1962, pp. 304–305.

Kleimack, J. J., and H. C. Theuere. Epitaxy and Transistor Fabrication. Bell Laboratories Record, v. 40, No. 8, September 1962, pp. 289–292.

Li, C. H. Epitaxial Growth of Silicon. J. Electrochem. Soc., v. 109, No. 10, October 1962, pp. 952–957.

Ludwig, G. W. Electron Spin Resonance. Science, v. 136, No. 3513, Apr. 27, 1962, pp. 899–905.

company secrets. These technological innovations lowered production costs and enabled silicon to assume a more favorable competitive position with respect to germanium. Gallium arsenide became a strong competitor of high-purity silicon in special electronic devices and solar cells. Intensive research and development involving silicon resulted from the intensive space program. Special encapsulation techniques were required to offset radiation hazards and shock that are common to space vehicles. Silicon and its compounds were also introduced as ceramic coatings that permitted metals to withstand elevated temperatures. No outstanding technical developments were reported for metallic silicon or the ferroalloys.

Silver

By J. P. Ryan [1] and Ethel M. Tucker [2]

AN ACTIVE market, reflecting increased demand and an uncertain supply, brought a sharp rise in the price of silver to the highest level since 1920. Domestic mine production and consumption of silver for industrial uses were moderately higher and net imports, mostly from Canada, rose sharply compared with those of 1961.

The increase in U.S. industrial consumption came chiefly from the metal joining and electrical and electronic industries, for both defense and civilian products. Consumption of silver for U.S. coinage rose sharply, reflecting continued growth in the use of coin-operated vending machines. The United States accounted for about half of the total silver consumed in the industries and coinage of the free world.

Outside the United States, estimated silver production increased slightly, but consumption, including coinage, was lower than in 1961. Total consumption of silver in free world countries was about 75 percent greater than production.

LEGISLATION AND GOVERNMENT PROGRAMS

Pursuant to recommendations of the President, legislation (S. 2885 and H.R. 10384) was introduced in the 87th Congress, 2d session, to repeal the Silver Purchase Acts; to amend the relevant part of the Internal Revenue Code imposing a tax on transfers of interest in silver; and to amend the Federal Reserve Act to authorize the issuance of Federal Reserve notes to replace $1 silver certificates currently in circulation. These bills were referred to the respective Committees on Banking and Currency, but no further action was taken by Congress.

An increased number of applications were recorded for exploring silver deposits under the Government program of financial assistance administered by the Office of Minerals Exploration. Three contracts costing $158 million were executed during 1962.

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

TABLE 1.—Salient silver statistics

	1953–57 (average)	1958	1959	1960	1961	1962
United States:						
Mine production thousand troy ounces	37,719	34,111	31,194	30,766	34,794	36,798
Value thousands	$34,138	$30,872	$28,232	$27,845	$32,167	$39,929
Ore (dry and siliceous) produced:						
Gold ore thousand short tons	2,259	2,411	2,289	2,267	2,060	2,159
Gold-silver ore do	122	107	137	347	248	353
Silver ore do	641	639	597	641	565	557
Percentage derived from—						
Dry and siliceous ores	32	41	45	37	39	33
Base-metal ores	68	59	55	63	61	67
Secondary—returned from industrial use thousand troy ounces	25,699	36,000	41,984	49,007	50,312	70,412
Imports, general thousand troy ounces	125,175	165,966	69,088	60,657	50,256	76,359
Exports do	4,684	2,733	9,180	26,593	39,828	13,057
Stocks Dec. 31: Treasury. million troy ounces	1,957	2,106	2,060	1,992	1,863	1,767
Consumption in industry and the arts thousand troy ounces	97,760	85,500	101,000	102,000	105,500	110,400
Coinage do	37,461	38,200	41,400	46,000	55,900	77,368
Price per troy ounce	[1] $0.905+	[1] $0.905+	[1] $0.905+	[1] $0.905+	[2] $0.924+	[2] $1.085+
World:						
Production thousand troy ounces	223,800	239,000	[3] 222,000	[3] 240,500	[3] 236,500	242,400
Consumption[4]—industry and the arts thousand troy ounces	190,080	190,500	214,900	226,100	238,100	239,700
Coinage do	73,520	79,500	86,400	99,300	112,600	127,400

[1] Treasury buying price for newly mined silver.
[2] Average New York price.
[3] Revised figure.
[4] Free world only.

DOMESTIC PRODUCTION

Output of recoverable silver from domestic mines increased 6 percent to 36.8 million ounces valued at $39.9 million, the second consecutive annual increase in production. Except for a 5-week shutdown at the Sunshine mine in Idaho, operations at silver-producing mines were generally stable. U.S. production of silver was exceeded only by that of Mexico.

Production gains were recorded in Arizona, Colorado, Idaho, Missouri, Montana, and New Mexico, whereas production declined in Nevada, Utah, and Washington. The gain in Arizona silver production again resulted chiefly from expanded output of silver-bearing copper ore from which most of the silver was recovered as a byproduct. Increased output of silver in Colorado was attributed to the advance in the price which encouraged greater production of silver-bearing ores, particularly copper-lead-zinc ore by the New Jersey Zinc Co. In Idaho, silver production rose to the highest level since 1938, reflecting relatively stable operating conditions at most mines and a substantially higher price for silver. Montana silver output reached the highest level since 1957, chiefly as the result of increased recovery of byproduct metal from copper-zinc ores by The Anaconda Company. Desilverization of lead bullion by St. Joseph Lead Co. recovered a substantial quantity of silver and caused a sharp rise in Missouri silver output. A moderate increase in silver production in New Mexico resulted primarily from expanded output of silver-bearing copper ores and gold-silver ores. Curtailed output of silver-bearing lead-zinc ores was the principal factor contributing to the drop in silver production in Nevada, Utah, and Washington.

Idaho maintained its rank as the leading silver-producing State by a wide margin, contributing about half of the total domestic output. Idaho, Arizona, Utah, and Montana supplied 88 percent of the total domestic output.

About two-thirds of the total domestic silver output was recovered as a byproduct of ores mined chiefly for base metals and gold; virtually all of the remainder came from silver ores in Idaho. Only 4 of the 25 leading silver-producing mines depended chiefly upon the value of silver in the ore. Seven mines, producing over 1 million ounces each, supplied 52 percent of the total domestic output; the 25 leading mines (table 4) contributed 81 percent. Domestic mine production constituted about one-third of the total silver used in the arts and industries of the United States.

Sunshine Mining Co., the leading producer, recovered 2.6 million ounces of silver valued at $2.9 million, compared with 3.4 million ounces valued at $3.2 million in 1961. The mine was closed for 5 weeks during the last quarter because of a labor strike. Tons milled decreased 28 percent, but average grade increased from 32.5 to 35.1 ounces per ton. Average-per-ton operating costs were $32.44, compared with $25.11 in 1961. The company reported ore reserves of 359,700 tons, slightly more than in 1961.[3]

Although a detailed breakdown by sources was unavailable, a large quantity of secondary silver was recovered annually by refiners from old jewelry, plate, scrap film, and other forms of scrap. In addition, a substantial quantity of silver was recovered from wornout coins and returned to monetary use by the U.S. Treasury. Silver returned from industrial and monetary sources totaled nearly 42 million ounces.

Approximately 3,600 persons were employed in the silver- and gold-silver mining industry at 380 separate lode mining operations, compared with 4,200 persons at 630 mines in 1961.

Terminology and definitions used in classifying silver-bearing ores were described in the silver chapter of the 1961 Minerals Yearbook.

Ore production and classification, methods of recovery, and metal yields, embracing all ores that yielded silver in the United States in 1962, are given in tables 6 to 9.

TABLE 2.—Silver produced in the United States according to mine and mint returns

(Thousand troy ounces of recoverable metal)

	1953-57 (average)	1958	1959	1960	1961	1962
Mine	37,719	34,111	31,194	30,766	34,794	36,798
Mint	37,450	36,800	23,000	36,800	34,900	36,345

[3] Sunshine Mining Co. Annual Report 1962, Feb. 23, 1963, 9 pp.

TABLE 3.—Mine production of silver in the United States in 1962, by months

Month	Thousand troy ounces	Month	Thousand troy ounces
January	3,203	August	3,054
February	2,885	September	2,812
March	3,399	October	2,815
April	3,270	November	2,909
May	3,434	December	3,040
June	3,098		
July	2,879	Total	36,798

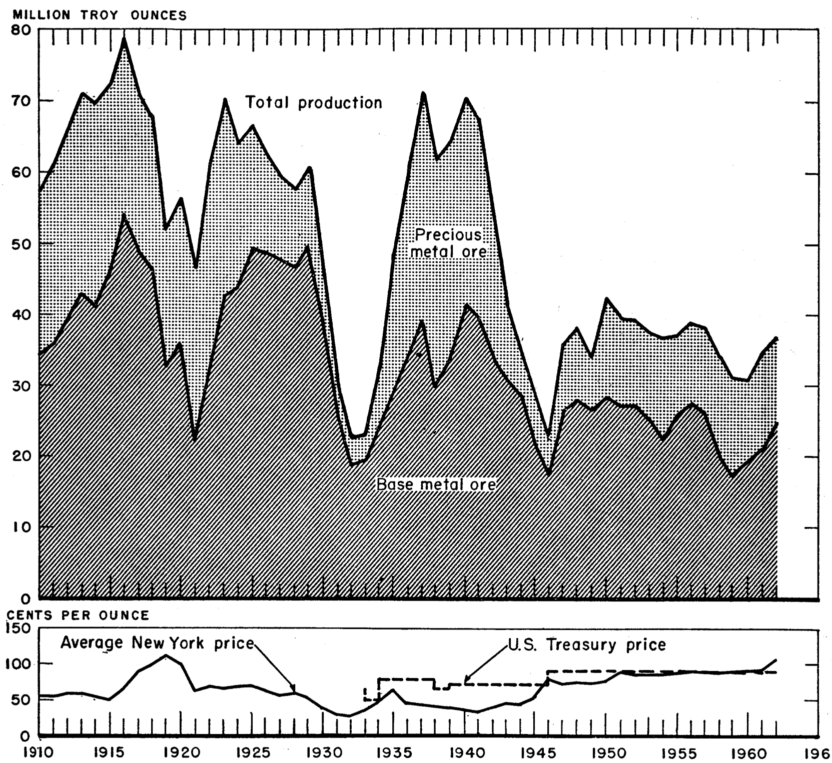

FIGURE 1.—Silver production in the United States and price per ounce, 1910–62.

TABLE 4.—Twenty-five leading silver-producing mines in the United States in 1962, in order of output

Rank	Mine	District or region	State	Operator	Source of silver
1	Sunshine	Coeur d'Alene	Idaho	Sunshine Mining Co.	Silver ore.
2	Galena	do	do	American Smelting and Refining Company	Do.
3	Lucky Friday	do	do	Lucky Friday Silver-Lead Mines Co.	Lead ore.
4	Utah Copper	West Mountain (Bingham)	Utah	Kennecott Copper Corp.	Copper ore.
5	Badger State	Summit Valley (Butte)	Montana	The Anaconda Company	Zinc ore.
6	Butte Hill Mines	do	do	do	Copper ore.
7	United States & Lark	West Mountain (Bingham)	Utah	United States Smelting, Refining and Mining Co.	Gold-silver, lead-zinc ores.
8	Eagle	Red Cliff (Battle Mountain)	Colorado	The New Jersey Zinc Co.	Copper, lead-zinc ores.
9	Crescent	Coeur d'Alene	Idaho	The Bunker Hill Co.	Silver ore.
10	Copper Queen-Lavender Pit	Warren	Arizona	Phelps Dodge Corp.	Copper ore.
11	Berkeley Pit	Summit Valley (Butte)	Montana	The Anaconda Company	Do.
12	Mission	Pima	Arizona	American Smelting and Refining Company	Do.
13	Silver Summit	Coeur d'Alene	Idaho	Hecla Mining Co	Silver ore.
14	Iron King	Big Bug	Arizona	Shattuck Denn Mining Corp.	Lead-zinc ore.
15	Idarado	Red Mountain-Upper San Miguel.	Colorado	Idarado Mining Co.	Copper, lead-zinc ores.
16	Morenci	Copper Mountain	Arizona	Phelps Dodge Corp.	Gold-silver, copper ores.
17	Bunker Hill	Coeur d'Alene	Idaho	The Bunker Hill Co.	Lead-zinc ore.
18	United Park City Mines	Unitah-Blue Ledge	Utah	United Park City Mines Co.	Silver-lead-zinc ores.
19	Page	Coeur d'Alene	Idaho	American Smelting and Refining Company	Lead-zinc ore.
20	New Cornelia	Ajo	Arizona	Phelps Dodge Corp.	Copper, gold-silver ores, gold tailings.
21	Kelley	Summit Valley (Butte)	Montana	The Anaconda Company	Copper ore.
22	Star and Morning Unit	Coeur d'Alene	Idaho	The Bunker Hill Co. and Hecla Mining Co.	Lead-zinc ore.
23	San Manuel	Old Hat	Arizona	Magma Copper Co.	Copper ore.
24	Magma	Pioneer	do	do	Copper, gold-silver ores.
25	Knob Hill & Gold Dollar	Republic	Washington	Knob Hill Mines, Inc.	Gold ore.

TABLE 5.—Mine production of recoverable silver in the United States, by States

(Troy ounces)

	1953-57 (average)	1958	1959	1960	1961	1962
Alaska	32,000	23,507	21,358	25,934	18,485	22,199
Arizona	4,748,585	4,684,580	3,898,336	4,774,992	5,120,007	5,453,585
California	752,111	188,260	172,810	179,780	93,351	132,505
Colorado	2,692,411	2,055,517	1,340,732	1,659,037	1,965,021	2,087,813
Idaho	14,575,590	15,952,796	16,636,486	13,646,508	17,576,322	17,772,435
Illinois	1,631					
Kentucky	17	99	75		2,065	1,410
Michigan	257,598					401,491
Missouri	291,982	250,917	339,760	15,594	11,793	490,896
Montana	6,178,405	3,630,530	3,420,376	3,606,991	3,490,350	4,560,714
Nevada	810,972	932,728	611,135	707,291	388,426	245,164
New Mexico	253,573	158,758	158,925	303,903	282,755	301,549
New York	56,835	66,738	51,588	49,324	40,507	19,451
North Carolina	2,744	15,157	16,319	212,368	169,742	100,439
Oregon	12,975	2,728	242	284	2,022	6,047
Pennsylvania	[1] 5,153	(1)	(1)	(1)	(1)	(1)
South Dakota	142,999	152,995	124,425	108,119	127,427	113,052
Tennessee	63,120	44,592	59,739	64,560	83,417	112,251
Texas	45					
Utah	6,385,224	5,277,693	3,734,297	4,782,960	4,797,583	4,628,446
Vermont	45,348	5,101				
Virginia	1,682	2,023	866			
Washington [1]	408,172	666,278	606,537	628,678	625,176	350,185
Wyoming	77	30		4	7	
Total [2]	37,719,000	34,111,000	31,194,000	30,766,000	34,794,000	36,798,000

[1] Combined with Washington, 1956 and 1957, and 1958–62.
[2] Data may not add to totals shown because of rounding.

CONSUMPTION AND USES

Domestic consumption of silver in the arts and industries increased 5 percent to 110.4 million ounces, according to the U.S. Bureau of the Mint. The 1962 gain was the fourth consecutive annual increase, and the quantity used was the largest since 1950. Most of the industrial supply came from imports; a relatively small quantity of silver from Treasury stocks was sold to other Government agencies for defense-related uses. Total U.S. consumption of silver, including coinage, rose 16 percent to 187.8 million ounces.

Although precise data on the end use of silver are unavailable, substantial quantities of silver continued to be consumed in such established industries as the manufacture of sterling and plated ware, photographic materials, and brazing alloys. Silver used in plated ware was estimated to have increased slightly, but consumption in sterling flatware and holloware dropped slightly. Consumption of silver increased in the metal-joining and electrical and electronic industries, for both military and civilian products. Demand for silver in manufacturing silver-zinc and silver-cadmium batteries for military uses continued to expand; it was estimated that more than 5 million ounces were absorbed in the battery program. Increased quantities of silver were acquired for the production of such civilian products as automobiles, electrical appliances, and electronic components for data-processing and other equipment.

The manufacture of U.S. subsidiary coin consumed 77.4 million ounces of silver, about 38 percent more than in 1961. The 1962 gain, the fourth consecutive annual increase, was again attributed principally to continued expansion of coin-operated merchandise-vending machines and other equipment. U.S. coinage requirements amounted to 60 percent of the total silver used in free world coinage.

Silver-infiltrated tungsten marketed by Firth Sterling, Inc., made possible the use of solid rocket fuels that had heretofore been impractical because of the lack of suitable nozzle materials to withstand very high temperatures.[4] In addition to rocket motor applications, the new material could be used in electrical equipment for contacts and switch gear, sliding and rotating bearings for space vehicles, and in nuclear reactors.

High-energy silver chloride-magnesium batteries, which operated by the flow of sea water through the battery, were developed by Yardney Electric Corp. to power torpedoes, sonar equipment, sonobuoys, beacons, pingers, and other applications in the field of antisubmarine warfare.

A sintered silver polymeric alloy was developed to meet stringent mechanical and thermal requirements for bearings. The alloy possessed physical properties of the metal, had greater strength and stability than metal-filled plastics, and had a low coefficient of friction.[5]

A silver-silicone corrosion-resistant coating was developed by Emerson and Cuming, Inc., for application to plastics, ceramics, and metals for service at elevated temperature. The new material acted as a conductor and as an electrostatic or radiofrequency energy shield, especially under high-voltage conditions where conventional conductive plastics lacked heat resistance.[6] A silver-copper-iridium alloy containing 63 percent silver was used in diffusion bonding of beryllium copper to produce high strength joints not attainable previously.[7] A thin film of the new alloy, sandwiched between the surfaces to be bonded, served as a catalyst to produce complete diffusion at the interface when subjected to light pressure at 1,475° F.

Silver-epoxy cement, having high-bonding strength and high-electrical conductivity, was developed by Epoxy Products Division, J. Waldman & Sons, for use in joining electrical components sensitive to heat damage, such as semiconductors and film resistors in printed circuits.[8]

A new silver brazing alloy was developed jointly by North American Aviation, Inc., and Handy & Harman for constructing the honeycomb sandwiches of stainless steel from which the XB–70 bomber was built. The new material, which contained small amounts of lithium, indium, and palladium, was dispersed in a nickel sponge matrix to solve the drainage problems encountered in brazing complex curved honeycomb panels. Some 5,000 pounds of it was to be used in each aircraft. Only brazed stainless honeycomb provided the high hot-strength required to withstand the heat and pressure generated at supersonic speeds.

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[4] Materials in Design Engineering. Silver-Infiltrated Tungsten Used in Rocket Nozzles. V. 56, No. 2, August 1962, p. 151.
[5] Product Bulletin. Polyment A–G. The Polymer Corp., November 1962.
[6] Chemical Engineering. Silicone-Silver Coating. V. 69, Aug. 20, 1962, pp. 82, 84.
[7] Bertossa, R.C. A New Technique for Bonding Beryllium Copper. Metal Progress, v. 81, May 1962, pp. 134, 136, 138, 140.
[8] Chemical Engineering. New Chemicals. V. 69, No. 13, June 25, 1962, pp. 82–84.

The quantity of silver absorbed in the manufacture of silver-zinc and silver-cadmium cells increased as demand for a compact, dependable power source of great capacity continued to increase—not only for space and military programs but for industrial and consumer applications as well. Rechargeable silver-cadmium batteries, which combined the high power output of silver with the long life of cadmium, gave excellent performance at subzero temperatures. The silver-zinc battery had the highest power output per unit of weight of any known battery system; consequently, it was well suited for such aerospace applications as missiles, satellites, balloons, and rockets. This battery also provided power in the experimental submarine, *U.S.S. Albacore*, the bathyscaphe, *Trieste*, electric torpedoes, and in modern jet aircraft for emergency electric current. Other equipment using silver-zinc batteries included helicopters, conventional aircraft, communications systems, TV cameras, underwater movie cameras, and lighting equipment.[9]

Commercial Filters Corp. reported the growing use of silver salts in its Hyla process as bactericides for water purification, food processing, vending machines, and domestic and institutional water supplies. The process was used for emergency water and survival kits for military and civilian use. A new type of fuel cell using a molten silver cathode and natural gas fuel was developed by General Electric Co. Metals and Controls Division of Texas Instruments, Inc., announced development of silver-clad copper-steel wire for coaxial cable and electronic applications. The silver outer cladding on coaxial cable wire helped to eliminate blisters, voids, and porosity that frequently developed with electroplated silver.

A silver substrate to replace conventional glass for depositing thin-film spots of nickel-iron for holding memory bits was said to be the principal factor in attaining increased speed in a computer operation.[10]

A radioisotope of silver, Ag 110, was used successfully to tag and follow the movement of the solids in a finely ground ore pulp during conditioning with reagents before flotation. The method was uniquely adaptable for defining the pattern and nature of a variety of dynamic metallurgical operations.

A low-friction material, consisting of a fluorocarbon dispersed in silver, was developed for high-temperature use. The new material withstood temperatures up to 700° F under moderate loads, provided long wear life without additional lubrication, had high-thermal conductivity, and had good resistance to radiation. Typical applications included instrument bearings, oxygen valve seats, ball-bearing retainers, and slip rings.[11]

A silver-filled paint marketed by J. Waldman & Sons, Epoxy Products Division, was reported to provide an excellent shield against electromagnetic radiation and was designed especially for use on electronic parts. After it was applied, the solvent evaporated, leaving a hard

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[9] Asarco Digest. Packing Power in Cramped Quarters. V. 3, No. 2, October–December 1961, p. 14–15.
[10] Materials in Design Engineering. V. 55, No. 6, June 1962, p. 97.
[11] Materials in Design Engineering. What's New in Materials. V. 56, No. 3, September 1962, p. 5.

silver coating having an electrical conductivity of 10,000 ohm-centimeters.[12]

TABLE 6.—Ore, old tailings, etc., yielding silver produced in the United States, and average recoverable content, in troy ounces of silver per ton in 1962 [1]

State	Gold ore		Gold-silver ore		Silver ore		Copper ore	
	Short tons	Average ounces of silver per ton	Short tons	Average ounces of silver per ton	Short tons	Average ounces of silver per ton	Short tons	Average ounces of silver per ton
Alaska	162	.414	--------	--------	--------	--------	--------	--------
Arizona	2,795	.153	128,718	.185	31,565	.348	78,878,533	.058
California	33,646	.592	20	53.500	--------	--------	7,296	1.737
Colorado	4,036	.410	278	4.360	1,585	37.825	24,909	24.179
Idaho	1,167	1.622	146	7.349	352,635	30.898	17,224	.675
Michigan	--------	--------	--------	--------	--------	--------	9,367.887	.043
Montana	3,051	.913	31,383	2.615	28,912	5.372	10,742,516	.233
Nevada	123,604	.016	--------	--------	1,393	22.502	12,991,011	.014
New Mexico	10	.100	46,919	1.342	1,423	3.407	7,323,561	.017
South Dakota	1,868,741	.060	--------	--------	--------	--------	--------	--------
Utah	3	.333	145,123	.111	137,555	1.576	29,181,456	.083
Undistributed [6]	122,032	2.546	796	2.987	2,192	2.676	299,660	.010
Total	2,159,247	.209	353,383	.540	557,260	20.423	148,834,053	.074

State	Lead ore		Zinc ore		Zinc-lead, zinc-copper, and zinc-lead-copper ores		Total ore	
	Short tons	Average ounces of silver per ton	Short tons	Average ounces of silver per ton	Short tons	Average ounces of silver per ton	Short tons	Average ounces of silver per ton
Alaska	--------	--------	--------	--------	--------	--------	162	.414
Arizona	2,281	3.230	19,435	.508	465,399	[2] 1.778	79,528,726	.069
California	210	1.538	--------	--------	1,770	[3] 52.578	42,942	2.958
Colorado	6,287	9.361	23	4.130	834,607	1.634	871,725	2.395
Idaho	255,241	14.759	77,531	.370	882,275	3.475	1,586,219	11.204
Michigan	--------	--------	--------	--------	--------	--------	9,367,887	.043
Montana	2,233	6.457	940,000	1.912	187	9.797	[4] 11,748,282	.388
Nevada	4,816	6.913	581	.341	46	21.197	13,121,451	.019
New Mexico	132	3.932	311,200	.346	[2] 4,100	.095	[5] 7,687,345	.039
South Dakota	27	52.407	--------	--------	--------	--------	1,868,768	.060
Utah	4	5.000	57,777	.273	458,586	4.278	29,980,504	.154
Undistributed [6]	1,168	2.648	3,208	.427	[7] 3,189,357	.047	[7] 3,618.413	.163
Total	272,399	14.268	1,409,755	1.391	5,836,327	1.386	159,422,424	.227

[1] Missouri excluded.
[2] Includes silver recovered from unanium ore.
[3] Includes silver recovered from tungsten ore.
[4] Includes manganese ore.
[5] Includes lead-barite ore.
[6] Includes Kentucky, New York, North Carolina, Oregon, Pennsylvania, Tennessee, and Washington.
[7] Includes fluorspar ore in Kentucky, tungsten ore in North Carolina, and magnetite-pyrite ore in Pennsylvania.

[12] Materials in Design Engineering. Silver-Filled Paint Shields Electronic Parts. V. 55, No. 4, October 1962, p. 206.

TABLE 7.—Mine and refinery production of silver in the United States in 1962, by States and sources

(Troy ounces of recoverable metal)

State	Mine production							Refinery production [1]
	Placers	Dry ore	Copper ore	Lead ore	Zinc ore	Zinc-lead, zinc-copper, lead-copper, and zinc-lead-copper ores	Total	
Alaska	22,132	67	----------	----------	----------	----------	22,199	23,000
Arizona	4	35,278	4,573,682	7,388	9,882	[2] 827,351	5,453,585	5,300,000
California	5,472	20,977	12,674	323	----------	[3] 93,059	132,505	135,000
Colorado	238	62,817	602,287	58,852	95	1,363,524	2,087,813	2,210,600
Idaho	97	10,898,799	11,622	3,767,189	28,673	3,066,055	17,772,435	17,000,000
Illinois	--------	----------	----------	----------	----------	----------	----------	35,000
Kentucky	--------	----------	----------	----------	----------	[4] 1,410	1,410	1,800
Michigan	--------	----------	401,491	----------	----------	----------	401,491	448,410
Missouri	--------	----------	4,082	486,814	----------	----------	490,896	693,000
Montana	11	240,174	2,506,824	14,442	1,797,431	1,832	[5] 4,560,714	4,479,000
Nevada	163	33,273	177,264	33,291	198	975	245,164	300,000
New Mexico	--------	[6] 67,791	125,076	519	107,774	389	301,549	282,400
New York	--------	----------	----------	----------	----------	19,451	19,451	40,000
North Carolina	--------	----------	5,894	----------	----------	94,545	100,439	107,100
Oregon	58	5,969	20	----------	----------	----------	6,047	5,000
Pennsylvania	(7)	(7)	(7)	(7)	(7)	(7)	(7)	6,280
South Dakota	--------	111,637	----------	1,415	----------	----------	113,052	127,200
Tennessee	--------	----------	109,655	2,596	----------	----------	112,251	115,600
Texas	--------	----------	----------	----------	----------	----------	----------	10
Utah	--------	232,981	2,417,773	20	15,759	1,961,913	4,628,446	4,700,000
Washington	--------	312,930	99	498	1,369	35,289	[8] 350,185	334,100
Wisconsin	--------	----------	----------	----------	----------	----------	----------	1,500
Total [9]	28,000	12,022,000	10,948,000	4,373,000	1,961,000	7,466,000	36,798,000	36,345,000
Percent	0.1	32.7	29.7	11.9	5.3	20.3	100.0	

[1] U.S. Bureau of the Mint.
[2] Includes silver recovered from uranium ore.
[3] Includes silver recovered from tungsten ore.
[4] Includes silver recovered from fluorspar ore.
[5] Includes silver recovered from manganese ore.
[6] Includes silver recovered from lead-barite ore.
[7] Pennsylvania included with Washington.
[8] Includes silver recovered from magnetite-pyrite ore in Pennsylvania.
[9] Data may not add to totals shown because of rounding.

TABLE 8.—Silver produced in the United States from ore and old tailings in 1962, by States and methods of recovery, in terms of recoverable metal [1]

State	Total ore, old tailings, etc., treated (short tons)	Ore and old tailings to mills					Crude ore to smelters	
		Short tons	Recoverable in bullion		Concentrates smelted and recoverable metal			
			Amalgamation (troy ounces)	Cyanidation (troy ounces)	Concentrates (short tons)	Troy ounces	Short tons	Troy ounces
Alaska	162	162	67					
Arizona	79,582,853	78,934,106		265	2,507,708	4,981,107	648,747	472,209
California	42,942	39,476	1,194	12	5,441	88,874	3,466	36,953
Colorado	871,725	842,076	2,006	318	130,203	1,390,586	29,649	694,665
Idaho	1,586,185	1,536,344	259		241,141	17,698,713	49,841	73,366
Michigan	9,367,887	9,367,887			230,466	401,491		
Montana	11,834,866	11,673,454	40		397,899	4,198,844	161,412	361,819
Nevada	13,121,451	13,028,696	109	1,996	282,886	168,400	92,755	74,496
New Mexico	7,721,545	7,584,758	1		305,470	233,930	136,787	67,618
South Dakota	1,868,768	1,868,741	85,514	26,123			27	1,415
Utah	30,000,939	29,638,525			846,621	4,351,428	362,414	277,018
Undistributed [2]	7,040,540	7,035,772	13	73,173	271,737	501,722	1,463,627	14,817
Total	163,039,863	161,549,997	89,203	101,887	5,219,572	34,015,095	2,948,725	2,074,376

[1] Missouri excluded.
[2] Includes Kentucky, New York, North Carolina, Oregon, Pennsylvania, Tennessee, and Washington.

TABLE 9.—Silver produced at amalgamation and cyanidation mills in the United States and percentage of silver recoverable from all sources

Year	Bullion and precipitates recoverable (troy ounces)		Silver from all sources (percent)			
	Amalgamation	Cyanidation	Amalgamation	Cyanidation	Smelting [1]	Placers
1953-57 (average)	93,735	308,298	0.2	0.8	98.8	0.2
1958	90,207	324,705	.3	.9	98.6	.2
1959	92,663	557,034	.3	1.8	97.7	.2
1960	86,353	533,286	.3	1.7	97.9	.1
1961	90,527	214,956	.2	.6	99.1	.1
1962	89,203	101,887	.2	.3	99.4	.1

[1] Crude ores and concentrates.

TABLE 10.—Consumption of silver in industry and the arts

(Thousand troy ounces)

Year	Issued for industrial use	Returned from industrial use [1]	Net industrial consumption	Year	Issued for industrial use	Returned from industrial use [1]	Net industrial consumption
1953-57 (average)	123,459	25,699	97,760	1960	151,007	49,007	102,000
1958	121,500	36,000	85,500	1961	155,812	50,312	105,500
1959	142,984	41,984	101,000	1962	180,812	70,412	110,400

[1] Includes secondary materials to monetary use, jewelry, plate, scrap film and other forms of scrap.

Source: U.S. Bureau of the Mint.

STOCKS

Silver bullion and coin held by the Treasury declined for the fourth consecutive year, falling 95.6 million ounces to 1,767 million ounces at yearend. Silver coinage in circulation, continuing its annual growth, increased 93.4 million ounces to 1,563.8 million ounces. Silver received by the Treasury totaled 12.5 million ounces and included 8.3 million ounces credited from lend-lease returns, 1.7 million ounces from withdrawn coins, and 2.5 million ounces from purchases of newly mined domestic silver and other receipts. The Treasury disposed of 80.5 million ounces, of which 77.4 million ounces was processed into U.S. subsidiary coins, 0.9 million ounces was sold to other Government agencies, and 2.2 million ounces was distributed in other transfers.

Nonmonetary or free silver bullion stocks increased 7.9 million ounces to 36.4 million ounces on December 31. About $98.5 million of silver $5 and $10 silver certificates were retired from circulation and replaced by Federal Reserve notes, thereby releasing 76.2 million ounces of silver which was transferred to the free silver reserve.

The ratio of the value of silver to the total value of gold and silver in the U.S. monetary stocks at yearend was 20.8 compared with 19.9 at the end of 1961.

TABLE 11.—U.S. monetary silver

(Million troy ounces)

	1958	1959	1960	1961	1962
n Treasury:					
Securing silver certificates:					
Silver bullion	1,736.3	1,741.3	1,741.8	1,730.5	1,654.5
Silver dollars	156.8	141.1	124.9	100.7	72.7
Subsidiary coin	10.9	2.4	2.0	2.6	2.5
Free silver bullion	202.2	175.1	123.5	28.5	37.0
Total	2,106.2	2,059.9	1,992.2	1,862.3	1,766.7
Coinage in circulation:					
Silver dollars	220.8	236.3	252.5	276.4	303.6
Subsidiary coin	1,046.2	1,094.7	1,140.0	1,194.0	1,260.2
Total	1,267.0	1,331.0	1,392.5	1,470.4	1,563.8
Grand total	3,373.2	3,390.9	3,384.7	3,332.7	3,330.5

Source: Compiled from U.S. Treasury Department Statements.

PRICES

The U.S. Treasury bought and sold silver at prices under the act of July 31, 1946, 90.5+ and 91.0 cents a fine troy ounce, respectively, but these prices were essentially inoperative in 1962. Only a small quantity of silver was bought by the Government under the act because the New York market price greatly exceeded the Treasury buying price, and sales of silver from the Treasury's nonmonetary stocks, except for a small quantity sold to other Government agencies, were terminated by Presidential order in November 1961.

Thus, the buying and selling activities of the U.S. Treasury, which had stabilized the price of silver in world markets during several earlier years, were not an influential market factor in 1962. Following the sharp rise in December 1961, resulting from termination of Treasury sales, the New York market price of silver in the first 7 months of 1962 was fairly stable, fluctuating between a low of 101.25 cents and a high of 105 cents per ounce. The buying and selling policy of the Bank of Mexico was the chief factor that tended to stabilize prices during this period. Increased speculative buying and foreign coinage demand brought several price rises in the August to October period, and the New York price rose from 105 cents to 122 cents per ounce, the highest price in 42 years. Sales of Mexican silver again was a factor restraining price advance in a rising market until September 24 when the sales were discontinued. The ending of sales by Mexico was followed by several sharp price increases in September and October which brought the New York price to the 1962 high of 122 cents an ounce. Prices became more stable in the last 2 months of 1962 and the New York quotation was 120.5 cents at yearend.

A change in the basis for quoting the New York price was effected on August 2, by Handy & Harman. Quotations on the new basis represented the actual price at which refined silver, in commercial bar form of acceptable brand and quality, was offered to Handy & Harman for New York delivery in quantities sufficient to meet daily requirements.

Based on the average 1962 New York price of 108.5 cents, the price ratio of gold to silver was 32.3 to 1 compared with 37.8 to 1 in 1961 when the average price was 92.4 cents.

Spot prices in the London silver market were generally lower than New York, ranging from a low of 84.375d. on April 6 to a high of 104.875d. on October 22, equivalent to 98.9 cents and 121.7 cents per ounce, respectively. The premium for forward silver (2-month delivery) over the cash price ranged from 0.125d. to 0.75d. (0.125 to 0.875 cent). Chinese sales of silver in the London market dropped to about half of the quantity sold in 1961.[13]

FOREIGN TRADE [14]

Imports.—Imports of silver, both refined and unrefined, aggregated 76.4 million ounces valued at $72.7 million, an increase of 52 percent in quantity and 62 percent in value over 1961. Canada, Mexico, and Peru supplied about 72 percent of the total imports compared with 90 percent in 1961. Imports from Mexico and Peru increased sharply, but imports from Canada, the largest supplier, were only slightly higher in 1962.

Exports.—Exports of silver from the United States dropped to 13 million ounces valued at $13 million, less than one-third the silver exported in 1961. About half of the exported silver went to Canada.

[13] S. Montagu & Co., Ltd. Annual Bullion Review, 1962. January 1963, pp. 16, 17, 25.
[14] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

LEND-LEASE SILVER

Of the 410.8 million ounces of silver supplied to foreign countries under lend-lease agreements, all but about 8.6 million ounces had been repaid at yearend. Of the remainder, 3.0 million ounces was due from Pakistan and 5.6 million ounces from Saudi Arabia.

TABLE 12.—U.S. imports of silver in 1962, by countries

(Thousand troy ounces and thousand dollars)

Country	Ore and base bullion		Refined bullion		U.S. coin value	Foreign coin value
	Quantity	Value	Quantity	Value		
North America:						
Bahamas					$4	
Canada	13,541	$13,369	10,724	$10,416	154	$43
Canal Zone					267	
El Salvador	(1)	(2)				
Guatemala	61	55				
Honduras	2,445	2,350				
Mexico	6,457	6,530	8,793	7,724		408
Nicaragua	271	260				
Panama	(1)	(2)				
Total	22,775	22,564	19,517	18,140	425	451
South America:						
Argentina	106	129				
Bolivia	632	606				
Chile	3,013	2,723				
Colombia	174	165				
Ecuador	70	64				
Peru	7,868	7,275	7,972	8,011		25
Total	11,863	10,962	7,972	8,011		25
Europe:						
Belgium-Luxembourg	7	7	1,117	1,005	2	1
France			2,546	2,292	2	
Germany, West			1,298	1,168		
Italy						9
Portugal	23	21				
Sweden			162	160		
Switzerland			789	731		(2)
United Kingdom	63	52	3,510	3,279	686	28
Total	93	80	9,422	8,635	690	38
Asia:						
Hong Kong			5	5		(2)
Japan			113	116		
Lebanon						(2)
Philippines	359	324	(1)	(2)		
Total	359	324	118	121		(2)
Africa:						
Liberia					112	
Rhodesia and Nyasaland, Federation of	77	70				
South Africa, Republic of	452	385	1,675	1,562		1
Total	529	455	1,675	1,562	112	1
Oceania: Australia	1,549	1,429	487	438		
Grand total	37,168	35,814	39,191	36,907	1,227	515

1 Less than 1,000 troy ounces.
2 Less than $1,000.

Source: Bureau of the Census.

TABLE 13.—U.S. exports of silver in 1962, by countries

(Thousand troy ounces and thousand dollars)

Destination	Ore and base bullion		Refined bullion		U.S. coin value	Foreign coin value
	Quantity	Value	Quantity	Value		
North America:						
Bahamas					$15	
Bermuda					9	
Canada			7.221	$7.051		$926
Guatemala			6	5		
Mexico			1,473	1.788		
Netherlands Antilles					1	
Panama			35	34		
Total			8,735	8.878	25	926
South America:						
Brazil			6	6		
Chile			15	14		
Colombia	10	$10	95	87		
Surinam					1	
Venezuela			6	6		
Total	10	10	122	113	1	
Europe:						
Belgium-Luxembourg	261	253				
Germany, West	51	59	1,496	1,480	1	
Ireland					10	
Italy			350	399		
Switzerland					100	
United Kingdom	448	467	1,176	1,306		
Total	760	779	3,022	3,185	111	
Asia:						
Israel			2	2		
Japan			406	408		
Total			408	410		
Africa: Liberia					700	
Grand total	770	789	12,287	12,586	837	926

Source: Bureau of the Census.

WORLD REVIEW

World silver production was estimated at 242.4 million ounces, about 5.9 million ounces more than in 1961. Increased output in the United States, Mexico, Peru, Australia, and Burma more than offset declines in production in Canada, the Congo, Southern Rhodesia, and South-West Africa. The four leading silver-producing countries, Mexico, United States, Peru, and Canada, supplied about 60 percent of the world silver output. Consumption of silver in free world countries was estimated at 365.9 million ounces, 5 percent more than in 1961.[15]

The quantity of silver consumed in industrial uses increased 1 percent to 239.7 million ounces, and coinage requirements rose 12 percent to 127.4 million ounces. The gain in both industrial and coinage consumption resulted primarily from increases in the United States and Canada, which more than offset declines in most other free world

[15] Handy & Harman, The Silver Market in 1962, p. 23.

countries. A sharp drop occurred in the quantity of silver used for coinage in France. Significant declines also occurred in the quantity of industrial silver used in West Germany and in the requirements for coinage in Italy.

TABLE 14.—World production of silver, by countries [1 2 3]

(Troy ounces)

Country	1953–57 (average)	1958	1959	1960	1961	1962
North America:						
Canada	28,931,327	31,163,470	31,923,969	34,016,829	31,381,977	30,669,028
Central America and West Indies:						
Cuba (U.S. imports)	212,157	325,278	215,000	121,415		
El Salvador	233,787	197,629	199,080	76,809		
Guatemala	429,404	320,621	[4] 88,000	[5] 663,121	[5] 515,905	[4] 32,400
Honduras	3,032,022	2,762,932	3,167,376	2,947,021	3,544,702	2,479,658
Nicaragua	245,553	304,277	298,413	326,673	417,253	500,050
Mexico	45,191,070	47,592,358	44,075,291	44,526,463	40,349,181	41,249,402
United States [6]	37,449,902	36,800,000	23,000,000	36,800,000	34,900,000	36,345,000
Total	115,725,200	119,466,600	102,967,100	119,478,300	111,109,000	111,275,500
South America:						
Argentina	1,394,393	1,543,200	1,549,600	1,671,838	1,430,675	1,318,150
Bolivia (exports)	5,986,836	6,051,284	4,504,126	4,887,138	3,901,203	3,760,383
Brazil	199,637	185,317	225,152	252,930	260,415	350,861
Chile	1,645,192	1,504,365	1,767,230	1,434,277	2,156,768	2,184,271
Colombia	111,836	105,162	102,678	134,333	127,943	131,599
Ecuador	60,874	84,522	162,608	126,419	101,190	127,739
Peru	22,164,445	25,918,353	27,225,216	30,755,496	34,161,707	36,016,676
Total	31,563,000	35,390,000	35,540,000	39,260,000	42,140,000	43,890,000
Europe:						
Austria	3,408		58,193	58,193	58,193	64,300
Czechoslovakia [7]	1,608,000	1,608,000	1,608,000	1,608,000	1,608,000	1,608,000
Finland	278,374	560,709	522,739	390,374	456,155	380,495
France	620,998	770,267	944,750	1,039,851	1,126,658	800,000
Germany:						
East [7]	4,740,200	4,800,000	4,800,000	4,800,000	4,800,000	4,800,000
West	2,239,692	2,112,304	1,897,730	1,842,559	1,879,790	1,957,562
Greece	81,811	99,410	150,273	105,487	113,396	[4] 128,600
Hungary [7]	64,300	64,300	64,300	64,300	64,300	64,300
Italy	915,724	1,334,256	1,060,749	943,946	973,139	929,832
Norway	87,450					
Poland [7]	122,180	128,600	128,600	128,600	128,600	128,600
Portugal	58,701	45,783	54,141	52,920	48,258	48,258
Rumania [7]	643,000	643,000	643,000	643,000	643,000	643,000
Spain	1,346,711	1,774,850	2,206,698	1,739,677	4,526,599	[4] 4,000,000
Sweden	2,251,870	2,944,301	3,098,142	2,659,448	2,825,246	3,367 777
U.S.S.R. [4]	25,000,000	25,000,000	25,000,000	25,000,000	25,000,000	27,000,000
United Kingdom	28,066	20,553	13,655	7,097	4,744	[4] 4,700
Yugoslavia	2,842,151	3,751,702	2,827,336	3,025,160	3,454,083	3,750,931
Total [4]	42,930,000	45,700,000	45,100,000	44,100,000	47,700,000	49,700,000
Asia:						
Burma	1,303,150	1,961,472	2,041,395	1,984,263	1,743,302	1,980,038
China [7]	448,000	600,000	800,000	800,000	800,000	800,000
India	112,037	109,828	124,777	132,718	191,008	126,706
Japan	6,170,113	6,552,032	6,650,928	6,912,602	7,960,202	8,620,482
Korea:						
North [7]	164,000	400,000	500,000	500,000	500,000	500,000
Republic of	131,165	247,788	241,898	329,649	460,341	412,812
Philippines	524,332	497,987	504,085	1,133,343	812,793	675,570
Saudi Arabia	42,861					
Taiwan	56,121	52,380	60,974	52,579	77,303	80,129
Total [4]	8,950,000	10,400,000	10,900,000	11,800,000	12,550,000	13,200,000

See footnotes at end of table.

TABLE 14.—World production of silver, by countries [1 2 3]—Continued

(Troy ounces)

Country	1953–57 (average)	1958	1959	1960	1961	1962
Africa:						
Algeria (recoverable) [8]	219,670	225,000	400,000	300,000	300,000	300,000
Bechuanaland	239	44	42	24	39	33
Congo, Republic of the (formerly Belgian)	4,085,003	3,793,788	4,768,180	3,962,836	3,472,280	1,189,577
Ghana (exports)	37,286	45,762	16,839	14,160	7,027	3,187
Kenya	20,519	44,146	46,420	35,797	40,731	46,307
Morocco	2,181,729	2,411,000	1,234,303	1,097,273	907,905	858,469
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia [9]	487,916	558,535	937,678	920,601	744,084	697,054
Southern Rhodesia	78,822	264,630	328,947	392,026	106,801	83,540
South Africa, Republic of	1,449,131	1,795,384	2,020,780	2,226,204	2,288,279	2,549,206
South-West Africa (recoverable)	1,255,281	1,719,990	1,966,955	1,004,921	1,833,437	1,253,200
Tanganyika (exports)	380,874	737,802	536,407	614,279	64,144	23,725
Tunisia	87,392	135,194	43,339	34,401	69,767	24,325
Uganda (exports)	57	36	54	109	70	39
Total	10,285,000	11,730,000	12,300,000	10,600,000	9,830,000	7,030,000
Oceania:						
Australia	14,222,210	16,270,181	15,160,631	15,215,956	13,061,549	17,250,000
Fiji	21,358	25,375	23,652	31,319	37,712	38,935
New Guinea	46,520	24,952	36,796	33,037	30,242	24,500
New Zealand	27,819	2,339	4,873	1,353	804	416
Total	14,318,000	16,323,000	15,226,000	15,282,000	13,130,000	17,314,000
World total (estimate)	223,800,000	239,000,000	222,000,000	240,500,000	236,500,000	242,400,000

1 A negligible amount of silver is produced in Bulgaria, Mozambique, Panama, and Turkey, for which countries no estimate has been included in the total.
2 This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
3 Data derived in part from the Yearbook of the American Bureau of Metal Statistics and the 49th annual issue of Metal Statistics (Metallgesellschaft) Germany.
4 Estimate.
5 Recoverable.
6 Refinery production.
7 Estimate, according to 49th annual issue of Metallgesellschaft (Germany), except 1962 which is an extension of the previous year's estimate.
8 Estimated recoverable silver content of lead and zinc concentrates, according to 1961 annual issue of Minerais et Metaux (France), except 1962 which is an extension of the previous year's estimate.
9 Partially recovered from refinery sludges and blister copper.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

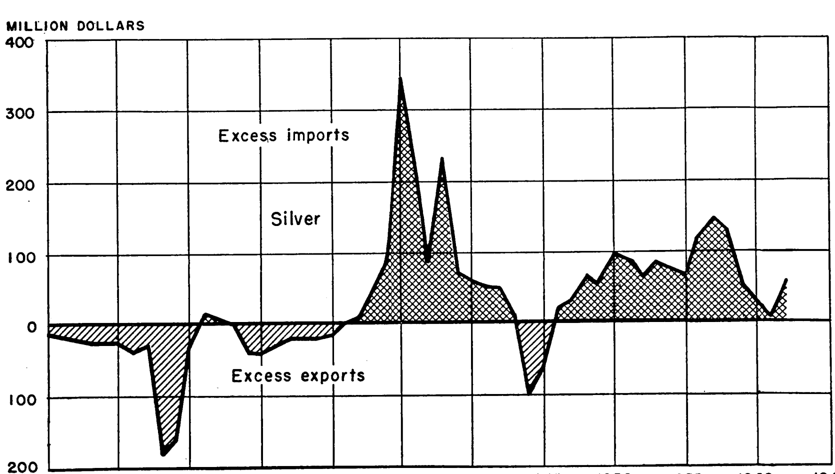

FIGURE 2.—Net imports or exports of silver, 1910-62.

Free world silver consumption exceeded production by approximately 159 million ounces, the largest margin ever recorded. Excluding U.S. coinage requirements, which were not part of the market demand, the production deficit was balanced chiefly by withdrawals from speculative holdings abroad, surplus inventories held by consumers, and sales from Mexican Government stocks. According to Handy & Harman, about one-third of the production deficit of about 91 million ounces—35 million ounces—came from speculative holdings acquired in 1961; 25 million ounces came from China; 25 million ounces came from demonetized coin and official stocks; and the remainder came from salvage and miscellaneous sources.[16]

Australia.—Output of silver increased nearly one-third to 17.3 million ounces, reflecting the sharp rise in production of lead concentrates yielding silver as a coproduct.

Mount Isa Mines, Ltd., Queensland, treated nearly 630,000 tons of silver-lead-zinc ore, about 23 percent less than in 1961. The reduction in output was caused for the most part by an 8-week strike. The company reported an ore reserve of 25.6 million tons, about the same as in 1961. New Broken Hill Consolidated, Ltd., treated 648,000 tons of silver-bearing lead-zinc ore, a considerable reduction from the 1961 output, and reported an ore reserve of 4.8 million tons. Broken Hill mines, New South Wales, and Electrolytic Zinc Co. of Australasia, Ltd., Rosebery mines increased production of silver-bearing lead-zinc ore.

Owing to the premium on the U.S. dollar in Canada, the Canadian price of silver was higher than the New York price, ranging from a low of 110.125 cents per ounce at the beginning of the year to a high of 131.75 cents in October. Favorable market conditions stimulated exploration and development activity in several areas and two new silver mines began production.

Exports of silver in ores and concentrates, most of which went to the United States, aggregated 18.2 million ounces, compared with 21.1 million ounces in 1961. Imports of silver rose 24 percent to 15.2 million ounces; however, imports from the United States dropped sharply from the 1961 level to about 5.5 million ounces, less than half those in 1961.

Consumption of silver for industrial use was estimated at 4.6 million ounces, about the same as in 1961. Consumption for coinage, however, increased sharply to 10.9 million ounces, compared with 5.0 million ounces in 1961. The Royal Canadian Mint purchased about 16.4 million ounces to meet its increased silver requirements.

Canada.—Output of silver in Canada decreased 2 percent to 30.7 million ounces, about 3.4 million ounces less than the record high in 1960. Most of the decline was in British Columbia and was attributed principally to lower lead production with which silver was recovered as a byproduct. Production also declined in Ontario, Saskatchewan, and the Yukon Territory; but increased in Quebec, Manitoba, and Nova Scotia.

British Columbia, Ontario, and the Yukon Territory together contributed about two-thirds of the silver output. United Keno Hill Mines, Ltd., and Consolidated Mining & Smelting Co. of Canada, Ltd. (Comico), the two largest silver producers, accounted for nearly half

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[16] Page 20 of work cited in footnote 15.

of the total silver production. More than three-fourths of the total silver was recovered as a coproduct or byproduct of base metal ores; the remainder came chiefly from silver and silver-cobalt ores.

Japan.—Industrial consumption of silver increased about 0.5 million ounces to 19.6 million ounces. Also, approximately 1.4 million ounces from Government stocks was used in coinage, virtually the same as in 1961.

Production of silver rose 8 percent to 8.6 million ounces, the third successive annual increase. Imports of silver were about 3.6 million ounces, 0.8 million ounces less than 1961. Most of the imported silver came from the United Kingdom. At yearend, Government stocks, which supply coinage requirements, were reduced from 47 million ounces at the end of 1961 to about 45.5 million ounces.[17]

Mexico.—Silver production increased 0.9 million ounces to 41.2 million ounces, attributed for the most part to the higher price for silver. Several small silver-producing mines reopened during 1962, and others prepared to expand operations.

Industrial consumption remained virtually unchanged at 3.3 million ounces, and 3.1 million ounces were used in domestic coinage. Only the 1-peso coin containing 10 percent silver was minted.

Exports of silver bullion aggregated about 34 million ounces, and most of it went to the United States and West Germany.

About 2.3 million ounces were recovered from demonetized coin, about 0.5 million ounces less than in 1961. It was estimated that approximately 75 million ounces of silver in demonetized coin was held by the public.

Peru.—Output of silver in the third largest silver-producing country rose for the 14th consecutive year. Production increased 1.9 million ounces to 36 million ounces, a new record. Exports of silver were 35 million ounces.

Cerro de Pasco Corp., the leading silver producer, reported an output of 16.8 million ounces, down 0.6 million ounces from 1961. The decline in output was attributed to a 28-day shutdown at the company smelter because of strikes and damage to property by riots. About 37 percent of the company's silver output came from its own mines; the remainder came from custom ore purchases.

The straight silver-mining companies, Castrovirreyna Metal Mines Co., Cia. Minera San Juan de Lucanas, Cia. Explotadora Millotengo, and Cia. Minera Caylloma, produced 6.3 million ounces, about 18 percent of Peru's total production of silver.

United Kingdom.—Consumption of silver in the arts and industries of the United Kingdom was estimated at about 20 million ounces, virtually unchanged from that of 1961. Imports of silver bullion aggregated 40.1 million ounces compared with 65.8 million ounces in 1961. Nearly two-thirds of the total imports, 25.7 million ounces, came from China; 7.4 million ounces came from Western Hemisphere countries; and the remainder came from several other countries.[18]

Exports from the United Kingdom aggregated 39.2 million ounces compared with 26.8 million ounces in 1961. Nearly 70 percent of the exported silver went to other European countries, principally France, Italy, and West Germany, the United States and Canada received most of the remainder.

[17] Page 18 of work cited in footnote 15.
[18] Pages 18, 20, and 24 of work cited in footnote 13.

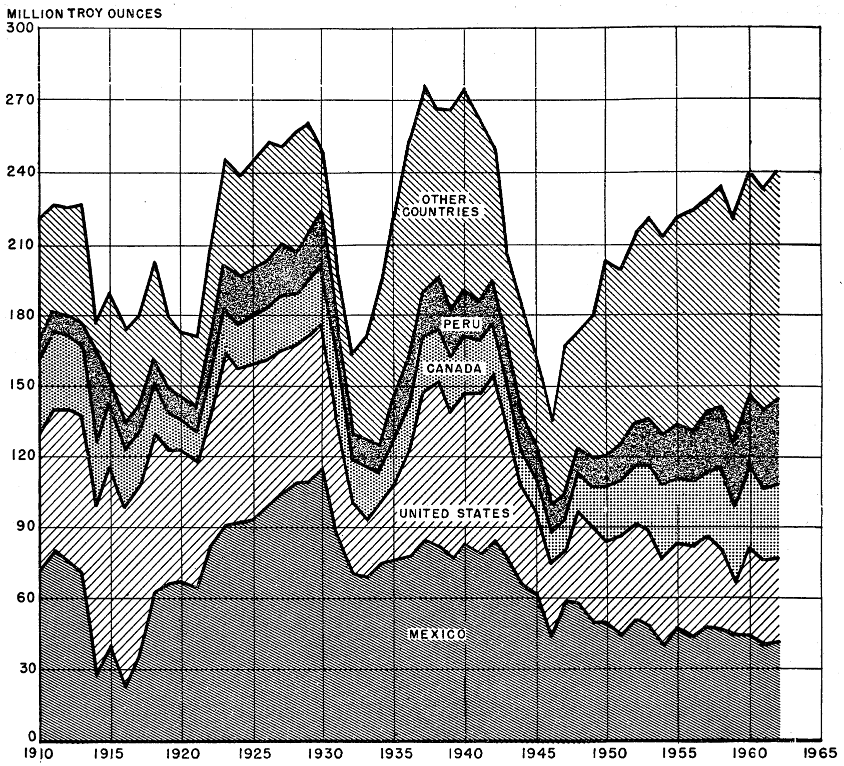

FIGURE 3.—World production of silver, 1910–62.

The proportion of silver coins in circulation continued to decline. Only 2.4 million ounces of demonitized United Kingdom silver coins was refined compared with about 5 million ounces in 1961. Official sales by the Bank of England were about 4 million ounces. The Royal Mint used about 2.5 million ounces in minting foreign coinage.

TECHNOLOGY

A method for directly plating silver onto aluminum without an intermediate coating was developed by Paco, Inc.[19] Adhesion of the silver plate was said to withstand temperatures as high as the melting point of aluminum without causing the silver plate to blister. Aluminum parts with as much as a 0.003-inch deposit of silver could be bent without flaking or chipping the silver. The silver plate provided low electrical contact resistance joints and direct solder connections to aluminum without using special soldering or cleaning methods.

Sylvania Electric Products, Inc., Sylcor Division, announced the development of a method of infiltrating large sintered tungsten rocket nozzles with silver.[20] Virtually 100 percent void infiltration was

[19] Materials in Design Engineering. Process Plates Silver on Aluminum. V. 55, No. 1, January 1962, p. 152.
[20] Sylcor Bulletin. Sylvania Electric Products, Inc., November 1962.

achieved by a vacuum-hydrogen high-temperature capillary action process. The cemented silver coolant metal was vaporized during the firing of the rocket, the vaporization absorbed some of the heat leaving a tungsten shell.

Research showed that copper in sterling silver could be replaced by tin as a hardening agent to produce an alloy with improved corrosion resistance while retaining comparable mechanical properties including excellent ductility.[21] The silver hardened with tin was not discolored by contact with salt and was more resistant to atmospheres containing sulfur dioxide.

Lightweight silver batteries, using membranes of modified polyethylene which permitted the passage of electrolyte but inhibited the passage of silver ions, were reported to have six times the power of conventional batteries having the same weights.[22]

Tests on a new silver-15 percent cadmium oxide material, containing an undisclosed amount of cobalt, showed that the new material had eroded 40 percent less than conventional oxidized silver-15 percent cadmium oxide when used in electrical contacts. The material, developed by Metals & Controls Division of Texas Instruments, Inc., was sold in the form of solid, overlay, and top-lay electrical contacts which were expected to be used in control and power relay equipment, motors, generators, and electrical appliances.[23]

A patent[24] was issued for a method of electrodepositing a nonporous layer of palladium-silver alloy by plating out these metals from an ammoniacal nitrate solution of palladium and silver having a pH ranging from 7.5 to 11.

A patent[25] was issued for an appliance for cleaning silver and silver-plated articles by immersing them in a liquid medium and bringing them into contact with a detached zinc wire helix adjustable to fit the articles to be cleaned.

Experiments to accelerate silver plating showed that the superposition of alternating or direct current in the electrolyte had a favorable effect on quality of deposit and rate of deposition, making it possible to obtain thick semibright silver deposits (1 millimeter and over) without intermediate scratch brushing.[26] On the basis of experimental results, the following electrolyte composition and conditions for silver deposition from cyanide solutions was recommended:

> $AgNO_3$–45 grams per liter, NaCN–45–50 grams per liter, Na_2CO_3–40–45 grams per liter; temperature=20° C, D_{dir} up to 1.5 amperes per square decimeter (D=current density), $D_{alt}/D_{dir}=$ 2.5 (for the AC amplitude) and $D_{alt}/D_{dir}=1.8$ (for the effective AC). Current efficiency was 95 to 98 percent.

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[21] Metal Industry (London). Hardening Silver. V. 101, No. 25, Dec. 20, 1962, p. 488.
[22] Materials in Design Engineering. Space Batteries With Six Times the Power-to-weight Ratio. V. 56, No. 1, July 1962, p. 81.
[23] Materials in Design Engineering. Electrical Contact Material Has Long Service Life. V. 56, No. 3, September 1962, p. 188.
[24] Media, V. E. (assigned to Leesona Corp.). Deposition of Metals, U.S. Pat. 3,053,741, Sept. 11, 1962.
[25] Gross, M. T. Appliances for Cleaning Silver and Silver-Plated Articles. U.S. Pat. 3,035,997, May 22, 1962.
[26] Kudryavtsev, N.T., Bek, R. Y. Electrodeposition of Silver By Reversing Current. J. of Appl. Chem. of the U.S.S.R., v. 35, March 1962, pp. 530–537.

Several miscellaneous articles on the technology of silver were published.[27]

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[27] Hellens, A. D. Silver Mining in the Cobalt Area. PreCambrian, v. 35, No. 6, June 1962, pp. 22–26; The Sisco Mine at O'Brien, July 1962, pp. 14–27.
McKnight, E. T. How about Silver? Where. Min. World, v. 24, No. 9, August 1962, pp. 18–21.
Colson, J. B. Silver Production in the Western Cordillera. Western Miner and Oil Rev. (Vancouver, Canada), v. 35, No. 11, November 1962, pp. 26–29.

Slag

Iron-Blast-Furnace

By Perry G. Cotter [1]

INCREASED production of pig iron in 1962 was not reflected in a corresponding rise in the tonnage of slag furnished to processors. Early predictions for output of processed slag, based in part on 1961 production figures, had indicated that production would be 26 million short tons, a 2-percent increase. However, output declined 9 percent in tonnage and 5 percent in value. The continuing shortage of iron-blast-furnace slag for processing, which compelled some producers to work at less than optimum capacity, brought out new interest in developing methods by which open-hearth slag could be utilized.

TABLE 1.—Iron-blast-furnace slag processed in the United States, by types

(Thousand short tons and thousand dollars)

Year	Air-cooled				Granulated		Expanded	
	Screened		Unscreened		Quantity	Value [1]	Quantity	Value
	Quantity	Value	Quantity	Value				
1953-57 (average)	24,456	$35,743	1,345	$881	3,921	$1,527	2,742	$7,330
1958	20,499	34,027	1,411	1,170	3,536	1,373	2,985	8,638
1959	21,816	36,774	1,039	957	2,702	1,396	2,812	8,037
1960	21,908	37,671	1,237	1,049	3,027	1,489	2,626	7,773
1961	19,250	33,906	1,493	985	2,663	1,367	2,275	6,806
1962	18,496	32,680	312	340	2,385	1,258	2,249	6,615

[1] Excludes value of slag used for manufacturing hydraulic cement.

Source: National Slag Association.

DOMESTIC PRODUCTION

Output of processed iron-blast-furnace slag was 23,442,000 tons, compared with 25,681,000 tons in 1961.

Forty companies operated 61 air-cooled-, 16 granulated-, and 21 expanded-slag plants.

Pennsylvania, Ohio, and Alabama, as in other years, were the top producers of the 16 States reporting slag processing. Ohio producers increased output 1.6 million tons over that of 1961.

Recovery of Iron.—Although less slag was supplied to processors than in 1961, the 385,345 tons of iron recovered for remelting represented an increase of 4 percent.

[1] Commodity specialist, Division of Minerals.

TABLE 2.—Iron-blast-furnace slag processed in the United States, by States

(Thousand short tons and thousand dollars)

Year and State	Screened air-cooled		All types	
	Quantity	Value	Quantity	Value
1961:				
Alabama	2,128	$3,901	2,704	$4,751
Ohio	3,312	6,204	4,152	8,224
Pennsylvania	5,511	10,421	6,699	11,352
Other States [1]	8,299	13,380	12,126	18,737
Total	19,250	33,906	25,681	43,064
1962:				
Alabama	2,062	3,801	2,570	4,536
Ohio	4,936	9,407	5,760	11,325
Pennsylvania	4,971	9,281	6,233	11,061
Other States [1]	6,527	10,191	8,879	13,971
Total	18,496	32,680	23,442	40,893

[1] California, Colorado, Illinois, Indiana, Kentucky, Maryland, Michigan, Minnesota, New Jersey, New York, Tennessee, Texas, and West Virginia.

Source: National Slag Association.

TABLE 3.—Shipments of iron-blast-furnace slag in the United States, by methods of transportation

Method of transportation	1961		1962	
	Thousand short tons	Percent of total	Thousand short tons	Percent of total
Rail	7,458	29	7,158	30
Truck	17,360	68	15,614	67
Waterway	578	2	670	3
Total shipments	25,396	99	23,442	100
Interplant handling [1]	285	1		
Total processed	25,681	100	23,442	100

[1] Confined mainly to granulated slag used in manufacturing cement.

Source: National Slag Association.

Employment and Injuries.—A total of 3,478,194 man-hours was worked by 1,680 plant and yard employees in processing commercial slag in 1962, compared with 3,554,000 man-hours by 1,854 employees in 1961, and the average employee worked 19 days more. Production per man-hour was 6.74 tons, compared with 7.23 tons per man-hour in 1961. The Ensley No. 1 plant of Birmingham Slag Division of Vulcan Materials Co. at Birmingham, Ala., won top honors in the National Slag Association Safety Competition of 1961 for having the best safety record in the large-plant group. In the small-plant group, the South Deering plant of Illinois Slag & Ballast Co. was first. For the second successive year no fatalities were reported. A comparison of data on safety showed that although the frequency rate of accidents in the slag-processing industry increased in 1961 compared with 1960, the severity rate decreased; both rates were lower than those reported for the sand and gravel and crushed stone industries. Safety data for 1962 were not completed.

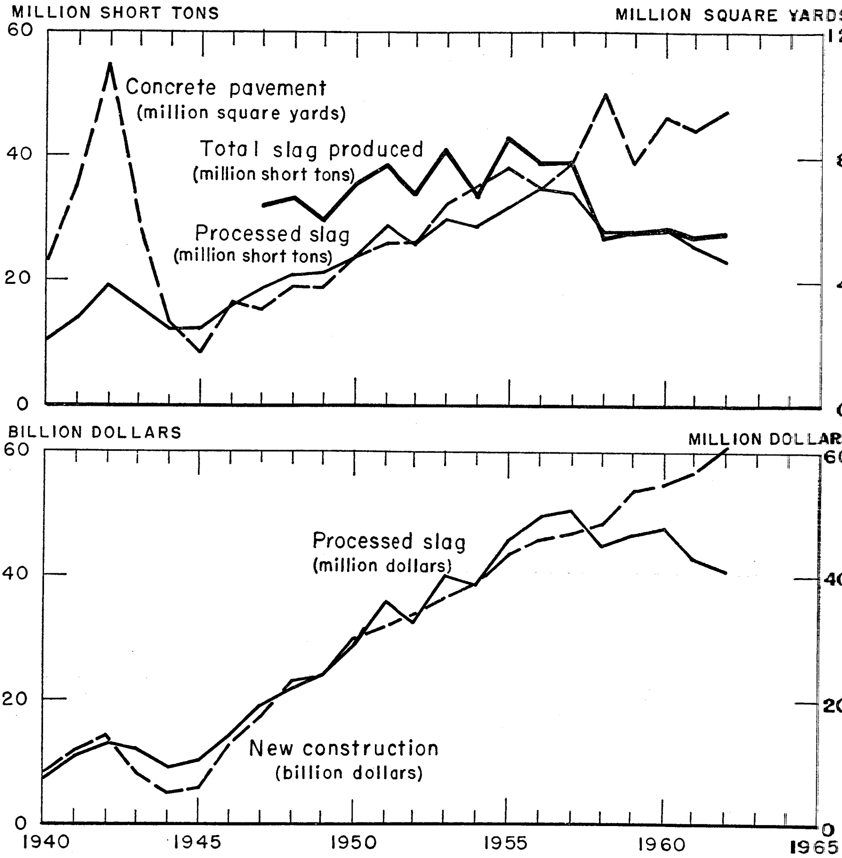

FIGURE 1.—Production of iron-blast-furnace slag compared with yards of concrete pavement (contract awards), monthly average, and value of new construction compared with value of processed slag, 1940–62.

Methods of Transportation.—Percentages of processed slag shipped by rail and water were slightly greater than in 1961, but most of the output was carried by truck.

CONSUMPTION AND USES

Screened air-cooled slag accounted for 79 percent of the total quantity of processed slag. Production of other types was as follows: Unscreened air-cooled, 1 percent; granulated, 10 percent; and expanded, 10 percent.

Screened Air-Cooled Slag.—Use of this material for railroad ballast increased 8 percent and for mineral wool 13 percent, but total consumption decreased 4 percent because less was used for various types of construction.

Unscreened Air-Cooled Slag.—Production of unscreened air-cooled slag dropped markedly because much of this material, formerly considered to be of low quality, was processed into grades having a higher market value. Fifty percent was used for highway and airport construction.

Granulated Slag.—Use in manufacture of portland blast-furnace slag cement accounted for 55 percent of the total production of 2,385,000 tons. Thirty percent was used for base, subgrade, and fill in highway construction compared with 27 percent in 1961. Total production dropped 10 percent below that of 1961.

Expanded Slag.—Production of expanded slag was 2,249,000 tons, approximately the same as in 1961. Ninety-eight percent was used in the manufacture of concrete block.

TABLE 4.—Air-cooled iron-blast-furnace slag sold or used by processors in the United States, by users

(Thousand short tons and thousand dollars)

Year and use	Screened		Unscreened	
	Quantity	Value	Quantity	Value
1961:				
Aggregate in—				
Portland-cement concrete construction	2,839	$5,149		
Bituminous construction (all types)	3,977	7,487	9	$8
Highway and airport construction [1]	7,851	14,153	793	688
Manufacture of concrete block	451	756		
Railroad ballast	2,841	3,616		
Mineral wool	496	859	9	6
Roofing (cover material)	376	1,162		
Sewage trickling filter medium	15	39		
Agricultural slag, liming	11	14		
Other uses	393	671	682	283
Total	19,250	33,906	1,493	985
1962:				
Aggregate in—				
Portland-cement concrete construction	2,508	4,719		
Bituminous construction (all types)	3,809	7,171		
Highway and airport construction [1]	7,009	12,641	157	195
Manufacture of concrete block	423	722		
Railroad ballast	3,067	3,727		
Mineral wool	560	1,026		
Roofing (cover material)	357	1,194		
Sewage trickling filter medium	27	60		
Agricultural slag, liming	5	9		
Other uses	731	1,411	155	145
Total	18,496	32,680	312	340

[1] Other than in portland-cement concrete and bituminous construction.

Source: National Slag Association.

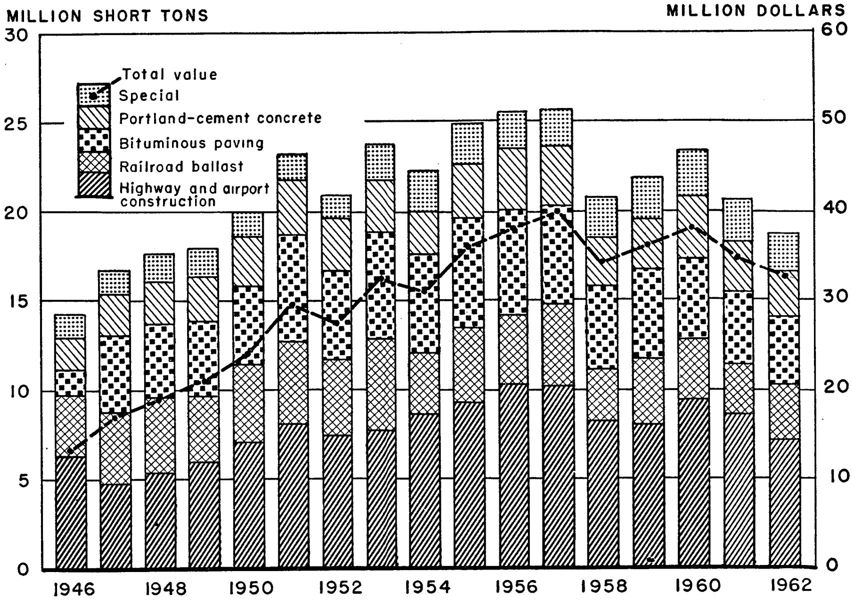

FIGURE 2.—Consumption and value of air-cooled, iron-blast-furnace slag sold or used in the United States, 1946–62.

TABLE 5.—Granulated and expanded iron-blast-furnace slag sold or used by processors in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1961				1962			
	Granulated		Expanded		Granulated		Expanded	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Highway construction (base and subgrade)	543	$758			504	$666		
Fill (road, etc.)	184	179			218	237		
Agricultural slag, liming	45	64			59	74		
Manufacture of hydraulic cement	1,545	(1)			1,320	(1)		
Aggregate for concrete-block manufacture	123	154	2,225	$6,646	92	106	2,195	$6,453
Aggregate in lightweight concrete			18	49			8	23
Other uses	223	212	32	111	192	175	46	139
Total	2,663	[2] 1,367	2,275	6,806	2,385	[2] 1,258	2,249	6,615

[1] Data not available.
[2] Excludes manufacture of hydraulic cement, value not available.

Source: National Slag Association.

PRICES

The average unit value of processed slag ranged from $0.91 to $3.34 per short ton depending upon quality and the amount of preparation required. Screened air-cooled slag used for concrete construction and block, mineral wool, built-up roofing, and agricultural slag-liming increased in price, as did unscreened slag used for highway and airport construction.

TABLE 6.—Average value of iron-blast-furnace slag sold or used by processors in the United States, by uses

(Per short ton)

Use	Air-cooled				Granulated		Expanded	
	Screened		Unscreened					
	1961	1962	1961	1962	1961	1962	1961	1962
Aggregate in—								
Portland-cement concrete construction	$1.81	$1.88	--------	--------	--------	--------	[1] $2.72	[1] $2.88
Bituminous construction (all types)	1.88	1.88	$0.89	--------	--------	--------	--------	--------
Highway and airport construction [2]	1.80	1.80	.87	$1.24	[3] $1.40	[3] $1.32	--------	--------
Manufacture of concrete block	1.68	1.71	--------	--------	1.25	1.15	2.99	2.94
Railroad ballast	1.27	1.22	--------	--------	--------	--------	--------	--------
Mineral wool	1.73	1.83	.67	--------	--------	--------	--------	--------
Roofing (cover material)	3.09	3.34	--------	--------	--------	--------	--------	--------
Sewage trickling filter medium	2.60	2.22	--------	--------	--------	--------	--------	--------
Agricultural slag, liming	1.27	1.80	--------	--------	1.42	1.25	--------	--------
Fill (road, etc.)	--------	--------	--------	--------	.97	1.09	--------	--------
Other uses	1.71	1.93	.41	.94	.95	.91	3.47	3.02

[1] Lightweight concrete.
[2] Other than in portland-cement and bituminous construction.
[3] Base and subgrade material.

Source: National Slag Association.

TECHNOLOGY

Studies on the bloating of blast-furnace slag revealed that reactions between atmospheric oxygen and sulfide compounds present in the slag are responsible for most of the effervescence that causes porosity. Oxygen may be introduced into the molten slag in the runner and while the slag is being poured into the pit. The desirability of bloating depended upon whether a high-density slag was desired for road aggregate or a low-density product, for lightweight aggregate. It was found that if slag was held molten for a sufficient time in air, complete desulfurization occurred. It was indicated that the presence of carbon monoxide, water vapor, carbonates, or nitrates did not cause effervescence.[2]

Developments in Japanese research on portland blast-furnace slag cements were reviewed.[3]

[2] Archibald, W. A., L. A. Leonard, and A. M. A. Mincer. Reactions Causing Bloating of Slags and Refractories. J. Iron and Steel Inst. (London), v. 200, pt. 2, February 1962, pp. 113–120.

[3] Rockwood, Nathan C. Japanese Experiments With Cement and Concrete Never Cease. Rock Products, v. 65, No. 2, February 1962, pp. 116–118.

Investigations on fly ash undertaken to determine whether the coarse and fine fractions differed significantly in characteristics other than size, indicated that the fine portions appeared to have a higher glass content.[4]

A tractor-drawn ripper was used to break up bedded air-cooled blast-furnace slag, thus eliminating the crushing operation. Grain size ranges, bulk densities, and impact and crushing strengths of aggregate were given, together with results of chemical, X-ray, and mineralogical examinations.[5]

The new 1,100 ton-per-hour processing plant of Edward C. Levy Slag Co. was described. The plant was designed to screen eight basic sizes of slag. Automatic or pushbutton controls with safety interlocks were used in all stages of processing. Discharge spouts on stackers combined electric proximity-sensing units with hoists to raise or lower spouts. A flow sheet of the operation was shown.[6]

The fire-resistance rating for concrete masonry walls in which pumice and expanded slag were used as aggregate was determined to be approximately twice that of walls in which siliceous gravel was the aggregate. A method was developed for estimating fire-resistance ratings for 12 types of masonry wall construction.[7]

The experience of Baltimore, Md. in using slag asphalt surfacing was reported. Outstanding properties of this type of surfacing were high stability, excellent skid resistance, and absence of polishing under traffic wear. Specifications for the slag aggregate-asphalt mix were given.[8]

Results of tests to determine effectiveness of welded-stud shear connectors in stone concrete and air-cooled slag concrete indicated that it is unnecessary to distinguish between air-cooled slag and stone concrete as far as shear connector strengths are concerned.[9]

The use of a mixture of slag sand and pozzolanic fly ash for heavy concrete construction was described. The chemical composition and screen size of the aggregate used were listed, as were the results of compressive and tensile strength tests.[10]

Rammed mixtures of blast-furnace slag and sodium silicate were reacted with carbon dioxide to form foundry ladle linings.[11]

The properties and methods of manufacturing lightweight aggregates suitable for making load-bearing concrete were detailed in an article. Typical values were reported for lightweight aggregate concrete made from blast-furnace slag and from furnace clinker.[12]

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[4] Luke, Wilbur I. Nature and Distribution of Particles of Various Sizes in Fly Ash. U.S. Army Engineers, Waterways Exp. Sta., Vicksburg, Miss., Corps of Engineers Tech. Rept. 6–583, November 1961, 21 pp.

[5] Stollenwerk, Hans. Erzeugung von kornabgestufter Hochofenschlacke mit dem Heckaufreiser (Production of Graded Blast-Furnace Slag With a Ripper). Stahl u. Eisen (Dusseldorf), v. 82, No. 19, Sept. 13, 1962, pp. 1308–1313.

[6] Trauffer, Walter E. Levy's New Slag Plant Features. Pit and Quarry, v. 54, No. 7, January 1962, pp. 135–143.

[7] National Concrete Masonry Association. Concrete Masonry Fire-Resistance Ratings. Washington, D.C., November 1962, 4 pp.

[8] Chilcote, William L. Resurfacing Roadways With Bituminous Slag. Am. Public Works Assoc. Ybk., 1962, pp. 166–169.

[9] Slutter, R. G. Pushout Tests for Composite Design Comparing Slag vs. Stone Concrete. Nat. Slag Assoc. Rept. 163–1, November 1962, 7 pp.

[10] Chapelle, J. Utilization du sable de laitier et des cendres volantes sans les bétons (Use of Slag Sand and Fly-Ash in Concretes). Revue des materiaux de construction et de travaux publics (Paris), No. 563, 1962, pp. 197–204.

[11] Chemical Trade Journal and Chemical Engineering (London). Linings for Foundry Ladles. V. 150, No. 3902, Mar. 16, 1962, p. 568.

[12] Short, A., and W. Kinniburgh. Lightweight Aggregates and Load-Bearing Lightweight Concrete. Cement, Lime, and Gravel (London), v. 37, No. 10, October 1962, pp. 291–297.

Results of electrical conductivity tests, made to determine suitability of open-hearth slag for railroad ballast, indicated that open-hearth slag is a better conductor than blast-furnace slag in the dry state because of higher metal content but that it has a lower electrical conductivity in the wet state because it is less porous and retains less water. Test results indicated that moisture-holding capacity of slag was a more important factor in electrical conductivity than the composition of the ballast itself.[13]

A method of pelletizing blast-furnace slag produced an improved aggregate for concrete. A stream of molten slag was diverted into a bowl rotating at high speed, thrown against the bowl's flaring sidewall and upward over the rim, and projected outward as discrete pellets. The pellets were deflected into a stream of water from which they were recovered.[14]

A low-cost hydraulic cement giving good workability and strength was made by grinding together 20 to 50 percent portland cement clinker, 20 to 50 percent slaked lignite ash, 0 to 60 percent blast-furnace slag, and 0 to 50 percent natural or artificial pozzolanic material such as fly ash. Accelerators and other chemical additives were used as needed.[15]

A road-surfacing composition consisting of 10 to 30 percent fly ash or other pozzolanic material, 70 to 90 percent inert aggregate of a specified screen size, and 2 to 6 percent of lime produced a road-surfacing material that could be used at temperatures below 40° F. The screen size of aggregate and percentages of lime, fly ash, and water required were listed. Strength curves of pavements were shown.[16]

A foamed blast-furnace slag consisting almost entirely of particles having 85 percent closed pores and resembling wollastonite was developed for use as a lightweight insulating concrete aggregate. No prewetting was required, and the slag did not absorb water by capillary action.[17]

Dried granulated blast-furnace slag was ball-milled with about 4 percent sodium sulfate and 2 percent hydrated lime to prepare a low-cost high-early-strength hydraulic cement that had a very low heat of hydration.[18]

A method for conveying foamed blast-furnace slag from the foaming device to stockpiles was patented. In this method a current of air conveys the semiplastic slag through a water-cooled tube and sintering of the foamed slag is avoided.[19]

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[13] American Railway Engineering Association. Advance Report of Committee 1, Ballast Tests. Bull. 573, September–October 1962, pp. 35–38.

[14] Bartholomew, G. A., and T. Bartholomew. Method and Apparatus for Pelleting Molten Slag. U.S. Pat. 3,054,139, Sept. 18, 1962.

[15] Cochery, A. (assigned to Sociéte d'Exploitations des Laitiers de Longwy). Ciments et leur fabrication (Cements and Their Manufacture). French Pat. 1,287,707, Mar. 16, 1962.

[16] Minnick, J. (assigned to G. & W. H. Corson, Inc., Plymouth Meeting, Pa.). Compositions for Building Load Supporting Surfaces. Australian Pat. 236,447, Nov 15, 1961.

[17] Rodis, F., and J. Cremer (assigned to Knapsack-Griesheim, A. G., Cologne). Aggregate of Slags. Canadian Pat. 647,647, Aug. 28, 1962.

[18] Purdon, A. (assigned to Soc. Financiere de Transports et d'Entreprises Industrielles, Brussels). Manufacture of High Early-Strength Cements from Granulated Blast Furnace Slags. Canadian Pat. 646,625. Aug. 14, 1962.

[19] Chocola, J. (Doksy, Czechoslovakia). Method of Conveying Foamed Slag and Similar Material in a Semi-Plastic State. U.S. Pat. 3,022,113, Feb. 20, 1962.

Sodium and Sodium Compounds

By Robert T. MacMillan [1] and Victoria R. Schreck [2]

OPENING of a new trona mine and increased output from other sources of natural soda ash together with modest gains in ammonia soda output were responsible for the largest total output of sodium carbonate since 1959. Byproduct sodium sulfate production also increased, reflecting the generally high level of industrial activity; however, production of natural sodium sulfate dipped slightly.

DOMESTIC PRODUCTION

Soda ash (sodium carbonate) output from natural sources exceeded the record high production levels of 1960 and 1961 by more than 20 percent. As in past years most of the soda ash consumed by industry was manufactured from salt by the ammonia soda process; however, the proportion of the total output produced from natural deposits of sodium carbonate increased to 17 percent.

The growth of natural soda ash production capacity, while conventional ammonia soda plants remained relatively stable, was attributed in part to the high cost of building new ammonia soda plants. The cost of a new 1,000-ton-per-day ammonia soda plant, the smallest that can be built and operated profitably, was estimated at $40 million. On the other hand, the capital investment needed for building a comparable plant to produce soda ash from natural sodium compounds was about half as great. As a result, natural sodium compounds producers increased the size of their plants and a new plant was completed in May by Stauffer Chemical Co. near Green River, Wyo., to produce soda ash from the large trona reserve in the State.

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

TABLE 1.—Manufactured sodium carbonate produced and natural sodium carbonates sold or used by producers in the United States

(Thousand short tons and thousand dollars)

Year	Manufactured soda ash (ammonia-soda process) [1] [2]	Natural sodium carbonates [3]	
	Quantity	Quantity	Value
1953-57 (average)	4,829	573	$14,871
1958	4,324	629	17,032
1959	4,904	735	19,078
1960	4,558	809	20,865
1961	4,516	806	20,444
1962	[4] 4,607	978	24,330

[1] Bureau of the Census.
[2] Includes quantities used to manufacture caustic soda, sodium bicarbonate, and finished light and dense soda ash.
[3] Soda ash and trona (sesquicarbonate).
[4] Preliminary figure.

TABLE 2.—Sodium sulfate produced and sold or used by producers in the United States

(Thousand short tons and thousand dollars)

Year	Production (manufactured [1] and natural)			Sold or used by producers (natural only)	
	Salt cake (crude)	Glauber salt (100 percent $Na_2SO_4 \cdot 10H_2O$)	Anhydrous refined (100 percent Na_2SO_4)	Quantity [2]	Value
1953-57 (average)	721	154	251	289	$5,118
1958	640	106	255	347	6,716
1959	734	99	308	403	7,689
1960	738	72	303	450	8,706
1961	780	64	327	466	9,296
1962	[2] [3] 883	([4])	337	458	9,092

[1] Bureau of the Census.
[2] Includes glauber salt converted to 100-percent Na_2SO_4 basis.
[3] Preliminary figure.
[4] Included with salt cake (crude).

Natural soda ash sources are found only in the western half of the United States and ammonia soda producers have always held a geographical advantage in being nearer to eastern markets where 80 percent of the soda ash is consumed. This advantage has been offset in part by reduced freight rates for soda ash and development of a high-capacity, 95-ton freight car, enabling western producers of natural soda ash to compete in many eastern market areas previously unavailable to them. The grade of the finished product, whether made from salt or natural soda compounds, is substantially the same.[3]

Natural sodium carbonate was produced from brines of Searles Lake and Owens Lake in southern California and from bedded deposits of trona in southwestern Wyoming. Searles Lake brine was processed to produce sodium carbonate and other chemicals by Amer-

[3] Oil, Paint and Drug Reporter. "Soda Ash on Parade." V. 182, No. 16, Oct. 15, 1962, pp. 3, 34, 37, 38.

ican Potash & Chemical Corp. at Trona, Calif. Several miles away, at Westend, the same lake brine was utilized to produce soda ash and chemicals by Stauffer Chemical Co., West End Division. Owens Lake was the source of sodium carbonate produced near Bartlett, Calif., by Pittsburgh Plate Glass Co., Chemical Division.

Vast underground trona deposits enabled Wyoming to maintain its leading position as producer of natural sodium carbonate. Two mines and plants were in operation in 1962. The FMC Corp. plant at Westvaco, Wyo., continued production begun in the early 1950's. The new mine and plant of Stauffer Chemical Co. near Green River began production in May, 5 months ahead of schedule. More detailed information on this mine is included in the section on technology.

Total production of sodium sulfate (salt cake) was over 1.2 million tons, an increase of 7 percent over that of 1961. All the increases came from byproduct sources, such as the production of rayon, cellophane, hydrochloric acid, sodium bichromate, boric acid, phenol, and miscellaneous chemicals. The output from natural sources dropped 2 percent, and the percentage of the total market supplied with natural salt cake dropped from 41 in 1961 to 38.

Fluctuations in natural salt cake production are not uncommon and decreases usually are associated with increased industrial activity, which results in a greater output of byproduct salt cake.

Natural sodium sulfate was produced in California, Wyoming, and Texas. In California, American Potash & Chemical Corp. and Stauffer Chemical Co., West End Division, produced sodium sulfate from Searles Lake brines at Trona and Westend, respectively; United States Borax & Chemical Corp. produced sodium sulfate as a coproduct in making boric acid from borax. In Texas, Ozark-Mahoning Mining Co. produced sodium sulfate from subterranean brines at Monahans and Brownfield, and in Wyoming, William E. Pratt produced sodium sulfate from semidry lakebeds.

Competition was intensified in the salt cake industry as increased capacity in natural production vied with an estimated 13 percent boost in rayon production, an important source of byproduct salt cake. Increased use of salt cake recovery procedures in kraft pulp mills, an important consumer of salt cake, was reflected in greater pulp output, without a corresponding increase in salt cake consumption.[4]

The possible entrance into the market of several new salt cake producers, both domestic and foreign, contributed to unsettled market conditions. A substantial reduction in transcontinental freight rates was put into effect in October, making western salt cake more competitive in the southeastern paper pulp area. Other freight rates were adjusted to enable eastern producers to maintain their share of markets.[5]

A 9-percent gain was noted in the production of metallic sodium, which increased from 109,100 tons in 1961 to 119,084 tons, according to the Bureau of the Census. Three companies were reported to be in production: E. I. du Pont de Nemours & Co., with plants at

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[4] Oil, Paint and Drug Reporter. "Salt Cake Industry Witnessing an Intensification of Competition." V. 182, No. 26, Dec. 24, 1962, pp. 4, 29.

[5] Oil, Paint and Drug Reporter. "Sodium Sulfate Freight Rate War Continues as Metal Climax Weighs Big Mexican Venture." V. 182, No. 20, Nov. 12, 1962, pp. 5, 30.

Niagara Falls, N.Y., and Memphis, Tenn.; Ethyl Corp., with plants at Baton Rouge, La., and Houston, Tex.; and National Distillers & Chemical Corp. at Ashtabula, Ohio. Metallic sodium was produced by electrolysis of molten salt.

The following estimated U.S. soda ash production capacity by company was reported in a trade journal.[6]

Company and plant location:	*Process*	*Yearly capacity, thousand ton*
Allied Chemical Corp.:		
Baton Rouge, La	Ammonia soda	875
Detroit, Mich	do	800
Syracuse, N.Y	do	900
American Potash & Chemical Corp., Trona, Calif.	Natural	150
Diamond Alkali Co., Painesville, Ohio	Ammonia soda	800
The Dow Chemical Co., Freeport, Tex	Caustic carbonation	180
FMC Corp., Green River, Wyo	Natural	750
Olin Matheison Chemical Corp.:		
Lake Charles, La	Ammonia soda	375
Saltville, Va	do	360
Pittsburgh Plate Glass Co.:		
Barberton, Ohio	do	600
Bartlett, Calif	Natural	70
Corpus Christi, Tex	Ammonia soda	240
Stauffer Chemical Co.:		
Green River, Wyo	Natural	150
Westend, Calif	do	150
Wyandotte Chemicals Corp., Wyandotte, Mich.	Ammonia soda	720
Total		7, 120

CONSUMPTION AND USES

The glass industry continued to be the largest consumer of soda ash, taking an estimated 40 percent of the total output. A tariff increase on imported window glass was expected to provide U.S. producers with a larger share of the U.S. market for window glass. Despite competition from high-density polyethylene containers, the glass container industry showed gains in the food and beverage fields. Growth also was noted in fibrous glass both for textiles and insulation.

The second largest use of soda ash was in manufacturing chemicals—chiefly sodium tripolyphosphate, sodium silicates, sodium bicarbonate, and lime soda caustic. The production of caustic soda by reacting sodium carbonate with lime formerly supplied a large part of the total caustic demand. However, byproduct caustic soda from chlorine production has largely superseded soda ash in this area.

Many chemical and metallurgical uses of soda ash are served as well by caustic soda and vice versa. Competition between the two types of soda for the same market is usually of small consequence as both types are often produced by the same company. Soda ash, however, is cheaper than caustic soda as a source of sodium oxide.

[6] Oil, Paint and Drug Reporter. "Soda Ash Capacity Now in the United States; Industry Poises on Plateau After Expansions." V. 182, No. 16, Oct. 15, 1962, p. 34.

Other uses of soda ash were in pulp and paper manufacture, water treatment, and production of nonferrous metals, cleaners, soap, textiles, and dyes.

The kraft paper industry continued to be the chief consumer of sodium sulfate. Sodium sulfate aids in dissolving lignin and releasing cellulose fibers in pulpwood digesters. An estimated 70 percent of the total sodium sulfate output was consumed by this industry. Sodium sulfate recovered and recirculated was not included in the total.

Other uses of sodium sulfate were in manufacturing glass, ceramic glazes, detergents, stock feeds, dyes, textiles, medicines, and miscellaneous chemicals.

The chief market for metallic sodium continued to be in manufacturing tetraethyl lead (TEL) and tetramethyl lead (TML), two compounds added in small quantities to motor fuels to increase their antiknock characteristics.

Other uses of metallic sodium included metal descaling, ore reduction, and manufacture of sodium peroxide, hydride, amide, cyanide, borohydride, and other chemicals.

New potential uses for sodium, such as for cooling both nuclear and high-temperature, conventional-fueled powerplants, have been slow in gaining acceptance. A full-scale powerplant using metallic sodium as one of the fluids required about 200,000 pounds of the metal initially, but very small quantities for makeup.

PRICES

Prices quoted for sodium carbonate, sodium sulfate, and metallic sodium by "Oil, Paint and Drug Reporter" were mostly unchanged from 1961. Prices for these commodities in 1962 were as follows:

Commodity:		*Price*
Sodium carbonate (soda ash 58 percent Na_2O):		
Light, bulk	per hundredweight	$1.55
Dense, paper bags, carlots	do	1.90
Dense, bulk	do	1.60
Sodium sulfate (100 percent Na_2SO_4):		
Technical, anhydrous, bags, carlots	per ton	[1] 56.00
Technical detergent, rayon grade, bags, carlots, works	do	38.00
Technical detergent, rayon grade, bulk, works	do	34.00
Domestic salt cake, bulk, works	do	28.00
National Formulary (N.F. VII), drums	per pound	.225
Metallic sodium:		
Bricks, lots of 18,000 pounds and over, works	do	.21
Fused, lots of 18,000 pounds and over, works	do	.195
Bulk, tank, works	do	.17

[1] Delivered east of Mississippi River.

FOREIGN TRADE [7]

Imports of sodium sulfate were equal to 15 percent of the total U.S. output and 4 percent below the record high tonnage imported in 1961.

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

Belgium and Luxembourg supplied 51 percent of the total; Canada, 41 percent; and West Germany and the United Kingdom, the remainder.

Exports of sodium sulfate increased 59 percent compared with 1961 and were 4 percent of the total output. Mexico and Canada were the chief recipients.

Exports of sodium carbonate increased 15 percent compared with 1961. About 3 percent of the total sodium carbonate output was exported.

Tariff rates on various grades of sodium sulfate were as follows:

	Tariff rate per short ton	
	1958 rate	*Rate as of July 1962*
Sodium sulfate, crude	Free	Free
Glaubers salt	$1.00	$1.00
Anhydrous Na_2SO_4	1.27	0.90

The tariff on sodium carbonate, unchanged since 1930, was 0.25 cent per pound.

TABLE 3.—U.S. imports for consumption of sodium sulfate

(Thousand short tons and thousand dollars)

Year	Crude (salt cake)		Anhydrous		Total [1]	
	Quantity	Value	Quantity	Value	Quantity	Value
1953-57 (average)	92	$1,769	4	$118	96	$1,887
1958	95	1,905	2	62	97	1,967
1959	118	2,478	4	97	122	2,575
1960	164	3,411	3	62	167	3,473
1961	193	4,089	3	64	196	4,153
1962	181	3,646	7	122	188	3,768

[1] Includes glauber salt, as follows: 1958, 12 tons ($830); 1959, 227 tons ($4,839); 1960, 7 tons ($479); 1961–62, none.

Source: Bureau of the Census.

TABLE 4.—U.S. exports of sodium carbonate and sodium sulfate

(Thousand short tons and thousand dollars)

Year	Sodium carbonate		Sodium sulfate	
	Quantity	Value	Quantity	Value
1953-57 (average)	180	$6,156	26	$879
1958	104	4,279	20	786
1959	153	5,644	22	805
1960	155	5,143	31	940
1961	132	4,045	32	992
1962	152	4,693	51	1,486

Source: Bureau of the Census.

WORLD REVIEW

Soda ash production capacity continued to increase throughout the world. In the Western Hemisphere new plants were planned in Mexico, Argentina, and Colombia, and in other parts of the free world new plants or expansions of existing plants were planned in several countries including India, Israel, Republic of Korea, Pakistan, Spain, Turkey, and Republic of South Africa.

Russia was reported to have opened an automated soda ash plant at Beresniki in the western Urals; automation of the existing plant at Slaviansk in the Donets basin was also planned. East Germany, Poland, Rumania, and Bulgaria also were reported to be increasing their output.

Figures were published on the capacity of various countries to produce soda ash.[8]

TABLE 5.—World soda ash capacities in 1962

(Thousand short tons)

Country	Quantity	Country	Quantity
North America:		Soviet Bloc:	
Canada	286	Bulgaria	264
Mexico	39	China	882
United States	7,120	Czechoslovakia	99
		Germany, East	701
Total	7,445	Poland	601
		Rumania	276
South America:		U.S.S.R.	2,205
Brazil	143	Yugoslavia	101
Colombia	55		
		Total	5,129
Total	198		
		Asia:	
Europe:		India	276
Austria	176	Japan	573
Belgium	221	Taiwan	5
Denmark	8		
France	1,301	Total	854
Germany, West	1,268		
Italy	628	Oceania:	
Netherlands	187	Australia	176
Norway	22		
Portugal	35	Total	176
Spain	173		
Switzerland	44	Africa:	
United Kingdom	1,764	Kenya	165
Total	5,827	Total	165
		Grand total	19,794

Source: Oil, Paint and Drug Reporter.

TECHNOLOGY

Mining operations at the Big Island trona mine of Stauffer Chemical Co. near Green River, Wyo., were described.[9] Two circular, cement-lined shafts were completed to the lower of two minable trona beds. The service shaft was 830 feet deep and the ore shaft 930 feet below the surface.

The designed daily capacity of the mine, using conventional room-and-pillar mining, was 1,200 tons of ore, averaging 90-percent trona. Thirty-five percent of the ore was left behind in supporting pillars.

[8] Work cited in footnote 3.

[9] Bogert, J. R. "Production Begins at Stauffer's Big Island Trona Mine." Min. World, v. 25, No. 1, January 1963, pp. 12–15.

All equipment was operated electrically except for one diesel-powered shuttle car. The mining cycle was begun by cutting a narrow slot 10 feet deep at the top of the working face. After drilling the face and blasting with ammonium dynamite, the broken ore was loaded mechanically into rubber-tired shuttle cars and carried to the main-haulage conveyer belt. At the end of the conveyor, before being hauled to the surface, the ore passed through a 24- by 60-inch single-roll crusher which reduced the size of the lumps to minus 5 inches.

The back was supported by roof bolts 54 and 60 inches long placed on 4-foot centers. Mine openings were 9 to 10 feet high and 16 feet wide. Three to four feet of trona were left in the back for support, as the marlstone and shales surrounding the trona are unstable.

Proper ventilation and other precautions necessary in a gassy mine were required because of the presence of methane in the surrounding shales.

A descriptive monograph of the saline minerals of southwestern Wyoming was published.[10] Vast quantities of these salines have been found in Wyoming since they were first discovered in 1938 near Green River. Extensive physical and chemical measurements of six important carbonates—shortite, trona, northupite, prissonite, gaylussite, and bradleyite—were included. With many millions of tons of proved reserves lying at depths between 800 and 1,500 feet, the area had become the largest producer of natural sodium carbonate in the United States.

Absolute stress determinations in various types of rock including trona and salt were made by Bureau of Mines engineers.[11] Structural stability in mines or underground openings is dependent not only on the strength of the rock but also on the stress field in the rock in place and the effect on the field caused by creating an opening.

A borehole deformation gage was used to measure the stresses in both walls and pillars of a trona mine and a salt mine. These measurements were compared with the values obtained after relieving the stresses either by undercutting and overcutting or overcoring the test area. The accuracy of absolute stress measurements in trona, limestone, and tuff were considered adequate, whereas measurements in salt, a more plastic rock, were less accurate. In all tests the stress concentrations near the surface of openings were either absent or less than theoretical.

Manufacturers of caustic soda and chlorine by electrolysis of salt brine continued to compare the advantages and disadvantages of platinized titanium anodes in place of the commonly used graphite anodes. Higher production and lower power consumption possible with the new electrodes were offset somewhat by difficulties in maintaining the correct gap of about 2 millimeters between the electrodes. Ripples in the mercury cathode caused short circuits in the cells, burning out the anodes.[12]

Makers of graphite anodes improved their products by eliminating the lowest grade containing 150 parts per million of vanadium, a cell

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[10] Fahey, J. J. Saline Minerals of the Green River Formation. Geol. Survey Prof. Paper 405, 1962, 50 pp.

[11] Obert, L. A. "In Situ Determination of Stress in Rock." Min. Eng., v. 14, No. 8, August 1962, pp. 51–58.

[12] Chemical Week. "Platinized Anode Proves Puzzler." V. 91, No. 24, Dec. 15, 1962, pp. 49–50.

poison, and lowered the prices on premium grades containing 50 parts per million vanadium.[13]

Pilot plant-scale evaluation of a novel chlorine cell, known as a Szechtman cell, was undertaken by a Japanese firm. The new cell electrolyzes molten salt instead of brine as in conventional cells; molten lead takes the place of the mercury cathode, and sodium vapor is produced instead of caustic soda. Among the advantages claimed for the cell are greater flexibility in the type of products, lower production costs, less space requirements, and smaller capital investment.[14]

Improvements in the recovery of sodium values from the sulfite paper pulp industry were reported.[15] Northern pulp producers utilizing a higher percentage of hard woods require less acid digestion liquor than southern (pine) pulpwood producers. Calcium-base sulfite pulping produces satisfactory pulp from hardwoods, but the process causes water and air pollution with the production of various sulfides including hydrogen sulfide.

Magnesium, sodium, and ammonium bases, while more expensive, are more soluble than calcium and produce liquors of greater alkalinity. A suitable recovery system for the sodium would offset the increased cost of sodium, compared with calcium.

The key to the sodium-base pulping process under development was found to be the addition of feldspar to the spent-liquor combustion operation. At the temperatures of the combustion furnace, the feldspar and sodium compounds formed a sodium silicate-sodium aluminate complex, releasing sulfur compounds which were recovered from the effluent gases. At lower temperatures, in aqueous solution, sulfur dioxide was reacted with the complex, forming soluble sodium bisulfite for recycling to the process and insoluble silica and alumina, which were separated by filtration. By introducing feldspar minerals to the process, the formation of sulfides and their associated pollution problems was largely eliminated, and the sodium content of the feldspar also was utilized as part of the makeup.

A two-fluid heat-transfer system using metallic sodium as one of the fluids was designed by a leading firm in the field of nuclear energy. Applied to a conventionally fired steam powerplant, the system would make possible a 20-percent reduction in capital costs of the plant.

In the proposed system, molten sodium leaves the gas-fired furnace at 1,120° F and enters a heat exchanger where steam at 1,050° F and 3,500 pounds per square inch is generated. Safety devices to minimize the possibility of contact between sodium and water included

[13] Chemical Week. "Graphite Anode Boost." V. 92, No. 2, Jan. 12, 1963, pp. 67, 69.
[14] Chemical Engineering. "Unique Electrolytic Cell Cuts Chlorine Costs." V. 69, No. 6, Mar. 19, 1962, pp. 90–94.
[15] Chemical Week. Sodium Recovery Frees Soluble Pulping From High Cost Shackles. V. 91, No. 9, Sept. 1, 1962, pp. 44–47.

hydrogen analyzers capable of detecting one part per million of hydrogen inside the system.[16]

Progress was noted in the development of a liquid-sodium-cooled, graphite-moderated, nuclear-power reactor. Results of tests on an experimental model indicated that the production of superheated steam for the efficient generation of electrical power was feasible and that future tests should be made at a higher level of power production.[17]

Direct conversion of thermal to electrical energy was accomplished in an experimental cell utilizing molten sodium as the anode and molten tin as the cathode. A eutectic mixture of sodium iodide and sodium chloride was a satisfactory electrolyte, and aluminum oxide met requirements as a structural material. Test results indicated 95-percent current efficiency, with a current density of 0.7 amperes per square centimeter under continuous, balanced charge-and-discharge operation.[18]

A patent was issued for an improved method of crystallizing sodium carbonate from solution and calcining the product to produce a high bulk-density soda ash.[19]

A method was patented for crystallizing sodium bicarbonate or sodium sesquicarbonate crystals that increased their size and improved their settling rate from trona solutions by the addition of alkyl benzene sulfonate or certain related surface-active compounds to the pregnant liquor.[20]

The use of sodium carbonate and bentonite to mix with iron oxide to produce a hardened pellet was patented. One pound of sodium carbonate and about 4 pounds of bentonite per ton of iron ore produced an agglomerate suitable for use in a blast furnace.[21]

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[16] Chemical Engineering. "Proposal for New Gas-Fired Power Station Heartens Sodium Producers." V. 69, No. 9, Apr. 30, 1962, pp. 51, 54.

[17] Journal of Metals. "Power Reactor Progress." V. 14, No. 17, July 1962, p. 470.

[18] Weaver, R. D., S. W. Smith, and N. L. Willmann. "The Sodium Tin Liquid-Metal Cell." J. Electrochem. Soc., v. 109, No. 8, August 1962, pp. 653–657.

[19] Frint, W. R. (assigned to FMC Corp.). "Preparation of Sodium Carbonate." U.S. Pat. 3,028,215, Apr. 3, 1962.

[20] Frint, W. R., and W. C. Bauer (assigned to FMC Corp.). "Method of Crystallizing a Sodium Carbonate." U.S. Pat. 3,037,849, June 5, 1962.

[21] Larpenteur, B. J. (assigned to Bethlehem Steel Co. of Pennsylvania). "Agglomeration of Iron Ores." U.S. Pat. 3,053,647, Sept. 11, 1962.

Stone

By Perry G. Cotter [1] and Nan C. Jensen [2]

Contents

AS A RESULT of the great expansion in roadbuilding and other types of construction, the combined output of dimension and crushed and broken stone reached a record high and, for the first time, the value exceeded $1 billion. The outstanding feature of the year was that production of every variety of stone increased both in tonnage and value over 1961.

TABLE 1.—Salient stone statistics in the United States [1]

(Thousand short tons and thousand dollars)

	1953-57 (average)	1958	1959	1960	1961	1962
Sold or used by producers:						
Dimension stone	2,481	2,522	2,442	2,257	2,315	2,729
Value	$77,836	$80,254	$87,571	$86,009	$88,093	$90,687
Crushed stone	448,883	533,401	581,721	614,527	[2] 609,623	654,225
Value	$618,005	$746,431	$824,411	$866,546	[2] $859,266	$935,010
Total stone	451,364	535,923	584,163	616,784	[2] 611,938	656,954
Value	$695,841	$826,685	$911,982	$952,555	[2] $947,359	$1,025,697
Imports for consumption (value) [3]	$6,607	$8,312	$11,064	$11,344	$12,268	$17,204
Exports (value)	$5,231	$6,756	$7,292	$6,166	$6,648	$6,009

[1] Includes slate. 1953-56 includes Territories of the United States, possessions, and other areas administered by the United States.
[2] Revised figure.
[3] Includes whiting.

[1] Commodity specialist, Division of Minerals.
[2] Supervisory statistical assistant, Division of Minerals.

TABLE 2.—Stone sold or used by producers in the United States, by States

(Thousand short tons and thousand dollars)

State	1961		1962	
	Quantity	Value	Quantity	Value
Alabama	[1] 13,651	[1] $19,909	[1] 12,680	[1] $19,667
Alaska	(2)	(2)	(2)	(2)
Arizona	3,582	4,626	4,333	6,616
Arkansas	12,029	12,402	20,611	19,866
California	33,850	50,327	34,776	54,722
Colorado	2,451	5,301	2,353	5,597
Connecticut	5,206	8,616	5,090	8,816
Delaware	(2)	(2)	(2)	(2)
Florida	[1] [3] 26,221	[1] [3] 33,671	27,279	32,608
Georgia	15,854	38,077	19,555	42,037
Hawaii	4,429	7,656	4,071	6,883
Idaho	1,873	3,111	1,381	2,698
Illinois	36,361	47,939	41,293	54,411
Indiana	18,001	33,062	18,709	34,653
Iowa	22,018	28,916	21,618	28,244
Kansas	[1] 12,328	[1] 16,411	[1] 13,527	[1] 17,274
Kentucky	17,085	23,309	19,472	27,682
Louisiana	[1] 4,641	[1] 7,656	[1] 5,711	[1] 8,067
Maine	998	4,694	1,127	4,249
Maryland	[3] 10,007	[3] 20,373	11,610	22,595
Massachusetts	5,210	13,399	4,985	12,541
Michigan	28,731	30,103	28,440	29,055
Minnesota	3,957	9,975	3,803	10,360
Mississippi	913	1,044	1,199	1,266
Missouri	25,631	36,577	28,876	44,006
Montana	1,512	1,849	996	1,708
Nebraska	3,622	6,324	3,670	6,626
Nevada	677	1,576	722	1,220
New Hampshire	117	684	154	1,368
New Jersey	11,315	24,539	14,214	28,979
New Mexico	1,853	2,206	2,004	2,782
New York	26,951	43,734	27,589	47,256
North Carolina	15,921	25,262	19,308	29,533
North Dakota	40	40	19	19
Ohio	33,652	55,701	34,470	57,202
Oklahoma	14,981	16,561	14,666	18,819
Oregon	[3] 17,455	[3] 21,202	18,258	20,977
Pennsylvania	41,834	71,344	48,144	82,087
Rhode Island	(2)	(2)	[1] 304	[1] 483
South Carolina	6,752	9,827	6,382	10,066
South Dakota	2,806	6,642	2,852	6,533
Tennessee	23,940	35,906	24,398	35,614
Texas	38,316	45,874	38,067	48,988
Utah	1,808	3,219	2,118	3,865
Vermont	2,731	18,715	1,715	19,815
Virginia	22,934	39,206	25,766	43,121
Washington	11,464	14,758	12,749	18,180
West Virginia	7,628	13,244	[1] 7,506	[1] 13,242
Wisconsin	13,418	19,686	13,392	19,709
Wyoming	2,594	3,315	1,755	3,054
Undistributed	[3] 2,590	8,791	3,237	10,538
Total	[3] 611,938	[3] 947,359	656,954	1,025,697
American Samoa	362	286	1,103	1,788
Canton Island	----------	----------	(4)	(4)
Guam	292	591	82	123
Johnston Island	1	2	----------	----------
Midway Island	11	34	----------	----------
Panama Canal Zone	163	271	207	359
Puerto Rico	5,049	7,284	5,589	8,551
Virgin Islands	20	75	21	82
Wake Island	24	62	5	41

[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] Figures withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[3] Revised figure.
[4] Less than 500 short tons and $500.

TABLE 3.—Stone sold or used by producers in the United States, by kinds

(Thousand short tons and thousand dollars)

Year	Granite		Basalt and related rocks (traprock)		Marble		Limestone and dolomite		Shell	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1953-57 (average)	28,858	$62,675	35,721	$57,621	891	$17,571	333,434	$456,029	[1] 16,610	[1] $23,470
1958	31,958	69,491	44,605	69,496	1,405	27,656	391,447	535,522	18,916	31,876
1959	37,571	78,416	51,779	80,454	1,895	32,269	433,955	600,497	20,180	34,810
1960	42,748	89,654	57,884	87,699	1,644	31,060	451,253	623,437	18,934	33,706
1961	44,058	[2] 93,870	[2] 62,776	[2] 95,576	1,592	30,960	438,253	608,139	[2] 18,004	[2] 30,375
1962	50,058	102,898	69,768	108,264	1,769	33,117	461,849	649,647	20,054	31,241

Year	Calcareous marl		Sandstone		Slate		Other stone [3]		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1953-57 (average)	[4] 1,916	[4] $1,804	12,725	$39,542	699	$12,242	20,510	$24,887	451,364	$695,841
1958	1,803	1,660	24,973	53,677	638	11,459	20,178	25,848	535,923	826,685
1959	2,043	1,926	17,553	46,467	656	11,288	18,531	25,855	584,163	911,982
1960	1,283	1,353	21,013	48,771	532	9,233	21,493	27,642	616,784	952,555
1961	1,099	987	23,386	49,114	496	9,334	22,274	29,004	[2] 611,938	[2] 947,359
1962	1,182	1,011	26,077	51,119	544	10,100	25,653	38,300	656,954	1,025,697

[1] Average for 1954-57 only.
[2] Revised figure.
[3] Includes mica schist, conglomerate, argillite, various light-colored volcanic rocks, serpentine not used as marble, soapstone sold as dimension stone, etc.
[4] 1957 only.

LEGISLATION AND GOVERNMENT PROGRAMS

The Federal Highway Administrator reported that 12,550 miles of the National System of Interstate and Defense Highways was in use by passenger and commercial vehicles on June 30. Of this mileage, 7,225 miles was completed to standards estimated to be adequate for 1,975 traffic burdens, and 3,024 miles was improved sufficiently to handle present traffic. Work was underway or completed on 71 percent of the program.[3]

The 1963 Federal appropriation for the Interstate System of Highways was $2.6 billion; the appropriation for Primary and Secondary Roads (ABC System) was $950 million.[4]

The Court of Appeals for the Eighth Circuit, on June 27, ruled that all size reduction processes necessary to obtain a marketable stone product were allowable in computing a depletion deduction. The court further indicated that all crushing or grinding operations that did not change the physical and chemical identity of the mineral were allowable.[5]

[3] American Roadbuilder. 12,550 Miles of Interstate. V. 39, No .9, September 1962, p. 27.
[4] The Constructor. V. 44, No. 12, December 1962, p. 40.
[5] Pit and Quarry. Court Decisions on Percentage Depletion. V. 55, No. 9, March 1962, pp 128-129.

DIMENSION STONE

Production of 2,729,000 short tons of dimension stone valued at $91 million represented an increase of 18 percent in tonnage and 3 percent in value over 1961.

Trends in Use.—Dimension stone producers faced intensified competition from an ever-increasing number of materials. In addition to the older alternates such as aluminum, stainless steel, and ceramics, newer materials such as rigid vinyl panels in many colors, cast stone in natural appearing color and texture, patterned glass, glare-reducing and heat-absorbing glass, vinyl-asbestos tile, and laminated wood panels were contesting for the market. The reaction of architects against bare concrete as a finished surface was being overcome by the ingenuity of concrete workers in developing techniques to impart attractive textures and finishes to poured concrete. In some areas, use of lightweight concrete for construction was increasing because reserves of orthodox aggregates were diminishing.

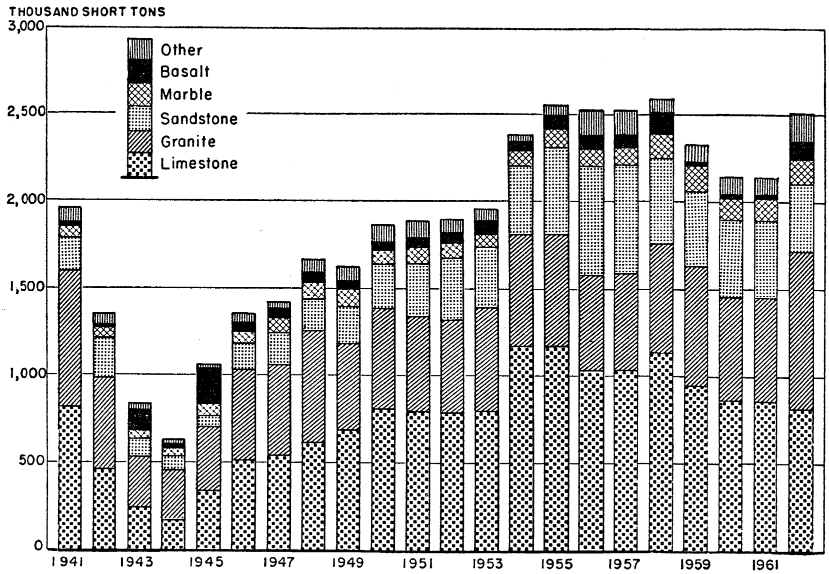

FIGURE 1.—Sales of dimension stone, except slate, in the United States, by kinds, 1941–62.

TABLE 4.—Dimension stone sold or used by producers in the United States, by uses

Use	1961			1962		
	Thousand short tons	Thousand cubic feet	Value (thousands)	Thousand short tons	Thousand cubic feet	Value (thousands)
Building:						
Rough:						
Construction	197	-----------	[1] $2,115	295	-----------	$2,056
Architectural [2]	353	4,692	6,722	300	3,973	6,380
Dressed:						
Sawed [3]	489	6,355	19,242	515	6,660	18,136
Cut	201	2,514	26,688	210	2,636	28,561
Rubble	424	-----------	2,143	537	-----------	2,022
Roofing (slate)	31	-----------	1,796	30	-----------	1,767
Millstock (slate)	26	-----------	3,202	30	-----------	3,529
Monumental (rough and dressed)[3]	226	2,745	18,770	227	2,744	19,246
Paving blocks [4]	76	-----------	295	264	-----------	937
Curbing	149	[1] 1,804	[1] 3,859	155	1,877	4,236
Flagging [5]	143	[1] 942	[1] 3,261	166	938	3,817
Total	2,315	-----------	88,093	2,729	-----------	90,687

[1] Revised figure.
[2] Includes stone for refractory use to avoid disclosing individual company confidential data.
[3] Includes stone for precision surface plates.
[4] Includes a substantial quantity of blocks for other uses.
[5] Includes a small quantity of slate for miscellaneous uses.

GRANITE

Production of dimension granite increased 36 percent in tonnage and 5 percent in value compared with 1961. Much of the increase was due to greater production of rubble, paving, and other blocks. Durax blocks, in combination with sized river pebbles, were used in landscaping. Dressed architectural granite increased in price $1.26 per cubic foot. Eight more producers were active than in 1961. Vermont, as in other years, led in value of monumental stone produced, although Georgia was first in tonnage.

TABLE 5.—Granite (dimension stone) sold or used by producers in the United States, by uses

Use	1961			1962		
	Thousand short tons	Thousand cubic feet	Value (thousands)	Thousand short tons	Thousand cubic feet	Value (thousands)
Building:						
Rough:						
Construction	41	-----------	$541	31	-----------	$396
Architectural	23	271	867	24	292	1,176
Dressed:						
Construction	23	279	1,952	20	250	1,728
Architectural	43	518	7,015	42	504	7,459
Rubble	102	-----------	438	165	-----------	463
Monumental: [1]						
Rough	164	1,989	7,876	157	1,904	8,256
Dressed	48	578	8,036	52	625	7,706
Paving blocks [2]	76	-----------	295	264	-----------	937
Curbing and flagging	142	[3] 1,711	[3] 3,549	147	1,773	3,891
Total	662	-----------	[3] 30,569	902	-----------	32,012

[1] Includes stone for precision plates.
[2] Includes substantial quantity of blocks for other uses.
[3] Revised figure.

TABLE 6.—Granite (dimension stone) sold or used by producers in the United States in 1962, by States

State	Active plants	Short tons	Value	State	Active plants	Short tons	Value
California	9	41,859	$1,080,251	New York	3	16,651	$259,535
Colorado	4	1,174	118,207	Oklahoma	9	9,424	1,028,391
Connecticut	6	5,280	181,718	South Carolina	5	7,750	340,446
Georgia	31	174,349	4,568,223	South Dakota	7	15,457	2,422,181
Maine	7	24,856	2,111,399	Washington	1	60	1,200
Maryland	1	750	6,500	Other States [1]	41	427,185	12,435,746
Massachusetts	12	103,839	3,595,090				
Minnesota	20	25,252	3,504,308	Total	158	901,832	32,012,008
Missouri	1	2,716	282,757	Puerto Rico		19,100	6,200
Nevada	1	45,230	76,056				

[1] Includes New Hampshire, 2 plants; North Carolina, 8; Pennsylvania, 4; Rhode Island, 1; Texas, 5; Vermont, 10; and Wisconsin, 11.

BASALT AND RELATED ROCKS (TRAPROCK)

Reported production of basaltic rock was 103,000 tons valued at $649,000. Included was 84,000 tons of rough construction stone valued at $90,000 produced by the Butte County, Calif., Highway Department. California, Oregon, and Washington produced 84 percent of the total tonnage of dimension basalt. While California led in tonnage, Pennsylvania led in value because dressed building and monumental stone and precision surface plates were produced in addition to rough building stone.

MARBLE

The reported value of dimension marble was slightly higher than in 1961, but output declined 7 percent. The average value of cut and dressed structural marble was $19.37 per cubic foot, an increase of $0.56 per cubic foot from 1961. The value of rough architectural marble increased $0.78 per cubic foot.

The recent development of precast concrete structural panels faced with thin strips or squares of marble was expected to lower cost of

TABLE 7.—Marble (dimension stone) sold or used by producers in the United States,[1] by uses

Use	1961			1962		
	Thousand short tons	Thousand cubic feet	Value (thousands)	Thousand short tons	Thousand cubic feet	Value (thousands)
Building: [2]						
Rough: Architectural	37	433	$1,168	34	382	$1,330
Dressed:						
Sawed	54	631	3,123	42	489	2,185
Cut	52	614	11,547	53	624	12,084
Monumental (rough and finished)	14	169	2,728	17	205	3,140
Total	157		18,566	146		18,739

[1] Produced by the following States in 1962 in order of value and with number of plants: Vermont, 7; Georgia, 1; Tennessee, 13; Missouri, 4; Alabama, 2; North Carolina, 1; Arkansas, 2; Montana, 2; Colorado, 2; Washington, 3; Maryland, 1; New Mexico, 1; Arizona, 2; and California, 1.

[2] Includes: 1961—1,190,000 cu ft, $8,934,000 for exterior use, and 488,000 cu ft, $6,904,000, for interior use; 1962—1,009,000 cu ft, $9,575,000 for exterior use, and 486,000 cu ft, $6,024,000, for interior use.

installation and make marble more competitive with substitute materials.

LIMESTONE

The term "dimension limestone" is applied to calcareous or dolomitic limestone that is cut, split, sawed, or otherwise shaped. Production increased 5 percent during 1962, although the total value remained about the same. The average value was $18.80 per ton compared with $19.58 per ton in 1961. Eight fewer plants were in production. Split-face limestone was used for facing smaller buildings; larger blocks and veneers were used in more massive buildings. Limestone house veneer totaled 1,766,000 cubic feet valued at $3,307,000 in 1962, a 3-percent drop. Buff and gray limestone produced in the Bedford-Bloomington, Ind., district accounted for 78 percent of the rough-block and dressed limestone in the United States.

TABLE 8.—Limestone (dimension stone) sold or used by producers in the United States, by uses

Use	1961			1962		
	Thousand short tons	Thousand cubic feet	Value (thousands)	Thousand short tons	Thousand cubic feet	Value (thousands)
Building:						
Rough:						
Construction	61		$323	82		$326
Architectural	223	3,057	3,455	197	2,708	3,000
Dressed:						
Sawed [1]	259	3,475	6,791	246	3,311	6,628
Cut	71	941	5,275	72	962	5,848
Rubble	219		725	284		928
Curbing and flagging	22	285	169	15	194	117
Total	855		16,738	896		16,847

[1] Includes house stone veneer.

TABLE 9.—Limestone (dimension stone) sold or used by producers in the United States in 1962, by States

State	Active plants	Short tons	Value	State	Active plants	Short tons	Value
Arizona	1	200	$5,600	Ohio	4	6,415	$21,305
California	4	1,942	17,755	Oklahoma	3	2,426	17,706
Illinois	5	17,763	167,384	Texas	6	24,909	793,175
Indiana	19	567,871	11,253,075	Washington	1	443	2,436
Iowa	3	8,525	139,061	Wisconsin	24	69,731	1,396,188
Kansas	6	9,642	130,805	Other States [1]	7	126,014	755,937
Michigan	4	7,798	51,603				
Minnesota	6	27,489	2,023,176	Total	100	895,570	16,846,419
Missouri	6	23,202	69,233	Puerto Rico		60,787	130,211
Nebraska	1	1,200	1,980				

[1] Includes Alabama, 1 plant; New York, 1; Oregon, 1; Pennsylvania, 1; Rhode Island, 1; South Dakota, 1; and Utah, 1.

TABLE 10.—Limestone sold by producers in the Indiana oolitic limestone district, by classes

Year	Construction					
	Rough blocks		Sawed and semifinished		Cut	
	Thousand cubic feet	Value (thousands)	Thousand cubic feet	Value (thousands)	Thousand cubic feet	Value (thousands)
1953–57 (average)	2,763	$3.141	3.553	$6.128	928	$5.265
1958	2,941	2.967	3,007	5.104	725	4.273
1959	2,719	2.731	3,380	6,037	951	5,443
1960	2,817	2,934	2.846	5,340	528	3,005
1961	2,820	3,159	2,498	4,675	497	2.784
1962	2,467	2,695	2,427	4,674	560	3,251

Year	Construction—Continued			Other uses		Total	
	Total						
	Thousand cubic feet	Thousand short tons	Value (thousands)	Thousand short tons	Value (thousands)	Thousand short tons	Value (thousands)
1953–57 (average)	7,244	525	$14.534	163	$422	688	$14.956
1958	6.673	484	12,344	168	449	652	12,793
1959	7,050	511	14,211	155	432	666	14,643
1960	6,191	449	11,279	139	413	588	11.692
1961	5,815	422	10,618	161	515	583	11.133
1962	5,454	395	10,620	191	659	586	11,279

SANDSTONE

The volume of dimension sandstone declined slightly and total value was 2 percent lower than in 1961. Dimension sandstone rep-

TABLE 11.—Sandstone (dimension stone) sold or used by producers in the United States, by uses

Use	1961			1962		
	Thousand short tons	Thousand cubic feet	Value (thousands)	Thousand short tons	Thousand cubic feet	Value (thousands)
Building:						
Rough:						
Construction	83		$1,173	82		$1,159
Architectural [1]	70	931	1,232	45	591	872
Dressed:						
Sawed [1]	106	1,417	4,226	105	1,410	3,918
Cut	34	431	2,597	42	534	2,852
Rubble	41		368	55		342
Curbing	7	93	310	8	104	345
Flagging	50	607	1,228	53	661	1,416
Total	391		11,134	390		10,904

[1] Includes stone for refractory use to avoid disclosing individual company confidential data.

resented only 14 percent of the total production of dimension stone. Ohio, Pennsylvania, New York, and Tennessee produced 68 percent of total tonnage and accounted for 81 percent of the value.

TABLE 12.—Sandstone (dimension stone) sold or used by producers in the United States in 1962, by States

State	Active plants	Short tons	Value	State	Active plants	Short tons	Value
Alabama	1	650	$3,687	New Mexico	1	25	$77
Arizona	15	9,031	90,184	New York	13	48,528	1,494,313
Arkansas	8	13,724	152,674	Ohio	18	103,011	5,518,126
California	7	1,126	16,828	Pennsylvania	29	75,161	744,834
Colorado	26	18,926	266,463	Tennessee	10	37,988	1,086,535
Georgia	3	2,610	57,154	Utah	6	4,462	161,282
Kansas	1	654	10,157	Virginia	4	1,191	12,159
Kentucky	3	1,603	26,452	Washington	6	4,236	214,664
Massachusetts	1	280	28,000	Wisconsin	7	3,541	37,449
Michigan	4	15,223	65,406	Other States [1]	16	42,413	791,714
Missouri	2	2,943	38,144				
Nevada	6	2,757	87,945	Total	187	390,083	10,904,247

[1] Includes Indiana, 8 plants; Maryland, 1; Mississippi, 1; Texas, 1; West Virginia, 2; and Wyoming, 3.

SLATE

Production of dimension slate increased 22 percent in tonnage and 10 percent in value. Pennsylvania, Vermont, and Virginia produced 89 percent of the total. The price for roofing slate increased slightly.

Exports of various types of structural slate increased over $7 million.

Results of research on slate problems were reported by The Pennsylvania State University, College of Mineral Industries. The general aspects of investment and cost analysis were discussed, as were the problems of waste slate utilization, the use of carborundum polishing machines, and the results of tests made on tungsten-carbide planer blades.[6]

Coniston Green River slate was used for cladding on the 600-foot high Canadian Imperial Bank of Commerce in Montreal. Polished slate was used in the lobbies for panels and floors.

[6] Pennsylvania State University, Minerals Industry Experiment Station. Progress Report, Slate Research. Jan. 1-Dec. 31, 1962, 8 pp.

TABLE 13.—Slate (dimension stone) sold or used by producers in the United States,[1] by uses

Use	1961			1962		
	Quantity		Value (thousands)	Quantity		Value (thousands)
	Thousand short tons	Unit of measurement		Thousand short tons	Unit of measurement	
		Thousand squares			*Thousand squares*	
Roofing slate	31	81	$1,796	30	79	$1,767
		Thousand sq. ft.			*Thousand sq. ft.*	
Millstock:						
Electrical, structural, and sanitary slate	22	2,313	2,141	25	2,657	2,423
Blackboards and bulletin boards [2]	3	1,272	912	3	1,066	902
Billiard tabletops	1	175	149	2	222	204
Total	26	3,760	3,202	30	3,945	3,529
Flagstones [3]	57	11,879	1,465	61	11,900	1,522
Miscellaneous uses [4]	10		286	30		623
Grand total	124		6,749	151		7,441

[1] Produced by the following States in 1962 in order of value of output and with number of plants: Pennsylvania, 10; Vermont, 23; Virginia, 2; New York, 9; Maine, 1; North Carolina, 2; California, 1; and Arizona, 1.
[2] Includes a small quantity of school slates.
[3] Includes slate used for walkways and stepping stones.
[4] Includes slate for aquarium bottoms, buildings, fireplaces, flooring, headstones, shims, and unspecified uses.

MISCELLANEOUS STONE

Miscellaneous types of stones such as soapstone, coquina, coral reef limestone, obsidian, mica schists, and volcanic tuffs were quarried for local building or other specialized uses. Production increased 25 percent, and value increased 6 percent.

TABLE 14.—Miscellaneous varieties of dimension stone sold or used by producers in the United States,[1] by uses

Use	1961			1962		
	Thousand short tons	Thousand cubic feet	Value (thousands)	Thousand short tons	Thousand cubic feet	Value (thousands)
Building:						
Sawed [2]	47	553	$3,150	102	1,200	$3,677
Rubble	62		611	32		280
Flagging	4	47	111	7	82	138
Total	113		3,872	141		4,095

[1] Produced by the following States in 1962 in order of value of output and with number of plants: Virginia, 2 plants; California, 34; Pennsylvania, 4; Maryland, 1; New Mexico, 2; Hawaii, 3; New Jersey, 1; Connecticut, 1; Oregon, 4; Utah, 1; Washington, 1; Montana, 1; and Colorado, 1.
[2] Includes rough and cut stone and stone for refractory use to avoid disclosing individual company confidential data.

FOREIGN TRADE

Italy supplied most of the imported marble and breccia blocks and slabs, travertine, and slate. Canada, Sweden, and Norway, in that order, were the chief suppliers of unmanufactured granite. Imports of Mexican onyx amounted to 5,000 cubic feet, valued at $29,428. Figures on imports and exports of various types of stone are given under "Foreign Trade" in the "Crushed Stone" section of this chapter.

WORLD REVIEW

Italy.—Production and local consumption of cut marble increased about 40 percent in 1961 because of the Italian construction boom.[7]

Malaya.—After many years of abandonment, marble quarries on the island of Langkawi, northwest of Malaya, were reopened. The white crystalline marble was said to be equal to any of the European marbles.[8]

Pakistan.—Machinery for the first marble-processing plant in Pakistan was purchased from Italy. The plant was to produce marble slabs, mosaic tiles, and marble chips.[9]

West Indies.—Marble deposits estimated to contain 1 million tons were discovered in the Blue Mountain area of Jamaica.[10]

TECHNOLOGY

An article reported the current techniques used in the wire cutting of various types of stone.[11]

Installation of diamond-faced frame saws increased production nearly 10 times for a marble-cutting firm in Brescia, Italy. The frames carried as many as 40 blades, each approximately 9 feet long.[12]

Coal cutters were converted to stone-cutting machines at the Monks Park dimension limestone quarry, Corsham, England. The Monks Park stone is fine-grained, fairly compact, and of medium hardness. The cutter chains were fitted with 0.5 percent carbon steel picks, and the jibs were mounted on universal heads so that cutting might be done at any oblique angle.[13]

A method was developed that used the principle of specific-volume permeability to determine rapidly and precisely the permeabilities of various porous rock such as sandstone.[14]

A description was given of quarrying practices and methods used in processing Tennessee "Crab Orchard Stone." [15]

Although black granite has been used for many years for high-precision surface plates in machine shops, new developments have shown its value to the aerospace industry when used for optical rails. Among other advantages reported were stability, which allows test reproducibility, and freedom from oxidation.[16]

The various factors that must be considered in developing specifications for natural building stone were outlined in detail. The

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[7] U.S. Embassy, Rome, Italy. State Department Dispatch 941, June 6, 1962, p. 6.
[8] Mining Journal (London). Malayan Marble. V. 259, No. 6623, July 27, 1962, p. 77.
[9] International Commerce. Business Bulletins from Around the World—Pakistan. V. 68, No. 28, Dec. 24, 1962, Inside Front Cover.
[10] Skillings' Mining Review. Marble Deposits in Jamaica, W.I. V. 51, No. 6, Feb. 10, 1962, p. 21.
[11] Fox, Ralph C. It's Done with Wires. Grits and Grinds, v. 53, No. 8, December 1962, pp. 3–6.
[12] Quarry Managers' Journal (London). Italian Marble Industry Increases Production with Diamond Saws. V. 46, No. 11, November 1962, p. 489.
[13] Quarry Managers' Journal (London). Building Stone from Underground. V. 46, No. 5, May 1962, pp. 175–184.
[14] Champlin, Jerry B. Rapid Determination of Permeability in Porous Rock. BuMines Rept. of Inv. 6098, 1962, 9 pp.
[15] Riley, Harold L., and H. J. Schroeder. Methods for Producing Dimension Stone, Crab Orchard Stone Co., Inc., Cumberland County, Tenn. BuMines Inf. Circ. 8135, 1962, 18 pp.
[16] van Osten, Richard. Black Granite May Fulfill Need for Lab Standard. Missiles and Rockets, v. 11, No. 21, Nov. 19, 1962, p. 36.

report discussed the different conceptions of durability held by architects, engineers, and users, the factors affecting durability, and the laboratory methods used to determine suitability of different types of stone for structural and ornamental use. It was suggested that a combination of physical tests and petrographic examination might be of value in predicting durability.[17]

CRUSHED AND BROKEN STONE

The production of 654 million tons of crushed and broken stone valued at $935 million represented an increase of 7 percent in tonnage and 9 percent in value over 1961. The average value was $1.43 per ton. The total value of new construction put-in-place was $61 billion, an increase of 6 percent over 1961 and a new record high. The value of new highways put-in-place was $6.3 billion, also a new record, as was the $18.3 billion expended for new private nonfarm housing units. Starts for new housing units, both public and private, in metropolitan areas were up 10 percent.[18]

TABLE 15.—Crushed and broken stone sold or used by producers in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1961		1962	
	Quantity	Value	Quantity	Value
Agriculture	[1] 22,444	[1] $38,857	23,269	$39,652
Cement	[1] 85,314	91,942	89,651	99,655
Concrete and roadstone	[1] 387,107	[1] 523,398	414,970	568,267
Fill	4,325	4,263	5,576	6,752
Filtration	189	362	133	329
Flux	27,623	41,220	26,512	38,562
Glass	1,599	5,007	1,646	5,461
Lime and dead-burned dolomite	19,544	30,065	20,797	34,835
Mineral food	698	3,737	697	3,873
Poultry grit	893	7,458	946	7,754
Railroad ballast	[1] 9,617	[1] 11,230	11,042	13,310
Refractory	[1] 697	[1] 5,081	711	5,692
Riprap	27,084	33,694	36,415	41,835
Roofing granules, aggregates, and chips	2,114	9,585	2,704	12,169
Stone sand	3,527	4,130	2,991	4,111
Terrazzo	407	4,667	380	4,869
Other uses [2] and unspecified	[1] 16,441	[1] 44,570	15,785	47,884
Total	[1] 609,623	[1] 859,266	654,225	935,010

[1] Revised figure.
[2] Includes some uses listed separately in the Limestone and Sandstone sections.

[17] Currier, Louis W., Problems in Specifications for Natural Building Stones. Materials Research & Standards, V. 2, No. 4, April 1962, pp. 292–294.
[18] Survey of Current Business, Construction, and Real Estate. V. 43, No. 3, March 1963, p. S-9.

TABLE 16.—Crushed stone sold or used by Government-and-contractor producers in the United States, by uses [1]

(Thousand short tons and thousand dollars)

Use	1961		1962	
	Quantity	Value	Quantity	Value
Concrete and roadstone	45,832	$52,465	40,832	$51,496
Riprap	13,092	15,275	20,506	21,462
Agricultural (limestone)	227	317	300	446
Other uses	4,979	5,007	4,208	5,786
Total	64,130	73,064	65,846	79,190

[1] Figures 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.

Trends in Use.—All of the types of rock used as dimension stone were also used for making crushed stone. The production of crushed and broken stone for construction was likely to be affected by the expanding use of lightweight aggregates, not only for blocks but for monolithic structures. Use of aggregate for concrete cast-in-situ may diminish as industrialization of the building industry and the use of precast panels and other structural sections increases. Increased efficiencies in blast-furnace operation would lessen demand for fluxstone, but declining production of blast-furnace slag may give local impetus to increased production of alternate aggregates.

Of the stone used for concrete and roadstone, 67 percent was limestone, 13 percent basalt, 10 percent granite, 3 percent sandstone, 3 percent shell, and 4 percent miscellaneous stone.

Prices.—The average price per ton for crushed and broken stone increased slightly, but technological advances enabled producers to keep prices low.

Size of Plants.—Most large-capacity plants were installed permanently near areas of high consumption, but smaller portable plants were generally restricted to the temporary production of crushed stone near points of consumption.

A total of 2,979 commercial crushed stone plants operated in 1962. The 92 plants that produced over 900,000 tons each, accounted for 26 percent of the total production. Forty percent of the plants produced less than 50,000 tons and contributed only 3 percent of the total.

Transportation.—The relative amounts of crushed stone moved by various means of transportation remained essentially the same as in 1961.

TABLE 17.—Crushed stone for concrete and roadstone sold or used by producers in the United States, by States

(Thousand short tons and thousand dollars)

State	1961		1962	
	Quantity	Value	Quantity	Value
Alabama	[1] 7,030	$8,859	6,626	$8,092
Alaska	(2)	(2)	(2)	(2)
Arizona	1,422	1,447	1,971	3,042
Arkansas	5,997	5,839	6,699	7,003
California	11,483	14,442	13,061	16,487
Colorado	273	571	302	774
Connecticut	4,830	7,153	4,711	7,137
Delaware	(2)	(2)	(2)	(2)
Florida	[1] 22,279	[1] 28,171	23,393	26,704
Georgia	[3] 10,897	[3] 15,931	[3] 14,176	[3] 19,684
Hawaii	3,995	7,029	3,735	6,440
Idaho	1,503	2,058	986	1,551
Illinois	27,237	36,169	32,747	43,398
Indiana	12,746	16,040	13,416	17,365
Iowa	16,996	22,215	16,618	21,321
Kansas	8,626	11,818	9,575	12,639
Kentucky	13,579	18,678	15,810	22,763
Louisiana	[3] 3,358	[3] 6,034	[3] 4,126	[3] 6,065
Maine	304	669	351	808
Maryland	[1] 7,629	[1] 12,537	8,901	14,729
Massachusetts	3,859	6,144	3,689	5,931
Michigan	4,675	5,365	3,802	4,682
Minnesota	3,168	3,861	2,877	3,354
Mississippi	(2)	(2)	(2)	(2)
Missouri	[3] 14,217	[3] 19,653	17,134	23,321
Montana	602	547	(2)	(2)
Nebraska	1,575	2,882	1,758	3,078
Nevada	22	19	56	37
New Hampshire	(2)	(2)	(2)	(2)
New Jersey	8,931	18,582	9,485	19,276
New Mexico	1,266	1,488	1,379	1,874
New York	18,780	30,392	18,183	32,976
North Carolina	15,515	22,542	18,954	27,091
North Dakota	40	40	(2)	(2)
Ohio	[1] 16,701	[1] 21,681	[3] 17,991	[3] 23,694
Oklahoma	11,055	11,828	10,108	11,257
Oregon	[1] 11,183	[1] 14,232	9,403	12,246
Pennsylvania	21,343	31,563	26,471	39,185
Rhode Island	(2)	(2)	287	466
South Carolina	[3] 4,768	[3] 6,896	[3] 4,274	[3] 6,432
South Dakota	[3] 1,674	[3] 2,306	1,693	2,477
Tennessee	19,125	23,891	19,344	24,169
Texas	25,224	27,516	24,472	28,084
Utah	31	17	128	127
Vermont	2,249	3,129	1,224	1,672
Virginia	15,894	23,284	17,834	26,125
Washington	6,743	7,417	10,504	13,832
West Virginia	3,918	6,359	3,469	5,815
Wisconsin	10,019	10,097	10,739	10,530
Wyoming	1,761	1,840	685	1,168
Undistributed	[1] 2,585	[1] 4,167	1,823	3,366
Total	[1] 387,107	[1] 523,398	414,970	568,267

[1] Revised figure.
[2] Included with "Undistributed."
[3] To avoid disclosing individual company confidential data, total is somewhat incomplete, the portion not included being combined as "Undistributed."

TABLE 18.—Number and production of commercial crushed-stone plants in the United States, by size of operation

Annual production (short tons)	1961 Number of plants	1961 Production Thousand short tons	1961 Production Percent of total	1961 Cumulative total, thousand short tons	1962 Number of plants	1962 Production Thousand short tons	1962 Production Percent of total	1962 Cumulative total, thousand short tons
Less than 25,000	[1] 813	[1] 6,670	1.2	6,670	889	7,462	1.3	7,462
25,000 to 50,000	323	11,586	2.1	18,256	292	10,805	1.8	18,267
50,000 to 75,000	270	16,536	3.0	34,792	241	14,828	2.5	33,095
75,000 to 100,000	186	15,922	2.9	50,714	193	16,899	2.9	49,994
100,000 to 200,000	[1] 496	[1] 70,088	12.9	120,802	499	71,421	12.1	121,415
200,000 to 300,000	248	60,715	11.1	181,517	248	60,554	10.3	181,969
300,000 to 400,000	[1] 173	[1] 59,765	11.0	241,282	187	65,654	11.1	247,623
400,000 to 500,000	113	50,604	9.3	291,886	137	61,046	10.4	308,669
500,000 to 600,000	81	43,944	8.1	335,830	94	50,556	8.6	359,225
600,000 to 700,000	[1] 45	[1] 29,245	5.4	365,075	50	32,325	5.5	391,550
700,000 to 800,000	33	24,622	4.5	389,697	36	26,900	4.6	418,450
800,000 to 900,000	20	17,009	3.1	406,706	21	17,627	3.0	436,077
900,000 tons and over	[1] 86	[1] 138,787	25.4	545,493	92	152,302	25.9	588,379
Total	[1] 2,887	[1] 545,493	100.0	545,493	2,979	588,379	100.0	588,379

[1] Revised figure.

TABLE 19.—Crushed stone sold or used in the United States, by methods of transportation

Method of transportation	1961 Thousand short tons	1961 Percent of total	1962 Thousand short tons	1962 Percent of total
Commercial:				
Truck	[1] 356,133	[1] 58	388,023	59
Rail	78,674	13	83,221	13
Waterway	[1] 50,469	8	53,200	8
Unspecified	60,217	10	63,935	10
Total commercial	[1] 545,493	[1] 89	588,379	90
Government-and-contractor: Truck [2]	64,130	[1] 11	65,846	10
Grand total	[1] 609,623	100	654,225	100

[1] Revised figure.
[2] Entire output of Government-and-contractor operations assumed to be moved by truck.

GRANITE

Crushed and broken granite production was 49 million tons valued at $71 million, an increase of 12 percent in value and 13 percent in volume. Average price was $1.44 per ton, a slight decrease from 1961. Nearly 2 million tons was sold for railroad ballast at $0.08 per ton less than in 1961. Approximately 200,000 tons was sold for poultry grit at an average price of $9.00 per ton. Production of concrete aggregate and roadstone increased 5 million tons over 1961. Georgia, North Carolina, Virginia, South Carolina, and California, in that order, led in value of production, and together accounted for 90 percent of total value.

TABLE 20.—Granite (crushed and broken stone) sold or used by producers in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1961		1962	
	Quantity	Value	Quantity	Value
Concrete and roadstone	36,658	$53,332	41,784	$60.210
Railroad ballast	1,291	1,568	1,995	2,262
Riprap	3,051	5,141	2,962	4,759
Fill	666	604	970	869
Stone sand	1,555	1,212	1,161	775
Poultry grit	142	1,269	197	1,774
Other uses [1]	33	175	87	237
Total	43,396	63,301	49,156	70,886

[1] Includes stone used for agriculture, filtration, roofing granules, and unspecified uses.

TABLE 21.—Granite (crushed and broken stone) sold or used by producers in the United States in 1962, by States

State	Short tons	Value	State	Short tons	Value
Arizona	113,274	$117,424	South Carolina	5,161,033	$7,825,819
California	4,441,748	4,894,883	South Dakota	10,466	20,000
Colorado	19,698	43,108	Utah	159,724	336,207
Georgia	14,810.799	20,316,573	Virginia	6,482,404	10,417,432
Minnesota	452,995	645,152	Washington	106.401	226,968
Missouri	1,736	2,850	Wisconsin	337,691	151,811
Nevada	5,200	3,224	Wyoming	350,417	411,842
New Hampshire	49,500	44,554	Other States [1]	1,973,799	3,461,250
New Jersey	768,499	1,661,664			
North Carolina	13,723,087	20,091,785	Total	49,156,029	70,886,262
Oklahoma	5,850	14,622	Puerto Rico	108,500	258,500
Oregon	181,708	199,094			

[1] Includes Alaska, Connecticut, Delaware, Maine, Maryland, Massachusetts, Montana, New York, Pennsylvania, Rhode Island, Texas, and Vermont.

BASALT AND RELATED ROCKS (TRAPROCK)

Production of basaltic rock for fill more than doubled in tonnage with a corresponding rise in value. Total tonnage produced for all uses increased 11 percent and the value increased by 13 percent. Oregon, New Jersey, and Washington accounted for 57 percent of the production.

TABLE 22.—Basalt and related rocks (traprock) (crushed and broken stone) sold or used by producers in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1961		1962	
	Quantity	Value	Quantity	Value
Concrete and roadstone	[1] 49,976	[1] $77,086	54,077	$85,051
Railroad ballast	1,561	2,194	1,499	2,302
Riprap	[1] 8,934	[1] 10,860	9,290	9,374
Fill	1,719	2,144	3,572	5,158
Stone sand	65	105	3	6
Other uses [2]	508	2,722	1,224	5,724
Total	[1] 62,763	[1] 95,111	69,665	107,615

[1] Revised figure.
[2] Includes stone used for agriculture, concrete blocks, filtration, filler, roofing granules, and unspecified uses.

TABLE 23.—Basalt and related rocks (traprock) (crushed and broken stone) sold or used by producers in the United States in 1962, by States

State	Short tons	Value	State	Short tons	Value
Arizona	586,323	$879,482	North Carolina	3,193,739	$4,013,193
California	1,802,230	2,109,828	Oregon	15,883,130	17,983,994
Connecticut	4,716,018	7,117,690	Pennsylvania	3,268,440	6,008,548
Hawaii	2,543,188	4,866,353	Virginia	2,709,440	4,641,231
Idaho	974,007	1,532,513	Washington	10,881,697	14,632,045
Maryland	3,266,345	5,141,482	Other States [1]	3,247,232	8,718,399
Massachusetts	3,528,788	5,520,353			
Michigan	72,701	73,134	Total	69,665,429	107,615,126
Minnesota	19,875	29,812	American Samoa	372,713	1,455,830
Nevada	45,000	27,900	Panama Canal Zone	135,148	258,593
New Jersey	12,778,418	24,117,411	Virgin Islands	21,273	82,348
New Mexico	148,858	201,758			

[1] Includes Alaska, Montana, New York, Texas, and Wisconsin.

MARBLE

Crushed marble for terrazzo sold at an average of $12.81 per ton, although some particularly uncommon or ornamental varieties used for scagliola work brought as much as $60.00 per ton.

TABLE 24.—Marble (crushed and broken stone) sold or used by producers in the United States,[1] by uses

(Thousand short tons and thousand dollars)

Use	1961		1962	
	Quantity	Value	Quantity	Value
Terrazzo	397	$4,535	380	$4,866
Other uses [2]	1,038	7,859	1,243	9,512
Total	1,435	12,394	1,623	14,378

[1] Produced by the following States in 1962, in order of tonnage: Georgia, Alabama, Missouri, Texas, North Carolina, California, New York, Tennessee, Washington, Arizona, Vermont, Virginia, Maryland, Colorado, New Jersey, Montana, Wisconsin, Nevada, Utah, and Arkansas.
[2] Includes stone used for agriculture, asphalt filler, flux, poultry grit, roofing, stone sand, stucco, whiting (excluding marble whiting made by companies that purchase marble), and unspecified uses.

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LIMESTONE

Production of crushed and broken limestone increased 5 percent in volume and 7 percent in total value. Value of stone for concrete construction and paving was 8 percent greater, although output increased only 7 percent. Output of fluxstone decreased 4 percent, although production of pig iron and ferroalloys was greater than in 1961. The total amount of fluxstone used in blast furnaces was 13,137,546 tons,[19] an average of 0.282 tons per ton of pig iron compared with 0.426 tons in 1952.[20] Of this amount, 5,735,175 tons was consumed in the production of agglomerates.[21]

The theoretical tonnage of agricultural limestone that should have been used for soil beneficiation, as reported for the various States, was 80 million tons; only 23 million tons was so used in 1962.

TABLE 25.—Limestone and dolomite (crushed and broken stone) sold or used by producers in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1961		1962	
	Quantity	Value	Quantity	Value
Concrete and roadstone	258,997	$338,798	276,878	$365,098
Flux	27,198	39,725	26,081	36,821
Agriculture	[1] 22,196	[1] 38,478	23,029	39,348
Railroad ballast	4,260	5,376	5,065	6,578
Riprap	9,138	10,440	10,016	12,253
Alkali manufacture	2,560	2,878	2,840	3,188
Calcium carbide manufacture	764	785	(2)	(2)
Cement—portland and natural	79,779	85,883	83,318	92,886
Coal-mine dusting	372	1,527	400	1,667
Fill material	266	277	440	330
Filler (not whiting substitute):				
Asphalt	2,130	5,408	3,208	6,955
Fertilizer	438	1,080	448	1,132
Other	219	873	351	1,567
Filtration	148	221	79	141
Glass manufacture	1,211	3,736	1,337	4,294
Lime and dead-burned dolomite	18,124	28,283	19,356	32,959
Limestone sand	1,693	2,596	1,706	3,103
Limestone whiting [3]	802	9,242	838	9,639
Mineral food	695	3,723	692	3,847
Paper manufacture	400	1,129	271	821
Poultry grit	153	1,185	161	1,333
Refractory (dolomite)	235	465	322	563
Sugar refining	[1] 882	[1] 2,215	623	1,506
Other uses [4]	2,838	4,603	1,741	4,253
Use unspecified	1,900	2,475	1,753	2,518
Total	437,398	591,401	460,953	632,800

[1] Revised figure.
[2] Included with "Other uses."
[3] Includes stone for filler for abrasives, calcimine, calking compounds, ceramics, chewing gum, fabrics, floor coverings, insecticides, leather goods, paint, paper, phonograph records, plastics, pottery, putty, roofing, rubber, wire coating, and unspecified uses. Excludes limestone whiting made by companies from purchased stone.
[4] Includes stone for acid neutralization, calcium carbide (1962), cast stone, chemicals (unspecified), concrete products, disinfectant and animal sanitation, electrical products, magnesia, magnesite, magnesium, mineral wool, oil-well drilling, patching plaster, rice milling, road base, roofing granules, stucco, terrazzo, and water treatment.

[19] American Iron & Steel Institute. Annual Statistical Report. 1962, p. 47.
[20] Page 46 of work cited in footnote 19.
[21] Page 23 of work cited in footnote 19.

TABLE 26.—Limestone and dolomite (crushed and broken stone) sold or used by producers in the United States in 1962, by States and uses

State	Riprap		Fluxing stone		Concrete and roadstone	
	Short tons	Value	Short tons	Value	Short tons	Value
Alabama	196,647	$233,172	979,585	$1,606,443	5,709,150	$7,175,181
Alaska	(1)	(1)	-----	-----	-----	-----
Arizona	-----	-----	(1)	(1)	(1)	(1)
Arkansas	577,986	1,094,250	(1)	(1)	2,203,860	3,048,631
California	148,237	123,677	(1)	(1)	1,184,637	1,695,363
Colorado	(1)	(1)	309,347	654,580	249,111	442,104
Connecticut	-----	-----	(1)	(1)	-----	-----
Florida	-----	-----	-----	-----	22,072,422	25,140,125
Georgia	(1)	(1)	-----	-----	1,290,284	1,987,556
Hawaii	-----	-----	-----	-----	603,984	892,455
Idaho	-----	-----	(1)	(1)	-----	-----
Illinois	318,732	385,638	357,586	610,395	32,747,121	43,397,590
Indiana	120,417	162,498	90,274	123,864	13,416,176	17,364,717
Iowa	377,948	535,499	(1)	(1)	16,618,193	21,320,604
Kansas	843,247	882,473	-----	-----	9,210,465	12,250,667
Kentucky	(1)	(1)	(1)	(1)	15,810,275	22,762,772
Maine	-----	-----	-----	-----	101,906	220,282
Maryland	(1)	(1)	(1)	(1)	4,956,556	8,447,146
Massachusetts	-----	-----	(1)	(1)	(1)	(1)
Michigan	113,660	130,373	10,512,738	11,068,740	3,729,510	4,609,356
Minnesota	70,389	91,576	90	540	2,725,638	3,063,969
Mississippi	342,077	342,077	-----	-----	-----	-----
Missouri	1,710,787	1,750,910	(1)	(1)	16,806,104	23,115,963
Montana	8	19	(1)	(1)	(1)	(1)
Nebraska	792,920	1,127,678	-----	-----	1,758,346	3,078,408
Nevada	-----	-----	(1)	(1)	(1)	(1)
New Jersey	-----	-----	(1)	(1)	(1)	(1)
New Mexico	105	1,804	24,556	18,539	455,385	636,263
New York	158,657	272,112	51,050	82,418	14,739,120	26,270,373
North Carolina	-----	-----	-----	-----	2,226,146	3,325,902
Ohio	224,614	282,762	4,386,457	6,810,896	17,990,967	23,693,633
Oklahoma	1,248,645	1,288,275	-----	-----	9,093,177	10,100,869
Oregon	(1)	(1)	(1)	(1)	(1)	(1)
Pennsylvania	(1)	(1)	4,566,923	8,448,314	20,982,066	30,749,247
Rhode Island	-----	-----	(1)	(1)	-----	-----
South Carolina	-----	-----	(1)	(1)	(1)	(1)
South Dakota	(1)	(1)	-----	-----	844,043	1,106,189
Tennessee	41,674	50,364	27,000	37,800	19,309,884	24,103,718
Texas	1,464,271	1,369,981	365,106	363,759	16,433,969	15,979,812
Utah	12,816	41,694	472,574	634,480	(1)	(1)
Vermont	(1)	(1)	-----	-----	887,122	1,264,118
Virginia	103,628	128,042	1,245,544	2,107,113	9,047,856	11,963,629
Washington	-----	-----	(1)	(1)	-----	-----
West Virginia	(1)	(1)	1,460,279	2,793,764	2,512,311	4,176,651
Wisconsin	60,478	75,110	6,901	13,375	10,173,361	10,212,238
Wyoming	(1)	(1)	(1)	(1)	(1)	(1)
Undistributed	1,088,039	1,883,432	1,224,568	1,446,138	989,089	1,502,674
Total	10,015,982	12,253,416	26,080,578	36,821,158	276,878,234	365,098,205
American Samoa	-----	-----	-----	-----	-----	-----
Canton Island	-----	-----	-----	-----	130	500
Guam	-----	-----	-----	-----	78,516	117,970
Puerto Rico	-----	-----	-----	-----	2,416,580	4,628,830
Wake Island	-----	-----	-----	-----	4,880	40,750

[1] Figures withheld to avoid disclosing individual company confidential data; included with "Undistributed."

TABLE 26.—Limestone and dolomite (crushed and broken stone) sold or used by producers in the United States in 1962, by States and uses—Continued

State	Railroad ballast		Agriculture		Miscellaneous		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Alabama	(1)	(1)	591,626	$986,669	(1)	(1)	12,325,185	$14,722,607
Alaska							(1)	(1)
Arizona					1,720,067	$2,015,901	1,985,891	2,424,603
Arkansas	(1)	(1)	276,664	420,640	1,594,506	1,957,422	4,872,184	6,878,468
California	(1)	(1)	(1)	(1)	12,810,326	20,703,963	14,719,423	23,086,616
Colorado					1,605,755	3,298,306	2,164,513	4,395,440
Connecticut			(1)	(1)	(1)	(1)	213,378	886,639
Florida	(1)	(1)	479,405	1,446,694	(1)	(1)	25,927,507	30,582,153
Georgia	(1)	(1)	(1)	(1)	(1)	(1)	2,292,440	3,577,206
Hawaii			(1)	(1)	269,857	242,235	883,540	1,158,209
Idaho			(1)	(1)	(1)	(1)	(1)	(1)
Illinois	293,342	$293,865	3,713,464	5,333,690	3,844,419	4,216,218	41,274,664	54,237,396
Indiana	233,165	288,015	1,972,069	2,751,206	2,223,161	2,054,682	18,055,262	22,744,982
Iowa	24,990	32,392	1,134,531	1,581,671	(1)	(1)	21,609,104	28,105,362
Kansas	(1)	(1)	404,422	645,663	2,575,703	3,118,616	13,088,481	16,975,777
Kentucky	452,824	473,168	1,667,020	2,318,972	(1)	(1)	19,470,619	27,655,159
Maine	54,101	82,846	(1)	(1)	(1)	(1)	814,724	1,328,971
Maryland	(1)	(1)	(1)	(1)	2,266,686	5,472,153	7,327,238	14,152,411
Massachusetts			175,438	546,275	413,629	1,412,018	618,340	2,004,185
Michigan	(1)	(1)	485,152	801,456	13,239,078	12,000,413	28,187,118	28,762,718
Minnesota			367,307	571,015	62,604	318,218	3,226,028	4,045,318
Mississippi			118,053	106,247	(1)	(1)	(1)	(1)
Missouri	20,073	26,184	2,852,619	4,616,789	6,474,784	11,276,062	27,877,773	40,819,874
Montana	(1)	(1)			578,306	1,142,145	649,797	1,273,040
Nebraska			124,585	198,616	993,415	2,219,222	3,669,266	6,623,924
Nevada					(1)	(1)	(1)	(1)
New Jersey			(1)	(1)	(1)	(1)	(1)	(1)
New Mexico					438,437	641,804	918,483	1,298,410
New York	588,163	952,102	339,492	935,444	7,950,794	9,400,853	23,827,276	37,913,302
North Carolina	1,148	1,549	6,560	13,120			2,233,854	3,340,571
Ohio	973,786	1,189,968	1,998,599	3,593,383	8,326,733	14,189,748	33,901,156	49,760,390
Oklahoma	(1)	(1)	127,318	163,588	2,090,488	4,209,028	12,576,400	15,775,260
Oregon			(1)	(1)	889,787	1,215,915	900,740	1,239,797
Pennsylvania	145,376	221,742	1,075,943	3,306,754	14,712,435	19,616,698	41,512,825	62,383,259
Rhode Island			(1)	(1)	(1)	(1)	(1)	(1)
South Carolina			(1)	(1)	(1)	(1)	(1)	(1)
South Dakota	102,000	112,200			613,357	929,735	1,569,300	2,161,624
Tennessee	105,194	120,835	1,682,647	2,140,359	2,907,681	4,777,658	24,074,080	31,230,734
Texas	(1)	(1)	173,514	170,346	6,893,553	8,837,129	25,692,557	27,058,074
Utah					1,114,489	2,180,167	1,608,466	2,862,366
Vermont			102,073	343,203	(1)	(1)	1,141,508	3,484,064
Virginia	410,813	558,051	899,925	1,721,926	3,988,422	6,460,537	15,696,188	22,939,298
Washington			(1)	(1)	1,115,142	1,807,460	1,170,121	1,964,128
West Virginia	521,066	726,479	(1)	(1)	1,951,268	3,623,047	6,529,210	11,543,884
Wisconsin			1,364,907	1,791,931	142,904	152,143	11,748,551	12,244,797
Wyoming	(1)	(1)			(1)	(1)	1,319,841	2,109,754
Undistributed	1,139,431	1,498,645	895,942	2,842,418	16,075,781	23,211,920	3,280,077	7,049,541
Total	5,065,472	6,578,041	23,029,275	39,348,075	119,883,567	172,701,416	460,953,108	632,800,311
American Samoa					730,400	$332,000	730,400	332,000
Canton Island							130	500
Guam					3,229	4,968	81,745	122,938
Puerto Rico			71,589	215,988	1,781,671	983,709	4,269,840	5,828,527
Wake Island							4,880	40,750

(1) Figures withheld to avoid disclosing individual company confidential data: included with "Undistributed."

TABLE 27.—Sales of fluxing limestone, by uses

(Thousand short tons and thousand dollars)

Year	Blast furnace		Open-hearth plants		Other smelters [1]		Other metallurgical [2]		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1953-57 (average)	29,814	$38,800	7,112	$10,471	1,055	$1,388	276	$437	38,257	$51,096
1958	19,427	28,153	4,777	6,641	866	975	546	768	25,616	36,537
1959	19,752	28,683	6,439	8,963	965	1,223	1,050	1,573	28,206	40,442
1960	21,627	30,809	7,409	10,958	997	1,311	1,382	2,004	31,415	45,082
1961	18,129	25,891	6,412	10,056	896	1,205	1,761	2,573	27,198	39,725
1962	16,996	23,062	6,411	9,835	646	952	2,028	2,972	26,081	36,821

[1] Includes flux for copper, gold, lead, zinc, and unspecified smelters.
[2] Includes flux for foundries and for cupola and electric furnaces.

Shell.—Production of shell from coastal waters increased 11 percent in tonnage and 3 percent in total value, but the price per ton dropped $0.13.

TABLE 28.—Shell sold or used by producers in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1961		1962	
	Quantity	Value	Quantity	Value
Concrete and road material	[1] 11,499	[1] $18,256	12,792	$18,611
Cement	[1] 4,406	4,881	5,117	5,531
Lime	1,420	1,782	1,441	1,876
Poultry grit	598	5,004	587	4,635
Mineral food	3	14	4	22
Other uses [2]	[1] 78	[1] 438	113	566
Total	[1] 18,004	[1] 30,375	20,054	31,241

[1] Revised figure.
[2] Includes agriculture, asphalt filler, and whiting.

TABLE 29.—Shell sold or used by producers in the United States in 1962, by States

State	Short tons	Value	State	Short tons	Value
Florida	1,351,163	$2,025,446	Other States [1]	2,918,564	$6,447,188
Louisiana	5,711,481	8,066,647			
Texas	10,072,803	14,701,243	Total	20 054,011	31,240,524

[1] Includes Alabama, California, Maryland, Mississippi, New Jersey, Pennsylvania, and Virginia.

Calcareous Marl.—Production of calcareous marl for cement increased 9 percent in tonnage and 4 percent in value over 1961. Marl produced and used for soil beneficiation close to the point of production sold for an average price of $0.69 per ton.

TABLE 30.—Calcareous marl sold or used by producers in the United States,[1] by uses

(Thousand short tons and thousand dollars)

Use	1961		1962	
	Quantity	Value	Quantity	Value
Agriculture [2]	223	$168	226	$156
Cement	876	819	956	855
Total	1,099	987	1,182	1,011

[1] Produced by the following States in 1962, in order of tonnage: Mississippi, Virginia, Michigan, Indiana, Minnesota, Wisconsin, Nevada, and Ohio.
[2] Includes marl used in mineral food.

SANDSTONE, QUARTZ, AND QUARTZITE

Sandstone produced for riprap, chiefly in Arkansas, increased greatly in both tonnage and value, but production for most other uses declined.

TABLE 31.—Sandstone, quartz, and quartzite (crushed and broken stone)[1] sold or used by producers in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1961		1962	
	Quantity	Value	Quantity	Value
Concrete and roadstone	14,688	$19,843	13,514	$19,923
Railroad ballast	771	1,017	754	921
Riprap	4,061	4,196	9,051	7,316
Refractory stone (ganister)	462	4,616	389	5,129
Abrasives	52	362	41	253
Ferrosilicon	132	508	56	258
Filtration	13	45	13	71
Flux	423	1,495	429	1,741
Foundry	373	1,034	60	187
Glass	388	1,271	309	1,167
Other uses [2]	1,632	3,593	1,071	3,249
Total	22,995	37,980	25,687	40,215

[1] Includes ground sandstone, quartz, and quartzite. Friable sandstone is reported in the chapter on sand and gravel.
[2] Includes cement, fill, filler, porcelain, pottery, roofing granules, stone sand, terrazzo, tile, and unspecified uses.

TABLE 32.—Sandstone, quartz, and quartzite (crushed and broken stone) sold or used by producers in the United States in 1962, by States

State	Short tons	Value	State	Short tons	Value
Arizona	592,501	$1,396,718	Oregon	132,478	$372,945
Arkansas	10,339,582	8,645,329	Pennsylvania	2,066,562	6,528,849
California	2,398,278	4,020,735	South Dakota	1,119,655	1,779,639
Colorado	48,452	227,134	Texas	1,264,982	2,042,127
Illinois	600	6,000	Utah	331,077	463,645
Maine	90,000	180,000	Vermont	236,293	261,765
Michigan	11,317	13,252	Virginia	291,794	494,445
Minnesota	42,333	104,038	Washington	77,252	343,116
New Mexico	70	1,048	West Virginia	976,676	1,698,407
New York	665,772	1,429,999	Wisconsin	739,518	1,198,625
North Carolina	51,709	167,618	Other States [1]	2,711,175	5,587,152
Ohio	459,414	1,901,900			
Oklahoma	1,039,711	1,350,966	Total	25,687,201	40,215,452

[1] Includes Alabama, Connecticut, Georgia, Idaho, Indiana, Kansas, Maryland, Missouri, Montana, Nevada, South Carolina, Tennessee, and Wyoming.

CRUSHED AND BROKEN SLATE

For the first time in several years, the downward trend in the production of crushed and broken slate was reversed. Production was up 6 percent in tonnage and 3 percent in value.

TABLE 33.—Slate (crushed and broken stone) sold or used by producers in the United States,[1] by uses

(Thousand short tons and thousand dollars)

Use	1961		1962	
	Quantity	Value	Quantity	Value
Granules [2]	257	$2,014	268	$2,079
Flour	108	565	110	570
Other uses [3]	7	6	15	10
Total	372	2,585	393	2,659

[1] Produced by the following States in 1962 in order of tonnage: Georgia, Arkansas, Pennsylvania, Virginia, California, and South Dakota.
[2] Includes crushed slate used for lightweight aggregates to avoid disclosing individual company confidential data.
[3] Includes concrete and roadstone and unspecified uses.

MISCELLANEOUS STONE

Output of crushed and broken stone under this classification increased 15 percent in tonnage and 36 percent in value. Use for concrete and roadstone accounted for 62 percent of the production. Production for riprap increased over 160 percent in tonnage and value, although the average price of $1.60 was about the same as in 1961.

TABLE 34.—Miscellaneous stone (crushed and broken stone) sold or used by producers in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1961		1962	
	Quantity	Value	Quantity	Value
Concrete and roadstone	15,289	$16,083	15,920	$19,372
Railroad ballast	1,734	1,075	1,728	1,247
Riprap	1,900	3,057	5,096	8,133
Fill	1,572	1,169	593	394
Other uses [1]	1,666	3,748	2,175	5,059
Total	22,161	25,132	25,512	34,205

[1] Includes stone used for agriculture, filler, filtration, flux, roofing granules, stone sand, terrazzo, and unspecified uses.

TABLE 35.—Miscellaneous varieties of stone (crushed and broken stone) sold or used by producers in the United States in 1962, by States

State	Short tons	Value	State	Short tons	Value
Arizona	1,033,310	$1,596,130	South Dakota	129,116	$123,903
Arkansas	5,310,642	3,458,533	Texas	583,559	498,695
California	10,212,668	16,941,590	Utah	6,797	7,477
Hawaii	622,070	781,289	Washington	488,929	463,567
Kansas	428,401	157,686	Wisconsin	58,000	36,000
Missouri	495,226	344,963	Wyoming	77,420	516,430
Nevada	128,821	175,024	Other States [1]	2,580,943	5,569,147
North Dakota	19,056	19,056			
Oklahoma	1,031,706	632,243	Total	25,512,045	34,204,981
Oregon	1,158,262	1,161,669	Panama Canal Zone	72,225	100,580
Pennsylvania	843,459	1,238,869	Puerto Rico	1,087,760	2,160,106
Rhode Island	303,660	482,710			

[1] Includes Alaska, Colorado, Louisiana, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New Mexico, New York, Vermont, and Virginia.

FOREIGN TRADE [22]

Exports of crushed, broken, or ground limestone to Canada amounted to 576,000 short tons valued at $1,349,207. Imports of crude or crushed limestone from Canada were 466,000 tons valued at $605,648. Quartzite imported from Canada was valued at $229,000.

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

TABLE 36.—U.S. imports for consumption of stone and whiting, by classes

Class	1961 Quantity	1961 Value	1962 Quantity	1962 Value
Marble, breccia, and onyx:				
Sawed or dressed, over 2 inches thick...cubic feet..	11,244	$104,096	6,152	$52,031
In blocks, rough, etc...do....	123,358	791,638	151,774	1,069,021
Slabs and paving tiles...superficial feet..	4,136,448	3,456,596	5,017,957	4,477,470
All other manufactures...	-------	3,766,892	-------	5,421,769
Total...	-------	8,119,222	-------	11,020,291
Granite:				
Rough...cubic feet..	102,193	577,702	129,501	557,636
Dressed [1]...do....	60,041	761,099	(1)	1,057,724
Paving blocks, wholly or partly manufactured [1] number..	1,674	47,332		
Total...	-------	1,386,133	-------	1,615,360
Quartzite...short tons..	22,989	19,527	105,335	296,029
Slate...	-------	481,132	-------	581,822
Travertine stone (unmanufactured)...cubic feet..	61,054	164,593	694,059	341,615
Stone (other):				
Dressed: Travertine, sandstone, limestone, etc. cubic feet..	147,358	418,758	(2)	1,087,690
Rough (monumental or building stone)...do....	1,909	3,678	5,219	23,151
Rough (other)...short tons..	301,611	466,180	50,068	650,075
Marble chip or granito...do....	26,848	269,938	31,002	287,524
Crushed or ground, n.s.p.f...	-------	656,519	-------	1,038,712
Total...	-------	1,815,073	-------	3,087,152
Whiting:				
Chalk or whiting, precipitated...short tons..	1,113	65,403	1,334	82,139
Whiting, dry, ground, or bolted...do....	11,667	217,021	11,663	179,266
Whiting, ground in oil (putty)...do....	(3)	254	(3)	136
Total...	-------	282,678	-------	261,541
Grand total...	-------	12,268,358	-------	17,203,810

[1] Effective July 1, 1962 not separately classified. Jan. 1 thru June 30, 1962: Dressed—34,000 cubic feet ($579,356); Paving blocks, wholly or partly manufactured 825 ($5,235); July 1 thru Dec. 30, 1962: Granite-hewn, dressed, pointed, pitched, lined, or polished (value only) $473,133

[2] Effective Jan. 1, 1962, quantity not recorded.

[3] Less than 1 ton.

Source: Bureau of the Census.

TABLE 37.—U.S. exports of stone

Year	Building and monumental stone: Cubic feet	Building and monumental stone: Value	Crushed, ground, or broken: Limestone: Short tons	Crushed, ground, or broken: Limestone: Value	Crushed, ground, or broken: Other: Short tons	Crushed, ground, or broken: Other: Value	Other manufactures of stone (value)
1953–57 (average)...	415,026	$1,025,517	869,431	$1,112,724	153,945	$2,622,603	$429,747
1958...	349,366	1,236,205	767,757	1,390,365	173,340	3,696,951	432,072
1959...	425,194	1,261,687	1,085,553	1,999,107	157,911	3,388,372	643,102
1960...	431,262	1,250,365	926,197	1,779,799	153,106	2,658,669	477,401
1961...	435,173	1,595,805	790,912	1,596,122	128,149	3,026,785	429,604
1962...	534,919	1,795,048	621,177	1,546,663	114,744	2,166,167	501,389

Source: Bureau of the Census.

TABLE 38.—U.S. exports of slate, by uses [1]

(Value)

Use	1953-57 (average)	1958	1959	1960	1961	1962
Roofing	$10,395	$12,026	(2)	(2)	(2)	$15,096
Structural (including floors and walkways) and granules and flour	206,025	212,460	$89,912	$47,811	$9,154	16,321
Other uses [3]	141,667	84,629	126,683	100,247	73,918	84,639
Total	358,087	309,115	216,595	148,058	83,072	116,056

[1] Figures collected by the Bureau of Mines from shippers of products named.
[2] Included with "Other uses" to avoid disclosing individual company confidential data.
[3] Includes electrical slate, school slate, blackboards, and billiard tabletops.

WORLD REVIEW

Canada.—A summary of present information regarding limestone deposits in the various areas of Newfoundland was published.[23]

Chile.—Production of limestone in 1961 was estimated at 1,764,000 tons, compared with 1,612,000 tons in 1960. Chilean deposits yielded grades ranging from 72 percent calcium carbonate, near Santiago, to 98 percent calcium carbonate, in Magallanes Province.[24]

Rhodesia and Nyasaland, Federation of.—Limestone production in Northern Rhodesia increased to 466,649 tons in 1961 from 403,474 tons in 1960. Production of limestone in Southern Rhodesia declined slightly from 807,129 tons in 1960 to 790,484 tons in 1961 because of relative inactivity in the building industry.[25]

South Africa, Republic of.—Local sales of limestone decreased from 5,836,452 tons in 1960 to 5,780,130 tons in 1961.

TECHNOLOGY

Ashley River calcareous marl was successfully used for hydraulic fill on Interstate Highway 26 in North Carolina.[26]

Publications dealing with limestone deposits in Southern California [27] and in Washington [28] were issued.

Results of experiments to develop a technique for fracturing rock by use of electro-thermal forces were unrewarding. Although some of the conducting materials could be fractured, the technique failed completely on nonconducting substances such as marble, limestone, and granite.[29]

Stone chips of 10 to 20 mesh were coated with epoxy resins and silver-coated glass beads to make a reflective crushed stone product for use on roads, airport runways, and other similar places.[30]

[23] McKillop, John H. Limestone Potentials of Newfoundland. Canadian Mining J. (Gardenvale, Quebec), v. 83, No. 4, April 1962, pp. 80-83
[24] U.S. Embassy, Santiago Chile. State Department Dispatch 645, Apr. 17, 1962. p. 27.
[25] U.S. Embassy, Johannesburg, Republic of South Africa. State Department Dispatch 431, Apr. 26, 1962. p. 12.
[26] Roads and Streets. Hydraulic Filling Methods with Marl. V. 105, No. 7, July 1962, pp. 65-68.
[27] Gray, Clifton H., Jr. Limestone Resources of Southern California. Miner. Inf. Service, Calif. Div. of Mines and Geol., v. 15, No. 5, May 1962, pp. 1-5; v. 15, No. 6, June 1962, pp. 4-7.
[28] Mills, Joseph W. High-Calcium Limestones of Eastern Washington. Washington Dept. of Conservation, Div. of Mines and Geol., Bull. 48, 1962, 268 pp.
[29] Quarry Managers' Journal (London). V. 46, No. 8, August 1962, p. 304.
[30] Palmquist, P. V., E. L. McKenzie, and T. L. Harrington (assigned to Minnesota Mining & Manufacturing Co., St. Paul, Minn.). Reflective Marking Aggregate. U.S. Pat. 3,043,196, July 10, 1962.

As part of a comprehensive survey of present methods for maintaining quality control of ready-mixed concrete, the grading requirements for various types of aggregate were described. ASTM designations were listed and an extensive bibliography was included.[31]

A publication presented detailed information on the chemical composition, depth of deposits, and results of sieve tests of the major Pennsylvanian sandstones of Illinois.[32]

Results of research conducted on dense graded aggregate at the laboratory of the National Crushed Stone Association were published. The methods of testing, effects of particle shape, plasticity, type of aggregate, and maximum size of aggregate and of fines were discussed and illustrated by charts and tables. A bibliography was included.[33]

The results of a study, conducted by the Bureau of Public Roads, to simplify, standardize, and uniformly apply various aggregate gradations were published. During the study it was found that no uniform method for designating aggregate gradations was in actual use by the various States, that there was no consistency in the number and sizes of sieves used to determine gradations, and that some States had their own systems of size designations, and others had no designations whatsoever. It was recommended that three American Association of State Highway Officials Standards and three American Society for Testing and Materials Standards be accepted for use by all highway departments. A new aggregate gradation chart was prepared to assist in developing more realistic specifications.[34]

Seismographic data, continuously supplied by specialists in the measurement of ground vibrations, enabled a contractor to blast rock on a road project at the edge of Ironton, Ohio, with a minimum of complaints from residents. Seismographic logs of each blast provided data for the contractor.[35] A paper described the methods of drilling, blasting, and processing used at an underground limestone mine in Iowa.[36] Results of blasting tests on hard limestone, fine-grained granite-gneiss, and dolomitic marble indicated that in-flight impact is an important breakage factor in quarry blasting.[37]

Drilling and Blasting.—The basic requirements to be evaluated in down-the-hole drilling machines and the principles on which their successful operation depend were published.[38] Recent progress in the design and utilization of tractor-mounted drills was summarized. The tractor units were highly mobile and could easily be adapted to percussion, rotary, and down-the-hole systems.[39] The various changes

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[31] National Ready Mixed Concrete Association. Control of Quality of Ready-Mixed Concrete. Pub. 44, 5th ed., October 1962, 51 pp.

[32] Bradbury, James C., M. E. Ostrom, and J. E. Lamar. Chemical and Physical Character of the Pennsylvanian Sandstones in Central Illinois. Illinois State Geol. Survey, Urbana, Circ. 331, 1962, 43 pp.

[33] Gray, J. E. Characteristics of Graded Base Course Aggregates Determined by Triaxial Tests. National Crushed Stone Assoc., Wash., D.C., Eng. Bull., No. 12, July 1962, 61 pp.

[34] Bureau of Public Roads, Department of Commerce. Aggregate Gradation for Highways. May 1962, 26 pp.

[35] Roads and Streets. Programmed Blasting, Grading for a Difficult City-Edge Project. V. 105, No. 1, January 1962, pp. 34–39, 110.

[36] Marshall, L. G. Mining Methods at the Fort Dodge Limestone Co., Inc. BuMines Inf. Circ. 8051, 1962, 13 pp.

[37] Atchison, Thomas C., W. I. Duval, and Benjamin Petkof. How Rock Breaks. Rock Products, v. 65, No. 2, February 1962, pp. 78–81, 119.

[38] Marshall, David R. Progress in Down-the-Hole Drilling. Quarry Managers' J. (London), v. 46 No. 8, August 1962, pp. 325–332.

[39] Inett, E. W. Recent Developments in the Design and Use of Tractor Drills. Quarry Managers' J. (London), v. 46, No. 8, August 1962, pp. 333–344.

in quarrying practice that had occurred in recent years and the effect of these changes on the techniques used in primary and secondary blasting were discussed.[40]

Mining and Processing.—Using drop-balls for secondary breakage in place of blasting decreased quarry costs, increased production, and improved public relations because of the reduction of noise. Cylindrical or hexagonal weights having a length three times the diameter were more efficient than round or pear-shaped drop-balls.[41] The advantages and disadvantages of various types of impact breakers were discussed.[42] An impact breaker for use as the main rock-breaking unit in quarries where a cubical-shaped product was desired was described. In one pass, the machine produced graded aggregate from run-of-quarry material up to 36 inches in size.[43]

The methods and techniques used in quarrying and crushing limestone at three Kansas quarries were described.[44]

A 5-year expansion and improvement program enabled a New York producer of crushed stone to double plant capacity without substantial changes in the flowsheet or plant layout.[45]

The 750 ton-per-hour road-base material plant of the Southern Materials Corp., Ocala, Fla., was described. At this high-grade limestone deposit, a ripper broke up the rock and bulldozed it into position for loading with a dragline. Explosives were rarely needed.[46]

A well-illustrated description was provided of the new $20 million Bethlehem Limestone plant at Hanover, Pa. Besides producing several sizes of fluxstone and sinter sand needed by the Sparrows Point steel mill, quarry-run material of lower grade was processed for concrete aggregate, road base, and agricultural uses.[47]

The application of engineering principles to the control of dust in aggregate plants that use rotary driers was discussed.[48]

The deposit and methods of production at a South Carolina crushed granite quarry were described. The geology of the deposit, method of removing overburden, primary drilling and blasting, secondary breakage, crushing, screening, sizing, and storage were given. The flowsheet of the operations was shown, and a table listed personnel requirements in man-hours per ton of production.[49]

Ripping of cemented conglomerate was a key factor in removing 8 million cubic yards of material in the building of the Antelope Valley Freeway north of Los Angeles.[50]

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[40] Watt, R. Trends in Quarry Blasting Practice. Quarry Managers' J. (London), v. 46, No. 7, July 1962, pp. 277–284.

[41] Quarry Managers' Journal (London). The use of Drop-Balls for Secondary Breakage at the Quarry Face. V. 45, No. 12, December 1961, pp. 505–509; v. 46, No. 1, January 1962, pp. 9–14.

[42] Wright, W. E. Impact Breaking of Rock. Quarry Managers' J. (London). V. 46, No. 2, February 1962, pp. 57–60.

[43] Quarry Managers' Journal (London). Single-Pass Stone Reduction. V. 46, No. 12, December 1962, pp. 524–528.

[44] Kline, H. D. Methods and Cost of Mining and Crushing Limestone at Three Quarries, Anderson-Oxandale Rock Co., Kansas. BuMines Inf. Circ. 8084, 1962, 15 pp.

[45] Trauffer, Walter E. Federal's Crushed Stone Plant Capacity Doubled. Pit and Quarry, v. 55, No. 3, September 1962, pp. 118–120, 123.

[46] Trauffer, Walter E. Southern Materials Crushing Plant Near Ocala, Fla. Pit and Quarry, v. 54, No. 10, April 1962, pp. 159–160.

[47] Herod, Buren C. Pacesetting Pennsylvania Plant. Pit and Quarry, v. 55, No. 5, November 1962, pp. 91–102, 107.

[48] Thompson, K. The Application of Dust-Control Equipment to Rotary Aggregate Dryers. Quarry Managers' J. (London), v. 46, No. 3, March 1962, pp. 111–116.

[49] Pace, N. A., H. J. Schroeder, and H. L. Riley. Methods and Practices for Producing Crushed Granite Columbia Operation, Palmetto Quarries Co., Columbia, S.C. BuMines Inf. Circ. 8074, 1962, 19 pp.

[50] Roads and Streets. Rugged Freeway Job is Methods Laboratory. V. 105, No. 7, July 1962, pp. 45–47 106, 167.

At Kingston, Jamaica, the Caribbean Cement Co., Ltd., used ripping and dozing to produce approximately 300,000 tons of shaley limestone per year. Advantages of ripping included greater safety, better drainage, and elimination of stocks of explosives and of compressed air for drilling. A reduction of 64 percent in cost per ton of crushed rock was achieved.[51]

An article discussed the principles of fine grinding of limestone for fillers, animal feedstuff, coal mining, and extenders. Details were given on the performance of hammer mills, roller mills, tube mills, ball mills, and air classifiers. Product grading curves were shown for the degree of pulverization accomplished by the various types of mills.[52]

An automatic machine was devised for buffing marble slabs in mutually perpendicular and parallel directions, according to a predetermined program.[53]

Transportation.—Nine conventional belt conveyors and a number of point-to-point dump trucks were eliminated at a West German crushed limestone plant by a newly developed transportation system. The continuous conveyor belt could turn through 180 degrees in a single plane and climb to a 90-degree angle. These conveyors had been used satisfactorily for some time for charging blast furnaces under the difficult conditions of abrasive dust, corrosive fumes, heat, and sharp-edged materials.[54]

Portable Plants.—A high-capacity portable aggregate plant, operated by one man, was designed to produce 1 million tons of crushed rock for Interstate Highway 80 east of Winnemucca, Nev.[55]

All units of a limestone processing plant in Kansas were portable including grizzly, crusher, washing, and screening phases, conveyors, truck scales, pug mill, and pumps. The plant produced concrete and bituminous mix, road-base material, and agstone (agricultural stone). A truck-mounted diesel-electric unit supplied power, and a testing laboratory for quality control was installed in a truck trailer.[56]

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[51] Moorhead, G. A. Rock Ripping at Long Mountain, Jamaica. Mine & Quarry Eng. (London), v. 28, No. 4, April 1962, pp. 146–151.

[52] North, R. Fine Grinding. Quarry Managers' J. (London), v. 46, No. 7, July 1962, pp. 285–291.

[53] De Zordo, B. (Bergamo, Italy). Automatic Machine for Lapping of Marble Slabs and Other Similar Stones. U.S. Pat. 3,026,653, Mar. 27, 1962.

[54] Ironman, Ralph. This Conveyor Lives Up to Its Name. Rock Products, v. 65, No. 7, July 1962, pp. 78–82.

[55] Rock Products. Here's a Portable Pacesetter. V. 65, No. 3, March 1962, pp. 93–95.

[56] Herod, Buren C. Kansas Producer Capitalizes on Complete Mobility. Pit and Quarry, v. 54, No. 10, April 1962, pp. 146–150.

Strontium

By Arnold M. Lansche[1] and Victoria R. Schreck[2]

CONSUMERS of stronium minerals continued to depend on imports for their supply. The domestic strontium-mining industry was inactive in 1962.

LEGISLATION AND GOVERNMENT PROGRAMS

The General Services Administration offered for sale, at its warehouse in Point Pleasant, W. Va., about 12,500 short tons of celestite ore; 9,632 tons were of Spanish origin, and the remainder was obtained from Mexico. All the ore, or quantities as small as 50 short tons, could be bought by bidding.

DOMESTIC PRODUCTION

The celestite deposit of Pan Chemical Co. in the Fish Creek Mountains, San Diego County, Calif., was inactive in 1962. As a result, no domestic production of strontium minerals was reported for the third consecutive year.

Imported celestite was converted to strontium chemicals by E. I. du Pont de Nemours & Co., Inc., at Grasselli, N.J.; Foote Mineral Co. at Exton, Pa.; and Inorganic Chemicals Division, FMC Corp., Modesto, Calif.

Information regarding the production of stronium metal was not available for 1962.

CONSUMPTION AND USES

New uses for strontium metal or strontium compounds were not reported. Celestite continued to be the chief mineral used for manufacturing strontium chemicals. These chemicals were utilized in pyrotechnics requiring a brilliant red flame, such as in tracer bullets, distress signal rockets and flares, military signal flares, transportation warning fusees, and fireworks. Other uses included ceramics, greases, caustic soda refining, plastics, luminous paints, and the preparation of high-purity electrolytic zinc.

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[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

Radioactive strontium 90 titanate was used as the heat source for the thermoelectric generation of electricity which powered buoy channel markers, remote site weather stations in Antarctica and the Arctic, and in space satellites.

PRICES

Prices of various strontium compounds were quoted in Oil, Paint and Drug Reporter throughout 1962 as follows: Strontium sulfate, air-floated, 90 percent, 325 mesh, bags, works, $56.70 to $66.15 per short ton; strontium carbonate, pure, drums, 5-ton lots or more, works, 35 cents per pound; drums, 1-ton lots, works, 37 cents per pound; technical-grade, drums, works, 19 cents per pound; and strontium nitrate, bags, carlots, works, $11 per 100 pounds and bags, less than carlots, works, $12 per 100 pounds. These prices were unchanged from those in 1961.

FOREIGN TRADE [3]

Quantity and value of strontium minerals imported declined 25 and 23 percent, respectively, below the 1961 figures. Mexico supplied 61 percent of the 1962 imports. Minor quantities, valued at $157, of strontium chemicals (carbonate, nitrate, and oxide) were imported in 1962.

TABLE 1.—U.S. imports for consumption of strontium minerals,[1] by countries

Country	1961		1962	
	Short tons	Value	Short tons	Value
Italy	11	$2,700	27	$6,750
Mexico	2,642	48,713	4,554	98,476
United Kingdom	7,278	193,064	2,908	83,609
Total	9,931	244,477	7,489	188,835

[1] Strontianite or mineral strontium carbonate and celestite or mineral strontium sulfate.

Source: Bureau of the Census.

WORLD REVIEW

World production of stronium minerals declined 31 percent compared with 1961, whereas output in Mexico increased 72 percent. Mexico, for the first time, surpassed the United Kingdom in production of strontium minerals.

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

TABLE 2.—Free world production of strontium minerals, by countries [1] [2]

(Short tons)

Country [1]	1958	1959	1960	1961	1962
Argentina	240	(3)	(3)	(3)	(3)
Italy	703	353	915	1,179	[4] 700
Mexico [5]	2,336	2,182	2,880	2,642	4,554
Morocco	1,124	435			
Pakistan	510	744	1,492	461	[4] 325
United Kingdom	6,272	6,720	7,396	9,720	[4] 4,000
United States		(6)			
Free world total [1]	11,185	[4] 10,700	[4] 12,900	[4] 14,300	[4] 9,800

[1] Strontium minerals are produced in Germany, Poland, and the U.S.S.R., but data on production are not available; no estimates are included in the total for these countries.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Data not available; estimate included in total.
[4] Estimate.
[5] U.S. imports.
[6] Figure withheld to avoid disclosing individual company confidential data; included in world total.

Compiled by Helen L. Hunt, Division of Foreign Activities.

TECHNOLOGY

Production of a megacurie quantity of strontium 90 was reported completed at the Hanford Laboratories of the Atomic Energy Commission. The purified material, a year in preparation, was to be converted to the titanate and pelletized for use in a series of thermoelectric power devices.[4] At Hanford the strontium 90 was adsorbed on solid sodium aluminum silicate or compounded as strontium carbonate ($SrCO_3$). The strontium material was shipped to the Fission Products Development Laboratory, Oak Ridge National Laboratory, Oak Ridge, Tenn., where it was dissolved with 28.5 percent ammonium nitrate or 6 percent nitric acid. A batch of the nitrate solution containing about 0.4 pound total strontium ion—equivalent to 15,000 curies of radiation—was reacted in a titania (TiO_2) slurry with ammonium hydroxide and ammonium carbonates to obtain strontium carbonate. The filtered mixture of $SrCO_3$ and TiO_2 was calcined for four hours at 2,012° F to produce strontium titanate. The titanate powder was compressed at 11,000 pounds per square inch to obtain pellets which were sintered for 8 hours at 2,552° F to yield a ceramic material containing about 2,000 curies of strontium 90 per cubic inch.[5]

A report was published on the strontium 90 content of the 1959 wheat crop of 18 Western and Midwestern States. Oklahoma wheat was found to have the highest average content for that year, 82.8 picocuries of strontium 90 per kilogram of wheat.[6] Analysis of lowland rice grown in Japan in 1960 indicated that 60 percent of the strontium 90 content was absorbed from the soil.[7]

[4] Chemical & Engineering News. Strontium-90 Process Details Revealed. V. 40, No. 8, Feb. 19, 1962, p. 50.
[5] Chopey, N. P. Strontium-90 Process Helps Stretch Total Worth of Nuclear Fuel. Chem. Eng., v. 69, No. 1, Jan. 8, 1962, pp. 76–78.
[6] Olson, Theodore A., Jr. Strontium-90 in the 1959 United States Wheat Crop. Science, v. 135, No. 3508, March 1962, p. 1064.
[7] Ichikawa, Ryushi, Masako Eto, and Michiko Abe. Strontium-90 and cesium-137 Absorbed by Rice Plants in Japan, 1960. Science, v. 135, No. 3508, March 1962, p. 1072.

Strontium 90 concentration was reported for the Eskimo and his chief source of meat, the caribou;[8] children's bones;[9] bovine bones;[10] and milk.[11]

A method was developed for producing finely divided $SrCO_3$ and strontium sulfate ($SrSO_4$) from brine solution in which the calcium-to-strontium molar ratio is not over 7.[12] A process for the purification of strontium nitrate containing barium impurities was developed.[13]

Celestite was utilized to precipitate lead and tin from ammoniacal ore-leach solutions in a recovery process for copper, nickel, cobalt, silver, and other metals.[14]

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[8] Schulert, Arthur R. Strontium-90 in Alaska. Science, v. 136, No. 3511, April 1962, pp. 146–148.

[9] Kulp, J. Lawrence, and Arthur R. Schulert. Stronium-90 in Man. V. Science, v. 136, No. 3516, May 1962, pp. 619–632.

[10] Caldwell, D. F., and J. Werboff. Distribution of Strontium in the Bovine Skeleton. Science, v. 136, No. 3522, June 1962, pp. 1120–1121.

[11] Chemical & Engineering News. Electro-dialysis Rids Milk of Sr-90. V. 40, No. 29, July 16, 1962, pp. 43–44.

[12] Goodenough, Robert D. (assigned to The Dow Chemical Co.). Method of Producing Strontium Carbonate and Strontium Sulfate From Brines Containing Calcium and Strontium Halides. U.S. Pat. 3,029,133, Apr. 10, 1962.

[13] Bundy, Willard S., and Albert Pavlik (assigned to Barium and Chemicals, Inc.). Purification of Strontium Nitrate. U.S. Pat. 3,065,052, Nov. 20, 1962.

[14] Tschirner, H. J., and L. A. Williams (assigned to Sherritt Gordon Mines, Ltd.). Precipitation of Lead and Tin Impurities From Ammoniacal Leach Solutions by the Addition of Celestite. Canadian Pat. 653,087, Nov. 27, 1962.

Sulfur and Pyrites

By Clarence O. Babcock [1] and Betty I. Stanley [2]

PRODUCTION and consumption of sulfur in the free world reached a new high in 1962, following record highs in 1960 and 1961. Both production and consumption increased 500,000 long tons or 3 percent. Increased output was mostly in the form of elemental sulfur. U.S. production of sulfur in all forms decreased 6 percent from 1961. U.S. consumption of sulfur was at a record high, 6 percent above the previous highs in 1959 and 1961. Sales of U.S. sulfur increased in the United States and overseas but decreased in Canada. Prices were stable for most of the country but were weaker in the Chicago area due to competition from Canadian recovered sulfur. Exports from the United States were lower for the second year, and imports increased. The use of molten sulfur continued to grow, and 80 percent of the elemental sulfur shipped on the North American continent was in that form.

TABLE 1.—Salient sulfur statistics

(Long tons, sulfur content)

	1953–57 (average)	1958	1959	1960	1961	1962
United States:						
Production	5,727,052	4,645,577	4,639,816	5,037,292	5,477,493	5,025,418
All forms	6,954,390	6,141,169	6,167,740	6,660,541	[1] 7,172,479	6,757,226
Imports, pyrites and sulfur	297,880	754,987	776,888	884,838	966,417	1,194,033
Exports, sulfur	1,570,021	1,602,126	1,635,607	1,786,543	1,596,043	1,553,986
Stocks Dec. 31: Producer, Frasch and recovered sulfur	3,680,780	4,619,028	3,949,954	3,777,799	4,813,521	4,934,238
Consumption, apparent, all forms [2]	5,377,100	5,262,800	5,917,100	[1] 5,862,000	[1] 5,893,000	6,252,600
World: Production:						
Sulfur, elemental	(3)	8,245,000	8,960,000	10,220,000	11,275,000	11,640,000
Pyrites	(3)	7,600,000	7,700,000	8,200,000	8,300,000	8,400,000

[1] Revised figure.
[2] Measured by quantity sold plus imports minus exports.
[3] Data not available.

DOMESTIC PRODUCTION

Output of sulfur in all forms totaled 6.8 million long tons, 6 percent less than the 7.2-million-ton production of 1961. Recovered sulfur increased 41,000 tons (5 percent). Frasch production decreased 401,000 tons (7 percent). About 4,985,000 tons was Frasch process sulfur from Gulf Coast mines in Texas and Louisiana. Other sources were native ore, 41,000 tons; byproduct of sour-natural and refinery gases, 900,000 tons; burning of pyrites, 373,000 tons; and various forms from other sources, 453,000 tons.

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.

TABLE 2.—Production of sulfur and sulfur-containing raw materials by producers in the United States

(Long tons)

	1953-57 (average)		1958		1959		1960		1961		1962	
	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content
Native sulfur or sulfur ore:												
Frasch-process mines	5, 664, 811	5, 664, 811	4, 643, 243	4, 643, 243	4, 553, 634	4, 553, 634	4, 942, 935	4, 942, 935	5, 385, 468	5, 385, 468	4, 984, 578	4, 984, 578
Other mines	211, 044	62, 241	6, 292	2, 334	331, 237	86, 182	379, 067	94, 357	400, 015	92, 025	162, 186	40, 840
Total		5, 727, 052		4, 645, 577		4, 639, 816		5, 037, 292		5, 477, 493		5, 025, 418
Recovered elemental sulfur:												
Brimstone	416, 588	414, 700	641, 890	640, 096	688, 487	686, 407	769, 319	766, 566	[1] 861, 413	[1] 858, 169	902, 124	899, 598
Paste	625	296										
Total		414, 996		640, 096		686, 407		766, 566		[1] 858, 169		899, 598
Pyrites (including coal brasses)	995, 121	412, 476	974, 114	403, 373	1, 056, 617	436, 871	1, 016, 263	416, 213	987, 309	398, 519	915, 890	379, 046
Byproduct sulfuric acid (basis—100 percent) produced at Cu, Zn, and Pb plants	963, 531	314, 906	1, 101, 754	359, 723	969, 678	316, 600	1, 056, 890	345, 075	1, 016, 731	331, 963	1, 088, 397	355, 362
Other byproduct sulfur compounds [2]	97, 726	84, 960	106, 527	92, 400	104, 887	88, 046	114, 359	95, 395	126, 923	106, 335	115, 670	97, 787
Total		6, 954, 390		6, 141, 169		6, 167, 740		6, 660, 541		[1] 7, 172, 479		6, 757, 211

[1] Revised figure.
[2] Hydrogen sulfide and liquid sulfur dioxide. In addition, a quantity of acid sludge is converted to H_2SO_4, but is excluded from the above figures.

NATIVE SULFUR

Twelve Frasch process mines were operating at the beginning of 1962 but this was reduced to 10 by yearend. The 12 facilities were Freeport Sulphur Co. at Grande Ecaille, Garden Island Bay, Lake Pelto, and Chacahoula in Louisiana and Grande Isle off the Louisiana coast; Texas Gulf Sulphur Co. at Boling, Spindletop, Moss Bluff, and Fannett in Texas; Jefferson Lake Sulphur Co. at Long Point Dome; Duval Sulphur & Potash Co. at Orchard Dome; and United States Sulphur Corp. at High Island, all in Texas. Freeport's Chacahoula operation ended commercial production in September. United States Sulphur Corp. stopped producing at High Island in January.

Duval Sulphur & Potash Co. production from the Orchard Dome, Tex., plant was 10 percent more than in 1961 and the highest since 1953. Deep area production continued to increase.[3]

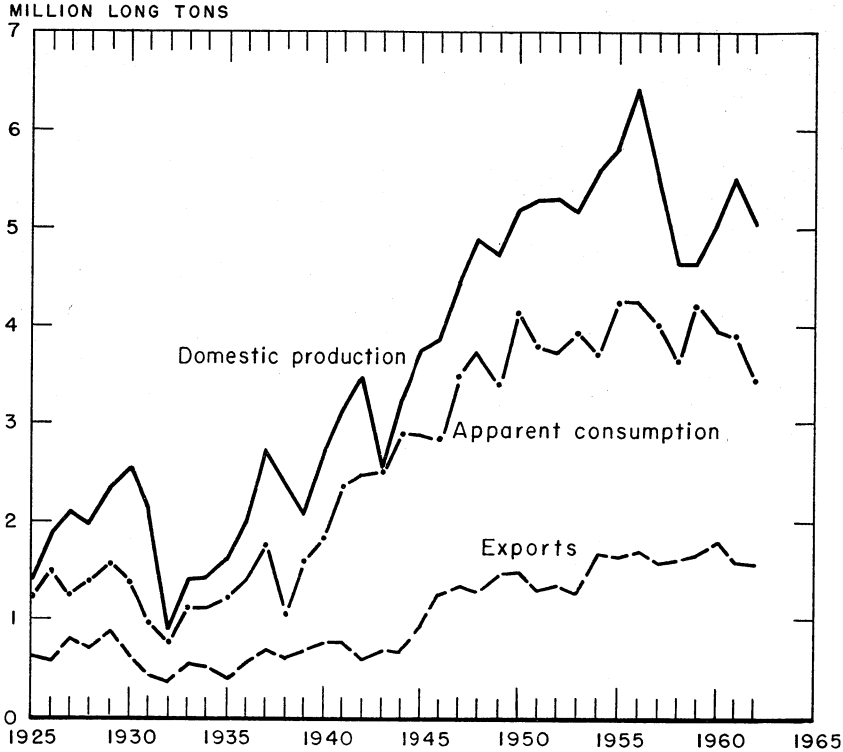

FIGURE 1.—Domestic production, apparent consumption, and exports of native sulfur, 1925–62.

[3] Duval Sulphur & Potash Co. Ann. Rept., 1962, p. 4.

Freeport Sulphur Co. Frasch production from mines in Louisiana or off the coast was below the record high of 1961, but overall sales at home and abroad increased. Reduced production was caused by lower requirements for stockpiling at mines and transshipment terminals. New transshipment terminals were completed at Nitro, W. Va.; Baton Rouge, La.; and Charleston, S.C. A second production platform was completed at the offshore sulfur mine, Grande Isle, in the Gulf of Mexico.[4] The drilling platform was expected to permit the drilling of 100 additional wells. In March a gas fire damaged the original platform, and production was suspended for 4 months while repairs were made.[5] A new research and development center at Belle Chasse, La., started operations.

The Jefferson Lake Long Point Dome, Tex., produced a record 256,000 tons of Frasch sulfur for an 11 percent increase over 230,000 tons in 1961. Trans-Jeff Chemical Corp., owned 50 percent each by Jefferson Lake and Transcontinental Gas Pipeline Corp., produced 14,000 tons of recovered sulfur from its Tilden, Tex., plant. Sales of sulfur produced in the United States was 282,000 tons—72,000 tons in the domestic market, and 210,000 tons overseas. Boiler capacity at the Long Point plant was increased by 400,000 gallons per day so that a maximum in excess of 3.0 million gallons per day could be maintained during periods of boiler cleaning and inspection.[6]

Texas Gulf Sulphur Co. production was 1 percent less than the 1961 total of 2.45 million tons. The 1962 total included 90-percent-Frasch sulfur from Texas and 10-percent (210,000 tons)-recovered sulfur from Worland, Wyo., and Okotoks and Windfall, Alberta, Canada. Production at Windfall rose almost to its rated annual capacity of 236,000 tons by the end of 1962. A 23-mile rail spur to the plant was completed in November and shipments started in December. New regional terminals for storing and reshipping molten sulfur were completed at Marseilles, Ill., Baltimore, Md., and Wilmington, N.C., and Texas Gulf Sulphur Co. had nine molten sulfur terminals.[7]

TABLE 3.—Sulfur produced and shipped from Frasch mines in the United States

Year	Produced (long tons)			Shipped	
	Texas	Louisiana	Total	Long tons	Approximate value (thousands)
1953–57 (average)	3,607,669	2,057,142	5,664,811	5,420,539	$143,899
1958	2,587,760	2,055,483	4,643,243	4,644,021	109,272
1959	2,519,090	2,034,544	4,553,634	5,222,206	121,777
1960	2,678,643	2,264,292	4,942,935	5,002,638	115,494
1961	2,777,674	2,607,794	5,385,468	5,082,585	117,884
1962	2,621,974	2,362,604	4,984,578	4,917,466	107,069

[4] Freeport Sulphur Co. Ann. Rept., 1962, pp. 3–8.
[5] Carrington, J. C. Sulphur. Eng. and Min. J., v. 164, No. 2, February 1963, pp. 144–145.
[6] Jefferson Lake Sulphur Co. Ann. Rept., 1962, p. 6.
[7] Texas Gulf Sulphur Co. Ann. Rept., 1962, pp. 5, 6.

TABLE 4.—Sulfur ore (10 to 70 percent S) produced and shipped in the United States[1]

Year	Produced (long tons)	Shipped		Year	Produced (long tons)	Shipped	
		Long tons	Value (thousands)			Long tons	Value (thousands)
1953–57 (average)	211,044	179,032	$1,414	1960	379,067	181,422	$1,732
1958	6,292	153,574	1,505	1961	400,015	177,549	1,694
1959	331,237	151,932	1,418	1962	162,186	150,550	1,439

[1] California, and Nevada (except 1954).

RECOVERED SULFUR

Production of recovered sulfur from sour-natural and refinery gases increased to 900,000 tons, 5 percent higher than in 1961. Included in the total was production from five new plants. In 1962, 64 sulfur recovery plants were operated by 46 companies in Arkansas, California, Delaware, Illinois, Indiana, Louisiana, Michigan, Minnesota, Mississippi, Montana, New Jersey, New Mexico, North Dakota, Ohio, Oklahoma, Pennsylvania, Texas, Virginia, and Wyoming. The leading producing States in descending order of production, Texas, Wyoming, California, and Delaware, provided 69 percent of the total.

The Person Field, Tex., plant of Shell Oil Co. achieved nearly 100-percent efficiency in sweetening 15 million cubic feet of natural gas per day. The process, a combination of the Girbotol process and a modified Claus process, removed nearly all of the 2.48 percent hydrogen sulfide (H_2S) and 8.80 percent carbon dioxide (CO_2) in the gas.[8]

TABLE 5.—Recovered sulfur produced and shipped in the United States

(Long tons)

Year	Production		Shipments		
	Gross weight	Sulfur content	Gross weight	Sulfur content	Value (thousands)
1953–57 (average)	416,588	414,700	382,007	380,178	$10,567
1958	641,890	640,096	592,415	590,754	15,428
1959	688,487	686,407	711,191	709,074	17,396
1960	769,319	766,566	778,079	775,214	18,163
1961[1]	861,413	858,169	834,046	831,001	18,861
1962	902,124	899,598	909,964	907,340	18,763

[1] Revised figures.

Trans-Jeff Chemical Corp. completed the expansion of its sulfur recovery plant from 27 to 90 tons of sulfur per day at Tilden, Tex., in April.

Recovered sulfur production began in March at a new Bryans Mill, Carr Co., Tex., plant. The plant, owned jointly by Shell Oil Co., Cities Service Oil Co., Humble Oil and Refining Co., Pure Oil Co., and McAlester Fuel Co., was designed to recover 130 tons of sulfur per day while cleaning 18 million cubic feet of gas.

[8] Brennen, Peter. Amine Treating of Sour Gas: Good Riddance to H_2S. Chem. Eng., v. 69, No. 22, Oct. 29, 1962, pp. 94–96.

PYRITES

Production of pyrites (ores and concentrates) totaled 916,000 long tons, 72,000 less than in 1961. The quantity of pyrites sold or consumed by producing companies totaled 895,000 tons. Of this quantity, 64,000 tons, having a sulfur content of 31,000 tons and valued at $359,000, was sold; and 831,000 tons, having a sulfur content of 338,000 tons and valued at $6,325,000, was consumed.

Tennessee was the leading pyrite-producing State by a wide margin. Next in decreasing order of production were Colorado, Pennsylvania, California, Arizona, Virginia, and South Carolina.

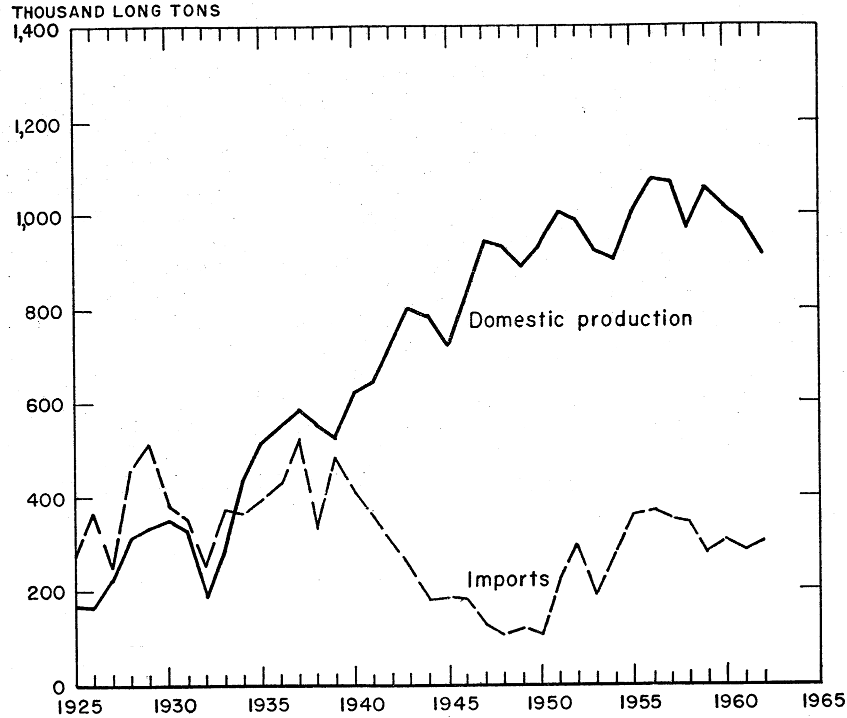

FIGURE 2.—Domestic production and imports of pyrites, 1925–62.

TABLE 6.—Production and shipments of pyrites (ores and concentrates) in the United States

(Long tons)

Year	Production		Value (thousands)	Shipments		Value (thousands)
	Gross weight	Sulfur content		Gross weight	Sulfur content	
1953–57 (average)	995, 121	412, 476	$7, 877	159, 364	76, 519	$1, 101
1958	974, 114	403, 373	7, 987	116, 282	55, 558	801
1959	1, 056, 617	436, 871	8, 148	131, 685	63, 456	868
1960	1, 016, 263	416, 213	7, 936	150, 281	72, 205	901
1961	987, 309	398, 519	7, 418	117, 957	56, 870	816
1962	915, 890	379, 046	6, 809	64, 476	31, 382	359

General Chemical Division of Allied Chemical Corp. closed down the Gossan mine, Carroll County, Va., on March 3.

The last pyrite producer in California, the Shasta County Hornet mine of Mountain Copper Co., was placed on a care and maintenance basis.

BYPRODUCT SULFURIC ACID

Copper and zinc plants in the United States produced 1,219,000 short tons (100 percent basis) of byproduct sulfuric acid, compared with 1,139,000 tons in 1961. Output increased 7 percent from 1961 and was the highest since 1958, when 1,234,000 tons was produced.

Production increases of 11 percent for copper plants and 5 percent for zinc plants reflected increased smelter activity. The acid was produced from the smelting of sulfide ores.

OTHER BYPRODUCT-SULFUR COMPOUNDS

Hydrogen sulfide and sulfur dioxide were recovered from 10 plants owned by 9 companies in California, Louisiana, Michigan, New Jersey, Pennsylvania, and Tennessee. The hydrogen sulfide production was from oil refineries, and the sulfur dioxide was from smelter gases.

TABLE 7.—Byproduct sulfuric acid [1] (basis, 100 percent) produced at copper, zinc, and lead plants in the United States

(Short tons)

Plants	1953–57 (average)	1958	1959	1960	1961	1962
Copper [2]	340,178	495,576	282,461	412,845	362,630	403,683
Zinc [3]	738,977	738,385	803,578	770,872	776,109	815,322
Total	1,079,155	1,233,961	1,086,039	1,183,717	1,138,739	1,219,005

[1] Includes acid from foreign materials.
[2] Includes acid produced at a lead smelter. Excludes acid made from pyrite concentrates in Arizona, Montana, Tennessee, and Utah.
[3] Excludes acid made from native sulfur.

CONSUMPTION

Apparent U.S. consumption of sulfur in all forms reached a record high of 6,252,600 long tons, 6 percent above the revised figure of 5,893,000 tons used in 1961. Apparent native sulfur consumption increased 4 percent to 4,071,000 tons. Recovered sulfur consumption (measured by sales and imports) increased 19 percent to 1,205,000 tons in 1962. Apparent pyrite consumption decreased 3 percent to 523,600 tons.

Free world consumption was 18.4 million tons, a 3 percent increase over the 17.9 million tons for 1961. Overseas consumption reached a new high for the 10th consecutive year. Elemental sulfur was responsible for the entire increase.[9]

[9] Gittinger, Leonard B. Sulphur. Min. Cong. J., v. 49, No. 2, February 1963, pp. 116–118.

STOCKS

On December 31, producer stocks of Frasch sulfur totaled 4,841,000 tons, 3 percent more than the 4,691,000 tons on hand December 31, 1961. This included 4,134,000 tons at the mines and 707,000 tons elsewhere. Producers' stocks of recovered sulfur were 93,000 tons at yearend, down from 1961 stocks. Pyrite stock data were unavailable.

Eighty percent of the elemental sulfur shipped by domestic producers was in the molten form and this was expected to rise to 90 percent in 1963.

Sixteen new liquid-sulfur storage facilities were completed. Molten sulfur deliveries became available to all major consumers on the Atlantic and Gulf Coasts and on the Mississippi-Ohio Rivers.[10]

TABLE 8.—Production of new sulfuric acid[1] (100 percent H_2SO_4) by geographic divisions and States

(Short tons)

Division and State	1958	1959	1960	1961	1962
New England [2]	174,531	195,614	192,664	179,341	184,142
Middle Atlantic:					
New York and New Jersey	1,458,124	1,673,150	1,681,302	1,652,868	1,684,590
Pennsylvania	647,972	764,239	754,703	770,272	797,207
Total	2,106,096	2,437,389	2,436,005	2,423,140	2,481,797
North Central:					
Illinois	1,219,517	1,368,644	1,355,647	1,399,349	1,464,064
Indiana	468,993	479,064	485,297	456,372	(3)
Michigan	298,946	334,609	324,318	307,979	331,901
Ohio	607,791	767,089	742,287	684,312	661,535
Other [3]	697,879	849,807	715,137	781,046	1,361,113
Total	3,293,126	3,799,213	3,622,686	3,629,058	3,818,613
South:					
Alabama	243,899	309,516	312,996	242,996	319,218
Delaware and Maryland	1,081,210	1,153,071	1,119,452	1,077,644	1,114,025
Florida	1,830,104	2,036,707	2,272,039	2,518,215	2,737,795
Georgia	302,195	345,552	337,140	345,775	384,010
Kentucky and Tennessee	893,530	1,014,735	997,379	1,024,717	(4)
Louisiana	653,573	640,180	595,232	598,534	675,159
North Carolina	119,613	149,774	131,221	133,115	140,591
South Carolina	133,748	152,241	142,652	149,493	143,250
Texas	1,600,683	1,674,284	1,593,303	1,585,307	1,885,553
Virginia	469,182	504,223	460,098	448,839	467,122
Other [4]	496,206	541,565	584,181	606,031	1,759,087
Total	7,823,943	8,521,848	8,545,693	8,730,666	9,625,810
West [5]	1,882,727	1,950,384	2,288,142	2,095,837	2,322,500
Total United States	15,280,423	16,904,448	17,085,190	17,058,042	18,432,862

[1] Includes data for Government-owned and privately operated plants.
[2] Includes data for plants located in Maine, Massachusetts, and Rhode Island.
[3] Includes data for plants located in Iowa (1961 and 1962), Indiana, Kansas, Minnesota, Missouri, and Wisconsin. Data for Indiana for prior years were reported separately.
[4] Includes data for plants located in Arkansas, Kentucky, Mississippi, Oklahoma, Tennessee, and West Virginia. Data for Kentucky and Tennessee for prior years were reported separately.
[5] Includes data for plants located in Arizona, California, Hawaii, Idaho, Montana, Nevada, New Mexico, Utah, Washington, and Wyoming. Also includes data for Colorado for 1960 and 1961. (Data for Hawaii not included for 1959.)

Source: U.S. Department of Commerce.

[10] Work cited in footnote 9.

TABLE 9.—Apparent consumption of native sulfur in the United States

(Long tons)

	1953–57 (average)	1958	1959	1960	1961	1962
Apparent sales to consumers [1] [2]	5,448,662	4,663,625	5,225,245	5,129,300	[3] 4,854,809	4,873,021
Imports	149,740	590,687	642,488	607,235	648,910	752,130
Total	5,598,402	5,254,312	5,867,733	5,736,535	[3] 5,503,719	5,625,151
Exports:						
Crude	1,543,431	1,577,919	1,612,158	1,775,526	1,585,531	1,537,419
Refined	26,590	24,207	23,449	11,017	10,512	16,567
Total	1,570,021	1,602,126	1,635,607	1,786,543	1,596,043	1,553,986
Apparent consumption	4,028,381	3,652,186	4,232,126	3,949,992	[3] 3,907,676	4,071,165

[1] Production adjusted for net change in stocks during year.
[2] Includes native sulfur from mines that do not use Frasch process. A small quantity was consumed before 1954; however, this tonnage was not included in these figures.
[3] Revised figure includes 451,119 tons not previously recorded.

TABLE 10.—Apparent consumption of sulfur in all forms in the United States [1]

(Long tons)

	1953–57 (average)	1958	1959	1960	1961	1962
Native sulfur	4,028,400	3,652,200	4,232,100	3,950,000	[2] 3,907,700	4,071,200
Recovered sulfur:						
Sales	388,240	590,800	709,100	775,200	[3] 831,000	907,300
Imports	(4)	(4)	(4)	134,100	182,600	297,300
Pyrites:						
Domestic production	412,460	403,400	436,900	416,200	398,500	379,000
Imports	148,140	164,300	134,400	146,000	134,900	144,600
Total pyrites	560,600	567,700	571,300	562,200	533,400	523,600
Smelter-acid production	314,920	359,700	316,600	345,100	332,000	355,400
Other productions [5]	84,940	92,400	88,000	95,400	106,300	97,800
Grand total	5,377,100	5,262,800	5,917,100	5,862,000	[2] 5,893,000	6,252,600

[1] Crude sulfur or sulfur content.
[2] Revised figure includes 451,119 tons not previously recorded.
[3] Revised figure.
[4] Data included with imports in table 9. Not separately available before 1960.
[5] 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 figure.

TABLE 11.—Liquid sulfur regional storage and transshipment terminals in operation in 1962

Producer controlled terminals	Number of storage tanks	Total storage capacity (thousand long tons)
Freeport Sulphur Co.:		
Baton Rouge, La.[1]	1	6.5
Bucksport, Me.	2	20.0
Charleston, S.C.[1]	1	10.0
Everett, Mass.	1	10.0
Joliet, Ill.	3	30.0
Nitro, W. Va.[1]	2	18.0
Tampa, Fla.	4	40.0
Warners, N.J.	2	12.5
Wellsville, Ohio	2	20.0
Total	18	167.0
Gulf Sulphur Corp.:		
Baltimore, Md.[1]	1	10.0
Tampa, Fla.[1]	1	10.0
Total	2	20.0
Pan American Sulphur Co.:		
Baltimore, Md.[1]	1	10.0
Newark, N.J.[1]	1	10.0
Tampa, Fla.[2]	3	30.0
Total	5	50.0
Texas Gulf Sulphur Co.:		
Baltimore, Md.[1]	2	24.0
Carteret, N.J.	2	26.0
Cincinnati, Ohio	3	16.8
Jacksonville, Fla.	1	11.0
Marseilles, Ill.[1]	1	10.0
Norfolk, Va.	2	20.8
Savannah, Ga.	1	11.0
Tampa, Fla.	1	7.5
Wilmington, N.C.[1]	1	8.0
Total	14	135.1

[1] Began operating in 1962.
[2] One additional storage tank of 10,000 ton capacity added in 1962.

PRICES

Posted prices of Frasch sulfur in the United States remained unchanged at $25 per long ton, f.o.b. Gulfports, for bright sulfur with a discount of $1 per ton for off-color material. Prices f.o.b. mine were $1.50 below port prices. Eighty percent of the Frasch sales in the United States were in the form of molten sulfur, much of which was delivered from terminals near major consuming areas. Prices for sulfur delivered from such terminals included transportation costs and terminal charges and tended to reflect competitive conditions within the distribution area.

Canadian sulfur on the Chicago market caused a general price decline of 5 to 6 percent in the area. Reduction in rail rates and an official 7.5 percent discount on the Canadian dollar were reflected in the decline. U.S. producers raised the competitive allowance from $1.50 to about $3.00 per ton in that area. Where Mexican competition was a factor, a $1.50-per-ton competitive allowance was in effect.[11]

Domestic prices were stabilized by the end of the year, but quotations for 1963 deliveries in overseas markets had weakened considerably.[12]

Overseas delivered prices, all cost and freight per ton, were: U.S. Frasch, Mexican Frasch, or French recovered sulfur to Western Europe, $27.50 to $31.00 for bright sulfur and $1.00 less for off-color sulfur; U.S. Frasch to India (50 percent in U.S. vessels), $40.00 to $41.00, and to Southeast Asia and Australia, $32.00 to $34.00; Canadian recovered sulfur to Southeast Asia and Australia, $29.00 to $33.00; Mexican, Canadian, and French production to South Africa, $28.50; and deliveries to South America, $31.00 to $33.00.

[11] Oil, Paint and Drug Reporter. Sulfur: Chicago Price Down as Canadians Dent the Market. V. 183, No. 2, Jan. 14, 1963, pp. 4, 27.
[12] Work cited in footnote 9.

Prices for European pyrites remained stable. Spanish crude fines pyrites, Rio Tinto, was $8.40 and Tharsis, $8.54 per ton, 48 percent sulfur, f.o.b.[13]

FOREIGN TRADE [14]

Imports.—Elemental sulfur imports rose 26 percent to a new record of 1,049,000 tons from 831,000 tons in 1961. Included in this total was 752,000 tons from Mexico and 297,000 tons from Canada. Imports from Mexico increased 16 percent from 649,000 tons in 1961 to 752,000 tons in 1962. Recovered sulfur imports from Canada increased 63 percent from 182,000 tons in 1961 to 297,000 tons. Imports of pyrites rose to 302,000 tons from 282,000 in 1961. Reduced rail rates and a 7.5-percent discount on the Canadian dollar aided imports from Canada to the Northwest and Chicago areas. Mexican imports were shipped primarily to the Eastern United States.

Exports.—Exports of sulfur by U.S. producers decreased 3 percent from 1,596,000 tons in 1961 to 1,554,000 tons. Reduction in exports to Canada was largely responsible for the decrease.

Major exports went to the United Kingdom, 257,000 tons; India, 239,500 tons; Australia, 124,000 tons; and Brazil, 124,000 tons. All sales of U.S. sulfur outside the North American continent were handled by Sulphur Export Corp., jointly owned by four major Frasch producers.

TABLE 12.—U.S. imports for consumption and exports of sulfur

Year	Imports				Exports			
	Ore		In any form, n.e.s.[1]		Crude		Crushed, ground, refined, sublimed, and flowers	
	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)
1953-57 (average)	10,798	$265	138,942	[2] $3,442	1,543,431	$45,174	26,590	$1,974
1958	18,906	445	571,781	13,106	1,577,919	39,507	24,207	1,932
1959	11,593	255	630,895	13,646	1,612,158	39,975	23,449	2,025
1960	103,281	2,268	638,089	13,185	1,775,526	40,880	11,017	1,413
1961	94,181	1,934	737,336	15,218	1,585,531	35,370	10,512	1,254
1962	448,132	8,618	601,301	11,957	1,537,419	35,496	16,567	1,799

[1] Not elsewhere specified.
[2] Data known to be not comparable with other years.

Source: Bureau of the Census.

[13] Sulphur (London). No. 43, December 1962, pp. 2–3.
[14] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 13.—U.S. imports for consumption of sulfur, by countries

Country	1961				1962			
	Ore		In any forms, n.e.s.[1]		Ore		In any forms, n.e.s.[1]	
	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)
North America:								
Canada	70,154	$1,427	112,431	$2,409	178,382	$2,846	118,898	$2,191
Mexico	24,027	507	624,883	12,804	269,750	5,772	482,380	9,761
Total	94,181	1,934	737,314	15,213	448,132	8,618	601,278	11,952
Europe: Germany, West	-------	-------	22	5	-------	-------	23	5
Grand total	94,181	1,934	737,336	15,218	448,132	8,618	601,301	11,957

[1] Not elsewhere specified.

Source: Bureau of the Census.

TABLE 14.—U.S. exports of sulfur, by countries

Destination	Crude				Crushed, ground, refined, sublimed, and flowers			
	1961		1962		1961		1962	
	Long tons	Value (thousands)	Long tons	Value (thousands)	Pounds	Value (thousands)	Pounds	Value (thousands)
North America:								
Canada	302,221	$7,028	176,646	$4,589	2,055,169	$200	2,612,338	$254
Central America	4,088	110	2,605	62	695,306	30	664,544	29
Mexico	-------	-------	425	14	418,412	58	420,700	55
West Indies	19,140	436	12,545	287	127,146	4	89,543	3
Total	325,449	7,574	192,221	4,952	3,296,033	292	3,787,125	341
South America:								
Argentina	24,176	554	20,305	469	202,300	44	366,470	56
Bolivia	2,311	51	-------	-------	-------	-------	-------	-------
Brazil	133,139	3,041	123,232	2,911	540,065	110	671,619	128
Chile	-------	-------	5,904	138	42,200	11	103,050	12
Colombia	-------	-------	2,468	58	208,805	22	1,039,601	42
Ecuador	74	3	-------	-------	71,546	3	53,396	2
Paraguay	3,074	77	91	3	-------	-------	-------	-------
Peru	10,130	230	10,517	246	198,661	17	180,631	17
Uruguay	4,348	108	5,126	125	72,922	5	33,196	2
Venezuela	6,197	174	9,800	258	5,051,417	113	625,788	48
Total	183,449	4,238	177,443	4,208	6,387,916	325	3,073,751	307
Europe:								
Austria	9,500	214	19,705	447	-------	-------	44,100	7
Belgium-Luxembourg	43,500	969	58,452	1,335	-------	-------	3,500	1
Czechoslovakia	21,000	470	44,500	1,012	-------	-------	-------	-------
Finland	23,600	535	7,200	166	-------	-------	-------	-------
France	62,600	1,373	83,539	1,883	28,000	2	115,580	4
Germany, West	56,495	1,272	39,980	915	621,375	104	117,518	16
Greece	-------	-------	-------	-------	21,704	1	15,483,369	511
Ireland	19,637	452	35,216	820	4,977	(1)	15,250	1
Netherlands	83,976	1,799	87,621	1,924	8,718	(1)	-------	-------
Norway	1,604	36	885	21	160,000	4	324,500	9
Spain	-------	-------	4,277	98	58,150	12	70,200	14
Sweden	5,615	127	1,800	40	12,740	(1)	31,910	5
Switzerland	37,077	836	21,815	506	120,600	22	-------	-------
United Kingdom	285,511	5,998	257,233	5,560	-------	-------	2,000	(1)
Yugoslavia	-------	-------	-------	-------	43,720	4	151,986	6
Other	-------	-------	-------	-------	10,000	(1)	2,000	(1)
Total	650,115	14,081	662,223	14,727	1,089,984	149	16,361,913	574

See footnotes at end of table.

TABLE 14.—U.S. exports of sulfur, by countries—Continued

Destination	Crude				Crushed, ground, refined, sublimed, and flowers			
	1961		1962		1961		1962	
	Long tons	Value (thousands)	Long tons	Value (thousands)	Pounds	Value (thousands)	Pounds	Value (thousands)
Asia:								
Ceylon	–	–	–	–	1,552,220	$28	4,500	$1
India	120,572	$2,734	237,363	$5,625	4,222,542	144	5,599,808	222
Indonesia	5,735	138	2,500	60	279,600	15	183,550	9
Iran	–	–	–	–	151,541	12	20,000	1
Israel	18,400	380	77	2	283,326	17	227,593	19
Japan	–	–	498	15	153,883	28	56,521	10
Jordan	20	1	–	–	752,576	15	781,387	21
Korea, Republic of	7,631	208	4,656	118	1,318,449	29	165,541	4
Lebanon	255	6	104	2	175,061	6	396,687	15
Malaya, Federation of	–	–	–	–	707,422	20	9,000	1
Pakistan	3,024	75	4,101	104	226,619	6	72,507	3
Philippines	1,121	29	1,114	28	738,840	36	1,131,513	38
Saudi Arabia	2,709	74	1,032	34	1,135,850	19	1,488,605	26
Taiwan	984	20	2,387	51	–	–	–	–
Turkey	–	–	–	–	73,912	1	669,978	16
Other	2,368	62	1,519	41	32,420	2	383,356	12
Total	162,819	3,727	255,351	6,080	11,804,261	378	11,190,546	398
Africa:								
Congo, Republic of the, and Ruanda-Urundi	–	–	–	–	–	–	421,514	10
South Africa, Republic of [2]	46,163	952	44,010	966	517,977	67	1,546,240	91
United Arab Republic, (Egypt)	–	–	83	2	19,140	3	21,800	3
Other	5,412	123	8,878	191	3,000	1	120,761	8
Total	51,575	1,075	52,971	1,159	540,117	71	2,110,315	112
Oceania:								
Australia	141,454	3,076	124,266	2,700	70,900	15	351,993	42
New Zealand	70,670	1,599	72,944	1,670	357,783	24	233,900	25
Total	212,124	4,675	197,210	4,370	428,683	39	585,893	67
Grand total	1,585,531	35,370	1,537,419	35,496	23,546,994	1,254	37,109,543	1,799

[1] Less than $1,000.
[2] Effective Jan. 1, 1962; formerly Union of South Africa.

Source: Bureau of the Census.

TABLE 15.—U.S. imports for consumption of pyrites, containing more than 25 percent sulfur, by customs districts

(Long tons)

Customs district	1953–57 (average)	1958	1959	1960	1961	1962
Buffalo	[1] 62,596	296,002	230,606	244,103	249,230	262,580
Chicago					52	
Connecticut	3		262			
Massachusetts						1
Michigan	[1] 14,108	16,768	13,182	11,870	12,583	16,379
Montana and Idaho				37	14	
New York	(2)	217				
Pittsburgh	300					
Rochester	42					1
St. Lawrence	5,755	13,373	14,640	21,338		
San Francisco						104
Vermont	9,460	16,523	21,948	28,868	19,725	22,834
Washington	7	177				
Total:						
Long tons	[1] 92,271	343,060	280,638	306,216	281,604	301,899
Value	[1] $472,715	$1,193,973	$868,495	[1] $1,075,271	$741,942	$746,644

[1] In addition to data shown, estimated amounts were imported through the Buffalo customs district: 1954, 232,920 long tons ($627,620); 1956, 292,520 long tons ($865,020); 1957, 282,400 long tons ($889,100); 1955, Buffalo customs district, 277,020 long tons ($706,840) and 840 long tons ($4,900) through the Michigan customs district.

[2] Less than 1 ton.

Source Bureau of the Census.

WORLD REVIEW [15]

NORTH AMERICA

Canada.—Production of sulfur in all forms, measured by shipments, was 855,000 tons in 1961, 39,000 tons less than the 894,000 tons for 1960. Of this total, 223,000 tons was sulfur contained in pyrites; 278,000 tons was the sulfur equivalent of smelter gases; and 354,000 tons was elemental sulfur recovered from natural gas and from treating nickel sulfide matte at Port Colborne, Ontario.[16] A preliminary estimate indicated that production in all forms measured by shipments was 1,089,000 tons in 1962. Of this total, 236,000 tons was sulfur contained in pyrites; 256,000 tons of sulfur contained in smelter gases; and 597,000 tons elemental sulfur.

[15] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.

[16] Bartley, C. M. Sulfur. Canadian Mineral Industry 1961 (Preliminary). Canada Dept. Mines and Tech. Surveys, Ottawa, September 1962, 64 pp.

TABLE 16.—World production of elemental sulfur by countries [1] [2]

(Long tons)

Country	1958	1959	1960	1961	1962
Native sulfur:					
Frasch:					
Mexico	1,201,483	1,293,181	1,261,574	1,148,494	1,350,375
United States	4,643,243	4,553,634	4,942,935	5,385,468	4,984,578
Total	5,844,726	5,846,815	6,204,509	6,533,962	6,334,953
From sulfur ores:					
Argentina	31,545	25,207	39,265	22,183	[3] 29,000
Bolivia (exports)	392	----------	1,175	4,896	7,247
Canary Islands	2,900	2,900	3,900	4,900	[3] 4,900
Chile	24,015	21,676	30,900	43,994	[3] 44,000
China [3]	70,000	100,000	120,000	120,000	120,000
Colombia	6,693	8,824	8,899	9,941	[3] 10,000
Italy	154,137	119,272	79,703	68,668	53,068
Japan [4]	178,052	215,669	243,684	238,456	220,438
Mexico	35,446	[3] 17,700	[3] 17,700	25,116	26,751
Philippines	1,200	----------	43	158	926
Poland	9,200	10,500	25,000	130,220	197,000
Spain	3,055	2,851	1,336	----------	----------
Taiwan	6,178	5,533	5,725	5,472	5,516
Turkey	12,622	13,174	16,830	15,506	18,247
U.S.S.R. [3]	400,000	600,000	800,000	900,000	950,000
United Arab Republic (Egypt)	1,425	1,200	3,500	9,000	[3] 9,000
United States	2,334	86,182	94.357	92,025	40,840
Total [3] [5]	940,000	1,230,000	1,490,000	1,690,000	1,740,000
Total native sulfur	6,785,000	7,080,000	7,700,000	8,225,000	8,070,000
Other elemental:					
Recovered:					
Bulgaria [6]	2,800	4,000	5,000	5,000	[3] 5,000
Canada (sales) [7]	84,265	130,050	244,963	352,466	596,541
China [3] [6]	100,000	100,000	120,000	120,000	120,000
France [8]	126,542	419,273	778,157	1,080,013	1,329,000
Germany:					
East	104,679	106,153	100,130	115,000	[3] 115,000
West	75,566	78,474	82,807	82,861	90,666
Iran [9]	12,800	[3] 19,000	[3] 19,000	[3] 19,000	[3] 15,000
Italy [3]	4,000	4,000	3,200	2,000	2,000
Japan [9]	7,889	7,829	8,326	8,163	8,549
Mexico [8]	27,641	46,231	46,839	52,849	47,939
Netherlands [6]	20,800	30,700	30,000	28,000	28,000
Netherlands Antilles: Aruba [3]	30,000	30,000	30,000	9,900	10,100
Norway [6]	89,126	77,111	71,254	61,156	45,175
Portugal [6]	17,373	15,888	10,915	8,813	6,637
Spain [6]	25,251	25,719	40,194	48,323	41,667
Sweden [10]	33,465	37,576	38,000	30,500	[3] 30,500
Taiwan [9]	----------	810	875	1,968	2,130
Trinidad [3] [9]	5,000	5,000	5,000	5,000	5,000
South Africa, Republic of [9]	----------	----------	----------	2,163	1,913
U.S.S.R. [3]	(11)	(11)	50,000	100,000	110,000
United Arab Republic (Egypt)	[3] 3,000	2,403	2,345	2,545	[3] 2,500
United Kingdom [12]	49,561	53,173	62,402	58,405	[3] 59,000
United States	640,096	686,407	766,566	858,169	899,598
Total other elemental	1,460,000	1,880,000	2,520,000	3,050,000	3,570,000
World total (estimate) [2]	8,245,000	8.960,000	10,220,000	11,275,000	11,640,000

[1] This table incorporates some revisions.
[2] Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Estimate.
[4] Includes sulfur from mixed sulfur—sulfide ore.
[5] In some years Iran produces mine sulfur equivalent to 250–1,500 tons of sulfur. No estimates in total.
[6] From sulfide ore.
[7] Produced from natural gas, includes a small quantity derived from treatment of nickel-sulfide matte at Port Colborne, Ontario.
[8] From natural gas.
[9] From refinery gases.
[10] From shale oil.
[11] Negligible.
[12] Including sulfur recovered from petroleum refineries.

Compiled by Helen L. Hunt, Division of Foreign Activities.

TABLE 17.—World production of pyrites (including cupreous pyrites)[1][2]

(Thousand long tons)

Country [1]	1953-57 (average) gross weight	1958		1959		1960		1961		1962	
		Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content
North America:											
Canada (sales)	748	1,064	458	982	416	922	391	462	223	475	236
Cuba	1	33	17	[3] 25	[3] 12	(4)	(4)	-----	-----	-----	-----
United States	995	974	403	1,057	437	1,016	416	987	399	916	379
South America: Venezuela	[5] 37	14	4	4	1	-----	-----	-----	-----	-----	-----
Europe:											
Bulgaria:											
Pyrites	133	69	29	31	13	36	15	11	5	[3] 11	[3] 5
Pyrites concentrates	58	83	34	113	47	117	49	120	50	[3] 121	[3] 51
Czechoslovakia	313	379	[3] 143	365	[3] 144	384	148	363	141	[3] 363	[3] 141
Finland	276	249	[3] 105	259	109	255	107	265	112	463	213
France	347	327	141	290	121	273	117	281	124	201	88
Germany:											
East	139	[3] 146	51	[3] 141	49	[3] 132	46	[3] 115	40	[3] 115	[3] 40
West	575	557	224	462	189	529	210	524	221	404	173
Greece	228	160	71	127	56	161	[3] 71	185	81	[3] 197	[3] 89
Italy	1,308	1,490	677	1,498	674	1,521	692	1,555	708	1,560	712
Norway	803	780	339	732	320	820	356	722	319	780	320
Poland	156	208	75	217	79	223	83	198	76	219	82
Portugal	678	589	271	622	286	645	297	643	296	631	284
Rumania	168	202	81	231	93	263	105	259	103	259	[3] 103
Spain	2,082	2,014	931	2,086	961	2,217	1,053	2,097	1,001	2,119	1,017
Sweden	429	329	163	341	169	406	203	436	222	[3] 436	[3] 222
U.S.S.R.[3]	1,673	1,968	1,043	2,214	1,171	2,461	1,304	2,953	1,565	3,199	1,693
United Kingdom	6	3	[3] 1	1	[3] 1	(6)	(6)	(6)	(6)	(6)	(6)
Yugoslavia	223	326	130	285	114	410	164	358	143	407	163
Asia:											
China [3]	(4)	689	310	837	374	984	443	1,181	541	1,181	541
Cyprus [7]	931	1,006	483	868	416	913	438	817	392	[8] 817	[8] 391
Japan	2,802	3,306	1,378	3,336	1,396	3,634	1,517	3,869	1,624	3,937	[3] 1,673
Korea, North	(4)	(4)	(4)	(4)	(4)	(4)	(4)	[3] 394	[3] 157	[3] 394	[3] 157
Philippines	11	19	[3] 8	25	[3] 11	25	[3] 11	51	[3] 22	8	3
Taiwan	28	32	12	33	13	42	16	47	16	45	20
Turkey	29	80	39	87	42	42	20	97	46	105	51

Africa:											
Algeria	22	24	11	29	13	38	17	48	22	42	19
Morocco	3	18	6	14	5	13	5	14	5	20	7
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	26	58	24	40	17	49	19	58	[3] 25	50	[3] 21
South Africa, Republic of	298	493	205	495	195	492	[3] 197	440	176	434	[3] 174
Oceania: Australia	200	227	109	223	107	239	115	213	102	[3] 182	[3] 84
World total (estimate)[1,2]	16,100	18,100	7,600	18,400	7,700	19,600	8,200	19,800	8,300	20,100	8,400

[1] Brazil produces pyrites, but production data are not available; no estimate is included in total.

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in detail.

[3] Estimate.

[4] Data not available; estimate by senior author of chapter included in total.

[5] Average annual production 1956–57.

[6] Less than 500 tons.

[7] Tons of ore mined containing pyrites in thousand long tons: 1953–57 average, 1,334; 1958, 1,668; 1959, 1,237; 1960, 1,810; 1961, 1,836.

[8] Exports.

Compiled by Helen L. Hunt, Division of Foreign Activities.

In Western Canada at the close of 1962, 17 sulfur-recovery plants were operating, 15 in Alberta and 1 each in Saskatchewan and British Columbia. Two of these plants were new, both in Alberta. The new plants were Shell Oil Company of Canada, Ltd., Waterton and Pan American Oil Corp. (later purchased by Texas Gulf Sulfur Co.) at Windfall. Its annual production capacity of 482,000 tons made the Waterton plant the largest of such plants in North America. The annual production capacity of 228,000 tons at Windfall was expected eventually to increase to 560,000 tons. The 15 plants in Alberta had a combined annual production capacity of 1,796,000 tons; 1 plant in Saskatchewan, 2,200 tons; 1 plant in British Columbia, 103,000 tons.[17]

Natural gas production regulated sulfur production. Natural gas had to be processed to make it saleable, according to Section 38 of the Alberta Oil and Gas Conservation Board Act. Removal of propane, butane, condensates, and hydrogen sulfide (H_2S) was required. All H_2S not converted to sulfur was to be burned to sulfur dioxide (SO_2) and discharged from a stack high enough that the SO_2 concentration at ground level would meet Provincial Department of Health requirements. Petrogas Processing Ltd., plant at East Calgary used the new potassium carbonate process, and all other plants used an amine process for H_2S removal. Forecasts of production by 19 plants through 1965 and the sulfur-selling rights by plants were included.[18]

Cansulex, a group of 28 oil and gas producing companies, was organized to export and market Canadian sulfur abroad. The organization planned to market 500,000 tons of sulfur per year in the beginning, and 1.5 million tons by 1970. Permission to form Cansulex was obtained under a 1960 amendment to the Canadian Combines Act. The amendment was made to protect Canadian exports.[19] Cansulex is the Canadian counterpart of the U.S. Sulexco. Cansulex began moving into Pakistan, South Korea, and the Philippines at yearend after penetrating Indian, Taiwanian, and Malayan markets several months earlier.[20]

The new Windfall plant of Texas Gulf Sulphur Co. near Whitecourt, Alberta, planned to remove sulfur from sour gas supplied by a multifield gas complex, owned by Pan American Petroleum Corp., Hudson Bay Oil and Gas Co., and Canadian Fina Oil, Ltd. Pan American Petroleum, operator of the Whitecourt gas processing plant, was to operate the sulfur plant for Texas Gulf. Hudson Bay was the operator of the Pine Creek and Beaver Creek fields and Canadian Fina, the operator of the Windfall field. Initial production was from the Windfall field, where 110 million cubic feet of gas per day was sweetened for the California market. This gas contained 15 percent hydrogen sulfide. Gas from the Pine Creek field, containing 23.5 percent hydrogen sulfide, was to be injected into the Windfall field to maintain reservoir pressure. Later when gas from the Pine Creek and Beaver Creek fields was processed, sulfur production was to increase gradually to more than 650 tons per day. Under the agreement, Texas

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[17] Woodrooffe, H. M. Industrial Minerals, Sulfur. Canadian Min. J., v. 84, No. 2, February 1963, pp. 117–121.
[18] Brese, W. G. An Analysis of the Sulphur Industry in Alberta. Research Council of Alberta. Inf. Ser. No. 38, 1962, p. 78.
[19] Chemical Age (London). V. 88, No. 2244, July 14, 1962, p. 52.
[20] Chemical Week. V. 91, No. 25, Dec. 22, 1962, p. 48.

TABLE 18.—Sulfur recovery plants in Western Canada, 1962

Company	Location	Approximate H_2S, percent	Capacity, long tons	
			Daily	Annual
British American Oil Co., Ltd	Pincher Creek, Alberta	10	674	236,000
Do	Nevis, Alberta	6	76	27,000
Do	Homeglen-Rimbey, Alberta	4-8	250	87,500
Canadian Oil Companies, Ltd	Innisfail, Alberta	14	98	34,000
Home Oil Co., Ltd	Carstairs, Alberta	1	50	17,500
Imperial Oil Ltd	Redwater, Alberta	3	9	3,125
Jefferson Lake Petrochemicals of Canada, Ltd.	Taylor Flats, British Columbia	3	295	103,000
Do	Coleman, Alberta	14	375	131,000
Texas Gulf Sulphur Co	Windfall, Alberta	15-20	[1] 652	228,000
Petrogas Processing, Ltd	Calgary, Alberta	16	857	300,000
Royalite Oil Co., Ltd	Turner Valley, Alberta	4	29	10,300
Shell Oil Company of Canada, Ltd	Waterton, Alberta	22	1,339	482,000
Do	Jumping Pound, Alberta	3	98	34,000
Standard Oil Co. of California and others.	Nevis, Alberta	6	116	40,000
Steelman Gas, Ltd	Steelman, Saskatchewan	1	6	2,187
Texas Gulf Sulphur Co. and others	Okotoks, Alberta	35	371	129,000
Western Lease Holds, Ltd	Wildcat Hills, Alberta	4	105	37,000
Total			5,400	1,902,000

[1] Eventual capacity—1,607 long tons per day or 560,000 long tons per year.

Source: Canadian Min. J., v. 84, No. 2, p. 119.

Gulf would pay the Whitecourt owners on the basis of the sulfur processed. Also included were plans to expand the recovery plant to handle all the hydrogen sulfide produced from the gas processing operations. Texas Gulf paid part of the cost of a Canadian National Railway branch line from Whitecourt to the plant.[21]

The Waterton Gas Plant of Shell Oil Company of Canada near Pincher Creek, Alberta, went on stream. The multimillion dollar plant was to process natural gas for market and recover sulfur, condensate, and natural gasoline. The plant was expected to be the largest sulfur producer of its kind on the North American continent, producing 1,500 tons of sulfur and 7,000 to 8,000 barrels of condensate and natural gasoline per day. The Waterton gas was extremely sour and was the source of the sulfur. Both solid and liquid forms were produced and shipped by boxcar or insulated tank cars. The first overseas shipments were to Formosa.[22]

Mexico.—Production of sulfur in all forms totaled 1,414,000 tons, 16 percent more than the 1,224,000 tons produced in 1961. Production was 1,350,000 tons from two Frasch mines, 46,000 tons from refineries, and 18,000 tons from volcanic sulfur mines. Texas International Sulphur Co. did not produce in 1962. Stocks in the hands of producers on December 31, totaled 892,000 tons, 40 percent above the 639,000 tons on hand December 31, 1961. Stocks reported by actively producing companies totaled 593,000 tons. Of the sulfur on hand, 888,000 tons was Frasch, and 4,000 tons was volcanic.[23] Pan American Sulphur Co. (PASCO) shipped in excess of 1 million tons for a new high, of which a record 435,000 tons was molten. Sales reached

[21] Oil, Paint and Drug Reporter. Texas Gulf Doubles Its Bet on Canadian Sulfur. V. 181, No. 10, Mar. 5, 1962, pp. 5, 58.
[22] Northern Miner (Canada). New Shell Refinery a Leading Source of Sulphur Output. V. 47, sec. 2, No. 50, Mar. 8, 1962, p. 27.
[23] U.S. Consulate. Mexico City, Mexico. State Department Dispatch 1243, Mar. 29, 1963.

an alltime high. PASCO completed additional molten storage facilities at Tampa, Fla.; at Baltimore, Md.; and at Newark, N.J., and had seven major and two minor terminals. Construction, on port of shipment molten sulfur facilities at Coatzacoalcos, was expected to increase capacity from 20,000 to 35,000 tons by mid-1963.[24] Gulf Sulphur Corp. produced 373,000 tons for a new high, 104,000 tons, or 39 percent, over 1961. Record shipments of 377,000 tons were 164,000 tons above those for 1961. Molten sulfur shipments to the United States began in the last quarter and totaled 45,000 tons by yearend. Molten sulfur terminals were completed at Baltimore, Md.; Tampa, Fla.; and Coatzacoalcos, Veracruz, Mex. A T-2 tanker, the *S.S. Pochteca*, converted to carry 10,500 tons liquid sulfur, was placed in service in November. About 60 percent of the shipments in 1963 were expected to be molten.[25] Texas Gulf Sulphur Co. reportedly negotiated to dispose of its Mexican interests. These included installations and 370,000 tons of stockpiled sulfur at Nopalapa and sulfur concessions at Nopalapa and near Texistipec.[26] Petroleos Mexicanos (PEMEX), the nationalized petroleum concern, planned a 70-ton-per-day recovered-sulfur plant to be constructed at Rosarito, Baja Calif. Present PEMEX plants at Mexico City (on stream 1959) and at Ciudad Madero, Tampico (on stream 1961), each produced 25 tons of recovered sulfur per day.[27]

TABLE 19.—Mexico: Exports of sulfur by countries

(Long tons)

Destination	1960	1961	1962
North America:			
Canada		2,905	14,803
Cuba	4,348		
Jamaica			299
Nicaragua		3,133	4,179
United States	633,727	649,207	735,550
South America:			
Brazil	7,980		15,831
Colombia			1,851
Peru	798		
Europe:			
Belgium	56,631	53,320	30,508
France	46,128	29,525	57,963
Germany, West	37,741	23,165	7,082
Greece		4,665	
Netherlands	63,686	13,788	118,361
Spain			1,999
United Kingdom	89,034	102,356	89,492
Asia:			
India	30,506	39,497	
Indonesia	1,400	700	
Israel	25,590	14,644	59,916
Africa:			
South Africa, Republic of	66,680	62,078	70,901
Tunisia	20,838	25,157	30,073
Oceania:			
Australia	74,196	61,325	52,452
New Caledonia			5,250
New Zealand	45,907	44,059	35,546
Total	1,205,190	1,129,524	1,332,056

Source: Compiled from U.S. Embassy, Mexico, D.F., Mexico, State Department Dispatch 958: Feb. 27, 1961, p. 1; Dispatch 896: Jan. 25, 1962, p. 2; and Airgram 1243: Mar. 29, 1963, p. 2, by Bertha M. Duggan, Division of Foreign Activities.

[24] Pan American Sulphur Co. Ann. Rept., 1962, p. 2.
[25] Gulf Sulphur Corp. Ann. Rept., 1962, p. 2.
[26] Page 4 of work cited in footnote 13.
[27] Page 19 of work cited in footnote 13.

SOUTH AMERICA

Brazil.—Pyrite was to be used to produce sulfuric acid in a plant to be built near Belo Horizonte by Companhia Agricola de Minas Gerais. A $2 million National Economic Development Bank loan was to be used for capital. Future expansion was expected to include a super phosphate unit.[28]

Chile.—Caliche (60 percent sulfur) production decreased from 18,100 tons in 1960 to 7,700 tons in 1961. An estimated 60 percent of the refined sulfur and nearly all the sulfur in caliche was used locally to produce sulfuric acid.[29] A new company, the International Mineral Development Co., having an operating capital of $150 to $200 million expected to exploit new sulfur, copper, gold, silver, and other mineral deposits near Vallenar, in northern Chile.[30]

EUROPE

Bulgaria.—Production of 55,000 tons of pyrite concentrate annually was expected from a plant under construction for open pit mining of copper ore from the Medet Cooper Field. This field had reserves of 200 million tons of copper ore. Production of copper concentrate was to be 153,000 tons annually.[31]

France.—Production of sulfur at Lacq by Société Nationale des Pétroles d'Aquitaine (SNPA) reached a record high. Production was 92 percent of capacity owing to reduced output during maintenance operations. Oil refineries produced 20,000 tons of recovered sulfur and hydrogen sulfide, which was converted to sulfuric acid. Domestic brimstone consumption was 490,000 tons, 6 percent more than 1961. Consumption of imported U.S. and Mexican Frasch sulfur remained at 110,000 tons. Exports were 6 percent less than 1961 or 529,000 tons. Export markets in order of decreasing size were the United Kingdom, Belgium- the Netherlands, and West Germany. The main sources of the pyrites were the Sain Bel and Chizeuil mines of Compagnie de Saint-Gobain, S.A.[32]

Germany, West.—Recovered sulfur production was estimated at 90,000 tons, a 7 percent increase from 84,000 tons in 1961. A new recovered sulfur plant at Dinslaken by Benzin and Petroleum A.G. was responsible for the increase. Recovered sulfur production was expected to reach 110,000 tons per year after four sulfur recovery plants were completed in 1963. A significant decrease in pyrite production to 180,000 tons of sulfur equivalent was caused by the reorganization of the Meggen mine of Sachtleben A. G.[33]

Ireland.—U.S. sulfur was expected to be used in a new $1.7 million sulfuric acid plant of 70,000 tons per year capacity at Dublin. The plant, owned by Sulphac, Ltd. (a subsidiary of W. and M. Goulding, Ltd.), and Freeport Sulphur Co., was to use the Monsanto process. A similar plant erected by Sulphac at Cork over a year ago also used elemental sulfur exclusively. Other plants used pyrite. Imports

[28] Chemical Week, V. 91, No. 4, July 28, 1962, p. 31.
[29] Bureau of Mines, Mineral Trade Notes. V. 55, No. 3, September 1962, p. 67.
[30] Mining Journal (London). V. 258, No. 6607, Apr. 6, 1962, p. 344.
[31] Mining Journal (London). V. 258, No. 6609, Apr. 20, 1962, p. 395.
[32] Sulphur (London). Supply, France. No. 44, February 1963, pp. 3–5.
[33] Work cited in footnote 32.

of pyrite from Spain decreased from 39,136 tons in 1956 to 20,137 tons in 1961.[34]

Italy.—A consortium of 19 sulfur companies representing about 65 percent of the production was formed in January. Government and European Investment Bank support was requested in closing uneconomic mines and in constructing two new sulfuric acid plants and an ammonium sulfate plant in Sicily to help absorb the sulfur output.[35] Pyrites were used in a new plant at Scarlino, operated by Montecatini, Soc. Generale per l'Industria Mineraria e Chimica, to produce high quality iron ore concentrate (65 percent iron), sulfuric acid, and electrical energy. Processing 1,480 tons of pyrite daily produced 490 tons of beneficiated ore, 980 tons of concentrated sulfuric acid, and heat to operate a 9,000 kilowatt steam power plant. Expansion in 1963 was expected to double production.[36] The Minerals Law, enacted December 22, and designed to solve the Sicilian sulfur industry crisis, provided for the reorganization and control of the sulfur industry by means of a Sicilian minerals agency (Ente Minerario Siciliano). This agency planned to exert sole control of mining, production, and marketing of sulfur and its byproducts, sulfuric acid, fertilizers, and pesticides. It was to gradually close down the operating uneconomical mines and retrain and relocate the unemployed miners. Government subsidies estimated at $774 million received by the industry since 1950 prevented bankruptcy. Italy, a part of the common market since 1960, agreed to submit to the European Economic Council by August a practical plan to bring the cost of Italian sulfur in line with that of other European common market nations. The European Economic Council allowed Italy provisionally to protect its internal market from foreign sulfur until 1968.[37]

Netherlands.—Sulexco (Sulphur Export Co., a U.S. company) planned to build a molten sulfur terminal of 200,000 tons-per-year capacity at Rotterdam. The terminal to be finished about the end of 1963 was to be equipped with molten sulfur storage tanks, a melter, and auxiliaries. The terminal would be supplied by a liquid sulfur tanker. Distribution from the terminal was to be by barge and road tanker. Space for solid sulfur storage and transshipment and loading facilities for solid sulfur were planned. Current imports were for the Netherlands, Belgium, West Germany, Switzerland, and Northeast France. Sulfur consumption in this area was 600,000 tons annually, half of which was shipped through Rotterdam. Terminal facilities were to be owned locally and leased under long-term contract to Sulexco.[38]

Norway.—Orkla Grube Aktiebolag planned to close down its smelting plant next year at Thamshavn, near Trondheim because of falling prices for sulfur and pyrites and higher operating costs. The Loekken mine pyrite deposits, the source of Orkla's raw material, were approaching exhaustion.[39]

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[34] Bureau of Mines. Mineral Trade Notes. V. 54, No. 5, May 1962, pp. 33–34.
[35] Bureau of Mines. Mineral Trade Notes. V. 56, No. 3, March 1963, pp. 38–39.
[36] Steel. V. 151, No. 2, July 9, 1962, p. 70.
[37] U.S. Consulate, Palermo, Italy. State Department Dispatch 42, Jan. 25, 1963.
[38] Sulphur (London). Europe's First Liquid Sulphur Terminal at Rotterdam. No. 42, October 1962, pp. 10–11.
[39] Mining Journal (London). V. 258, No. 6613, May 18, 1962, p. 509.

Spain.—Hidro Nitro Espanola, S.A., Madrid, was building a mechanical-type multi-stage roaster at its Tarragona plant. Technical help was supplied by the German firm Chemiebau Dr. A. Zieren, GmbH. Spanish pyrites and flotation pyrites were to be used to produce sulfur dioxide for sulfuric acid manufacture in a contact plant. Waste heat was to produce steam for a turbine.[40]

United Kingdom.—Imports of elemental sulfur totaled 498,000 tons of which 237,000 tons (48 percent) was from the United States; 145,000 tons (29 percent), from France; 106,000 tons (21 percent), from Mexico; and 10,000 tons (2 percent), from Canada. The decrease in imports from the United States was offset by increased imports from Mexico and Canada. During 1962, 318,000 tons of iron pyrites was consumed in the manufacture of 419,000 tons of acid. The declining trend in the use of pyrites as a sulfurous raw material was expected to continue.[41]

ASIA

China.—Pyrite output in 1961 was derived mainly from the Hsiangshan mine in Anhwei, the Ying-te mine in Kwangtung, and various nonferrous mines. Nearly one-third of the pyrite was used to produce elemental sulfur making up nearly one-half of the elemental sulfur output. Most of the remainder was from small native sulfur and mixed sulfur and pyrite deposits. An excess of 50,000 to 80,000 tons of sulfur was exported to the Soviet bloc.[42] Reports indicated that 3,000 geologists and prospectors were searching for new mineral wealth, and pyrite was one of the minerals sought. The shortage of sulfuric acid curtailed manufacturing.[43]

Cyprus.—Production of iron pyrites was about nine times as great as that of cupreous pyrites in 1962. Exports of iron pyrites were 790,000 tons, and exports of cupreous pyrites were 106,000 tons.[44]

India.—Sulfur requirements were supplied entirely by imports, which increased to 191,000 tons in 1961. The three countries which supplied 98 percent of the total were the United States, 138,000 tons; France, 25,000 tons; and Mexico, 24,000 tons. The estimated average price increased from $32.00 per ton in 1960 to $34.50 per ton in 1961. Consumption in 1961 was 227,000 tons, of which 76 percent was used for sulfuric acid, 11 percent for carbon disulfide, 6 percent for sugar manufacture, and 7 percent for miscellaneous. Two new sulfuric acid plants began operating near the end of 1961 bringing the total to 46 plants having a total annual capacity of 591,000 tons. A large deposit of iron pyrites, averaging 40 percent sulfur, was discovered in the Amjore area.[45]

Japan.—Pyrite reserves of 29 mines totaled 174 million tons, averaging 28 percent sulfur: Proved reserves, 85 million tons; probable reserves, 44 million tons; and possible reserves, 45 million tons. Re-

[40] Chemical Age (London). V. 89, No. 2272, Jan. 26, 1963, p. 157.
[41] Sulphur (London). No. 45, April 1963, pp. 14–15.
[42] Wei, Anton W. T. Minerals in China in 1961–III. Min. J. (London), v. 258, No. 6610, Apr. 27, 1962, p. 411.
[43] U.S. Consulate, Hong Kong. State Department Dispatch 808, Feb. 15, 1963.
[44] U.S. Consulate, Nicosia, Cyprus. State Department Dispatch 428, Mar. 20, 1963.
[45] Bureau of Mines. Mineral Trade Notes. V. 55, No. 6, December 1962, pp. 37–38.

coverable quantity was about 89 million tons of average grade of 31-percent sulfur.[46]

Turkey.—The primary objectives in the development of a chemical industry were the search for sulfur deposits and the building of sulfuric acid plants.[47]

TECHNOLOGY

A method of preparing elemental sulfur from indigenous ores was reported. The ore was simultaneously burned and distilled in a fluidized bed. Heat released by burning part of the sulfur to sulfur dioxide melted the remaining sulfur. Highest distillation efficiency was obtained by keeping the temperature as low as possible, usually below 600° C. Elemental sulfur in the cinder was below 0.01 percent, and this amount was independent of the temperature. The compound sulfur ranged from 1.8 to 4.7 percent and increased with the temperature. The sulfur distilled from an ore containing 20 percent sulfur ranged from 45 to 75 percent. The rest was burned to sulfur dioxide. Richer ores gave higher values.[48]

Sulfur and zinc sulfate were produced when finely ground zinc sulfide concentrate was treated with sulfuric acid and air. The process avoided the expensive roasting step and recovered about 99 percent of the zinc from the ore.[49]

Farbenfabriken Bayer, A. G., Leverkusen, the largest chemical firm in West Germany, perfected a process to recover sulfuric acid and iron oxide from copperas ($FeSO_4 \cdot 7H_2O$) produced in the manufacture of titanium dioxide and in the pickling of iron to remove scale. Following a fluidized first stage in which the monohydrate was produced, a multiple-hearth furnace fired with sulfur was used. Molten sulfur was fed to the higher hearth to reduce the sulfur trioxide to sulfur dioxide. The advantages of firing with sulfur over coal included a threefold increase in sulfur dioxide in the gases (28 to 30 percent) and a corresponding decrease in repairs, labor, and capital. Capacity was 180,000 tons of ferrous sulfate per year. The yield was 58,000 tons of 96-percent acid and 52,000 tons of iron oxide (62 to 63 percent iron). The iron oxide was to be fed directly to blast furnaces.[50]

Molten sulfur at 150° to 225° C was used to convert the surfaces of certain oxides to sulfides so that flotation was possible. The minerals successfully converted were cerrusite, cuprite, malachite, and azurite. Particle sizes were minus 65, minus 100, or minus 200 mesh. The sulfur-to-mineral ratio was 10:1. Reaction times were from 1 to 24 hours. Temperature appeared to be more important than reaction time.[51]

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[46] Bureau of Mines. Mineral Trade Notes. V. 54, No. 6, June 1962, p. 48.
[47] Chemical Week. Turks Take First Step in Chemicals. V. 92, No. 4, Jan. 26, 1963, pp. 57–64.
[48] Ciborowski, Janusz, and Młodzin'ski. (A New Method of Preparing Elemental Sulfur from Indigenous Ore.) Prezemysł. Chem. (Mlada Bolesłau, Czechoslovakia), v. 39, No. 10, 1960, pp. 608–613. (Abs. from the SOV-STEP Program under sponsorship of U.S. Air Force.)
[49] Chemical Engineering. New Processes and Technology. V. 69, No. 16, Aug. 6, 1962, p. 119.
[50] Bureau of Mines. Mineral Trade Notes. V. 55, No. 2, August 1962, pp. 67–70.
[51] Bautista, R. G., and C. L. Sollenberger. Conversion of Metallic Oxide Mineral Surfaces to Sulphides. Eng. and Min. J., v. 163, No. 11, November 1962, pp. 81–83.

A process disposed of radioactive wastes by dispersing them in a matrix of sulfur. The process was being evaluated by E. I. du Pont de Nemours & Co., Inc. at the Atomic Energy Commission, Savannah River Laboratory, Aiken, S.C. Small-scale tests were encouraging and large-scale tests were planned. Sulfur was stable to radiation and did not undergo radiation damage or form radioactive isotopes under storage conditions.[52]

Plasticized sulfur showed promise of becoming an important pavement-marking material. It was applied to pavements in a molten state, even in wet and freezing weather, when it was impossible to apply paints. Under adverse weather conditions, it exhibited outstanding bonding characteristics and durability.[53]

Case histories of explosions which occurred with molten sulfur were described and safety measures proposed. The hazard was largely attributable to hydrogen sulfide, that was either dissolved in the molten sulfur or formed during transportation. Carbon monoxide and/or carbon disulfide might have been present in smaller quantities. Organic matter in sulfur reacted slowly to form hydrogen sulfide. A minimum concentration of 3.1 percent hydrogen sulfide in air and an ignition source were required for an explosion to occur. It was thought that static charges might cause detonation.[54]

Processes for recovering sulfur from volcanic rock, sour natural gases, papermill wastes, and other secondary sources, and bibliographical references to technical publications containing specific information on more than 50 different types of processes were published.[55] A revised brochure, Properties of Sulfur, including chemical and physical properties and a bibliography on the nuclear properties of sulfur, was published by the Texas Gulf Sulphur Co.[56] An international symposium on the biogeochemical cycle of sulfur isotopes was held at Yale University, New Haven, Conn. The role of bacteria in oxidizing or reducing sulfur or sulfur compounds was the subject of most of the papers.[57]

Sulfur was produced from sewage sludge and gypsum by a microbial process. Micro-organisms in the sludge reduced gypsum to hydrogen sulfide, which was converted into sulfur or sulfuric acid by the usual methods.[58]

A book on sulfur bonding was published, summarizing reactions of sulfur in elemental form and combined in thiols, disulfides, and polysulfides. It cited 1174 references.[59]

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[52] Chemical Engineering News. Sulfur Holds Radioactive Wastes. V. 40, No. 42, Oct. 15, 1962, p. 60.

[53] Chemical Week. Building A Road for Growth. V. 91, No. 22, Dec. 1, 1962, pp. 75–81.

[54] Donovan, J. R. Safe Handling of Molten Sulfur. Chem. Eng. Prog., v. 58, No. 1, January 1962, pp. 92–95.

[55] Shibler, B. K., and M. W. Hovey. Processes for Recovering Sulfur From Secondary Source Materials. BuMines Inf. Circ. 8076, 1962, 62 pp.

[56] Chemical Engineering Progress. V. 58, No. 9, September 1962, p. 128.

[57] Science. Sulfur Isotopes. V. 137, No. 3528, Aug. 10, 1962, pp. 470–472.

[58] Rock Products. V. 65, No. 1, October 1962, p. 14.

[59] Price, C. C., and S. Doe. Sulphur Bonding. Ronald Press Co., New York, 1962, 208 pp.

Talc, Soapstone, and Pyrophyllite

By Harold J. Drake[1] and Betty Ann Brett[2]

WORLD PRODUCTION of talc, soapstone, and pyrophyllite in 1962 remained at practically the same level as in 1961.

Domestic mine production and sales increased 1 and 7 percent, respectively. Sales of pyrophyllite rose 3 percent and sales of talc and soapstone 8 percent.

TABLE 1.—Salient talc, soapstone, and pyrophyllite statistics

(Thousand short tons and thousand dollars)

	1953–57 (average)	1958	1959	1960	1961	1962
United States:						
Mine production	680	798	792	734	[1] 762	772
Value [2]	$4,238	$4,718	$5,641	$5,378	[1] $5,277	$5,278
Sold by producers	671	694	782	722	[1] 727	777
Value	$13,735	$14,206	$17,068	$16,073	[1] $16,022	$17,882
Imports for consumption	24	23	25	24	27	26
Value	$766	$785	$861	$849	[1] $1,055	$1,069
Exports [3]	33	59	59	60	48	47
Value	$972	$1,451	$1,707	$1,893	$1,805	$2,230
World: Production	$1,920	2,270	[1] 2,580	[1] 2,770	[1] 2,940	2,930

[1] Revised figure.
[2] Partly estimated.
[3] Excludes powders—talcum (in package), face, and compact.

DOMESTIC PRODUCTION

Talc and soapstone were produced in 13 States, and pyrophyllite was produced in 3 States. New York, California, and North Carolina were the leading producers of these nonmetallic minerals.

The Montana Bureau of Mines and Geology, Great Northern Railway, and Pacific Power and Light Co. sponsored a minerals survey of industrial raw materials in northwestern Montana. Two deposits, one of which is talc, were being drilled to determine commercial possibilities.

C. K. Williams and Co., East St. Louis, Ill., acquired the Kennedy Mineral Co., Los Angeles, Calif.

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

The first talc-finishing mill in western Texas was erected at Allamoore[3] by Pioneer Talc Co. The mill was built to take advantage of extensive talc reserves and availability of shipping routes.

TABLE 2.—Crude talc, soapstone, and pyrophyllite produced in the United States, by States

State	1961		1962	
	Short tons	Value [1] (thousands)	Short tons	Value [1] (thousands)
California	161,068	$1,524	117,912	$1,339
Georgia	47,950	98	45,940	96
Maryland and Virginia	28,548	72	(2)	(2)
Nevada	3,090	33	6,157	55
North Carolina	90,711	367	100,298	433
Texas	78,214	376	73,635	387
Washington	2,927	23	2,835	11
Other States [3]	[4] 349,872	[4] 2,784	424,951	2,957
Total	[4] 762,380	[4] 5,277	771,728	5,278

[1] Partly estimated.
[2] Included with "Other States" to avoid disclosing individual company confidential data.
[3] Includes States indicated by footnote 2 and Alabama, Arkansas, Montana, New York, Pennsylvania, and Vermont.
[4] Revised figure.

TABLE 3.—Talc, soapstone, and pyrophyllite sold by producers in the United States, by classes

Year	Crude			Sawed and manufactured		
	Short tons	Value at shipping point: Total	Value at shipping point: Average per ton	Short tons	Value at shipping point: Total	Value at shipping point: Average per ton
1953–57 (average)	36,795	$262,375	$7.13	1,104	$400,906	$363.14
1958	61,287	349,471	5.70	801	400,453	499.94
1959	64,856	349,484	5.39	710	416,144	586.12
1960	44,477	240,077	5.40	860	410,194	476.97
1961	65,705	344,660	5.25	695	407,000	585.61
1962	58,699	302,841	5.16	660	416,000	630.30
	Ground [1]			**Total**		
	Short tons	Value at shipping point: Total	Value at shipping point: Average per ton	Short tons	Value at shipping point: Total	Value at shipping point: Average per ton
1953–57 (average)	633,097	$13,072,097	$20.65	670,996	$13,735,378	$20.47
1958	631,804	13,455,650	21.30	693,892	14,205,574	20.47
1959	716,837	16,302 657	22.74	782,403	17,068,285	21.82
1960	676,344	15,423,193	22.80	721,681	16,073,464	22.27
1961	[2] 661,053	[2] 15,270,294	[2] 23.10	[2] 727,453	[2] 16,021,954	[2] 22.02
1962	717,559	17,162,912	23.92	776,918	17,881,753	23.02

[1] Includes some crushed material.
[2] Revised figure.

[3] Herod, Buren C. Pioneer Talc Leads. Pit and Quarry, v. 54, No. 10, April 1962, pp. 134–136, 156.

CONSUMPTION AND USES

The increased consumption of talc, soapstone, and pyrophyllite occurred principally in the ceramic and paint industries. The ceramic industry accounted for about 33 percent, the paint industry, 17 percent, and the insecticide industry, about 10 percent of total consumption.

TABLE 4.—Pyrophyllite[1] produced and sold by producers in the United States

Year	Production (short tons)	Sales					
		Crude		Ground		Total	
		Short tons	Value	Short tons	Value	Short tons	Value
1953-57 (average)	147,383	14,517	$81,676	[2] 129,214	$1,793,141	143,731	$1,874,817
1958	155,476	20,732	135,790	122,419	1,886,531	143,151	2,022,321
1959	151,175	31,615	186,090	123,236	1,936,397	154,851	2,122,487
1960	124,631	9,849	57,269	122,508	1,792,387	132,357	1,849,656
1961	157,421	14,544	86,314	115,163	1,712,502	129,707	1,798,816
1962	125,247	(3)	(3)	(3)	(3)	133,336	1,779,075

[1] Includes sericite schist.
[2] Includes a small quantity of sawed material for 1955 only.
[3] Included with "Total" to avoid disclosing individual company confidential data.

TABLE 5.—Talc, soapstone, and pyrophyllite sold or used by producers in the United States, by uses

(Short tons)

Use	Talc and soapstone		Pyrophyllite	
	1961	1962	1961	1962
Ceramics	209,492	223,849	30,368	31,706
Foundry facings	3,092	4,116		
Insecticides	46,581	48,045	36,445	31,297
Paint	[1] 112,110	125,133	274	3,280
Paper	21,048	26,239		
Rice polishing	1,697	2,064		
Roofing	50,251	55,504		(2)
Rubber	24,806	25,466	7,136	(2)
Textile	7,538	8,447		
Toilet preparations	10,463	9,671	(2)	
Other	[3] 110,668	[3] 115,048	[4] 55,484	[4] 67,053
Total	[1] 597,746	643,582	129,707	133,336

[1] Revised figure.
[2] Included with "Other" to avoid disclosing individual company confidential data.
[3] Includes adhesive, asphalt filler, composition floor and wall tile, crayons, exports, instrument wire and cable, joint cement, refractories, stucco, vault manufacturing, and miscellaneous products.
[4] Includes uses indicated by footnote 2 and asphalt filler, battery, joint cement, plaster products, refractories, and related products.

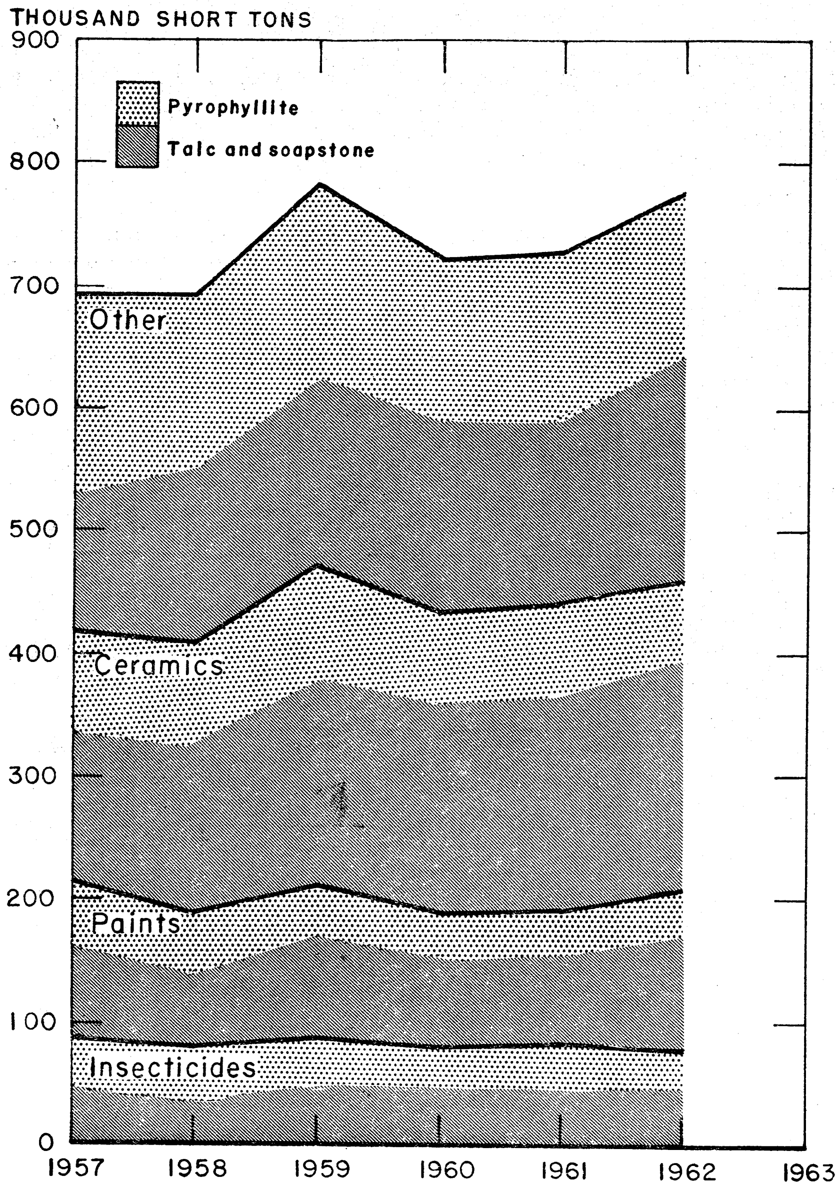

FIGURE 1.—Consumption of talc, soapstone, and pyrophyllite by major uses in the United States, 1957–62.

PRICES

Talc quotations in trade journals remained unchanged throughout 1962. Quotations in the journals indicated the range in prices; actual prices were negotiated between buyer and seller and were based on a wide range of specifications.

TABLE 6.—Prices quoted on ground talc, in bags, carlots, in 1962

(Per short ton)

Grade	1962
Domestic, f.o.b. works:	
Ordinary:	
California	$34.00 to $39.50.
Vermont	$19.40.
Fibrous (New York):	
Off-color	$28.00.
325 mesh:	
99.5 percent	$31.00.
99.5 percent, micronized	$38.00.
Imported (Canadian) f.o.b. mines	$20.00 to $35.00.

Source: Oil, Paint and Drug Reporter.

TABLE 7.—Prices quoted on talc, carlots, f.o.b. works, in 1962

(Per short ton)

Grade [1]	1962
Georgia: 98 percent minus 200 mesh:	
Gray, packed in paper bags	$10.50 to $11.00.
White, packed in paper bags	$12.50 to $15.00.
New Jersey: Mineral pulp, ground, bags extra	$10.50 to $12.50.
Vermont:	
100 percent through 200 mesh, extra white, bulk basis [2]	$12.50.
99.5 percent through 200 mesh, medium white, bulk basis [2]	$11.50 to $12.50.
Virginia:	
200 mesh	$10.00 to $12.00.
325 mesh	$12.00 to $14.00.
Crude	$5.50.

[1] Containers included unless otherwise specified.
[2] Packed in paper bags, $1.75 per ton extra.

Source: E&MJ Metal and Mineral Markets.

FOREIGN TRADE [4]

Imports.—Imports for consumption declined 6 percent in 1962 because the principal suppliers, France and Italy, shipped less talc to the United States. Canada, the other major source, increased exports to the United States 14 percent.

Exports.—Exports of crude and ground talc declined about 2 percent in 1962, although value rose 24 percent.

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

707-626—63——76

TABLE 8.—U.S. imports for consumption of talc, steatite or soapstone, and French chalk, by classes and countries

Year	Crude and unground		Ground, washed, powdered, or pulverized, except toilet preparations [1]		Cut and sawed		Total unmanufactured	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1953-57 (average)	151	$24,365	23,319	[2] $707,784	87	$34,158	23,557	[2] $766,307
1958	31	6,040	22,760	737,584	99	41,114	22,890	784,738
1959	499	18,453	24,778	807,816	74	34,272	25,351	860,541
1960	74	3,376	23,850	821,054	51	24,416	23,975	848,846
1961:								
Canada			1,884	33,561			1,884	33,561
Denmark			8	595			8	595
France			4,656	97,415			4,656	97,415
Germany, West			7	583			7	583
India	39	4,679	557	16,722			596	21,401
Italy	1	180	20,074	859,968	4	1,789	20,079	861,937
Japan			51	2,647	80	35,738	131	38,385
United Kingdom			1	867			1	867
Total	40	4,859	[3] 27,238	[3] 1,012,358	84	37,527	[3] 27,362	[3] 1,054,744
1962:								
Canada			2,152	45,601			2,152	45,601
France			3,993	92,258			3,993	92,258
India	27	3,536	505	18,286			532	21,822
Italy			18,978	857,341	5	1,875	18,983	859,216
Japan					95	48,702	95	48,702
Mexico			10	200			10	200
Norway			12	1,445			12	1,445
Total	27	3,536	25,650	1,015,131	100	50,577	25,777	1,069,244

[1] 1961 revised to include West Germany.
[2] Data known to be not comparable with other years.
[3] Data adjusted by Bureau of Mines to exclude less than 1 ton ($930) of ground, washed, powdered, or pulverized, valued not over $14 per ton from Hong Kong.

Source: Bureau of the Census.

TABLE 9.—U.S. exports of talc, pyrophyllite, and talcum powders

Year	Talc, steatite, soapstone, and pyrophyllite				Powders-talcum (in packages), face and compact (value thousands)
	Crude and ground		Manufactures, n.e.c.[1]		
	Short tons	Value (thousands)	Short tons	Value (thousands)	
1953-57 (average)	32,793	$869	183	$104	$1,262
1958	58,647	1,358	212	93	1,341
1959	58,751	1,532	197	175	1,276
1960	59,457	1,801	158	92	1,378
1961	47,912	1,721	134	84	1,396
1962	46,939	2,133	122	97	1,286

[1] Not elsewhere classified.

Source: Bureau of the Census.

WORLD REVIEW[5]

Austria, France, Italy, and Japan reported decreased output and world production declined about 10,000 tons. Norway, India, and the United States increased production.

Austria.—Production in 1961 of talc and soapstone continued to rise.[6] About 73 percent of this production was exported, principally to Poland and West Germany.

Brazil.—Paraná was the leading talc-producing State in 1962 accounting for 43 percent of the total tonnage.[7] Minas Gerais and Bahia produced most of the remaining talc.

Canada.—Production of talc and soapstone in 1961 was about 10 percent higher than 1960.[8] Shipments of pyrophyllite from Newfoundland increased substantially. Talc and soapstone were consumed primarily in the roofing, paint, ceramic, and rubber industries. Small amounts of talc and soapstone were exported to the United States and several Central American countries.

Korea, Republic of.—Production of pyrophyllite in Korea increased considerably in 1961.[9] The unit value of exports, principally to Japan, was $23 per ton for talc powder, $24, for lump talc, and $11, for pyrophyllite.

South Africa, Republic of.—Principal producers of talc in 1961 were E. J. Horner, Vryheid, Natal, and Scotia Talc, Ltd., Johannesburg.[10] Talc exports were minimal and small amounts of wonderstone were exported to the United States and Europe.

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[5] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.
[6] Bureau of Mines. Mineral Trade Notes. V. 55, No. 6, December 1962, pp. 40–41.
[7] Bureau of Mines. Mineral Trade Notes. V. 56, No. 5, May 1963, pp. 37–38.
[8] Reeves, J. E. Talc, Soapstone, and Pyrophyllite. Dept. of Mines and Tech. Surveys (Canada), Prelim. Rev., 1962, 4 pp.
[9] Bureau of Mines. Mineral Trade Notes. V. 55, No. 4, October 1962, pp. 33–34.
[10] Bureau of Mines. Mineral Trade Notes. V. 55, No. 2, August 1962, p. 71.

TABLE 10.—World production of talc, soapstone, and pyrophyllite by countries [1] [2]

(Short tons)

Country [1]	1953–57 (average)	1958	1959	1960	1961	1962
North America:						
Canada (shipments)	29,532	35,405	39,176	41,636	48,116	46,794
United States	679,946	718,165	791,558	734,473	762,380	771,728
Total	709,478	753,570	830,734	776,109	810,496	818,522
South America:						
Argentina	32,235	30,060	29,938	[3] 30,000	[3] 30,000	[3] 30,000
Brazil	25,266	31,442	23,369	21,956	24,284	[3] 24,000
Paraguay	112	[3] 110	[3] 110	[3] 110	[3] 110	[3] 110
Peru	2,112	2,073	1,694	1,732	3,236	3,134
Uruguay	1,248	1,990	2,335	3,297	1,857	1,890
Total	60,973	65,675	57,446	[3] 57,100	[3] 59,500	[3] 59,000
Europe:						
Austria	71,284	78,074	56,475	90,695	93,639	83,523
Finland	7,155	6,522	8,261	11,008	6,967	7,088
France	131,571	185,643	193,528	206,997	227,076	200,620
Germany, West (marketable)	36,089	30,315	30,364	32,277	[3] 35,000	[3] 33,000
Greece	1,599	1,962	327	2,008	2,044	[3] 2,200
Italy	102,276	120,704	120,436	137,117	146,584	140,171
Norway	87,467	107,828	123,959	113,628	[3] 110,000	142,198
Portugal	25	-----------	243	750	794	772
Spain	26,937	33,360	30,661	30,853	30,498	[3] 30,000
Sweden	13,320	14,581	15,910	17,527	17,306	[3] 17,600
U.S.S.R.	[4]	220,462	[3] 275,000	[3] 300,000	[3] 330,000	[3] 340,000
United Kingdom	4,605	4,645	6,365	7,244	7,761	7,716
Yugoslavia	[5] 974	-----------	-----------	-----------	-----------	-----------
Total [1] [3]	610,000	805,000	860,000	950,000	1,010,000	1,005,000
Asia:						
China	[4]	[4]	[4]	[4]	[3] 165,000	[3] 165,000
India	45,848	50,906	71,082	102,947	102,370	114,117
Japan	334,964	377,994	535,140	652,953	699,510	[3] 660,000
Korea, Republic of	17,634	17,581	19,272	24,889	50,330	51,235
Taiwan	5,864	3,677	7,079	11,637	13,685	14,737
Total [3]	515,000	615,000	800,000	960,000	1,030,000	1,005,000
Africa:						
Kenya	57	-----------	-----------	-----------	-----------	-----------
South Africa, Republic of	4,362	765	1,412	1,979	3,279	13,921
Swaziland	[6] 22	157	1,008	1,714	2,955	3,902
United Arab Republic (Egypt)	5,190	7,253	6,708	6,614	6,565	[3] 6,600
Total	9,631	8,175	9,128	10,307	12,799	24,423
Oceania: Australia	14,291	17,539	18,729	18,112	16,613	[3] 14,000
World total (estimate) [1] [2]	1,920,000	2,270,000	2,580,000	2,770,000	2,940,000	2,930,000

[1] Talc or pyrophyllite is reported in Rumania, but data are not available; estimates are included in total.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Estimate.
[4] Data not available; estimate by senior author of chapter included in total.
[5] Average annual production 1955–57.
[6] One year only, as 1957 was first year of commercial production.

Compiled by Liela S. Price, Division of Foreign Activities.

TABLE 11.—Austria, France and Italy: Exports of talc and soapstone by countries [1]

(Short tons)

Destination	Exporting countries					
	Austria		France		Italy	
	1961	1962	1961	1962	1961	1962
Algeria			4,137	2,201		
Belgium-Luxembourg	3,965	3,698	5,466	5,526	(2)	(2)
Denmark	319	373	225	274		
Finland			258	265		
France	1,659	1,593			(2)	(2)
Germany:						
East	1,791	4,004				
West	21,149	21,915	10,144	11,584	7,869	6,745
Hungary	2,319	1,934				
Israel	44	71	360	397		
Italy	4,276	6,031	557	702		
Ivory Coast			357	307		
Morocco			1,032	1,472		
Netherlands	1,358	1,267	1,381	1,655	(2)	(2)
Poland	26,950	16,007				
Portugal			607	560	(2)	(2)
Sweden	104	71	941	959		
Switzerland	4,211	3,953	8,842	9,550	(2)	(2)
Tunisia			515	741		
United Kingdom	524	487	7,275	7,845	10,048	8,610
United States			4,348	3,926	18,973	19,309
Viet-Nam			643	288		
Other countries	95	205	1,697	1,155	18,416	22,217
Total	68,764	61,609	48,785	49,407	55,306	56,881

[1] This table incorporates some revisions.
[2] Data not separately recorded.

Compiled from Customs Returns of Austria, France, and Italy by Corra A. Barry, Division of Foreign Activities.

TABLE 12.—Republic of South Africa: Salient statistics of pyrophyllite (wonderstone)

	1961 [1]	1962 [2]
Production short tons	1,023	1,848
Exports do	722	1,142
Value	$73,196	$109,143
Local sales short tons	265	664
Value	$23,166	$55,709

[1] U.S. Embassy, Johannesburg, Republic of South Africa. State Department Dispatch 390. Mar. 14, 1962, p. 4.
[2] Republic of South Africa, Department of Mines (Pretoria). Quarterly Information Circular, Minerals. October–December 1962, pp. 64, 66, 68.

TECHNOLOGY

Pyrophyllite from Graves Mountain, Ga., was used to synthesize mullite.[11] The crystallization of mullite occurred in the range 970° to 1,200° C with a few associated energy changes.

The use of pyrophyllite as a dielectric filter for insulating rubber was studied.[12] Pyrophyllite performed satisfactorily when used with 50 to 60 percent rubber.

[11] Heller, L. The Thermal Transformation of Pyrophyllite to Mullite. Am. Mineral., v. 57, January–February 1962, pp. 156–157.
[12] Ovcharenko, F. D., and G. A. Blokh. (Pyrophyllite—A New Filler for Cable Rubbers). Transl. of Vestnik Elektropromyshlennosti (U.S.S.R.), v. 31, No. 9, 1960, pp. 5–8.

A sealing and waterproofing compound containing talc was used in cracks, crevices, and joints.[13]

Finely divided talc was a parting agent in a dry fire-extinguishing compound.[14]

Talc mixed with potassium chloride, ammonium sulfate, ammonium di-hydrogen phosphate, tricalcium phosphate, and an insoluble metal stearate formed a fire-extinguishing compound.[15]

A patent was issued for a talc filler compound and the method for producing it.[16]

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[13] Sterling, G. B. (assigned to The Dow Chemical Co., Midland, Mich.). Calking and Sealing Composition Containing Elastomeric Polymers of Acrylic Acid Esters. U.S. Pat. 3,067,154, Dec. 4, 1962.

[14] Cawood, E. E. C. (assigned to Nu-Swift, Ltd.). Fire Extinguishing Composition. U.S. Pat. 3,063,940, Nov. 13, 1962.

[15] Cawood, E. E. C. (assigned to Nu-Swift, Ltd.). Canadian Pat. 645,060, July 17, 1962.

[16] Lubino, D., and L. V. Gagin (assigned to Johns-Manville Fiber Glass, Inc., Cleveland, Ohio). U.S. Pat. 3,017,318, Jan. 16, 1962.

Thorium

By John G. Parker [1]

THE FIRST commercially operated nuclear powerplant to use a fuel composed of a homogeneous mixture of thorium oxide in highly enriched uranium oxide achieved criticality in August. Late in the year the U.S. Atomic Energy Commission (AEC) issued a report stressing design and construction of breeder reactors which may use thorium. Thorium use continued, largely for alloys, gas mantles, and nuclear energy research. Its use in alloys, as for the past several years, continued to decrease.

Domestic mine production of thorium-bearing minerals increased but remained less than 50 tons of thorium dioxide (ThO_2). The estimated reserve in the Idaho-Montana area was revised upwards several fold. In addition, availability studies showed the presence in granite of thorium that could be extracted commercially, if necessary, for use in breeder reactors. Most of the thorium consumed in the United States was derived from Canadian uranium sludges and from the Vanrhynsdorp monazite lode operation in the Republic of South Africa. This mine was reopened in the spring.

LEGISLATION AND GOVERNMENT PROGRAMS

Research and development sponsored by the Atomic Energy Commission were continued. Beside obtaining new knowledge concerning nuclear energy and its utilization, these efforts also contributed to an understanding of two other modern frontiers, outer space and the deep sea.

Financial assistance remained available from the U.S. Department of the Interior, Office of Minerals Exploration (OME) for eligible thorium mining claims, but no exploration contracts for the metal were made in 1962.

The U.S. Department of Agriculture, Commodity Credit Corporation (CCC) barter program for 4 million pounds of thorium nitrate was continued. The nitrate, destined for incorporation into the supplemental stockpile, was processed in the United States from South African monazite and in France from Malagasy Republic uranothorianite.

[1] Commodity specialist, Division of Minerals.

DOMESTIC PRODUCTION

Mine Production.—Domestic production came from byproduct processing of southeastern U.S. beach sands and from Montana thorite ores. Although more than in 1961, it remained less than 50 tons of ThO_2. High-grade thorite ore from the Northwest was used experimentally. Northwest Prospecting and Development Co. conducted some shallow exploratory drilling, but most of the routine assessment work in the area was completed.

Reasonably assured reserves in the Lemhi pass area of Idaho and Montana were estimated at 100,000 tons ThO_2 recoverable at prices competitive with those for uranium.

Refinery Production.—The principal domestic processors of thorium-bearing ores and refiners of compounds were American Potash & Chemical Corp., West Chicago, Ill.; W. R. Grace & Co., Davison Chemical Division, Pompton Plains, N.J., and Erwin, Tenn.; and Vitro Chemical Co., Chattanooga, Tenn. Two of these firms, W. R. Grace & Co., Erwin, Tenn., and Vitro Chemical Co., as well as Ronson Metals Corp., Newark, N.J. and United Nuclear Corp., N.Y., offered thorium metal. Vitro also produced thorium-magnesium master alloys for use in magnesium-thorium alloys. Westinghouse Electric Corp., Lamp Division, Bloomfield, N.J., produced some thorium metal for use in tungsten lamp filaments, and Metal Hydrides, Inc., Beverly, Mass., continued production of high-purity thorium metal powder and crystal bar. National Lead Co., Albany, N.Y., melted. cast, and fabricated reactor-grade thorium metal. Thorium nitrate, oxide, and other compounds were produced by American Potash & Chemical Corp. Thorium oxide pellets and powder were available from United Nuclear Corp. and from Zirconium Corporation of America, Solon, Ohio. High-purity thorium oxide ceramic was offered by Coors Porcelain Co., Golden, Colo.; National Beryllia Corp., Haskell, N.J.; and Norton Co., Worcester, Mass.

CONSUMPTION AND USES

Nonenergy Uses.—Alloys applications were reduced sharply over the past several years, owing to defense and space requirements for materials having higher temperature resistance. A new magnesium-thorium alloy, however, was developed to withstand temperatures up to 600° F. in aerospace conditions without undue diminution of desirable mechanical properties. Thorium oxide dispersed in nickel was reported to form a superalloy having better high-temperature creep strength and resistance to oxidation. Thorium consumption for gas mantle manufacture increased so that the quantity required for this application nearly equaled that consumed in alloys. Other non-nuclear uses were mostly in the refractories, chemical, and electronics industries.

Energy Uses.—Utilization research on thorium as a nuclear fuel and prospecting interest were stimulated by the special publication of AEC, Civilian Nuclear Power, A Report to the President, 1962. Technology of thorium fuels lagged behind that of plutonium fuels for use in economically competitive power reactor systems. Two principal processors, early in the year, agreed to produce 20 tons each of thorium metal ingots, with a total value of over $1.2 million, from AEC stockpiled materials. The metal was to be used in evaluating the thorium-uranium 233 (Th-U^{233}) cycle in test reactors at the Savannah River Site, Aiken, S.C. Industry, using several new reactor designs, shortly expected to offer economically competitive Th-U^{233} fuel cycle power reactors and to increase the core life by using thorium in pressurized water reactors.

The Sodium Reactor Experiment (SRE) at Santa Susana, Calif. (operated by Atomics International Division of North American Aviation, Inc. for AEC and using a thorium-uranium alloy fuel) permitted accumulation of data on the improvement of fuel and fuel element configurations and provided reactor heat, when available, for generation of electrical power by a utility company.

A mixture of thorium and highly enriched uranium oxides clad with stainless steel served as the core of the Consolidated Edison Co. Indian Point atomic powerplant, Buchanan, N.Y. Criticality was achieved in August. In mid-November, several weeks after the reactor had reached 50 percent of its full power output, a shutdown was necessary to correct piping in the conventional oil-fired superheater portion of the plant.

The 40,000 electrical kilowatt high-temperature gas-cooled utility-owned reactor in Peach Bottom Township, Pa., on which construction began in the spring, was to be fueled with thorium-uranium carbide particles encased in graphite.

Mixtures of molten fluoride salts, including those of thorium, were to be used as fuel and coolant in the Molten Salt Reactor Experiment (MSRE) which was being installed at Oak Ridge National Laboratory, Oak Ridge, Tenn.

PRICES

No changes occurred in monazite quotations listed in E&MJ Metal and Mineral Markets during the year. The quotations were as follows:

Type and grade, rare-earth oxide including thoria, percent:	*Price per pound c.i.f. U.S. ports*
Massive, 55	$0.14
Sand, 55	.10–.15
Sand, 66	.18
Sand, 68	.20

Prices for domestic thorite-type minerals ranged from $1.75 to $2.25 per pound of contained thoria in 20 to 30 percent concentrates.

Thorium compounds, offered for sale by several producers, in lots between 10 to 49 pounds, were as follows:

Thorium compound:	*ThO_2 percent*	*Price per pound* [1]
Carbonate	80	$8.70–9.35
Chloride	50	8.40
Fluoride	79–80	6.60–8.50
Nitrate (mantle grade)	47	3.60
Oxide	98–99.9+	6.90–16.00

[1] Variable, depending upon purity and upon thorium and rare-earth content. Larger lot sizes available at reduced prices.

Thorium metal pellets were quoted at $15 per pound by American Metal Market.

Thorium hardener for alloying purposes, containing 20 to 40 percent ThO_2, sold for $12.50 to $15.00 per pound of contained thorium.

FOREIGN TRADE

Imports of monazite and other thorium ore from Australia, the Federation of Malaya, the Republic of South Africa, and an unidentified country totaled 7,650 tons valued at $1,115,000. U.S. imports of monazite concentrate from the Republic of South Africa were three times those of 1961. Over 5 tons of thorium, virtually all from Canada, and a substantial quantity of thorium nitrate from India were imported. During the year, 19 foreign countries purchased from the United States 1,095,000 pounds of thorium ores, concentrates, and compounds valued at $358,000. Thorium metal, alloys, and other forms, except special nuclear material, totaling 980 pounds, worth $46,500, were exported to 8 countries.

WORLD REVIEW

Monazite production expanded in the Republic of South Africa. This source, and Australia, Malagasy Republic, and India, supplied much of the free world thorium needs. Byproduct production from a Canadian uranium mill met most of the U.S. requirements for thorium metal. Almost 2 million pounds of thorium nitrate and other compounds was imported from India.

Canada.—Crude thorium sulfate cake, processed from uranium-mill waste liquors by Rio Tinto Dow, Ltd. since 1959, competed successfully, after refinement, with concentrates of thorite and monazite. Much of the world market for thorium was supplied by the new extraction plant at Rio Algom's Nordic mill near Elliott Lake, Ontario. The plant had a designed annual capacity of 150 to 200 tons of thorium compounds that could be converted to thorium oxide at the nearby refining plant adjacent to the Quirke mill.[2] In the second half of the year, production of metallurgical grade thorium oxide was curtailed at the Quirke plant.[3]

India.—Travancore Minerals Ltd. operated its monazite recovery plant at Manavalakurichi, State of Kerala, southwestern India. At Alwaye, in the same State, Indian Rare Earths Ltd. operated a monazite processing plant. This installation added some equipment, streamlined production schedules, and could process 3,000 tons of monazite a year.

Italy.—Plans were made to erect a chemical pilot plant to reprocess irradiated thorium in Lucania.[4]

Malagasy Republic.—It was reported that 599 tons of uranothorianite valued at about $2,650 per ton was exported.[5]

Rumania.—The export of 160 grams of thorium in a solution to Rumania was approved by the U.S. AEC. The material will be injected into patients as a contrast medium in X-ray diagnosis.[6]

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[2] Chemical Engineering. Canadian Thorium Wins Big Slice of Market. V. 69, No. 9, Apr. 30, 1962, pp. 64, 66.
[3] Breaking New Ground in 1962. Review of the Ontario Department of Mines, Toronto, Canada, p. 68.
[4] Chemistry and Industry (London). No. 10, Mar. 10, 1962, p. 458.
[5] U.S. Embassy, Tananarive, Malagasy Republic, State Department Dispatch A-333, May 25, 1963, p. 1. (encl.)
[6] Chemical and Process Engineering and Atomic World (London). V. 43, No. 6, June 1962, p. 303.

TECHNOLOGY

Under AEC sponsorship, geologists at Rice University, Houston, Tex., used advanced radiometric equipment to determine the availability of thorium in the Conway granite of New Hampshire. This, and similar rocks, could be a long-term source of thorium if studies proved the economic feasibility of large-scale thorium breeder reactor usage. The Blind River area, Ontario, Canada, which produced uranium and thorium, was the site for studies of systematic variations in thorium-uranium ratios. In general, the higher ratios were obtained at the edges of the ore sheets, where the conglomerate was less dense. Perhaps this was evidence of contemporaneous deposition in the enclosing rocks of uranium and thorium detrital minerals.[7] Soviet geologists determined the period of uranium and thorium enrichment of certain granitic type rocks. This was attributed to increased concentrations of these elements in the final stages of the magmatic process, or more specifically to metasomatism.[8]

A new, comprehensive bibliography contained numerous references on genesis, mineralogy, geochemistry, prospecting, exploration, and reserves of thorium and uranium.[9]

Improved analytical methods were investigated. By means of neutron activation with helium 3 ions, it was believed that one part per billion of oxygen may be determinable in thorium.[10] A rapid method suited to production control used X-ray fluorescence to determine thorium and certain rare-earth metals in magnesium alloys. It provided accuracy comparable with chemical and spectrographic methods.[11]

A new process used countercurrent extraction stripping with sulfuric acid and alkali metal carbonate solutions to recover high purity thorium oxide from a thorium organic extract.[12]

In an effort to find better and more efficient means of producing thorium metal, metallothermic reduction and fused-salt electrolysis techniques were studied. Aluminum in excess was used to reduce thorium oxide.[13] Thorium was deposited electrolytically from a fused salt into molten zinc with current efficiency approximately 100 percent and thorium recovery 15 percent in the zinc.[14] The radiological hazard involved in casting thorium by consumable arc melting

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[7] Robertson, David S. Thorium and Uranium Variations in the Blind River Ores. Econ. Geology, v. 57, No. 8, December 1962, pp. 1175–1184.

[8] Mineyeva, I. G., and I. M. Aver'yanova. (Distribution of Uranium and Thorium in the Granites of Central Kazakhstan), Sovetskaya Geologiya, No. 3, March 1962, pp. 83–95; JPRS 16, 090, Nov. 7, 1962, available from Office of Technical Services, U.S. Dept. of Commerce, Washington, D.C.

[9] International Atomic Energy Agency, Vienna, Austria. Geology of Uranium and Thorium. Bibliographical Series No. 4 (STI/PUB/21/4), 1962, p. 134.

[10] Markowitz, Samuel S., and John D. Mahony. Activation Analysis for Oxygen and Other Elements by Helium-3-Induced Nuclear Reactions. Anal. Chem., v. 34, No. 3, March 1962, pp. 329–335.

[11] Stoner, Graham A. Rapid, Automatic X-Ray Analysis of Magnesium Alloys. Anal. Chem., v. 4, No. 1, January 1962, pp. 123–126.

[12] Christensen, Charles, and John Dingle Prater (assigned to Kennecott Copper Corp.) Liquid-Liquid Extraction Process for the Recovery of High Purity Thorium Oxide. British Pat. 907,187, Oct. 3, 1962.

[13] Raleigh, Douglas O. Equilibrium Studies in the Reduction of Thorium Oxide by Aluminum. J. Electrochem. Soc., v. 109, No. 6, June 1962, pp. 521–525.

[14] Johnson, Ralph E. Electrodeposition of Thorium From Fused Salts Into a Molten Zinc Cathode. J. Electrochem. Soc., v. 109, No. 10, October 1962, pp. 989–991.

was described. Essentially, all of the radium 228 was removed by two successive arc meltings.[15]

Methods were described whereby degassed thorium carbide was iodized. The thorium tetraiodide was heated to at least 480° C, preferably to 540° C, and the resultant vapor decomposed and deposited as crystalline thorium on a tantalum or thorium filament heated to between 1,350° and 1,400° C.[16] Effects of exposing compacts and powders of thorium monocarbide and dicarbide to air, water, and electrolytic solutions in fabricating and reprocessing thorium-uranium carbide fuels were summarized. These fuels should be fabricated in an inert atmosphere and be clad to prevent subsequent hydrolysis in air because both carbides readily hydrolyze with exfoliation, gain weight, and become contaminated with hydrolysis products.[17] Mass spectrographic studies showed that in hydrolysis at room temperature thorium monocarbide produced practically all methane. Thorium dicarbide yielded mostly ethane and hydrogen.[18]

Crystallographic research showed that the unit cell of thorium hydride is face-centered tetragonal and that the structure and lattice constants vary with the hydrogen content.[19] The composition of thorium dihydride also varied directly as a function of temperature and pressure. Most of the increase in reaction rate is the result of an increase in the concentration difference across the hydride layer.[20] Thorium monosulfide was prepared by electrolytic reduction of the higher sulfide in an oxygen-free, fused-salt medium containing thorium chloride.[21]

Alloying studies showed that the addition of thorium considerably lowered the critical point of pure cerium.[22]

Research was continued to determine the economic feasibility of thorium as a fertile material in breeder reactors. At Oak Ridge National Laboratory approximately equal efforts were expended on the evaluation of thorium-burning reactor designs, on the development of an economic method of remote recycling and refabrication, and on engineering and radiation studies of unclad pellets and particles.

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[15] Cofield, R. E. Radioactivity Distributions in the Metallurgical Processing of Thorium. Health Physics, v. 7, Nos. 3/4, February 1962, pp. 191–204.

[16] Wylie, A. W., and R. E. Wilmshurst. Production of Pure Thorium From Thorium Carbide. Brit. Chem. Eng., (London), v. 7, No 3, March 1962, p. 175.

[17] Lawrence, J. J., and D. J. O'Connor. Hydrolysis of Thorium Carbides. J. Nuclear Materials, v. 5, January 1962, pp. 156–157.

[18] Kempter, C. P., and N. H. Krikorian. Some Properties of Thorium Monocarbide and Dicarbide. J. Less-Common Metals (Amsterdam, Netherlands), v. 4, No. 3, June 1962, pp. 244–251.

[19] Korst, William L. The Lattice Constants of Thorium Dihydride. Acta Cryst. (Copenhagen, Denmark), v. 15, pt. 3, Mar. 10, 1962, pp. 287–288.

[20] Peterson, D. T., and J. Rexer. The Composition of ThH_2 and Diffusion of Hydrogen in ThH_2. J. Less-Common Metals (Amsterdam, Netherlands), v. 4, No. 1, February 1962, pp. 92–97.

[21] Didchenko, R., and L. M. Litz. Preparation of Lanthanide and Actinide Monosulfides by Fused Salt Electrolysis. J. Electrochem. Soc., v. 109, No. 3, March 1962, pp. 247–250.

[22] Gschneidner, K. A., Jr., R. O. Elliott and R. R. McDonald. Effects of Alloying Additions on the $\alpha \rightleftharpoons \gamma$ Transformation of Cerium. Part II. Effects of Scandium, Thorium and Plutonium Additions. The Physics and Chemistry of Solids, v. 23, September 1962, pp. 1191–1199.

Tin

By John E. Shelton [1] and John B. Umhau [2]

CONSUMPTION of primary tin in the United States rose 9 percent to the highest since 1956; however, consumption of secondary tin dropped 12 percent to the lowest since 1939. Tin imports declined 4 percent. After July concentrate was no longer received from Indonesia for smelting at Texas City. Virtually no imported tin-base alloys were reported used for the first time since reporting began in early 1952. Tin mills featured production of lightweight tinplate. More tinplate was shipped to canmakers and more tinplate cans were shipped by can manufacturers than ever before. The price of tin received support from buffer stock buying when it dropped to the International Tin Agreement's may-buy range. The average price of Straits tin in the United States was the highest since 1952.

Sales of tin from the national stockpile and the purchase of tin by the International Tin Council Buffer Stock manager were the predominant factors influencing the world tin situation in 1962. Other outstanding features were the entry into force of the Second International Tin Agreement and the adoption of new floor and ceiling prices by the International Tin Council. Free world production of tin was lower than consumption, and commercial stocks were drawn upon to meet the demand. Virtually no shipments of Soviet tin entered Free Europe markets for the first time since 1955. Bolivian national mines increased tin production for the first time since 1953. A second smelter began production in Nigeria.

The United States continued to be the leading Free World consumer of tin. The United Kingdom resumed second place as a free world tin consumer, with West Germany third. Australia began producing electrolytic tinplate.

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[1] Commodity specialist, Division of Minerals.
[2] Mineral specialist, Division of Minerals.

TABLE 1.—Salient tin statistics

(Long tons)

	1953–57 (average)	1958	1959	1960	1961	1962
United States:						
Production:						
Mines	71.98		50	10	(1)	(1)
Smelter	[2] 21,299	(1)	(1)	(1)	(1)	(1)
Secondary	27,166	22,810	23,700	22,050	21,690	21,040
Imports for consumption:						
Metal	64,746	41,149	43,578	39,538	[3] 39,893	41,408
Ore (tin content)	19,001	5,440	10,773	14,026	8,917	5,364
Exports (exports and reexports)	911	1,341	1,371	857	800	435
Consumption:						
Primary	56,623	47,998	45,833	51,530	[3] 50,288	54,602
Secondary	29,746	24,587	31,540	29,030	[3] 27,962	24,483
Price: Straits tin, New York, average cents per pound	95.95	95.09	102.01	101.40	113.27	114.61
World:						
Production:						
Mine	195,000	153,500	161,500	[3] 180,600	[3] 185,200	190,200
Smelter	196,700	[3] 158,200	[3] 155,500	[3] 191,100	[3] 189,100	196,300

[1] Figures withheld to avoid disclosing individual company confidential data.
[2] Includes tin content of alloys made directly from ores.
[3] Revised figure.

LEGISLATION AND GOVERNMENT PROGRAMS

The Export Control Act of 1949, extended to June 30, 1965, governed the destination of tin shipments. Exports were under general license except to China, North Korea, the Communist-controlled area of Viet-Nam and the Pacific region of the U.S.S.R. Regulations administered by the Office of Export Control, U.S. Department of Commerce, required a license (except to Canada) for export of detinned tinplate, terneplate scrap, and detinned cans. Exports of tinplate, terneplate scrap, and old cans were exempted from licensing, except to the Sino-Soviet bloc, Hong Kong, and Macao.

The foreign assets control regulations of the U.S. Treasury Department prohibited the entry of Chinese tin. Soviet tin could enter the United States but required a license (none was issued) on the presumption that it might be of Chinese origin. Alloys that might include Chinese and/or Soviet tin also were prohibited.

The Office of Minerals Exploration offered financial assistance to the extent of 50 percent of the total allowable costs for exploration of eligible domestic tin deposits.

On January 3, the General Services Administration (GSA) sold 700 long tons of pig tin. This completed the sale of 3,900 tons from the Federal Facilities Corporation (FFC) stock that was in excess of the Government's needs and not in the national stockpile.

The disposal of approximately 50,000 tons of pig tin in excess of national stockpile needs was authorized by Congress June 21, 1962 (H. Con. Res. 473). On August 24, GSA announced a disposal program under which the tin would be offered at a maximum rate of 200 tons per week for sale in the market on the basis of competitive bidding. Unsold tin was to be utilized in foreign aid programs, or transferred to other agencies of the U.S. Government for use. On August 31, the initial details of the weekly sales offering were issued for September 12 through October 31. The second sales offering, issued

October 19, was for November 7 through December 19, and the third period, announced December 21, was from January 3 to January 30, 1963, inclusive. The total tin offered for sale during the three periods was 4,000 tons. As a result of the 15 weekly offerings in 1962, totaling 3,000 tons, 1,400 tons was sold and bids were rejected on 1,600 tons. The remaining 1,000 tons was the tin presented for sale in January 1963.

The statutory requirement that tin be included in the alloy of the 1-cent piece was repealed by Public Law 87–643, September 5, 1962.

GSA administered the production-payment provisions of the Texas City, Tex., tin smelter sales contract.

DOMESTIC PRODUCTION

MINE PRODUCTION

A small tonnage of tin concentrate was recovered as a byproduct of molybdenum mining in Colorado.

SMELTER PRODUCTION

Tin smelting was continued on a small scale by Wah Chang Corp., Texas City, Tex. The production-payment provisions of the sales contract were administered by GSA. Under this program in fiscal year 1962, GSA received $186,320 (mortgages repaid, $140,000; interest on mortgages, $37,600; smelter production, $8,720). On June 30, GSA held a note with a balance of $800,000 bearing interest at 4 percent per year, obtained from the sale of the tin smelter. Payment of $8,717 was made on 7,783 long tons of tin produced during the year ending April 22, 1962.

Originally the sales contract with Wah Chang Corp. provided for payment of $10 per ton on all production of tin metal in excess of 2,000 short tons per year, up to 4,000 tons; in addition the contract promised $2.50 per ton for each of the next 1,000 tons and another $2.50 per ton (a total of $15) for production over 5,000 tons. Before tin production began at Texas City (April 23, 1958) the payment terms were reduced and continued at $5 per ton on all metal produced in excess of 2,000 tons. However on April 22, 1960, they were further reduced to $1 per ton for a 2-year period ending April 22, 1962, that was extended to April 22, 1963 in 1962.

The toll contract between the Indonesian State Mining Enterprises and Wah Chang Corp. for smelting Indonesian tin concentrate at the Texas City smelter expired. After July no concentrate was imported from Indonesia. Negotiations began for procuring supplies of Bolivian ore for the smelter.

SECONDARY TIN[3]

Secondary tin production decreased 3 percent. Almost 85 percent was recovered from seven scrap items—drosses, composition or red brass, tinplate, bronze, railroad-car boxes, auto radiators, and solder.

[3] The assistance of Edith E. den Hartog is acknowledged.

Tin from old scrap dropped for the seventh consecutive year to the lowest tonnage recorded. New scrap supplied 530 tons less than in 1961. The largest tonnage was recovered in bronze and brass; however, recovery in this category declined the most (370 tons). Next in rank was tin reclaimed in solder, which showed a small loss of 60 tons.

The tonnage of tinplate scrap treated in 1962 was the largest on record. The industry treated 706,190 long tons—5,560 tons more than in 1961, and 3,315 tons more than the previous peak of 702,875 tons in 1959. Lower recovery per ton of scrap (for the 16th consecutive year) indicated that a larger proportion of electrolytic tinplate carried a thinner coating of tin.

TABLE 2.—Secondary tin recovered from scrap processed at detinning plants in the United States

	1961	1962
Tinplate scrap treated [1] ... long tons	700,628	706,188
Tin recovered in the form of—		
Metal ... do	2,520	2,521
Compounds (tin content) ... do	710	650
Total [2] ... do	3,230	3,171
Weight of tin compounds produced ... do	1,439	1,389
Average quantity of tin recovered per long ton of tinplate scrap used ... pounds	10.33	10.06
Average delivered cost of tinplate scrap ... per long ton	$31.55	$21.86

[1] Tinplate clippings and old tin-coated containers have been combined to avoid disclosing individual company confidential data.
[2] Recovery from tinplate scrap treated only. In addition, detinners recovered 287 long tons (366 tons in 1961) of tin as metal and in compounds from tin-base scrap and residues in 1962.

TABLE 3.—Stocks, receipts, and consumption of new and old scrap and tin recovered in the United States in 1962

(Long tons)

Type of scrap and class of consumer	Gross weight of scrap						Tin recovered		
	Stocks Jan. 1	Receipts	Consumption			Stocks Dec. 31			
			New	Old	Total		New	Old	Total
Copper-base scrap:									
Secondary smelters:									
Auto radiators (unsweated)	2,304	40,012	------	39,476	39,476	2,840	------	1,697	1,697
Brass, composition or red	3,525	73,661	24,420	48,452	72,872	4,314	1,046	1,821	2,867
Brass, low (silicon bronze)	233	2,247	1,225	977	2,202	278	------	2	2
Brass, yellow	6,858	46,539	6,227	41,929	48,156	5,241	18	379	397
Bronze	1,402	27,074	6,714	20,295	27,009	1,467	527	1,600	2,127
Low-grade scrap and residues	3,274	27,399	19,953	6,882	26,835	3,838	18	------	18
Nickel silver	679	3,379	308	3,178	3,486	572	3	24	27
Railroad-car boxes	325	829	------	916	916	238	------	43	43
Total	18,600	221,140	58,847	162,105	220,952	18,788	1,612	5,566	7,178
Brass mills: [1]									
Brass, low (silicon bronze)	2,218	19,361	19,361	------	19,361	2,537	------	------	------
Brass, yellow	14,167	167,711	167,711	------	167,711	13,623	18	------	18
Bronze	311	1,848	1,848	------	1,848	925	89	------	89
Mixed alloy scrap	7,884	10,716	10,716	------	10,716	13,101	23	------	23
Nickel silver	2,467	7,605	7,605	------	7,605	3,210	------	------	------
Total	27,047	207,274	207,274	------	207,274	33,396	130	------	130
Foundries and other plants: [2]									
Auto radiators (unsweated)	353	4,479	------	4,484	4,484	344	------	202	202
Brass, composition or red	1,434	3,029	1,055	2,263	3,318	1,532	49	108	157
Brass, low (silicon bronze)	247	627	50	322	372	418	------	------	------
Brass, yellow	1,216	8,449	3,871	3,980	7,851	1,105	4	32	36
Bronze	1,039	2,376	1,099	1,260	2,359	935	84	97	181
Low-grade scrap and residues	710	8,950	2,453	5,951	8,404	1,333	------	------	------
Nickel silver	54	31	------	42	42	31	------	------	------
Railroad-car boxes	1,923	29,332	------	29,381	29,381	1,837	------	1,396	1,396
Total	6,976	57,273	8,528	47,683	56,211	7,535	137	1,835	1,972
Total tin from copper-base scrap	------	------	------	------	------	------	1,879	7,401	9,280
Lead-base scrap:									
Smelters, refiners, and others:									
Babbitt	584	10,618	------	10,881	10,881	321	------	528	528
Battery lead plates	14,539	343,733	------	337,366	337,366	20,906	------	355	355
Drosses and residues	[3] 14,709	56,381	57,857	------	57,857	13,233	1,967	------	1,967
Solder and tinny lead	208	7,785	8	7,689	7,697	296	2	1,340	1,342
Type metals	1,158	22,339	------	22,543	22,543	954	------	1,071	1,071
Total	[3] 31,198	440,856	57,865	378,479	436,344	35,710	1,969	3,294	5,263
Tin-base scrap:									
Smelters, refiners, and others:									
Babbitt	[3] 72	485	3	481	484	73	3	402	405
Block-tin pipe	28	554	1	534	535	47	1	529	530
Drosses and residues	469	3,970	3,748	------	3,748	691	2,350	------	2,350
Pewter	14	49	------	48	48	15	------	41	41
Total	[3] 583	5,058	3,752	1,063	4,815	826	2,354	972	3,326
Tinplate scrap: Detinning plants	------	------	706,188	------	706,188	------	3,171	------	3,171
Total tin recovered	------	------	------	------	------	------	9,373	11,667	21,040

[1] Lines in brass mills and total sections do not balance as stocks include home scrap and purchased scrap assumed to equal receipts.
[2] Omits "machine shop scrap."
[3] Revised figure.

TABLE 4.—Tin recovered from scrap processed in the United States, by form of recovery

(Long tons)

Form of recovery	1961	1962
Tin metal:		
At detinning plants	2,670	2,664
At other plants	330	313
Total	3,000	2,977
Bronze and brass:		
From copper-base scrap	9,335	8,770
From lead and tin-base scrap	435	630
Total	9,770	9,400
Solder	4,820	4,764
Type metal	1,570	1,555
Babbitt	1,030	1,070
Antimonial lead	390	344
Chemical compounds	1,020	868
Miscellaneous [1]	90	62
Total	8,920	8,663
Grand total	21,690	21,040
Value thousands	$55,033	$54,015

[1] Includes foil, cable lead, and terne metal.

CONSUMPTION

Total tin consumption in the United States increased 835 long tons in 1962. The use of primary tin rose 4,314 tons, whereas the consumption of secondary tin dropped 3,479 tons. Virtually no imported tin-base alloys were reported used after May. Three items—tinplate, solder, and bronze and brass—consumed more than 80 percent of the tin used. Consumption of tin in tinplate (the leading use of primary tin, which accounted for 53 percent of the total) decreased 8 percent.

Tinplate production was 3 percent less than in 1961. The mills featured lightweight tinplate. Electrolytic tinplate comprised 96 percent (95 percent in 1961), and hot-dipped tinplate 4 percent of the total output.

The United States required 43 percent of the world consumption of tin for tinplate in 1962. Nearly 90 percent of the tinplate was used for making cans, 63 percent of the cans was for food and 37 percent for nonfood products. The tonnage of tinplate shipments to canmakers rose 2 percent to a new record. Can shipments increased 3 percent to the highest total ever recorded. Slightly more vegetables and vegetable juices (the leading products packed) were packed than in 1961. Beer ranked second among products packed, and the production of beer cans rose 3 percent.

Fruit and fruit juices made the largest gain. Cans for soft drinks increased for the sixth consecutive year to an alltime high. Cans for fish and seafood, and pet foods and for pressure packing also reached new peaks in 1962. Cans for coffee remained virtually unchanged. Evaporated and condensed milk showed the largest loss in base boxes of metal consumed.

TABLE 5.—Consumption of primary and secondary tin in the United States
(Long tons)

	1953-57 (average)	1958	1959	1960	1961	1962
Stocks Jan. 1[1]	25,432	32,030	30,003	35,521	33,459	36,209
Net receipts during year:						
Primary	59,300	46,553	51,269	50,661	53,565	50,694
Secondary	2,435	2,524	2,471	2,217	2,897	2,409
Terne	166					
Scrap	28,875	23,680	30,814	27,448	26,344	22,542
Total	90,776	72,757	84,554	80,326	82,806	75,645
Available	116,208	104,787	114,557	115,847	116,265	111,854
Stocks Dec. 31[1]	27,217	30,003	35,521	33,459	36,209	30,876
Total processed during year	88,991	74,784	79,036	82,388	80,056	80,978
Intercompany transactions in scrap	2,366	2,199	1,663	1,828	1,806	1,893
Tin consumed in manufactured products	[2] 86,626	72,585	77,373	80,560	78,250	79,085
Primary	56,623	47,998	45,833	51,530	[3] 50,288	54,602
Secondary	29,746	24,587	31,540	29,030	[3] 27,962	24,483

[1] Stocks shown exclude tin in transit or in other warehouses on Jan. 1, as follows: 1953-57 (average), 1,185 tons; 1958, 1,310 tons; 1959, 1,940 tons; 1960, 1,900 tons; 1961, 2,570 tons; 1962, 425 tons; 1963, 115 tons.
[2] Includes tin losses in manufacturing.
[3] Revised figure.

TABLE 6.—Tin content of tinplate produced in the United States

Year	Tinplate (hot-dipped)			Tinplate (electrolytic)			Tinplate waste-waste, strips, cobbles, etc., gross weight (short tons)	Total tinplate (all forms)		
	Gross weight (short tons)	Tin content (long tons)	Tin per short ton of plate (pounds)	Gross weight (short tons)	Tin content (long tons)	Tin per short ton of plate (pounds)		Gross weight (short tons)	Tin content (long tons)[1]	Tin per short ton of plate (pounds)
1953-57 (average)	1,094,176	13,104	27.0	3,951,959	19,254	10.8	[2] 336,090	5,382,225	[3] 32,942	13.8
1958	476,697	5,793	27.2	4,489,275	23,343	11.7	401,126	5,367,098	29,136	12.2
1959	396,739	4,685	26.5	3,997,171	20,590	11.5	374,130	4,768,040	25,275	11.9
1960	454,808	5,443	26.8	5,300,277	27,795	11.8	495,536	6,250,621	33,238	11.9
1961	296,919	3,610	27.2	5,143,839	27,575	12.0	499,258	5,940,016	31,185	11.8
1962	212,525	2,291	24.1	4,989,463	26,417	11.9	545,623	5,747,611	28,708	11.2

[1] Includes small tonnage of secondary pig tin and tin acquired in chemicals.
[2] Not reported during January-June 1954.
[3] Includes 584 long tons in tinplate waste-waste, strips, and cobbles through June 1954, thereafter not separately reported.

TABLE 7.—Consumer receipts of primary tin, by brands

(Long tons)

Year	Banka	English	Katanga	Longhorn	Straits	Others	Total
1953-57 (average)	4,060	4,500	4,835	242	42,889	2,774	59,300
1958	8,785	4,779	2,143	----------	25,999	4,847	46,553
1959	8,369	10,537	595	----------	24,496	7,272	51,269
1960	[1] 10,065	1,635	1,546	----------	31,355	6,060	50,661
1961	[1] 7,763	2,074	579	2,234	37,420	[2] 4,084	[2] 54,154
1962	8,978	1,448	1,369	1,113	34,341	3,445	50,694

[1] Total deliveries of Banka tin to domestic consumers reported as 10,225 long tons in 1960 and 9,845 tons in 1961; the difference has been reported by respondents under "Others."
[2] Revised figure.

TABLE 8.—Consumption of tin in the United States, by finished products

(Long tons of contained tin)

Product	1961			1962		
	Primary	Secondary [1]	Total	Primary	Secondary [1]	Total
Alloys (miscellaneous)	300	120	420	322	106	428
Babbitt	1,744	1,794	3,538	2,186	1,477	3,663
Bar tin	1,165	108	1,273	1,439	110	1,549
Bronze and brass	3,168	13,025	16,193	3,959	12,428	16,387
Chemicals including tin oxide	674	1,415	2,089	824	1,486	2,310
Collapsible tubes and foil	939	59	998	1,010	79	1,089
Pipe and tubing	31	28	59	30	14	44
Solder	[2] 7,598	[2] 9,847	17,445	12,349	7,220	19,569
Terne metal	51	167	218	166	182	348
Tinning	2,035	41	2,076	2,180	59	2,239
Tinplate [3]	31,185	----------	31,185	28,708	----------	28,708
Type metal	96	1,193	1,289	104	1,212	1,316
White metal	1,190	124	1,314	1,215	85	1,300
Other	112	41	153	110	25	135
Total	[2] 50,288	[2] 27,962	78,250	54,602	24,483	79,085

[1] Includes 2,771 (revised) long tons of tin contained in imported 94/6 tin-base alloys in 1961 and 285 tons in 1962; also includes tin content of alloys imported in 1961 and 1962 under the category of "babbitt metal and solder."
[2] Revised figure.
[3] Includes secondary pig tin and tin acquired in chemicals.

Historical data for 1935 to 1962, inclusive, on consumption of primary and secondary tin and on tin content of tinplate are shown in tables 9 and 10. Table 11 shows historical data on the tin content of terneplate for 1935 through June 1954.

TABLE 9.—Consumption of primary and secondary tin in the United States

(Long tons)

	1935	1936	1937	1938	1939	1940	1941
Stocks Jan. 1 [1]	16,920	14,981	17,978	25,984	25,260	29,025	56,999
Net receipts during year:							
Primary	55,584	73,137	82,946	50,052	70,732	98,125	114,281
Secondary	2,218	2,176	3,461	1,983	4,976	5,409	6,879
Terne	903	994	1,052	787	1,171	1,086	1,851
Scrap	12,687	12,925	13,895	8,609	12,139	23,410	26,112
Total	71,392	89,232	101,354	61,431	89,018	128,030	149,123
Available	88,312	104,213	119,332	87,415	114,278	157,055	206,122
Stocks Dec. 31 [1]	14,981	17,978	25,984	25,260	29,025	56,999	67,421
Total processed during year	73,331	86,235	93,348	62,155	85,253	100,056	138,701
Intercompany transactions in scrap	1,805	2,827	2,782	2,122	2,390	2,190	2,936
Tin consumed in manufactured products	71,526	83,408	90,566	60,033	82,863	97,866	135,765
Plant losses	353	358	436	259	435	712	1,070
Tin content of manufactured products	71,173	83,050	90,130	59,774	82,428	97,154	134,695
Primary	55,928	68,232	[2] 72,928	[2] 48,116	[2] 66,583	[2] 72,324	[2] 103,086
Secondary	15,245	14,818	17,202	11,658	15,845	24,830	31,609

	1942	1943	1944	1945	1946	1947	1948
Stocks Jan. 1 [1]	67,421	43,853	34,735	27,391	25,789	27,100	25,743
Net receipts during year:							
Primary	33,126	40,548	55,323	54,663	56,603	59,882	62,119
Secondary	5,096	4,462	2,536	2,623	2,236	2,836	3,004
Terne	405	188	228	312	257	417	681
Scrap	26,941	29,903	28,883	28,498	26,057	26,598	29,840
Total	65,568	75,101	86,970	86,096	85,153	89,733	95,644
Available	132,989	118,954	121,705	113,487	110,942	116,833	121,387
Stocks Dec. 31 [1]	43,853	34,735	27,391	25,789	27,100	25,743	27,070
Total processed during year	89,136	84,219	94,314	87,698	83,842	91,090	94,317
Intercompany transactions in scrap	2,547	2,889	3,205	3,239	2,091	1,957	2,535
Tin consumed in manufactured products	86,589	81,330	91,109	84,459	81,751	89,133	91,782
Plant losses	902	1,000	1,140	876	808	1,033	994
Tin content of manufactured products	85,687	80,330	89,969	83,583	80,943	88,100	90,788
Primary	56,288	46,253	59,156	55,642	54,627	59,166	59,863
Secondary	29,399	34,077	30,813	27,941	26,316	28,934	30,925

See footnotes at end of table.

TABLE 9.—Consumption of primary and secondary tin in the United States—Con.

(Long tons)

	1949	1950	1951	1952	1953	1954	1955
Stocks Jan. 1 [1]	27,070	24,621	31,856	20,764	23,105	24,525	23,326
Net receipts during year:							
Primary	47,782	79,992	48,298	48,657	57,969	52,673	64,544
Secondary	2,606	3,371	3,273	2,338	2,582	2,351	2,191
Terne	470	997	594	622	604	[3] 226	(4)
Scrap	22,193	30,839	28,974	32,917	29,754	28,601	30,262
Total	73,051	115,199	81,139	84,534	90,909	83,851	96,997
Available	100,121	139,820	112,995	105,298	114,014	108,376	120,323
Stocks Dec. 31 [1]	24,621	31,856	20,764	23,105	24,525	23,326	27,757
Total processed during year	75,500	107,964	92,231	82,193	89,489	85,050	92,566
Intercompany transactions in scrap	2,167	2,168	2,726	2,397	2,566	2,159	2,083
Tin consumed in manufactured products	73,333	105,796	89,505	79,796	86,923	82,891	90,483
Plant losses	927	1,332	1,336	1,378	1,283	(4)	(4)
Tin content of manufactured products	72,406	104,464	88,169	78,418	85,640	[5] 82,891	90,483
Primary	47,163	[5] 71,191	[5] 56,884	[2, 5] 45,323	[2] 53,959	[2] 54,427	[2] 59,828
Secondary	25,243	33,273	31,285	[6] 33,095	[6] 31,681	[6] 28,464	[6] 30,655

	1956	1957	1958	1959	1960	1961	1962
Stocks Jan. 1 [1]	27,757	28,446	32,030	30,003	35,521	33,459	36,209
Net receipts during year:							
Primary	62,099	59,215	46,553	51,269	50,661	54,154	50,694
Secondary	2,185	2,868	2,524	2,471	2,217	2,897	2,409
Terne	(4)	(4)	(4)	(4)	(4)	(4)	(4)
Scrap	28,999	26,758	23,680	30,814	27,448	25,755	22,542
Total	93,283	88,841	72,757	84,554	80,326	82,806	75,645
Available	121,040	117,287	104,787	114,557	115,847	116,265	111,854
Stocks Dec. 31 [1]	28,446	32,030	30,003	35,521	33,459	36,209	30,876
Total processed during year	92,594	85,257	74,784	79,036	82,388	80,056	80,978
Intercompany transactions in scrap	2,270	2,750	2,199	1,663	1,828	1,806	1,893
Tin consumed in manufactured products	90,324	82,507	72,585	77,373	80,560	78,250	79,085
Plant losses	(4)	(4)	(4)	(4)	(4)	(4)	(4)
Tin content of manufactured products	90,324	82,507	72,585	77,373	80,560	78,250	79,085
Primary	[2] 60,470	[2] 54,429	[2] 47,998	[2] 45,833	[2] 51,530	[2] 50,288	[2] 54,602
Secondary	[6] 29,854	[6] 28,078	[6] 24,587	[6] 31,540	[6] 29,030	[6] 27,962	[6] 24,483

[1] Stocks shown exclude tin in transit or in other warehouses on Jan. 1, as follows: 1942, 2,700 tons; 1943, 78 tons; 1944, 316 tons; 1945, 1,941 tons; 1946, 1,600 tons; 1947, 1,000 tons; 1948, 940 tons; 1949, 328 tons; 1950, 61 tons; 1951, 1,355 tons; 1952, 971 tons; 1953, 325 tons; 1954, 240 tons; 1955, 1,340 tons; 1956, 2,005 tons; 1957, 1,815 tons; 1958, 1,310 tons; 1959, 1,940 tons; 1960, 1,900 tons; 1961, 2,570 tons; 1962, 425 tons; 1963, 115 tons.

[2] From 1937 through 1941 and from 1952 through 1962 includes small tonnage of secondary pig tin; beginning with 1952 includes tin acquired in chemicals for tinplate.

[3] 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.

[4] Not separately reported.

[5] Includes copan alloy produced by Longhorn Smelter, Texas City, Tex.

[6] Includes tin contained in imported tin-base alloy.

TABLE 10.—Tin content of tinplate produced in the United States

Year	Tinplate (hot-dipped)			Tinplate (electrolytic)			Tinplate waste-waste, strips, cobbles, etc.			Total tinplate (all forms)		
	Gross weight (short tons)	Tin content (long tons)	Tin per short ton of plate (pounds)	Gross weight (short tons)	Tin content (long tons)	Tin per short ton of plate (pounds)	Gross weight (short tons)	Tin content (long tons)	Tin per short ton of plate (pounds)	Gross weight (short tons)	Tin content (long tons)	Tin per short ton of plate (pounds)
1935	1,926,896	27,290	31.7	------	------	------	------	------	------	1,926,896	27,290	31.7
1936	2,349,402	33,750	32.2	------	------	------	------	------	------	2,349,402	33,750	32.2
1937	2,724,278	37,921	31.2	------	------	------	95,357	1,300	30.5	2,819,635	[1] 39,221	31.2
1938	1,625,131	22,649	31.2	------	------	------	66,631	896	30.1	1,691,762	[1] 23,545	31.2
1939	2,546,216	35,322	31.1	------	------	------	98,488	1,318	30.0	2,644,704	[1] 36,640	31.0
1940	2,583,327	36,741	31.9	63,282	348	12.3	112,288	1,585	31.6	2,758,897	[1] 38,674	31.4
1941	3,188,713	42,860	30.1	87,836	457	11.7	111,590	1,537	30.9	3,388,139	[1] 44,854	29.7
1942	2,428,634	27,538	25.4	82,013	434	11.9	48,522	550	25.4	2,559,169	28,522	25.0
1943	1,684,807	19,386	25.8	327,713	1,787	12.2	64,582	553	19.2	2,077,102	21,726	23.4
1944	1,779,117	20,874	26.3	644,958	3,404	11.8	79,727	690	19.4	2,503,802	24,968	22.3
1945	1,709,412	20,762	27.2	859,636	4,598	12.0	87,287	720	18.5	2,656,335	26,080	22.0
1946	1,716,591	20,770	27.1	882,537	4,702	11.9	76,782	655	19.1	2,675,910	26,127	21.9
1947	1,872,152	22,159	26.5	1,734,535	7,981	10.3	124,661	840	15.1	3,731,348	30,980	18.6
1948	1,848,373	22,028	26.7	1,918,708	8,518	9.9	147,242	957	14.6	3,914,323	31,503	18.0
1949	1,648,001	19,613	26.7	2,030,567	8,814	9.7	185,233	1,190	14.4	3,863,801	29,617	17.2
1950	1,845,009	21,875	26.6	2,693,777	12,110	10.1	228,488	1,395	13.7	4,767,274	35,380	16.6
1951	1,557,006	17,789	25.6	2,832,044	11,595	9.2	202,381	1,138	12.6	4,591,431	30,522	14.9
1952	1,308,173	15,012	25.7	2,712,657	11,022	9.1	228,563	1,282	12.6	4,249,393	[1] 27,316	14.4
1953	1,375,606	14,807	24.1	3,331,386	14,605	9.8	360,018	1,915	11.9	5,067,010	[1] 31,327	13.9
1954	1,339,611	15,906	26.6	3,526,982	16,115	10.2	[2] 150,634	[3] 1,005	([4])	5,017,227	[1] 33,026	14.7
1955	1,062,850	13,395	28.2	4,002,068	20,154	11.3	357,526	([4])	([4])	5,422,444	[1] 33,549	13.9
1956	1,006,196	13,041	29.0	4,305,774	21,720	11.3	377,091	([4])	([4])	5,689,061	[1] 34,761	13.7
1957	686,616	8,370	27.3	4,593,587	23,676	11.6	435,181	([4])	([4])	5,715,384	[1] 32,046	12.6
1958	476,697	5,793	27.2	4,489,275	23,343	11.7	401,126	([4])	([4])	5,367,098	[1] 29,136	12.2
1959	396,739	4,685	26.5	3,997,171	20,590	11.5	374,130	([4])	([4])	4,768,040	[1] 25,275	11.9
1960	454,808	5,443	26.8	5,300,277	27,795	11.8	495,536	([4])	([4])	6,250,621	[1] 33,238	11.9
1961	296,919	3,610	27.2	5,143,839	27,575	12.0	499,258	([4])	([4])	5,940,016	[1] 31,185	11.8
1962	212,525	2,291	24.1	4,989,463	26,417	11.9	545,623	([4])	([4])	5,747,611	[1] 28,708	11.2

[1] From 1937 through 1941 and from 1952 through 1962 includes small tonnage of secondary pig tin; beginning with 1952 includes tin acquired in chemicals for tinplate.
[2] Not reported during January–June 1954.
[3] Through June 1954 only; thereafter not separately reported.
[4] Not separately reported.

TABLE 11.—Tin content of terneplate produced in the United States

Year	Short ternes			Long ternes			Terneplate waste-waste			Total terneplate		
	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)
1935	104,596	644	13.8	113,990	420	8.3				218,586	1,064	10.9
1936	140,319	872	13.9	125,266	440	7.9				265,585	1,312	11.1
1937	162,724	924	12.7	129.754	473	8.2				292,478	1,397	10.7
1938	129,139	739	12.8	78,749	268	7.6				207,888	1,007	10.9
1939	181,959	1,009	12.4	104,917	445	9.5				286,876	1,454	11.4
1940	167,321	933	12.5	149,787	580	8.7				317,108	1,513	10.7
1941	267,675	1,157	9.7	292,301	852	6.5	8,981	37	9.2	568,957	2,046	8.1
1942	174,366	512	6.6	128,135	356	6.2	4,855	14	6.5	307,356	882	6.4
1943	118,033	225	4.3	105,334	203	4.3	1,960	6	6.9	225,327	434	4.3
1944	177,681	413	5.2	184,757	317	3.8	4,859	10	4.6	367,297	740	4.5
1945	193,586	447	5.2	170,442	281	3.7	7,419	13	3.9	371,447	741	4.5
1946	69,861	178	5.7	142,917	262	4.1	2,976	6	4.5	215,754	446	4.6
1947	92,683	221	5.3	142,818	270	4.2	4,798	10	4.7	240,299	501	4.7
1948	181,141	388	4.8	137,045	272	4.4	5,902	12	4.6	324,088	672	4.6
1949	81,682	177	4.9	150,143	435	6.5	7,816	14	4.0	239,641	626	5.9
1950	60,952	188	6.9	209,223	753	8.1	4,788	11	5.1	274,963	952	7.8
1951	52,614	201	8.6	216,069	555	5.8	4,561	11	5.1	273.244	767	6.3
1952	56,961	225	8.8	165,260	347	4.7	3,458	8	5.5	225,679	580	5.8
1953	59,429	241	9.1	215,360	392	4.1	3,453	10	6.0	278,242	643	5.2
1954 [1]	23,786	80	7.5	69,478	145	4.7				93,264	225	5.4

[1] Through June only; thereafter not separately reported.

STOCKS

Tinplate mills, holding nearly 85 percent of the plant stocks of pig tin in the United States, decreased their inventories by 1,775 long tons. Tin in process at tin mills on December 31 dropped to 6,205 tons; pig tin stocks at other plants were depleted by 2,760 tons to the lowest yearend level recorded.

GSA sold 700 long tons of pig tin, the remnant of the FFC stock of 3,900 long tons that was excess to the Government's needs and not in the national stockpile. Congress approved the release of 50,000 tons of tin from the national stockpile, of which GSA sold 1,400 tons during 1962. On December 31, there was 347,290 tons of tin in Government stockpiles; of this, 339,785 tons was in the national (strategic) stockpile and 7,505 tons, obtained largely through the Commodity Credit Corporation barter program, was in the supplemental stockpile.

TABLE 12.—U.S. industry tin stocks

(Long tons)

	1953-57 (average)	1958	1959	1960	1961	1962
Plant raw materials:						
Pig tin:						
Virgin	15,693	18,173	22,830	20,881	23,679	19,201
Secondary	296	281	270	257	249	193
In process [1]	11,228	11,549	12,421	12,321	12,281	11,482
Total	27,217	30,003	35,521	33,459	36,209	30,876
Additional pig tin:						
In transit in United States	1,342	1,940	1,900	2,570	425	115
Jobbers-importers	600	1,050	1,945	1,090	2,675	[2] 2,145
Afloat to United States	4,095	1,660	1,855	2,990	3,170	4,140
Total	6,037	4,650	5,700	6,650	6,270	6,400
Grand total	33,254	34,653	41,221	40,109	42,479	37,276

[1] Tin content, including scrap.
[2] Includes 1,600 tons, representing bids rejected by GSA, from tin offered by Defense Materials Services of GSA in DMS-MET-20, Aug. 31 (1,600 tons), and in DEM-MET-25, Oct. 19 (1,400 tons). Does not nclude 1,000 tons representing total of weekly tin offerings in January 1963 (DMS-MET-25, Dec. 31).

PRICES

The tin market in 1962 mainly reflected buying operations by the manager of the international buffer stock and offerings and sales by GSA. The highest price of Straits tin during 1962 for prompt (immediate) delivery in New York was 124.25 cents per pound on March 16, 19, and 20. The price dropped to 107.375 cents per pound on October 10 and 11, the lowest since April 18, 1961.

The cash price on the London market averaged £896.5 per long ton, compared with £888.6 in 1961. The 1962 high was £976 on March 19. The price dropped to £825 on July 30, the low for 1962, but was quickly raised by buffer stock buying to the maximum support figure of £850. Beginning October 9, a premium developed in the price of cash over 3-month tin from a stringency in spot supplies, resulting mainly from the removal of tin from the market for the buffer stock.

On the Singapore-Penang market the average price of Straits tin ex-works was £880.4 per long ton (£877.2 for 1961). The highest quotation was £956.8 on March 19, and the lowest was £827 on October 11. The headquarters of the Malayan tin market was transferred from Singapore to Penang on May 1.

TABLE 13.—Monthly prices of Straits tin for prompt delivery in New York
(Cents per pound)

Month	1961			1962		
	High	Low	Average	High	Low	Average
January	100.750	100.125	100.381	120.875	119.500	120.301
February	102.375	100.250	100.979	121.375	120.750	121.056
March	104.625	101.625	103.403	124.250	121.125	123.085
April	109.500	104.500	107.075	123.250	120.875	122.119
May	111.250	107.500	110.034	120.375	115.750	117.187
June	120.000	111.125	114.551	115.625	111.000	113.018
July	118.000	115.250	116.250	113.375	109.250	111.446
August	125.750	116.500	119.783	109.250	107.875	108.457
September	125.000	120.500	121.850	108.875	108.250	108.461
October	122.500	120.125	121.054	111.250	107.375	108.761
November	123.625	121.875	122.894	111.625	109.875	110.776
December	122.250	119.625	120.981	111.250	109.250	110.637
Total	125.750	100.125	113.270	124.250	107.375	114.609

Source: American Metal Market.

FOREIGN TRADE [4]

The principal tin items in the foreign trade of the United States were imports of metallic tin and tin concentrates, and exports of tinplate and tin cans. The trade in tin scrap (including tin-alloy scrap, tinplate scrap, and tinplate circles, cobbles, strip, and scroll) was of less importance. Significant quantities of tin ingot, miscellaneous tin manufactures, and tin compounds were exported. Tin contained in babbitt, solder, type metal, and bronze imported and exported is shown in the Lead and Copper chapters. Ferrous scrap exports included tinplate and terneplate scrap not separately classified.

TABLE 14.—U.S. imports for consumption of tin concentrate (tin content), by countries

Country	1961		1962	
	Long tons	Value	Long tons	Value
Bolivia	262	$538,851	930	$1,799,383
Burma			100	127,156
Indonesia	8,556	21,175,902	4,321	11,630,857
Mexico	87	189,048	13	37,249
Thailand	12	19,374		
Total	8,917	21,923,175	5,364	13,594,645

Source: Bureau of the Census.

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

TABLE 15.—U.S. imports for consumption of tin,[1] by countries

Country	1961		1962	
	Long tons	Value (thousands)	Long tons	Value (thousands)
Belgium-Luxembourg	680	$1,530	1,826	$4,605
Bolivia	[2] 1,672	[2] 3,830	1,850	4,464
Canada	7	23	(3)	4
Congo, Republic of the, and Ruanda-Urundi	4	11		
Indonesia	150	337	50	120
Malaya, Federation of, and Singapore	32,955	80,243	[4] 34,815	[4] 86,695
Netherlands	55	118	(3)	1
Nigeria	544	1,310	1,176	2,908
Portugal	1,016	2,455	345	903
United Kingdom	2,810	7,039	1,346	3,424
Total	[2] 39,893	[2] 96,896	[4] 41,408	[4] 103,124

[1] Bars, blocks, pigs, grain, or granulated.
[2] Revised figure.
[3] Less than 1 ton.
[4] Adjusted by the Bureau of Mines to include 15 long tons ($39,776), reported by the Bureau of the Census as India; and 344 long tons ($855,508), classified by the Bureau of the Census as alloys, chief value tin, n.s.p.f.

Source: Bureau of the Census.

TABLE 16.—U.S. exports of tin; imports for consumption and exports of tinplate and terneplate in various forms

Year	Ingots, pigs, and bars				Tinplate and terneplate		Tinplate circles, strips, and cobbles	Tinplate scrap
	Exports		Reexports		Imports	Exports	Exports	Imports
	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Long tons	Long tons	Long tons
1953-57 (average)	441	$723	470	$991	233	623,495	15,893	31,217
1958	917	1,336	424	899	51	331,813	15,728	32,824
1959	943	1,890	428	970	59,811	328,888	15,082	37,151
1960	608	1,294	249	549	17,612	504,942	20,491	36,352
1961	543	1,264	257	626	13,527	358,707	20,960	29,499
1962	335	840	100	267	46,857	294,510	21,994	18,832

Source: Bureau of the Census.

TABLE 17.—U.S. imports for consumption and exports of miscellaneous tin, tin manufactures, and tin compounds

Year	Miscellaneous tin and manufactures						Tin compounds	
	Imports			Exports				
	Tinfoil, tin powder, flitters, metallics, tin and manufactures, n.s.p.f. value (thousands)	Dross, skimmings, scrap, residues, and tin alloys, n.s.p.f.		Tin cans, finished or unfinished		Tin scrap and other tin-bearing material, except tin-plate scrap value (thousands)	Imports (long tons)	Exports (long tons)
		Long tons	Value (thousands)	Long tons	Value (thousands)			
1953-57 (average)	[1] $623	5,851	[2] $10,110	28,175	$12,602	$2,887	6	152
1958	610	3,208	5,771	35,849	18,322	992	11	(3)
1959	1,008	3,350	6,469	36,320	19,027	1,231	6	(3)
1960	839	809	1,642	32,875	17,362	1,355	3	(3)
1961	676	612	1,299	30,929	15,093	3,352	22	(3)
1962	819	[4] 2,173	[4] 880	25,531	13,927	2,111	58	(3)

[1] Data for 1954–57 known to be not comparable with other years.
[2] Data for 1955–56 known to be not comparable with other years.
[3] Beginning Jan. 1, 1958, not separately classified.
[4] Adjusted by the Bureau of Mines.

Source: Bureau of the Census.

WORLD REVIEW

INTERNATIONAL TIN AGREEMENT

The International Tin Council held several meetings in 1962. On January 12 the tin agreement floor price was raised from £730 (91.25 cents per pound) to £790 per long ton (98.75 cents per pound); the ceiling price was raised from £880 (110 cents per pound) to £965 per ton (120.625 cents per pound). The middle sector in the new range was fixed at £850 (106.25 cents per pound) to £910 (113.75 cents per pound). In April, percentages and votes of the producing countries and votes of the consuming countries were revised, effective from July 1. As requirements had been met, the Council announced on March 7 and April 7 that the Second International Tin Agreement had been converted to a definitive entry into force on February 21. Problems of stockpile disposals were considered. A delegation was sent to Washington, D.C., in July to discuss the Council's stockpile disposal plan. No agreement resulted, but assurance was given that disposal would be in moderate quantities at a regulated rate in accordance with market conditions. At a November 6–7 meeting, Harold W. Allen of Australia was elected chairman of the Council. At the eighth meeting in Bangkok, Thailand, November 27–30, U.S. tin stockpile disposals were discussed. On invitation, the Council decided to send a delegation to Washington, D.C., December 13–19, for a consultation and review of the operation of the first plan for disposing of tin surplus to the needs of the national stockpile. Progress was made towards a mutual understanding of problems and objectives. Noncommercial stocks of Canadian tin were 460 tons at the end of 1962. The Council expected that 750 tons of tin would be sold in Italy from the Italian Government's tin stockpile in 1963. The buffer stock held 1,805 tons of tin on September 30, and 3,270 tons on December 31.

TABLE 18.—Second International Tin Agreement: Percentages and voting powers of producing countries [1]

Country	Percentage	Votes allocated	Country	Percentage	Votes allocated
Bolivia	16.389	164	Nigeria	5.909	62
Congo, Republic of the	8.180	85	Thailand	9.774	100
Indonesia	17.757	177			
Malaya, Federation of	41.991	412	Total	100.000	1,000

[1] Effective from July 1, 1962, through June 30, 1963. Established at fourth meeting of the Second International Tin Council, Apr. 3-5, 1962. Based on production from Oct. 1, 1960, to Sept. 30, 1961, inclusive, except that for Republic of the Congo "exceptional circumstances" were accepted.

TABLE 19.—Second International Tin Agreement: Voting power and tonnage of consuming countries [1]

Country	Tonnage	Votes	Country	Tonnage	Votes
Australia	3,578	49	Japan	12,715	161
Austria	711	14	Korea	202	7
Belgium	2,493	36	Mexico	1,087	18
Canada	4,061	55	Netherlands	3,133	43
Denmark	4,331	58	Spain	983	17
France	10,857	138	Turkey	967	17
India	4,208	57	United Kingdom	21,451	269
Italy	4,517	61			
			Total	75,294	1,000

[1] Effective from July 1, 1962, through June 30, 1963. Established at fourth meeting of the Second International Tin Council, Apr. 3-5, 1962. Based on averages of the consumption of primary metallic tin by each country for the 3 years ending on Dec. 31, 1961.

TABLE 20.—Authority of the tin buffer stock manager

Provisions	From Mar. 22, 1957, to Jan. 11, 1962	Revised Jan. 12, 1962
Must sell [1]	£880 or higher per long ton (110 cents or higher per pound).	£965 or higher per long ton (120.625 cents or higher per pound).
Upper range—may sell	£830 to £880 per long ton (103.75 to 110 cents per pound).	£910 to £965 per long ton (113.75 to 120.625 cents per pound).
Midrange—abstains from buying or selling.	£780 to £830 per long ton (97.5 to 103.75 cents per pound).	£850 to £910 per long ton (106.25 to 113.75 cents per pound).
Lower range—may buy	£730 to £780 per long ton (91.25 to 97.5 cents per pound).	£790 to £850 per long ton (98.75 to 106.25 cents per pound).
Must buy [2]	£730 or lower per long ton (91.25 cents or lower per pound).	£790 or lower per long ton (98.75 cents or lower per pound).

[1] If the buffer stock manager has tin.
[2] If the buffer stock manager has money.

TABLE 21.—World mine production of tin (content of ore), by countries [1]

(Long tons)

Country	1953–57 (average)	1958	1959	1960	1961	1962
North America:						
Canada	262	355	334	278	389	307
Mexico	481	544	377	365	530	577
United States	72	----------	50	10	(2)	(2)
Total	815	899	761	653	(2)	(2)
South America:						
Argentina	121	205	225	238	524	[3] 515
Bolivia (exports)	29,241	17,731	23,811	19,406	20,408	21,493
Brazil	198	409	461	1,556	(4)	(4)
Peru	3	30	43	6	14	11
Total	29,563	18,375	24,540	21,206	(4)	(4)
Europe:						
Czechoslovakia [5]	200	200	200	200	200	200
France	469	----------	----------	21	141	[3] 290
Germany, East [3]	646	720	720	720	720	720
Portugal [6]	1,278	1,249	1,129	772	729	598
Spain	826	467	326	196	230	319
U.S.S.R. [7] [8]	10,900	13,500	15,000	16,000	17,000	17,000
United Kingdom	1,030	1,087	1,252	1,199	1,210	1,181
Total [3] [8]	15,300	17,200	18,600	19,100	20,200	20,300
Asia:						
Burma [6]	1,158	1,300	1,200	1,200	1,130	950
China [7]	16,000	23,000	26,000	28,000	30,000	30,000
Indonesia	32,165	23,201	21,613	22,596	18,574	17,583
Japan	845	1,108	998	842	853	859
Laos	231	301	294	383	332	355
Malaya, Federation of	59,955	38,458	37,525	51,979	56,028	58,603
Thailand	11,387	7,718	9,519	12,080	13,270	14,680
Total [3] [8]	121,700	95,100	97,200	117,100	120,200	123,000
Africa:						
Cameroon	82	75	62	65	68	[3] 60
Congo, Republic of the (formerly Belgian)	12,948	9,689	9,190	8,900	6,570	7,197
Congo, Republic of	----------	27	32	34	46	46
Morocco	8	6	9	10	11	10
Niger, Republic of	65	61	57	53	47	41
Nigeria	8,583	6,200	5,541	7,675	7,779	8,210
Rhodesia and Nyasaland, Federation of	179	532	605	642	716	703
Ruanda-Urundi	1,942	1,490	1,124	1,277	1,474	[3] 1,440
South Africa, Republic of	1,373	1,417	1,273	1,266	1,430	1,422
South-West Africa	418	164	4	261	302	369
Swaziland	30	15	5	6	5	6
Tanganyika (exports)	31	19	65	138	163	206
Uganda	63	41	36	32	33	74
Total	25,722	19,736	18,003	20,359	18,644	19,784
Oceania: Australia	1,935	2,237	2,351	2,202	2,745	2,650
World total (estimate)	195,000	153,500	161,500	180,600	185,200	190,200

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[2] Figure withheld to avoid disclosing individual company confidential data; included in world total.
[3] Estimated by authors of the chapter and in a few instances from the Statistical Bulletin of the International Tin Council, London, England.
[4] Data not available; estimate included in world total.
[5] Estimate, according to the 49th annual issue of Metal Statistics (Metallgesellschaft) through 1961.
[6] Includes tin content of mixed concentrates.
[7] Estimated smelter production.
[8] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.

Compiled by Catherine M. Judge, Division of Foreign Activities.

TABLE 22.—World smelter production of tin, by countries [1]

(Long tons)

Country	1953–57 (average)	1958	1959	1960	1961	1962
North America:						
Mexico	243	460	377	365	559	528
United States [2]	21,299	[3] 5,440	[3] 10,773	[3] 14,026	[3] 8,917	[3] 5,364
Total	21,542	5,900	11,150	14,391	9,476	5,892
South America:						
Argentina	78					
Bolivia (exports) [3]	233	705	955	1,069	2,015	2,024
Brazil	1,306	629	1,227	1,311	1,525	[4] 1,500
Total	1,617	1,334	2,182	2,380	3,540	3,524
Europe:						
Belgium	10,087	8,723	5,945	7,947	6,002	8,607
Germany:						
East [4]	577	600	600	600	600	600
West	522	646	1,010	769	947	1,309
Netherlands	27,883	17,098	9,592	6,393	2,729	4,282
Portugal	870	1,259	1,167	601	784	674
Spain	693	449	328	304	659	655
U.S.S.R. [4 5 6]	10,900	13,500	15,000	17,000	20,000	20,500
United Kingdom	[6] 28,837	31,326	26,614	26,286	24,449	21,440
Total [4 5]	80,400	73,600	60,300	59,900	56,200	58,100
Asia:						
China [4]	16,000	23,000	26,000	28,000	30,000	30,000
Indonesia	838	1,569	1,971	1,977	[4] 2,000	[4] 2,000
Japan	1,003	1,307	1,308	1,260	1,644	1,856
Malaya, Federation of	69,752	45,336	45,729	76,130	79,114	82,073
Total [4 5]	87,600	71,200	75,000	107,400	112,800	115,900
Africa:						
Congo, Republic of the (formerly Belgian)	2,817	2,642	3,291	[4] 3,500	[4] 2,400	[4] 612
Morocco	8	[4] 10	[4] 10	[4] 10	[4] 10	[4] 10
Nigeria					623	8,024
Rhodesia and Nyasaland, Federation of	67	503	572	609	673	677
South Africa, Republic of	788	901	726	622	870	821
Total	3,680	4,056	4,599	4,741	4,576	10,144
Oceania: Australia	1,833	2,121	2,226	2,254	2,546	2,740
World total (estimate)	196,700	158,200	155,500	191,100	189,100	196,300

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[2] Includes tin content of alloys made directly from ores.
[3] Imports into the United States of tin concentrates (tin content).
[4] Estimated by authors of the chapter and in a few instances from the Statistical Bulletin of the International Tin Council, London, England.
[5] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.
[6] Includes secondary.

Compiled by Catherine M. Judge, Division of Foreign Activities.

REVIEW BY COUNTRIES

SOUTH AMERICA

Bolivia.—Exports of tin, mostly in concentrate, totaled 21,490 long tons valued at US$54 million, an increase of 5 percent in tonnage and 7 percent in value compared with 1961. Tin represented 77 percent of the gross value of Bolivian minerals exported in 1962. Tin production in nationalized mines rose 3 percent, reversing an 8-year downward trend. A sharp fall in exports occurred in November owing to a 20-day railroad strike. The Bolivan government authorized the sale of up to 5,000 metric tons (4,920 long tons) of metallic tin, in a minimum of 12,000 tons of concentrates for each year of a 3-year period to Wah Chang Corp., New York. During this period Wah Chang Corp. was expected to perfect its hydrogen-reduction process for smelting low-grade concentrate.

TABLE 23.—Bolivia: Tin production by nationalized mines

(Long tons of contained tin)

Mine	1961	1962	Mine	1961	1962
Caracoles	774	776	Oploca-Santa Ana	25	----------
Catavi	4,196	4,076	San Jose	869	1,058
Chorolque	492	673	Santa Fe	486	614
Colavi	148	210	Tasna	485	447
Colquechaca	47	34	Unificada	976	1,293
Colquiri	2,566	2,314	Viloco	463	674
Huanuni	2,628	2,414	Others	29	79
Japo	91	90			
Morococala	304	241	Total	14,579	14,993

Source: U.S. Embassy, La Paz, Bolivia, from data furnished by Corporation Minera de Bolivia.

TABLE 24.—Bolivia: Exports of tin by groups

(Long tons of contained tin)

Group	1955–59 (average)	1960	1961	1962
Corporation Minera de Bolivia [1]	19,874	12,677	12,622	13,219
Banco Minero:				
Medium mines	2,011	2,393	2,475	2,731
Small mines	2,412	2,868	3,297	3,521
Smelter (tin metal)	523	1,468	2,015	[2] 2,022
Total	24,820	19,406	20,409	21,493

[1] Decree of Oct. 31, 1952, nationalized the major producers of tin included in this group; namely Patino Mines & Enterprises Inc., Compagnie Aramayo de Mines en Bolivia, and Maurico Hocschild, S.A.M.I.
[2] Includes tin content of alloys made directly from ore.
Source: Departmento de Estadistica—Direccion General de Minas, Ministrio de Mines y Petroleo.

TABLE 25.—Bolivia: Exports of tin, by countries

(Long tons of contained tin)

Destination	1961	1962	Destination	1961	1962
Brazil	476	----------	United Kingdom	15,147	15,523
Germany, West	1,467	1,587	United States	2,743	3,523
Korea, Republic of	10	----------			
Netherlands	564	860	Total	20,409	21,493
Peru	2	----------			

Source: Departmento de Estadistica—Direccion General de Minas, Ministrio de Mines y Petroleo.

Brazil.—Placer production had quadrupled since 1959 to an average of 1,500 long tons annually. Tin concentrate produced near Porto Velho, Rondonia (formerly Guapore), was flown by airfreight in 1962 to the Volta Redonda smelter of Companhia Estabifera do Brazil from airstrips cut into the jungle.

Cia. Industrial Fluminense Ltd. announced that it was moving its electric and kiln furnaces from Niterói to Carandai. Power was to be supplied from the Carandai River Dam. The new smelter may handle the entire output of Brazilian concentrate.

EUROPE

U.S.S.R.—Imports from China were 10,000 long tons (estimated), compared with 11,000 tons in 1961. Tin imported from Malayan and Western European markets was 5,000 tons in 1962, the highest since 1951. For the first time since 1955, Free Europe imported virtually no Soviet tin. Tin consumption was estimated at 25,000 tons (23,000 in 1961). Imports from Western Europe were 43,290 tons of tinplate (44,460 in 1961). Exports were 71,500 tons (estimated), against 66,200 tons in 1961. Cuba was the largest market. Tinplate production, hot-dipped and electrolytic, was 381,600 tons (361,500 in 1961), including lightweight electrolytic tinplate at 65 pounds per base box. About 25 percent of the food pack was produced in tin cans, and the remainder, in glass and aluminum.

TABLE 26.—Sino-Soviet bloc: Shipment of tin metal

(Long tons)

Source and destination	1961	1962
From U.S.S.R. to—		
Germany, West	519	
Finland	300	
India	200	
Japan	503	
United Arab Republic	223	
United Kingdom	51	69
Yugoslavia	335	
Total	2,131	69
From China to—		
Argentina	39	
Austria	5	21
Belgium		2
Denmark	298	120
From China to—Con.		
Finland	50	108
France	150	500
Germany, West	2,783	1,558
Hong Kong	115	56
Japan	914	820
Netherlands	1,325	1,351
Sweden	120	70
Switzerland	73	220
Syria	5	26
United Arab Republic	568	580
United Kingdom	901	1,534
Total	7,346	6,966
Grand total	9,477	7,035

Source: Statistical Bulletin of the International Tin Council.

United Kingdom.—Mine production in Cornwall, England, was 1,180 long tons of tin, derived principally from 700 tons of black tin (65 percent tin) produced by Geevor Tin Mines, Ltd., and 820 tons (70 percent tin) produced by South Crofty, Ltd.

The United Kingdom ranked second as a free world smelter of tin ore, as a consumer of pig tin, and as a producer of tinplate. Most of the concentrate treated was from Bolivia. Receipts were the lowest for many years because imports from Bolivia dropped and Nigerian ore was diverted to its own smelters. Primary tin consumption was 21,440 tons, compared with 20,240 tons (revised) in 1961. About 48 percent was used for making tinplate. The production of tinplate was 1.2 million tons, 13 percent more than in 1961 (1,043,000 tons). Of the 1962 tinplate output, 78 percent was electrolytic and 22 percent was hot dipped. Tinplate exports rose to 454,540 tons from 424,600 tons in 1961. Peak shipments to Greece, Israel, Norway, Poland, Portugal, Spain, Sweden, and Yugoslavia and large increases in tonnages to France and the United States, offset sharp drops to

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Australia-New Zealand, Bulgaria, Hungary, and some countries in Africa, Asia, and South America. Exports to Sweden rose for the seventh consecutive year. The United States received 36,115 tons, compared with 14,930 in 1961, and was the third largest buyer of tinplate from the United Kingdom.

Imports of tin metal, mainly from Nigeria (for the first time) and China, rose to 9,230 tons (1,800 tons in 1961). Tin metal exports, mostly to the U.S.S.R. and the United States, dropped to 8,030 tons (12,190 tons in 1961).

Pig-tin stocks totaled 6,370 (revised) tons at the beginning of 1962 and 5,920 tons at yearend. Stocks of tin in concentrate were 1,876 tons at the beginning of 1962 and 1,411 tons at the end. Yearend stocks of tin in concentrate afloat were 695 tons (952 tons at beginning of 1962).

ASIA

Indonesia.—Tin output in 1962 dropped 5 percent to the lowest since 1947. The islands of Banka, Billiton, and Singkep furnished 55, 35, and 10 percent, respectively, of the total. All of these operations are owned by the Indonesian Government.

Tin in concentrate exports totaled 16,437 tons in 1962, of which 13,080 tons (the highest since 1941) went to Malaya-Singapore and 3,357 tons went to the United States. None was shipped to the United States after May. In addition, 273 tons of tin in slags was shipped to Malaya-Singapore in 1962.

The Government of Indonesia negotiated with a British firm for the procurement of a large tin dredge for working offshore near Billiton.

Malaya, Federation of.—Of the total mine production of 58,600 long tons of tin in concentrate, 61 percent came from European-operated mines (mostly by dredges) and 39 percent came from Asian-operated mines (mostly by gravel pumps), including 2 percent from dulang washing. European mines produced 35,988 tons (36,243 tons in 1961), and Asian mines produced 22,615 tons (19,785 tons in 1961). Except for dredging, which decreased by 1,110 tons, and hydraulicking (50 tons) gains in output were made by other mining methods. Gravel pumping increased the most, by 2,770 tons. Output of open-pit mines rose to 2,030 tons, the highest since 1941. Recovery by dulang washers was 1,270 tons, the highest since 1951. Export duties on tin were M$67 (US$20.4) million, compared with M$65 (US$19) million in 1961.

There were 696 active mines at the beginning of 1962 and 704 at yearend. The number of dredges declined from 72 to 66, whereas the number of gravel-pumping units increased for the fourth consecutive year, from 572 to 582.

The Malayan Government collected M$24 per picul (US$134.4 per long ton) on exports of tin concentrate during 1962 for the second buffer stock.

The principal world source of tin continued to be the large plants of the Eastern Smelting Co., Ltd., on the island of Penang; the Straits Trading Co., Ltd., at Pulau Brani, Singapore; and Butterworth, Wellesley Province. The concentrate treated was derived mostly from the Federation of Malaya, Indonesia, and Thailand. Total tin in concentrate available for the Federation smelters was 83,054 tons (72,209 tons in 1961). Tin in concentrate received by the Singapore smelter was 677 tons, against 3,308 in 1961. Smelter production was the highest since 1941. Exports of tin metal, mostly from Penang, were the largest since 1950. Construction of a new smelter with an annual capacity of 12,000 tons of tin at Port Swettenham was scheduled to start in 1963 for completion in late 1964. Capital for the project, called the Malayan Smelting Co., was to be M$5 (US$1.5) million. Ishihara Sangyo Kaisha of Japan was to provide three-fourths of the amount, and the Malayan Government-sponsored National Investment Co. was to supply the balance.

Stocks of tin metal increased from 3,966 tons at the beginning of 1962 to 4,607 tons at yearend. Tin in concentrate (including mine stocks) rose from 5,968 tons (revised) at the beginning of 1962 to 7,120 tons at the end. Concentrate delivered by mines to smelters dropped in December owing to a railway labor strike.

TABLE 27.—Federation of Malaya and Singapore: Exports of tin in metal, by countries

(Long tons)

Destination	1961	1962	Destination	1961	1962
Argentina	1,669	935	Japan	10,629	10,319
Australia-New Zealand	1,002	2,218	Netherlands	842	2,395
Belgium	4,275	5,855	United Kingdom	1,490	1,955
Canada	2,153	1,862	United States	33,596	34,481
Denmark	194	184	Yugoslavia	781	1,155
France	3,940	4,388	Others	2,811	5,773
Germany, West	5,561	655			
India	4,332	4,478	Total	78,025	81,393
Italy	4,750	4,740			

Source: Federation of Malaya, Department of Statistics, Monthly Statistical Bulletin, March 1963.

TABLE 28.—Federation of Malaya and Singapore: Imports of tin in concentrate, by countries

(Long tons)

Country	1961		1962	
	Gross weight	Tin content	Gross weight	Tin content
Burma	1,827	1,323	1,982	1,427
Indonesia	11,183	8,068	17,635	12,706
Laos	768	550	715	514
Thailand	12,374	8,939	12,801	9,225
Other countries	203	145	180	129
Total	26,355	19,025	33,313	24,001

Thailand.—Tin was the most important mineral resource of Thailand and ranked as the third major export, exceeded only in value by rice and rubber. Production and exports of tin concentrate in 1962 were the largest since 1941. The tonnage shipped to the Netherlands was the highest recorded. The Government Ministry of Industry announced there would be refunded contribution and a distribution of apportioned profits to holders of buffer stock certificates under the first International Tin Agreement beginning July 3, 1962. Rasa Mining Co., a subsidiary of Rasa Industries Co., Tokyo, was given permission to establish a tin smelter in Thailand by the Japanese Government.

TABLE 29.—Thailand: Exports of tin in concentrate, by countries

(Long tons)

Destination	1960	1961	1962	Destination	1960	1961	1962
Brazil	1,062	607	1,270	Portugal	72		
Germany, West	53			Spain		1,021	183
Japan	58	503	432	United Kingdom		14	65
Malaya-Singapore	9,961	9,089	9,270	United States	938		
Mexico	28	96					
Netherlands	446	1,616	2,780	Total	12,618	12,946	14,000

AFRICA

Congo, Republic of the.—The tin situation continued to be confused. Tin concentrate production improved. The concentrate moved at a higher rate to Belgium for smelting as a result of better Congo river transportation. The Manono smelter operated intermittently, and tin output dropped to the lowest recorded. Some tin shipments were made through the port of Dar-es-Salaam, Tanganyika on the Indian Ocean. The only concentrate treated by the smelter in 1962 was from Minière des Ingénieurs et Industriels Belges (Geomines).

Nigeria.—Of the 11,100 long tons of tin concentrate produced in 1962, 65 percent was from mechanized mines and 35 percent was from mines worked primarily by manual labor. Cyclones and jigs were introduced to recover more fine-size material. Columbium was produced as a byproduct. Most of the output was retained for local smelting, and small tonnages were shipped to Portugal and the United Kingdom. The smelter output went to the United Kingdom and the United States. Stocks of tin in concentrate at mines and smelters dropped from 1,030 tons at the beginning of 1962 to 810 tons at yearend.

In the year that ended March 31, 1962, Nigeria's largest producer, Amalgamated Tin Mines of Nigeria, Ltd., reported treating about 13.4 million cubic yards, compared with 13.7 million in 1961.

The output (in long tons) was obtained by the following methods:

Method:	*Cassiterite*	*Columbite*
Jig plants	469	406
Dragline washing plants	998	49
Gravel pumps and elevators	2,224	222
Dredge	111	27
Contractors	725	69
Mill-tailing treatment	118	111
Total	4,645	884

Nigerian Embel Tin Smelting Co., Ltd. (Portuguese-Nigerian), continued to operate on a smal scale until November when they ceased. The larger Makeri Smelting Co., Ltd. (a subsidiary of Consolidated Tin Smelters, Ltd.), on the outskirts of Jos, began producing metallic tin on January 1, 1962.

OCEANIA

Australia.—Tin production in Queensland, the principal source, dropped because the output of Tableland Tin Dredging, N.L., the major producer, was retarded by harder ground and excessive clay. Test drilling by Aberfoyle Tin, N.L., conducted with financial assistance from the New South Wales Mines Department, proved the existence of 1.6 million tons of ore (averaging 0.4 percent tin) in the Ardlethan tinfield. The company announced it would begin mining by opencut methods in 1963. Tin consumption in Australia was 4,500 long tons, against 3,370 tons in 1961; tinplate required 2,460 tons in 1962 and 1,550 tons (revised) in 1961. The Port Kembla mill increased its hot-dip tinpots to 10, and began producing electrolytic tinplate from a new line in May. Total tinplate production was 171,875 tons (101,595 tons in 1961). The December output of 18,850 tons was about 80 percent of total mill capacity.

Tinplate production exceeded domestic requirements, and most of the surplus was exported to New Zealand in 1962. Receipts of tinplate from the United States dropped to 200 tons in 1962.

TECHNOLOGY

The geology and mining operations at some tin deposits were discussed.[5] Numerous discoveries of tin ore in Australia, Brazil, Java, the Federation of Malaya, and Nigeria were reported.

The variables of jig operations for concentrating cassiterite were studied.[6] Other types of gravity concentration equipment were compared.[7] A shaking table afforded the best recovery of cassiterite in slime-free feed size down to 10 compared with a tilting concentrator, helicoid, vanner, or round frame. The effects of calcium and iron salts on the flotation of cassiterite with sodium hexadecylsulphate were discussed.[8]

Many tinplate manufacturers expanded facilities for producing thin tinplate.[9]

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[5] Gellatly, D. C. Tin Deposits in Somalia. Min. Mag. (London), v. 106, No. 1, January 1962, pp. 20–24.
Ljunggren, Pontus. Bolivian Tin Mineralization and Orogenic Evolution. Econ. Geol., v. 57, No. 6, September–October 1962, pp. 978–981.
Mine & Quarry Engineering, Hydraulic Tin, Brissol. V. 28, No. 1, January 1962, pp. 2–9.
Riddell, J. E. Tin in Southern New Brunswick: With Special Reference to the Mount Pleasant Deposit. Canadian Min. J. (Quebec, Canada), v. 83, No. 4, April 1962, pp. 69–75.
Stoll, W. C. A. Contribution to the Geology of the Caracoles Tin and Tungsten Mines, Bolivia. Econ. Geol., v. 57, No. 4, June–July 1962, pp. 536–547.

[6] Batzer, D. J. Investigation Into Jig Performance. Inst. of Min. and Met. Bull. (London), v. 72, No. 672, November 1962, pp. 61–68.

[7] Chaston, I. R. M. Gravity Concentration of Fine Cassiterite. Inst. of Min. and Met. Bull. (London), v. 71, No. 662, January 1962, pp. 215–225.

[8] Mining Journal (London). Flotation of Cassiterite. V. 259, No. 6630, Sept. 14, 1962, pp. 231–233.

[9] Steel. Steelmakers Bet Millions on Thin Tin for Cans. V. 151, No. 3, July 16, 1962, pp. 24–25.
Steel and Coal (London). RTB Meets Tinplate Demand With Second Electrolytic Tinning Line. V. 184, No. 4878, Jan. 12, 1962, pp. 73–75, 77.
Steel and Coal (London). SCOW's New Tinning Line. V. 184, No. 4884, Feb. 23, 1962, p. 374.

Papers described the processing and coating,[10] annealing,[11] automatic gage control,[12] and automatic classification [13] of steel strips.

The physical properties and applications of columbium-tin superconducting alloys were studied.[14]

Additions of tin in cast iron for engine blocks resulted in more uniform hardness and better machinability.[15]

Tin had little effect on the hot workability, yield, strength, or tensile strength of three stainless steels.[16]

Sheets of glass, without scratches with high transparency, and free from distortions, were made by moulding the glass on molten tin.[17]

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[10] McArthur, D. A. Strip Processing. Iron and Steel Eng., v. 39, No. 2, February 1962, pp. 111–134.

[11] Bishop, Tom. British Study New Method for Annealing Strip. Metal Prog., v. 82, No. 2, August 1962, pp. 93–94.

[12] Bryan, Thomas E., and Paul L. McMath. Automatic Gauge Control for Thin Tin. Blast Furnace and Steel Plant, v. 50, No. 10, October 1962, pp. 970–974, 976.

[13] Metal Industry (London). Automatic Classification of Tinplate. V. 101, No. 23, Dec. 6, 1962, pp. 422–423.

[14] American Metal Market. G.E. Claims Computer Device With Cryogenic Circuit. V. 69, No. 53, Mar. 19, 1962, pp. 1, 14.

Jones, William H., Frederick J. Milford, and Sherwood L. Fawcett. Status of Superconductivity. Battelle Tech. Rev., v. 11, No. 9, September 1962, pp. 2–11.

The following articles appeared in the IBM Journal of Research and Development, v. 6, No. 1, January 1962:

Coles, B. R. Effects of Electron Concentration and Mean Free Path on the Superconducting Behavior of Alloys. Pp. 68–70.

Goodman, B. B. The Magnetic Behavior of Superconductors of Negative Surface Energy. Pp. 63–67.

Mapother, D. E. Thermodynamic Consistency of Magnetic and Calorimetric Measurements on Superconductors. Pp. 77–81.

Meissner, Hans. Surface Energy at the Boundary Between a Superconductor and a Normal Conductor. Pp. 71–74.

Morse, R. W. Ultrasonic Attenuation in Superconductors. Pp. 58–62.

Seraphim, D. P., and P. M Marcus. First-And-Second-Order Stress Effects on the Superconducting Transitions of Tantalum and Tin. Pp. 94–111.

Swenson, C. A. The Temperature and Pressure Dependence of Critical Field Curves. Pp. 82–83.

[15] Chemical and Engineering News. Chrysler Switches to Tin for Alloying. V. 40, No. 35, Aug. 27, 1962, pp. 44, 46, 47.

[16] Mitchell, J. R., M. E. Potter, and E. C. Rudolphy. The Effect of Tin on the Properties of Three Stainless Steels. Trans. AIME, v. 224 (Met. Soc.), 1962, pp. 686–693.

[17] Tin and Its Uses. Molten Tin Is the Mould for Float Glass. No. 56, 1962, pp. 1–4.

Titanium

By John W. Stamper [1]

CONSUMPTION of 7,100 short tons of titanium sponge metal was about the same as in 1961. However, increased use of scrap metal resulted in an 11 percent increase in output of titanium ingot to 10,400 tons. Mill product output was 6,500 tons, the highest in the 16-year history of the titanium metal industry.

Ilmenite production of 808,000 tons was 3 percent higher than in 1961, and rutile output increased 10 percent to 10,000 tons. Titanium dioxide pigment production, which utilized most of the ilmenite, was a near-record, 4 percent higher than in 1961. Shipments of pigment were 5 percent higher than in 1961.

World production of 2.3 million tons of ilmenite and titanium slag, used chiefly for making titanium pigment by the sulfate process in the United States and foreign countries, was slightly below the record high of 1961. World output of rutile rose 17 percent to 151,000 tons, most of which was used in welding-rod coatings and for making titanium metal. New plants under construction in the United States for production of titanium pigment from rutile by the chloride process were expected to require about 100,000 tons of rutile annually when operating at capacity.

LEGISLATION AND GOVERNMENT PROGRAMS

Barter agreements for titanium sponge metal between the U.S. Department of Agriculture, Commodity Credit Corporation (CCC), and Japanese producers expired in January. Imports of 270 tons of sponge metal from Japan during the year completed deliveries under the contracts. Deliveries under the program totaled 6,625 tons. Toho Titanium Industry Co., Ltd. (Japan), supplied 3,445 tons of the total and Nippon Soda Co., Ltd. (Japan), 3,180 tons.

[1] Commodity specialist, Division of Minerals.

TABLE 1.—Salient titanium statistics

	1953–57 (average)	1958	1959	1960	1961	1962
United States:						
Ilmenite concentrate:[1]						
Mine shipments..short tons..	627,125	565,164	637,263	[2] 789,237	782,629	809,037
Value..........thousands..	$12,173	$11,155	$12,106	$14,655	[2] $13,312	$13,974
Imports [3]........short tons..	346,927	348,144	371,687	265,645	[2] 207,151	166,434
Consumption..........do....	762,872	731,424	917,747	868,080	929,147	944,797
Titanium slag: Consumption do....	117,641	117,581	143,329	120,492	130,184	138,205
Rutile concentrate:						
Mine shipments.......do....	9,134	1,863	8,648	9,433	7,664	8,033
Value..........thousands..	$1,197	$210	$877	$879	$778	$933
Imports..........short tons..	[4] 36,866	36,563	23,228	29,235	27,497	35,966
Consumption..........do....	33,968	21,677	23,741	24,229	29,548	31,749
Sponge metal:						
Production..........do....	9,371	4,585	3,898	5,311	6,727	6,730
Imports for consumption do....	1,275	2,073	1,563	2,231	2,490	925
Consumption..........do....	[5] 6,409	4,147	3,953	5,487	6,991	7,136
Price: Grade A-1, Dec. 31 per pound..	$3.60	$1.82	$1.60	$1.60	$1.60	$1.50
World production:						
Ilmenite concentrate..short tons..	1,500,500	[2] 1,710,200	[2] 1,937,900	[2] 2,235,500	[2] 2,326,900	2,295,100
Rutile concentrate..........do....	92,300	103,200	106,400	114,200	128,600	150,900
Sponge metal..............do....	12,071	7,700	7,900	9,200	9,800	8,600

[1] Includes a mixed product containing rutile, leucoxene, and altered ilmenite.
[2] Revised figure.
[3] Includes titanium slag.
[4] Excludes 36 tons rutile content of zirconium ore as reported to the Bureau of Mines by importers.
[5] 1954–57 only. Data for previous years not available.

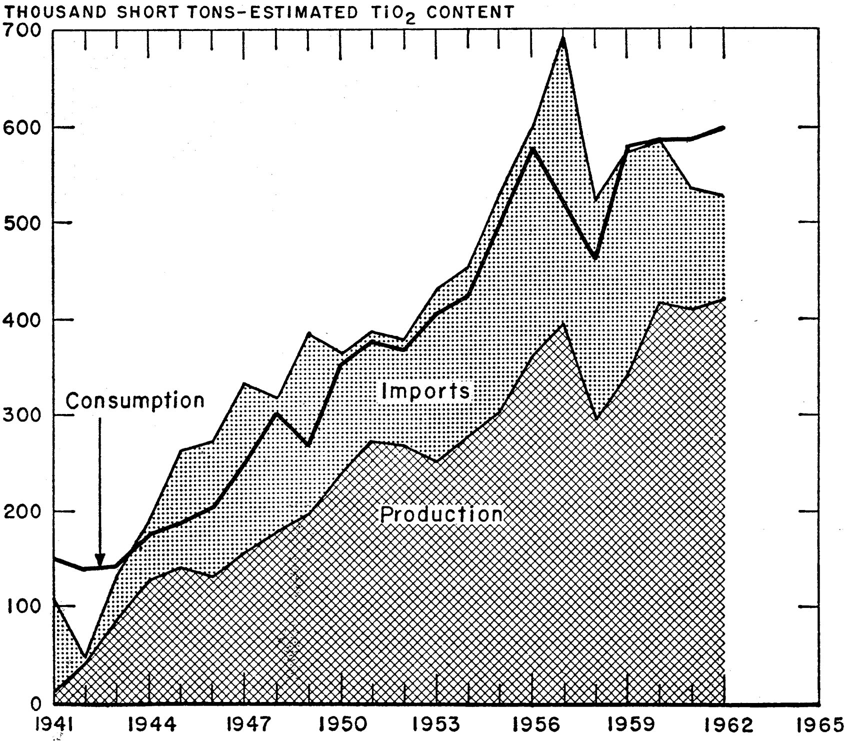

FIGURE 1.—Domestic production, imports, and consumption of ilmenite (includes titanium slags and mixed product), 1941–62.

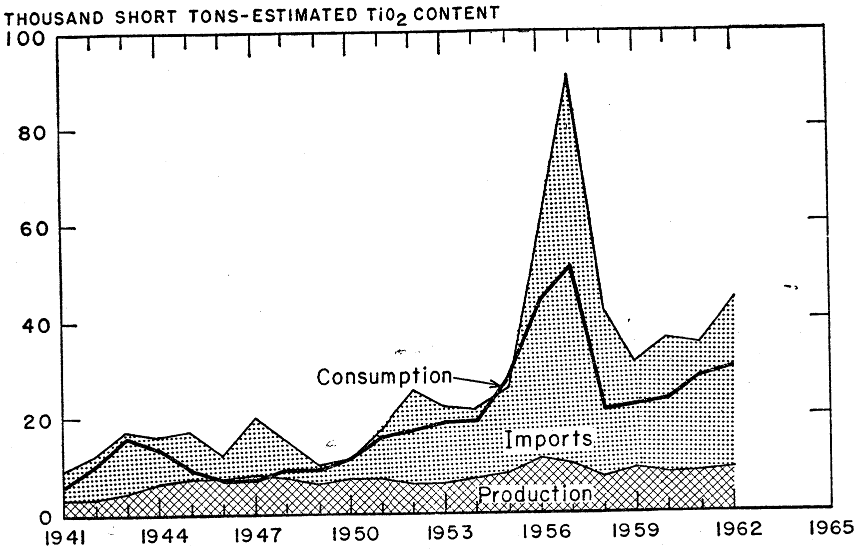

Figure 2.—Domestic production, imports, and consumption (excluding consumption (1962) for making TiO_2 pigments) of rutile, 1941–62.

DOMESTIC PRODUCTION

Concentrates.—A record 808,000 tons of ilmenite was produced in New York, Florida, and Virginia. Rutile production in Florida and Virginia of 10,000 tons was the highest since 1957. The Glidden Co. opened a new ilmenite mine at Lakehurst, N.J.

Ilmenite production was reported by American Cyanamid Co., Piney River, Va.; E. I. du Pont de Nemours & Co., Inc., Starke and Lawtey, Fla.; M & T Chemicals, Inc., Hanover County, Va.; National Lead Co., Tahawus, N.Y.; The Glidden Co., Lakehurst, N.J.; Titanium Alloy Manufacturing Division, National Lead Co., Skinner, Fla.; and The Florida Minerals Co., Vero Beach, Fla. J. R. Simplot Co., and Porter Brothers Corp. shipped ilmenite from stockpiles at Boise and Lowman, Idaho.

Rutile producers were as follows: M & T Chemicals, Inc., Beaver Dam, Va.; Titanium Alloy Manufacturing Division, National Lead Co., Skinner, Fla.; and The Florida Minerals Co., Vero Beach, Fla.

Metal.—Production and consumption of titanium sponge metal was about the same as in 1961, but increased utilization of titanium scrap metal resulted in a high output of titanium ingot.

National Distillers & Chemical Corp. became sole owner of the titanium production, melting, and fabricating plants of Reactive Metals, Inc., at Ashtabula and Niles, Ohio. The sponge production facilities at Ashtabula were under U.S. Industrial Chemicals Co. (USI), and the melting and fabricating plant at Niles was under the management of Bridgeport Brass Co. (Reactive Metals Products), both Divisions of National Distillers. Bridgeport announced plans for a $1.2 million modernization program for the Niles plant.

TABLE 2.—Production and mine shipments of titanium concentrates from domestic ores in the United States

Year	Production, short tons (gross weight)	Shipments		
		Short tons (gross weight)	Short tons TiO_2 content	Value (thousands)
ILMENITE [1]				
1953–57 (average)	617,317	627,125	324,080	$12,173
1958	563,338	565,164	297,021	11,155
1959	634,886	637,263	342,746	12,106
1960	786,372	789,237	417,202	14,655
1961	782,412	782,629	[2] 410,191	[2] 13,312
1962	807,725	809,037	420,606	13,974
RUTILE				
1953–57 (average)	9,090	9,134	8,571	1,197
1958	7,406	1,863	1,804	210
1959	9,466	8,648	8,148	877
1960	8,808	9,433	9,065	879
1961	9,045	7,664	7,251	778
1962	9,981	8,033	7,617	933

[1] Includes a mixed product containing rutile, leucoxene, and altered ilmenite.
[2] Revised figure.

Harvey Aluminum, Inc., expected to put into production a new titanium bar and rod rolling mill early in the year. The new mill was to be installed in a separate building at the main plant at Torrance, Calif., and was to be capable of turning out titanium rod 3/8 inch to 6 inches in diameter and all intermediate sizes.

Titanium Metals Corp. of America (TMCA), completed a $2 million expansion at its Toronto, Ohio, plant, enabling the company to produce seamless titanium tubing and welded and redrawn tubing in diameters up to 3 inches and lengths up to 30 feet. The company also began construction, at the same site, of a new $14 million mill, that would produce titanium sheet and strip in widths up to 48 inches and thicknesses down to 0.01 inch on a continuous basis.

TMCA also reported development of a casting technique using permanent metal molds and indicated that up to 100 pours per mold could be made with good surfaces and section sizes as thin as 1/8 inch. The process lent itself to the casting of complex shapes where disposable cores were not required.

Commercial producers of titanium sponge were as follows: E. I. du Pont de Nemours & Co., Inc., Newport, Del.; USI, Ashtabula, Ohio; and TMCA, Henderson, Nev. Du Pont and TMCA used magnesium to reduce titanium tetrachloride to titanium; USI used sodium.

Titanium melters were Harvey Aluminum, Inc., Torrance, Calif.; Bridgeport Brass Co. (Reactive Metals Products), Niles, Ohio; Oregon Metallurgical Corp., Albany, Oreg.; Crucible Steel Company of America, Midland, Pa.; Republic Steel Corp., Massillon and Canton, Ohio; and TMCA, Henderson, Nev.

Oregon Metallurgical Corp. produced ingots and castings. The other companies produced and processed ingots into mill products

TABLE 3.—Titanium-metal data

(Short tons)

	1958	1959	1960	1961	1962
Sponge metal:					
Production	4,585	3,898	5,311	6,727	6,730
Imports for consumption	2,073	1,563	2,231	2,490	925
Industry stocks	1,000	1,100	1,100	1,200	1,300
Government stocks (DPA inventories)	22,463	22,474	22,474	22,461	22,461
Consumption	4,147	3,953	5,487	6,991	7,136
Scrap-metal consumption	1,336	1,690	[1] 2,527	2,501	3,160
Ingot: [2]					
Production	5,408	6,017	8,297	9,371	10,400
Consumption	4,971	5,964	7,978	8,878	9,773
Mill shape production [3]	2,594	3,211	5,071	[1] 5,647	[4] 6,507

[1] Revised figure.
[2] Includes alloy constituents.
[3] Bureau of the Census and Business and Defense Services Administration, Current Industrial Reports, Series BDSAF-263 (63).
[4] Net shipments derived by subtracting the sum of producers' receipts of each mill shape from the industry's gross shipments of that shape. Data not comparable with previous years.

such as sheet, strip, plate, forging billets, and bars. Harvey Aluminum, Inc., produced titanium castings in addition to other mill products. Ladish Co., Cudahy, Wis., processed ingots into forged products.

The Babcock & Wilcox Co., Beaver Falls, Pa., and the Wolverine Tube Division of Calumet & Hecla, Inc., Allen Park, Mich., produced titanium pipe, tubing, and extrusions.

Pigments.—On a gross-weight basis, production of titanium dioxide pigments increased 4 percent and shipments increased 5 percent above the levels of 1961. Data on domestic production and shipments in table 4 are based on TiO_2 content.

Titanium pigments were produced by the following companies: American Cyanamid Co., Piney River, Va., and Savannah, Ga.; The Glidden Co., Baltimore, Md.; E. I. du Pont de Nemours & Co., Inc., Edge Moor, Del., Baltimore, Md., and New Johnsonville, Tenn.; National Lead Co., St. Louis, Mo., and Sayreville, N.J.; and The New Jersey Zinc Co., Gloucester City, N.J.

Cabot Corp., Boston, Mass., and Ruberoid Co., N.Y., reportedly formed a new titanium pigment company to be called Cabot Titania Corp. Cabot Titania, of which two-thirds was owned by Cabot and one-third by Ruberoid, planned to complete construction of facilities for producing 20,000 tons of titanium dioxide per year at Ashtabula, Ohio, by mid-1963. Additional expansion to 40,000 tons a year was also planned. A chloride process, licensed from Fabriques de Produits Chimiques de Thann et de Mulhouse (FPC) of France, was to be used. Cabot reportedly reached a 5-year agreement for 50,000 tons of rutile with an Australian producer, N.S.W. Rutile Mining Co. Pty., Ltd., and purchased facilities for chlorinating the rutile at Ashtabula, Ohio, from National Distillers & Chemical Corp.

Du Pont announced that construction had started on its 27,000 ton-per-year titanium dioxide plant at Antioch, Calif., and that completion was expected in the fall of 1963. The chloride process was to be used. Du Pont had agreements with Rutile and Zircon Mines (New Castle), Ltd., an Australian producer, for 50,000 tons of rutile.

TABLE 4.—Titanium pigment data (TiO_2 content)

Year	Production (short tons)	Shipments[1]	
		Quantity (short tons)	Value, f.o.b. (thousands)
1953-57 (average)	407,525	393,819	$195,481
1958	403,867	425,765	231,888
1959	506,334	481,930	259,944
1960	455,583	468,228	252,835
1961	502,879	491,122	262,255
1962	523,201	(2)	(2)

[1] Includes interplant transfers.
[2] Data not available.

Source: Facts for Industry and Current Industrial Reports series, M19A and M28A, Inorganic Chemicals, published jointly by the Bureau of the Census and Business and Defense Services Administration, U.S. Department of Commerce.

Welding-Rod Coatings.—A total of 231,000 tons of welding rods, containing titaniferous materials in their coatings, was produced. Of the total output, 43 percent contained rutile; 17 percent, ilmenite; 15 percent, a mixture of rutile and manufactured titanium dioxide; 14 percent, manufactured titanium dioxide; 8 percent, slag; and 3 percent, miscellaneous mixtures.

CONSUMPTION AND USES

Concentrates.—Consumption of ilmenite, which is used principally for making titanium dioxide pigments, increased 2 percent to 945,000 tons. Titanium slag consumption, also used chiefly for pigment production, rose 6 percent above that of 1961. Rutile consumption, exclusive of that used for making pigment and other uses not reported in table 5, was 7 percent more than that in 1961.

Metal.—The consumption of 7,100 tons of titanium sponge metal was about the same as in 1961. However, increased use of titanium scrap resulted in production of a near-record 10,400 tons of titanium ingot. Use of titanium mill products, as gaged by shipments, was at the highest level in the 16-year history of the titanium metal industry.

As in past years, approximately 60 percent of the mill products went into manned military aircraft, according to one large producer. About 25 percent went into missiles and spacecraft, 10 percent went into commercial aircraft, and the remaining 5 percent was used in the chemical processing industry. The following estimated distribution of titanium mill product consumption in 1961 also was reported:[2]

Application	*Consumption, Percent*
Military jet engines	55
Military airframes	13
Missiles and spacecraft	16
Commercial aircraft	13
Chemical processing equipment	3
Total	100

[2] Finlay, Walter L. Titanium in American Ordnance. Weapons Technology, American Ordnance Association. October 1962, pp. 15–24.

TABLE 5.—Consumption of titanium concentrates in the United States, by products

(Short tons)

Year and product	Ilmenite[1]		Titanium slag		Rutile	
	Gross weight	Estimated TiO_2 content	Gross weight	Estimated TiO_2 content	Gross weight	Estimated TiO_2 content
1953–57 (average)	762,872	401,370	117,641	83,166	33,968	32,196
1958	731,424	379,765	117,581	82,937	21,677	20,579
1959	914,747	476,660	143,329	101,106	23,741	22,462
1960	868,080	464,614	120,492	85,095	24,229	22,942
1961:						
Pigments	[2] 926,241	495,745	129,292	91,379	(3)	(3)
Titanium metal	(4)	(4)	-----	-----	13,558	12,917
Welding-rod coatings	542	320	667	468	13,285	12,550
Alloys and carbide	2,302	1,410	(5)	(5)	346	333
Ceramics	59	37	-----	-----	366	342
Fiber glass	-----	-----	-----	-----	732	714
Miscellaneous[6]	3	2	225	164	1,261	1,160
Total	929,147	497,514	130,184	92,011	29,548	28,016
1962:						
Pigments	[2] 941,954	499,471	137,576	98,195	(3)	(3)
Titanium metal	(4)	(4)	-----	-----	13,633	13,126
Welding-rod coatings	503	298	453	318	15,492	14,627
Alloys and carbide	2,282	1,391	(5)	(5)	223	211
Ceramics	50	31	-----	-----	330	309
Fiber glass	-----	-----	-----	-----	1,018	993
Miscellaneous[6]	8	5	176	119	1,053	969
Total	944,797	501,196	138,205	98,632	31,749	30,235

[1] Includes a mixed product containing rutile, leucoxene, and altered ilmenite used to make pigments and metal.
[2] Includes ilmenite that was upgraded to a product containing more than 90 percent TiO_2 for use in making pigments and the losses of ilmenite incurred in upgrading the ilmenite.
[3] Figure withheld to avoid disclosing individual company confidential data.
[4] Included with "Pigments" to avoid disclosing individual company confidential data.
[5] Included with "Miscellaneous" to avoid disclosing individual company data.
[6] Includes consumption for chemicals and experimental purposes and losses in grinding.

The performance of the A3J Vigilante, the Navy Mach 2 attack airplane, was reportedly increased by installing a system made from titanium for directing air at 750° F over the upper wing surface. The use of titanium instead of stainless steel saved 300 pounds of weight and was said to make construction simpler because the modulus of elasticity of titanium permitted its use without major changes in the aluminum substructure.

A new helicopter blade-retention system utilized bundles of 88 titanium straps to achieve a compact, lightweight control system.[3]

Titanium alloys, on a strength-to-weight basis, are superior to either steel or glass as potential materials for the construction of rocket motor cases, according to a Defense Metals Information Center study.[4]

An 8-foot-diameter, 24-foot-long titanium container for liquid hydrogen was built as part of an Air Force research program. It was tested successfully with 7,000 gallons of water under 42 pounds of pressure.[5]

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[3] Materials In Design Engineering. Titanium Straps Simplify Helicopter Controls. V. 56, No. 7, December 1962, pp. 132–133.
[4] Achbach, W. P., and R. J. Runck. An Evaluation of Materials for Rocket Motor Cases based on Minimum Weight Concepts. Battelle Memorial Institute, DMIC Memo. 147, March 1962, 30 pp.
[5] American Metal Market. Large Titanium Alloy Tank for Liquid Hydrogen Gets Green Light. V. 69, No. 153, Aug. 9, 1962, p. 11.

The use of titanium in the chemical and electrochemical processing industries was reviewed.[6] About 50 percent of the titanium tubing employed in the process industries was for cooling wet chlorine. Other uses included anodizing racks, chlorine dioxide mixers, and pulp and paper processing equipment. Titanium was used in solutions of sodium hypochlorite, chlorate, nitric acid, sulfuric acid, and brine. Total annual use of titanium in these industries was expected to grow from an estimated 200 tons in 1962 to 3,000 tons by 1973.

A total of 36 titanium heat exchangers (plate-type, 83 inches long by 18 inches wide) was used to heat solutions of sodium perchlorate and ammonium chloride in the production of ammonium perchlorate.[7]

A 120-foot-high titanium-lined stack exposed to fumes of hydrochloric acid and ferric and cupric chlorides at 180° to 1,000° F replaced an unlined stack that had failed in 8 months. The titanium-lined stack cost $36,000 compared with $17,000 for the unlined stack.[8]

Titanium wire plated with copper, nickel, solder, or gold became commercially available.[9] It was said to be possible to manufacture fine thread screws from it by the economical method of thread rolling, because of the good drawing characteristics of the copper-plated wire.

Soviet engineers reportedly tested steam-turbine blades of titanium for use in a 1.5-million-kilowatt generator.[10]

TABLE 6.—Distribution of titanium-pigment shipments, by industries [1]

(Percent)

Industry	1953–57 (average)	1958	1959	1960	1961	1962
Distribution by gross weight:						
Paints, varnishes, and lacquers	65.4	65.8	64.8	65.1	63.4	61.9
Paper	10.2	11.5	11.7	11.3	12.5	13.0
Floor coverings (linoleum and felt base)	4.4	5.0	4.9	4.8	4.5	4.7
Rubber	3.4	3.9	4.2	4.0	4.1	4.2
Coated fabrics and textiles (oilcloth, shade cloth, artificial leather, etc.)	2.6	2.9	3.1	2.8	3.3	3.3
Printing ink	1.3	1.5	1.7	1.3	1.6	1.7
Other	12.7	9.4	9.6	10.7	10.6	11.2
Total	100.0	100.0	100.0	100.0	100.0	100.0
Distribution by titanium dioxide content:						
Paints, varnishes, and lacquers	57.7	59.1	58.2	58.5	57.0	55.3
Paper	13.9	15.2	15.1	14.6	15.7	16.2
Floor coverings (linoleum and felt base)	5.1	6.4	6.3	6.2	5.6	5.8
Rubber	4.4	5.1	5.4	4.9	5.1	5.2
Coated fabrics and textiles (oilcloth, shade cloth, artificial leather, etc.)	3.4	3.7	3.9	3.5	4.1	4.0
Printing ink	1.7	1.9	2.2	1.7	2.0	2.1
Other	13.8	8.6	8.9	10.6	10.5	11.4
Total	100.0	100.0	100.0	100.0	100.0	100.0

[1] Data based on figures supplied to the Bureau of Mines by producers.

[6] Chemical Week. Titanium. V. 91, No. 15, Oct. 13, 1962, pp. 123–130.
[7] Titanium Metals Corporation of America, Technical Service Department. Titanium Data for Chemical Process Industry: How Titanium Plate Heat Exchangers Succeed Where Other Metals Fail in Perchlorate Process. New York, 1962, 4 pp.
[8] Steel. Titanium Lining Extends Life of Steel Stack. V. 151, No. 16, Oct. 15, 1962, p. 98.
[9] American Metal Market. Orbit Electric Displays Plated Titanium Wire at Metal Show in New York. V. 69, No. 210, Oct. 31, 1962, p. 14.
[10] Metalworking News. Titanium Blade Soviet Turbine Undergoes Tests. V. 3, Whole No. 91, July 2, 1962, p. 16.

Pigments.—Consumption of titanium pigments, based on gross weight and using shipments as a gage, increased 5 percent above 1961. Consumption of pigments not separately classified in table 6 included use in plastic, roofing granules, welding rods, synthetic fabrics, and ceramics.

STOCKS

Industry stocks of rutile decreased by 3,800 tons and represented about 2.5 years' supply at the 1962 consumption rate. Government stocks of rutile on December 31 totaled 47,823 tons of which 18,599 tons was in the national (strategic) stockpile; 17,592 tons, in Defense Production Act (DPA) inventories; and 11,632 tons, in the supplemental stockpile. Ilmenite stocks also declined, but titanium-slag inventories increased.

Yearend stocks of titanium sponge held by producers, melters, and semifabricators totaled 1,300 tons, compared with 1,100 tons on hand at the end of 1961. In addition, the Government held 22,456 tons in DPA inventories and 9,021 tons in the supplemental stockpile, for a total of 31,477 tons.

Titantium metal scrap held by melters and semifabricators at yearend was 3,300 tons, the same as at the end of 1961.

TABLE 7.—Stocks of titanium concentrates in the United States, December 31

(Short tons)

Year and stock	Ilmenite		Titanium slag		Rutile	
	Gross weight	TiO_2 content, estimated	Gross weight	TiO_2 content, estimated	Gross weight	TiO_2 content, estimated
1961:						
Mine	[1] 30,433	[1] 14,381			7,200	6,776
Distributor	303	177			3,434	3,286
Consumer	675,052	[1] 377,046	130,916	[1] 93,377	68,524	64,699
Total	[1] 705,788	[1] 391,604	130,916	[1] 93,377	79,158	74,761
1962:						
Mine	29,121	14,387			9,148	8,605
Distributor	254	149			5,701	5,431
Consumer	572,071	313,504	140,152	100,095	60,538	57,522
Total	601,446	328,040	140,152	100,095	75,387	71,558

[1] Revised figure.

PRICES

Concentrates.—The price quoted for ilmenite in E&MJ Metal and Mineral Markets remained unchanged $23 to $26 per long ton (59.5 percent TiO_2, f.o.b. Atlantic seaboard).

The quoted price of rutile (94 percent TiO_2, f.o.b. Atlantic seaboard) increased from $80 per short ton at the end of 1961 to $95 per short ton at the end of 1962.

Manufactured Titanium Dioxide.—The prices of rutile and anatase grades of manufactured titanium dioxide pigment and calcium-rutile base titanium pigments were unchanged. Some reduction of the base price was given to purchasers of large lots. The following prices were quoted in the Oil, Paint and Drug Reporter at yearend:

	Price per pound
Anatase, chalk-resistant, regular and ceramic, carlots, delivered	$0.255
Less than carlots, delivered	.265
Rutile, nonchalking, bags, carlots, delivered East	.275
Less than carlots, delivered East	.285
Titanium pigment, calcium-rutile base, 30 percent TiO_2, bags, carlots, delivered	.09375
Less than carlots, delivered	.09875

Metal.—Prices per pound for various grades of titanium sponge metal at the beginning of 1962 ranged from $1.34 to $1.85 and at the end of the year from $1.32 to $1.60.

Quoted prices of most titanium mill shapes declined during the year. Prices per pound of mill shapes (f.o.b. mill, commercially pure grades, in lots of 10,000 pounds) were quoted in January and December as follows:

	Jan. 1, 1962	Dec. 31, 1962
Sheet	$7.25–$8.00	$4.90–$5.10
Strip	6.75– 7.50	4.90– 5.10
Plate	5.25– 6.00	3.80– 4.00
Wire	5.55– 6.05	3.50– 3.80
Forging billets	[1] 3.00– 3.30	2.40– 2.55
Hot-rolled bars	[1] 3.15– 3.35	3.15– 3.35

[1] Revised figure.

Ferrotitanium.—Nominal prices at yearend for various grades of ferrotitanium were quoted in E&MJ Metal and Mineral Markets as follows:

	Price
Low-carbon: [1]	
Titanium, 40 percent; carbon, 0.10 percent maximum	$1.35
Titanium, 25 percent; carbon, 0.10 percent maximum	1.50
Medium-carbon: [2]	
Titanium, 17 to 21 percent; carbon, 3 to 5 percent	375
High-carbon: [2]	
Titanium, 15 to 19 percent; carbon, 6 to 8 percent	310

[1] Price per pound contained titanium in 1-ton lots or more, lump (½-inch, plus) packed; f.o.b. destination Northeastern United States.
[2] Price per short ton, carload lots, lump, packed; f.o.b. destination Northeastern United States.

FOREIGN TRADE [11]

Imports.—Imports of ilmenite and titanium slag decreased for the third successive year. Slag containing 70 percent titanium dioxide was imported from Canada. Rutile imports rose 31 percent.

Imports of titanium metal were only 925 tons, 63 percent below 1961, as a result of the cessation of barter contracts with Japanese producers. Titanium imports included 270 tons from Japan brought in free for the Government under the CCC barter agreements. About 11 tons of metal was imported from the United Kingdom and Canada and classified free under certain public laws. The remainder was dutiable.

During the first 6 months of the year, 5,979 tons, classified as "titanium potassium oxylate and all compounds and mixtures containing

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

titanium," was imported. Beginning in July, imports of titanium pigments and compounds were classified as "titanium dioxide and titanium pigments," and "titanium compounds, n.e.c. (not elsewhere classified)." In the last 6 months of the year imports under the new classification totaled 10,678 tons of titanium dioxide and pigment and 143 tons of titanium compounds, n.e.c.

TABLE 8.—U.S. imports for consumption of titanium concentrates[1] by countries

(Short tons)

Country	1953-57 (average)	1958	1959	1960	1961	1962
Ilmenite:						
Australia	50	22,736	47,317	33,089	35,362	57,941
Canada[2]	165,567	112,874	157,296	104,243	[3] 127,123	108,493
India	175,066	212,479	167,074	128,313	44,666	
Malaya, Federation of	6,229					
Other countries	15	55				(4)
Total: Short tons	346,927	348,144	371,687	265,645	[3] 207,151	166,434
Value	[5] $7,400,535	$6,766,391	$7,991,208	$5,066,502	[3] $5,017,911	[4] $4,469,648
Rutile:						
Australia	[6] 36,835	36,507	22,954	27,847	26,047	35,542
South Africa, Republic of[7]			274	1,358	1,450	424
Other countries	31	56		30		
Total: Short tons	[6] 36,866	36,563	23,228	29,235	27,497	35,966
Value	$4,818,046	$4,512,937	$2,943,258	$3,610,616	$2,544,312	$2,646,174

[1] Classified as "ore" by the Bureau of the Census.
[2] Chiefly titanium slag averaging about 70 percent TiO_2.
[3] Revised figure.
[4] Bureau of the Census shows less than 1 pound, valued at $1,710 from Brazil adjusted to none by Bureau of Mines.
[5] Data known to be not comparable with other years.
[6] Excludes 36 tons rutile content of zirconium ore as reported to Bureau of Mines by importers. P. 1249, table 8, 1961 Minerals Yearbook should read excludes 67 tons (revised figure).
[7] Effective Jan. 1, 1962; formerly Union of South Africa.

Source: Bureau of the Census.

Finland, France, and Japan were the principal suppliers of these materials. Other suppliers were Canada, Denmark, the United Kingdom, the Netherlands, Belgium-Luxembourg, West Germany, Switzerland, Spain, and Italy.

Exports.—Titanium dioxide and pigment exports declined for the sixth successive year. Canada, as in past years, was the destination of most of the pigments, receiving 12,805 tons. Other countries that received 1,000 tons or more were as follows: Italy, 2,100; Philippines, 1,900; the Netherlands, 1,700; France, 1,500; Korea, 1,200; and Belgium-Luxembourg, 1,200.

Exports of 1,224 tons of ores and concentrates included 667 tons to Canada, 165 tons to Hong Kong, 115 tons to Mexico, and 100 tons to Iran. Small quantities were sent to Colombia, Sweden, West Germany, the United Kingdom, Belgium-Luxembourg, Argentina, India, and the Philippines.

Titanium sponge and scrap exports decreased 8 percent. Of the 818 tons exported, 583 tons were sent to the United Kingdom; 123 tons to West Germany; 60 tons to France; and the remainder to Ecuador, Peru, Sweden, the Netherlands, Belgium-Luxembourg, Austria, Switzerland, Italy, and India.

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TABLE 9.—U.S. exports of titanium products, by classes

Year	Ores and concentrates		Metal and alloys in crude form and scrap [1]		Primary forms n.e.c.[2]		Ferroalloys		Dioxide and pigments	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1953–57 (average)	1,406	$195,657	29	$258.683	315	$4,661,171	267	$86,441	55,140	$19.635,040
1958	1,246	172,481	97	172,285	336	5,227,932	323	138,431	37,016	11,346,651
1959	4,656	289,507	496	543,104	499	5,161,074	321	145,621	36,282	10,558,287
1960	1,260	166,685	879	868,846	426	3,237,949	245	157,419	33,655	10,000,884
1961	1,436	190,480	886	926,783	384	2,702,322	212	93,389	31,104	9,215,839
1962	1,224	166,987	818	925,495	561	4,102,113	130	95,265	29,095	8,636,350

[1] Beginning Jan. 1, 1955, classified as sponge and scrap.
[2] Beginning Jan. 1, 1955, classified as intermediate mill shapes and mill products, n.e.c. (not elsewhere classified).

Source: Bureau of the Census.

Exports of primary forms of titanium metal products increased 46 percent to 561 tons. Of this total 441 tons went to Canada, 64 tons to France, and most of the remainder to Italy and West Germany. Of the 130 tons of ferroalloys exported Canada received 116 tons, Italy received 7 tons, and most of the remainder went to Belgium-Luxembourg, Australia, and Liberia.

WORLD REVIEW [12]

The United States continued to be the free world's principal source and consumer of ilmenite, and the chief market for rutile. As in previous years, Australia was the leading rutile producer, accounting for 88 percent of the world total. In addition to the announcements of titanium dioxide pigment plants to be built in the United States (see Domestic Production), plans for expansion of capacity also were reported in Canada, Argentina, Italy, Norway, and Japan. New titanium dioxide plants began operating in the Netherlands and the Republic of South Africa.

NORTH AMERICA

Canada.—The Department of Mines and Technical Surveys published a review of the titanium industry in 1961.[13] Data in table 11 on the 1959 consumption of titanium pigments were included in the report.

Quebec Iron & Titanium Corp. (QIT) continued to smelt ilmenite-hematite ore, but output of titanium slag decreased markedly owing to a strike which shut down the plant for 3 months in the latter half of the year.

Capacity of the Canadian Titanium Pigments, Ltd., titanium pigment plant was expanded from 16,000 to 25,000 tons per year in

[12] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.
[13] Schnéider, V. B. Titanium. Canada. Dept. of Mines and Tech. Surveys, 1961, 9 pp.

TABLE 10.—World production of titanium concentrates (ilmenite and rutile) by countries [1] [2]

(Short tons)

Country [1]	1953–57 (average)	1958	1959	1960	1961	1962
Ilmenite:						
Australia (shipments)	17,121	78,342	93,606	119,377	187,459	204,000
Canada [3]	186,100	161,312	270,477	389,586	463,361	301,448
Ceylon				6,720	11,199	4,652
Finland	76,582	117,384	94,966	92,219	21,272	96,110
Gambia	[4] 4,128	31,851	14,553			
India	299,792	346,260	334,024	275,303	191,800	152,100
Japan (titanium slag)	5,913	3,932	3,445	1,444	1,774	578
Malagasy Republic (Madagascar)		1,151	659	3,008	3,640	[5] 110
Malaya (exports)	75,958	83,806	81,593	132,255	119,694	113,856
Mexico	[6] 4	166				
Mozambique			11,400	784		
Norway	184,268	233,585	250,206	258,542	342,723	[7] 330,000
Portugal	648	506	2,113	1,002	109	[5] 110
Senegal	21,510	36,900	32,941	24,159	19,290	24,727
South Africa, Republic of	1,380	29,611	87,232	90,431	99,009	87,096
Spain	5,225	18,161	8,113	12,267	33,184	52,572
Thailand	[8] 1,200	922	550			
United Arab Republic (Egypt Region)	3,336	[7] 3,000	17,100	[7] 42,000	[7] 50,000	[7] 120,000
United States [9]	617,317	563,338	634,886	786,372	782,412	807,725
World total ilmenite (estimate) [1] [2]	1,500,500	1,710,200	1,937,900	2,235,500	2,326,900	2,295,100
Rutile:						
Australia	82,440	93,327	91,734	99,274	113,600	133,283
Brazil	181	269	231	238	245	[7] 240
Cameroon, Federal Republic of	76					
India	308	503	429	1,082	898	1,770
Norway	12					
Senegal	179	1,157			187	811
South Africa, Republic of	[10] 32	552	3,381	3,695	3,483	3,575
United Arab Republic (Egypt)			1,157	[7] 1,100	[7] 1,100	[7] 1,200
United States	9,090	7,406	9,466	8,808	9,045	9,981
World total rutile (estimate) [1] [2]	92,300	103,200	106,400	114,200	128,600	150,900

[1] Titanium concentrates are produced in Brazil and the U.S.S.R., but no reliable figures are available; no estimates are included in the total.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Represents titanium slag containing approximately 70 percent TiO_2 and small quantities of "titanium ore".
[4] Average annual production 1954–57.
[5] Exports.
[6] Average annual production 1955–57.
[7] Estimate.
[8] Average annual production 1956–57.
[9] Includes a mixed product containing ilmenite, leucoxene, and rutile.
[10] 1 year only, as 1957 was the first year of commercial production.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

TABLE 11.—Consumption of titanium dioxide and extended titanium-dioxide pigments in Canada, 1959

	Short tons
Refined titanium dioxide (TiO_2):	
Paints	15,316
Polishes and dressings	128
Pulp and paper	2,244
Linoleum and oilcloth	2,301
Rubber goods	871
Miscellaneous nonmetallic minerals	516
Total	21,376
Extended titanium dioxide pigments: Paints	[1] 14,489

[1] Estimated TiO_2 content 4,300 tons.

TABLE 12.—Quebec Iron & Titanium Corp. smelting operations

(Short tons)

	1953–57 (average)	1958	1959	1960	1961	1962
Ore smelted	415,665	420,932	626,310	967,373	1,155,977	745,753
Titanium slag produced	181,024	161,312	243,700	386,639	463,361	301,448
Estimated TiO_2 content	129,713	116,150	175,464	278,380	333,620	217,048
Value of slag produced	$5,933,912	$6,575,077	$8,509,149	$14,257,292	(1)	(1)
Desulfurized iron produced	133,230	117,878	163,509	248,578	310,360	207,190

[1] Data not available.

1961. Its operations were described.[14] A new pigment plant at Ville-de-Tracy, Quebec, with a 22,000-ton capacity was scheduled to be completed in 1962 by British Titan Products (Canada), Ltd.

SOUTH AMERICA

Argentina.—American Cyanamid Co., a titanium pigment producer in the United States, reportedly reached an agreement with Hafen S.A. to build a titanium pigment plant near Buenos Aires. The plant was expected to cost $11 million and produce 10,000 tons per year.[15]

EUROPE

Finland.—Automatic continuous analysis of magnetite and titanium dioxide in ilmenite concentrate produced at the titanium mine at Otanmaki was described.[16] The concentration of Otanmaki ore was by wet magnetic separation of magnetite, flotation of pyrite, and finally flotation of ilmenite. The automatic analyzer system was installed to permit improved control of the process.

Italy.—An 8,000- to 12,000-ton-per-year titanium dioxide plant at Gallipoli Lecce in Apulia was planned by the Societa Metalchimica Merodionale Finanziaria Breda, a new company formed by the Societa Finanziaria Ernesto Breda S.p.A. of Milan and S.p.A. Solbar of Milan.[17] Completion of the plant was expected in 1964.

Netherlands.—Titaandioxydefabriek N.V. opened its 12,000-ton-a-year titanium pigment plant near Rotterdam.[18] The plant, reportedly built at a cost of $11.2 million, used a process licensed from Glidden International. Annual consumption of titanium dioxide was reported at 18,000 tons. The company was owned by N.V. Billiton Maatschappij (55 percent), Koninklijke Nederlandse Zoutindustries (22.5 percent), and Cyprus Mines Corp. (22.5 percent).

Norway.—Titan Co. A/S, planned to build a 15,000-ton-per-year titanium pigment plant at Fredrikstad.[19] Titan A/S and Titania

[14] Levine, Sidney. Canadian Titanium Pigments Expands for Rapidly Growing Markets. Nonmetallic Minerals Processing, v. 3, No. 2, February 1962, pp. 21–23.

[15] Chemical Week. Titanium Dioxide/Argentina. V. 90, No. 26, June 30, 1962, p. 23. Chemical Trade Journal and Chemical Engineer (London). V. 151, No. 3942, Dec. 21, 1962, p. 1279.

[16] Mining Journal (London). Continuous Assaying of Magnetite and Ilmenite Pulps. V. 259, No. 6639, Nov. 9, 1962, p. 435.

[17] Chemical Trade Journal and Chemical Engineer (London). Third Titania Plant for Italy. V. 151, No. 3942, Dec. 21, 1962, p. 1279.

[18] Oil, Paint and Drug Reporter. Titanium Dioxide Installation Officially Opened in Holland. V. 182, No. 20, Nov. 12, 1962, p. 56.

[19] Engineering and Mining Journal. National Lead Will Build Titanium Plant in Norway. V. 163, No. 10, October 1962, p. 112. Chemical Week, Titanium Pigment/Norway. V. 91, No. 14, Oct. 6, 1962, p. 77.

A/S, both owned by National Lead Co. (U.S.A.), produced ilmenite from deposits at Tellnes and Sokndal in southern Norway.

ASIA

Ceylon.—Ceylon Mineral Sands Corp. made its first shipment of ilmenite to Japan.[20] Ilmenite production at the mine, which was opened in 1961, was expected to be about 12,000 tons per year. Ultimate capacity was expected to be 60,000 tons per year. Reserves were reported sufficient to last 40 years at the higher capacity rate.[21]

India.—Travancore Minerals, Ltd., at two mines in Chavara near Quilon, Kerala, and one in southwestern Madras, was producing at a rate equivalent to 80 percent of the ilmenite and 30 to 40 percent of the rutile totals for the year. F. X. Pereira Minerals, Ltd., produced the remainder.[22]

Japan.—Sumitomo Light Metals Industries, Ltd., Kobe Steel Works, Ltd., and Furukawa Electric Co., Ltd., produced commercially pure grades of titanium mill products, 80 percent of which were in sheet form.[23] Annual capacity on a one-shift-per-day basis for producing commercially pure titanium mill products in terms of ingot was reported as follows:

	Short tons, ingot
Kobe Steel Works, Ltd	1,300
Sumitomo Light Metals Industries, Ltd	400
Furukawa Electric Co., Ltd	400

The output of 70,000 tons of titanium dioxide pigments was a record high. The completion of expanded facilities at several titanium dioxide plants and the expansion plans of several firms were reported. Industry expansion was expected to raise total capacity to 100,000 tons by 1965 and to 140,000 tons by 1970. Consumption was expected to reach 45,000 tons in 1963, 55,000 tons in 1965, and 80,000 tons in 1970.[24]

TABLE 13.—Japan: Titanium metal and titanium dioxide data

(Short tons)

	1958	1959	1960	1961	1962
Titanium metal:					
Production	1,812	2,730	2,543	2,516	1,696
Exports	1,962	1,982	2,130	1,728	1,365
Stock, Dec. 31	677	1,148	1,100	1,289	913
Titanium dioxide:					
Production	33,285	39,192	54,446	54,210	70,124
Exports	15,223	15,587	21,160	17,353	24,530
Stocks, Dec. 31	2,754	1,077	2,295	2,113	4,909

[20] Foreign Trade (Ottawa, Canada). Ilmenite. V. 118, No. 11, Dec. 1, 1962, p. 27.
[21] Mining Journal (London). Shipments From Pulmoddai Start. V. 259, No. 6631, Sept. 21, 1962, p. 273.
[22] U.S. Consulate General, New Delhi, India. State Department Airgram No. A–69, July 31, 1962.
[23] U.S. Consulate General, Tokyo, Japan. State Department Despatch 963, May 25, 1962.
[24] Oil, Paint and Drug Reporter. TiO_2 and Japan: Output Traveling an Upward Road. V. 183, No. 2, Jan. 14, 1963, p. 7.

AFRICA

South Africa, Republic of.—South African Titan Products (Pty.), Ltd., began producing titanium dioxide in its new 10,000-ton-per-year plant at Umbogintwini.[25]

OCEANIA

Australia.—Associated Minerals Consolidated, Ltd., entered into an agreement with American Potash & Chemical Corp. (U.S.A.) for 110,000 tons of rutile and an option to purchase an additional 100,000 tons. Deliveries were planned over a 10-year period to begin in 1963.[26]

Cable, Ltd. at Bunbury, Western Titanium, N.L. at Capel, and Western Oil, Ltd. at Yoganup produced ilmenite concentrate in West Australia. A fourth producer, Western Mineral Sands (Pty.) was scheduled to start production in 1964 from a mine at Capel. Estimated capacity of the four producers was expected to be 370,000 tons per year.[27]

TABLE 14.—Australia: Exports of ilmenite concentrates by countries
(Short tons)

Destination	1958	1959	1960	1961	1962 [1]
Belgium-Luxembourg	3,228	3			(2)
France	5,730	6,274	2,011	4,563	(2)
Japan	10,848	9,969	25,500	31,799	(2)
Netherlands	3,395	34	698	12,533	(2)
United Kingdom	13,693	354	35,159	76,813	(2)
United States	22,738	60,108	20,377	35,334	(2)
Other countries	3,360	145	612	248	(2)
Total	62,992	76,887	84,357	161,290	[1] 70,890

[1] January through June, inclusive.
[2] Countries of destination not available for 1962.

Compiled from Customs Returns of Australia by Virginia G. Huguley and Corra A. Barry, Division o Foreign Activities.

TABLE 15.—Australia: Exports of rutile concentrates by countries [1]
(Short tons)

Destination	1958	1959	1960	1961	1962 [2]
Belgium	2,532	1,390	1,314	2,846	(3)
France	5,459	7,482	9,675	8,084	(3)
Germany, West	4,114	10,037	10,546	9,855	(3)
Italy	3,293	3,519	4,536	6,030	(3)
Japan	2,920	7,967	9,042	13,765	(3)
Netherlands	10,579	12,243	11,091	13,590	10,247
Sweden	3,687	2,824	3,771	4,013	(3)
United Kingdom	13,026	9,690	14,243	15,989	7,087
United States	29,365	25,241	29,360	26,357	9,687
Other countries	9,714	10,258	11,372	11,081	31,922
Total	84,689	90,651	104,950	111,610	[2] 58,943

[1] This table incorporates some revisions.
[2] January through June, inclusive.
[3] Data not separately recorded.

Compiled from Customs Returns of Australia by Virginia G. Huguley and Corra A. Barry, Division of Foreign Activities.

[25] Sulphur. South Africa's First Titanium Dioxide Plant. No. 40, June 1962, p. 30.
[26] Steel and Coal (London). Australian Rutile for U.S. Company. V. 185, No. 4920, Nov. 2, 1962, p. 854.
[27] Chemical Trade Journal and Chemical Engineer (London). W. Australian Ilmenite. V. 151, No. 3940, Dec. 7, 1962, p. 1157.

The formation and physiographical environment of beach sand deposits in Queensland were described. Resources of heavy minerals in the area were estimated as follows:

	Tons
Rutile	3,500,000
Ilmenite	7,700,000
Zircon	2,250,000
Monazite	17,500

Over three-fourths of these resources were located in large low-grade deposits on North Stradbroke Island.[28]

At the annual conference of the Australian Institute of Mining and Metallurgy, 15 papers on the technical and economic aspects of the mineral sands industry in Eastern Australia were presented.[29]

TECHNOLOGY

The development of a process for making titanium dioxide pigments from titanium tetrachloride ($TiCl_4$) continued at an accelerated pace, but little information on the practical techniques involved was published. The method consisted of chlorinating a titanium-bearing material (usually rutile) with carbon to produce $TiCl_4$ which is reacted as a vapor with oxygen to yield titanium dioxide. Chlorine regenerated in the reaction is recycled to the chlorinator.[30]

A patent was granted for a process of burning titanium tetrachloride and oxygen in a vertical reactor whereby pigmentary titanium dioxide was formed substantially out of contact with stationary surfaces.[31]

The Bureau of Mines investigated methods for chlorinating titanium slags prepared from ilmenite concentrates from deposits in Valley County, Idaho; Trail Ridge, Fla.; Aiken, S.C.; and MacIntyre, N.Y. A slag made from titaniferous magnetite from Iron Mountain, Wyo., also was evaluated. The tests were made in moving bed chlorinators 4 inches and 36 inches in diameter. Preliminary testing was done in a 40-millimeter bench-type unit. The slags from Idaho, Florida, and South Carolina ilmenites were chlorinated as readily as rutile. About 70 to 80 percent of the titanium in the slags was converted to titanium tetrachloride. In a given chlorinator, about 50 to 70 percent as much $TiCl_4$ was made from slags as from rutile. The New York and Wyoming slags, that contained high concentrations of magnesium and calcium oxides, were not suitable for the moving-bed chlorinators.[32]

Finely divided titania (1 to 50 microns) was chlorinated with 92-percent efficiency.[33] Dust losses of only 3 to 4 percent were obtained

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[28] Mining Journal (London). The Beach Sand Deposits of Queensland. V. 259, No. 6640, Nov. 23, 1962, pp. 488–489, 491.

[29] Paterson, O. D. The Search for Deposits of Rutile and Zircon. Mineral Sands in Eastern Australia—Paper No. 1, The Australian Inst. of Min. and Met., Aug. 5–11, 1962, 21 pp.

[30] Chemical Engineering. TiO_2 Technology Keeps Pace With Competition. V. 69, No. 15, July 23, 1962, pp. 62–64.

[31] Nelson, Earl W. (assigned to American Cyanamid Co., New York.) Combustion of Titanium Tetrachloride With Oxygen. U.S. Pat. 3,022,137, Feb. 20, 1962.

[32] Perkins, E. C., H. Dolezal, H. Leitch, and R. S. Lang. Chlorination of Titaniferous Slags: A Study of the Moving Bed Technique. BuMines Rept. of Inv. 5983, 1962, 17 pp.

[33] Cole, S. S., and L. W. Rowe. Flash Chlorination of Very Finely Divided Metal Oxides. Trans. AIME (Met. Soc.) V. 224, No. 1, February 1962, pp. 120–121.

by conducting the reaction in a fluidized restraining bed of coarse-grained rutile.

A report described the method used at a West German titanium plant for recovering sulfuric acid and ferrous oxide from byproduct copperas ($FeSO_4 \cdot 7H_2O$).[34] The copperas was converted to the monohydrate ($FeSO_4 \cdot H_2O$) in a fluidized bed furnace at about 800° C. Dissociation of the monohydrate was conducted by burning sulfur at 1,000° to 1,100° C. and passing the resulting sulfur dioxide through the monohydrate in a hearth-type furnace. The sulfur dioxide produced by burning the sulfur and dissociating the monohydrate was then used conventionally to make sulfuric acid for the pigment plant. A fluidized bed furnace for carrying out the dissociation step at 1,100° to 1,200° C. was expected to be on stream in 1962.

M & T Chemicals, Inc. rutile and aplite mine in Hanover County, Va. was described.[35] Raw ore was crushed wet in a swing hammer mill, ground to 20 mesh in a closed-circuit rod mill, and deslimed in cyclones. Gravity separation was in three stages—two stages of spirals followed by tabling. The aplite was separated in the first-stage spirals and processed for use as a source of alumina in glass and other industrial products. Concentrate from the tables was dried and treated by hightension and magnetic separators, yielding a granular rutile of approximately 97 percent titanium dioxide and an ilmenite concentrate. Some of the rutile was sold in the granular form, but most of it was ground to approximately 325 mesh in a continuous dry ball mill for use in ceramics. Ilmenite produced at the plant was marketed principally for titanium-alloy production. Separation techniques and possible commercial applications for titanite, which also occurs in the deposit, were under development.

The equilibrium relationship between titanium dichlorides and sodium dissolved in molten sodium chloride was determined from measurements of the potential difference between a titanium electrode and a reference electrode in molten sodium chloride containing the lower chloride of titanium or sodium.[36]

Dry chlorine gas will rapidly attack titanium; however, the presence of a trace of water (about 0.1 percent) is normally adequate to inhibit corrosion by stabilizing the resistant surface oxide film. In a preliminary investigation of the cause of unexpected corrosion of titanium in wet chlorine gas in a production installation, Crucible Steel Company of America concluded that titanium had a tendency to corrode in wet chlorine in deep crevices. Slow dehydration below the critical moisture level was believed to occur in stagnant crevices having a large metal-area to gas-volume ratio.[37]

A two-stage process for reducing titanium tetrachloride with sodium was patented.[38] The process, developed by the Bureau of Mines,

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[34] Sulphur. Sulphuric Acid From Ferrous Sulphate. No. 40, June 1962, pp. 27–28.

[35] Doud, D. E., and W. W. Coffeen. Unique Mining Operation Yields Rutile and Aplite. Min. Eng., v. 14, No. 10, October 1962, pp. 59–62.

[36] Boozenny, Alex. Na^o–$TiCl_2$–$TiCl_3$ Equilibrium in NaCl Melts. Trans. AIME, Met. Soc., v. 224, No. 5, October 1962, pp. 950–956.

[37] Crucible Steel Company of America. Titanium Review. V. 10, No. 1, August 1962, pp. 1–5.

[38] Baker, Don H., Jr., and Vernon E. Homme (assigned to the U.S. Department of the Interior). Production of High Purity Titanium by Metallic Sodium Reduction of Titanic Halide. U.S. Pat. 3,069,255, Dec. 18, 1962.

involved a partial reduction of titanium tetrachloride with sodium to form lower valent chlorides which were then reduced to titanium in a separate compartment. Titanium with a Brinell hardness number as low as 49 was produced by the process.

The titanium-iridium alloy system was investigated between 500° and 2,400° C.[39] The phase diagram of the system containing 0 to 100 atomic percent titanium was constructed and indicated the formation of two intermetallic compounds, Ti_3Ir and $TiIr_3$, and one intermediate solid solution centered about the 50 atomic percent iridium composition. The alloys containing either of the intermetallic compounds were extremely brittle, but alloys containing 45 to 55 atomic percent iridium were less brittle and somewhat forgeable. The high neutron cross section and melting point of these alloys suggested high-temperature applications.

The physical properties and homogeneity for four titanium-base alloys in ingot and sheet form were evaluated and correlated with variations in the melting and casting procedure.[40] Consumable-electrode melting was used, arc current and furnace backfill pressure were varied, and ingots were formed both by melting directly into a water-cooled copper mold and by skull melting followed by pouring into a graphite mold. Alloying metal additions for the alloys tested were (1) 8 percent manganese, (2) 6 percent aluminum and 4 percent vanadium, (3) 6 percent molybdenum and 2 percent aluminum, and (4) 16 percent vanadium and 2.8 percent aluminum.

Physical and mechanical properties of the intermetallic compound titanium nitride were evaluated.[41] The hardening capacity, paramagnetism, corrosion and abrasion resistance, low density, and fine dendritic weld structure of titanium nitride and titanium nitride-rich alloys indicated a possible use of wrought titanium nitride and titanium nitride-base alloys in nonmagnetic structural applications such as hard tools.

The Bureau of Mines described a spectrochemical procedure for determining 19 impurity elements in high-purity titanium metal, titanium oxides, and titanium halides.[42] All samples were converted to titanium dioxide before analysis. Determination of impurities was studied in the concentration range of 0 to 1,000 parts per million, but different determination limits were found for the various elements. The procedure was quantitative for 18 elements but semiquantitative for beryllium.

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[39] Croeni, J. G., C. E. Armantrout, and H. Kato. Titanium-Iridium Phase Diagram. BuMines Rept. of Inv. 6079, 1962, 15 pp.

[40] Calvert, E. D., P. C. Magnusson, M. D. Carver, and R. A. Beall. Composition and Mechanical Properties of Selected Cold-Mold and Skull-Cast Titanium Alloys. BuMines Rept. of Inv. 6014, 1962, 26 pp.

[41] Buehler, W. J., and R. C. Wiley. TiNi-Ductile Intermetallic Compound. Trans. ASM, v. 55, 1962, pp. 269–276.

[42] Wells, J. Robert, and Lloyd Carpenter. Spectrochemical Analysis of High-Purity Titanium. BuMines Rept. of Inv. 6105, 1962, 23 pp.

Tungsten

By Andrew S. Prokopovitsh [1] and Mary J. Burke [2]

DOMESTIC production of tungsten concentrate increased for the third consecutive year and totaled 8.3 million pounds of contained tungsten, more than any of the 5 preceding years. Imports also increased, but represented only 29 percent of the tungsten consumed in the United States.

World production decreased slightly, following 4 years of rising production and 2 years of declining prices. Depressed marketing conditions prevailed throughout most of 1962, many mines shut down, and many others curtailed output.

TABLE 1.—Salient tungsten statistics

(Thousand pounds of contained tungsten)

	1953–57 (average)	1958	1959	1960	1961	1962
United States:						
Mine production	12,210	(1)	(1)	6,669	8,188	8,280
Mine shipments	11,412	3,605	3,473	6,972	7,847	8,021
Imports, general	21,801	6,873	6,248	5,178	2,744	3,709
Imports for consuption	21,565	6,542	5,435	3,525	2,123	3,977
Consuption	7,669	5,320	9,835	11,605	11,128	13,691
Stocks:						
Producer	1,410	(1)	(1)	2,402	2,667	3,004
Consumer and dealer	3,767	4,670	3,196	3,143	3,212	3,054
World: Production	74,520	53,392	[2] 54,343	66,049	[2] 70,237	67,667

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

[2] Revised figure.

LEGISLATION AND GOVERNMENT PROGRAMS

General Services Administration announced a plan to dispose of 852 tons of domestic tungsten ore and 310 pounds of foreign tungsten concentrate from Government stockpiles, which had been declared in excess of Government requirements.

During 1962, 1,470,721 pounds of tungsten, amounting to more than 92,700 short ton units were sold from the Defense Production Act Inventory. This was in accordance with Defense Mobilization Order V–7 issued June 30, 1958, and amended April 25, 1962, which provided that Government agencies that directly use strategic and critical materials shall fulfill their requirements by using materials from Govern-

[1] Commodity specialist, Division of Minerals.

[2] Statistical assistant, Division of Minerals.

ment inventories that are excess to needs, whenever such action was consistent with the best interests of the Government.

An additional quantity of 7,800 short ton units, containing approximately 123,700 pounds of tungsten was disposed of in connection with upgrading fees.

Tungsten was one of the elements investigated by a subcommittee of the Committee on Armed Services, United States Senate, that inquired into Government stockpiles.[3]

DOMESTIC PRODUCTION

U.S. tungsten mine production increased slightly despite the closing of one of the four principal mines, a strike at another, and a declining trend in the price of tungsten concentrate. Of the nine mines in six States that reported production, only two mines maintained output throughout 1962. These were the Pine Creek mine of Union Carbide Nuclear Co. near Bishop, Calif., and the Hamme mine of Tungsten Mining Corp. in Vance County, N.C. Production at the Climax mine of American Metal Climax, Inc., near Leadville, Colo., was interrupted by a strike lasting 6 months. The remaining seven mines that reported tungsten production were in Inyo and Madera Counties, Calif.; Lake County, Colo.; Custer County, Idaho; Beaverhead County, Mont.; and Churchill County, Nev. One of the seven mines, the Strawberry mine of New Idria Mining and Chemical Co., Idria, Calif., started operations late in 1962. In addition nine small mining and milling operations in California and Nevada had some tungsten output during the first 6 months of 1962. In the last half of the year, however, the small mines and those that operated principally for the tungsten content of their ore had either shut down or were doing so because of the low-market price of tungsten concentrate. Virtually all U.S. tungsten production was limited to three large mines, two of which depended on metal values beside tungsten.

One of the largest tungsten mines, Nevada-Massachusetts Co., sold its equipment at auction in September: An ore milling plant of 600-tons-per-day capacity, a companion crushing plant, heavy mining equipment, and a townsite of 80 houses. The sale resulted from the decision to abandon tungsten operations and to allow the vast mine to fill with water. The mine had been closed since 1958, with only a maintenance crew on standby. Nevada-Massachusetts and predecessor companies had operated the mine intermittently since 1914 with shutdowns in the 1920's, 1930's, and 1940's.

The Calvert mine of Minerals Engineering Co., Beaverhead County, Mont., one of the few mines worked solely for tungsten, began to terminate its mining operations in December 1961, and by early 1962 all activity had ceased.

Plans were also underway to close the Hamme tungsten mine near Henderson, N.C., operated by Tungsten Mining Corp., Vance County, N.C., a subsidiary of Howe Sound Company.

[3] Inquiry into the Strategic and Critical Material Stockpiles of the United States. Hearings before the National Stockpile and Naval Petroleum Reserves Subcommittee, U.S. Senate. 87th Cong., 2d Sess., pt. 8, Nov. 13–29, 1962.

New Idria Mining and Chemical Co. completed its new tungsten refining plant at Fresno, Calif. New Idria's tungsten ore was obtained from its Strawberry mine near Bass Lake, Calif., where it also operated a 150-ton-per-day concentrating mill.

TABLE 2.—Tungsten concentrate shipped from mines in the United States

Year	Quantity			Reported value, f.o.b. mines [1]		
	Short tons, 60 percent WO_3 basis	Short ton units WO_3 [2]	Tungsten content (thousand pounds)	Total (thousands)	Average per unit of WO_3	Average per pound of tungsten
1953-57 (average)	11,990	719,431	11,412	$41,521	$57.71	$3.64
1958	3,788	227,255	3,605	3,991	17.56	1.11
1959	3,649	218,927	3,473	4,502	20.56	1.30
1960	7,325	439,530	6,972	9,815	22.33	1.40
1961	8,245	494,741	7,847	10,565	21.36	1.35
1962	8,429	505,685	8,021	11,639	23.02	1.45

[1] Values apply to finished concentrate and are in some instances f.o.b., custom mill.
[2] A short-ton unit equals 20 pounds of tungsten trioxide (WO_3) and contains 15.862 pounds of tungsten

CONSUMPTION AND USES

Consumption of tungsten concentrate increased 23 percent, the highest yearly average since 1945. In the major use categories, consumption of tungsten in pure metal uses increased 12 percent; consumption in high-speed and other alloy steels increased 20 percent; and consumption in high-temperature and other nonferrous alloys increased 16 percent.

Carbides accounted for 46 percent of the total consumption, cemented carbides for 38 percent, and other carbides for 8 percent.

Data in table 5 include consumption of imported ferrotungsten, other imported products, and scrap. The nonferrous alloys include cutting and wear-resistant alloys, high-temperature and other superalloys, alloy welding rods, and electrical contact and resistance alloys. The pure-metal uses include wire, rod, and sheet, as well as various shaped parts produced by powder metallurgy techniques.

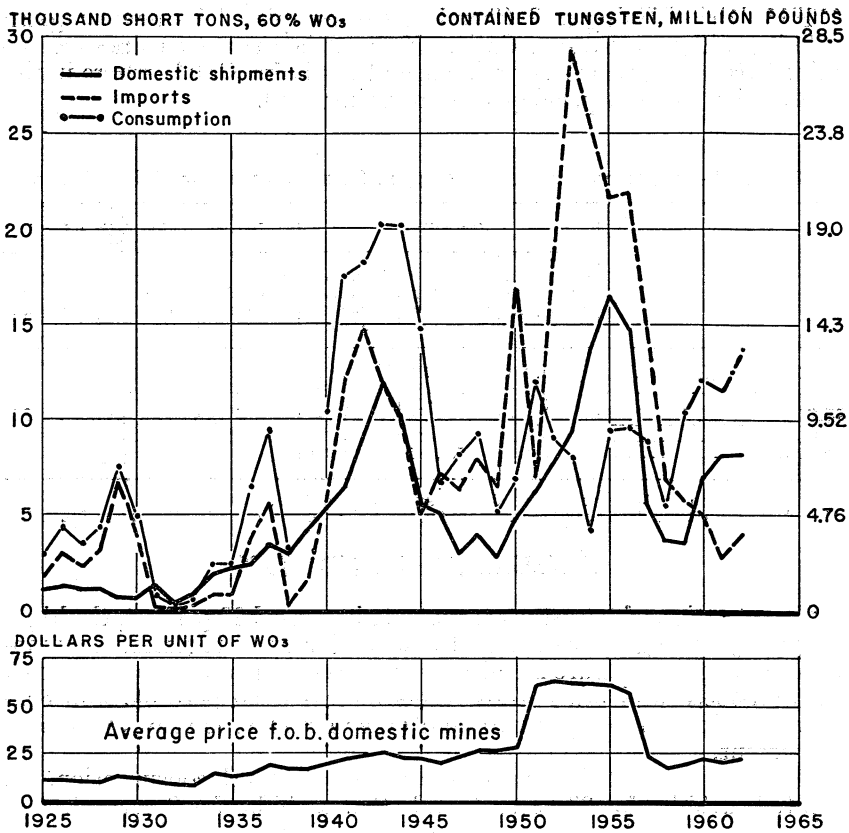

FIGURE 1.—Domestic shipments, imports, consumption, and average price of tungsten ore and concentrate, 1925–62.

TABLE 3.—Distribution of tungsten concentrate consumed

	Tungsten content (thousand pounds)		Short tons (60 percent WO_3)		Percent of total	
	1961	1962	1961	1962	1961	1962
Manufacturers of steel ingots and ferrotungsten	2,071	2,281	2,176	2,397	19	17
Manufacturers of hydrogen-reduced metal powder	4,900	5,509	5,148	5,789	44	40
Manufacturers of carbon-reduced metal powder and tungsten chemicals, and consumption by firms making several products	4,157	5,901	4,368	6,200	37	43
Total	11,128	13,691	11,692	14,386	100	100

TABLE 4.—Production, shipments, and stocks of tungsten products in the United States in 1962

(Thousand pounds of contained tungsten)

	Product					
	Hydrogen and carbon-reduced metal powder	Tungsten carbide powder		Chemicals	Other [1]	Total
		Made from metal powder	Crushed cast			
Received from other producers	3,165	12	----------	2,623	1,740	7,540
Gross production during year	8,317	4,012	1,059	9,052	2,021	24,461
Used to make other products listed here	4,342	----------	----------	6,320	546	11,208
Net production	3,975	4,012	1,059	2,732	1,475	13,253
Shipments [2]	6,579	4,029	987	4,456	3,215	19,266
Producer stocks, Dec. 31	2,012	177	119	2,182	773	5,263

[1] Includes ferrotungsten, tungsten carbide powder (crystalline), scheelite (produced from scrap), nickel-tungsten, self-reducing oxide, pellets, and scrap.
[2] Includes quantities consumed by producing firms for manufacture of products not listed here.

TABLE 5.—Consumption of tungsten products, by end uses, in 1962

(Thousand pounds of contained tungsten)

End use	Ferrotungsten, melting base, self-reducing tungsten, tungsten sponge mix, etc.	Carbon reduced tungsten powder [1]	Hydrogen reduced tungsten powder [2]	Tungsten carbide powder		Chemicals	Scheelite (natural or synthetic)	Scrap	Total
				Made from metal powder	Crystalline and crushed cast				
Steel:									
High speed	563	20	--------	--------	--------	--------	1,072	111	1,766
Hot work and other tool	354	1	--------	--------	--------	--------	133	104	592
Alloy (other than tool) [3]	210	5	2	--------	--------	--------	90	51	358
High temperature nonferrous alloys [4]	61	56	77	--------	--------	--------	170	234	598
Other nonferrous alloys [5]	16	6	133	7	208	221	3	83	677
Tungsten metal:									
Wire, rod, and sheet	------------	--------	1,670	--------	--------	--------	--------	------	1,670
Other	------------	--------	521	1	--------	--------	--------	------	522
Carbides:									
Cemented or sintered	------------	--------	21	3,072	1,374	--------	--------	74	4,541
Other (including cast or fused)	3	65	33	18	690	--------	--------	95	904
Chemicals [6]	------------	--------	--------	--------	--------	142	--------	------	142
Total	1,207	153	2,457	3,098	2,272	363	1,468	752	11,770
Stocks at consumer plants Dec. 31	241	16	83	89	4	37	--------	246	716

[1] Includes tungsten metal pellets that may be hydrogen or carbon reduced or scrap.
[2] Does not include quantities consumed in making tungsten carbide powder.
[3] Includes steel mill rolls, stainless, and other alloy steels.
[4] Includes cutting and wear resistant alloys.
[5] Includes diamond drill bit matrices, electrical contact points, and welding rods.
[6] Includes fluorescent powders and organic and inorganic pigments.

STOCKS

Stocks of concentrate held by consumers and dealers at yearend were 5 percent below the end of 1961.

Industry stocks at all locations are given in table 1.

Data on tungsten materials in Government inventories on December 31, are presented in table 6.

TABLE 6.—Tungsten materials in Government inventories, as of Dec. 31, 1962[1]

(Thousand pounds, tungsten content)

	National (strategic stockpile)	Defense Production Act inventory	Commodity Credit Corporation and supplemental stockpile	Tota
Tungsten, all forms:				
Stockpile grade	103,843	52,904	4,479	161,226
Non-stockpile grade	16,230	25,464	1,283	42,977
Tungsten carbide powder [2]	(886)		(1,080)	(1,966)
Ferrotungsten [2]	(1,652)			(1,652)
Tungsten metal powder: Hydrogen reduced [2]	(1,092)			(1,092)
Tungsten metal powder: Carbon reduced [2]	(499)			(499)

[1] See corresponding table in 1961 Tungsten Chapter for background information.
[2] Figures in parentheses are upgraded forms and are included in the figures for tungsten, all forms.

PRICES AND SPECIFICATIONS

Domestic concentrate, quoted in E&MJ Metal and Mineral Markets from January to August, ranged from $20.00 to $22.00 per short-ton unit of tungsten trioxide (WO_3), f.o.b. mine or mill. Thereafter, prices dropped to $16.00 to $20.00 where they remained. Foreign tungsten concentrate declined from $13.00 in January to $8.50 in December. The lowest price, $7.50, was reached in August.

Tungsten metal powder (98.8 percent in 1,000-pound lots) was quoted at $2.75 per pound in E&MJ Metal and Mineral Markets. The price of hydrogen-reduced tungsten metal powder (99.99 percent) ranged from $2.70 to $3.55 per pound.

Ferrotungsten prices in January remained at the 1961 quotation of $2.45 per pound of contained tungsten (in lots of 5,000 pounds or more, ¼-inch lump, packed; f.o.b. destination, continental United States, 70 to 80 percent tungsten). By March the price had declined to $2.15, where it remained.

TABLE 7.—Prices of tungsten concentrate in 1962

	Foreign ore per short-ton unit of WO_3, 65-percent basis c.i.f. U.S. ports, duty extra		London market, per long-ton unit of WO_3
	Wolfram	Scheelite	
Jan. 5	$13.00 to $13.50	$13.00 to $13.50	103s. to 105s.
Feb. 1	13.50 to 14.00	13.50 to 14.00	110s. to 114s.
Mar. 1	13.50 to 14.00	13.50 to 14.00	105s. to 108s.
Apr. 5	12.25 to 12.75	12.25 to 12.75	97s. to 100s.
May 3	12.25 to 12.75	12.25 to 12.75	97s. to 100s.
June 7	10.75 to 11.00	10.75 to 11.00	85s. to 87½s.
July 5	10.00 to 10.50	10.00 to 10.50	80s. to 82½s.
Aug. 2	7.50 to 8.00	7.50 to 8.00	60s. to 70s.
Sept. 6	7.50 to 8.50	7.50 to 8.50	62½s. to 75s.
Oct. 4	9.00 to 10.50	9.00 to 10.50	73s. to 85s.
Nov. 1	9.50 to 10.50	9.50 to 10.50	75s. to 85s.
Dec. 6	8.50 to 9.50	8.50 to 9.50	66s. to 76s.
Average price	10.95	10.95	
Duty	7.93	7.93	
Average price, duty paid	18.88	18.88	

Source: E&MJ Metal and Mineral Markets.

FOREIGN TRADE[4]

Imports.—General imports of tungsten concentrate increased 35 percent; 89 percent of the total imports came from the Republic of Korea, Portugal, Bolivia, Australia, and Peru, in descending order of importance, and 11 percent came from seven other countries. Imports for consumption of tungsten concentrate increased 87 percent. Import of tungsten metal, tungsten carbide, and combinations containing tungsten or tungsten carbide in lumps, grains, or powder, contained 497,054 pounds of tungsten valued at $937,950.

Imports of tungstic acid and other tungsten compounds, not specifically provided for, contained 356 pounds valued at $890. Imports of tungsten or tungsten carbide scrap were 193,092 pounds, gross weight, valued at $181,310. Imports of ore and concentrate duty free for the U.S. Government were 869,100 pounds tungsten content, valued at $711,788 from the Republic of Korea, 662,472 pounds; Bolivia, 107,705 pounds; Australia, 78,632 pounds; and Spain 20,291 pounds.

TABLE 8.—U.S. imports for consumption of tungsten ore and concentrate, by countries

(Thousand pounds and thousand dollars)

Country	1961			1962		
	Gross weight	Tungsten content	Value	Gross weight	Tungsten content	Value
North America[1]				2	1	$1
South America:						
Argentina				110	59	39
Bolivia	502	203	$133	[2] 1,304	721	438
Chile				272	150	98
Peru	97	29	17	350	202	173
Uruguay				106	4	2
Total	599	232	150	2,142	1,136	750
Europe:						
Netherlands	55	33	35			
Portugal	822	468	442	1,522	862	676
Spain	66	39	42	132	80	78
Total	943	540	519	1,654	942	754
Asia:						
Japan				3	2	2
Korea, Republic of	1,455	805	760	2,688	1,491	1,060
Malaya, Federation of	19	11	16			
Total	1,474	816	776	2,691	1,493	1,062
Africa:						
British East Africa	112	58	54			
Congo, Republic of the, and Ruanda-Urundi	109	62	63			
Total	221	120	117			
Oceania: Australia	722	415	421	701	405	303
Grand total	3,959	2,123	1,983	[2] 7,190	3,977	2,870

[1] Canada and Mexico. [2] Adjusted by Bureau of Mines.

Source: Bureau of the Census.

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

TABLE 9.—U.S. imports for consumption of ferrotungsten, by countries

(Thousand pounds and thousand dollars)

Country	1961			1962		
	Gross weight	Tungsten content	Value	Gross weight	Tungsten content	Value
Austria	325	257	$315	409	328	$333
Belgium-Luxembourg	24	19	22	15	12	11
France	12	10	13	36	30	31
Germany, West	24	19	27	16	13	14
Japan				12	10	11
Netherlands				1	(1)	1
Portugal	6	5	5			
Sweden				169	141	130
United Kingdom	37	30	40			
Total	428	340	422	658	534	531

[1] Less than 1,000 pounds.

Source: Bureau of the Census.

TABLE 10.—U.S. imports for consumption of tungsten or tungsten carbide forms

Year	Ingots, shot, bars and scrap		Wire, sheets, or other forms, n.s.p.f.[1]		Total	
	Gross weight (pounds)	Value	Gross weight (pounds)	Value	Gross weight (pounds)	Value
1953–57 (average)	271,894	[2] $525,132	92,315	[2] $278,353	364,209	[2] $803,485
1958	53,299	57,543	196,190	348,179	249,489	405,722
1959	258,051	199,464	193,061	367,324	451,112	566,788
1960	170,383	207,217	174,877	528,035	345,260	735,252
1961	131,117	164,460	93,199	551,473	224,316	715,933
1962	194,111	188,668	73,448	383,670	267,559	572,338

[1] Not specifically provided for.
[2] Data known not to be comparable with other years.

Source: Bureau of the Census.

Exports.—Exports and reexports of tungsten concentrate were 79,080 and 317,636 pounds, gross weight, respectively, valued at $79,550 and $131,548. Exports of ferrotungsten were 12,096 pounds, gross weight, valued at $26,136.

Exports of tungsten metal powder totaled 148,780 pounds, gross weight, valued at $738,237. Exports of tungsten metal and alloys in crude form and scrap were 73,977 pounds, gross weight, valued at $148,777. Exports of semifabricated forms were 49,001 pounds, gross weight, valued at $1,090,908.

WORLD REVIEW

A continuing decline in the price of tungsten concentrate in the world market again overshadowed most other developments. The decline was unusually severe at midyear when marketing activity was notably restrained and the onset of a depressed market situation was evident. Some improvement occurred during the last few months of 1962, but it was apparent that world production was considerably in excess of what could be consumed at prevailing prices. As a result, a

TABLE 11.—World production of tungsten ore and concentrates by countries[1]

(Short tons, 60 percent WO_3 basis)

Country	1953–57 (average)	1958	1959	1960	1961	1962
North America:						
Canada	1,791	575	----	----	----	----
Mexico	580	8	138	198	193	88
United States (shipments)	11,990	3,788	3,649	7,325	8,245	8,429
Total	14,361	4,371	3,787	7,523	8,438	8,517
South America:						
Argentina	1,166	1,127	827	893	[2] 830	[3] 1,800
Bolivia (exports)	5,023	2,457	2,671	2,370	3,104	2,798
Brazil (exports)	1,878	2,596	1,609	2,205	1,157	827
Peru	1,039	992	542	538	428	491
Total	9,106	7,172	5,649	6,006	5,519	5,916
Europe:						
Austria	[4] 140	146	152	243	317	320
Finland	76	163	42	----	63	----
France	1,306	1,152	959	753	834	750
Italy	29	10	6	8	2	----
Portugal	5,208	2,109	2,478	3,189	3,213	2,364
Spain	2,112	1,301	854	1,028	1,190	739
Sweden	511	660	336	336	440	[2] 440
U.S.S.R.[2]	8,400	9,400	9,900	10,500	11,000	11,600
United Kingdom	75	2	----	----	----	----
Yugoslavia	89	99	86	86	9	[2] 10
Total[2]	17,950	15,050	14,800	16,150	17,100	16,200
Asia:						
Burma[5]	2,270	1,100	820	1,215	1,215	880
China[2]	19,000	16,500	19,800	22,000	22,000	22,000
Hong Kong	60	46	47	39	20	19
India	4	----	1	3	11	12
Japan	1,000	881	1,194	1,082	1,033	1,056
Korea:						
North[2]	2,040	3,300	4,400	5,500	5,500	5,500
Republic of	5,212	3,597	3,492	5,870	7,529	7,628
Malaya	121	57	24	46	41	11
Thailand	1,422	725	553	486	565	463
Total[2]	31,100	26,200	30,350	36,250	37,900	37,600
Africa:						
Algeria	7	----	----	----	----	----
Congo, Republic of the (formerly Belgian)[5]	948	1,200	1,038	634	642	[2] 550
Morocco	7	----	----	----	----	----
Nigeria	6	----	----	----	----	----
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	282	103	36	11	55	24
Ruanda Urundi	828	279	171	504	734	165
South Africa, Republic of	485	61	42	37	30	28
South-West Africa[5]	281	64	2	154	192	71
Tanganyika (exports)	8	----	----	----	3	----
Uganda (exports)	202	31	14	84	243	105
United Arab Republic (Egypt)	8	----	----	----	[2] 95	----
Total	3,062	1,738	1,303	1,424	1,994	943
Oceania:						
Australia	2,714	1,587	1,218	2,064	2,866	1,940
New Zealand	36	3	11	9	6	[2] 6
Total	2,750	1,590	1,229	2,073	2,872	1,946
World total (estimate)	78,300	56,100	57,100	69,400	73,800	71,100

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[2] Estimate.
[3] Exports.
[4] One year only as 1957 was the first year of commercial production.
[5] Including WO_3 in tin-tungsten concentrates.

Compiled by Pearl J. Thompson, Division of Foreign Activities

U.N. Exploratory Meeting on Tungsten was scheduled to be held in New York City early in 1963. This special meeting was arranged at the request of the Interim Co-ordinating Committee for International Commodity Arrangements, which had been established by the Economic and Social Council of the United Nations.

World production declined about 4 percent, and only 2 continents showed increased production or shipments. Among the other 4 producing areas, Africa and Oceania had the largest decreases, 53 percent and 32 percent respectively. Tungsten production in Europe decreased 5 percent and in Asia was about the same as in 1961.

Approximately 70 percent of all 30 countries credited with tungsten production had smaller outputs than in 1961. Although 30 percent of the countries increased tungsten outputs, none of them produced more than 1 percent of the world total.

NORTH AMERICA

Canada.—Canada Tungsten Mining Corp., Ltd., began shipping samples of tungsten concentrate to prospective customers in Canada, the United States, Japan, and Europe. More than 92,000 tons of ore was broken and hauled to stockpiling facilities at the millsite in preparing for production in 1963. The average grade of the stockpiled ore was 2.85 percent tungsten trioxide (WO_3). By the end of 1962, almost 12,000 tons of ore had been treated in the gravity circuit. Ore reserves were estimated at 1,163,000 tons averaging 2.47 percent WO_3. A complete description of the mining and milling operations was published.[5]

SOUTH AMERICA

Argentina.—The Government agency, Comite para la Comercialización de Minerales, continued to maintain official support prices and offered to purchase tungsten minerals, but there was virtually no output in 1962. Dealings in tungsten were generally limited to exports of tungsten stocks.

Bolivia.—Corporación Minera de Bolivia, the State mining entity, tried to close the Kami tungsten mine in 1962, but the shutdown was not completed. Other operating mines included Caracoles, Bolsa, Negra, and Unificada.

EUROPE

France.—Le Montmins was the only tungsten mine in operation. A new mine at Castobonne in the French Pyrenees was prepared for operation.

Portugal.—Tungsten production declined 26 percent compared with 1961. Except for a small quantity of scheelite, production consisted of wolframite containing 65 to 71 percent WO_3.

Exports also declined 23 percent. The United Kingdom, the United States, and the Netherlands received 83 percent of the exports; the remaining 17 percent went to Japan, France, the Republic of South Africa, and other countries.

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[5] Western Miner and Oil Review (Canada). Canada Tungsten Mining Corp., Ltd. V. 35, No. 12, December 1962, pp. 28–39.

United Kingdom.—Tungsten concentrate was imported from more than 27 countries in 1962, most being obtained from Portugal, Czechoslovakia, U.S.S.R., Republic of Korea, Peru, Australia, Bolivia, China, and Burma.

ASIA

Burma.—Mawchi tungsten mine continued operating on a small scale. Much of the wolframite was exported to the United States. Private mineowners exported ore directly to the United Kingdom.

Korea, Republic of.—Exports of tungsten ore and concentrate during 1961 totaled 5,927 tons, compared with 3,999 tons in 1960. About 95 percent of the material was exported to Western Europe, Japan, and the United States. Construction began in Yongdongpo on a plant to produce tungsten metal in May 1962.

AFRICA

Uganda.—Virtually all production stopped because of the low price of tungsten concentrate.

OCEANIA

Australia.—A wolframite treatment plant was successfully commissioned by Hard Metals Pty., Ltd., Auburn, New South Wales. The plant was part of a development and expansion program to increase the manufacture of cemented carbides.

TECHNOLOGY

The Bureau of Mines published the heats of formation of sodium tungstates. The values were obtained by using a solution calorimetry method.[6] The Bureau also reported on the chemical analysis of tungsten, describing and evaluating spectrophotometric and polarographic methods for quantitatively determining the impurities in high-purity tungsten.[7] Another Bureau report described the properties of cemented tungsten carbide modified by adding 1, 2, and 5 percent of titanium diboride.[8]

A patent was granted to Bureau of Mines metallurgists for a method of separating tungsten from molybdenum by electrolysis from a fused electrolyte bath.[9]

Tungsten and tungsten-alloy tubing in various cross sections and as long as 5 feet was produced experimentally and underwent development for use in compact, high-temperature nuclear reactors. Tungsten sheet was available in production quantities in widths over 3 feet and weights up to 130 pounds per sheet; applications considered were aircraft, missile, and high-temperature furnace industries.

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[6] Koehler, Mary F., L. B. Pankratz, and R. Barany. Heats of Formation of Sodium Molybdates and Tungstates. BuMines Rept. of Inv. 5973, 1962, 13 pp.

[7] Haymes, J. G., and Albert Ollar. Methods for Determining Microquantities of Impurities in Tungsten. BuMines Rept. of Inv. 6005, 1962, 22 pp.

[8] Tyrrell, M. E., and G. M. Farrior. Cemented Tungsten Carbide with Titanium Diboride Additions. BuMines Rept. of Inv. 6095, 1962, 12 pp.

[9] Zadra, J. B., and J. M. Gomes. Method for Separating Molybdenum from Tungsten by Electrolysis from a Fused Electrolyte Bath. Official Gazette (U.S. Pat. Office), v. 786, No. 5, January 1963, p. 1488.

Porous tungsten infiltrated with silver was available as a material of construction for rocket and missile components, particularly throats and nozzles. Another new use for tungsten was as an additive to boron-epoxy resin for use in special structures and reinforcements. Higher purity tungstate chemicals for laser and electronic applications were in commercial production. Tungsten carbides were used widely in component materials, such as grinding quills and aircraft stabilizers, and in a broadening market for cutting tools and structural parts. Flame-plated coatings of tungsten carbide on working surfaces, knives, drills, and rocket engines were used successfully as erosion barriers. New tungsten carbides, having improved radiation resistance because of shorter half-life binders, were developed. New work rolls that were expected to last 20 to 50 times longer than conventional-type rolls in rolling mills were reported available in the form of solid tungsten carbide.[10] Detailed reviews of available information on the oxidation of tungsten and its alloys were compiled. They included an overall picture of the oxidation of tungsten at room temperature to very high temperatures and summarized the status of alloying, cladding, and coating methods to prevent oxidation.[11] The effect of orientation on the stresses activation energies and activation volumes for yielding and plastic flow of tungsten single crystals were described.[12]

The effect of molten lead on tungsten was investigated. Experiments performed from 650° to 1,740° C indicated no appreciable reaction between lead and tungsten.[13] Machining tungsten alloys at low voltages and high amperages was described.[14] Centrifugal casting of tungsten into rings by consumable electrode, vacuum arc, skull melting, and vacuum pouring into a mold rotating about a vertical axis was described.[15] Calcium tungstate crystals doped with neodymium were reported to have an energy output several times greater than other substances for such applications as communications and welding.[16] The direct-current, straight-polarity tungsten arc was investigated in a high-vacuum, open-arc system. Ingot purity and the effects of ambient pressure variations on the melt rate and arc behavior were described.[17] Investigation of the compatibility of tungsten with a variety of nozzle structural materials at 4,000° to 6,000° F and at times up to 120 seconds indicated that the reaction of tungsten with these materials is confined to the solid state alone and is

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[10] Iron and Steel Engineer. Tungsten Carbide Rolls Possess Great Rigidity. May 1962, p. 157.

[11] Andes, G. M., and R. W. Heckel. Oxidation Behavior of Tungsten Base Alloys. Am. Soc. Metals Trans., v. 55, No. 1, March 1962, pp. 193–201.

Ong, J. N., Jr. Oxidation of Refractory Metals as a Function of Pressure, Temperature, and Time. Tungsten in Oxygen. J. Electrochem. Soc., v. 109, No. 4, April 1962, pp. 284–288.

[12] Rose, R. M., D. P. Ferriss, and J. Wulff. Yielding and Plastic Flow in Single Crystals. AIME Met. Soc. Trans. v. 224, No. 5, October 1962, pp. 981–990.

[13] Wurms, C., and R. Steinitz. The Effect of Molten Lead on Tungsten. AIME Met. Soc. Trans., v. 224, No. 6, December 1962, pp. 1283–1284.

[14] Yutani, N., and A. Pickrell. Electrical Discharge Machining of Difficult Alloys. Metal Prog., v. 82, No. 2, August 1962.

[15] Hardy, R. C., J. L. Gunter, and T. Hamm. Centrifugal Casting of Tungsten and Molybdenum Alloys. Metal Prog., v. 82, August 1962, pp. 72–77.

[16] Andrews, W. Doped Tungstate Tops Ruby Energy Yield. Electronic News, v. 7, No. 330, August 6, 1962, p. 41.

[17] Butler, T. E., and R. P. Morgan. J. Metals, v. 14, June 1962, pp. 418–420.

not detrimental.[18] A summary of the latest state-of-the-art information on the hot-pressing of tungsten was published.[19]

Among the new developments, uses, and applications for tungsten were the following:

Chemical research confirmed the association of one constitutional water molecule with the metatungstate ion.[20]

Calcium tungstate became available in commercial quantities for optical maser use.

A new compound, europium tungstate, was reported to fluoresce strongly within a narrow spectral range.[21]

In chemical analysis, the distribution coefficient of tungsten between ion-exchange resins and mixtures of hydrochloric and hydrofluoric acid solutions was determined.[22] A thermodynamic study of the paratungstate ions was made by using paper chromatography and a tungsten radioisotope. The thermodynamic equilibrium constant and entropy changes were evaluated and discussed.[23] Observation of a new energy peak in the gamma spectrum of tungsten fallout resulted in a reexamination of the half-life of the isotope tungsten 181.[24]

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[18] Lally, F. J., and R. H. Hiltz. Tungsten—Its High-Temperature Reactivity. J. Metals, June 1962, pp. 424–428.

[19] St. Germain, F., and S. E. Slosarik. Introduction to Hot-Pressed Tungsten. J. Metals, June 1962, pp. 421–423.

[20] Mooney, R. W., V. Chiola, C. Hoffman, and C. D. Vanderpool. The Dehydration of Ammonium Metatungstate. J. Electrochem. Soc. v. 109, December 1962, pp. 1179–1182.

[21] Chemical and Engineering News. Research and Technology Concentrates. v. 40, No. 29, July 16, 1962.

[22] Headridge, J. B., and E. J. Dixon. The Analysis of Complex Alloys with Particular Reference to Niobium Tantalum, and Tungsten. Analyst (London), v. 87, No. 1030, January 1962, pp. 32–42.

[23] Duncan, J. F., and D. L. Kepert. J. Chem. Soc., January 1962, pp. 205–214.

[24] Godt, K. J. Neubestimmung der Halbwertszeit des Wolframisotops 181 W mit Fallout- und Laboratoriumspräparaten Atom-Kernenergie, v. 6, July-August 1961, pp. 318–323.

Uranium

By John G. Parker [1] and Ethel M. Tucker [2]

IN 1962, the 20th anniversary of the first controlled, sustained atomic fission reaction, domestic uranium ore production dropped considerably from 1961, the most productive year in history. More than 1,000 mines produced over 7 million tons of ore valued at $138.3 million in 1962; production of uranium oxide (U_3O_8) concentrate was 17,010 tons valued at approximately $272 million. Total free world production was 33,550 tons of U_3O_8, compared with 36,080 tons in 1961. The year 1962 was marked by a decrease of 10 percent in receipts of foreign uranium concentrates, by relaxation of production limitations on small domestic miners, by initiation of the 1962–66 procurement program with an established price for U_3O_8, and by an announcement late in the year of a new stretchout program designed to extend domestic uranium procurement through 1970.

TABLE 1.—Salient uranium statistics

(Short tons)

	1958	1959	1960	1961	1962
United States:					
Production:					
Mine (ore shipments)	5,178,315	6,934,927	7,970,211	8,041,329	7,052,870
Mill (U_3O_8 content) [1]	12,570	16,420	17,760	17,399	17,010
Imports: Concentrate (U_3O_8)	16,500	18,120	15,770	12,915	11,680
Free world: Production (U_3O_8 content)	36,250	43,500	40,730	36,080	33,550

[1] Concentrate marketed.

Almost one-third of the manpower in nuclear energy work was employed by defense production facilities, another third was employed by the U.S. Atomic Energy Commission (AEC) laboratories, and the remainder was employed in miscellaneous activities, including production of feed materials and uranium milling. Nuclear reactors of various types operable in the United States at the end of 1962 totaled 190. The active U.S. Navy nuclear fleet increased to 31 vessels, and 49 others were being built. A U.S. Army gas-cooled reactor became the first mobile nuclear powerplant.

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

Foreign power-reactor projects were assisted by the joint United States-European Atomic Energy Community (Euratom) power-reactor program and by tentative arrangements for financial assistance through a funding system of the International Atomic Energy Agency (IAEA).

LEGISLATION AND GOVERNMENT REGULATIONS

Pursuant to Section 274 of the Atomic Energy Act, AEC signed agreements with four States—California, Kentucky, Mississippi, and New York—for the transfer to the States of certain regulatory authority for control of byproduct and source material and of small quantities of special nuclear material. A license for burial of low-level radioactive wastes on State-owned land was granted for the first time to a private concern.

A Labor-Management Advisory Board established in March will allow representatives of labor, management, and AEC to discuss problems related to the radiological aspects of industrial safety. In August, joint action by the Chairman of the Missile Sites Labor Commission and the Chairman of AEC created the Nevada Test and Space Site Construction Labor Board to review uneconomical labor practices and work continuity.

Three new regulations, a new section added to an old regulation, a revised regulation, and amendments to eight others were adopted by AEC and published in the Federal Register. The new regulations were "Reactor Site Criteria" (10 CFR part 100); "Dominic Nuclear Test Series, 1962" (10 CFR part 112); (27 F.R. 3989, Apr. 26, 1962), which was revoked during the year (27 F.R. 10941, Nov. 9, 1962); and "Exemptions and Continued Regulatory Authority in Agreement States Under Section 274" (10 CFR part 150). Amendments were made to "Statement of Organization, Delegations and General Information" (10 CFR part 1); "Rules of Practice" (10 CFR part 2); "Standards for Protection Against Radiation" (10 CFR part 20); "Licensing of Byproduct Material" (10 CFR part 30); "Radiation Safety Requirements for Radiographic Operations" (10 CFR part 31); "Licensing of Production and Utilization Facilities" (10 CFR part 50); "Procedures for the Review of Certain Nuclear Reactors Exempt From Licensing Requirements" (10 CFR part 115), and "Financial Protection Requirements and Indemnity Agreements" (10 CFR part 140). A major revision of 10 CFR part 2 made use of experience gained under existing rules and was expected to facilitate proceedings. The new section 30.24(m) of 10 CFR part 30 specified criteria under which tritium can be used in automobile lock illuminators.

DOMESTIC PRODUCTION

Mine Production.—The total production of over 7 million tons of uranium ore, valued at more than $138 million, was a drop of almost 1 million tons from that of 1961, the highest year in history. The leading State in production was, by far, New Mexico, followed by Wyoming, Colorado, Utah, Arizona, Washington, Texas, South Dakota, Alaska, Oregon, Idaho, North Dakota, and Montana.

Production limitations were eased on small domestic mining properties with annual production allocations of less than 20,000 pounds U_3O_8. Several private ore-buying stations were established or proposed in the Dakotas to accept ore mined and processed from uraniferous lignites by at least five mining companies in that area.

TABLE 2.—Uranium mine production in 1962, by States

State	Ore shipped		U_3O_8 content	
	Short tons	Value (thousands)	Percent	Pounds
Arizona	143,196	$3,047	0.26	735,594
Colorado	1,135,440	18,044	.21	4,705,385
New Mexico	3,478,238	63,504	.23	15,787,497
South Dakota	29,452	370	.18	104,390
Utah	781,955	23,653	.35	5,492,006
Wyoming	1,301,784	25,715	.25	6,386,210
Other States [1]	182,805	3,961	.26	960,489
Total	7,052,870	138,294	.24	34,171,571

[1] Includes Alaska, Idaho, Montana, North Dakota, Oregon, Texas, and Washington.

Mill Production.—Uranium concentrate produced by the 24 domestic ore-processing mills totaled 17,010 tons U_3O_8, compared with 17,399 tons in 1961. Under the 1962–66 AEC procurement program, which started on April 1, the established price for acceptable concentrates was $8 per pound U_3O_8. The outlook for uranium after 1966 was brightened by the announcement late in the year of a stretchout of the 1962–66 program, whereby the 22 milling companies with contracts through 1966 would be allowed to defer to the period 1967–68 a portion of the material scheduled for delivery to AEC prior to 1967. In return, during 1969–70, the Commission would purchase at fixed formulated prices U_3O_8 concentrates equal to the quantity deferred and delivered in 1967 and 1968. The mill at Gunnison, Colo., closed but a new mill in Carbon County, Wyo., started to process ore in April 1962.

Receipts of foreign U_3O_8 concentrates dropped considerably; those from Canada were cut sharply because of the stretchout agreement between AEC and Canada. Deliveries from one Australian contract were completed and final deliveries of Portuguese ore were made in April. Concentrates were received as projected from South Africa, which was scheduled to continue delivery through December 1966.

TABLE 3.—Uranium processing plants,[1] December 31, 1962

State and company	Plant location	Estimated cost of mill (thousands)	Tons U_3O_8 deliverable under contract Apr. 1, 1962–Dec. 31, 1966
Arizona:			
El Paso Natural Gas Co.[2]	Tuba City	$3,600	1,034
Colorado:			
American Metal Climax, Inc	Grand Junction	3,088	1,410
Cotter Corp	Canon City	1,800	752
Union Carbide Corp.[3]	Maybell	2,208	927
Union Carbide Nuclear Co	Rifle	8,500	[4] 5,625
Do	Uravan	5,000	
Vanadium Corporation of America [5]	Durango	813	1,781
New Mexico:			
The Anaconda Company	Grants	19,358	5,354
Homestake-Sapin Partners	do	9,000	7,495
Kermac Nuclear Fuels Corp	do	16,000	11,350
Kerr-McGee Oil Industries, Inc	Shiprock	3,161	855
Phillips Petroleum Co	Grants	9,500	6,673
South Dakota:			
Mines Development, Inc	Edgemont	1,900	1,581
Texas:			
Susquehanna Western Corp	Falls City	2,000	624
Utah:			
Atlas Corp.[6]	Moab	11,172	7,625
Texas-Zinc Minerals Co	Mexican Hat	7,000	4,204
Vitro Chemical Co	Salt Lake City	5,500	805
Washington:			
Dawn Mining Co	Ford	3,100	1,305
Wyoming:			
Federal-Radorock-Gas Hills Partners	Fremont County	3,370	1,850
Globe Mining Co	Natrona County	3,100	1,546
Petrotomics Co	Carbon County	1,500	1,579
Susquehanna-Western Corp	Riverton	3,500	1,948
Utah Construction & Mining Co	Fremont County	6,900	4,562
Western Nuclear, Inc.[5]	Jeffrey City	4,300	4,525
Total		135,370	75,410

[1] These are privately owned and operated mills licensed to buy uranium ore from producers. AEC buys the concentrate product under the terms of contracts with each mill operator. All contracts extend through December 31, 1966, except the one with Cotter Corp., which expires Feb. 28, 1965, and the one with Vitro Chemical Co., which expires Dec. 31, 1963.
[2] Formerly Rare Metals Corporation of America.
[3] Formerly Trace Elements Corp.
[4] Total for both mills.
[5] Ore upgraders were operated by Vanadium Corporation of America at Naturita, Colo., and by Western Nuclear, Inc., in Converse County, Wyo.
[6] Formerly Uranium Reduction Co.

Source: AEC Annual Report for 1962, table 1, p. 213; AEC Annual Report for 1961, table 2, p. 177.

TABLE 4.—Actual procurement record for U_3O_8 by fiscal years[1]

Fiscal year	United States		Canada		Other countries		Total, short tons
	Short tons	Percent of total	Short tons	Percent of total	Short tons	Percent of total	
1953	990	34	225	8	1,685	58	2,900
1954	1,450	31	690	15	2,550	54	4,690
1955	2,140	36	830	14	2,970	50	5,940
1956	4,200	40	1,590	15	4,650	45	10,440
1957	7,580	47	3,370	21	5,210	32	16,160
1958	10,245	39	9,475	36	6,655	25	26,375
1959	15,160	45	13,505	41	4,660	14	33,325
1960	16,565	48	13,445	39	4,570	13	34,580
1961	17,760	55	10,250	32	4,250	13	32,260
1962	17,255	59	7,730	26	4,380	15	29,365
Total	93,345	48	61,110	31	41,580	21	196,035

[1] July 1 to June 30.

Source: AEC Annual Reports, appendix 16.

Refinery Production.—Costs at the Government-owned feed-material plant operated by Mallinckrodt Chemical Works at Weldon Springs, Mo., were reduced by consolidation of refining operations. The Government-owned refinery operated by National Lead Co. at Fernald, Ohio, was placed on standby.

The greatly increased quantity of enriched uranium furnished as uranium hexafluoride (UF_6), over 97.5 percent of the total in 1962, indicates the greater role played in recent years by commercial processors of fuel. Forms other than UF_6 require further processing in AEC facilities.

TABLE 5.—Enriched uranium furnished to all sources (excluding the weapons production chain)

(Pounds) [1]

	Fiscal year				
	1958	1959	1960	1961	1962
Furnished as UF_6	52, 910	243, 170	190, 040	[2] 261, 025	276, 900
Furnished in forms other than UF_6	46, 300	13, 890	7, 500	15, 210	6, 610
Total	99, 210	257, 060	197, 540	[2] 276, 235	283, 510

[1] Converted from data in AEC Annual Report for 1962, p. 53.
[2] Corrected figure.

TABLE 6.—Employment in domestic uranium mills

Fiscal year	Number of employees	Fiscal year	Number of employees
1955	1, 840	1959	3, 185
1956	2, 059	1960	3, 535
1957	2, 413	1961	[1] 3, 850
1958	2, 857	1962	[1] 4, 300

[1] AEC Annual Report for 1961, table 7, p. 299; AEC Annual Report for 1962, table 9, p. 390.

Nine companies converted UF_6 to forms from which uranium fuel elements could be fabricated, and 17 firms were in the highly competitive fabrication field. Firms in both fields were Davison Chemical Co., Erwin, Tenn.; General Dynamics Corp., San Diego, Calif.; National Lead Co., Albany, N.Y.; Nuclear Materials & Equipment Corp., Apollo, Pa.; and United Nuclear Corp., Hematite, Mo., and New Haven, Conn.

Production of Fissionable Materials.—Two Government-owned feed materials plants—one at Oak Ridge, Tenn., operated by Union Carbide Nuclear Co. and the other at Portsmouth, Ohio, operated by Goodyear Atomic Corp.—were shut down late in 1961 and early in 1962, respectively.

AEC reviewed its activities in plutonium and assessed the possibility of allowing private processing of plutonium for peaceful uses from power reactors already in operation. Uranium hexafluoride (UF_6), for enrichment in uranium 235 (U^{235}), was produced only at the AEC plant at Paducah, Ky., and at the privately owned Allied Chemical

Corp. plant at Metropolis, Ill. Plutonium and related reactor products were produced in Government-owned production reactors operated by General Electric Co. at Richland, Wash., and by E. I. du Pont de Nemours & Co., Inc., at the Savannah River Site, Aiken, S.C.

AEC continued its gas centrifuge studies with a classified program that included development of materials, mechanical testing, and separation of heavy isotopes as uranium enrichment techniques.

Nuclear Fuel Processing.—Reprocessing of irradiated fuels from nuclear reactors, heretofore an AEC function, was to be performed by a private chemical processing plant on State-owned land near Buffalo, N.Y. The license application from Nuclear Fuel Services, Inc., indicated that construction of the plant probably would start in the spring of 1963, with the plant scheduled to operate late in 1965.

Late in 1962, AEC announced that reactor operators, under certain conditions, may transfer spent nuclear fuel elements to AEC or store them at the reactor sites. Storage at the sites would avoid reshipment from AEC processing plants in Idaho and South Carolina if the reactor operators exercise an additional option to have the fuels processed in a private facility.

CONSUMPTION AND USES

Domestic nuclear reactors operable at the end of 1962 totaled 190 and were classified as civilian, military, and production reactors.

A special AEC publication, "Civilian Nuclear Power, A Report to the President—1962", indicated that the Nation was on the threshold of economically competitive nuclear energy; emphasized the need for developing an improved converter and, later, breeder reactors, which would make even very low-grade sources of uranium and thorium economically acceptable; and cited the role of Government research in meeting long-range objectives.

Production Reactors.—Eight graphite-type reactors at Hanford, Wash., and five heavy-water-type reactors at Aiken, S.C., produced plutonium and recovered other reactor products from plant wastes. Near the end of the year, 69.5 percent of the construction and 100 percent of the reactor design on the New Production Reactor (NPR) at Hanford were complete. An authorization bill signed by President Kennedy provided that a group of public power agencies in the State of Washington would build an 800,000-kilowatt generating facility using excess steam from the NPR. Completion of the NPR would provide the United States with 20 reactors for materials production, process development, and testing.

Civilian Reactors.—Civilian reactors totaled 155—105 operable, 30 being built, and 20 planned. Costs incurred during 1962 for civilian nuclear-reactor projects under design or under construction totaled $150.7 million. Four new facilities increased the number of operable central-station, electrical prototype plants to seven with a capacity of 826,800 net kilowatts of electricity, over twice that of the preceding year. The new reactors were Indian Point Unit No. 1, Buchanan, N.Y.; Hallam Nuclear Power Facility, Sheldon Station, Hallam, Nebr.; Big Rock Nuclear Power Plant, Big Rock Point, Mich.; and Elk River Reactor, Elk River, Minn. The nuclear ship *Savannah*, using a 69,000 thermal kilowatt pressurized water reactor which delivered 22,314 horsepower to the shaft, attained a maximum speed of 24 knots during sea trials early in the year. Two new reactor concepts for nuclear merchant ship propulsion, which are compact and require no heavy secondary shield, are a pressurized water reactor, consolidated nuclear steam generator and an air-cooled, high-enrichment water-moderated nuclear steam generator.

Civilian reactors used in testing, research, and teaching totaled 114 and were composed of 86 that were operable, 12 being built, and 16 planned. Thirty-eight of the teaching reactors were in operation, 30 at colleges and universities.

TABLE 7.—Civilian reactors operable, being built, and planned in the United States in 1962

	Operable	Being built	Planned
Power reactor prototypes:			
Large central-station plants	6	5	3
Small central-station plants	1	3	
Maritime propulsion (seagoing)	1		
Experimental power reactors and reactor experiments:			
Experimental power reactors (generate electricity)	5	2	
Power reactor experiments (token electrical production, if any)	4	2	
Advanced reactor system experiments	1	4	1
Space propulsion experiments (ROVER)		(1)	(1)
Auxiliary power for space (SNAP)	1	2	
Test, research, and teaching reactors:			
General irradiation test (Government-owned)	3	1	
General irradiation test (privately owned)	1		
Special test	10		
Research	34	9	3
Teaching	38	2	13
Total	105	30	20

[1] A number of KIWI-B and NRX series reactors are expected to be tested in 1963.

Source: AEC Annual Report for 1962, appendix 7, p. 486.

Military Reactors.—Early in 1962 three U.S. Army pressurized water reactors designed for power generation in remote installations achieved criticality in Alaska, the Antarctic, and Wyoming. A gas-cooled reactor, generating 300 to 500 kilowatts and mounted on skids, became the first mobile nuclear powerplant, transportable by standard transportation methods.

Power for 31 U.S. naval units in active service was provided by 41 reactors. The Navy had 28 nuclear-powered submarines and 3 nuclear-propelled surface ships in operation. These surface ships were the aircraft carrier *Enterprise*, powered by 8 reactors, the guided-missile destroyer leader *Bainbridge*, and the cruiser *Long Beach*, each powered by 2 reactors. A total of 51 reactors will be used to power 47 submarines and 2 guided-missile destroyer leaders under construction.

Research on prototype reactors included construction by the Navy of a reactor using natural convection to recirculate cooling water even under rough weather conditions. Meanwhile the Army planned to build a more powerful mobile nuclear plant to be placed in the hull of a surplus Liberty ship and used to supply electricity to remote military installations or to disaster areas.

Reactors for Export.—Of the reactors for export, 43 were operable, 11 were being built, and 9 were planned. Thirty-seven of those in operation were for research and teaching. U.S.-built central-station electric power reactors were operable in West Germany and in Belgium, and a reactor achieved criticality as part of the proplusion system for the first British nuclear submarine.

Radioisotopes.—Record levels in production and sales were reached in 1962 as new applications for radioisotopes continued to be developed. During the first 11 months of 1962, 11,976 shipments totaling 515,637 curies valued at $2.8 million were made from Oak Ridge National Laboratory. Compared with the first 11 months of 1961, this was an increase of almost 80,000 curies and $100,000.

TABLE 8.—Military reactors operable, being built, and planned in the United States in 1962

	Operable	Being built	Planned
Defense power reactor applications:			
Electric power reactors, remote installations	4		
Propulsion reactors (naval)	41	51	
Developmental power reactors:			
Electric power reactor experiments and prototypes	3		1
Special purpose reactors (auxiliary power for space)	1		3
Naval propulsion reactor prototypes	6	1	
Aircraft propulsion reactor experiments			
Missile propulsion reactor experiments		1	
Test and research reactors:			
Test	4	1	
Research	7		1
Total	66	54	5

Source: AEC Annual Report for 1962, appendix 7, p. 486.

Shipments from Oak Ridge National Laboratory of cobalt 60 (Co^{60}) for the first 11 months of 1962 dropped considerably from those of the first 11 months of 1961. A new commercial-size plant, to open in 1963 and use Co^{60} as a catalyst in the production of ethyl bromide, was expected to increase the demand for the isotope. Shipments of strontium 90 (Sr^{90}) and of cesium 137 (Cs^{137}) increased to 256,488 curies and 120,589 curies, respectively, over shipments in a comparable period in 1961. The large increase in shipments of Sr^{90} and Cs^{137} was attributed to their use in power units at remote unmanned weather installations and in navigational buoys. Other uses for these isotopes were in medical teletherapy and process radiation. Limited quantities of two heavy-element radioisotopes were made available. These isotopes, neptunium 237 (Np^{237}) and americium 241 (Am^{241}) were used principally in neutron detection instruments and in neutron-activation analysis. The world's largest single Co^{60} source—nearly 1.3 million curies—made at Savannah River, will be used in food sterilization research at the Army Quartermaster Radiation Laboratory, Natick, Mass. The Bureau of Mines at Albany, Oreg., was testing the effects of radiation on metallurgical processes from a 100,000-curie Co^{60} source also produced at Savannah River.

Smaller quantities of Co^{60}, but still comparatively large, as well as other radioisotopes, were available from the General Electric test reactor at Pleasanton, Calif., to commercial users. Before it shut down in March 1962, the Westinghouse test reactor at Waltz Mill, Pa., also had produced and distributed large quantities of Co^{60} and other radioactive isotopes.

In the year that ended November 30, 1962, the number of byproduct-material (radioisotopes) licenses issued was slightly greater than in the preceding year. The greatest increase was recorded by Federal and State laboratories with 374 new licenses, followed by industrial firms with 354 licenses. New licenses in the field of medicine dropped to 304, and other licenses dropped to 55.

Weapons.—New nuclear weapons produced by AEC under Presidential authorization were more effective, more reliable, and safer than older weapons that were gradually being retired from the stockpile. Weapons research was performed by Sandia Corporation at Albuquerque, N. Mex., at the Los Alamos Scientific Laboratory, Los Alamos, N. Mex., and at the Lawrence Radiation Laboratory, Livermore, Calif.

AEC continued tests on weapons of low and intermediate yield at the Nevada Test Site. Only 3 of 61 tests occurred above ground. In the absence of a nuclear test ban, the United States resumed atmospheric testing in the Pacific. The first detonation was made on April 25, and the last of the 36 announced events was carried out on November 4.

Other Uses.—Research on the development of compact, dependable, lightweight, and long-lived nuclear electric-power devices for special applications was continued by AEC under the Systems for Nuclear Auxiliary Power (SNAP) program. SNAP units derived their initial power from heat supplied by radioisotope decay and nuclear fission. This heat was transformed to electrical energy by devices using thermoelectric, thermionic, and turboelectric conversion. As of November, 15 radioisotope units, primarily for use in navigational buoys, in weather stations, and in space applications, were complete, scheduled for delivery, or in design or development stages. The isotopic units had no moving parts, which was an advantage; however, they could generate only a few hundred watts of power. The generation of greater power will require the use of nuclear reactors using thermoelectric converters or turbogenerators. Near the end of 1962, four reactor units—SNAP 2, 8, 10–A, and 50—capable of generating from 0.5 up to 1,000 kilowatts for a period of 1 year were being developed for space use, including communications and ion propulsion.

The goal of cratering experiments, such as Sedan and other projects being conducted by AEC under the Plowshare program, was to achieve a refined nuclear excavation technology within 5 years. At the Nevada Test Site on July 6 a 100-kiloton thermonuclear device that detonated at a depth of 635 feet formed a crater 320 feet deep with an average diameter of 1,280 feet.

PRICES AND SPECIFICATIONS

Uranium Ore and Concentrate.—The program of guaranteed prices for ore and for individually negotiated concentrate prices expired and

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was superseded on April 1 by the 1962–66 procurement program. Through December 31, 1966, acceptable concentrates will be purchased by AEC from mills at an established price of $8 per pound U_3O_8. Table 3 indicates mills having contracts valid through 1966 to whom AEC, in November, offered a stretchout program. According to the plan, milling companies will be allowed to submit proposals deferring part of the concentrates deliverable under their present contracts to January 1, 1967, through December 31, 1968. In return, the Government will purchase a quantity equivalent to that deferred from January 1, 1969, through December 31, 1970. Prices paid for the first half of the stretchout program will be those established under present contracts; prices paid for concentrates during the second half will be fixed by a formula based on allowable production costs for the period 1963–68. During the last 2 years of the program the maximum price will be $6.70 per pound U_3O_8.

Problems faced by small domestic mine operators in mining and developing eligible properties were considered when AEC eased certain production limitations in June. Uranium mills were authorized to accept deliveries of ore from small mining operations having annual production allocations of less than 20,000 pounds of U_3O_8 in ore, irrespective of the allocations assigned to them. The maximum allowable prices were to be paid for concentrates derived from these ores.

After January 1, 1969, ore production will be permitted from any domestic source with the exception that, unless specifically exempted by prior AEC approval, ore producers or milling companies will not be permitted to produce and sell concentrates to AEC from ore derived from a mining property controlled, or formerly controlled, by other companies engaged in the program.

Uranium Metal.—The price of commercially available normal uranium metal was $24 per pound.[3]

Special Nuclear Materials.—AEC reiterated its belief that industrial production of these materials would have a sound economic basis and, accordingly, a number of specific proposals were considered. One of these bases guaranteed prices for plutonium and U^{233} on AEC estimates of their values as nuclear reactor fuels.

Base charges for enriched uranium again were revised, effective July 1. Charges were lowered from $4.99 to $4.77 per gram contained U^{235} for the 1.0 weight-percent material and from $13.65 to $12.01 per gram contained U^{235} for the 90.0 weight-percent material.

Base charges for plutonium metal and uranium 233 in the form of uranyl nitrate for research and development purposes were $12 and $15 per gram, respectively, and the base charge for plutonium metal for commercial-industrial uses was $30 per gram.

In addition to the base charges for U^{235}, U^{233}, and plutonium, there also was an annual lease charge, which was 4.75 percent of the base charge.

Depleted Uranium.—Intermediate base charges for depleted uranium furnished as UF_6 from the AEC Paducah, Ky., gaseous diffusion plant were increased up to 24 percent. Prices varied from $2.50 per

[3] American Metal Market. V. 69, No. 249, Dec. 31, 1962, p. 7.

kilogram of uranium for material assaying less than 0.38 weight-percent U^{235}, to $22.60 per kilogram for material assaying 0.7 weight-percent U^{235}. For uranium with a specified U^{235} content between 0.38 and 0.22 weight-percent, the charge was $3 per kilogram.

Uranium Concentrate Specifications.—Specifications remained essentially as shown in the chapter on uranium in Minerals Yearbook 1958. Revised specifications were expected to be released during 1963.

FOREIGN TRADE

Uranium from foreign sources in 1962 supplied 41 percent of domestic needs, compared with 43 percent in 1961. Imports totaled 11,680 tons contained U_3O_8; 7,410 tons came from Canada, 4,085 tons from South Africa, and 185 tons from Australia and Portugal under contracts of the Combined Development Agency (CDA).

Under the stretchout agreement between AEC and Canada, about 315 tons U_3O_8 scheduled for delivery in fiscal years 1962 and 1963 was deferred. Deliveries from South Australia were completed under terms of a contract which expired at the end of December 1961, and deliveries of Portuguese concentrate were completed in April. The last contract through CDA was to terminate in January 1963 but procurement from the Republic of South Africa was to continue through 1966.

Imports of radioisotopes were 10 percent more than in 1962, and were valued at $1.7 million. Canada shipped about 80 percent of the total, and the United Kingdom shipped almost 15 percent. Other suppliers, rated according to importance, were Belgium, the Netherlands, the U.S.S.R., France, West Germany, Israel and Czechoslovakia.

WORLD REVIEW [4]

Production of uranium oxide in the free world totaled 33,550 tons, a decrease of 7 percent from the 1961 production of 36,080 tons. North America provided 76 percent of the total production. The United States supplied about 2 percent less than in 1961; Canadian production dropped 13 percent.

Euratom continued to cooperate with AEC in joint U.S.-Euratom nuclear-power and associated research and development programs. The European agency sponsored more than 60 percent of the research projects at a cost of about $15 million. Euratom obtained the right, with U.S. approval, to process, convert, and fabricate in the European Economic Community (EEC) special nuclear material obtained from the United States.

As part of the safeguarding functions of IAEA, several U.S. reactors were inspected by agency representatives, and agreements were made for inspection of other U.S. reactors in the immediate future. In the field of nuclear liability 13 countries signed a Convention on Liability of Operators of Nuclear Ships presented at a diplomatic conference in Brussels. The limit of liability was raised from $70 million to $120 million by most of the signatories of the

[4] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.

liability convention of the Organization for Economic Cooperation and Development (OECD).

TABLE 9.—Free world production of uranium oxide (U_3O_8) by countries [1 2 3]

(Short tons)

Country [1]	1958	1959	1960	1961	1962
North America:					
Canada	13,403	15,892	12,748	9,641	8,431
United States	[4] 12,570	[4] 16,420	[4] 17,760	[4] 17,399	17,010
South America: Argentina [5]	19	13	7	1	1
Europe:					
Finland [5]			40	20	
France	660	955	1,185	1,767	1,656
Germany, West [5]		3	12	12	12
Spain [5]			60	55	55
Sweden	10	[5] 10	[5] 10	[5] 10	[5] 10
Africa:					
Congo, Republic of the (formerly Belgian)	2,300	2,300	1,200		
Malagasy Republic [5]	95	115	(6)	(7)	(7)
Rhodesia and Nyasaland, Federation of	50	38			
South Africa, Republic of	6,245	6,445	6,409	5,468	5,024
Oceania: Australia [5]	700	1,100	1,100	1,500	1,300
Free world total (estimate) [1 2]	36,250	43,500	40,730	36,080	33,550

[1] Uranium is also known to have been produced in Colombia, India, Italy, Japan, Morocco, Mozambique, and Portugal, but production data are not available; however, an estimate for these countries has been included in the world total.

[2] Uranium is also believed to be produced in Czechoslovakia, East Germany, Hungary, U.S.S.R., and other Soviet bloc countries; however, production data are not available, and no estimate for these countries has been included in the world total. Estimates of production for the Soviet bloc countries range from 10,000 to 20,000 tons per year.

[3] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

[4] Data represent deliveries to AEC. Includes uranium production from phosphate rock in Eastern United States.

[5] Estimate.

[6] Madagascar included with France.

[7] Madagascar and Gabon included with France.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

NORTH AMERICA

Canada.—The long-awaited uranium purchase contract, which provided for deliveries between Canada and the United Kingdom until early in 1970, was signed. A stretchout agreement called for purchase by the United Kingdom Atomic Energy Authority (UKAEA) from Eldorado Mining and Refining Ltd., of 12,000 short tons of uranium oxide at an average price of Can$5.03 a ton. To defray any possible rise in cost levels, an escalation clause was included and a premium was offered for deferred deliveries.[5]

Mexico.—Commercially usable uranium from uranium oxides, ores, and compounds was to be extracted at Mexico's first experimental refining plant.[6] Ore reserves were said to total approximately 700,000 tons, averaging 0.14 percent uranium oxide.[7]

SOUTH AMERICA

Brazil.—An Argonaut-type reactor, to be used for training and educating scientists in all fields of nuclear energy, was being built in

[5] Mining Journal (London). V. 259, No. 6624, Aug. 3, 1962, p. 113.
[6] Mining Journal (London). V. 259, No. 6632, Sept. 28, 1962, p. 293.
[7] Engineering and Mining Journal. V. 163, No. 8, August 1962, p. 180.

Brazil and was to be under the supervision of the newly created Institute of Nuclear Engineering. Enriched uranium, supplied by the United States, was to be used as fuel for the reactor that was to be located on the coast a few miles south of Rio de Janeiro.[8]

EUROPE

Within the next 20 years, it was predicted, the European nations will need a new source of energy, unless imports of conventional fuels are greatly expanded. To fill this need nuclear energy was considered the most practical source. Two reports, among others, which dealt with Europe's future electrical needs were the Robinson report, prepared by the Organization for European Economic Co-operation (OEEC), and the Euratom report. The first dealt with all Western Europe; the second, with the European Economic Community.

Assuming that European economic growth for the next 15 years would be at the same rate as that of the past decade, OEEC predicted an increase in total energy needs of 25 to 30 percent between 1955 and 1965, and it estimated an increase of 58 to 83 percent above the 1955 figure by 1975. However, in recent years, the use of electrical energy had exceeded the growth rate for all energy by an average of 6.2 percent. On this basis, using the total electrical energy produced in 1955 (385 billion kilowatt-hours), the Robinson report predicted a need for 700 billion kilowatt-hours in 1965 and 1,200 billion in 1975. The 1950–60 average yearly growth of EEC industrial production was 5.5 percent. A 5-percent increase for 1961–70 and a 4-percent increase for 1971–80 were predicted. These rates of increase indicated a need for 950 billion kilowatt-hours of electrical energy in 1980 by EEC.[9]

France.—Pierrelatte near Marcoule in the Rhone Valley was chosen as the site for construction of a large new uranium processing plant. The proposed complex was to cost at least 200 million French francs (about $40 million) and would consist of several plants for uranium isotopes separation, as well as other nuclear installations.[10]

A nuclear power program, aimed at an 850 megawatt installed capacity by 1965, was initiated by Électricité de France. Natural uraium, graphite-moderated reactors for use in the program were being built at Chinon in the Loire Valley.[11]

Germany, West.—The upper Black Forest area of southern Germany was reported to contain the most important deposit of uranium, in the form of pitchblende, yet found in the Federal Republic of Germany. Gewerkschaft Brunhilde, financed by the Federal and Baden-Württemberg Governments, was to examine the deposit.[12]

One of Central Europe's largest nuclear power plants, a 250,000-kilowatt boiling-water reactor station, was to be erected near Gundremmingen in southern Germany. Production of electricity was expected in 1966. Rheinisch Westfälisches Elektrizitätswerk and

[8] Bureau of Mines. Mineral Trade Notes. V. 54, No. 5, May 1962, pp. 43–44.
[9] Battelle Technical Review. V. 11, No. 9, September 1962, pp. 14–18.
[10] Chemical Trade Journal and Chemical Engineer (London). V. 151, No. 3918, July 6, 1962, p. 38.
[11] Battelle Technical Review. V. 11, No. 6, June 1962, p. 255a.
[12] Mining Journal (London). V. 259, No. 6634, Oct. 12, 1962, p. 343.

Bayernwerk A. G., two of West Germany's largest utility companies, ordered the plant from International General Electric Company of New York. Atomic Power Equipment Department, General Electric Co. in San Jose, Calif., was commissioned to design and build the reactor as well as associated equipment and to provide the first fuel load for the station. Allgemeine Elektrizitäts Gesellschaft (AEG) was to provide all architectural services, including plant erection, and was to design and provide the turbine generator and associated auxiliaries.[13]

Gesellschaft für Kernenergieverwertung in Schiffbau und Schiffahrt m.b.H. (Society for the Application of Nuclear Energy in Shipbuilding and Shipping Ltd.), which was composed of 33 German industrial and financial interests, undertook the building of the world's second nuclear-powered merchant ship. Primarily an experimental vessel for investigating the operation of a nuclear ship-propulsion unit and such problems as safety, collision protection, and economy, the ore carrier was to be capable of refueling without the aid of a second ship. A completely removable reactor would permit testing of more than one type of nuclear powerplant. At 10,000 shaft horsepower output, the fully loaded, 520-foot vessel was expected to make an experimental speed of 15.75 knots. Provision was made for a number of laboratories and working spaces and for a complement of 60 and 53 scientists and engineers. Completion of the vessel was slated for 1967.[14]

Hungary.—Soviet experts planned the installation of at least three atomic power plants and numerous subsidiary industries, such as metal working and chemical concentration plants, in the uranium producing areas of Kövágószöllös, Tótvár, and Bakonya. A stepped-up delivery of radioisotopes to the U.S.S.R. was expected to result from the expansion program.[15]

Italy.—At Latina, near Rome, Italy's first commercial nuclear power station went critical. The station used a natural uranium, graphite-moderated reactor cooled with carbon dioxide, and was expected to provide 200 megawatts of electricty by spring of 1963.

Criticality of a nearly completed 150-megawatt, boiling water reactor near the Garigliano River was expected in February or March 1963. The 257-megawatt, pressurized water reactor near Torino also was expected to go critical in 1963.[16]

A $29 million sales contract for delivery, over a 20-year period, of enriched uranium to Euratom was signed by AEC. The fuel was to be used for the 150-electrical-megawatt Società Elettronucleare Nazionale (SENN) power reactor near Rome.[17]

Some 34,750 pounds of U^{235} in the form of UF_6 was shipped from the Oak Ridge gaseous diffusion plant of AEC. Processed at Erwin, Tenn., for reduction to uranium oxide, and fabricated into fuel elements at Cheswick, Pa., the material constituted part of the fuel

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13 Engineering News Record. V. 169, No. 22, Nov. 29, 1962, p. 49.
14 New Scientist (London). V. 16, No. 317, Dec. 13, 1962, pp. 635–636.
15 Mining Record. V. 73, No. 20, May 17, 1962, pp. 1, 4.
16 Chemical & Engineering News. V. 41, No. 1, Jan. 7, 1963, p. 47.
17 Chemical & Engineering News. V. 40, No. 50, Dec. 10, 1962, p. 19.

requirements of the 165,000-electrical-kilowatt pressurized water reactor for Società Elettronucleare Italiana (SELNI) near Milan.[18]

Sweden.—Construction of an estimated 50 million kroner ($9,650,000) uranium extraction plant was begun at Ranstad, near Skövde. Planned for completion in 1964, the plant would produce 126 tons of uranium concentrate annually from the Billingen uranium-bearing shale, which is 3.6 meters (11.8 feet) thick and lies 13 meters (42.6 feet) under an overburden of earth, limestone, and barren shale. It was estimated that 1.5 million cubic meters (nearly 2 million cubic yards) of topsoil and rock would have to be removed annually to extract approximately 850,000 tons of shale. Mined by dragline excavator, the shale was to be transported by 20-ton trucks through a 500-meter (1,640 feet) tunnel, then crushed, concentrated by flotation, ground to minus 3 millimeters, and finally treated with sulfuric acid. The Billingen shale deposits were considered to be the world's largest source of uranium, but the average uranium content is lower than that of other deposits.[19]

Switzerland.—Government and private industry representatives convened to discuss exploitation of recently discovered uranium deposits in the region between the Emme and Ilfis Rivers in the canton of Berne.[20]

United Kingdom.—At Dounreay (Scotland), the world's largest fast nuclear reactor went on stream in its third test. Although contributing only 3 megawatts to the National Electricity Grid, its significance lay in the fact that such a prototype for commercial power had reached so advanced a stage. The Dounreay plant cost £25 million ($70 million) to build and was fueled with 46-percent enriched uranium, with a liquid sodium-potassium (Na-K) coolant system. It was planned to raise the present 30-megawatt heat output to 60 megawatts.[21]

A proposal by the National Institute for Research in Nuclear Science to build a new laboratory was approved by the British Government. The £3.5 million ($9.8 million) installation, to be built at Daresbury in North Cheshire, will house a 4 billion electron volt synchrotron and serve as a research center for university physicists.[22]

With operation scheduled for late 1966, construction began on Britain's eighth nuclear-power generating plant. The 550,000-kilowatt station, in Oldbury, Gloucestershire, was to have graphite cores encased in prestressed concrete pressure vessels. Contracts were awarded for an 800,000-kilowatt station at Wylfa Head, Wales.[23] This station, too, was to have prestressed concrete pressure vessels for its two reactors.[24]

Bradwell (Essex) and Berkeley (Gloucestershire), the first nuclear energy stations designed expressly for power, began producing electricity.[25]

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[18] American Metal Market. V. 69, No. 243, Dec. 20, 1962, p. 12.
[19] Bureau of Mines. Mineral Trade Notes. V. 54, No. 4, April 1962, pp. 27–28.
[20] Bureau of Mines. Mineral Trade Notes. V. 54, No. 5, May 1962, pp. 44–45.
[21] Mining Magazine. V. 108, No. 1, January 1963, pp. 34–35.
[22] United Kingdom Atomic Energy Authority (London) press releases, AE/20/62, July 25, 1962, and AE/29/62 Oct. 24, 1962.
[23] Engineering News-Record. V. 169, No. 3, July 19, 1962, p. 50.
[24] New Scientist (London). V. 14, No. 292, June 21, 1962, p. 641.
[25] New Scientist (London). V. 14, No. 292, June 21, 1962, p. 640.

Yugoslavia.—Yugoslavia's first uranium metal manufacturing plant was under construction in the Stara Planina hills near Nis.[26]

Transfer of $33,000 worth of uranium for use in an IAEA research project in Yugoslavia was approved by AEC. Included in the transfer would be 13,000 grams of 20-percent enriched uranium and 5 grams of 90-percent enriched uranium, which would provide fuel for the U.S.-made Triga Mark II research reactor at the Josef Stefan Institute near Ljubljana.[27]

ASIA

India.—The Indian Government contracted with International General Electric Co. of New York for construction of a 380-megawatt nuclear power station at Tarapur, about 100 miles from Bombay.[28] The plant, using enriched uranium, was scheduled for completion in 1966. A second atomic power plant, with a 200-megawatt capacity, was to be built at Rana Pratap Sagar.[29]

A bill, introduced by the Indian Government, would give the Government acquisition, upon payment of compensation, of any newly discovered uranium or thorium from which uranium or any of its isotopes could be obtained.[30] The Department of Atomic Energy, after making radiometric surveys and field investigations, reported high radioactivity at Chhinjra in the Parbati Valley in Kulu. A seam of radioactive coal, about 1 mile long, was revealed in the Gara Hills district of Assam along the Ronju River. In Madras, high radioactivity was recorded in an area off the Manavalakurichi coast.[31]

Iran.—Announcement was made by the Iranian Government of the discovery of uranium deposits near Khawaja-Marad in Khorassan province.[32]

Japan.—Sale by AEC of 4,700 kilograms of enriched uranium was made to Japan. Costing approximately $1 million, the material was intended as initial fuel for the 12 megawatt Japan Power Demonstration Reactor under construction at the Japan Atomic Energy Research Institute at Tokai-mura, about 70 miles from Tokyo. Scheduled for completion in 1963, it would be the first operating power reactor in Asia.[33]

Korea, Republic of.—The first atomic reactor of the self-regulating TRIGA type began operation at the Government's new $1 million nuclear research center near Seoul.[34]

Thailand.—The Government requested IAEA to survey the country's power needs and potential. The economic feasibility of introducing nuclear power, after studying the power needs and alternative power sources of a conventional nature, was to be considered.[35]

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[26] Mining Journal (London). V. 258, No. 6616, June 8, 1962, p. 596.
[27] Mining Engineering. V. 14, No. 3, March 1962, p. 14.
[28] Chemical Trade Journal and Chemical Engineer (London). V. 151, No. 3931, Oct. 5, 1962, p. 687.
[29] Nuclear India. V. 1, No. 4, February 1963, p. 2.
[30] Mining Journal. V. 259, No. 6630, Sept. 14, 1962, p. 244.
[31] Foreign Trade (Ottawa). V. 118, No. 5, Sept. 8, 1962, p. 17.
[32] Mining Journal (London). V. 259, No. 6624, Aug. 3, 1962, p. 109.
[33] Mining Record. V. 73, No. 51, Dec. 20, 1962, p. 2.
[34] Chemical and Process Engineering and Atomic World. V. 43, No. 6, June 1962, p. 303.
[35] Chemistry and Industry (London). No. 50, Dec. 15, 1962, p. 2096.

AFRICA

Congo, Republic of the.—Under an agreement between AEC and IAEA, the United States was to supply the Republic of the Congo with 1,000 grams of 20-percent enriched uranium and 5.5 grams of 90-percent enriched uranium for supplemental fuel loading of the 50-kilowatt research and training reactor at the University of Lovanium at Leopoldville.[36] Two other agreements were concluded: One was an overall project agreement between IAEA and the Republic of the Congo, and the other was a trilateral contract involving IAEA, the Republic of the Congo, and Belgium.[37]

Gabon Republic.—During the first half of 1962, Gabon produced 355 tons of uranium concentrate.[38] A uranium extraction plant and a companion sulfuric acid plant were under construction by Compagnie de Mines d'Uranium de Franceville.[39]

South Africa, Republic of.—The first major nuclear reactor in South Africa and laboratories for chemistry and metallurgical research were under construction at Pelindaba, 15 miles west of Pretoria. The site is near three universities, is surrounded by rivers, and is easily accessible to uranium mines. The station, which would produce isotopes, was designed in two sections to allow cheaper removal of radioactive particles from the air. The "hot" section was to house the reactor itself and the chemical and metallurgical laboratories. The "cold" section was for physics and engineering laboratories. A whole-body counter, which would allow sensitive quantitative and qualitative determinations of radioactivity to be made, was to be installed primarily to determine routinely the internal contamination of National Nuclear Research Centre workers.[40]

OCEANIA

Australia.—At the end of February the Port Pirie uranium mill ceased operation. Before February 1962 concentrate from the Government-owned Radium Hill mine in South Australia had been converted to oxide at this plant. In the Northern Territory, South Alligator Uranium N.L., which completed its contract with the United Kingdom Atomic Energy Authority, treated high-grade stockpiled ore at its Rockhole Creek plant until late in 1962.[41]

It was announced that extensive drilling and underground development in 1961 had established existence of a new ore-body at Rum Jungle Creek South that contained 600,000 tons of pitchblende ore averaging 0.3 percent U_3O_8.[42] Although the current contract for uranium with the Combined Development Agency was scheduled to expire early in 1963, it was stated that production at Rum Jungle would be continued after January 1963. The reasons for this were

[36] American Metal Market. V. 69, No. 134, July 13, 1962, p. 13.
[37] Mining Record. V. 73, No. 42, Oct. 18, 1962, p. 1.
[38] Mining Journal (London). V. 259, No. 6642, Dec. 7, 1962, p. 548.
[39] Sulphur Institute News. V. 2, No. 6, June 1962, p. 3.
[40] South African Mining and Engineering Journal. V. 73, pt. 2, No. 3636, Oct. 12, 1962, p. 827.
[41] Australia, Bureau of Mineral Resources, Geology and Geophysics. The Australian Mineral Industry. Part 1—Quarterly Review. V. 15, No. 1, September 1962, p. 23.
[42] Investors' Guardian (London). V. 199, No. 6229, June 29, 1962, p. 1529 (incorporating Mining World and Engineering Record, v. 178, No. 4570).

the financial success of the operation, managed by Territory Enterprises Pty., Ltd., and the contribution made by the operation to the development of the Northern Territory during the past 10 years.[43] Chemical treatment of the uranium ore and, if necessary, other ores would be accomplished at the Rum Jungle milling facilities.

The Mary Kathleen mine in northwest Queensland, the largest Australian producer, was referred to as the lowest cost uranium producer in the world.[44] Despite this, the contract with the British Government for 4,500 tons of uranium concentrate was scheduled to end at the close of 1963. Although 1962 production was greater than that in 1961, the operator, Conzinc Rio Tinto of Australia Ltd., announced that continuation of operations would depend largely upon procurement of new uranium contracts.[45]

On the assumption that Australian producers, like their Canadian counterparts, had amortized their capital investment in plant and equipment, it was indicated that the Australian companies remaining in production would be able to compete with Canada in the sale of uranium oxide, in spite of the large supply held by the United Kingdom.[46]

ANTARCTICA

The 1,500-kilowatt nuclear power plant at McMurdo Sound went critical in March and made its first contribution to the electric power supply at the U.S. Naval Air Facility in July. The prefabricated plant was assembled in less than 3 months and provided five times as much electric power as was previously supplied by diesel generators.[47]

TECHNOLOGY

The bulk of U.S. uranium reserves occur in continental sediments. Isotopic studies of sulfides in the sandstone-type ores suggested they were formed by precipitation by hydrogen sulfide resulting from reduction of sulfate by sulfate-reducing bacteria. Uranium in salt-dome structures and in fractures transecting permeable carbonaceous sediments, oxidation of black uranium-vanadium ores, and formation of carnotite-type deposits were discussed.[48] Economically available uranium occurs most commonly in the outermost zones of certain mineralized centers in the Western Hemisphere Cordillera. Pipelike bodies of hydrothermally altered rocks are characterized by intensity-temperature-pressure gradients decreasing outwardly. Determination of the position of zones around these mineralized districts may allow selection of the most promising localized areas for examination.[49]

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[43] Page 1528 of work cited in footnote 42.
[44] Queensland Government Mining Journal (Australia). V. 63, No. 729, July 1962, p. 336.
[45] Investors' Guardian (London). V. 200, No. 6254, Dec. 21, 1962, p. 1504 (incorporating Mining World and Engineering Record, v. 180, No. 4595).
[46] Investors' Guardian (London). V. 200, No. 6241, Sept. 21, 1962, p. 714 (incorporating Mining World and Engineering Record, v. 179, No. 4582).
[47] Science News Letter. V. 82, No. 4, July 28, 1962, p. 63.
[48] Adler, Hans H. The Genesis of Uranium Ores. AEC Div. of Raw Materials, March 1962, 2 pp.
[49] Gabelman, John W. Application of Hydrothermal Zoning to Uranium Exploration. Trans. Soc. Min. Eng., v. 223, No. 4, December 1962, pp. 406–411.

Host rock sandstones were evaluated in their relationship to the distribution and composition of Colorado Plateau uranium deposits. An abundance of carbonaceous material and volcanic ash as well as channel-type sandstone bodies characteristically are present in these rocks.[50] Locations of actual and potential domestic raw-material sources of uranium were shown on a new map. These deposits contained at least 0.01 percent U_3O_8; few uranium-bearing pegmatites and no uranium-bearing phosphatic rocks or black shales were included.[51]

Bureau of Mines research on uranium and radioactive materials included a study of methods for disposing of mill solutions containing dissolved radionuclides, a radioisotope study of carbide and sulfide phases in steel, construction of a low-cost incinerator for solid burnable wastes of low-level radioactivity, and investigation of a simple, reasonably accurate spot-check method for estimating daily exposure to radiation in mines.[52] Cooperative research was conducted between the Bureau of Mines and AEC on the use of depleted uranium in certain alloys.[53]

A number of articles appeared on means for detecting radioactive fallout and radiation. The National Bureau of Standards completed an improved radioactive fallout predictor which can compute fallout expected from a single blast of known characteristics.[54] An air monitor of high sensitivity and capable of discriminating between uranium and plutonium was developed. The success of this instrument was attributable to silicon surface-barrier detectors, which were able to resolve energies due to alpha particles emitted by the various radioactive elements concerned.[55]

Methods similar to those used in the heap leaching of copper sulfide ores were used to recover uranium rapidly from Portuguese and Australian ores. Bacterial action assists oxidation of reagent pyrite to release ferric iron rapidly at low pH. Particularly suitable for handling local ores below cutoff grade for plant treatment, some of the more amenable ores yielded about 80 percent of their uranium in 20 weeks under relatively mild conditions.[56] Mineral beneficiation procedures using flotation and high-tension separation techniques

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[50] Miesch, A. T. Composition of Sandstone Host Rocks of Uranium Deposits. Trans. Soc. Min. Eng., v. 233, No. 2, June 1962, pp. 178–184.

[51] Butler, A. P., Jr., W. I. Finch, and W. S. Twenhofel. Epigenetic Uranium in the United States (Exclusive of Alaska and Hawaii). Geol. Survey, Miner. Inv. Res. Map MR–21, 1962.

[52] Bates, R. C., and R. L. Rock. Estimating Daily Exposures of Underground Uranium Miners to Airborne Radon-Daughter Products. BuMines Rept. of Inv. 6106, 1962, 22 pp.

Cochran, A. A., and J. W. Jensen. Autoradiography of Carbon and Sulfur in Titanium Steels. BuMines Rept. of Inv. 6122, 1962, 17 pp.

Corey, R. C., and C. H. Schwartz. Incinerator for Solid Combustible Wastes Containing Low-Level Radioactivity. BuMines Rept. of Inv. 6083, 1962, 38 pp.

Tame, K. E., E. G. Valdez, and J. B. Rosenbaum. Disposal of Radioactive Waste in the Vitro-Type Uranium Milling Flowsheet. BuMines Rept. of Inv. 6011, 1962, 10 pp.

Tame, K. E., E. G. Valdez, and J. B. Rosenbaum. Radioactive Waste Disposal in the Shiprock-Type Uranium Milling Flowsheet. BuMines Rept. of Inv. 6045, 1962, 9 pp.

[53] Higley, L. W. Use of Depleted Uranium in Bearing Metals and Low-Alloy Steels. Final Metallurgical Report for the Period of April 1, 1959, to June 30, 1962, prepared by the Bureau of Mines for the U.S. Atomic Energy Commission. AEC Rept. TID–8212, November 1962, 39 pp.

[54] National Bureau of Standards. Radioactive Fallout Predictor. Tech. News Bull., v. 46, No. 7, July 1962, pp. 87–89.

[55] AEI Engineering (London). A Monitor for Uranium and Plutonium in the Air. V. 2, No. 6, November–December 1962, pp. 309–311.

[56] Miller, R. P., Elizabeth Napier, R. A. Wells, A. Audsley, and G. R. Daborn. Natural Leaching of Uranium Ores. Trans. Inst. Min. and Met., v. 72, pt. 4, 1962–63, pp. 217–254.

were described.[57] Two solvent-extraction systems were devised in England to reprocess enriched uranium. These new systems using improved mixer-settlers have 100 times the throughput capacity of the Dounreay enriched uranium plant.[58] Uranium recovery of 99.5 percent was achieved by differential extraction. Pilot-plant studies led to recovery of U^{235} from an aqueous solution containing nitric and sulfuric acids.[59] Uranium was separated effectively from iron, molybdenum, columbium, zirconium, and chromium by a single equilibration in a fused salt oxidation-reduction method, largely by control of zinc chloride additions which selectively oxidize and additions of magnesium which selectively reduce various combinations of the components in the original solute.[60]

The need for new, rapid analytical methods led to development of improved techniques for use on metals, compounds, gases, and in process control. A method using uranium metal of known purity as a primary standard was used to assay uranium and its alloys.[61] The magnesium content in uranium was determined spectrophotometrically after solvent extraction of the uranium.[62] Instruments were designed by the United Kingdom Atomic Energy Authority to monitor the uranium production process, thereby insuring high-purity standards. A continuous recording of the uranium content in process solutions was made by instruments that also separate, evaluate, and correct for the radiation due to isotopes resulting from radioactive decay of U^{238}.[63] Very small quantities of carbon were determined in uranium tetrafluoride by infrared spectrophotometry.[64] In order to determine extremely short-lived fission gases from a gas stream rapidly and cheaply, a stainless-steel trap containing a negatively charged rod was developed. The positively charged daughter products from gas decay were collected on the rod which then was assayed by gamma spectrometry.[65]

The growing importance of uranium dioxide as a nuclear fuel led to increased efforts to produce single crystals of the oxide with a nearly perfect homogeneous structure. Crystals of the oxide, which resist

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[57] Light, D. E., C. A. Freitag, G. B. Hudson, and E. J. Nurse. The Flotation of Radioactive Minerals, II. Canadian Min. and Met. Bull., v. 55, No. 597, January 1962, pp. 30–34; Battelle Tech. Rev. v. 11, No. 5, May 1962, p. 219a.
Madhaven, T. R., and K. K. Majumdar. Flotation of a Low-Grade Uranium Ore From Keruadungri, S. Bihar. Min. Mag. (London), v. 107, No. 1, July 1962, pp. 11–14.
Vijaykar, S. V., and K. K. Majumdar. The Behaviour of Some Commonly-Occurring Uranium Minerals in High-Tension Separation. Min. Mag. (London), v. 107, No. 1, July 1962, pp. 9–11.

[58] Chemical Engineering. Two Ways Found to Hike Enriched-Uranium Output. V. 69, No. 14, July 9, 1962, p. 98.

[59] Chemical Engineering. Differential extraction may win nuclear reprocessing role. V. 69, No. 15, July 23, 1962, pp. 53, 55.

[60] Chiotti, Premo, and Sidney J. S. Parry. Separation of Various Components From Uranium by Oxidation-Reduction Reactions in a Liquid Potassium Chloride-Lithium Chloride-Zinc System. J. Less-Common Metals (Amsterdam), v. 4, No. 4, August 1962, pp. 315–337.

[61] Duckitt, J. A., and G. C. Goode. A Method for High-Precision Assay of Uranium Metal. Analyst (Cambridge, England), v. 87, No. 1031, February 1962, pp. 121–124.

[62] Athavale, V. T., R. L. Bhasin, and B. L. Jangida. Spectrophotometric Determination of Magnesium in Uranium. Analyst (Cambridge, England), v. 87, No. 1032, March 1962, pp. 217–219.

[63] South African Mining and Engineering Journal (Johannesburg). Improved Uranium Analysis. V. 73, pt. 2, No. 3623, July 13, 1962, p. 91.

[64] Simons, R. E., and M. H. Randolph. Determination of Micro Amounts of Carbon in Uranium Tetrafluoride. Anal. Chem., v. 34, No. 9, August 1962, pp. 1119–1122.

[65] Battelle Technical Review. Determining Fission Gases. V. 11, No. 4, April 1962, p. 3.

irradiation and high-temperature reactor water better than does the metal, were produced by sublimation.[66]

Uranium metal was protected from corrosion in gaseous and aqueous media by a nickel coating applied from the vapor phase by nickel-carbonyl decomposition. Good covering power and absence of water in the carbonyl plating process apparently contribute to its superiority over electrodepositional methods.[67] It was believed that elimination of hydrogen from uranium, creating more ductility at room temperature, might permit cold fabrication with consequent prevention of oxidation. Presence of a trace quantity of an impurity hydride was suggested as the cause of embrittlement.[68]

Plutonium research included studies of self-irradiation deterioration of the lattice structures of plutonium compounds, development of a new semicontinuous anion exchange method for large scale concentration and purification of crude plutonium obtained from spent nuclear fuel, and heat treatment studies of plutonium metal.[69] Equilibrium studies showed very sluggish transformations between plutonium allotropes, which may indicate near equality of stability of these phrases.[70]

A general review of irradiation effects on metals discussed the aspects of electron and deuteron bombardment, compared lattice and macroscopic expansion, and indicated promising avenues for future research.[71] A similar paper reported how irradiation can affect surface chemical reactions by changing catalysis effects and the rates of absorption and desorption.[72] The need to develop more radiation-resistant materials for special purposes, including prolonged space missions, was explained.[73]

Properties of uranium compounds and processing techniques were investigated as nuclear reactors of high operating temperatures were considered for space propulsion. Room temperature, gaseous hydrolysis products from uranium carbides are similar to those resulting from the hydrolysis of the carbides of thorium and plutonium and consist mostly of methane, ethane, and other alkanes.[74] The advantages of uranium nitride over uranium oxide and carbide as a nuclear fuel were enumerated. Uranium nitride has higher thermal conductivity, greater uranium density, more compatibility with cladding materials, is more easily fabricated, and is easier to handle than the carbide.[75] The melting point of uranium nitride was redetermined to

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[66] New Scientist (London). Belgium. Single Crystals of UO_2. V. 16, No. 308, Oct. 11, 1962, p. 95.

[67] Owen, L. W. Protective Coatings for Uranium. J. Less-Common Metals (Amsterdam), v. 4, No. 1, February 1962, pp. 35–39.

[68] Owen, L. W. Effect of Hydrogen on Mechanical Properties of Uranium. Metallurgia (Manchester, England), v. 66, No. 393, July 1962, pp. 3–6.

[69] New Scientist (London). Plutonium Expands as It Decays. V. 15, No. 301, Aug. 23, 1962, p. 420. Chemical Engineering. New Finesse Wins Favor in Plutonium Processing. V. 69, No. 7, Apr. 2, 1962, pp. 44, 46. Gardner, H. R. The Heat Treatment of Plutonium. Trans. AIME, Met. Soc., v. 224, No. 2, April 1962, pp. 358–366.

[70] Hill, J. D. Exploring the Transformation Behaviour of the Allotropes of Plutonium. J. Less-Common Metals (Amsterdam), v. 4, No. 4, August 1962, pp. 376–386.

[71] Seitz, Frederick. The Effects of Irradiation on Metals. Science, v. 138, No. 3540, Nov. 2, 1962, pp. 563–571.

[72] Cropper, William H. Radiation Effects on the Reactivity of Solid Surfaces. Science, v. 137, No. 3534, Sept. 21, 1962, pp. 955–961.

[73] Chemical Week. Zeroing in on Radiation. V. 90, No. 23, June 9, 1962, pp. 93–94.

[74] Kempter, C. P. Hydrolysis Properties of Uranium Monocarbide and Dicarbide. J. Less-Common Metals (Amsterdam), v. 4, No. 5, October 1962, pp. 419–425.

[75] American Metal Market. Uranium Nitride's Advantage as Atomic Fuel Cited by Battelle's Keller. V. 70, No. 1, Jan. 2, 1963, p. 13.

be about 2,850° C, roughly 200° higher than previously reported. A nitrogen pressure of at least 2.9 atmospheres was necessary to prevent decomposition, a phenomenon which earlier workers may have mistaken for melting.[76] A high density for uranium mononitride was achieved by gas pressure bonding at 2,700° F and 10,000 pounds per square inch and ranged up to 96 percent of theoretical density. It was not possible to attain this density when using powder compaction processes. Uranium monocarbide and uranium dioxide were densified to about 99 percent of theoretical density. All three compounds developed at lower temperatures than in the sintering process have finer grain size and more uniform structure.[77] Meanwhile it was shown that steam sintering of uranium dioxide is more effective than hydrogen sintering. Sintering times and temperatures were lowered considerably.[78]

A new aluminum-steel alloy, possible forerunner of materials better suited than stainless steel for use as a uranium fuel container because of its greater resistance to high temperature oxidizing gaseous atmospheres, was announced by the French Commissariat à l'Energie Atomique.[79] Stainless steel containing dispersed uranium dioxide particles was found to have a lower coefficient of thermal expansion than the steel alone.[80]

The U.S. Army developed a method for casting 20-millimeter spotting rounds from depleted uranium. Compared with the 6,000° F melting point of tungsten, another heavy metal of relatively high cost, depleted uranium can be melted and cast at 2,350° F.[81]

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[76] Chemical and Engineering News. Uranium Nitride's Melting Point Revised Upward. V. 40, No. 31, July 30, 1962, p. 56.

[77] Paprocki, S. J., E. S. Hodge, and P. J. Gripshover. Obtain Perfect Metallurgical Bonds With—Gas Pressure Bonding. Materials in Design Eng., v. 55, No. 3, March 1962, p. 15.

[78] Baily, W. E., J. C. Danko, H. M. Ferrari, and R. Colombo. Steam Sintering of Uranium Dioxide. Am. Ceram. Soc. Bull., v. 41, No. 11, November 1962, pp. 768–772.

[79] Steel and Coal (London). Aluminium-steel Alloy Developed for Nuclear Reactors. V. 185, No. 4916, Oct. 5, 1962, p. 659.

[80] Kalish, H. S., and F. B. Litton. Thermal Expansion of Stainless Steel UO_2 Dispersion-Type Nuclear Fuel Plates. Materials Res. and Standards, v. 2, No. 8, August 1962, pp. 638–639.

[81] Industrial and Engineering Chemistry. V. 54, No. 3, March 1962, p. 7.

Vanadium

By Richard F. Stevens, Jr.[1] and Huguette A. Lizotte [2]

THE YEAR 1962 marked a substantial change in the vanadium industry. Production of vanadium pentoxide in the United States decreased 38 percent although world production remained about the same as in 1961. U.S. consumption, however, increased approximately 15 percent. The greatest single reason for decreased domestic production was the decreased output of uranium ores from which vanadium was obtained as a byproduct.

TABLE 1.—Salient vanadium statistics

(Short tons of contained vanadium)

	1953–57 (average)	1958	1959	1960	1961	1962
United States:						
Production:						
Ore and concentrate processed	5,483	6,829	8,026	8,800	6,772	7,602
Recoverable vanadium [1]	3,385	3,030	3,719	4,971	5,343	5,233
Value ... thous.	(2)	$10,817	$13,278	$17,748	$19,076	$18,682
Vanadium pentoxide	3,375	2,791	4,092	5,495	5,817	3,586
Imports:						
Ore and concentrate	129		3	3		
Exports:						
Ferrovanadium and other vanadium alloying materials containing over 6 percent vanadium (gross weight)	128	76	152	162	120	201
Vanadium pentoxide vanadic oxide, vanadium oxide, and vanadates	464	631	1,240	3,690	2,081	1,009
World: Production	4,189	4,235	5,321	7,090	8,871	8,350

[1] Measured by receipts at mills.
[2] Figure withheld to avoid disclosing individual company confidential data.

LEGISLATION AND GOVERNMENT PROGRAMS

On July 6, 1962, the General Services Administration (GSA) invited bids for the purchase of 65,447 pounds of ferrovanadium authorized for disposal by the Congress.[3] On August 13, GSA announced that no acceptable bids had been received and that offers for purchase of the ferrovanadium on a negotiated basis would be considered.[4] Subsequently, a contract was executed with Vanadium Corporation

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.
[3] GSA News Release. GSA 1727, July 6, 1962.
[4] GSA News Release. GSA 1766, Aug. 13, 1962.

of America providing for the conversion of vanadium concentrates to ferrovanadium; payment was made in aluminum.[5]

The Supreme Court upheld the right of Continental Ore Co. to seek civil antitrust damages from Union Carbide Corp. and Vanadium Corporation of America. A new trial was ordered in the legal action which began in 1945. Continental claimed that Union Carbide and Vanadium Corp. conspired to eliminate it from the vanadium industry.[6]

The U.S. Atomic Energy Commission (AEC) announced uranium procurement plans for the period 1967–70. AEC did not propose to purchase more uranium during this period but rather to "stretch out" the uranium contracts which had been scheduled to terminate in 1966. The effect of this AEC policy was a noticeable decline in the production of vanadium pentoxide obtained as a byproduct of uranium mining operations.

DOMESTIC PRODUCTION

Most of the vanadium produced domestically was obtained as a byproduct of uranium mining. Susquehanna-Minerals Co. produced vanadium pentoxide (V_2O_5) from impure ferrophosphorus supplied by FMC Corp. as a waste material from FMC's phosphorus operations. Susquehanna-Minerals received a preconcentrated slag containing 15 to 16 percent V_2O_5. The vanadium pentoxide was produced from this concentrate by salt-roasting, leaching, and stripping from solution by solvent extraction. The operation was shut down in May and Minerals Engineering Co. subsequently filed suit in Federal Court against both Susquehanna-Western Corp. and the parent organization, the Susquehanna Corp., Chicago, Ill., claiming Sherman antitrust violations.

A plant designed to recover V_2O_5 from impure ferrophosphorus was under construction by Kermac Nuclear Fuels Corp., a subsidiary of Kerr-McGee Oil Industries, Inc., near Soda Springs, Idaho. Monsanto Chemical Corp. and Chemical Farmers Fertilizers Co., Soda Springs, Idaho, contracted to supply the raw material for the plant. Expected plant capacity was reported to be 750 tons of V_2O_5 per year.

Vitro Chemical Co., Salt Lake City, Utah, announced plans for a ferrophosphorus processing plant to recover the equivalent of 3 million pounds of V_2O_5 per year in the form of vanadium pentoxide, ammonium metavanadate, and other vanadium compounds. During the year Vitro conducted pilot plant operations to develop methods of extracting vanadium from unconcentrated ferrophosphorus.[7]

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[5] Office of Emergency Planning. Stockpile Report to the Congress. January–June 1962, p. 11.

[6] American Metal Market. Continental Ore Wins Ruling on Vanadium Case. V. 69, No. 122 June 26, 1962, pp. 1, 4.

[7] Mining Record. Vitro Chemical Planning Vanadium Manufacturing. V. 74, No. 11, Mar. 14, 1963, p. 1.

TABLE 2.—Recoverable vanadium in ore and concentrate produced in the United States, by States

(Short tons of contained vanadium)

State	1953–57 (average)	1958	1959	1960	1961	1962
Colorado	2,550	2,395	2,949	4,026	4,149	3,742
Utah	407	376	536	462	514	525
Arizona and other States [1]	428	259	234	483	680	966
Total	3,385	3,030	3,719	4,971	5,343	5,233

[1] Includes Idaho, 1953–54, 1961–62; Montana, 1957; New Mexico, 1953–54, 1956–62; South Dakota, 1954, 1960–62; Wyoming, 1954, 1956–58, 1960–62; California, 1962; Maryland, 1962; New Jersey, 1962, and Pennsylvania, 1962.

TABLE 3.—Vanadium and recoverable vanadium [1] in ore and concentrate produced in the United States

(Short tons)

Year	Mine production	Recoverable vanadium	Year	Mine production	Recoverable vanadium
1953–57 (average)	5,497	3,385	1960	8,047	4,971
1958	7,266	3,030	1961	6,359	5,343
1959	7,392	3,719	1962	7,647	5,233

[1] Measured by receipts at mills.

Oxide.—Domestic production of vanadium pentoxide decreased 38 percent compared with that of 1961. Six plants produced vanadium pentoxide from domestic uranium-vanadium ores. Two plants were being constructed or altered to produce vanadium pentoxide from ferrophosphorus. Data in table 4 include vanadium pentoxide produced as a byproduct of foreign chromium ores, 1953–62; produced from Peruvian concentrate, 1953–55; produced as a byproduct of domestic phosphate rock, 1953–54; and produced from impure ferrophosphorus, 1961–62.

Ferrovanadium.—Ferrovanadium was produced in the United States principally by Vanadium Corporation of America, Union Carbide Metals Co., and Shieldalloy Corp., a subsidiary of Metallurg, Inc. Production of ferrovanadium was about 16 percent more than that in 1961.

Vanadium Metal.—High-purity vanadium metal (99 percent plus) was produced by Vanadium Corporation of America, Union Carbide Metals Co., and Oregon Metallurgical Corp. The industry reported output of 6.5 tons of high purity vanadium which was slightly less than the quantity produced in 1961.

TABLE 4.—Production of vanadium pentoxide in the United States[1]

(Short tons)

Year	Gross weight	V_2O_5 content	Year	Gross weight	V_2O_5 content
1953-57 (average)	6,810	6,027	1960	10,767	9,812
1958	5,470	4,983	1961	10,796	[2] 10,387
1959	7,906	7,305	1962	6,876	6,403

[1] Includes a relatively small quantity recovered as a byproduct of Peruvian concentrate and foreign chromium ore.
[2] Revised figure.

CONSUMPTION AND USES

Ores and Concentrates.—Domestic and foreign vanadium-bearing ores and concentrates consumed at domestic plants contained 7,602 tons of vanadium, 830 tons or 12 percent more than was in the ores and concentrates processed in 1961.

Alloys and Compounds.—Consumption of ferrovanadium reported by domestic industry increased 15 percent, after a 3-year period of little change. The ferroalloy and steel industries reported increases of 43 percent in the use of vanadium in high-speed steel, 40 percent in hot-work tool steel, 10 percent in other tool steel, 8 percent in other alloy steel, 23 percent in iron casting, and 200 percent in carbon steel, compared with its use in 1961. The other alloy steel category may not be precise since steelmakers do not always classify their products the same way. The only decrease in the use of vanadium reported by steelmakers in 1962 was 32 percent in stainless steel. Vanadium reported consumed by the chemical industry was 41 percent more than that reported in 1961.

Catalyst and Chemicals, Inc., Louisville, Ky., obtained an exclusive license to manufacture and sell a new vanadium catalyst developed by Genie Metallurgique et Chimique, S.A. for use in the production of sulfuric acid; its optimum operating temperature is 900° F.[8]

TABLE 5.—Vanadium consumed and in stock in the United States in 1962, by forms

(Short tons of vanadium)

Form	Stocks at consumer plants, Dec. 31, 1961	Consumption	Stocks at consumer plants, Dec. 31, 1962
Ferrovanadium	262	1,710	267
Oxide	[1] 20	165	20
Ammonium metavanadate	17	126	31
Other	68	313	63
Total	[1] 367	2,314	381

[1] Revised figure.

[8] Chemical & Engineering News, V. 40, No. 48, Nov. 26, 1962, p. 59.

TABLE 6.—Vanadium consumed in the United States in 1962, by uses

Use	Short tons	Use	Short tons
Steel:		Steel—Continued:	
High-speed	394	Gray and malleable castings	21
Hot-work tool	111	Nonferrous alloys	235
Other tool	75	Chemicals	163
Stainless	19	Other	45
Other alloy [1]	1,103		
Carbon	148	Total	[2] 2,314

[1] Includes some vanadium used in high-speed or other tool steels not specified by reporting firms.
[2] Represents approximately 90 percent of total consumption.

STOCKS

The Bureau of Mines does not obtain data on the inventory of vanadium ore, concentrate, or pentoxide held at primary producers' plants. Consumer stocks on December 31, 1962, were 4 percent more than on December 31, 1961.

The National (strategic) stockpile inventory on December 31, 1962, was 7,865 short tons of stockpile grade vanadium, 28 short tons of nonstockpile grade vanadium, and 1,001 short tons of vanadium contained in ferrovanadium.

PRICES

The prices of vanadium concentrate, vanadium pentoxide, ferrovanadium, vanadium metal (90 percent), and high purity vanadium metal (99 plus percent) remained constant during 1962.

Vanadium pentoxide contained in ore was quoted at 31 cents per pound. Technical grade (fused) vanadium pentoxide was quoted at $1.38 per pound of contained V_2O_5. The price of ferrovanadium ranged from $3.20 to $3.45 per pound of contained vanadium. Vanadium metal (90 percent purity) for alloying was quoted at $3.45 per pound, in 100-pound lots. High-purity vanadium metal (over 99 percent vanadium) was quoted at $30 to $37 per pound, in 1,000-pound lots.

FOREIGN TRADE [9]

Imports of vanadic acid and vanadium compounds increased three times over those of 1961. Ferrovanadium totaling 175,877 pounds was imported; 55 percent came from Belgium-Luxembourg, 28 percent from Sweden, and 17 percent from West Germany. No ferrovanadium was imported in 1961.

Exports of ferrovanadium reached a new high and were 68 percent more than those in 1961. Steel and ferroalloy industries of Canada received 99 percent of the total. Exports of vanadium oxides were about half those of 1961 as competition continued to develop from foreign producers, principally South-West Africa and the Republic of South Africa. All vanadium produced by these countries was exported to Europe.

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

Shipments of vanadium oxides to Japan were 63 percent less than those in 1961, whereas shipments of vanadium ores were 23 percent more. Shipments of vanadium oxides to Italy decreased 73 percent and shipments of vanadium ores increased six times. Shipments of vanadium oxides to Austria increased 10 percent, the only increased export of vanadium oxides reported.

TABLE 7.—U.S. exports of vanadium, by countries

(Pounds)

Destination	Ferrovanadium and other vanadium alloying materials containing over 6 percent vanadium (gross weight)		Vanadium ore, concentrates, pentoxide, vanadic ox de, vanadium oxide, and vanadates (except chemically pure grade) (vanadium content)		Vanadium flue dust and other vanadium waste materials (vanadium content)	
	1961	1962	1961	1962	1961	1962
North America:						
Canada	230,503	398,523	15,689	22,625		
Mexico	500		5,208	1,736		
Total	231,003	398,523	20,897	24,361		
South America:						
Argentina	278		100	633		
Brazil			4,964	5,650		
Chile			246	246		
Colombia				493		
Venezuela		2,000				
Total	278	2,000	5,310	7,022		
Europe:						
Austria			249,091	153,889		
Belgium-Luxembourg			1,080,864	681,724	38,391	13,776
Czechoslovakia			54,661			
France	1,675		455,150	253,977		
Germany, West	928		438,806	187,534	10,080	
Italy			143,638	71,090		
Netherlands	43		409,614	265,448	135,427	119,746
Norway	600					
Portugal				2,469		
Spain			410			
Sweden	331		86,244			
Trieste			37,240			
United Kingdom	567	252	223,631			29,904
Total	4,144	252	3,179,349	1,616,131	183,898	163,426
Asia:						
Hong Kong	144			432		
India			1,286	956		
Indonesia		93				
Japan	660		955,136	369,767	425	
Pakistan	1,120			288		
Philippines	2,000					
Thailand		1,100				
Viet-Nam	200					
Total	4,124	1,193	956,422	371,443	425	
Grand total:						
Quantity	239,549	401,968	4,161,978	2,018,957	184,323	163,426
Value	$436,208	$745,912	[1]$7,659,955	$2,960,705	$29,077	$23,527

[1] Revised figure.

Source: Bureau of the Census.

WORLD REVIEW

Australia.—Manganore Pty., Ltd., an Australian subsidiary of Union Carbide Corp., was granted seven exclusive vanadium and iron reserves by the State government of Western Australia. Vanadium-bearing magnetite ores were discovered by geologists near Southern Cross. The vanadium content of the ores in these reserves was reported to be less than 1 percent. A 2-year development program of mapping, diamond drilling, and shaft sinking was begun to determine the extent and limits of the reserves.[10]

Belgium.—M & R Refractory Metals, Inc., Springfield, N.J., signed a long-term licensing agreement with Société Anonyme d'Applications de Chimie Industrielle (SADACI), a Belgian ferroalloy manufacturer. SADACI was granted the exclusive European rights to certain processes developed by M & R relating to the manufacture of ferrovanadium, ferrotungsten, and ferromolybdenum. Reportedly, the processes offered greatly improved economics in ferroalloy production, while yielding products of higher purity.[11]

Table 8.—World production of vanadium in ores and concentrates, by countries [1]

(Short tons)

Country	1953–57 (average)	1958	1959	1960	1961	1962
North America: United States (recoverable vanadium)	[2] 3,385	3,030	3,719	4,971	5,343	5,233
South America:						
Argentina	(3)	4	4	(4)	(4)	(4)
Peru (content of concentrate)	130					
Europe: Finland	[5] 166	430	556	625	701	[6] 705
Africa:						
Angola	[7] 9	20	3			
Rhodesia and Nyasaland, Federation of: Northern Rhodesia (recovered vanadium)					260	
South Africa, Republic of	[8] 8	316	320	656	1,422	1,393
South-West Africa (recoverable vanadium)	491	435	719	838	1,145	1,019
World total (estimate)[1] [9]	4,189	4,235	5,321	7,090	8,871	8,350

1 This table incorporates some revisions.
2 Includes vanadium recovered as a byproduct of phosphate-rock mining, 1953–54.
3 Less than 1 ton.
4 Data not available.
5 Average annual production 1956–57.
6 Estimate.
7 Average annual production 1955–57.
8 One year only, as 1957 was the first year of commercial production.
9 Total represents data only for countries shown in table and excludes vanadium in ores produced in Republic of the Congo (formerly Belgian), Mexico, Morocco, Norway, Spain, and U.S.S.R., for which figures are not available; the table also excludes quantities of vanadium recovered as byproducts from other ores and raw materials.

Compiled by Kathleen W. McNulty, Division of Foreign Activities.

Germany, East.—Hoyerswerda, a chemical plant at Lauta, announced the development of a new method of extracting vanadium pentoxide (95 percent purity) from bauxite ore as a byproduct of alumina processing.[12]

10 Mining World. Union Carbide Explores Australian Vanadium. V. 24, No. 1, January 1962, p. 61.
11 American Metal Market. M & R Refractory Metals Licenses Belgium Ferroalloy Producer. V. 70, No. 40, Feb. 28, 1963, p. 14.
12 Mining Journal (London). V. 260, No. 6652, Feb. 15, 1963, p. 162.

South Africa, Republic of.—Transvaal Vanadium Corp., the vanadium producing subsidiary of Anglo-American Corporation of South Africa, Ltd., began producing vanadium from an open-pit magnetite mine in November. The ore contained about 2 percent vanadium. Magnetite reserves were estimated to be at least 12 million tons.[13]

Highveld Development Co., Ltd., a subsidiary of Anglo-American Corporation of South Africa, Ltd., operated a steel pilot plant in Witbank to develop methods of recovering vanadium as a byproduct from magnetite and at the same time prevent contamination of the steel by vanadium.[14]

South-West Africa.—South-West Africa Co., Ltd., a British-controlled company under the technical management of Gold Fields of South Africa, Ltd., produced vanadium from complex lead-zinc-vanadium concentrate at its Berg Ankas mine, about 10 miles north of Grootfontein.[15]

United Arab Republic (Egypt).—Vanadium was discovered in coal dust at Oyoun Moussa, about 32 miles south of Suez in the Sinai Peninsula.[16]

TECHNOLOGY

The Bureau of Mines continued its research on the production and utilization of vanadium and vanadium alloys of both commercial and high purity grades. Vanadium reserves, resources, production, properties, and utilization were discussed in a special Bureau report.[17]

Bureau metallurgists investigated methods of upgrading commercial red cake and recovering vanadium pentoxide from uranium-vanadium mill solution.[18] The simplest and best procedure for converting red cake containing about 10 percent combined sodium and potassium oxides into a 98 to 99 percent vanadium pentoxide product was found to be a metathesis in an ammoniacal solution of ammonium sulfate; molybdenum also was removed by this procedure.

Other scientists determined and evaluated the properties of pure vanadium metal. They discovered that hardness could be used as an approximate measure of tensile strength; also, that hardness could be used as a measure of the ductility and hence of the purity of vanadium metal. Tests proved that the malleability or rollability of high-purity vanadium metal was dependent upon the total content of oxygen, nitrogen, and carbon.[19] The division between rollable and nonrollable material appeared to be at a concentration of these three impurities totaling about 2,600 parts per million.

The properties of vanadium-hafnium alloys also were determined. Additions of small quantities of hafnium reduced as-cast hardness and electrical resistivity, impaired rollability, and increased oxidation

[13] U.S. Embassy, Johannesberg, Republic of South Africa. State Department Dispatch A-331, Mar. 12, 1963.
[14] U.S. Embassy, Johannesberg, Republic of South Africa. State Department Dispatch A-323, Mar. 6, 1963.
[15] U.S. Embassy, Johannesberg, Republic of South Africa. State Department Dispatch 498, June 28, 1962.
[16] U.S. Embassy, Cairo, United Arab Republic (Egypt). State Department Dispatch A-527, Jan. 5, 1963.
[17] Busch, P. M. Vanadium, A Materials Survey. BuMines Inf. Circ. 8060, 1961, 95 pp.
[18] Chindgren, C. J., L. C. Bauerle, and J. B. Rosenbaum. Preparing Metal-Grade Vanadium Oxide From Red Cake and Mill Solutions. BuMines Rept. of Inv. 5937, 1962, 14 pp.
[19] Lincoln, R. L., G. Asai, and H. Kato. Some Properties of Vanadium. BuMines Rept. of Inv. 5975, 1962, 33 pp.

resistance and tensile strength. Large additions of hafnium caused greater as-cast hardness, increased electrical resistivity, further impaired rollability, increased oxidation resistance, and decreased tensile strength. The main disadvantage of vanadium-hafnium alloys was in fabrication.[20]

Columbium-vanadium (Cb-V) alloys also were investigated by Bureau researchers. These alloys showed promise for use at elevated temperatures. Test results indicated that a columbium alloy containing 10 atomic percent vanadium had optimum properties. The strength and hardness values of the Cb-V alloys tested increased with vanadium content, reaching a maximum at 50 atomic percent vanadium. The investigation indicated that Cb-V alloys have good machinability, good workability, high strength, good ductility, and good oxidation resistance at 600° C.[21]

Chemical and galvanic corrosion tests disclosed that vanadium metal is resistant to corrosion in substitute ocean water, tap water, 3 percent sodium chloride, and 10-percent sodium hydroxide solutions at 35° C. Vanadium is relatively resistant to corrosion in all concentrations of sulfuric, hydrochloric, and phosphoric acid solutions at 35° C. and is almost inert in 10-percent formic, acetic, citric, lactic, and tartaric acids. In contrast with other metals, vanadium is protected galvanically by magnesium. Because of this, vanadium was being considered for use as a structural material in chemical industries. However, vanadium corrodes rapidly in dilute nitric acid, 20-percent ferric chloride, and cupric chloride solutions.[22]

Bureau scientists also determined the thermodynamic properties of various vanadium compounds. In one investigation the heats and free energies of formation were determined for calcium and magnesium vanadates.[23] The data indicated that the calcium and magnesium vanadates were stable during all decompositions in which vanadium remained pentavalent.

Thermodynamic data on magnesium metavanadates, magnesium pyrovanadates, and calcium vanadates were published.[24]

Silicide-base coatings on tantalum-columbium-vanadium alloys were found to have exceptional oxidation resistance at all temperatures in the range of 1,200 to 2,700° F in tests made at the Batelle Memorial Institute.[25]

At Armour Research Foundation tests showed that flame-sprayed nickel coatings were self-healing on defects up to 0.005 inch wide. When flame-sprayed on vanadium-columbium alloys, nickel forms an intermetallic compound with an outer glassy phase when exposed to

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[20] Lincoln, R. L., and H. Kato. Effects of Hafnium Additions on Properties of Vanadium. BuMines Rept. of Inv. 5949, 1962, 17 pp.

[21] Babitzke, H. R., G. Asai, and H. Kato. Columbium-Vanadium Binary Alloys for High-Temperature Service. BuMines Rept. of Inv. 5987, 1962, 19 pp.

[22] Kenahan, C. B., D. Schlain, and W. L. Acherman. Chemical and Galvanic Corrosion Properties of High-Purity Vanadium. BuMines Rept. of Inv. 5990, 1962, 22 pp.

[23] King, E. G., M. F. Koehler, and L. H. Adami. Heats and Free Energies of Formation of Calcium and Magnesium Vanadates. BuMines Rept. of Inv. 6049, 1962, 11 pp.

[24] Weller, W. W., and E. G. King. Low-Temperature Heat Capacities and Entropies at 298.15° K of Magnesium Metavandate and Three Calcium Vanadates. BuMines Rept. of Inv. 6130, 1962, 5 pp.

King, E. G., and W .W. Weller. Low-Temperature Heat Capacities and Entropies at 298.15° K of Three Calcium Vanadates. BuMines Rept. of Inv. 5954, 1962, 6 pp.

[25] Klopp, W. D., C. F. Powell, D. J. Maykuth, and H. R. Ogden. Development of Protective Coatings for Tantalum-Base Alloys. Air Force Systems Command, Aeronautical Systems Division, Rept. ASD-TR-61-676, March 1962, 98 pp.

elevated temperature. Nickel coatings protected vanadium-1 titanium-60 columbium alloys for 45 hours in air at 2,200° F, and for more than 150 hours at 2,000° F.[26]

Investigators at Armour also studied vanadium-columbium alloys for use at elevated temperatures.[27] Vanadium-5 titanium-20 columbium (V-5Ti-20Cb) and vanadium-60 columbium alloys exhibited excellent weldability and fabricability; both alloys had good strength retention to at least 2,200° F. Exposure to a salt solution under stress at 800 and 1,000° F did not impair mechanical properties of the V-5Ti-20Cb alloy.

The mechanical properties of titanium-aluminum-vanadium alloys at cryogenic temperatures were investigated.[28]

Vanadium-containing iron piston rings were said to wear better against the harder cylinder bores and resist high-temperature corrosion better than rings previously used.[29]

Nuclear radio-release techniques for tracing surface water employed nonradioactive vanadate ions as the tracer material.[30] The vanadate ion released radioactive silver–110 to give a sensitivity for detecting one part vanadium in more than 10^7 parts of water. When the silver–110 has a specific activity of 1 millicurie per gram, 0.1 parts per million vanadate can be determined with ease.

An analyzer to monitor the vanadium content in refinery process streams was developed by Gulf Oil Corp. and Varian Associates.[31] Using this monitoring system the refinery cracking catalyst was kept free of metallic poisons.

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[26] Rausch, J. J., and F. C. Holtz. High-Temperature Oxidation Protective Coatings for Vanadium-Base Alloys. Armour Res. Foundation, Rept. ARF 2227–5, May 8, 1962, 30 pp.

[27] Rajala, B. R., and F. C. Holtz, Improved Vanadium-Base Alloys, Armour Research Foundation, Rept. ARF 2210–6, Dec. 20, 1961, 38 pp.

[28] Hickey, C. F., Jr., Mechanical Properties of Titanium and Aluminum Alloys at Cryogenic Temperatures. Watertown Arsenal Laboratories. Rept. WAL TR 340.2/1, March 1962, 37 pp.

[29] Dunne, J. Automotive Uses of Ferrous Metals. Automotive Industries, v. 128, No. 1, Jan. 1, 1963, p. 47.

[30] Gillespie, A. S., Jr., and H. G. Richter. A Radio-Release Technique for Tracing Surface Water. Trans. Am. Nuclear Soc., v. 5, No. 2, November 1962, p. 273.

[31] Chemical Engineering. V. 69, No. 20, Oct. 1, 1962, p. 35.

Vermiculite

By John W. Hartwell [1] and Nan C. Jensen [2]

CONSUMPTION of vermiculite in the United States during 1962 increased 1 percent over that in 1961. Domestic crude production remained about the same.

TABLE 1.—Salient vermiculite production statistics

	1953–57 (average)	1958	1959	1960	1961	1962
United States:						
Production:						
Crude......thousand short tons..	193	191	207	199	206	205
Average value........per ton..	$13.30	$14.28	$14.89	$15.62	$16.26	$16.06
Exfoliated..thousand short tons..	[1] 156	155	153	151	151	152
Average value........per ton..	$64.73	$63.13	$62.69	$68.25	$71.44	$73.37
World: Production, crude thousand short tons..	246	246	261	269	279	293

[1] Average 1954–57.

DOMESTIC PRODUCTION

Crude Vermiculite.—Five producers reported an output of over 205,000 short tons of crude vermiculite. Three companies produced the major quantity: Zonolite Co., Libby, Mont., and Lanford, S.C.; Patterson Vermiculite Co., Enoree, S.C.; and American Vermiculite Co., Woodruff, S.C.

Zonolite Co., Chicago, Ill., leased all-aluminum railroad hopper cars from the Union Tank Car Co. for hauling crude vermiculite to processing plants throughout the United States. The capacity of each car was 4,000 cubic feet.

Exfoliated Vermiculite.—Twenty-six companies with 52 plants in 34 States produced 152,000 tons of exfoliated vermiculite, a 1-percent increase over 1961 production. The average value per ton increased $1.93, resulting in a 3-percent gain in value to $11,152,000.

At the 21st annual meeting of the vermiculite producers in association with the Vermiculite Institute, a new use for expanded vermiculite was as a growing medium for grass seed planted between two layers of burlap. It was reported at this meeting that the market for

[1] Commodity specialist, Division of Minerals.
[2] Supervisory statistical assistant, Division of Minerals.

vermiculite as a carrier for herbicides, insecticides, and pesticides continues to grow, as does its use as masonry fill.

The Food and Drug Administration approved limited use of vermiculite, sold by Zonolite Co. under a new trade name, for animal feeds.

TABLE 2.—Screened and cleaned domestic crude vermiculite sold or used by producers in the United States

(Thousand short tons and thousand dollars)

Year	Quantity	Value	Year	Quantity	Value
1953–57 (average)	193	$2,566	1960	199	$3,108
1958	191	2,728	1961	206	3,350
1959	207	3,082	1962	205	3,293

TABLE 3.—Exfoliated vermiculite sold or used by producers in the United States

Year	Operators	Plants	States	Thousand short tons	Value (thousands)
1954–57 (average) [1]	27	53	34	156	$10,098
1958	25	51	35	155	9,785
1959	25	52	34	153	9,591
1960	27	53	34	151	10,305
1961	28	56	35	151	10,787
1962	26	52	34	152	11,152

[1] Data not compiled before 1954.

CONSUMPTION AND USES

Although many companies failed to report the uses for their exfoliated vermiculite products, available data indicated that the quantities in acoustical uses, fireproofing, and building plaster remained about the same as in 1961. The quantities of vermiculite used for insulation and agriculture and as a carrier for herbicides, fungicides, and fumigants increased, while the quantities for miscellaneous uses (such as insulation for pipes, stoves, refrigerators, and safes) decreased.

PRICES

E&MJ Metal and Mineral Markets quoted nominal yearend prices for crude vermiculite as follows: Per short ton, f.o.b. mines, Montana, $9.50 to $18; and South Africa, c.i.f. Atlantic ports, $24.75 to $38.50.

The average mine value of all domestic crude vermiculite sold or used was $16.06 per ton, compared with $16.26 in 1961.

The average value of all exfoliated vermiculite, f.o.b. processors' plants, was $73.37 per ton, compared with $71.44 in 1961.

FOREIGN TRADE

Crude vermiculite was imported into the United States duty free. The Republic of South Africa continued to be virtually the only source of imports. Nearly 16 percent of the South African exports went to the United States, but the quantity was 6 percent less than in 1961, or a decrease of 815 tons.

WORLD REVIEW [3]

The United States and the Republic of South Africa produced nearly all vermiculite used in the free world. Some vermiculite was produced in the U.S.S.R., but data were not available.

TABLE 4.—Free world production of vermiculite, by countries [1] [2]

(Short tons)

Country [1]	1953-57 (average)	1958	1959	1960	1961	1962
Argentina	740	161	[3] 880	[3] 880	[3] 880	[3] 880
Australia	7					
India	236		2	17	1	410
Kenya	359	96	112	283		
Morocco	[4] 147					
Rhodesia and Nyasaland, Federation of:						
Southern Rhodesia	153	280	50			
South Africa, Republic of	51,659	54,314	52,398	69,022	71,118	85,534
Sudan		[3] 130	[3] 130		55	[3] 55
Tanganyika		91	125	20	157	
United Arab Republic (Egypt)	29	302	331	132		
United States (sold or used by producers)	193,146	190,564	206,579	199,072	206,637	205,747
Free world total [1] [2]	246,476	245,938	260,607	269,426	278,848	292,626

[1] Vermiculite is produced in Brazil, but data are not available, and no estimates of the production are included in the total.
[2] This table incorporates some revisions.
[3] Estimate.
[4] One year only, as 1957 was the first year of commercial production.

Compiled by Liela S. Price, Division of Foreign Activities.

Canada.—Information on vermiculite occurrences in Ontario and methods of mining, processing, and marketing were presented. Uses and specifications for exfoliated vermiculite and competitive materials were also described.[4]

Grant Industries, Ltd., plant at Regina, Saskatchewan, produced exfoliated vermiculite.[5]

Sudan.—Vermiculite production of 55 tons valued at over $1,000 was reported for 1962 by the Sudanese Geological Survey Department.[6]

United Kingdom.—The vermiculite-distributing company, Mandoval Ltd., acquired a new research and development plant at Godalming, Surrey. This company was under the management of the Rio Tinto Mining Group.[7]

[3] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.
[4] Guillet, G. R. Vermiculite in Ontario With an Appendix on Perlite. Ontario Dept. of Mines, Ind. Miner. Rept. No. 7, 1962, 39 pp.
[5] Precambrian-Mining in Canada (Winnipeg, Canada). Unique Operations at Grant Industries, Regina. V. 35, No. 11, November 1962, pp. 34–35.
[6] U.S. Embassy, Khartoum, Sudan. State Department Airgram A-310, Apr. 25, 1963, p. 1.
[7] Chemical Age (London). New Vermiculite Research Premises for Mandoval. V. 87, No. 2217, Jan. 6, 1962, p. 7.

TABLE 5.—Republic of South Africa: Exports of crude vermiculite, by countries [1]

(Short tons)

Destination	1961	1962
North America:		
Canada	2,593	2,917
Mexico	111	120
Puerto Rico	151	166
United States	12,913	12,098
Europe:		
Austria	123	186
Belgium	971	457
Denmark	857	761
Finland	201	145
France	9,133	7,513
Germany, West	7,239	7,815
Italy	11,154	12,029
Netherlands	1,330	501
Spain	389	829
Sweden	431	436
Switzerland	206	239
United Kingdom	18,813	26,250
Asia:		
Iraq	87	190
Israel	124	42
Japan	989	875
Kuwait	334	317
Africa:		
Algeria	376	124
Morocco	52	110
Rhodesia and Nyasaland, Federation of	168	100
Oceania: Australia	1,911	2,046
Other countries	407	631
Total	71,063	76,897
Total value [2]	$1,328,250	$1,458,708
Average value	$18.69	$18.97

[1] This table incorporates some revisions.
[2] Converted to U.S. currency at the rate of 1 rand equals US$1.3957 (1961) and US$1.3987 (1962).

Source: Compiled from Quarterly Information Circular on Minerals for the Republic of South Africa and the Territory of South-West Africa, by Bertha M. Duggan, Division of Foreign Activities.

TECHNOLOGY

Sources of vermiculite in the Spruce Pine district of North Carolina were described.[8]

Underwriters' Laboratories awarded five new fire ratings to vermiculite protection for structural steel. These ratings included plaster on metal lath and coatings for the underside of formed steel floors, columns, beams, girders, and trusses.[9]

Limitations and advantages of compounds used as solid lubricants in metalworking equipment were discussed. One advantage of vermiculite for use as a solid lubricant was its heat resistance up to 1,000° C.[10]

A heat-resistant paint containing vermiculite was developed by a Japanese company. It was claimed that the paint would resist temperatures up to 1,832° F and that it was also an insulation against noise.[11]

[8] Brobst, Donald A. Geology of the Spruce Pine District, Avery, Mitchell, and Yancey Counties, North Carolina. Geol. Survey Bull. 1122–A, 1962, 26 pp.
[9] Rock Products. Vermiculite Achieves New UL Fire Ratings. V. 65, No. 3, March 1962, p. 65.
[10] Smith, E. A. Solid Lubricants in Metalworking. Metal Ind. (London), v. 101, No. 8, Aug. 24, 1962, pp. 149–150.
[11] Oil, Paint and Drug Reporter. Vermiculite Is the Basis of New Japanese Paint. V. 182, No. 1, July 2, 1962, p. 30.

The influence of calcination on the ion-exchange capacity of vermiculite for strontium was reported. Indications were that the capacity remained practically unchanged when vermiculite was heated to 600° C, but after complete dehydration the capacity was almost zero.[12]

Vermiculite had become increasingly important as an insulating refractory material up to 2,000° F. Refractory companies perfected unusual insulating shapes containing vermiculite and solved many problems in the low-temperature field. The history of development and the future possibilities for vermiculite uses in cryogenics were reported.[13]

A report was issued on the second series of tests to explore the potential of high-air-content lightweight concrete with a low-strength aggregate as a shock mitigator or insulator. The cushioning characteristics of lightweight vermiculite concrete were presented as acceleration-time and stress-strain curves. The effect of impact velocity and material thickness on the cushioning properties were shown. The measurement technique was a variation of a drop-test facility for determining the properties of cushioning materials. The impact energy was provided by a projectile fired from an air gun, instead of by a free-falling mass.[14]

A lightweight brick was made using vermiculite, clay, and water,[15] and a lightweight structural block had a similar composition.[16]

Phosphate slimes were treated with an organic foaming agent and exfoliated vermiculite to accelerate drying. The dry product was impervious to water and could be used as a nonabsorptive lightweight aggregate.[17]

Several processes for making materials with vermiculite as an ingredient were patented: A sprayable fireproof insulating composition suitable for application to metal surfaces,[18] metal or metal alloy products containing lightweight aggregate,[19] a composition for insulating board,[20] and flame-resistant compositions.[21]

Vermiculite was exfoliated after treatment with a saturated solution of sodium chloride or other suitable electrolyte.[22]

Unexfoliated vermiculite in an alkaline-modified silicon carbide-base composition was suggested for use in the production of gray iron.[23]

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[12] Bagretsov, V. F., V. V. Pushkarev, A. R. Beketov, and V. M. Nikolaev. (Effect of Calcination on the Ion-Exchange Capacity of Vermiculite.) Zhur. Prikladnoi Khimii, v. 34, No. 11, November 1961, pp. 2558–2560.

[13] Harder, Paul B. Vermiculite—Key to Unusual Insulating Refractory Shapes. Ceram. Age, v. 78, No. 3, March 1962, pp. 26–28.

[14] Shield, Richard, Ervin S. Perry, E. A. Ripperger, and J. Neils Thompson. Shock Mitigation With Lightweight Vermiculite Concrete. Univ. Texas, Structural Mech. Res. Lab., Austin, Tex., DASA–1263, February 1962, 53 pp.

[15] Robinson, G. C. (assigned to Zonolite Co., Chicago, Ill.). Method of Making Refractory Clay Products. U.S. Pat. 3,030,218, Apr. 17, 1962.

[16] Jones, O. M. (assigned to Vermiculite Mfg. Co., Seattle, Wash.). Brick Package and Method of Making Same. U.S. Pat. 3,015,192, Jan. 2, 1962.

[17] Bradt, H. A. Process for Separation of Liquid From Liquid-Solid Mixtures of Fine Solid Particle Size. U.S. Pat. 3,053,761, Sept. 11, 1962.

[18] Sefton, R. C. (assigned to Steel City Industries, Inc.). Insulating Coating Comprising Polyvinyl Alcohol, Asbestos, Cement, and Aggregate. U.S. Pat. 3,042,681, July 3, 1962.

[19] Kreigh, J. R., and J. K. Gibson. Metal Aggregate Product. U.S. Pat. 3,055,763, Sept. 25, 1962.

[20] Kingsbury, J. C. Insulating Composition. U.S. Pat. 3,051,624, Jan. 2, 1962.

[21] Doedens, J. D. (assigned to the Dow Chemical Co., Midland, Mich.). Flame Resistant Poly(Diphenyl)-Type Compositions. U.S. Pat. 3,038,871, June 12, 1962.

[22] Hayes, J. C. (assigned to Zonolite Co., Chicago, Ill.). Method of Exfoliating Vermiculite. U.S. Pat. 3,062,753, Nov. 6, 1962.

[23] Drenning, J. F. (assigned to The Carborundum Co., Niagara Falls, N.Y.). Composition for Metallurgical Use and Process of Using the Same. U.S. Pat. 3,051,564, Aug. 28, 1962.

Four British patents covered a design for vermiculite-classifying equipment,[24] a heat-resistant material for coating parts of rocket or jet engines,[25] a dry plaster composition,[26] and a process for making an acoustic tile.[27]

Vermiculite uses in French patents included an absorbent material for liquids [28] and a plastering material.[29]

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[24] Standard Filterbau G.m.b.H. Brit. Pat. 899,449, June 20, 1962.

[25] Takei, M., and M. Umeda (assigned to Chimaki Oda). Brit. Pat. 889,866, Feb. 21, 1962.

[26] Tellentire, A. G., and C. Green (assigned to Imperial Chemical Industries, Ltd.). Brit. Pat. 895,398, May 2, 1962.

[27] Garrod, H. A. Brit. Pat. 906,463, Sept. 19, 1962.

[28] Thevenot, C., and Y. Delamarre-Deboutteville. French Pat. 1,284,521, June 18, 1962.

[29] Lavergne, E. French Addition, 78,262 to French Pat. 1,244,344, June 29, 1962.

Water

By Robert T. MacMillan [1]

ESTIMATED water supply potential for the United States excluding Alaska and Hawaii was in the median range or slightly above, according to measurements of streamflow and ground water levels in 1962. Water problems including long-range supply, quality, pollution, reuse, treatment, and saline water conversion received increasing attention from Government officials, planning organizations, public and private research institutions, scientists, and engineers. Progress was made in the program of the Federal Government to insure adequate water supplies for the future.

LEGISLATION AND GOVERNMENT PROGRAMS

An amendment [2] to the Act of July 15, 1955, relating to the conservation of anthracite coal resources through measures of flood control and anthracite mine drainage, was passed. The new act provided for funds, not to exceed $8.5 million, on a matching basis with the Commonwealth of Pennsylvania, not only to control drainage into but also to fill voids and seal abandoned coal mines where such work was in the interest of public health and safety. The broadened provisions of the new act were expected to stimulate a greater number of requests for acid mine water control projects which had slackened in 1962.

A survey of the literature on acid mine water control was published by the Bureau of Mines.[3] Type and occurrence of minerals responsible for acid pollution were enumerated and the mechanism of acid generation was explained. Procedures for backfilling and sealing mines against inflow of both water and air were described. Properly filled and sealed mines produced no acid water.

The program of the Office of Saline Water (OSW) was expanded, as a result of Public Law 87–295 passed in 1961, making more funds available for basic research and development. The greatest increase was in basic research for which 51 new contracts were awarded totaling over $3 million compared with 38 contracts having a total value of $377,000, in 1961. The expenditures for process development contracts tripled in the same period.[4]

Progress in the construction and operation of saline water conversion plants was outstanding. Two new plants began operations in

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[1] Commodity specialist, Division of Minerals.

[2] U.S. Congress. An Act to Amend the Act of July 15, 1955, Relating to the Conservation of Anthracite Coal Resources. U.S. Government Printing Office, Public Law 87–818, Oct. 15, 1962, 76 Stat. 934–935.

[3] Lorenz, W. C. Progress in Controlling Acid Mine Water: A Literature Review. BuMines Inf. Circ. 8080, 1962, 40 pp.

[4] U.S. Department of the Interior. Saline Water Conversion Report for 1962. January 1963, 163 pp.

March: The first at Point Loma, Calif., was a multiple effect flash evaporation plant capable of producing 1 mgd (million gallons per day) of fresh water from sea water; the second was an electrodialysis plant of 250,000 gallons per day capacity utilizing brackish water. The Freeport distillation plant, opened in 1961, continued to convert sea water to fresh water at its rated capacity of 1 mgd. At Roswell, N. Mex., construction was started on a forced circulation vapor compression plant designed to use brackish water to produce 1 mgd of fresh water. Specifications for the fifth and last of the first generation demonstration plants were prepared. The plant, which was to demonstrate the freezing method of saline water conversion, was scheduled to be built at Wrightsville Beach, N.C.

The Public Health Service, U.S. Department of Health, Education, and Welfare, published new standards for potable water used on carriers subject to Federal Quarantine Regulations.[5] Bacteriological standards remained substantially the same as in the previous specification, issued in 1946, but limits for certain chemical pollutants were included and radioactivity limits were established in microcuries per liter as follows: 3 for radium 226; 10 for strontium 90; and 1,000 for gross beta activity.

DOMESTIC SUPPLY

A convenient measure of the water supply potential of the United States was the flow or runoff of the major river systems. Excessive runoff was noted in the north-central plains, South central and Eastern Appalachian region, and in parts of Colorado, Wyoming, Nevada, and New Mexico. Runoff in other areas was near the median except for deficiencies in New England, Florida, Texas, Arkansas, and Arizona.[6]

The average flow of the Mississippi River at Vicksburg, Miss., was 117 percent of the 34-year median. Near Grand Canyon, Ariz., the average flow of the Colorado River was 134 percent. At The Dalles, Oreg., the average flow of the Columbia River was 90 percent of the median after adjusting for changes in 9 major power reservoirs. Stream flow was deficient in the Northeast during the last half of 1962.

With few exceptions, water storage in major power reservoirs was average to above average in volume throughout the nation. In irrigation reservoirs, the quantity of water stored was also above average although there were many exceptions. Multiple-purpose reservoirs were generally higher than normal; combined contents of Lakes Mead and Mohave were 123 percent of average.

Ground water levels fluctuated with the seasons and generally were above average in the areas which received excessive precipitation. In certain heavily pumped areas, for example, Arizona and parts of Texas, the ground water levels continued their steady decline.

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[5] Public Health Service. U.S. Department of Health, Education, and Welfare. Drinking Water Standards. 1962, 61 pp.

[6] Geological Survey (in collaboration with Canada Department of Northern Affairs and National Resources). Water Resources Review: Annual Summary, Water Year 1962. 19 pp.

CONSUMPTION AND USES

Estimates of total water withdrawal from streams, lakes, reservoirs, and ground water resources continued to increase, exceeding 320 billion gallons per day (bgd) estimated for 1961. The use pattern also was similiar to that of the previous year; industry required slightly more than half of the total, irrigation took less than half, and municipal and rural use accounted for the remaining 8 percent. Hydroelectric power generation required the use of an estimated 2,000 bgd including reuse. This quantity was not included with other withdrawal estimates as it was returned to the stream immediately and was available for reuse without treatment by downstream users. The nonwithdrawal uses of water including navigation, recreation, waste dilution, and conservation of wildlife were also important although often overshadowed by the withdrawal uses.

Assuming a total daily water supply of 1,200 billion gallons based on average runoff of all streams, the withdrawal use was slightly more than one-quarter of the potential supply. However, in areas of low annual and seasonal precipitation the water usage was much closer to the available supply.

An article published on water use in the United States took a broader than usual concept of the present and projected water requirements.[7] Whereas most water use studies were based on the water withdrawn from streams and reservoirs for limited and specific uses, the article considered the total water needed to produce plants and animals necessary to provide the food, fiber, and manufactured goods required for daily living. Taking into account factors such as transpiration ratios (pounds of water transpired per pound of usuable vegetable material produced) and pounds of vegetable material needed to produce 1 pound of meat protein, as well as industrial and domestic water requirements, an estimate of 15,000 gallons of water per day per person was needed to maintain the American standard of living. This figure was ten times greater than the average daily per capita water consumption based only on total municipal and rural water use.

Assuming 30 inches of average annual precipitation, the total potential water supply for the United States was calculated to be 5,000 bgd. By dividing this quantity by a population figure of 180 million, a total per capita daily water supply of 28,000 gallons was derived—a figure less than twice the estimated usage in 1962. Using projections of population growth and expansion of water use it was estimated that before the year 2000 all available water supply would be in use, and continued economic growth of the nation would be slowed by a lack of adequate water supply.

Estimates of water injected into oil-bearing strata for the secondary recovery of oil and for the maintenance of pressure in producing oil fields were made by Bureau of Mines engineers. About 3.8 billion barrels of water (1 barrel equals 42 gallons) was used in the secondary recovery of 375 million barrels of oil by water flooding in 1962—an increase, compared with 1961, of about 14 percent both in water used and oil recovered. About 65 percent of the water

[7] Bradley, C. C. Human Water Needs and Water Use in America. Science, v. 138, No. 3539, Oct. 26, 1962, pp. 489–491.

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was saline, and the remainder was fresh. Water injected for maintaining pressure in producing oil fields was estimated at 1.6 billion barrels, nearly twice the quantity used in 1961. About 321 million barrels of oil was produced in fields where pressures were maintained by water injection—a 54 percent increase compared with 1961. About 80 percent of the water injected was saline. An unknown percentage of the water used for both secondary recovery and pressure maintenance in oil fields was reinjected.

PRICES

Quotations for water varied from a few cents to $1 or more per thousand gallons depending upon area and type of use. An average for the United States of 40 cents per thousand gallons ($135 per acre foot) was estimated for potable water and 15 cents ($50 per acre foot) for irrigation water. On a weight basis, these prices were less than 10 cents per ton including distribution.[8]

Water used by industry was largely self-supplied, and the costs depended upon the quality of raw water available and the cost of treatment required to process water of adequate quality.

The price of heavy water (D_2O) available for sale or lease by the Atomic Energy Commission (AEC) was reduced from $28.00 to $24.50 per pound f.o.b. Savannah River plant, Aiken, S.C. The price reduction resulted from lower than expected depreciation costs of the heavy water generating equipment at Aiken. It was expected that the lower cost of heavy water would reduce the costs of power generated in heavy-water-moderated-and-cooled nuclear power plants by 0.2 mills per kilowatt hour.

Heavy water was also available for leasing by foreign governments for 5-year periods or for the duration of bilateral agreements. Annual rental based on 4.75 percent of the purchase price of the water was charged.

FOREIGN TRADE

Heavy water was sold or leased to the following countries by AEC:

	Quantity in pounds	
	Sold	*Leased*
Belgium	245	------
Canada	50,000	------
China	------	9
Germany, West	5,000	------
Japan	5,500	------
Spain	------	10,200
Sweden	------	57,210
Switzerland	2,620	------
United Kingdom	------	10,900
Total	63,365	78,319

TECHNOLOGY

With three successful demonstration plants in operation and a fourth under construction, the program of Office of Saline Water

[8] Williams, V. C. Saline Water Conversion Economics. Trans., Society Min. Eng. V. 223, No. 1, March 1962, pp. 74–87.

(OSW), Demonstration Plant Division, was well advanced. The first distillation plant completed in 1961 at Freeport, Tex., continued to convert sea water to fresh at or near its rated capacity of 1 mgd. The plant was a 12-effect, long tube vertical, falling-film-type. Scaling and corrosion problems were overcome by pH control and the use of proper corrosion-resistant alloys.

The second demonstration plant was dedicated in March and was a 36-stage flash distillation plant rated at 1 mgd. Corrosion and scaling problems also were encountered at this plant. Control of pH in the feed and the use of brass and copper-nickel alloys in the heat exchangers were successful in overcoming the difficulty.

At Webster, S. Dak., the third demonstration plant was placed in operation March 5. It was an electrodialysis plant capable of producing 250,000 gallons per day of potable water from a brackish feed containing 1,450 to 1,800 parts per million of dissolved solids. To avoid scaling problems in or on the membranes, the feed water was pretreated with potassium permanganate to oxidize and precipitate the iron compounds. Calcium scale was prevented by adding sulfuric acid to the system in sufficient quantities to prevent precipitation of alkaline scale in the membrane stacks.

The fourth demonstration plant was under construction at Roswell, N. Mex. It was designed to convert brackish water containing 24,500 parts per million of dissolved solids to potable water at a rate of 1 mgd, using the principle of vapor compression distillation. The design needed no auxiliary heat to be added to the brine except at start-up. All the energy requirements for distilling fresh water from the brine were to be supplied by the compression of the vapor.

The fifth and last of the five demonstration plants originally authorized was scheduled to be built at Wrightsville Beach, N.C. One of several possible types of freezing procedures was to be used. The plant was to have a capacity of 250,000 gallons per day.

With the end of the demonstration plant program approaching, the OSW expanded its basic and applied research programs because the most far-reaching contribution to saline water conversion was likely to be found through research. Emphasis was placed on the development of fundamental principles covering many fields of endeavor. Included were (1) composition, structure, and properties of water and aqueous solutions, (2) kinetics, thermodynamics, and transport phenomenon, (3) phase transitions, nucleation, and crystal growth, (4) surface chemistry and physics, (5) biological and organic systems, (6) materials, and (7) economic studies.

An interesting phenomenon investigated in connection with the effects of boundary layers was the formation of a bubble or sphere of pure liquid water floating in a flask of pure water and separated by an invisible film of water vapor or other gas. Other liquids, such as methyl ethyl ketone, were found to exhibit similar properties under special refluxing conditions. Complete understanding of the phenomena awaited further investigations.

The recovery of minerals from sea water in connection with saline water conversion processes was uneconomical in most instances; however, a process combining the recovery of potash, magnesia, calcium, and phosphate from sea water and the recovery of fresh water from the resulting descaled sea water was under investigation.[9] Production of a high-grade fertilizer, having desirable proportions of these elements needed for plant growth, was the aim of the investigation. The chief advantage of the process was in removing the scale-forming elements from the sea water and converting them into a marketable byproduct.

The research activities of the Public Health Service in waste treatment included attack on problems created by industrial and agricultural as well as domestic wastes. Upgrading industrial waste water to make it available for reuse was said to offer more challenges to the chemical industry than converting saline water. The benefits to be gained also were greater, including not only the water saved but also the potentially valuable byproduct minerals.[10]

One of the problems under study was the biological degradation of alkyl benzene sulfonate (ABS), an important ingredient in synthetic detergents. Under proper conditions of soil permeability and waste application, these so-called "hard detergents" were successfully broken down into harmless components. Small quantities of ABS persisting in waste treatment plant effluents were considered to be responsible for foaming observed in certain streams and ground water sources in heavily populated areas.

Heavy water (D_2O) continued to be separted from ordinary water at the Savannah River plant of the AEC at Aiken, S.C. As a moderator and coolant in nuclear reactors, heavy water had several advantages over ordinary water and other moderators. Heavy water containing deuterium, a heavy isotope of hydrogen, was sold at a concentration of 99.75 mol percent.

The greatly increased life expectancy of the extraction plant allowed a substantial price reduction to be made in 1962. Further reductions were anticipated if a market were found for unused production capacity.

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[9] Salutsky, M. L. Mineral By-Products From the Sea. Presented at the Saline Water Conference, U.S. Dept. of the Interior, W. R. Grace & Co., Clarksville, Md., Mar. 28, 1962, 11 pp.

[10] U.S. Department of Health, Education and Welfare. Public Health Service. Water Supply and Pollution Control, Research Activities, Fiscal Year 1962. August 1962, 62 pp.

Zinc

By A. D. McMahon,[1] Esther B. Miller,[2] and Dora D. Rice[2 3]

Contents

SUBSTANTIAL increases in mine production and consumption of refined metal were recorded by the domestic zinc industry in 1962. Smelter production also rose, although a number of the major smelters curtailed operations in the third quarter to reduce stocks. The larger use of zinc-base diecasting alloys accounted for most of the increased consumption. Producer stocks dropped slightly from 146,900 to 144,700 tons, but consumer stocks were reduced almost 17 percent to 80,000 tons.

Import quotas remained in effect, and general imports increased 12 percent for ore and concentrates and metal combined. Exports of slab zinc fell 28 percent to 36,100 tons.

Prime Western zinc at East St. Louis declined from 12 cents per pound to 11.5 cents on April 3 and remained at this price until yearend.

Government stockpiles contained 1.6 million tons of zinc. No additions or withdrawals were made during 1962.

The lead-zinc stabilization program authorized by legislation late in 1961 was financed by appropriations approved by Congress in July and was implemented by the General Services Administration.

The International Lead-Zinc Study Group held three meetings at Geneva during 1962.

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[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.
[3] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from reports of the U.S. Department of Commerce, Bureau of the Census.

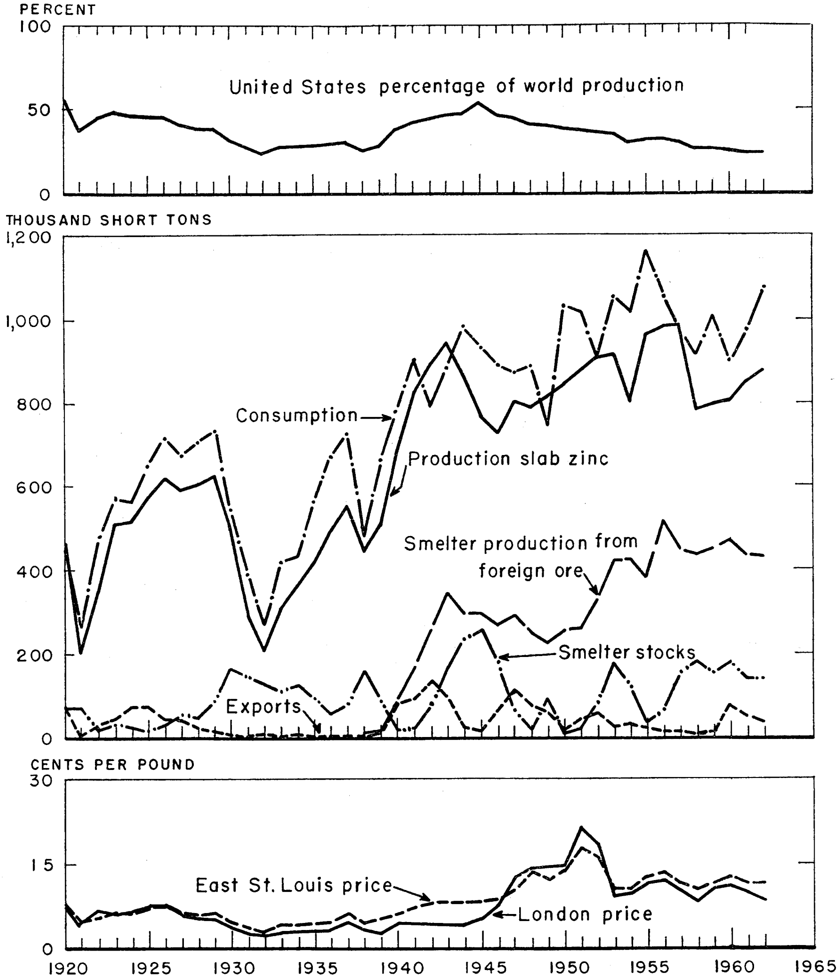

FIGURE 1.—Trends in the zinc industry in the United States, 1920–62. Consumption figures represent primary slab zinc plus zinc contained in pigments made directly from ore.

LEGISLATION AND GOVERNMENT PROGRAMS

The International Lead-Zinc Study Group held meetings at Geneva, Switzerland in March, May, and October. At the October meeting, efforts to evaluate means of bringing lead and zinc production and consumption into better balance were continued, and the working group adopted measures to improve the quality of Study Group world statistics for lead and zinc. Forecasts by the Study Group indicated that new records would be established for zinc production and consumption in 1962. New supplies were expected to exceed demand by a small quantity.

TABLE 1.—Salient zinc statistics

	1953-57 (average)	1958	1959	1960	1961	1962
United States:						
Production:						
Domestic ores, recoverable content____short tons__	521,929	412,005	425,303	435,427	464,390	505,491
Value____thousands__	$125,169	$84,113	$97,787	$112,365	$106,848	$116,413
Slab zinc:						
From domestic ores short tons__	493,689	346,240	348,443	334,101	[1] 413,282	448,095
From foreign ores short tons__	436,599	435,006	450,223	465,415	[1] 433,513	431,300
From scrap____do____	66,308	46,605	57,818	68,731	55,237	58,880
Total____do____	996,596	[2] 827,851	[2] 856,484	[2] 868,247	[2] 902,032	[2] 938,275
Secondary zinc [3]____do____	218,065	184,182	219,027	197,810	183,357	203,800
Imports (general):						
Ores (zinc content)____do____	499,712	461,560	500,115	457,155	415,700	467,398
Slab zinc____do____	220,223	195,199	156,963	120,767	127,562	141,957
Exports of slab zinc____do____	16,126	2,073	11,629	75,144	50,055	36,102
Stocks, December 31:						
At producer plants____do____	113,072	184,020	156,210	185,882	[1] 146,887	144,746
At consumer plants____do____	101,076	93,609	102,428	68,871	[1] 95,869	80,036
Consumption:						
All classes [4]____do____	1,309,348	1,142,165	1,278,376	1,158,938	1,207,469	1,330,590
Price, Prime Western, East St. Louis____cents per pound__	11.75	10.31	11.46	12.95	11.55	11.63
World:						
Production:						
Mine____short tons__	3,250,000	[1] 3,370,000	[1] 3,400,000	[1] 3,620,000	[1] 3,770,000	3,870,000
Smelter____do____	2,920,000	3,010,000	3,120,000	3,280,000	[1] 3,560,000	3,650,000
Price: Prime Western, London cents per pound__	10.58	8.24	10.27	11.05	9.78	8.43

[1] Revised figure.
[2] Includes production of zinc used directly in alloying operations.
[3] Excludes redistilled slab zinc.
[4] Includes slab zinc, recoverable zinc content of ores and secondary zinc.

Import quotas on zinc metal and ore, established October 1, 1958, were in effect throughout 1962. The annual quotas were set at 80 percent of the U.S. average annual competitive import rate from 1953 through 1957—379,840 tons of zinc in ore and 141,120 tons of zinc in pigs, slabs, and certain other forms.

In response to a U.S. Senate resolution, the U.S. Tariff Commission conducted public hearings on January 16 and 17, and submitted a report in May on the condition of the lead-zinc industry. On October 1, the Commission submitted to the President its third periodic report on the escape clause action imposing quotas and advised that conditions had not changed enough to warrant a formal inquiry into the question of relaxing existing regulations on imports of unmanufactured lead and zinc.

The Government subsidy program to provide stabilization payments to small domestic producers of lead and zinc ores and concentrates was authorized by Public Law 87-347 (75 Stat. 766) enacted October 3, 1961. Funds for financing the program during 1962 were provided for in the Second Supplemental Appropriation Act, 1962 (Public Law 87-545) enacted July 25, 1962. Participation in the program, by eligible producers, was retroactive for production from January 1, 1962. The General Services Administration (GSA) implemented all functions of the act under authority delegated by the Secretary of the Interior. Stabilization payments for the program were based on sales of ores or concentrates made in normal commercial channels after

January 1. Payments per pound of contained lead and zinc were lead, 75 percent of the difference between 14.5 cents and the average monthly market price for common lead at New York, N.Y., for the month in which the sale occurred; zinc, 55 percent of the difference between 14.5 cents and the average monthly market price for prime western zinc at East St. Louis, Ill., for the month in which the sale occurred. The maximum total amount of payments for the entire program was limited by law to $4.5 million per year for the calendar years 1962 and 1963, $4 million for 1964, and $3.5 million for 1965. Participation in the program was less than expected; only $654,140 was disbursed to producers from the $4,500,000 appropriated by Congress. As of December 31, 1962, the GSA had received 103 applications, certified 70, and disbursed payments to 42 producers.

Zinc, lead, and copper were removed from the list of minerals eligible for Government assistance through the Office of Minerals Exploration program effective July 1, 1962. However, in the first half of the year, two applications for assistance were received, one new contract was executed, and two contracts were amended to increase amounts of authorized work and costs. The new contract was awarded to Commonwealth Silver, Inc., Kootenai County, Idaho, for a total value of $46,640; Government participation totaled $23,320. An amendment to the contract of United Park City Mines Co. Salt Lake, Summit, and Wasatch Counties, Utah, authorized an increase in costs from $165,930 to $293,830; additional Government participation totaled $63,950. The Keystone Mining Co., Summit County, Utah, contract was amended to allow an increase in exploration costs from $111,710 to $157,400; additional Government participation totaled $22,845. One lead and zinc contract was terminated.

DOMESTIC PRODUCTION

MINE PRODUCTION

Mines in the United States produced 505,500 tons of recoverable zinc, an increase of 9 percent over that of 1961 and the highest annual output since 1957. Monthly production rose significantly in March and, except for July, the higher rate was maintained throughout 1962 despite the strikes that closed mines in Missouri and Montana. States east of the Mississippi River produced 46 percent of total output; Western States, 51 percent; and West-Central States, 3 percent.

Tennessee maintained its rank as the leading producing State although production declined almost 13 percent. Surface exploration and underground development by American Zinc, Lead and Smelting Co. continued as in the past 3 years at the operating properties and consisted of 54,000 feet of surface and underground drilling and 14,000 feet of underground drifts and raises. Reserves were increased 1,269,000 tons from which 60,000 tons of 60-percent zinc concentrates was to be recovered. Combined proved and indicated ore reserves totaled 80,365,000 tons, including New Market Zinc Co. reserves of 20,791,000 tons. From these reserves, 4,500,000 to 5,000,000 tons of zinc concentrates was expected. The company's production from Tennessee mines was 22 percent greater than in 1961 because of additional milling facilities made available upon completion of the New Market Zinc Co. concentrator.[4] The Mascot No. 2 and Young mines worked at capacity during 1962, and the Coy and Grasselli mines were brought into production in the third quarter. The New Jersey Zinc Co. Jefferson City mine resumed operations in September, following a shutdown caused by flooding in late 1961.[5]

Production in Idaho totaled 62,900 tons, an increase of approximately 8 percent over that of 1961 and the highest since 1953. All but 152 tons came from mines in Shoshone County. The Star Unit area, operated by Hecla Mining Co., yielded the largest output of zinc. Other principal sources were the Bunker Hill and Page mines. The Morning mine (American Smelting and Refining Company) was operated through the Star mine as a part of the Star Unit area. According to the Hecla Mining Co. annual report, 218,674 tons of ore from the Star mine and 20,675 tons from the Morning mine averaged 5.06 percent lead, 11.04 percent zinc, and 1.66 ounces of silver per ton.

New York production of recoverable zinc declined slightly to 53,700 tons. St. Joseph Lead Co., the only zinc producer in the State, operated its Balmat and Edwards mines and mills at St. Lawrence, N.Y., throughout 1962 on a 40-hour-week basis. All production of zinc concentrates was shipped to the company's zinc smelter at Josephtown, N.Y.

In Colorado, zinc production was 43,400 tons, compared with 42,600 tons in 1961. The leading producing mines were The New Jersey Zinc Co. Eagle mine, Idarado Mining Co. Idarado mine, and Emperius Mining Co. Emperius mine. Idarado Mining Co. milled less ore than in 1961; however, owing to a somewhat higher ore grade, improved metallurgy, and higher metal recoveries, total metal production (zinc, lead, and copper) increased 6 percent.

Montana production of zinc rose to 37,700 tons from 10,300 in 1961, as The Anaconda Company reinstated its Elm Orlu-Black Rock block-caving project at the Badger State mine. Three ore blocks were undercut during 1962, and 769,074 tons of zinc ore was mined. The company announced plans for constructing a zinc concentrator near the Badger State mine at Butte, Mont. This new plant, with a capacity of 4,000 tons of ore per day, was to receive ore by belt conveyor from the Badger State mine and by rail or truck from other zinc mines in the district.

Zinc production in Utah declined almost 8 percent to 34,300 tons, the lowest level since 1954. The United States and Lark mine of the United States Smelting, Refining and Mining Co. maintained its position as the leading Utah producer. According to its annual report, the United Park City Mines Co. produced 8,700 tons of zinc in 1962. Two main exploration projects were continued with Government aid administered by the Office of Minerals Exploration.

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4 American Zinc, Lead and Smelting Co. Annual Report. 1962, pp. 10–11.
5 The New Jersey Zinc Co. Annual Report. 1962, p. 6.

These projects have been instrumental in discovering new ore and will continue into 1963.[6]

Arizona mine output increased 11 percent to 32,900 tons. The largest producer in the State, Shattuck Denn Mining Corp., mined 271,171 tons of ore at its Iron King mine and produced 50,684 tons of concentrates containing 15,735 tons of zinc and other values in lead, copper, gold, and silver. Following settlement of a 9-week strike in December 1961, the mine operated without interruption throughout 1962.[7] The second largest producer was the Old Dick mine, operated by Cyprus Mines Corp. The mill processed 111,000 tons of ore from the Old Dick mine and from the Corporation's Copper Queen mine to produce concentrates containing 7,800 tons of zinc and 3,800 tons of copper.[8] Other zinc-producing properties in the State include the Johnson Camp mine of McFarland and Hullinger, the Atlas mine of B. S. & K. Mining Co., and the Flux mine of Nash and McFarland.

Virginia output of zinc was 26,500 tons, a drop of 9 percent from 1961 production. The New Jersey Zinc Co. equaled its 1961 production from the Austinville and Ivanhoe mines.[9] The Tri-State Zinc Co., Inc., operated its mine and mill at Timberville.

In the northern Illinois-Wisconsin district, production of zinc was the same as in 1961. The American Zinc, Lead and Smelting Co. reported that production at its Wisconsin mines decreased 7 percent because of a breakdown of major equipment in the first quarter. The mines were later restored to capacity operations.[10] The New Jersey Zinc Co. completed development work on the new mine, and further work was suspended.[11] Other producers included The Eagle-Picher Co., the Tri-State Zinc Co., Inc., and Piquette Mining and Milling Co.

Zinc production in Pennsylvania was 24,300 tons, 4 percent greater than in 1961. The higher output was achieved at The New Jersey Zinc Co. Friedensville mine, the only producing property in the State.

Production of zinc in New Mexico declined 4 percent to 22,000 tons from 22,900 tons in 1961. Leading producers in the State during 1962 were the Hanover and Oswaldo mines, The New Jersey Zinc Co.; and the Kearney mine, Hydrometals, Inc., and American-Peru Mining Co. The New Jersey Zinc Co. announced the closing of its Hanover mine in December owing to the adverse effect of foreign imports of zinc at low prices. The American-Peru Mining Co. initiated a long-range development program at its mine at Silver City and reported encouraging results.

Washington mine output increased 7 percent to 21,600 tons. The principal producing mines were Pend Oreille, Pend Oreille Mines and Metals Co., and the Grandview and Mineral Rights mines, American Zinc, Lead and Smelting Co. The American Zinc, Lead and

[6] United Park City Mines Co. Annual Report. 1962, p. 2.
[7] Shattuck Denn Mining Corp. Annual Report. 1962, p. 1.
[8] Cyprus Mines Corp. Annual Report. 1962, p. 9.
[9] The New Jersey Zinc Co. Annual Report. 1962, p. 6.
[10] Page 10 of work cited in footnote 4.
[11] Page 6 of work cited in footnote 5.

TABLE 2.—Mine production of recoverable zinc in the United States, by States

(Short tons)

State	1953-57 (average)	1958	1959	1960	1961	1962
Arizona	26,232	28,532	37,325	35,811	29,585	32,888
Arkansas			49	50	37	211
California	4,925	51	78	465	304	322
Colorado	39,111	37,132	35,388	31,278	42,647	43,351
Idaho	58,878	49,725	55,699	36,801	58,295	62,865
Illinois	19,381	24,940	26,815	29,550	26,795	27,413
Kansas	21,352	4,421	1,017	2,117	2,446	3,943
Kentucky	440	1,258	673	869	1,147	1,172
Missouri	5,400	362	92	2,821	5,847	2,792
Montana	66,170	33,238	27,848	12,551	10,262	37,678
Nevada	4,460	91	217	420	453	281
New Jersey	22,391	607			112	15,309
New Mexico	19,269	9,034	4,636	13,770	22,900	22,015
New York	56,303	53,014	43,464	66,364	54,763	53,654
North Carolina						
Oklahoma	32,118	5,267	1,049	2,332	3,148	10,013
Oregon					3	
Pennsylvania		10,812	16,718	13,746	23,428	24,308
Tennessee	42,619	59,130	89,932	91,394	81,734	71,548
Texas						
Utah	37,998	44,982	35,223	35,476	37,239	34,313
Virginia	18,804	18,472	20,334	19,885	29,163	26,479
Washington	26,847	18,797	17,111	21,317	20,217	21,644
Wisconsin	19,231	12,140	11,635	18,410	13,865	13,292
Total	521,929	412,005	425,303	435,427	464,390	505,491

Smelting Co. according to the annual report, curtailed ore production operations at both mines in order to use the labor for development work.

Zinc production in New Jersey rose from 100 tons in 1961 to 15,300 tons as The New Jersey Zinc Co.'s Sterling mine completed its first full year of operation since 1957.

Mine production of zinc in Oklahoma rose to 10,000 tons from 3,100 tons in 1961. All production came from Ottawa County.

Mine production in Missouri declined about 52 percent to 2,800 tons in 1962 owing to a strike at the St. Joseph Lead Co. Southeast Missouri operations that began July 27 and lasted through the end of the year.

TABLE 3.—Mine production of recoverable zinc in the United States, by months

(Short tons)

Month	1961	1962	Month	1961	1962
January	40,227	38,092	August	40,431	44,616
February	38,676	36,927	September	37,380	42,202
March	43,007	42,929	October	38,939	47,621
April	38,989	42,160	November	36,011	44,280
May	39,464	43,824	December	36,596	42,033
June	39,643	42,551			
July	35,027	38,256	Total	464,390	505,491

The 25 leading zinc-producing mines in the United States listed in table 4, yielded 78 percent of the total domestic output. The three leading mines supplied 19 percent, and the first six contributed 33 percent.

TABLE 4.—Twenty-five leading zinc-producing mines[1] in the United States in 1962, in order of output

Rank	Mine	District or region	State	Operator	Source of zinc
1	Balmat	St. Lawrence County.	New York	St. Joseph Lead Co.	Lead-zinc ore.
2	Badger State	Summit Valley	Montana	The Anaconda Co.	Zinc ore.
(2)	Star and Morning Unit.	Coeur d'Alene	Idaho	The Bunker Hill Co. and Hecla Mining Co.	Lead-zinc ore.
(2)	Eagle	Red Cliff (Battle Mountain).	Colorado	The New Jersey Zinc Co.	Do.
(2)	Friedensville	Lehigh County	Pennsylvania	do	Zinc ore.
(2)	United States & Lark.	West Mountain (Bingham).	Utah	United States Smelting, Refining and Mining Co.	Gold-silver-lead-zinc ore.
7	Austinville & Ivanhoe.	Austinville	Virginia	The New Jersey Zinc Co.	Lead-zinc ore.
8	Young	Eastern Tennessee	Tennessee	American Zinc Co. of Tennessee.	Zinc ore.
9	Iron King	Big Bug	Arizona	Shattuck Denn Mining Corp.	Lead-zinc ore.
10	Bunker Hill	Coeur d'Alene	Idaho	The Bunker Hill Co.	Do.
11	Zinc Mine Works	Eastern Tennessee	Tennessee	United States Steel Corp., Tennessee Coal & Iron Division.	Zinc ore.
12	Sterling Hill	New Jersey	New Jersey	The New Jersey Zinc Co.	Do.
13	Pend Oreille	Metaline	Washington	Pend Oreille Mines and Metals Co.	Lead-zinc ore.
14	Mascot No. 2	Eastern Tennessee	Tennessee	American Zinc Co. of Tennessee.	Zinc ore.
15	Page	Coeur d'Alene	Idaho	American Smelting and Refining Company.	Lead-zinc ore.
16	Idarado	Eureka (Red Mountain) & Upper San Miguel.	Colorado	Idarado Mining Co.	Copper-lead-zinc ore.
17	Hanover	Central	New Mexico	The New Jersey Zinc Co.	Zinc ore.
18	Edwards	St. Lawrence County.	New York	St. Joseph Lead Co.	Do.
19	Boyd, Calloway, Eureka and Mary.	Eastern Tennessee	Tennessee	Tennessee Copper Co.	Copper-zinc ore.
20	Kearney	Central	New Mexico	Hydrometals, Inc., American-Peru Mining Co.	Zinc ore.
21	United Park City	Park City Region	Utah	United Park City Mines Co.	Lead-zinc-silver ore.
22	Gray	Upper Mississippi Valley.	Illinois	Tri-State Zinc, Inc.	Lead-zinc ore.
23	Bowers-Campbell	Rockingham County.	Virginia	do	Zinc ore.
24	Old Dick	Eureka	Arizona	Cyprus Mines Corp.	Copper-zinc ore.
25	Graham-Snyder-Spillane.	Upper Mississippi Valley.	Illinois	The Eagle-Picher Co.	Zinc ore.

[1] Excludes old slag dumps.
[2] Not listed in order of rank.

SMELTER AND REFINERY PRODUCTION

The zinc smelting and refining industry operated 15 primary reduction plants and 11 secondary plants producing slab zinc, zinc pigments, zinc dust, and zinc alloys. Some manufacturers of chemicals, pigments, diecasting alloys, rolled zinc, and brass also produced secondary zinc.

Many of the major smelters curtailed output during the third quarter to reduce stocks. The American Zinc, Lead and Smelting Co. announced a 10-percent cutback in production of Prime Western grade;

TABLE 5.—Primary and redistilled secondary slab zinc produced in the United States

(Short tons)

	1953-57 (average)	1958	1959	1960	1961	1962
Primary:						
From domestic ores	493,689	[1] 346,240	348,443	[3] 334,101	[3] 413,282	448,095
From foreign ores	436,599	435,006	450,223	465,415	[3] 433,513	431,300
Total	930,288	[2] 781,246	[2] 798,666	[2] 799,516	[2] 846,795	[2] 879,395
Redistilled secondary	66,308	46,605	57,818	68,731	55,237	58,880
Total (excludes zinc recovered by remelting)	996,596	[2] 827,851	[2] 856,484	[2] 868,247	[2] 902,032	[2] 938,275

[1] Includes a small tonnage of slab zinc further refined into high-grade metal.
[2] Includes production of zinc used directly in alloying operations.
[3] Revised figure.

The Anaconda Company reduced output at Great Falls 15 percent; American Smelting and Refining Company curtailed its Corpus Christi operations 5 percent; The New Jersey Zinc Co. and the St. Joseph Lead Co. were operating at a rate about 15 percent lower than at the beginning of 1962; and American Metal Climax, Inc. reduced output at its Blackwell smelter. The Bartlesville smelter of National Zinc Co. was closed from May 31 to August 1 owing to a labor strike.

Slab Zinc.—Domestic smelter output of slab zinc increased for the fourth consecutive year and was the highest for any year since 1957. Included in the 938,300 tons of slab zinc output was molten zinc, used directly in alloying operations. Of the total, 879,400 tons was primary metal and 58,900 tons was redistilled secondary zinc. Primary output was 51 percent from domestic ores and 49 percent from foreign ores; 40 percent was electrolytic and 60 percent was distilled slab zinc. Of the 58,900 tons of redistilled secondary slab zinc, primary smelters produced 71 percent of the total, and the remainder was obtained from secondary smelters.

TABLE 6.—Distilled and electrolytic zinc, primary and secondary, produced in the United States, by method of reduction

(Short tons)

	1953-57 (average)	1958	1959	1960	1961	1962
Electrolytic primary	378,380	326,449	280,813	319,777	324,399	354,138
Distilled	551,909	454,797	517,853	479,739	522,396	525,257
Redistilled secondary:						
At primary smelters	27,897	24,297	28,451	40,009	35,319	41,732
At secondary smelters	38,410	22,308	29,367	28,722	19,918	17,148
Total	996,596	[1] 827,851	[1] 856,484	[1] 868,247	[1] 902,032	[1] 938,275

[1] Includes production of zinc used directly in alloying operations.

In 1962, Special High Grade was the principal grade produced, furnishing 42 percent of the total (39 percent in 1961). Prime Western Grade constituted 38 percent (41 percent in 1961); High Grade 10 percent (10 percent); Brass Special 8 percent (8 percent); Intermediate and Select 2 percent (2 percent).

TABLE 7.—Distilled and electrolytic zinc, primary and secondary, produced in the United States, by grades

Short tons)

	1953-57 (average)	1958	1959	1960	1961	1962
Special High Grade	334,397	298,442	331,312	357,205	353,466	392,901
High Grade	153,310	86,859	71,792	71,332	89,496	94,185
Intermediate	25,550	19,388	17,493	15,841	15,368	14,101
Brass Special	73,934	81,841	75,305	83,507	69,681	75,951
Select	2,123	1,300	1,414	73		130
Prime Western	407,282	340,021	359,168	340,289	374,021	361,007
Total	996,596	[1] 827,851	[1] 856,484	[1] 868,247	[1] 902,032	[1] 938,275

[1] Includes production of zinc used directly in alloying operations.

Pennsylvania was the leading producing State, with Texas ranking second and Oklahoma third. The slab zinc output of Pennsylvania, West Virginia, Oklahoma, and Arkansas was produced by the distillation process; the output of Montana and Idaho by the electrolytic process. Part of the Illinois and Texas slab output was distilled and part was electrolytic.

TABLE 8.—Primary slab zinc produced in the United States, by States where smelted

(Short tons)

	1953-57 (average)	1958	1959	1960	1961	1962
Arkansas	20,233	17,952	15,964	1,521	12,342	14,446
Idaho	56,939	55,454	61,191	26,449	74,736	76,756
Illinois	106,819	[1] 82,844	102,708	[1] 88,291	78,814	99,055
Montana	199,307	148,921	86,620	132,290	111,223	129,144
Oklahoma	154,706	122,138	152,072	161,894	164,319	147,384
Pennsylvania	207,652	[2] 187,243	[2] 217,368	[2] 194,514	[2] 214,308	[2] 234,038
Texas and West Virginia [3]	184,632	[4] 166,694	[4] 162,743	[4] 194,557	[4] 191,053	[4] 178,572
Total	930,288	[5] 781,246	[5] 798,666	[5] 799,516	[5] 846,795	[5] 879,395
Value (thousands)	$224,076	$159,687	$183,214	$205,476	$193,916	$201,733

[1] Includes Missouri.
[2] Includes West Virginia.
[3] Includes Missouri 1953, 1955, and 1956.
[4] Texas only.
[5] Includes production of zinc used directly in alloying operations.

Primary Smelters and Electrolytic Plants.—Primary reduction plants processed zinc ores and concentrates, zinc fume from Waelz kilns and slag-fuming plants, other primary zinc-bearing materials, and 71 percent of all zinc-base scrap used for redistilled slab zinc.

Production at primary zinc plants totaled 921,100 tons of slab zinc; 41,700 tons were redistilled. In addition to slab zinc, primary plants produced zinc oxide, zinc dust, and zinc-base alloys.

Primary plant capacity for slab zinc at the 15 operating zinc plants at yearend was reported to be 1,196,300 tons. Five electrolytic plants reported 2,734 of their 4,082 electrolytic cells in use at the end of the year and an output of 354,100 tons (73 percent of the 485,500 tons of capacity). The 7 horizontal-retort plants reported 33,512 of their 43,648 retorts in use during 1962. Four remaining primary smelters were continuous-distilling vertical-retort plants at Meadowbrook, W. Va.; Depue, Ill.; Palmerton, Pa.; and Josephtown, Pa. The first three used The New Jersey Zinc Co. externally gas-fired vertical retorts, and the one at Josephtown used electrothermic distillation retorts. Combined horizontal- and vertical-retort production of 567,000 tons was 80 percent of the reported 1962 capacity of 710,800 tons.

Slag-Fuming Plants.—Many lead smelters recover a zinc-fume product from lead blast-furnace slags containing 7.5 to 12.5 percent zinc. Such slags were treated to extract zinc and remaining lead by the following companies in 1962:

Company:	*Plant location*
American Smelting and Refining Company	Selby, Calif.
Do	El Paso, Tex.
The Anaconda Company	East Helena, Mont.
The Bunker Hill Co	Kellogg, Idaho.
International Smelting & Refining Co	Tooele, Utah.

These five plants treated 688,600 tons of hot and cold lead slag (including some crude ore and zinc residue), which yielded 122,300 tons of oxide fume, containing 84,300 tons of recoverable zinc. Corresponding figures for 1961 were 685,400, 120,700, and 79,500 tons, respectively.

Secondary Zinc Smelters.—Zinc-base scrap (a term that includes skimmings and drosses, die-cast alloys, old zinc, engravers' plates, new clippings, and chemical residues) was smelted chiefly at secondary smelters, although about one-fourth was usually reduced at primary smelters and most sal ammoniac skimmings were processed at chemical plants. Secondary smelters depended on the galvanizers and scrap dealers for their supply of scrap materials.

TABLE 9.—U.S. primary zinc plants, their location and group capacity for slab zinc in 1962

Type of plant	Plant location	Slab zinc capacity (short tons)
Electrolytic plants:		
American Smelting and Refining Company	Corpus Christi, Tex	
American Zinc Co. of Illinois	Monsanto, Ill	
The Anaconda Company	Anaconda, Mont	485, 500
Do	Great Falls, Mont	
The Bunker Hill Co	Kellogg, Idaho	
Horizontal-retort plants:		
American Smelting and Refining Company	Amarillo, Tex	
American Zinc Co. of Illinois	Dumas, Tex	
Athletic Mining & Smelting Co	Fort Smith, Ark	
Blackwell Zinc Co., Division of American Metal Climax, Inc.	Blackwell, Okla	
The Eagle-Picher Co	Henryetta, Okla	
Matthiessen & Hegeler Zinc Co [1]	LaSalle, Ill	710, 800
National Zinc Co	Bartlesville, Okla	
Vertical-retort plants:		
Matthiessen & Hegeler Zinc Co	Meadowbrook, W. Va	
The New Jersey Zinc Co	Depue, Ill	
Do	Palmerton, Pa	
St. Joseph Lead Co	Herculaneum, Mo	
Do [2]	Josephtown, Pa	

[1] Plant closed July 1, 1961.
[2] Electrothermic slag-fuming unit, yielding a slab zinc product.

TABLE 10.—U.S. secondary zinc plants, their location and capacity for slab zinc in 1962

Type of plant	Plant location	Slab zinc capacity (short tons)
American Smelting and Refining Company	Beckemeyer, Ill.	63,500
Do	Sand Springs, Okla.	
Do	Trenton, N.J.	
American Zinc Co. of Illinois	Hillsboro, Ill.	
Apex Smelting Co.	Chicago, Ill.	
Arco Die Cast Metals Co.	Detroit, Mich.	
W. J. Bullock, Inc.	Fairfield, Ala.	
General Smelting Co.	Bristol, Pa.	
Gulf Reduction Co.	Houston, Tex.	
H. Kramer Co.	El Segundo, Calif.	
Pacific Smelting Co.	Torrance, Calif.	
Sandoval Zinc Co.	Sandoval, Ill.	
Superior Zinc Corp.	Bristol, Pa.	
Wheeling Steel Corp.	Martins Ferry, Ohio	

TABLE 11.—Stocks and consumption of new and old zinc scrap in the United States in 1962

(Short tons, gross weight)

Class of consumer and type of scrap	Stocks Jan. 1 [1]	Receipts	Consumption			Stocks Dec. 31
			New scrap	Old scrap	Total	
Smelters and distillers:						
New clippings	128	1,491	1,421		1,421	198
Old zinc	856	3,790		4,035	4,035	611
Engravers' plates	310	2,992		2,994	2,994	308
Skimmings and ashes	7,541	42,290	43,414		43,414	6,417
Sal skimmings	304	1,446	1,527		1,527	223
Die-cast skimmings	651	7,912	7,770		7,770	793
Galvanizers' dross	5,912	56,008	53,674		53,674	8,246
Diecastings	4,805	32,363		32,217	32,217	4,951
Rod and die scrap	172	741		692	692	221
Flue dust	132	5,651	5,070		5,070	713
Chemical residues	5,153	6,393	10,270		10,270	1,276
Total	25,964	161,077	123,146	39,938	163,084	23,957
Chemical plants, foundries, and other manufacturers:						
New clippings	15	107	99		99	23
Old zinc	3	3		3	3	3
Engravers' plates		77		77	77	
Skimmings and ashes	2,392	7,051	7,160		7,160	2,283
Sal skimmings	7,425	14,995	15,277		15,277	7,143
Die-cast skimmings		4	4		4	
Galvanizers' dross	14	36	1		1	49
Diecastings	21	898		891	891	28
Rod and die scrap	3	63		66	66	
Flue dust	30	354	337		337	47
Chemical residues	2,091	17,275	16,799		16,799	2,567
Total	11,994	40,863	39,677	1,037	40,714	12,143
Grand total:						
New clippings	143	1,598	1,520		1,520	221
Old zinc	859	3,793		4,038	4,038	614
Engravers' plates	310	3,069		3,071	3,071	308
Skimmings and ashes	9,933	49,341	50,574		50,574	8,700
Sal skimmings	7,729	16,441	16,804		16,804	7,366
Die-cast skimmings	651	7,916	7,774		7,774	793
Galvanizers' dross	5,926	56,044	53,675		53,675	8,295
Diecastings	4,826	33,261		33,108	33,108	4,979
Rod and die scrap	175	804		758	758	221
Flue dust	162	6,005	5,407		5,407	760
Chemical residues	7,244	23,668	27,069		27,069	3,843
Total	37,958	201,940	162,823	40,975	203,798	36,100

[1] Figures partly revised.

Primary and secondary smelting plants treating zinc-base scrap produced 58,900 tons of redistilled zinc, 3,500 tons of remelt, and 41,000 tons of zinc dust. The zinc content of these products totaled 86,600 tons.

Additional details on the zinc recovered in processing copper-base scrap (table 13) may be obtained in the secondary copper and brass section of the "Copper" chapter of this volume.

TABLE 12.—Production of secondary zinc and zinc-alloy products in the United States

(Short tons, gross weight)

Product	1953–57 (average)	1958	1959	1960	1961	1962
Redistilled slab zinc	66,308	46,605	[1] 57,818	[1] 68,731	[1] 55,237	[1] 58,880
Zinc dust	24,379	[2] 23,068	[2] 26,421	[2] 26,681	[2] 22,878	24,863
Remelt spelter	5,343	5,236	4,718	4,883	4,260	3,540
Remelt die-cast slab	10,214	12,980	13,150	7,800	9,548	10,834
Zinc-die and diecasting alloys	4,914	6,082	5,864	6,945	5,894	5,531
Galvanizing stocks	245	249	245	222	117	369
Rolled zinc	2,222	10	14	18	19	14
Secondary zinc in chemical products	30,742	32,482	40,204	38,007	35,639	36,331

[1] Includes redistilled slab made from remelt die-cast slab.
[2] Revised figure.

TABLE 13.—Zinc recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

Kind of scrap	1961	1962	Form of recovery	1961	1962
New scrap:			As metal:		
Zinc-base	101,846	109,324	By distillation:		
Copper-base	74,874	87,893	Slab zinc [1]	54,610	58,217
Aluminum-base	1,809	2,994	Zinc dust	[2] 22,427	24,497
Magnesium-base	31	53	By remelting	4,352	3,892
Total	178,560	200,264	Total	[2] 81,389	86,606
Old scrap:			In zinc-base alloys	14,400	15,183
Zinc-base	32,759	33,588	In brass and bronze	[2] 102,624	118,487
Copper-base	24,628	25,929	In aluminum-base alloys	3,789	5,256
Aluminum-base	1,925	2,192	In magnesium-base alloys	126	154
Magnesium-base	95	44	In chemical products:		
			Zinc oxide (lead-free)	17,189	18,985
Total	59,407	61,753	Zinc sulfate	(3)	(3)
			Zinc chloride	11,426	11,753
Grand total	237,967	262,017	Miscellaneous	7,024	5,593
			Total	[2] 156,578	175,411
			Grand total	237,967	262,017

[1] Includes zinc content of redistilled slab made from remelt die-cast slab.
[2] Revised figure.
[3] Included with "Miscellaneous."

BYPRODUCT SULFURIC ACID

Sulfuric acid was made from sulfur dioxide gases produced in roasting zinc sulfide concentrate at some primary zinc smelters. At several plants elemental sulfur was burned to increase acid-making capacity. Acid production at zinc-roasting plants from zinc sulfide was 815,300 short tons, valued at $11.3 million, and from elemental sulfur, 77,500 tons, valued at $1.1 million.

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ZINC DUST

Zinc dust included in data in tables 12, 13, and 14 is restricted to commercial grades that comply with close specifications as to percentage of unoxidized metal, evenness of grading, and fineness of particles; it does not include blue powder. Zinc content of the dust produced ranged from 95.00 to 99.71 percent, averaging 98.55 percent. Total shipments of zinc dust were 38,800 tons; 200 tons was shipped abroad. Producer stocks of zinc dust were 3,600 tons at the end of the year.

Most of the zinc dust was made from zinc scrap, chiefly galvanizers' dross, but some was recovered from refined metal.

TABLE 14.—Zinc dust produced in the United States

Year	Short tons	Value		Year	Short tons	Value	
		Total	Average per pound			Total	Average per pound
1953-57 (average)	27,378	$8,087,787	$0.148	1960	30,788	$10,283,192	$0.167
1958	26,512	7,253,683	.137	1961	34,772	10,570,688	.152
1959	32,758	9,683,265	.148	1962	40,978	12,539,268	.153

CONSUMPTION AND USES

Zinc consumed as refined metal in slab or other forms totaled 1,031,800 tons (931,200 tons in 1961); zinc content of ore and concentrate consumed to make pigments and salts and used directly in galvanizing totaled 98,900 tons (97,300 tons); and zinc content of scrap used to make alloys, zinc dust, pigments, and salts totaled 199,900 tons (179,000). Consumption totaled 1,330,600 tons of primary and secondary zinc, 10 percent more than in 1961. The quantity of zinc consumed directly in making pigments and salts is reported in table 21. Zinc consumed in scrap form and the manufactured products other than remelt and redistilled are reported in tables 11, 12, and 13.

TABLE 15.—Consumption of zinc in the United States

(Short tons)

	1953-57 (average)	1958	1959	1960	1961	1962
Slab zinc	986,890	868,327	956,197	877,884	931,213	1,031,821
Ores (recoverable zinc content)	111,858	[1] 94,938	[1] 108,070	[1] 88,275	[1] 97,251	[1] 98,861
Secondary (recoverable zinc content) [2]	210,600	178,900	214,109	192,779	179,005	199,908
Total	1,309,348	1,142,165	1,278,376	1,158,938	1,207,469	1,330,590

[1] Includes ore used directly in galvanizing.
[2] Excludes redistilled slab and remelt zinc.

Slab zinc consumption, as reported by 700 plants, was 1,031,800 tons, 11 percent higher than 1961 consumption and only 8 percent below the record of 1,119,800 tons used in 1955. The quantity of zinc used in diecastings and zinc-base alloys increased 24 percent; this was the largest industrial use for zinc, accounting for 41 percent of the total zinc consumed. Slab zinc used in galvanizing steel products accounted for 38 percent, brass and bronze products accounted for 12 percent, and rolled zinc, zinc oxide, light-metal alloys, desilverizing lead, wet batteries, zinc dust, chemicals, bronze powders, and zinc in cathodic anodes accounted for the remaining 9 percent.

TABLE 16.—Reported slab zinc consumption in the United States, by industry use

(Short tons)

Industry and product	1953-57 (average)	1958	1959	1960	1961	1962
Galvanizing: [1]						
Sheet and strip	183,699	194,196	175,691	196,057	211,300	213,970
Wire and wire rope	43,312	35,638	35,602	35,262	37,608	38,203
Tubes and pipe	84,053	67,318	59,830	56,680	54,957	54,003
Fittings	10,409	8,904	10,239	9,258	6,540	8,039
Other	92,226	[2] 75,173	[2] 79,665	[2] 74,332	[2] 71,672	[2] 74,355
Total	413,699	381,229	361,027	371,589	382,077	388,570
Brass products:						
Sheet, strip, and plate	64,748	46,967	61,234	45,870	60,018	61,210
Rod and wire	39,633	32,568	40,286	29,971	41,018	41,875
Tube	14,235	9,645	11,808	8,504	10,168	10,627
Castings and billets	6,663	4,423	4,967	4,699	4,061	4,923
Copper-base ingots	7,360	7,094	10,276	9,412	12,874	10,884
Other copper-base products	1,178	678	707	567	384	286
Total	133,817	101,375	129,278	99,023	128,523	129,805
Zinc-base alloy: [3]						
Die castings	341,464	309,408	383,358	331,112	337,227	419,042
Alloy dies and rod	9,444	5,400	3,745	3,442	1,629	850
Slush and sand castings	2,221	2,022	2,228	3,819	2,910	3,716
Total	353,129	316,830	389,331	338,373	341,766	423,608
Rolled zinc	48,471	40,616	42,949	38,696	41,204	42,233
Zinc oxide	20,279	13,331	18,248	15,593	18,137	18,517
Other uses:						
Wet batteries	1,356	846	1,244	1,152	1,058	1,133
Desilverizing lead	2,718	2,521	1,949	2,521	2,630	2,302
Light-metal alloys	4,748	3,657	3,363	3,181	4,347	4,920
Other [4]	8,673	7,922	8,808	7,756	11,471	20,733
Total	17,495	14,946	15,364	14,610	19,506	29,088
Total consumption [5]	986,890	868,327	956,197	877,884	931,213	1,031,821

[1] Includes zinc used in electrogalvanizing and electroplating, but excludes sherardizing.
[2] Includes 28,502 tons used in job galvanizing in 1958, 31,521 tons in 1959, 31,616 tons in 1960, 30,954 tons in 1961, and 34,871 tons in 1962.
[3] After 1957 figures include zinc used in direct alloying operations.
[4] Includes zinc used in making zinc dust, bronze powder, alloys, chemicals, castings, and miscellaneous uses not elsewhere mentioned.
[5] Includes 8,073 tons of remelt zinc in 1958, 5,209 tons in 1959, 6,622 tons in 1960, 7,528 tons in 1961, and 7,518 tons in 1962.

Of the 1,031,800 tons of slab zinc used, 48 percent was Special High Grade, 29 percent Prime Western, 11 percent High Grade, 10 percent Brass Special, 1 percent Intermediate and 1 percent for Select and Remelt combined. All grades were used in galvanizing and in brass and bronze products. Of the 423,600 tons of slab zinc used in zinc-base alloys, 99 percent was Special High Grade.

Rolling mills used 42,200 tons of slab zinc and remelted and rerolled 13,600 tons of metallic scrap produced in fabricating plants operated

TABLE 17.—Reported slab zinc consumption in the United States in 1962, by grades and industry use

(Short tons)

Industry	Special High Grade	High Grade	Inter-mediate	Brass Special	Select	Prime Western	Remelt	Total
Galvanizing	16,944	21,719	1,702	81,927	240	264,038	2,000	388,570
Brass and bronze [1]	27,166	73,942	243	5,385	2,689	16,213	4,167	129,805
Zinc-base alloys [2]	419,676	1,888	38			1,100	906	423,608
Rolled zinc	15,138	11,730	5,761	9,578		26		42,233
Zinc oxide	3,895	10				14,612		18,517
Other	10,783	1,338	277	6,226		10,019	445	29,088
Total	493,602	110,627	8,021	103,116	2,929	306,008	7,518	1,031,821

[1] Includes brass mills, brass ingotmakers, and brass foundries.
[2] Includes producers of zinc-base diecastings, zinc-alloy dies, and zinc-alloy rods.

in connection with the rolling mills. In addition, a small quantity of purchased scrap (new clippings and old zinc) was melted and rolled. Small quantities of alloying metals were added for some uses. The rolled-zinc industry, however, classified these alloys as rolled zinc.

Output of salable rolled zinc increased to 40,700 tons. Stocks of rolled zinc at the mills declined to 2,700 tons by yearend. Besides shipments of 20,500 tons of rolled zinc, the rolling mills consumed 34,000 tons of rolled zinc in manufacturing 21,200 tons of semifabricated and finished products.

Rolled zinc was used to make sheet, strip, ribbon, foil, plate, rod, and wire. Its major domestic use was for dry cell battery cases and similar extruded cases for radio condensers and tube shields. Weather-stripping, roof flashing, photoengraving plates, and household electric fuses were other uses.

TABLE 18.—Rolled zinc produced and quantity available for consumption in the United States

	1961			1962		
	Short tons	Value		Short tons	Value	
		Total	Average per pound		Total	Average per pound
Production:						
Sheet zinc not over 0.1 inch thick	12,683	$7,186,096	$0.283	13,442	$7,739,555	$0.288
Boiler plate and sheets over 0.1 inch thick	201	84,662	.210	241	98,966	.206
Strip and ribbon zinc [1]	24,908	10,410,161	.209	25,301	10,445,238	.206
Foil, rod, and wire	1,806	996,341	.276	1,723	823,362	.239
Total rolled zinc	39,598	18,677,260	.236	40,707	19,107,121	.235
Imports	1,183	354,034	.150	1,315	367,210	.140
Exports	3,219	2,271,467	.353	3,547	2,390,712	.337
Available for consumption	37,810			38,746		
Value of slab zinc (all grades)			.115			.115
Value added by rolling			.121			.120

[1] Figures represent net production. In addition, 12,699 tons of strip and ribbon zinc and sheet zinc in 1961 and 13,556 tons in 1962 were rerolled from scrap originating in fabricating plants operating in connection with zinc rolling mills.

CONSUMPTION OF SLAB ZINC BY GEOGRAPHIC AREAS

Ohio, Pennsylvania, Indiana, and Illinois accounted for 60 percent of the slab zinc used in galvanizing. The iron and steel industry used zinc to galvanize steel sheets, wire, tube, pipe, cable, chain, bolts, railway-signal equipment, building and pole-line hardware, and other items.

Connecticut again ranked first in consuming slab zinc in brass making, followed by Illinois and Michigan.

Michigan led the 22 States in the consumption of slab zinc in making zinc-base alloys. Other large consuming States were Illinois, Ohio, New York, and Pennsylvania.

TABLE 19.—Reported slab zinc consumption in the United States in 1962, by industries and States

(Short tons)

State	Galvanizers	Brass mills [1]	Diecasters [2]	Other [3]	Total
Alabama	(4)	(4)	-	(4)	33,938
Arizona	(4)	-	-	(4)	(4)
Arkansas	-	-	-	(4)	(4)
California	22,029	2,491	11,635	786	36,941
Colorado	(4)	(4)	-	-	(4)
Connecticut	2,963	37,459	(4)	(4)	44,768
Delaware	(4)	(4)	(4)	(4)	(4)
Florida	(4)	-	(4)	-	1,289
Georgia	(4)	-	-	-	(4)
Hawaii	(4)	-	-	-	(4)
Idaho	-	-	(4)	(4)	(4)
Illinois	46,757	18,230	61,941	19,371	146,299
Indiana	50,229	(4)	(4)	(4)	96,299
Iowa	(4)	-	-	(4)	1,416
Kansas	-	(4)	(4)	(4)	(4)
Kentucky	(4)	(4)	-	-	(4)
Louisiana	(4)	-	-	(4)	688
Maine	327	-	-	-	327
Maryland	(4)	(4)	-	(4)	(4)
Massachusetts	3,212	(4)	-	(4)	6,633
Michigan	3,473	14,047	105,566	887	123,973
Minnesota	(4)	-	-	(4)	1,844
Mississippi	(4)	-	-	-	(4)
Missouri	4,391	(4)	7,751	(4)	13,117
Montana	-	-	-	(4)	(4)
Nebraska	(4)	(4)	-	(4)	1,859
New Hampshire	-	(4)	-	-	(4)
New Jersey	3,213	5,847	(4)	(4)	26,773
New York	6,395	(4)	41,293	(4)	65,653
North Carolina	(4)	-	(4)	-	(4)
Ohio	83,805	(4)	56,433	(4)	151,448
Oklahoma	2,208	-	(4)	(4)	10,974
Oregon	393	(4)	(4)	(4)	580
Pennsylvania	52,821	(4)	20,718	(4)	113,253
Rhode Island	781	(4)	(4)	(4)	(4)
South Carolina	(4)	-	-	-	(4)
South Dakota	(4)	-	-	-	(4)
Tennessee	642	-	(4)	(4)	1,640
Texas	9,942	(4)	(4)	(4)	43,892
Utah	(4)	(4)	-	-	(4)
Virginia	(4)	28	(4)	(4)	(4)
Washington	(4)	-	-	(4)	1,626
West Virginia	(4)	(4)	-	(4)	(4)
Wisconsin	1,593	(4)	(4)	(4)	13,025
Undistributed	91,396	47,536	117,365	68,349	86,048
Total [5]	386,570	125,638	422,702	89,393	1,024,303

[1] Includes brass mills, brass ingotmakers, and brass foundries.
[2] Includes producers of zinc-base diecastings, zinc-alloy dies, and zinc-alloy rods.
[3] Includes slab zinc used in rolled-zinc products and in zinc oxide.
[4] Figure withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[5] Excludes remelt zinc.

ZINC PIGMENTS AND SALTS

Production of zinc pigments and salts increased 3 percent over 1961 production. The output of natural and synthetic rubber, a major zinc-pigment-consuming product, increased 11 percent; paint, varnish, and lacquer industries, also using large quantities of zinc pigments, increased 5 percent in value of shipments.

Production.—Output of lead-free zinc oxide increased 8 percent, but production of leaded zinc oxide declined to 14,400 tons. Zinc chloride (50° Baumé) and zinc sulfate production increased 2 and 4 percent, respectively.

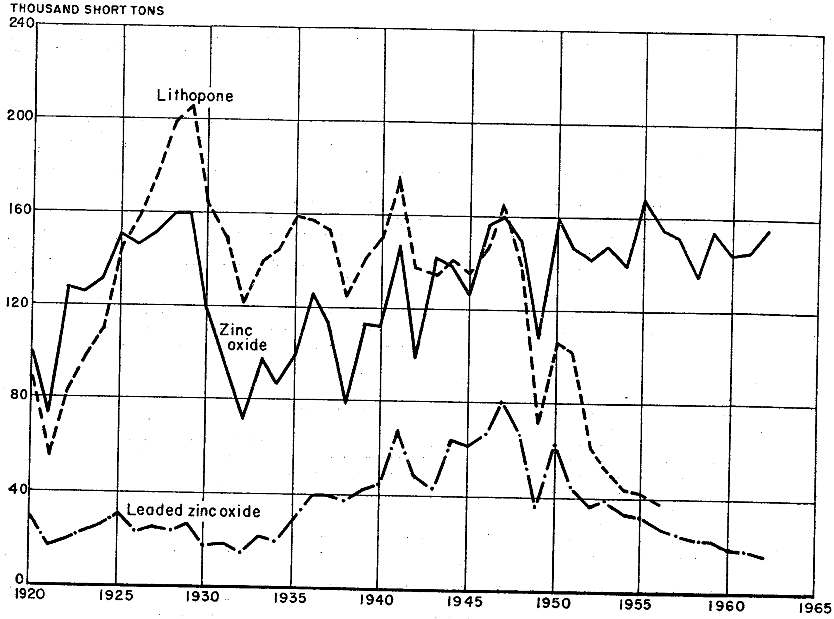

FIGURE 2.—Trends in shipments of zinc pigments, 1920–62.

Pigments and salts were made from various zinc-bearing materials, including ore, slab zinc, scrap, and residues. Zinc contained in pigments and salts made directly from ore, both domestic and foreign, exceeded 89,000 tons; zinc in zinc oxide and zinc chloride from slab zinc exceeded 18,000 tons; and the zinc derived from secondary materials in zinc pigments and salts exceeded 39,000 tons.

Lead-free zinc oxide was made by several processes; 66 percent was made from ores and residues by the American process, 19 percent from metal by the French process, and 15 percent from scrap residues and secondary materials by other processes. Leaded zinc oxide was made from ores; zinc chloride was made from slab zinc and secondary zinc materials; and zinc sulfate was made from ores and secondary materials.

Four grades of leaded zinc oxide, classified according to lead content, were produced. Only a very small quantity of 5 percent or less

TABLE 20.—Production and shipments of zinc pigments and salts[1] in the United States

Pigment or salt	1961				1962			
	Production (short tons)	Shipments			Production (short tons)	Shipments		
		Short tons	Value[2]			Short tons	Value[2]	
			Total	Average per ton			Total	Average per ton
Zinc oxide[3]	147,555	145,208	$33,219,370	$299	158,844	154,849	$35,627,808	$230
Leaded zinc oxide[3]	20,335	18,007	4,204,066	233	14,377	15,694	3,652,330	233
Zinc chloride, 50° B[4]	52,479	53,099	(5)	(5)	53,733	50,438	(5)	(5)
Zinc sulfate	29,269	28,891	(5)	(5)	30,539	31,231	(5)	(5)

1 Excludes lithopone; figure withheld to avoid disclosing individual company confidential data.
2 Value at plant, exclusive of container.
3 Zinc oxide containing 5 percent or more lead is classed as leaded zinc oxide.
4 Includes zinc chloride equivalent of zinc ammonium chloride and chromated zinc chloride.
5 Figure withheld to avoid disclosing individual company confidential data.

leaded zinc oxide was produced; the more than 5 to 35 percent grade constituted most of the production. Small quantities of the more than 35 through 50 percent and over 50 percent grades were produced.

Lithopone, a coprecipitate of zinc sulfide and barium sulfate, was produced, but figures are withheld to avoid disclosing individual company confidential data.

TABLE 21.—Zinc content of zinc pigments[1] and salts produced by domestic manufacturers, by sources

(Short tons)

Pigment or salt	1961					1962				
	Zinc in pigments and salts produced from—				Total zinc in pigments and salts	Zinc in pigments and salts produced from—				Total zinc in pigments and salts
	Ore		Slab zinc	Secondary material		Ore		Slab zinc	Secondary material	
	Domestic	Foreign				Domestic	Foreign			
Zinc oxide	63,872	10,305	17,936	25,639	117,752	63,565	17,256	18,297	27,622	126,740
Leaded zinc oxide	7,665	4,752			12,417	5,232	3,378			8,610
Total pigments	71,537	15,057	17,936	25,639	130,169	68,797	20,634	18,297	27,622	135,350
Zinc chloride[2]			(3)	11,410	11,410			(3)	11,715	11,715
Zinc sulfate	(3)	(3)		(3)	10,667	(3)	(3)		(3)	10,922

1 Excludes zinc sulfide and lithopone; figures withheld to avoid disclosing individual company confidential data.
2 Includes zinc content of zinc ammonium chloride and chromated zinc chloride.
3 Figure withheld to avoid disclosing individual company confidential data.

Consumption and Uses.—Shipments of lead-free zinc oxide were 7 percent greater than in 1961. The quantity consumed by the rubber, paint, and ceramic industries increased, and these three groups accounted for 79 percent of the total 154,800 tons shipped.

The paint industry accounted for 95 percent of the leaded zinc oxide shipped.

TABLE 22.—Distribution of zinc oxide shipments, by industries

(Short tons)

Industry	1953–57 (average)	1958	1959	1960	1961	1962
Rubber	79,675	68,176	79,505	75,120	71,534	80,247
Paints	32,420	33,335	33,708	31,610	30,405	31,381
Ceramics	9,418	9,095	10,486	9,840	10.058	11,092
Coated fabrics and textiles [1]	7,674	2,327	2,125	1,331	1,185	202
Floor coverings	1,790	971	1,207	1,316	1,174	457
Other	21,758	22,087	27,203	25,561	30,852	31,470
Total	152,735	135,991	154,234	144,778	145,208	154,849

[1] Includes the following tonnages for rayon: 1957—2,838; 1958—1,149. Figures for 1959, 1960, 1961, and 1962 withheld to avoid disclosing individual company confidential data.

TABLE 23.—Distribution of leaded zinc oxide shipments, by industries

(Short tons)

Industry	1953–57 (average)	1958	1959	1960	1961	1962
Paints	31,174	23,021	20,748	17,616	16,533	14,959
Rubber, Other	368	267	1,878	1,662	1,474	735
Total	31,542	23,288	22,626	19,278	18,007	15,694

Lithopone was used in paint, varnish, and lacquer, coated fabrics and textiles, rubber, and floor covering.

The principal uses of zinc chloride were for battery making, galvanizing, vulcanizing fiber, preserving wood, and refining oil, as well as for fungicides, solder, and tinning fluxes.

The chief uses of zinc sulfate were in rayon and agriculture. Other uses were in glue manufacture, flotation reagents, rubber, and medicine.

TABLE 24.—Distribution of zinc sulfate shipments, by industries

(Short tons)

Year	Rayon		Agriculture		Other		Total	
	Gross weight	Dry basis	Gross weight	Dry basis	Gross weight	Dry basis	Gross weight	Dry basis
1953–57 (average)	13,468	11,900	7,779	6,735	4,939	3,912	26,186	22,547
1958	19,796	17,747	11,525	9,819	2,416	2,191	33,737	29,757
1959	26,062	23,354	5,262	4,696	9,346	7,428	40,670	35,478
1960	15,727	14,097	4,320	3,848	8,749	7,882	28,796	25,827
1961	12,284	11,007	5,673	5,086	10,934	9,926	28,891	26,019
1962	(1)	(1)	8,544	7,313	22,687	20,359	31,231	27,672

[1] Figure withheld to avoid disclosing individual company confidential data, included with "Other."

Prices.—American-process zinc oxide was quoted at 13.00 cents per pound in carlots throughout 1962. Leaded zinc oxide of the 35 percent grade was quoted at 13.875 cents per pound for carlots throughout 1962.

Quotations for Red-seal, Green-seal, and White-seal French-process zinc oxide in carlots remained unchanged at 14.75 cents per pound, 14.75 cents, and 15.00 cents, respectively.

Zinc chloride (50° Baumé) was quoted at 5.15 cents per pound throughout 1962. Zinc sulfate (Monohydrate, 36 percent) in less than carlots was quoted at 9.00 cents per pound but increased to 9.25 cents in May and remained at this level.

Foreign Trade.—Imports of zinc pigments and salts increased 21 percent in quantity but only 16 percent in value over that in 1961. Imports of zinc oxide increased to 12,900 tons and to 1,000 tons for zinc chloride.

TABLE 25.—U.S. imports for consumption of zinc pigments and salts

Kind	1961		1962	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Zinc oxide	10,222	$1,962	12,890	$2,325
Zinc sulfide	353	[1] 112	461	140
Lithopone	74	9	98	13
Zinc arsenate	----------	----------	1	(2)
Zinc chloride	800	137	1,000	168
Zinc sulfate	1,159	128	832	83
Total	12,608	[1] 2,348	15,282	2,729

[1] Revised figure.
[2] Less than $1,000.

Source: Bureau of the Census.

Exports of zinc oxide were 2,100 tons valued at $590,000, and lithopone exports were 350 tons valued at $68,000.

TABLE 26.—U.S. exports of zinc pigments

Kind	1961		1962	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Zinc oxide	2,183	$671	2,061	$590
Lithopone	608	88	350	68
Total	2,791	759	2,411	658

Source: Bureau of the Census.

STOCKS

National Stockpile.—There was 1,257,000 tons of zinc in the national (strategic) stockpile and 324,000 tons in the supplementary stockpile at the end of the year; a total of 1,581,000 tons at yearend.

Producer Stocks.—Smelter stocks of slab zinc were 146,900 tons at the beginning of 1962. By the end of March, inventories had declined to 139,000 tons, but thereafter they gradually increased to 168,900 tons by the end of September. At the yearend they had declined to 144,700 tons.

TABLE 27.—Stocks of zinc at zinc-reduction plants in the United States, Dec. 31

(Short tons)

	1958	1959	1960	1961	1962
At primary reduction plants	182,111	152,410	178,209	[1] 143,494	142,059
At secondary distilling plants	1,909	3,800	7,673	3,393	2,687
Total	184,020	156,210	185,882	[1] 146,887	144,746

[1] Revised figure.

Consumer Stocks.—Stocks of slab at consumer plants were 97,200 tons at the beginning of 1962. An almost steady decline during the first 9 months brought the total to the low level of about 62,000 tons at the end of September. Thereafter gradual increases brought the total to 80,200 by yearend. An additional 6,700 tons of slab zinc was in transit to consumer plants. At the average monthly rate of consumption, total consumer stocks plus metal in transit represented less than a 5-week supply.

TABLE 28.—Consumer stocks of slab zinc at plants Dec. 31, by industries

(Short tons)

	Galvanizers	Brass mills [1]	Zinc die-casters [2]	Zinc rolling mills	Oxide plants	Other	Total
Dec. 31, 1961 [3]	59,208	11,095	20,955	1,918	577	2,116	[4] 95,869
Dec. 31, 1962	43,121	8,786	24,827	1,297	271	1,734	[4] 80,036

[1] Includes brass mills, brass ingotmakers, and foundries.
[2] Includes producers of zinc-base diecastings, zinc-alloy dies, and zinc-alloy rods.
[3] Figures partly revised.
[4] Stocks on Dec. 31, 1961, and Dec. 31, 1962, exclude 1,286 and 207 tons, respectively, of remelt spelter.

PRICES

The quoted price for Prime Western zinc at East St. Louis was 12 cents per pound at the beginning of 1962 but decreased to 11.50 cents on April 3. This quotation held for the remainder of the year.

On the London Metal Exchange the yearly average quotation was £67.457 per ton (equivalent to 8.43 cents per pound computed at the exchange rate recorded by the Federal Reserve Board). For January the average was £70.213 (8.78 cents per pound). The average fell to £68.784 (8.67 cents) in February but increased slightly to £69.352 (8.74 cents) in March and to £69.428 (8.75 cents) in April. Thereafter, monthly average quotations continued to drop until October when the monthly average quotation rose to £66.030 (8.25 cents). By December, the average was £67.030 (8.38 cents).

During 1962 the quoted price for new clippings ranged from 5.00 to 5.25 cents per pound, averaging 5.12 cents. For old zinc, the quotation ranged from 3.00 to 3.25 cents and averaged 3.12 cents per pound.

TABLE 29.—Average monthly quoted prices of 60-percent zinc concentrate at Joplin, and of common zinc (prompt delivery or spot), East St. Louis and London [1]

Month	1961			1962		
	60-percent zinc concentrates in the Joplin region (per ton)	Metallic zinc (cents per pound)		60-percent zinc concentrates in the Joplin region (per ton)	Metallic zinc (cents per pound)	
		East St. Louis	London [2 3]		East St. Louis	London [2 3]
January	$69.09	11.56	9.81	$72.00	12.00	8.78
February	68.00	11.50	10.25	72.00	12.00	8.67
March	68.00	11.50	10.44	72.00	12.00	8.74
April	68.00	11.50	10.48	68.00	11.51	8.75
May	68.00	11.50	10.34	68.00	11.50	8.62
June	68.00	11.50	10.01	68.00	11.50	8.37
July	68.00	11.50	9.80	68.00	11.50	8.26
August	68.00	11.50	9.67	68.00	11.50	8.07
September	68.00	11.50	9.39	68.00	11.50	8.01
October	68.00	11.50	9.18	68.00	11.50	8.25
November	68.00	11.50	8.91	68.00	11.50	8.56
December	72.00	12.00	9.05	68.00	11.50	8.38
Average for year	68.42	11.55	9.78	69.00	11.63	8.43

[1] Joplin: Metal Statistics, 1963, p. 517. East St. Louis: Metal Statistics, 1963, p. 515. London: E&MJ Metal and Mineral Markets.
[2] Conversion of English quotations into U.S. 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 30.—Average price received by producers of zinc, by grades

(Cents per pound)

Grade	1958	1959	1960	1961	1962
Special High Grade	10.45	11.78	13.68	11.58	11.43
High Grade	10.13	11.42	13.19	11.42	11.47
Intermediate	10.81	11.85	13.34	12.12	11.84
Brass Special	10.38	11.39	12.89	11.52	11.76
Select	10.48	10.93	12.64	11.60	12.88
Prime Western	9.98	11.18	12.15	11.32	11.45
All grades	10.22	11.47	12.85	11.45	11.47
Prime Western; spot quotation at St. Louis [1]	10.31	11.46	12.95	11.55	11.63

[1] Metal Statistics, 1963, p. 515.

FOREIGN TRADE

Import quotas imposed October 1, 1958, by Presidential Proclamation 3257, dated September 22, 1958, remained in effect through 1962. Quotas limited annual competitive imports of unmanufactured zinc (not including zinc fume) to 379,840 tons in ores and concentrates and 141,120 tons as metal. Quotas established were 80 percent of the average dutiable imports into the United States during 1953–57. Specific quotas based on a calendar quarter for zinc in ore were assigned as follows: Mexico, 35,240 tons; Canada, 33,240 tons; Peru, 17,560 tons; and all other countries combined, 8,920 tons. Quarterly quotas for zinc in blocks, pigs, and slabs and in zinc-base scrap, but excluding zinc dust, were assigned as follows: Canada, 18,920 tons; Belgium-

Luxembourg, 3,760 tons; Mexico, 31,160 tons; Republic of the Congo, 2,720 tons; Peru, 1,880 tons; Italy, 1,800 tons; and all other countries combined, 3,040 tons.

Imports.—General imports (imports for immediate consumption plus entries into bonded warehouses) presented in table 31 show all physical entries of unmanufactured zinc into the United States. General im-

TABLE 31.—U.S. imports [1] of zinc, by countries

(Short tons)

Country	1953–57 (average)	1958	1959	1960	1961	1962
Ores (zinc content):						
North America:						
Canada	166,241	155,506	152,134	120,336	119,113	192,423
Cuba	1,214	223	188	78	----------	----------
Guatemala	7,866	6,483	8	6,063	13,870	2,511
Honduras	1,548	1,435	1,427	4,714	6,851	7,048
Mexico	183,361	158,609	182,409	190,621	186,174	165,005
Other	1	(2)	1	----------	----------	----------
Total	360,231	322,256	336,167	321,812	326,008	366,987
South America:						
Argentina	33	9	101	----------	----------	----------
Bolivia	10,146	7,328	2,530	1,214	572	1,791
Chile	2,330	977	479	30	(2)	518
Peru	95,808	102,990	86,672	80,100	74,369	77,501
Other	156	121	66	58	53	13
Total	108,473	111,425	89,848	81,402	74,994	79,823
Europe:						
Germany, West	2	----------	5,756	2	11	----------
Italy	1,748	----------	14,766	----------	----------	----------
Spain	1,723	----------	16,479	18,913	----------	----------
Other	5,014	80	3,613	100	109	19
Total	8,487	80	40,614	19,015	120	19
Asia:						
Philippines	924	92	48	4,774	3,203	24
Other	184	240	1	24	----------	----------
Total	1,108	332	49	4,798	3,203	24
Africa:						
South Africa, Republic of [3]	11,407	21,700	7,957	12,300	7,551	9,589
Other	940	1,032	787	39	2	----------
Total	12,347	22,732	8,744	12,339	7,553	9,589
Oceania: Australia	9,066	[4] 4,735	24,693	17,789	3,822	10,956
Grand total: Ores	499,712	461,560	500,115	457,155	415,700	467,398
Blocks, pigs, or slabs:						
North America:						
Canada	109,464	93,475	88,414	74,168	71,628	72,825
Mexico	20,755	23,256	9,338	8,950	8,598	12,334
Total	130,219	116,731	97,752	83,118	80,226	85,159
South America: Peru	10,891	9,736	12,337	7,517	7,519	7,615
Europe:						
Austria	663	110	220	----------	----------	----------
Belgium-Luxembourg	22,671	21,707	7,666	5,724	12,854	23,232
Germany, West	9,543	2,673	55	2,680	779	1,162
Italy	11,789	6,166	7,459	3,517	1,820	992
Netherlands	3,069	2,520	----------	----------	120	----------
Norway	1,509	2,769	168	----------	----------	----------
Spain	----------	----------	----------	2,986	6,756	2,572
United Kingdom	1,764	672	841	333	(2)	----------
Yugoslavia	2,662	5,781	3,643	4,520	3,198	3,310
Other	55	----------	----------	----------	441	640
Total	53,725	42,398	20,052	19,760	25,968	31,908
Asia: Japan	1,554	2,039	----------	----------	----------	----------

See footnotes at end of table.

TABLE 31.—U.S. imports[1] of zinc, by countries—Continued

(Short tons)

Country	1953–57 (average)	1958	1959	1960	1961	1962
Blocks, pigs, or slabs—Continued						
Africa:						
Congo, Republic of the, and Ruanda-Urundi [5]	16,159	20,991	12,790	9,307	11,420	10,882
Rhodesia and Nyasaland, Federation of [6]	1,176	1,064	4,667	615	1,400	4,643
Other	925					
Total	18,260	22,055	17,457	9,922	12,820	15,525
Oceania: Australia	5,574	2,240	9,365	450	1,029	1,750
Grand total: Blocks, pigs, or slabs	220,223	195,199	156,963	120,767	127,562	141,957

1 Data include zinc imported for immediate consumption plus material entering country under bond.
2 Less than 1 ton.
3 Effective Jan. 1, 1962; formerly Union of South Africa.
4 Includes 52 tons imported from French Pacific Islands.
5 Effective July 1, 1960; formerly Belgian Congo.
6 Effective July 1, 1954; formerly Northern Rhodesia.

Source: Bureau of the Census.

ports of zinc in ores and concentrates increased 13 percent to the highest level since 1959. Canada, Mexico, Peru, Australia, the Republic of South Africa, and Honduras supplied the bulk of these imports. Slab zinc imports of metal rose to 142,000 tons and were supplied mostly by Canada, Belgium-Luxembourg, Mexico, the Republic of the Congo, Peru, and the Federation of Rhodesia and Nyasaland.

TABLE 32.—U.S. imports for consumption[1] of zinc, by classes

Year	Ore (zinc content)		Blocks, pigs, slabs		Sheets	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1953–57 (average)	491,419	[2] $54,992	219,280	[2] $51,922	414	[2] $146
1958	537,699	51,121	185,693	35,511	901	285
1959	424,134	37,475	164,462	33,996	951	311
1960	382,938	38,704	120,925	29,639	904	302
1961	357,653	31,920	125,186	27,540	1,183	354
1962	387,321	31,817	135,995	28,478	1,315	367

Year	Old and worn out		Dross and skimmings		Zinc dust		Total value [3]
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	
1953–57 (average)	870	$94	826	$81	260	[2] $45	[2] $107,280
1958	235	31	737	77	96	14	87,039
1959	183	26	955	116	44	6	71,930
1960	106	14	1,099	175	19	7	68,841
1961	303	32	1,107	146	86	28	60,020
1962	861	120	1,907	286	909	207	61,275

1 Excludes imports for manufacture in bond and export, which are classified as "imports for consumption" by Bureau of the Census.
2 Data known to be not comparable with other years.
3 In addition manufactures of zinc were imported as follows: [2] 1953–57 (average), $157,819; 1958—$389,803; 1959—$811,916; 1960—$836,871; 1961—$787,496; 1962—$1,138,940.

Source: Bureau of the Census.

Imports for consumption (imports for immediate consumption plus withdrawals from bonded warehouses for consumption) given in table 33 give a close approximation of dutiable imports of unmanufactured zinc entering the United States. Imports of zinc fume, excluded from the quota restrictions, amounted to approximately 33,000 tons, aver-

TABLE 33.—U.S. imports for consumption [1] of zinc, by countries

(Short tons)

Country	1953–57 (average)	1958	1959	1960	1961	1962
Ores (zinc content):						
North America:						
Canada	171,609	169,474	137,426	133,080	110,312	135,430
Cuba	556	52	72	17	----------	----------
Guatemala	7,980	6,093	10	1,811	7,244	8,375
Honduras	944	1,428	1,116	2,140	1,574	4,154
Mexico	181,620	208,202	147,877	142,478	140,057	139,374
Other	(2)	111	1	----------	(2)	(2)
Total	362,709	385,360	286,502	279,526	259,187	287,333
South America:						
Argentina	21	9	(2)	45	6	4
Bolivia	9,206	6,838	1,704	790	1,018	681
Chile	2,230	1,072	34	5	7	216
Peru	91,235	110,165	80,616	71,391	69,473	75,333
Other	119	121	(2)	49	75	18
Total	102,811	118,205	82,354	72,280	70,579	76,252
Europe:						
Germany, West	2	----------	7,290	----------	12	1
Italy	1,744	----------	9,930	4,241	2,189	695
Spain	3,463	----------	13,476	10,405	8,122	947
Other	4,947	11	2,344	982	----------	----------
Total	10,156	11	33,040	15,628	10,323	1,643
Asia:						
Philippines	609	92	29	679	4,426	2,663
Other	628	211	----------	1	16	(2)
Total	1,237	303	29	680	4,442	2,663
Africa:						
South Africa, Republic of [3]	7,384	27,190	4,331	5,333	6,218	10,391
Other	549	524	1,140	131	9	11
Total	7,933	27,714	5,471	5,464	6,227	10,402
Oceania: Australia	6,573	[4] 6,106	16,738	9,360	6,895	9,028
Grand total: Ores	491,419	537,699	424,134	382,938	357,653	387,321
Blocks, pigs, or slabs:						
North America:						
Canada	109,464	93,327	88,414	74,168	71,628	72,850
Mexico	19,689	22,804	9,718	8,675	8,527	12,334
Total	129,153	116,131	98,132	82,843	80,155	85,184
South America: Peru	10,890	9,736	12,337	7,517	7,582	7,615
Europe:						
Austria	663	55	305	2	----------	----------
Belgium-Luxembourg	22,706	17,969	11,648	5,724	12,380	16,829
Germany, West	9,669	2,035	662	1,619	1,431	1,889
Italy	11,821	5,816	7,173	4,237	1,820	992
Netherlands	3,069	730	1,705	----------	----------	----------
Norway	1,509	2,601	329	7	----------	----------
Spain	----------	----------	----------	2,809	4,560	2,429
United Kingdom	1,764	112	1,363	373	(2)	----------
Yugoslavia	2,594	5,009	3,384	5,640	3,277	2,750
Other	55	----------	----------	----------	417	642
Total	53,850	34,327	26,569	20,411	23,885	25,531
Asia: Japan	1,554	1,708	355	----------	----------	----------

See footnotes at end of table.

TABLE 33.—U.S. imports for consumption[1] of zinc, by countries—Continued

(Short tons)

Country	1953–57 (average)	1958	1959	1960	1961	1962
Blocks, pigs, or slabs—Continued						
Africa:						
Congo, Republic of the, and Ruanda-Urundi[5]	16,159	20,991	12,790	9,308	11,420	10,882
Rhodesia and Nyasaland, Federation of[6]	1,825	560	4,840	396	1,107	5,033
Other	275	----------	298	----------	8	----------
Total	18,259	21,551	17,928	9,704	12,535	15,915
Oceania: Australia	5,574	2,240	9,141	450	1,029	1,750
Grand total: Blocks, pigs, or slabs	219,280	185,693	164,462	120,925	125,186	135,995

[1] Excludes imports for manufacture in bond and export, classified as "imports for consumption" by Bureau of the Census. [2] Less than 1 ton.
[3] Effective Jan. 1, 1962; formerly Union of South Africa.
[4] Includes 52 tons imported from French Pacific Islands.
[5] Effective July 1, 1960; formerly Belgian Congo.
[6] Effective July 1, 1954; formerly Northern Rhodesia.

Source: Bureau of the Census.

aging 77 percent zinc (43,000 tons in 1961). Mexico was the source of this material.

Exports.—Exports of slab zinc continued to fall, declining to 36,100 tons. India received 90 percent and the Republic of Korea received about 3 percent of total exports.

Tariff.—Duty on slab zinc remained unchanged throughout 1962 at 0.7 cent per pound; duty on zinc contained in ore and concentrate remained at 0.6 cent per pound; and duty on zinc scrap remained at 0.75 cent per pound. The duty on zinc fume continued at 15 percent ad valorem and on zinc dust, at 0.7 cent per pound.

TABLE 34.—U.S. exports of slab and sheet zinc, by countries

(Short tons)

Destination	Slabs, pigs, and blocks				Sheets, plates, strips, or other forms, n.e.s.			
	1959	1960	1961	1962	1959	1960	1961	1962
North America:								
Canada	13	11	382	495	1,790	1,516	1,356	1,512
Cuba	114	105	----	----	76	64	----	----
Mexico	1,255	1,119	----	1	316	283	56	21
Other	55	1	19	16	71	42	65	80
Total	1,437	1,236	401	512	2,253	1,905	1,477	1,613
South America:								
Argentina	43	----	61	----	----	17	35	36
Brazil	135	2,414	4,598	262	26	28	27	12
Chile	523	10	314	39	14	53	36	43
Colombia	37	1,045	404	----	134	55	55	213
Venezuela	----	10	161	7	105	75	78	119
Other	----	463	233	110	11	12	18	24
Total	738	3,942	5,771	418	290	240	249	447
Europe:								
Belgium-Luxembourg	1,624	340	----	----	19	3	21	20
Denmark	----	140	56	----	111	107	173	164
Germany, West	56	3,364	336	2	174	121	63	32
Italy	----	560	224	----	4	12	33	29
Netherlands	280	2,522	2,252	----	60	42	170	127
Sweden	2,475	4,847	1,993	----	123	84	140	231
Switzerland	----	336	----	----	133	142	165	221
United Kingdom	4,065	25,394	12,265	112	162	302	335	242
Other	----	700	1,806	733	81	103	229	228
Total	8,500	38,203	18,932	847	867	916	1,329	1,294
Asia:								
India	635	11,172	10,490	32,625	3	3	10	19
Japan	25	18,125	7,353	1	1	----	29	----
Korea, Republic of	----	75	3,139	903	----	----	1	1
Philippines	----	979	1,685	10	35	54	22	37
Other	14	1,403	2,274	680	4	97	9	40
Total	674	31,754	24,941	34,219	43	154	71	97
Africa:								
South Africa, Republic of	----	----	----	----	50	74	76	80
Other	----	9	8	106	4	2	4	3
Total	----	9	8	106	54	76	80	83
Oceania	280	----	2	----	22	33	13	13
Grand total	11,629	75,144	50,055	36,102	3,529	3,324	3,219	3,547

Source: Bureau of the Census.

TABLE 35.—U.S. exports of zinc ore and manufactures of zinc

Year	Zinc ore, concentrates (zinc content)		Slabs, pigs, or blocks		Sheets, plates, strips, or other forms n.e.s.		Zinc scrap and dross (zinc content)		Semifabricated forms, n.e.c.		Zinc dust	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1953–57 (average)	763	$184	16,126	$3,842	4,166	$2,599	11,938	$1,361	509	$250	485	$165
1958	----	----	2,073	704	[1]3,818	[1]2,637	5,344	364	11,168	542	519	170
1959	1	(2)	11,629	2,673	[1]3,529	[1]2,708	11,332	1,053	[1]1,071	612	521	182
1960	13	3	75,144	18,122	[1]3,324	[1]2,443	12,169	1,499	[1]2,569	1,195	777	267
1961	1,670	124	50,055	11,196	[1]3,219	[1]2,271	5,900	871	[1]3,036	1,317	717	224
1962	136	46	36,102	8,050	[1]3,547	[1]2,391	7,940	956	[1]1,613	1,254	676	240

[1] Owing to changes in classification by Bureau of the Census, data not strictly comparable to earlier years.
[2] Less than $1,000.

Source: Bureau of the Census.

WORLD REVIEW

NORTH AMERICA

Canada.—Production of zinc in all forms totaled 457,144 tons, 10 percent more than in 1961. The increase was accounted for by new mines in Quebec which completed their first full year of production and by expanded output at long-established mines, mostly in British Columbia and Ontario. Refined zinc production from Canada's two electrolytic zinc refineries at Trail, British Columbia (Consolidated Mining &

TABLE 36.—World mine production of zinc (content of ore) recoverable where indicated, by countries [1 2 3]

(Short tons)

Country [2]	1953–57 (average)	1958	1959	1960	1961	1962
North America:						
Canada	[4] 409,597	[4] 425,099	[4] 396,008	[4] 406,873	[5] 443,099	[5] 501,937
Cuba	[6] 1,175	[7] 110	[8] 188	[8] 77	------	------
Greenland [7]	[9] 7,700	6,700	8,400	11,000	8,800	4,400
Guatemala [4]	8,795	5,278	------	11,069	8,737	[8] 2,511
Honduras [8]	1,548	1,435	1,427	4,714	6,851	7,048
Mexico	267,072	247,033	290,938	289,274	296,492	276,330
United States [4]	521,929	412,005	425,303	435,427	464,390	505,491
Total	1,217,816	1,097,660	1,122,264	1,158,434	1,228,369	1,297,717
South America:						
Argentina	24,116	40,100	44,100	38,200	33,300	[7] 33,600
Bolivia (exports)	22,566	15,677	3,740	4,439	5,878	4,020
Chile	2,813	1,340	1,117	1,159	179	[7] 154
Colombia [7]	------	------	800	350	800	300
Peru	174,897	149,094	[4] 157,739	[4] 196,346	[4] 191,658	[4] 183,258
Total	224,392	206,211	207,496	240,494	231,815	221,332
Europe:						
Austria	5,591	6,463	6,522	7,250	6,651	7,264
Bulgaria	37,000	67,200	75,500	84,900	81,500	[7] 95,000
Finland	24,391	51,826	59,588	46,328	51,363	57,509
France	13,348	16,386	17,616	18,933	17,196	17,747
Germany:						
East [7]	7,300	7,700	7,700	7,700	7,700	7,700
West	102,384	94,232	90,566	95,159	96,134	95,634
Greece	8,000	17,300	13,200	16,200	19,342	20,100
Ireland	1,980	463	1,303	1,377	184	------
Italy	131,969	151,010	146,089	143,541	147,954	145,505
Norway	6,746	10,016	10,907	11,395	10,285	12,566
Poland	174,760	135,300	142,500	158,800	153,857	159,961
Spain	95,157	90,764	94,645	94,920	96,983	83,417
Sweden	65,250	77,808	86,549	77,491	82,893	69,856
U.S.S.R. [7 10]	280,000	360,000	370,000	380,000	440,000	440,000
United Kingdom	2,582	283	------	------	------	------
Yugoslavia	64,490	66,160	66,882	62,150	66,009	67,365
Total [2 7]	1,030,800	1,167,000	1,204,000	1,220,000	1,292,000	1,290,000
Asia:						
Burma	7,600	12,100	12,100	11,000	8,100	8,900
China [7]	30,000	50,000	72,000	88,000	110,000	110,000
India	3,400	4,300	6,000	5,900	5,600	6,100
Iran [11]	5,700	9,900	7,400	9,400	14,900	8,300
Japan	126,476	157,601	156,899	172,769	185,474	212,036
Korea:						
North [7]	55,000	90,000	90,000	90,000	90,000	90,000
Republic of	154	369	4	46	496	463
Philippines	441	------	6	5,487	3,652	4,905
Thailand	2,480	600	840	1,170	990	[7] 1,000
Turkey [7]	2,890	2,094	1,653	2,976	2,205	5,071
Total [7]	234,000	327,000	347,000	387,000	421,000	447,000

See footnotes at end of table.

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TABLE 36.—World mine production of zinc (content of ore) recoverable where indicated, by countries[1 2 3]—Continued

(Short tons)

Country[2]	1953-57 (average)	1958	1959	1960	1961	1962
Africa:						
Algeria	31,287	36,725	42,774	44,240	47,000	45,900
Congo, Republic of the (formerly Belgian)	110,705	125,646	77,131	120,352	109,828	105,530
Morocco	44,981	54,257	61,301	54,199	44,951	37,919
Rhodesia and Nyasaland, Federation of: Northern Rhodesia	34,933	38,034	46,497	49,242	50,081	50,307
South-West Africa[4]	21,427	15,896	12,394	13,119	14,905	25,201
Tunisia	5,021	4,566	3,656	4,212	3,743	4,709
Total	248,354	275,124	243,753	285,364	270,508	269,566
Oceania: Australia	294,768	294,610	279,030	325,051	322,795	342,023
World total (estimate)[2]	3,250,000	3,370,000	3,400,000	3,620,000	3,770,000	3,870,000

[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 (Overseas Geological Surveys, London).
[2] Czechoslovakia and Rumania also produce zinc, but production data are not available; estimates for these countries are included in totals.
[3] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[4] Recoverable.
[5] Data for 1961 and 1962 not strictly comparable to previous years.
[6] Average annual production 1955-57.
[7] Estimate.
[8] United States imports.
[9] Average annual production 1956-57.
[10] Smelter production.
[11] Year ended March 20 of year following that stated.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

Smelting Co. of Canada, Ltd.), and Flin Flon, Manitoba (Hudson Bay Mining & Smelting Co., Ltd.), totaled 280,158 tons, compared with 268,006 tons in 1961. Exports of zinc in ores and concentrates rose markedly, with all of the increase going to the United States. European imports from Canada were much lower; this was largely accounted for by decreased exports to West Germany. The quarterly U.S. zinc import quotas for Canada—33,240 tons of zinc in ores and concentrates and 18,920 tons of refined zinc and other metallic forms—were filled for all quarters in 1962.[12]

Consolidated Mining & Smelting Co. of Canada, Ltd., established a new record of zinc production at 199,363 tons (193,649 tons in 1961). The combined zinc-lead production was derived from Sullivan mine concentrates (approximately 69 percent) from concentrates from other company mines (13 percent), from treatment of stockpiles of zinc plant residues and lead-blast-furnace slag (6 percent), and from purchased ores and concentrates (12 percent). Reclamation of the zinc plant residues was completed by mid-1962, but changes in the electrolytic zinc plant permitted treatment of additional zinc concentrates to replace the production lost from residues. The distribution of the total zinc and lead sold in 1962 was about 24 percent to Canada, 32 percent to the United States, 30 percent to the United Kingdom, and 14 percent to other countries. Extraction of ore from

[12] Patterson, J. W. Miner. Res. Division, Dept. of Mines and Tech. Surveys (Ottawa, Canada), Miner. Inf. Bull. MR-63, 1963, pp. 28-32.

TABLE 37.—World smelter production of zinc by countries [1] [2] [3]

(Short tons)

Country	1953-57 (average)	1958	1959	1960	1961	1962
North America:						
Canada	252,750	252,093	255,306	260,968	268,006	280,158
Mexico [4]	61,065	63,329	61,362	58,318	57,119	62,730
United States	930,288	781,246	798,666	799,516	846,795	879,395
Total	1,244,103	1,096,668	1,115,334	1,118,802	1,171,920	1,222,283
South America:						
Argentina	14,430	17,400	14,100	17,600	15,900	18,500
Peru	17,691	32,034	29,595	35,712	35,006	35,566
Total	32,121	49,434	43,695	53,312	50,906	54,066
Europe:						
Austria	[5] 6,572	11,698	12,608	12,700	13,302	13,325
Belgium [6]	239,156	236,730	247,250	272,891	270,670	227,248
Bulgaria	[5] 5,405	9,076	10,024	18,639	24,385	24,000
France	120,568	163,606	161,218	165,785	178,482	181,405
Germany:						
East [7]	-----------	-----------	-----------	-----------	4,400	11,000
West	190,554	146,816	152,046	156,299	155,373	143,127
Italy	75,095	80,020	81,497	87,518	86,424	85,613
Netherlands	30,579	29,285	35,445	39,771	43,643	40,837
Norway	49,802	50,180	53,767	48,460	51,287	48,688
Poland	165,075	179,252	185,263	193,501	200,633	199,400
Spain	25,392	27,239	27,039	49,565	57,865	68,925
U.S.S.R.[7]	280,000	360,000	370,000	380,000	440,000	440,000
United Kingdom	88,178	83,537	81,722	83,220	104,030	108,949
Yugoslavia	20,124	34,445	35,220	39,612	40,640	43,325
Total [1] [7]	1,304,000	1,423,000	1,464,000	1,559,000	1,682,000	1,644,000
Asia:						
China (refined) [7]	28,700	45,000	66,000	77,000	100,000	100,000
Japan	125,190	155,401	175,642	198,920	234,163	270,401
Korea, North [7]	[8] 5,300	22,000	27,000	50,000	65,000	65,000
Total [7]	159,000	222,000	269,000	326,000	399,000	435,000
Africa:						
Congo, Republic of the (formerly Belgian)	36,386	58,905	60,418	58,817	62,788	61,600
Rhodesia and Nyasaland, Federation of: Northern Rhodesia	31,058	33,880	33,483	33,368	33,444	44,624
Total	67,444	92,785	93,901	92,185	96,232	106,224
Oceania: Australia	114,494	128,546	130,436	134,658	155,338	188,078
World total (estimate)	2,920,000	3,010,000	3,120,000	3,280,000	3,560,000	3,650,000

[1] Czechoslovakia and Rumania also produce zinc, but production data are not available; estimates are included in the totals.
[2] Data derived in part from the Yearbook of the American Bureau of Metal Statistics, the United Nations Monthly Bulletin and Statistical Yearbook, and the Statistical Summary of the Mineral Industry (Overseas Geological Surveys, London).
[3] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[4] In addition, other zinc-bearing materials were as follows: 1953-57 (average), 30,376 short tons; 1958, 19,572; 1959, 314; 1960, 1,246; 1961, 1,992; and 1962, 1,795.
[5] Average annual production 1955-57.
[6] Includes production from reclaimed scrap.
[7] Estimate.
[8] One year only as 1957 was the first year of commercial production.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

company properties increased at the Sullivan mine to 2,583,000 tons from 2,462,000 tons in 1961; however, extraction declined slightly at the Bluebell lead-zinc mine (from 253,000 tons in 1961 to 238,000 tons in 1962) and at the H. B. zinc-lead mine (from 473,000 tons in 1961 to 469,000 tons in 1962). Pine Point Mines, Ltd., a subsidiary, proceeded with engineering design and initial work to bring the Pine Point mine into production in 1966.[13]

According to the annual report of Reeves MacDonald Mines, Ltd., the company operated its Remac, British Columbia, mine at capacity and produced 33,518 dry tons of concentrates from 417,448 tons of ore. The concentrates contained 14,600 tons of zinc, 4,581 tons of lead, 167,000 pounds of cadmium, and 41,800 ounces of silver. Development work consisted of 408 feet of shaft sinking, 7,000 feet of drifts and raises, 130 feet of station cutting, and 7,100 feet of diamond drilling.[14]

Sheep Creek Mines, Ltd., Windermere, British Columbia, reported production for the year ending May 31, 1962, to be 210,407 tons of ore grading 5.80 percent zinc and 2.63 percent lead, yielding concentrates containing 10,894 tons of zinc, 4,787 tons of lead, 35 tons of copper, 55,454 pounds of cadmium, and 240,000 ounces of silver. Both zinc and lead concentrates were sold in the United States. Development totaled 4,000 feet of drifting and crosscutting, 1,400 feet of raising, and 25,800 feet of underground diamond drilling. The cost of mining was $2.52 and the cost of milling was $1.45. The ore reserve as of June 1, 1962, was 488,200 tons averaging 5.71 percent zinc, 2.18 percent lead, and 1.5 ounces of silver. The company was associated with prospecting syndicates operating in the Mattagami and Ungava districts of Quebec.[15]

Hudson Bay Mining & Smelting Co., Ltd., the second largest producer of zinc in Canada, milled 1,702,000 tons of ore in 1962 derived almost wholly from its own mines; 54.8 percent came from the Flin Flon mine, 20.0 percent came from the Coronation mine, 19.9 percent came from the Chisel Lake mine, 5.2 percent came from the Schist Lake mine, and 0.1 percent came from purchased ore. Production of slab zinc was 80,800 tons, the highest in the company's history. Production of other metals included: Copper, cadmium, selenium, gold, and silver. In addition, a lead concentrate was produced containg 4,000 tons of lead, 10,400 ounces of gold, and 417,000 ounces of silver. Development and exploration at the company's four operating mines consisted of 28,000 feet of underground workings and 21,000 feet of diamond drilling. Substantial development work was also done at the Stall Lake and Osborne Lake mines. Proven ore reserves as of December 31, 1962, totaled 14,934,000 tons averaging 4.9 percent zinc, 2.77 percent copper, 0.3 percent lead, 0.89 ounce of silver per ton, and 0.056 ounce of gold per ton.[16]

Willroy Mines, Ltd., reported milling 495,028 tons of ore from its Manitouwadge, Ontario, operations averaging 5.56 percent zinc, 1.70 percent copper, 0.14 percent lead, and 1.43 ounces of silver per ton. The concentrates produced contained 21,270 tons of zinc and recoverable amounts of copper, lead, silver, and gold. Unit costs for mining and milling per ton of ore milled were $2.08 and $1.36, respectively. Development included 200 feet of shaft sinking, 3,800 feet of crosscuts, drifts, and raises, and 46,500 feet of underground diamond drilling. Total ore reserves including indicated ore, as of January 1, 1963,

[13] Consolidated Mining & Smelting Co. of Canada, Ltd. Annual Report. 1962, pp. 4–5.
[14] Reeves MacDonald, Ltd. Annual Report. 1962, p. 1.
[15] Sheep Creek Mines, Ltd. Annual Report. 1962, pp. 3–5.
[16] Hudson Bay Mining & Smelting Co. Annual Report. 1962, pp. 7–8.

amounted to 2,002,900 tons averaging 3.27 percent zinc, 1.64 percent copper, and 1.11 ounces of silver per ton.[17]

Geco Mines, Ltd., at its Manitouwadge, Ontario, operations milled 1,280,000 tons of ore in 1962 with a calculated grade of 4.68 percent zinc, 1.81 percent copper, and 2.14 ounces per ton of silver; it also produced separate copper, lead, and zinc concentrates. The zinc concentrates were shipped to smelters in the United States and Europe, the lead concentrate to a smelter in the Western United States, and the copper concentrates to the Noranda smelter. The zinc concentrate contained 49,350 tons of zinc, 17 percent more than in 1961. Based on drilling during the year and detailed recalculation, the ore reserve for 1962 was 22,046,000 tons averaging 4.67 percent zinc, 2.00 percent copper, and 2.32 ounces of silver per ton.[18]

In Quebec, Quemont Mining Corp., Ltd., milled 804,600 tons of ore containing 2.64 percent zinc plus copper, silver, gold, and pyrite. The zinc concentrate produced contained 15,760 tons of zinc.[19] Solbec Copper Mines, Ltd., started milling operations in February 1962 and, for the remainder of the fiscal year ending August 31, produced 6,400 tons of zinc in concentrates from 158,000 tons of ore averaging 4.89 percent zinc. Development of the property included 700 feet of shaft sinking and 14,500 feet of diamond drilling to delineate the main ore body above the 875-foot level. Ore reserves on September 1, 1962, were 1,132,750 tons grading 4.06 percent zinc, 2.19 percent copper, 0.54 percent lead, 0.019 ounce of gold per ton, and 1.382 ounces of silver per ton.[20] Cupra Mines, Ltd., completed construction of the surface plant and resumed shaft sinking in August 1962. The ore body of Cupra was expected to be ready for mining in 1964.[21] Sullico Mines, Ltd., mined and milled 997,400 tons of ore producing a zinc concentrate containing 4,700 tons of zinc.[22] Other Quebec producers of zinc concentrate included Normetal Mining Corp., Ltd., which milled 354,751 tons of ore averaging 5.17 percent zinc, 2.71 percent copper, 0.026 ounce of gold per ton, and 1.88 ounces of silver per ton, and yielding 28,000 tons of zinc concentrate containing 14,800 tons of zinc. Ore reserves December 31, 1962, were 1,132,000 tons with 4.88 percent zinc and 3.53 percent copper.[23] Waite Amulet Mines, Ltd., was absorbed by Noranda Mines, Ltd. Mining of the Waite Amulet and Amulet Dufault ore bodies was completed on October 26, 1962, and mine and mill equipment was being salvaged for use elsewhere.[24]

The Coniagas Mines, Ltd., in northwestern Quebec reported production in the year ending December 31, 1962, as having a net value of $1,479,610 with a mine operating profit of $484,000. Comparative figures for 1961 were a net value of $1,285,000 and an operating profit of $481,600. Ore reserves were reported at 147,731 tons averaging 14.04 percent zinc, 1.73 percent lead, and 5.37 ounces of silver per ton.[25]

Canadian Electrolytic Zinc, Ltd., began construction of a 200-ton-per-day electrolytic zinc reduction plant at Valleyfield near Montreal

[17] Willroy Mines, Ltd. Annual Report. 1962, pp. 2–3.
[18] Geco Mines, Ltd. Annual Report. 1962, pp. 8–10.
[19] Quemont Mining Corp., Ltd. Annual Report. 1962, p. 4.
[20] Solbec Copper Mines, Ltd. Annual Report. 1962, pp. 31–32.
[21] Cupra Mines, Ltd. Annual Report. 1962, p. 34.
[22] Sullico Mines, Ltd. Annual Report. 1962, p. 17.
[23] Normetal Mining Corp., Ltd. Annual Report. 1962, pp. 3–4.
[24] Noranda Mines, Ltd. Annual Report. 1962, p. 18.
[25] Northern Miner. V. 49, No. 15, July 4, 1963, p. 2.

in January 1962, and the main process buildings were almost ready for equipment installation by yearend. Completion in the latter part of 1963 was anticipated. The plant was owned by five mining companies: Mattagami Lake Mines, Ltd., Orchan Mines, Ltd., Geco Mines, Ltd., Quemont Mining Corp., Ltd., and Normetal Mining Corp., Ltd. Noranda Mines, Ltd., was responsible for management and sales.[26] Mattagami Lake Mines, Ltd., Orchan Mines, Ltd., and New Hosco Mines, Ltd., announced intentions of beginning production in 1963.

In the New Brunswick Bathurst area, Heath Steele Mines, Ltd., began milling ore in January from the nearby Wedge mine of Consolidated Mining and Smelting Co. of Canada, Ltd., in one section of the mill and activated the other section in June for treatment of its own ore.[27] The Brunswick Mining & Smelting Corp., Ltd., completed financial arrangements to bring its lead-zinc properties into production at the rate of 3,000 tons of ore per day in early 1964. Contracts were awarded to cover mine development and mill construction.[28] The company has a contract to deliver concentrates to Société Générale des Minerais in Belgium for 12 years.[29]

In Newfoundland, Buchans Mining Co., Ltd., completed preproduction development work at the MacLean mine, and full production from this ore body commenced in January 1963.[30]

Mexico.—Zincamer, S.A., a company formed by the Mexican Government began constructing the $9.6 million zinc smelter at Saltillo, Coahuila on May 7, 1962. The plant was designed to produce 30,000 tons of zinc and 60,000 tons of sulfuric acid.[31] The Government invited private companies to participate, offering stock first to Mexican investors. Six percent of the stock was owned by the Belgian firm Syndicat Belge d'Enterprises à l'Etranger (SYBETRA) which is expected to assume operation of the facility upon completion of construction scheduled for September or October 1964.[32]

The regulations to the Mining Law of February 6, 1961 were published in the Diario Oficial of February 28, 1962. In accordance with Transitory Article 14 of the regulations, its provisions were to enter into force 30 days after the date of their publication. The Ministry of National Patrimony set April 5, 1962 as the date when the regulations would be in force.[33]

American Smelting and Refining Company operated its Mexican mines and plants without interruption throughout 1962. The company continued its efforts to Mexicanize its subsidiary operations in Mexico. When accomplished, the company planned to proceed with a number of projects for expanding the mines and plants.

American Metal Climax, Inc., owned 49 percent of Metalurgica Mexicana Peñoles, S.A., the Mexicanized organization that conducted the corporation's former metal business. This firm had not received

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26 Page 20 of work cited in footnote 24.
27 American Metal Climax, Inc. Annual Report. 1962, p. 30.
28 Work cited in footnote 12.
29 Mining Journal. Annual Review 1963. May 1963, p. 205.
30 American Smelting and Refining Co. Annual Report. 1962, p. 13.
31 Commission De Fomento Minero, Mexico Mineral News, May 1962.
32 Chemical Week. V. 91, No. 11, Sept. 15, 1962, p. 112.
33 U.S. Embassy, Mexico City, Mexico. State Department Airgram A-123, July 27, 1962, 13 pp.

the reduction in production and export taxes to which it was entitled under the new law for Mexicanization of operations.[34]

San Francisco Mines of Mexico, Ltd., treated a record tonnage of ore (928,688 tons) at the sulfide mill and produced 112,500 tons of zinc concentrates averaging 57.19 percent zinc. Of the tonnage milled 733,470 tons was from the San Francisco mine and 195,200 tons from the Clarines mine. Development was carried out at both mines on a very reduced scale. Ore reserves were estimated at 6,693,200 tons containing 7.94 percent zinc, 5.54 percent lead, and 0.57 percent copper.

The Fresnillo Co. reported that development results indicated a long life at the Fresnillo and Naica mines and diamond drilling and development at Zimapan continued to expose moderate additions of ore. Production was reported for the operating period July 1, 1961 to August 31, 1962. Zinc concentrate produced at the Fresnillo mill was 40,223 tons containing 51.4 percent zinc and at the Naica mill 46,123 tons averaging 54.1 percent zinc. Concentrates produced from 31,200 tons of ore from the Zimapan Unit contained 2,000 tons zinc, 1,650 tons lead, 60 tons copper, 299,000 ounces silver, and 170 ounces gold. The sulfide ore reserve at the Fresnillo and Naica mines as of August 31, 1962 was 5,235,600 tons with 5.0 percent zinc, 5.2 percent lead, and 0.37 percent copper.

SOUTH AMERICA

Argentina.—Cia. Minera Aguilar, S.A., a subsidiary of St. Joseph Lead Co. (99.9 percent owned) operated its lead-zinc-silver mine in the Province of Jujuy in Northern Argentina. The mine worked continuously throughout 1962 producing 56,000 tons of zinc concentrates compared with 55,600 tons in 1961. The Aguilar mine had an excellent future with proven ore reserves higher than in the previous 27 years of operation. Cia. Metalurgica Austral-Argentina, S.A. (43.3 percent owned affiliate of Aguilar) operated a zinc smelter at Comodoro Rivadavia in Patagonia that produced 11,626 tons of Prime Western zinc in 1962 compared with 9,614 tons in 1961. Sulfacid, S.A. (50 percent owned affiliate of Aguilar) operated a sulfuric acid plant and an electrolytic zinc plant. The latter began production in November 1962 and was expected to furnish Special High Grade zinc to markets being developed.[35]

Cia. Minera Castaño Viejo, S.A., a partially own affiliate of National Lead Co., operated its mine at full capacity throughout the year. However, in November the company announced exhaustion of ore reserves and made plans for an extensive exploration program.[36]

Bolivia.—Most of the production of zinc in 1962, came from the Animas Telemayu mine. All proposals for exploiting the Government-owned Matilda mine were unacceptable. A team from the Consolidated Mining & Smelting Co. of Canada, Ltd., was studying the Matilda situation.

Brazil.—A zinc-processing plant was constructed by Companhia Mercantil e Industrial Inga at Itaguai, State of Rio de Janeiro. The plant was designed to process calamine ores from the Januaria and

[34] Page 36 of work cited in footnote 27.
[35] St. Joseph Lead Co. Annual Report. 1962, pp. 17–18.
[36] Mining World. V. 25, No. 5, Apr. 25, 1963, p. 119.

Vazante deposits in Minas Gerais. Initial production would be at an annual rate of 8,000 tons.

Peru.—Cerro de Pasco Corp. produced 35,782 tons of slab zinc at its La Oroya electrolytic zinc plant from concentrates of its own ores (35,006 tons in 1961). In addition, 63,992 tons of zinc concentrates was sold for export. Expansion of the electrolytic zinc refinery was completed late in 1962 increasing slab zinc capacity from 35,000 to 55,000 tons per year. The capacity of the lead-zinc circuit of the Paragsha concentrator at the Cerro de Pasco mine was increased from 42,000 to 65,000 tons per month. The greater capacity was used to treat ore from the McCune open pit which was of lower grade than underground ore from the Cerro de Pasco mine. Operations of the metal mines at Casapalca, Cerro de Pasco, Morococha, San Cristobal, and Yauricocha were normal except for interuptions of from 6 to 14 days because of strikes. Twenty-eight days of smelter production was lost because of three strikes.[37]

Cia. Minerals Santander, Inc., a St. Joseph Lead Co. subsidiary (100 percent owned) operated an open pit lead-zinc mine in the Peruvian Andes. In 1962, 29,356 tons of zinc concentrates were produced, compared with 37,806 tons in 1961.[38] Other sizable zinc producers were Cia. Minera Atacocha, S.A., Cia. des Mines de Huaron, and Northern Peru Mining Corp.

EUROPE

Austria.—The output of lead-zinc ores increased in 1962 but the grade was lower and less concentrates were produced. The value of lead and zinc metals produced in 1962 was the lowest in the last 10 years.[39]

Bulgaria.—Zinc production was estimated to have increased substantially to 95,000 tons in 1962, based on 1961 production and planned expansion projects for 1962. Two smelters at Kirjali and Plovdiv were scheduled for completion by 1965 when Bulgaria would be second only to Belgium in zinc production.[40]

Finland.—The Pyhasalmi mine of Outokumpu Oy started producing in 1962. The reserve of pyrites, estimated at 18.7 million tons, averaged 3.0 percent zinc. Production of the Vihanti zinc mine was approximately the same as in 1961.

Germany, West.—Mine production of zinc declined about 4 percent in 1962. Operators of the lead-zinc mines sought higher protective duties and a Government subsidy or equalization fund. German prices, which were based on London Metal Exchange quotations, were lower than prices in many countries with higher protective tariffs and/or quota restrictions.[41]

Ireland.—Northgate Explorations, Ltd., a Canadian company, drilled approximtely 140 holes at its lead-zinc-silver deposit at Tynagh, County Galway, and developed 4.5 million tons of oxidized and residual ore contaning 9.3 percent lead, 7.3 percent zinc and 0.6 percent copper. Production of about 2,000 tons per day was planned for late 1964.[42]

[37] Cerro Corp. Annual Report. 1962, pp. 3–4.
[38] St. Joseph Lead Co. Annual Report. 1962, p. 18.
[39] Page 126 of work cited in footnote 36.
[40] Page 268 of work cited in footnote 29.
[41] Pages 127–128 of work cited in footnote 36.
[42] Page 126 of work cited in footnote 36.

Italy.—A Ministry of Industry minerals survey in 1962 estimated ore reserves of zinc to be 2 million tons. Forecasts based on the data indicated that production of zinc concentrates would increase from about 295,000 tons in 1962 to 386,000 tons in 1966 and similarly, the production of zinc metal would increase from 85,600 tons to 125,000 tons. The capacity of the electrolytic plant at Porto Marghera (near Venice) was being increased 50 percent to 33,000 tons per year and the zinc processing plant at Vado Liguire was closed.[43]

Norway.—Zinc production declined about 6 percent in 1962. Increasing annual output to 72,000 tons by 1965 was still planned.[44]

Poland.—Zinc production fell slightly in 1962 but expansion continued for the 1965 goal and a production of 3.5 million tons of lead-zinc ore.

Spain.—Mine production of zinc ore declined sharply in 1962 but output of zinc metal continued its rise to 71,600 tons (58,000 tons in 1961) which was attributed to capacity output of the new refinery of Compania Espanola del Zinc.[45]

Yugoslavia.—Production of zinc rose over 6 percent in 1962. The smelters at Celje introduced fluidized bed roasters and doubled their sulfuric acid production. The electrolytic zinc plant at Sabac, Serbia increased production in 1962.[46]

ASIA

Burma.—The Burma Corp., Ltd., operations at its Bawdwin lead-zinc-silver mine registered a loss in the fiscal year ending June 30, 1962 but recovered in the last quarter of the calendar year. A preliminary study under the survey sponsored jointly by the Burmese Government and the United Nations stated that the lower grade deposits having an estimated 5.5 million tons of ore could be mined profitably. The survey for which the U.N. Special Fund granted $676,000 would take another 2 years to complete.[47]

China.—Production of zinc was expected to increase for the next 2 or 3 years as large new producers began operations. The new district under development, Taolin in Hunan, was expected to produce an estimated 1 million tons of ore annually for many years.[48]

India.—For supplies of zinc, the country was completely dependent upon imports which amounted to 83,000 tons in 1962. About 11,000 tons of zinc concentrates produced from ores of the Zawar mines in Rajasthan was sent to Japan for smelting on a toll basis. However, construction of two zinc smelters were planned, one by the Metal Corporation of India, Ltd., at Udaipur in Rajasthan and another by Cominco-Binani Zinc Ltd., near Cochin in Kerala State. The latter plant was expected to be ready by mid-1965 and will process imported concentrates. Consumption of zinc in India more than doubled in the last 5 years.[49]

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[43] U.S. Embassy, Rome, Italy. State Department Airgram A-1823, June 15, 1963.
[44] Page 128 of work cited in footnote 29.
[45] Page 128 of work cited in footnote 36.
[46] Page 128 of work cited in footnote 36.
[47] Page 255 of work cited in footnote 29.
[48] Page 245 of work cited in footnote 29.
[49] Page 253 of work cited in footnote 29.

Japan.—Production of refined zinc in 1962 was 265,000 tons with about 170,000 tons coming from domestic mines. Planned expansions aimed at 400,000 tons and 220,000 tons, respectively, by 1970. Imports of concentrates coming from Australia, Canada, Central and South America, and Korea, would be increased as a result of long-term contracts and mine investments.[50]

Philippines.—Benguet Exploration, Inc., with properties in the Baguio district, was a primary gold producer but its ore contained considerable zinc and cadmium.[51]

AFRICA

Algeria.—Société Algérienne du Zinc (ALZI) and Société Nord-Africaine du Plomb (NAP), each 17.15 percent owned by St. Joseph Lead Co., operated lead-zinc mines near the Algerian-Moroccan border south of Oryda, Morocco. The mines produced 114,200 tons of ore, compared with 143,600 tons in 1961. All exploration at ALZI was curtailed because of the disturbed political situation, and the remaining ore reserves were being rapidly depleted. Consolidation of ALZI with the adjoining A in Arko property and the eventual liquidation of NAP were being considered.

Congo, Republic of the.—Mining of zinc and copper sulfide ores at the Union Minière du Haut-Katanga Prince Leopold mine at Kipushi was limited to 970,792 tons in 1962 because of a mine flood in December 1961. The Kipushi concentrator produced 166,990 tons of 57.33 percent zinc concentrates. A subsidiary of the company, Société Generalé Industriéllé et Chimique du Katanga (Sogechim), treated 130,127 tons of these concentrates and produced 105,523 tons of roasted concentrates and 113,845 tons of sulfuric acid. During the year, 109,913 tons of calcined concentrates were sold to Société Metallurgique du Katanga (Metalkat), which produced 61,759 tons of electrolytic zinc, and exported 63,661 tons of sulfide and roasted concentrates.[52]

Rhodesia and Nyasaland, Federation of.—The Rhodesia Broken Hill Development Co., Ltd., mined 212,900 tons of ore, compared with 246,700 tons in 1961. The mining rate was adjusted to the requirements of the metallurgical plants. The Imperial Smelting Furnace plant was completed and started operating January 21. A number of modifications and alterations were made during 1962, and major changes were made at the concentrator to accommodate the output of this new plant. The heavy-medium separation plant treated 154,800 tons of ore and recovered 101,900 of sink product which provided the major portion of the concentrator feed. Mixed fines were no longer milled but passed directly to the sintering plant. The mill produced 32,586 tons of zinc concentrate containing 59.7 percent zinc. The leach plant treated 94,376 tons of feed material composed of calcines, flotation plant tailings, and zinc silicate ore, averaging 41.6 percent zinc.

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[50] Page 238 of work cited in footnote 29.
[51] Page 236 of work cited in footnote 29.
[52] Union Minière du Haut-Katanga. Annual Report. 1962, pp. 2–7.

Leach solution and calcined concentrate were processed in the electrolytic plant to yield 31,025 tons of slab zinc (1961—32,573 tons). An additional 731 tons of slab zinc was recovered from 2,500 tons of smelter dross. As of December 31, 1962, ore reserves totaled 5.9 million tons averaging 26.9 percent zinc and 13.5 percent lead. Production of zinc and lead from the new Imperial Smelting furnace was substantially below expectations because of technical difficulties and two strikes in May and September by African employees.

South-West Africa.—Tsumeb Corp., Ltd., mined and milled 714,900 tons of complex copper-lead-zinc sulfide and oxide ore and produced 22,640 tons of zinc concentrate averaging 55.96 percent zinc and 1.40 percent cadmium. The mill recovery of zinc in the zinc concentrate was 47.65 percent (50.60 percent in 1961). The ore reserve on June 30, 1962 was 7.3 million tons of positive ore above the 30 level averaging 3.93 percent zinc and 3 million tons of probable ore from the 30 to 34 level with a grade of 2.30 percent zinc. Diamond drilling for exploration, development, and water control totaled 1,765 feet, and the Number 6 internal shaft was sunk to a final depth of 114 feet below the 38 level (4,286 feet below the surface).[53]

South-West Africa Co., Ltd., processed about 7,000 tons of lead-zinc ore per month during 1962. The company estimated its Berg Aukas ore reserves at 880,000 tons on June 30.[54]

OCEANIA

Australia.—The Broken Hill mines in New South Wales returned to full production after a period of voluntary restriction of output. Broken Hill South, Ltd., treated 261,000 tons of ore with an average mill recovery of zinc of 86.6 percent. Ore reserves were estimated at 1,370,000 tons. North Broken Hill, Ltd., milled 352,000 tons recovering 89.3 percent of the zinc in the zinc concentrate. Ore reserves were estimated at 4,035,000 tons. New Broken Hill Consolidated, Ltd., produced well below capacity because of voluntary restriction and 648,000 tons of ore was milled. An ore reserve of 4,800,000 tons was reported.[55]

Conzinc Riotinto of Australia Ltd., was formed in July 1962, consolidating in one company all the assets owned by Consolidated Zinc Pty. Ltd., and the Rio Tinto Mining Co. of Australia, Ltd. The Zinc Corp., Ltd. (wholly owned), was the second largest producer of zinc with about 90,000 tons. Sulphide Corp. Pty. Ltd. (75 percent owned) at Cockle Creek, New South Wales was a major producer of slab zinc, lead bullion, cadmium, sulfuric acid, and phosphatic fertilizers. The corporation's newly constructed Imperial Smelting type furnace produced 35,000 tons of zinc and 16,600 tons of lead in its first full year of operation.[56]

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[53] Tsumeb Corp., Ltd. Annual Report. 1962, pp. 6–7.
[54] Republic of South Africa Department of Mines Quarterly Information Circular, Minerals. October–December 1962.
[55] Page 229 of work cited in footnote 29.
[56] Pages 348–349 of work cited in footnote 29.

Mount Isa Mines, Ltd., zinc concentrate production declined about 23 percent in 1962 mainly because of an 8-week strike. The mill treated 629,894 tons of silver-lead-zinc ore and produced 45,837 tons of zinc concentrate containng 23,855 tons of zinc. The silver-lead-zinc ore reserves were estimated at 25.6 million tons averaging 5.8 percent zinc, 7.8 percent lead, and 5.6 ounces of silver per ton.[57]

The Lake George Mines Pty., Ltd., at Captain's Flat, New South Wales, was closed March 11, 1962, because exploration failed to find any extension of existing orebodies or new deposits in the area.

The Electrolytic Zinc Co. of Australasia, Ltd., produced a record 144,500 tons of zinc at its Risdon, Tasmania electrolytic plant (141,000 tons in 1961). Record output was also achieved at the West Coast Mines at Rosebery and Williamsford; 265,578 tons of ore was mined or approximately 20 percent more than in 1961.[58]

The lead and zinc mining and refining companies formed two associations—the Australian Lead Development Association and the Australian Zinc Development Association. With the help of technical services provided by the sponsoring companies, these associations will actively promote the uses of zinc and lead by emphasizing their basic properties and variety of applications.[59]

TECHNOLOGY

The Zinc Development Association and Lead Development Association in England reviewed the lead and zinc articles in more than 200 technical and scientific journals published throughout the world and other published research work. Abstracts of important articles were presented in two monthly companion publications entitled "Zinc Abstracts" and "Lead Abstracts."

The Expanded Research Program (ERP), sponsored by the American Zinc Institute, was active in 1962 on investigations concerned with the development of fundamental and technological knowledge to expand and promote new uses for zinc. Projects initiated in 1962 included studies on the methods of joining and organic adhesives, the holding power of galvanized fasteners, standardization of procedures for testing rolled-zinc alloys, the flow of metal in die casting dies, chemistry of organic zinc compounds, zinc in agriculture, the influence of zinc oxide in structural clays and in sewer pipe glazes, organic coatings for galvanized metal, zinc-rich paint, and zinc shot blasting of structural steel.

The American Zinc Institute and the Lead Industries Association published the ERP Research Digest, which provided abstracted accounts of progress reports covering the projects sponsored by these two groups.[60]

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[57] Mount Isa Mines, Ltd. Annual Report. 1962, p. 26.
[58] E Z Industries, Ltd. Annual Report. 1962, p. 4.
[59] Page 7 of work cited in footnote 58.
[60] Kettler, Louis. ERP Research Digest. Apr. 1, 1962, pp. 1–30; Oct. 1, 1962, pp. 1–41.

Numerous papers reported research by the Bureau of Mines [61] and Geological Survey.[62]

Geochemical prospecting, an effective exploration technique, was important in discovering and exploring the Flat Gap mine in East Tennessee.[63]

Genesis and other geologic phenomena were reported for the Broken Hill [64] and Mount Isa [65] ore bodies in Australia and the East Tennessee [66] and other lead-zinc deposits in the United States.

Data by I. P. Kuz'mina explained the paragenetic relationship of sphalerite and galena and their vertical zoning in ore deposits.[67]

A continuously operated, high-capacity pyrometallurgical unit of novel design for producing high-purity zinc was described.[68]

Patents were granted for a method of smelting zinc ore in ceramic retorts,[69] the separation of lead and zinc from blast-furnace melts,[70] and a process to recover metallic zinc from a molten zinciferous slag from a lead blast furnace.[71]

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[61] Bardill, John D., Donald R. Corson, and William R. Wayments. Factors Influencing the Design of Hydraulic Backfill Systems (in Two Parts). 2. Friction-Head Losses of Barite and Limestone Slurries During Pipeline Transport. BuMines Rept. of Inv. 6066, 1962, 33 pp.

Panek, Louis A. The Effect of Suspension in Bolting Bedded Mine Roof. BuMines Rept. of Inv. 6138, 1962, 59 pp.

Panek, Louis A. The Combined Effects of Friction and Suspension in Bolting Bedded Mine Roof. BuMines Rept. of Inv. 6139, 1962, 31 pp.

Staff, Office of the Chief Economist. Copper, Lead, and Zinc in Three Recessions Following World War II. BuMines Inf. Circ. 8064, 1961, 79 pp.

Stanczyk, Martin H., and Carl Rampacek. Recovery of Zinc From Ammoniacal-Ammonium Sulfate Leach Solutions. BuMines Rept. of Inv. 6038, 1962, 12 pp.

Wayment, William R., and George L. Wilhelm, and John D. Bardill. Factors Influencing the Design of Hydraulic Backfill Systems (in Two Parts). 1. Friction-Head Losses of Sand Slurries During Pipeline Transport. BuMines Rept. of Inv. 6065, 1962, 43 pp.

[62] Heyl, A. V., Jr., and C. N. Bozion. Oxidized Zinc Deposits of the United States, Part 1. Geol. Survey Bull. 1135–A, 1962, pp. A1–A49.

Johnson, R. F. Lead-Zinc Deposits of the Boquira District, State of Bahia, Brazil. Geol. Survey Bull. 1110–A, 1962, pp. 1–33.

McKnight, E. T., W. L. Newman, and A. V. Heyl, Jr. Zinc in the United States, Exclusive of Alaska and Hawaii. Geol. Survey Miner. Inv. Res. Map, M R–19, 1962.

Morris, H. T., T. S. Lovering, and H. D. Goode. Stratigraphy of the East Tintic Mountains, Utah. Geol. Survey Prof. Paper 361, 1962, 145 pp.

Nolan, T. B. The Eureka Mining District, Nevada. Geol. Survey Prof. Paper 406, 1962, 78 pp.

[63] Hoagland, Alan D. Distribution of Zinc in Soils Overlying the Flat Gap Mine. Trans. AIME, v. 223 (Soc. Min. Eng.), 1962, pp. 399–402.

[64] Mining Magazine (London). Genesis of the Broken Hill Zinc Lode. V. 106, No. 1, January 1962, pp. 57–58.

[65] Stanton, R. L. Elemental Constitution of the Black Star Orebodies, Mount Isa, Queensland, and Its Interpretation. Bull. Inst. Min. and Met. (London), v. 72, pt. 2, No. 672, November 1962, pp. 69–124.

[66] Behre, Charles H., Jr. Types of Evidence for Genesis of Ore Deposits in the East Tennessee and Other Lead-Zinc Deposits. Econ. Geol., v. 57, No. 1, January–February 1962, pp. 115–118.

[67] Economic Geology. Geology of Ore Deposits. Nauk SSSR. V. 3, No. 1, January–February 1961, in Russian. V. 57, No. 6, September–October 1962, pp. 990–991.

[68] Enterline, S. M., and J. F. Pierce, Sr. Amax Zinc Refiner. J. Metals, v. 14, No. 9, September 1962, pp. 653–656.

[69] Phillips, Kenneth A. (assigned to American Zinc, Lead and Smelting Co.). Smelting of Zinc in Ceramic Retorts. U.S. Pat. 3,033,674, May 8, 1962.

[70] Davey, Thomas Ronald Albert (assigned to Metallurgical Processes, Ltd. and The National Smelting Co., Ltd). Separation of Lead and Zinc. U.S. Pat. 3,031,296, Apr. 24, 1962.

[71] Lumsden, John (assigned to Metallurgical Processes, Ltd. and The National Smelting Co., Ltd.). Recovery of Zinc From Zinc-Containing Materials. U.S. Pat. 3,017,261, Jan. 16, 1962.

A number of patents were issued on the preparation and use of alloys,[72] pigments,[73] and compounds.[74]

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[72] Koji Takada, Shinjuku-ku (assigned to Toyo Kinzokukagaku Kabushikikaisha, Tokyo, Japan). Process for the Electro-Plating of Zinc-Titanium-Zinconium Alloy. U.S. Pat. 3,070,521, Dec. 25, 1962.

Larrieu, Leslie J. (assigned to Morris P. Kirk & Son, Inc.). Zince Base Alloy. U.S. Pat. 3,037,859, June 5, 1962.

[73] Csonka, Lajos, Ferenc Horkay, Ferenc Szanto, Janos Szerecz, and Jeno Gonczy (all of Budapest, Hungary). Process for the Preparation of Zinc Oxide Pigments. U.S. Pat. 3,042,539, July 3, 1962.

Dunn, Edward J., Jr. (assigned to National Lead Co.). Composite Zinc Pigments. U.S. Pat. 3,028,250, Apr. 3, 1962.

[74] Weil, Edward D. (assigned to Hooker Chemical Corp.). Zinc Phosphide Pesticide. U.S. Pat. 3,029,182, Apr. 10, 1962.

Zirconium and Hafnium

By F. W. Wessel[1] and John W. Stamper[2]

ZIRCONIUM sponge and ingot production decreased markedly in 1962. Imports of zircon declined 9 percent. Domestic production increased but consumption decreased. Hafnium production, based on the metal content of oxide produced, was slightly more than half of the 1961 output.

LEGISLATION AND GOVERNMENT PROGRAMS

The General Services Administration sold 7,012 tons of zircon from the national stockpile during the year. At yearend 16,533 tons of baddeleyite, 1,395 tons of zircon, and 1,723 tons of a semifinished concentrate remained unsold.

TABLE 1.—Salient zirconium and hafnium statistics in the United States

	1958	1959	1960	1961	1962
Zircon:					
Production short tons	30,443	(1)	(1)	(1)	(1)
Price: Dec. 31 per short ton	$41.00	$47.25	$47.25	$47.25	$47.25
Imports short tons	19,225	54,878	34,280	33,805	30,872
Price: Dec. 31 per short ton	$42.00	$44.60	$44.60	$44.60	$50.00
Zirconium sponge:					
Production short tons	1,265	1,404	1,423	1,697	1,272
Price: Dec. 31 per pound	$6.25	$6.25	$6.25	$6.25	$6.25
Hafnium: Production short tons	[2] 31	[3] 17	[4] 53	[4] 47	[4] 25

[1] Figure withheld to avoid disclosing individual company confidential data.
[2] Includes metal content of oxide.
[3] Sponge only, estimated.
[4] Metal content of oxide produced.

DOMESTIC PRODUCTION

E. I. du Pont de Nemours & Co., Inc., Titanium Alloy Manufacturing Division of National Lead Co., and The Florida Minerals Co. produced zircon at a greater rate than in 1961. These companies operated mines in Florida at Trail Ridge, South Jacksonville, and Vero Beach, respectively.

Production of zirconium sponge amounted to 1,272 short tons, a 24 percent decrease below production in 1961. This quantity was

[1] Project coordinator, Bureau of Mines, Pittsburgh, Pa.
[2] Commodity specialist, Division of Minerals.

produced by Reactive Metals, Inc., Ashtabula, Ohio; Carborundum Metals Co., Parkersburg, W. Va.; Columbia-National Corp., Pensacola, Fla.; and Wah Chang Corp., Albany, Oreg. Slightly over one-half of this metal was produced under long-term U.S. Atomic Energy Commission (AEC) purchase contracts.

These zirconium producers also reported production of 58,089 pounds of hafnium oxide. Wah Chang Corp. and Carborundum Metals Co. continued to produce hafnium sponge, which was converted to crystal bar by Foote Mineral Co., Exton, Pa., and Nuclear Materials & Equipment Corp., Apollo, Pa.

Carborundum Metals Co. reportedly received a contract in excess of $500,000 from AEC for electroyltic refining and melting and fabricating of hafnium metal.[3]

Production of zirconium ingot was 1,282 tons, a decrease of 9 percent below 1961 output. Leading producers were The Carborundum Metals Co., Akron, N.Y., Oregon Metallurgical Corp., Albany, Oreg., Reactive Metals, Inc., Niles, Ohio and Wah Chang Corp., Albany, Oreg.

Melters and fabricators generated 554,000 pounds of scrap and returned 567,000 pounds to ingot production.

Union Carbide Metals Co. Division of Union Carbide Corp. produced zirconium ferroalloys, and Vanadium Corporation of America produced zirconium-bearing Grainal 79. Total production declined 14 percent from the 1961 volume.

Output of zirconium oxide, not including that produced as an intermediate step in zirconium metal production, totaled 8,989,000 pounds. Major producers were Norton Co. at Huntsville, Ala., Titanium Alloy Manufacturing Division of National Lead Co. at Niagara Falls, N. Y., and Harbison-Carborundum Corp. at Falconer, N. Y.

The leading producers of a total of 37,100 short tons of zircon and zirconia refractories were Corhart Refractories Co., with plants at Louisville, Ky., and Buckhannon, W. Va.; Harbison-Carborundum Corp.; The Chas. Taylor Sons Co., subsidiary of National Lead Co., Cincinnati, Ohio; and Walsh Refractories Corp., St. Louis, Mo.

Foote Mineral Co., Carborundum Metals Co., and Nuclear Materials & Equipment Corp. produced 39,946 pounds of zirconium powder. Stauffer Chemical Co., Kawecki Chemical Co., and Titanium, Zirconium Co., with plants at Niagara Falls, N.Y., Boyertown, Pa. and Flemington, N.J., respectively, continued to be the principal manufacturers of zirconium chemicals.

CONSUMPTION AND USES

Apparent consumption of zircon in the United States was 89,000 tons. This quantity was distributed approximately as follows:

Use:	*Percent*
Foundry zircon	58
Milled zircon, foundry and ceramic	12
Refractories	16
Metal and alloys	8
Chemicals, ceramic compounds, and abrasives	6

[3] American Metal Market. Carborundum Co. Books Contract for Hafnium. V. 69, No. 147, Aug. 1, 1962, p. 16.

Consumption of zircon ingot was 1,463,000 pounds; Westinghouse Electric Corp., Wah Chang Corp., U.S. Industrial Chemicals Co., and Jessop Steel Co. were among the principal fabricators.

R. S. Corcoran Co., Joliet, Ill., offered zirconium pumps, in capacities up to 500 gallons per minute, for pumping hydrochloric acid and other chemicals.

Zirconium was used as a minor component of three nonferrous alloys. An addition of 0.25 percent zirconium to copper improved the creep resistance of commutator segments. Copper containing 0.15 percent zirconium was used as a liner in test chambers for rocket engines, because it has a high coefficient of thermal conductivity. Molybdenum containing 0.08 percent zirconium and 0.5 percent titanium had a greatly increased service life as a core material in aluminum diecasting.

Westinghouse Electric Corp. and General Electric Co. independently developed solid-state fuel cells, using zirconia as a solid electrolyte.

STOCKS

Dealer stocks of zircon concentrate decreased from 7,598 tons (revised figure) to 7,370 tons at the end of 1962, and consumer stocks increased from 12,428 tons (revised figure) to 16,368 tons. Total inventory increased 3,710 tons. Estimated yearend inventories of zirconium sponge (a quantity of which was converted to ingot) was 4,000,000 pounds. Stocks of ingot were 543,000 pounds. The four zirconium producers ended the year with a total inventory of 2,378,000 pounds of hafnium-free zirconia.

PRICES

Zircon prices remained unchanged during the year. Domestic zircon sold at $47.25 per short ton, f.o.b. Starke, Fla., and imports at $50 per long ton, c.i.f. Atlantic ports. Most of a $4-per-ton freight increase between Australia and the United States during the third quarter was absorbed by the shippers. Prices in the London market firmed slightly, closing the year at £15.5 to £17 per long ton.

Reactor-grade zirconium sponge prices continued at about $6 to $6.25 per pound, although some domestically produced sponge was offered in Western Europe at about $5.50.

No significant price changes in other zirconium commodities were reported.

The American Society for Testing and Materials initiated a program to develop specifications for zircon refractories.

FOREIGN TRADE [4]

Imports.—Imports of zircon were 30,872 short tons, 9 percent less than in 1961. Australia supplied 87 percent of all imports, and the Republic of South Africa 11 percent; the remainder was accounted

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

for by a large shipment of Nigerian zircon in September. Brisbane was the principal shipping port, accounting for 73 percent of all U.S. imports.

Philadelphia was again the principal port of entry, receiving 40 percent of the tonnage. Other Atlantic ports received 35 percent, Pacific ports received 19 percent, and Gulf ports, 6 percent.

Péchiney Compagnie de Produits Chimiques et Electrometallurgiques interests purchased control of Howe Sound Co., whose F. Samuel Division in Philadelphia was the major importer of zircon.

Less than 2 tons of zirconium metal was imported, all from West Germany. Japan was the source of 140,000 pounds of ferrozirconium, valued at $12,283.

TABLE 2.—U.S. imports for consumption of zircon, by countries

(Short tons)

Country	1953–57 (average)	1958	1959	1960	1961	1962
Australia [1]	28,052	19,175	53,650	29,183	31,225	27,001
Brazil [2]	899	----------	----------	----------	4	----------
Canada [3]	63	----------	24	2	----------	1
Nigeria	----------	50	868	1,850	----------	544
South Africa, Republic of [4]	----------	----------	280	3,133	2,576	3,326
United Kingdom [3]	35	----------	56	112	----------	----------
Total: Quantity	29,049	19,225	54,878	34,280	33,805	30,872
Value [5]	$761,174	$467,391	$1,517,485	$1,233,815	$873,376	$844,939

[1] Imports from Australia through 1954 were partly in the form of mixed concentrate containing small quantities of rutile and ilmenite.
[2] Concentrate from Brazil includes some baddeleyite.
[3] Believed to be country of shipment rather than country of origin.
[4] Effective Jan. 1, 1962; formerly Union of South Africa.
[5] 1954 data known to be not comparable with other years.

Source: Bureau of the Census.

Exports.—Exports of zircon (primarily milled) totaled 1,666 short tons; 1,020 tons was shipped to Canada, 440 tons to South America, 69 tons to Western Europe, and 137 tons to Mexico, Italy, the Philippines, and Japan. Total value of these shipments was $365,184. Zircon reexported totaled 511 short tons.

Exports of 72 tons of crude metal, alloy, and scrap, principally to the United Kingdom, were valued at $658,545. Semifabricated forms totaling 37 tons and valued at $1,081,372 were exported, principally to Canada.

WORLD REVIEW

Australia.—Production of 23,000 tons of zircon was expected as a byproduct of 36,000 tons of rutile produced under contracts placed with Coffs Harbour Rutile, N. L., and National Minerals Holdings, Ltd., by E. I. du Pont de Nemours & Co., Inc. Pressure on the mid-1962 zircon price of A£15 per long ton was foreseen.

Western Titanium, N. L., at Capel, Western Australia, produced zircon throughout the year; Westralian Oil, Ltd., at Yoganup was reported to have begun zircon production late in the year.

Canada.—Atlas Titanium, Ltd., conducted research and development in the fabrication of zirconium and other metal at its new research laboratory at Welland, Ont.

France.—Société d'Électro-Chimie, d'Électro-Métalurgie et des Aciéries Electriques d'Ugine (Ugine) reportedly was the only zirconium producer in Western Europe, although other companies had production facilities. Output was at the rate of 100,000 pounds per year. Principal sponge melters, in addition to Ugine, were Imperial Metal Industries, Ltd., in the United Kingdom, and Heraeus Quarzschmelze, G.m.b.H., in West Germany.

TABLE 3.—Free world production of zirconium ores and concentrates by countries [1]

(Short tons)

Country	1953–57 (average)	1958	1959	1960	1961	1962
Australia	62,351	66,381	125,834	114,645	152,859	[2] 150,000
Brazil [3]	3,111	10,471	10,846	6,358	7,405	(4)
India	[5] 3	10	[2] 10	[2] 10	[2] 10	(4)
Malagasy Republic (Madagascar)	----------	26	50	145	353	390
Malaya, Federation of	[6] 49	[7] 28	130	63	[7] 63	[7] 72
Nigeria	----------	101	1,250	1,968	832	[8] 544
Senegal, Republic of	1,490	7,606	9,557	11,408	5,939	2,575
South Africa, Republic of	----------	1,129	5,924	7,366	7,607	7,581
United Arab Republic (Egypt)	189	[2] 45	[2] 65	408	(4)	(4)
United States	33,862	30,443	(9)	(9)	(9)	(9)

[1] This table incorporates some revisions.
[2] Estimate.
[3] Chiefly baddeleyite.
[4] Data not available.
[5] Average annual production 1955–57.
[6] Average annual production 1956–57.
[7] Exports.
[8] U.S. imports.
[9] Figure withheld to avoid disclosing individual company confidential data.

Compiled by Liela S. Price, Division of Foreign Activities.

Germany, East.—Reactor-grade zirconium was produced at the VEB Electrochemisches Kombinat plant at Bitterfeld. Raw material for this operation was recovered from beach sands on Poland's Baltic coast.

Italy.—A plant was under construction at Carasco, near Genoa to produce zircon for the ceramic industry. The new company, Almitalia, S.p.A., was a joint venture of Goodlass Wall and Lead Industries, Ltd., and the Milanese firm of Beghe & Chiapetta.

Pakistan.—The Geological Survey of Pakistan began a detailed survey of beach placers extending 100 miles from Chittagong south to the Burma border along the east side of the Bay of Bengal. Zircon was said to be present in recoverable quantities.

Senegal, Republic of.—Beach placers were discovered between M'Bour and Joal. Gaziello Mining Co. planned to mine these deposits for their content of zircon and titanium minerals, anticipating zircon production at the rate of 10,000 tons annually by mid-1964.

South Africa, Republic of.—Baddeleyite was discovered in an operating phosphate mine at Phalaborwa, East Transvaal, in recoverable quantities. The mineral occurs as steel-gray needles.

Tanganyika.—Application was made for a license to prospect for zircon in the Handeni district; the material was said to have a hafnium content somewhat greater than that of most zircon.

United Kingdom.—Imperial Metal Industries, Ltd., installed a Sendzimir mill and was to roll 0.0008-inch zirconium foil for flashbulbs and for use in nuclear energy applications. The use in flashbulbs was the only significant non-nuclear application for zirconium.[5]

A steel company began using zircon for pouring nozzles; nozzle failure was substantially eliminated.

TECHNOLOGY

Since the purity of zirconium is a function of the purity of the zirconium tetrachloride from which it is reduced, a method for fused-salt scrubbing of the tetrachloride, as developed by Carborundum Metals Co., was of interest.[6]

Using solvent extraction techniques, researchers in the U.S.S.R. separated zirconium from hafnium in a nitrate system, and determined distribution coefficients.[7]

According to results of a study, enough oxygen remains in columbium-zirconium alloys to affect the phase diagram materially.[8] The tungsten-hafnium phase diagram was described.[9] Various aspects of zirconium- and hafnium-based alloys, particularly those with titanium, were studied. Columbium-zirconium alloys continued to attract interest in the field of superconductivity. Atomic International Division of North American Aviation, Inc., developed and tested for the AEC a new alloy, 3Z1; based on zirconium, it contains 1.25 percent aluminum and 1 percent each of tin and molybdenum, and has excellent strength and fabricability. Hafnium alloys containing 34 to 51 percent columbium were found to have superior strength and corrosion resistance at elevated temperatures.[10] Zirconium beryllides were prepared and fabricated by powder metallurgy, arc melting, and casting techniques.[11]

F. W. Berk & Co. announced a ceramic coating which protects zirconium and other metals against oxidation during heat treatment.

Watertown Arsenal Laboratory developed a foundry mold material consisting of zircon sand bonded with amorphous carbon, which permitted production of sound castings of steel, aluminum, or bronze with a good surface finish, that required little subsequent machining. Use of zircon sand cores for intricate castings had become standard procedure at the Dure & Co. Waterloo, Iowa, plant.

Results of several years of research on stabilizing zirconia at Zirconium Corporation of America were reported. Zirconia may be stabilized by addition of oxides of either RO, R_2O_3, or RO_2 type; the advantages of each were discussed.[12] Systems Research Laboratories, Inc.,

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[5] Metal Industry (London). Titanium and Zirconium. V. 101, No. 13, Sept. 27, 1962, p. 30.

[6] Spink, D. R. Fused Salt Scrubbing of Zirconium Tetrachloride. Trans. AIME, v. 244 (Met. Soc.), 1962, pp. 965–970.

[7] Kolikov, V. M., and A. P. Perovskii. Separation of Zirconium and Hafnium During Extraction of Their Nitrates. J. Appl. Chem., v. 34, No. 12, December 1961, pp. 2469–2472.

[8] Richter, H., and others. Zur Konstitution von Zirkonium-Niob-Legierungen. J. Less-Common Metals, v. 4, No. 3, June 1962, pp. 252–265.

[9] Giessen, B. C., I. Rump, and N. J. Grant. The Constitution Diagram Tungsten-Hafnium. Trans. AIME, v. 224 (Met. Soc.), No. 1, February 1962, pp. 60–64.

[10] Babitzke, H. R., G. Asai, and H. Kato. Columbium-Hafnium Binary Alloys for Elevated-Temperature Service. BuMines Rept. of Inv. 6101, 1962, 17 pp.

[11] Mannas, D., and J. P. Smith. Beryllium Intermetallic Compounds. J. Metals, v. 14, No. 8, August 1962, pp. 575–578.

[12] Yavorsky, Paul J. Properties and High-Temperature Applications of Zirconium Oxide. Ceram. Age, v. 78, No. 6, June 1962, pp. 64–69.

announced satisfactory stabilization of zirconia with 15 percent lime for use as a high-temperature conductor; research at Oak Ridge National Laboratory several years ago indicated that for refractory purposes 8 percent lime was sufficient. U.S.S.R. research indicated the necessity for eliminating titania before attempting stabilization.[13]

The ceramic character of pure metal oxides, their superiority over silicate-based refractories, and their application to metal-oxide formulations were discussed.[14]

A study of refractory zircon in glass manufacture was reported, giving extensive corrosion data.[15]

The preparation and properties of zirconium and hafnium carbides were described.[16]

The National Bureau of Standards announced the availability of spectrographic standard samples of two grades of zirconium and of Zircalogy 2.

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[13] Keler, E. K., and A. B. Andreyeva. The Effect of Impurities and Titanium Dioxide Admixtures on the Process of Stabilizing Zirconium Dioxide. Ogneupory, v. 23, No. 12, 1958, pp. 552–558.

[14] Ryshkewitch, E. Metal-Oxide Ceramics. Internat. Sci. and Technol., No. 2, February 1962, pp. 54–61, 70.

[15] Vago, E., and C. F. Griffith. The Corrosion of Zircon Refractories by Molten Glass. Glass Technol., v. 2, No. 6, December 1961, pp. 218–234.

[16] Kieffer, R. Hafniumkarbidhaltige Hartmetalle. Metall, Berlin, Germany, v. 13, No. 10, October 1959, pp. 919–922.

Samsonov, G. V., and V. N. Paderno. Preparation and Certain Properties of Hafnium Carbide. J. Appl. Chem. (U.S.S.R.), v. 34, No. 5, May 1961, pp. 963–969.

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Minor Metals and Minerals

By Staff, Division of Minerals

Contents

CESIUM AND RUBIDIUM[1]

PRODUCTION of cesium, cesium salts, and rubidium salts in the United States declined somewhat from 1961 levels; rubidium production was virtually unchanged. Imports of pollucite declined because consumption was supplied partially out of inventory.

Domestic Production.—About 50 tons of pollucite was reported mined at the Tin Mountain mine in the Black Hills of South Dakota. The Dow Chemical Co., Midland, Mich., MSA Research Corp., Callery, Pa., and Penn Rare Metals, Inc., Revere, Pa., produced a total of 159 pounds of cesium. Rubidium production remained essentially the same as in 1961. Shipments of the two metals by these companies and by American Potash & Chemical Corp., Trona, Calif., totaled 279 pounds. Production of cesium and rubidium salts by American Potash & Chemical Corp., Penn Rare Metals, Inc., and Rocky Mountain Research, Inc., Denver, Colo., declined substantially during 1962.

Consumption and Uses.—Cesium and rubidium continued to be used in vacuum tubes, photoelectric cells, extremely accurate timers, and other specialized technical applications. Most of the metal produced, however, continued to be used in research and development, principally in the ion-propulsion engine and the thermoelectric generator.

The National Aeronautics and Space Administration and contracting firms continued research on the ion-propulsion engine. Space trials of a prototype engine were conducted late in 1962.

A thermoelectric generator, incorporating a cesium thermionic generator, was constructed and operated by Thermo Electron Engi-

[1] Prepared by F. W. Wessel.

neering Corp., Waltham, Mass., and Minnesota Mining & Manufacturing Co., St. Paul, Minn.

Beckman Instruments, Inc., Fullerton, Calif., announced the availability of an infrared spectrophotometer to measure film thicknesses of semiconductors. Cesium bromide was used in its optical system. Ohmart Corp., Cincinnati, Ohio, marketed a continuous-weighing device for conveyor belts that used radiation from a cesium 137 source to generate an electric current proportional to the weight on the belt.

Stocks.—Inventories of pollucite held by dealers and consumers at yearend totaled 98,000 pounds, only slightly less than the (revised) 1961 figure of 98,823 pounds. Producer yearend stocks of cesium and rubidium totaled 208 pounds, and stocks of cesium and rubidium salts, over 12,000 pounds.

Prices.—No price changes in cesium and rubidium ores, metals, and salts were announced during 1962. The U.S. Atomic Energy Commission, however, announced a 50-percent decrease in the price of cesium 137 from $1.50 to $0.75 per curie.

Foreign Trade.—Imports of pollucite came principally from the Bikita operation in Southern Rhodesia, although some pollucite was imported from Canada and a smaller quantity from Mozambique.

World Review.—*Canada.*—Chemalloy Minerals, Ltd., and Strategic Materials Corp. entered into an agreement whereby Chemalloy pollucite would be processed by Strategic Materials to produce cesium chloride. Production at the Chemalloy mine at Bernic Lake remained suspended, but the company continued drilling to develop further reserves.

South-West Africa.—Pollucite production was 1,120 pounds, a decrease from 3,900 pounds in 1961.

United Kingdom.—Hopkins and Williams, Ltd., announced the availability of several cesium salts of various degrees of purity.

Technology.—Research into the production and uses of cesium and rubidium continued during the year.

A presentation before the Institute of Aeronautical Sciences indicated that a 4,000-pound vehicle could reach an altitude of 20,000 miles, using 300 pounds of cesium in addition to preliminary boosters.[2] The Systems for Nuclear Auxiliary Power (SNAP) reactors were to be used to provide energy for vaporizing the cesium.

Cesium was prepared from its fluoride using magnesium as a reductant.[3] Cesium carbonate was prepared from a mixed pollucite-spodumene concentrate by autoclave leaching with lime.[4]

Hazards involving cesium and rubidium metals and precautions to be taken in handling were described.[5]

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[2] American Metal Market. V. 69, No. 18, Jan. 25, 1962, p. 14.

[3] Zhuraviev, N. N. (Preparation of Metallic Cesium From Cesium Fluoride.) J. Inorg. Chem. (U.S.S.R.), v. 3, No. 9, 1958, pp. 2210–2220.

[4] Goroshchenko, Y. G., and others. (Obtaining Cesium Carbonate From Pollucite-Spodumene Concentrate.) Tsvetnye Metalli (U.S.S.R.), v. 2, No. 5, May 1961, pp. 57–59.

[5] Brotherton, T. D., O. N. Cole, and R. E. Davis. Properties and Handling Procedures for Rubidium and Cesium Metals. Trans. AIME, v. 224 (Met. Soc.), 1962, pp. 287–293.

Early in 1962 the United Kingdom Atomic Energy Authority and the South African Council of Scientific and Industrial Research announced a jointly developed, improved method for recovering cesium 137 from radioactive waste.[6] This was accomplished by forming a complex with ammonium phosphomolybdate and subsequently stripping with zirconium phosphate. A method for recovering cesium 134 by sorption on heavy-metal ferrocyanides also was described.[7]

Certain properties of cesium and rubidium borates of interest to the glass industry were determined.[8]

GALLIUM [9]

Domestic Production.—Aluminum Company of America, Bauxite, Ark., produced gallium metal, and The Eagle-Picher Co., at its Miami plant near Quapaw, Okla., produced gallium metal and gallium sesquioxide (Ga_2O_3). Production and shipments, each, of gallium in 1962 were almost as large as in 1961, and producers consumed much more of their own gallium output. Production and shipments of gallium sesquioxide were larger in 1962 than in 1961.

Uses.—No major new use for gallium was reported during 1962. The major use for high-purity gallium continued to be in the development of gallium arsenide, gallium antimonide, and gallium phosphide. The greatest interest in gallium and several of its compounds was for use in semiconductors. Gallium arsenide was used in high-temperature and high-frequency transistors, lasers, and tunnel diodes. The latter were used in switching and FM transmitter circuits, amplifiers, and solar batteries, and as replacement for phase-locked oscillators. Gallium oxide was used for the vapor-phase doping of semiconductor materials. Gallium ammonium chloride was employed in electrodepositing gallium on the whisker wire leads of transistors. Gallium phosphide had electronic applications.

Smaller quantities of gallium were used in certain selenium rectifiers, sealment material for glass joints in laboratory equipment, backing material for optical mirrors, and alloys for dentistry.

Prices.—Market prices per gram of various purity gallium metal and gallium sesquioxide crystals, from a sphalerite source are shown in table 1.

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[6] Mining Magazine (London). Caesium-137 From Radioactive Waste. V. 106, No. 3, March 1962, pp. 156–157.

[7] Pushkarev, V. V., L. D. Skrylev, and V. F. Bagrestsov. (Extraction of Radioactive Cesium With Mixed Heavy-Metal Ferrocyanides.) J. Appl. Chem. (U.S.S.R.), v. 33, No. 1, January 1960, pp. 81–85.

[8] Li, Pei-Ching, A. C. Ghose, and Gouq-Jen Su. High-Temperature Density Determination of Boron Oxide and Binary Rubidium and Cesium Borates. J. Am. Ceram. Soc., v. 45, No. 2, February 1962, pp. 89–91.

Li, Pei-Ching, A. C. Ghose, and Gouq-Jen Su. Viscosity Determination of Boron Oxide and Binary Borates. J. Am. Ceram. Soc., v. 45, No. 2, February 1962, pp. 83–88.

[9] Prepared by Donald E. Eilertsen.

TABLE 1.—Market prices of gallium metal and gallium sesquioxide in 1962

(Per gram)

Quantity	Gallium metal (99.999 percent)	Gallium sesquioxide (99.999 percent)	Gallium metal (99.9999 percent)	Gallium sesquioxide (99.9999 percent)	Gallium metal (99.99999 percent)
Less than 100 grams	$2.15	$2.15	$2.65	$2.90	$2.90
100 to 999 grams	1.85	1.85	2.40	2.65	2.65
1,000 to 4,999 grams	1.70	1.70	2.25	2.50	2.50
5,000 to 9,999 grams	1.55	1.55	2.00	2.25	2.25
10,000 or more grams	1.45	1.45	1.75	2.00	2.00

Technology.—Gallium research continued at about the same level as in 1961. A comprehensive bibliography on gallium for 1950 to 1959 was published.[10]

New values for the heat of formation of gallium sesquioxide were determined at 298.15° K by combustion calorimetry.[11]

Certain hard gallium alloys prepared by mixing liquid gallium with powdered gold, copper, nickel, or silver were evaluated.[12]

Methods were patented to electroplate gallium onto electrically conductive substrates.[13]

GERMANIUM [14]

Germanium production and consumption in the United States continued to decrease. Smaller semiconductor devices and the more efficient utilization of germanium per device were the major causes of decreasing consumption.

Domestic Production.—An estimated 37,000 pounds of germanium was produced from primary ores and concentrates. Part of the germanium was produced from germanium concentrates from South-West Africa and part as a byproduct from domestic zinc ores.

Companies that produced germanium were American Metal Climax, Inc., Carteret, N.J.; American Zinc Co., Fairmont, Ill.; The Eagle-Picher Co., Miami, Okla.; Penn Rare Metals, Inc., Revere, Pa.; Sylvania Electric Products, Inc., Towanda, Pa.; and United Minerals and Chemicals Corp., New Brunswick, N.J. Each company produced germanium dioxide and several electronic grades of single-crystal and polycrystalline germanium. All companies reclaimed germanium from scrap.

Consumption and Uses.—The largest use of germanium was in the production of transistors, diodes, and rectifiers. The production of transistors, diodes, and rectifiers continued to increase, but the quantity of germanium used in manufacturing them declined owing to

[10] Brennecke, M. W. Gallium Bibliography 1950–1959. Aluminum Co. of America, Res. Labs., New Kensington, Pa., 1962, 125 pp.

[11] Mah, Alla D. Heats and Free Energies of Formation of Gallium Sesquioxide and Scandium Sesquioxide. BuMines Rept. of Inv. 5965, 1962, 6 pp.

[12] Harmon, G. G. Detailed Techniques for Preparing and Using Hard Gallium Alloys. NBS Tech. Note 140, April 1962, 23 pp.; U.S. Dept. of Commerce, Office of Tech. Serv., PB 161,641.

[13] Foley, Francis D. (assigned to Hughes Aircraft Co., Culver City, Calif.) Gallium Plating and Methods Therefor. U.S. Pat. 3,061,528, Oct. 30, 1962.

[14] Prepared by John E. Shelton.

smaller units and more efficient processing. A small quantity of germanium was used as a colored modifier in fluorescent lights.

Prices.—The quoted price for germanium remained unchanged for the third consecutive year. Price quotations were as follows:

Grade:	Price (cents per gram)
First reduction	28.15 to 35.15
Intrinsic quality	29.95 to 36.95
Single crystal	60.50 to 68.50
Dioxide, high-purity	16.75 to 21.75

Foreign Trade.—Imports of germanium metal and compounds totaled 9,217 pounds valued at $595,000, compared with 30,748 pounds valued at almost $2 million in 1961. Of the total imported, 7,204 pounds came from West Germany, 1,855 pounds from Belgium, 97 pounds from the United Kingdom, and 61 pounds from Canada. In addition 18, 666 pounds of germanium in concentrate was imported from South-West Africa for refining.

World Review.—*Belgium.*—Germanium concentrates and dioxide from the Republic of the Congo and South-West Africa were refined at Société Generale Metallurgique de Hoboken and the Société Vieille-Montagne de Balen.

Japan.—Refined germanium was produced from imported germanium dioxide and scrap.

South-West Africa.—Production of germanium in concentrate was 86,800 pounds in 1962. About 32,000 pounds of the production was refined to germanium dioxide at the plant, and the balance was exported as concentrates to Belgium and the United States for refining.

Technology.—A process was described for recovering germanium from brown coals.[15] Furnace conditions were adjusted during the burning of Czechoslovakian brown coal to take full advantage of the volatility of germanium. The germanium-bearing ash was removed from the flue gases by cyclones and then treated by distillation to produce high-purity germanium dioxide. The applications of chlorination technology for the extraction of germanium from various feed materials and problems encountered were discussed in a paper.[16]

The occurrences, physical and chemical properties, and alloy systems of germanium have been described.[17]

The sources, properties, and uses of germanium were presented.[18]

GREENSAND [19]

Domestic production of greensand (glauconite) was 12 percent lower than in 1961. The entire output came from the open-pit operations of Inversand Co. (Gloucester County, N.J.), Kaylorite Corp. (Calvert County, Md.), and National Soil Conservation, Inc. (Burlington County, N.J.). Average annual output for the 5-year period 1958–62 was 6,100 tons valued at $208,000.

[15] New Scientist. Germanium Extraction From Brown Coal. No. 300, Aug. 16, 1962, p. 353.

[16] Ernst, R. G., and R. E. Halfacre. Production of Germanium via Chlorination Techniques. Pres. at ann. meeting, AIME, Feb. 18–22, 1962, 19 pp.

[17] Cirkler-Trettin, Franke E., and others. System 45: Germanium, Weinheim/Bergstrass, West Germany, Gmelins Handbuch der anorganischen Chemie. 8th Ed., 1958, 576 pp.

[18] Germanium Information Center. Germanium. Midwest Res. Inst., St. Louis, Mo., 1962, 35 pp.

[19] Prepared by Milford L. Skow.

Soil conditioning used 63 percent of the quantity sold; the other 37 percent was used in water softening.

Prices of greensand, f.o.b. mine, ranged from $17.00 to $82.67 per short ton.

A report on glauconite occurrences in southwestern New Mexico included detailed descriptions of environment and conclusions concerning formation.[20]

The geology of extensive greensand deposits in the Chichali formations in Pakistan was described.[21] The feasibility of extracting potash from these greensands and using it as a water softener were discussed.[22]

INDIUM [23]

Domestic Production.—American Smelting and Refining Company, Perth Amboy, N.J., was the only domestic producer of indium. This firm also produced some indium chloride and indium sulfate. Indium production and shipments were somewhat smaller than in 1961.

Uses.—The largest use of indium was in intermetallic semiconductors. The metal was used in germanium transistors to connect lead wires to germanium and to modify the properties of germanium.

Indium arsenide was of interest for devices utilizing the Hall effect and magnetoresistance. Indium antimonide was attractive for applications of photodetecting infrared light and in devices using magnetoresistance or the Hall effect to perform such functions in automation as counting, sorting, indexing, and timing. A large use for indium was in sleeve-type bearings where it promoted dependability and long life. Other uses were in solders, glass-sealing alloys, dental alloys, and electrical contacts.

Thirteen new low-melting indium alloy solders, which have great wettability and very low vapor pressure, were produced and offered by the Indium Corporation of America.

Prices.—Market prices for indium metal were $2.25 per troy ounce up to 100 troy ounces, $1.80 per troy ounce in 100-troy-ounce lots, $1.70 per troy ounce in 1,000-troy-ounce lots, and $1.60 per troy ounce for 5,000-troy-ounce lots.

Technology.—The entropy of indium sesquisulfide was determined to be 39.1 plus or minus 0.6 cal/deg mole at 298.15° K.[24]

A report summarized the variation of thermal expansion and specific heat of indium and six other metals in the range of 293° to 3,000° K.[25]

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[20] Lewis, D. W. Glauconite in the Cambrian-Ordovician Bliss Formation Near Silver City, New Mexico. New Mexico Bur. Mines and Miner. Res. Circ. 59, 1962, 30 pp.

[21] Kidwai, A. H. Geology of Greensand in the Chichali Formation of the Kalabagh-Manerwal Area, West Pakistan. Presented at CENTO Symposium on Industrial Rocks and Minerals, Lahore, West Pakistan, Dec. 3–8, 1962; Central Treaty Organization Economic Committee. Report of the CENTO Symposium on Industrial Minerals. CENTO Unclassified EC/11/M/D20, Ankara, Jan. 16, 1963, p. 7.

[22] Bakhsh, N., M. Hussain, and M. Amin. Commercial Utilization as Potash Fertilizer and Water Softener of Greensand. Pres. at CENTO Symposium on Industrial Rocks and Minerals, Lahore, West Pakistan, Dec. 3–8, 1962; Central Treaty Organization Economic Committee. Report of the CENTO Symposium on Industrial Minerals. CENTO Unclassified EC/11/M/D20, Ankara, Jan. 16, 1963, p. 7.

[23] Prepared by Donald E. Eilertsen.

[24] King, E. G., and W. W. Weller. Low-Temperature Heat Capacities and Entropies at 298.15° K. of Antimony and Indium Sulfides. BuMines Rept. of Inv. 6040, 1962, 5 pp.

[25] Carter, W. J. Thermodynamic Properties of Seven Metals at Zero Pressure. Univ. of California, for U.S. AEC, LAMS–2640, 1962, 62 pp.; U.S. Dept. of Commerce, Office of Tech. Serv.

A continuous process for producing high-purity electrolytic indium was patented.[26]

A method was patented for jet plating indium electrodes onto germanium blanks in the manufacture of semiconductors, such as transistors.[27]

The alloying of indium and gallium antimonides, arsenides, and phosphides with gold, silver, tin, and other metals and alloys was discussed.[28]

MEERSCHAUM [29]

The principal use for meerchaum (sepiolite) was in manufacturing pipe bowls, cigarette and cigar holders, and other smokers' accessories. There continued to be no domestic production of the mineral, so supplies had to be imported. Although these imports were 12,000 pounds less than in 1961, the total was the second highest in recent years. Turkey again furnished most of the imports.

The location, geology, mineralogy, and analyses by various methods were reported for a number of domestic occurrences of sepiolite.[30] The meerschaum deposits in the Lake Amboseli area of Tanganyika and the history of their exploitation were described briefly.[31]

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[26] Morawietz, Wilhelm (assigned to Duisburger Kupferhutte, Duisburg, West Germany). Process for the Production of Pure Indium. U.S. Pat. 3,049,478, Aug. 14, 1962.

[27] Schnable, George L., and John G. Javes (assigned to Philco Corp., Philadelphia, Pa.). Method of Jet Plating Indium-Lead Alloy Electrodes on Germanium. U.S. Pat. 3,017,332, Jan. 16, 1962.

[28] Bernstein, L. Alloying to III–V Compound Surfaces. J. Electrochem. Soc., v. 109, No. 3, March 1962, pp. 270–272.

[29] Prepared by Milford L. Skow.

[30] Ehlmann, A. J., L. B. Sand, and A. J. Regis. Occurrences of Sepiolite in Utah and Nevada. Econ. Geol., v. 57, November 1962, pp. 1085–1094.

[31] Harris, J. F. Summary of the Geology of Tanganyika. Tanganyika Geol. Survey Memoir 1, pt. 4; Economic Geology, 1961, pp. 102–103.

TABLE 2.—U.S. imports for consumption of meerschaum, by countries

Country	1953-57 (average)		1958		1959		1960		1961		1962	
	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value
Austria											101	$275
France					1,019	$471	2,566	$1,186	821	$380	1,063	557
South Africa,[1] Republic of	102	$217										
Turkey	9,781	18,995	17,392	$15,432	6,304	15,862	38,998	28,274	80,373	54,624	67,954	56,832
Total	9,883	19,212	17,392	15,432	7,323	16,333	41,564	29,460	81,194	55,004	69,118	57,664

[1] Effective Jan. 1, 1962; formerly Union of South Africa.

Source: Bureau of the Census.

RADIUM [32]

Domestic radium consumption revived as indicated by almost a fourfold increase in the quantity of radium and radium salts imported. A trend back to radium usage in medicine was apparent but was offset by a decrease in other uses. Increasingly larger quantities of replacement materials were used.

Domestic Production.—No domestic production of radium was reported. Distributors of radium, its derivatives, and related compounds included Canadian Radium & Uranium Division, Canrad Precision Industries, Inc., and Radium Chemical Co., Inc., New York, N.Y., and United States Radium Corp., Morristown, N.J. A. Bruce Edwards, Bala-Cynwyd, Pa., continued as sales representative for Atomic Energy of Canada, Ltd., which discontinued radium production in early 1950, but had a small quantity in stock for sale or lease.

Consumption and Uses.—The distinctive radioactive properties of radium that led to its use by the medical profession and by industry are possessed in their entirety by a number of radioisotopes that were becoming more available at relatively low prices. In industrial radiography, radium was being replaced by cobalt 60, iridium 192, and thulium 170; in luminescent compounds, by tritium; in static elimination, by americium and polonium; and in neutron sources, by polonium, americium, and plutonium.

Prices.—E&MJ Metal and Mineral Markets quoted radium at $16.00 to $21.50 per milligram, depending upon quantity. As a result of the replacement of old radium by other radioactive materials, larger quantities of old or used radium were available. Prices for this material were depressed to between $5.00 and $6.00 per milligram.

Foreign Trade.—Almost half of the radium salts imported came from Belgium-Luxembourg. Other important sources were Canada, Netherlands, and the United Kingdom, with minor quantities coming from Colombia, Brazil, and Trinidad-Tobago. Radium metal and alloys containing 328 milligrams of radium were exported to Canada and Argentina.

TABLE 3.—U.S. imports for consumption of radium salts and radioactive substitutes

Year	Radium salts		Radioactive substitutes, value [1] (thousands)
	Milligrams	Value (thousands)	
1953–57 (average)	65,581	$1,000	[2] $373
1958	38,419	538	908
1959	32,967	518	1,145
1960	23,333	364	1,394
1961	12,947	185	1,509
1962	46,962	700	1,732

[1] Includes artificial radioactive isotopes that are not substitutes for radium.
[2] Owing to changed tabulating procedures by the Bureau of the Census, data known not to be comparable with other years.

Source: Bureau of the Census.

[32] Prepared by John G. Parker.

Technology.—The emanation power of carbonate rocks and certain aggregates was determined by using a new dissolution technique. When the material was dissolved, small quantities of radon gas were determined by counting alpha particles from radon, radium A, and radium C. It was pointed out that this will allow controlled monitoring of building materials, some of which proved to have abnormally high background radiation.[33]

RHENIUM [34]

Domestic Production.—Chase Brass & Copper Co., Inc., Waterbury, Conn. (a subsidiary of Kennecott Copper Corp.), and the Department of Chemistry, University of Tennessee, Knoxville, Tenn., were the only domestic producers of rhenium in 1962. Production, consumption, and shipments of domestic rhenium metal, alloys, and compounds were the highest ever reported.

Uses.—Promising applications for rhenium were in electronics, electrical contacts, welding materials, thermocouples, catalysts, and coatings. Rhenium-tungsten wire (about 3 percent rhenium) was used for igniters in photoflash bulbs. Tubing of tungsten and 26 percent rhenium was used for thermocouples that measured temperatures up to 3,000° C in advanced nuclear reactors. Rhenium-plated molybdenum was used for X-ray-tube targets in France.

Prices.—Chase Brass & Copper Co., Inc., quoted the following prices, minimum order $50: Ammonium perrhenate, $425 per pound up to 5 pounds, and $400 per pound for larger quantities; potassium perrhenate, $395 per pound up to 5 pounds, and $370 per pound for larger quantities; first-grade rhenium powder, $650 per pound up to 1 pound, and decreasing prices to $580 per pound for lots of 20 or more pounds; and rhenium sintered bar (melting stock), $800 per pound up to 1 pound and decreasing prices to $750 per pound for lots of 5 or more pounds. Also available were rhenium rod and wire, molybdenum-rhenium and tungsten-rhenium rod, and wire and sheet.

Technology.—The Bureau of Mines continued its research on rhenium with emphasis on producing rhenium from molybdenite concentrate by means of solvent extraction-electrolytic procedures.

Rhenium was one of several metals studied in connection with columbium, molybdenum, tantalum, and tungsten at high temperature.[35]

Various methods were reported for separating and determining rhenium.[36]

A comprehensive book of papers presented at a symposium on rhenium was published.[37]

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[33] Gabrysh, A. F., N. D. McKee, and H. Eyring. Determination of the Radon Emanation From Carbonate Rocks and Its Potential Hazard in Building Materials. Materials Res. & Standards, v. 2, No. 4, April 1962, pp. 265–268.

[34] Prepared by Donald E. Eilertsen.

[35] English, J. J. Binary and Ternary Phase Diagrams of Columbium, Molybdenum, Tantalum and Tungsten. Defense Metals Inf. Center, Battelle Memorial Inst., Columbus, Ohio, Apr. 28, 1961, 225 pp.; U.S. Dept. of Commerce, Office of Tech. Serv. PB 171421.

Passmore, E. M., J. E. Boyd, and B. S. Lement. Investigations of Diffusion Barriers for Refractory Metals. Report prepared by Manlabs, Inc., Cambridge, Mass., for U.S. Air Force, July 1962, 87 pp.; U.S. Dept. of Commerce, Office of Tech. Serv., AD 285569.

[36] Ryabchikov, K. I., and Yu. B. Gerlit. The Present State of the Analytical Chemistry of Rhenium. Ch. in Detection and analysis of Rare Elements. National Science Foundation, 1962, pp. 703–741 (trans. from Russian); U.S. Dept. of Commerce, Office of Tech. Serv., 62-11021.

[37] Gonser, B. W. Rhenium. Proc. Electrochem. Soc. Symp. on Rhenium, 1960. American Elsevier Pub. Co., New York, 1962, 220 pp.

SCANDIUM [38]

Domestic Production.—Imports of scandium oxide derived from Australian uranium milling were six times greater than in 1961. These imports were upgraded by domestic companies which shipped high-purity oxide and, in one instance, produced and sold the metal. Production and shipments of the purified oxide from these companies also increased about sixfold, but the extremely small production of metal decreased.

American Scandium Corp., Newtown, Ohio, Research Chemicals Division, Nuclear Corporation of America, Phoenix, Ariz., and Vitro Chemical Co., Chattanooga, Tenn., supplied high-purity scandium oxide. Sales of oxide were less than thiry pounds. American Scandium Corp. continued to be the producer of metal.

Semi-Elements, Inc., Saxonburg, Pa., announced an expansion of its Pure Chemicals Division facilities, including a new process for the production of high-purity scandium compounds. The process was expected to reach its maximum output of 500 pounds per month early in 1963.[39]

Uses.—The only practical uses announced thus far have been for scandium radioisotopes as tracers in oil-well drilling and in analytical work. A newly developed isotopic pair, titanium 44 with a long half life and its very short-lived scandium 44 daughter product, was considered unparalleled as a gamma-ray standard.[40] Metallurgical research indicated that the metal has interesting alloying characteristics, and it is probably being used in nuclear energy applications. The constantly decreasing cost of the oxide is apparently stimulating research on applications for the metal.

Prices.—Imported scandium concentrates were priced 30 to 50 percent lower than during 1961. High-purity scandium oxide was made available at prices that approximated those quoted in 1961 for lower purity oxide. The 99.9-percent grade, in small lots, sold for about $5 per gram. Higher purity oxide was quoted at $15 per gram for 99.99-percent grade and $20 per gram for 99.999-percent grade.[41] Larger lots were available at prices significantly less than those quoted in the 1960 Minerals Yearbook. For example, in quantities less than 1 ton, 99.9-percent oxide was quoted at $2,200 per pound, and in larger lots, at $500 per pound.[42]

No official prices for metal were available, but judging from the small quantity sold a reduction from previous quotations was indicated.

World Review.—*Australia.*—At Port Pirie on Spencer Gulf in South Australia, a plant was converted to produce scandium oxide for export to the United States.[43]

Technology.—A long-term, mineralogical and geochemical study of scandium-bearing deposits, contained quantitative spectrochemical

[38] Prepared by John G. Parker.
[39] American Metal Market. V. 69, No. 206, Oct. 25, 1962, p. 13.
[40] American Metal Market. V. 69, No. 116, June 18, 1962, p. 18.
[41] American Metal Market. V. 69, No. 206, Oct. 25, 1962, p. 13.
[42] American Metal Market. V. 69, No. 206, Oct. 25, 1962, p. 13.
[43] Steel. V. 150, No. 8, Feb. 19, 1962, p. 71.

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data, physical and chemical properties, occurrences, types of deposits, and potentitial sources of scandium.[44]

The Bureau of Mines investigated potential sources of scandium, devised methods for its recovery, and obtained thermochemical data on the metal and its oxide.[45]

About 2 grams of 99.5-percent-pure scandium was obtained by vacuum distillation of a melt. It was discovered that the degree of purity markedly affected the physical properties but not the chemical properties of scandium.[46]

A luminescent reagent, salicylalsemicarbazide, was used in the quantitative determination of scandium in pure solutions and in salts of other elements.[47] Scandium detection in double mixtures of oxides was based on the measurement of total optical density of a hydrochloric acid solution with thoron II at pH 4.0.[48]

The effects of adding small quantities of scandium to manganese and iron at high temperatures were studied. It was believed that the addition of scandium must reduce the alpha-to-beta transition temperature of manganese appreciably and raise alpha-to-gamma transition temperature of iron.[49] Investigations of scandium in cadmium showed that the solubility of scandium was 8,200 parts per million in saturated solutions at 400° C. One of three new intermetallic phases reported was $ScGd_3$.[50] The existence of a number of new intermetallic compounds of scandium with metals such as cobalt, nickel, and copper was cited.[51] In the scandium-titanium system the maximum solubility of scandium in alpha titanium is 6.5 weight-percent at 875° C. The potential usefulness of hard alloys with high strength-to-weight ratios quenched from the beta region was deterred by the relatively high price of scandium.[52] A fairly limited mutual solubility of scandium-titanium alloy components existed owing to restrictions imposed by the electronegativity factor.[53] In studies of the

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[44] Borisenko, L. F. Scandium. Its Geochemistry and Mineralogy. Consultants Bureau Enterprises, Inc., New York, 1962, 78 pp.; Abs. in Materials Res. & Standards, v. 2, No. 9, September 1962, p. 793.

[45] Bauer, D. J. Foam Concentration of Scandium. BuMines Rept. of Inv. 5942, 1962, 15 pp.

Mah, Alla D. Heats and Free Enegries of Formation of Gallium Sesquioxide and Scandium Sesquioxide. BuMines Rept. of Inv. 5965, 1962, 6 pp.

Weller, W. W., and K. K. Kelley. Low-Temperature Heat Capacity and Entropy at 298.15° K. of Scandium. BuMines Rept. of Inv. 5984, 1962, 3 pp.

Ross, J. R., and J. B. Rosenbaum. Reconnaissance of Scandium Sources and Recovery of Scandium From Uranium Mill Solutions. BuMines Rept. of Inv. 6064, 1962, 16 pp.

[46] Men'kov, A. A., L. N. Komissarova, V. V. Karelin, Y. A. Priselkov, A. N. Nesmeyanov, and V. I. Spitsyn. (Investigation of High-purity Metallic Scandium.) Doklady Akad. Nauk SSSR, v. 144, No. 1, May 1, 1962, pp. 122–125; abstract resulting from the SOV/STEP program under the sponsorship of the U.S. Air Force, Available from U.S. Dept. of Commerce, Office of Tech. Serv.

[47] Korenman, I. M. and V. S. Efimychev. (Fluorimetric Determination of Scandium.) Zhur Analiticheskoi Khim., v. 17, No. 4, July–August, 1962, pp. 425–428; Nuclear Sci. Abs., v. 16, No. 21, Nov. 15, 1962, p. 3781.

[48] Sentyurina, N. N. (Photometric Determination of Microgram Quantities of Yttrium, Lanthanum, and Scandium in Y_2O_3–La_2O_3, Y_2O_3–Sc_2O_3,La_2O_3–Sc_2O_3 Mixtures.) Zhur. Analiticheskoi Khim., v. 17, No. 4, July–August 1962, pp. 442–446; Nuclear Sci. Abs., v. 16, No. 21, Nov. 15, 1962, p. 3781.

[49] Hellawell, A. Solubility of Scandium in Manganese and Iron at Elevated Temperatures. J. Less-Common Metals (Amsterdam, Netherlands), v. 4, No. 1, February 1962, pp. 101–103.

[50] Chasanov, M. G., P. D. Hunt, I. Johnson, and H. M. Feder. Solubility of 3-d Transition Metals in Liquid Cadmium. Trans. AIME, v. 224 (Met. Soc.), 1962, pp. 935–939.

[51] Aldred, A. T. Intermediate Phases Involving Scandium. Trans. AIME, v. 224 (Met. Soc.), 1962, pp. 1082–1083.

[52] Beaudry, B. J., and A. H. Daane. Sc-Ti System and the Allotropy of Sc. Trans. AIME, v. 224 (Met. Soc.), 1962, pp. 770–775.

[53] Savitskii, E. M., and G. S. Burkhanova. (Phase Diagrams of Titanium Alloys With Rare-Earth Metals). J. Less-Common Metals (Amsterdam, Netherlands), v. 4, No. 4, August 1962, pp. 301–314.

alpha-to-beta transformation of cerium, it was found that additions of scandium prevented the formation of beta cerium and increased the heat of transformation.[54]

SELENIUM [55]

Domestic selenium production and consumption decreased in 1962 while producers' stocks increased sharply.

Producers' stocks of marketable-grade selenium at the end of 1962 were 773,000 pounds, an increase of 50 percent over stocks at yearend 1961.

Selenium remained in Group I of the National Stockpile List of Critical and Strategic Materials. The Office of Minerals Exploration included selenium among minerals and mineral products eligible for Government financial participation up to 50 percent of approved costs.

Domestic Production.—Production of primary selenium was 999,000 pounds, 2 percent less than in 1961. Selenium recovered from secondary sources was about 1 percent of the supply.

Companies reporting production, shipments, and stocks were American Metal Climax, Inc., Carteret, N.J.; American Smelting and Refining Company, Baltimore, Md.; International Smelting & Refining Co., Perth Amboy, N.J.; Kawecki Chemical Co., Boyertown, Pa.; and Kennecott Copper Corp., Magna, Utah. Selenium was produced as a byproduct of the electrolytic refining of copper at all companies except Kawecki Chemical Co.

TABLE 4.—Salient selenium statistics

(Thousand pounds of contained selenium)

	1953-57 (average)	1958	1959	1960	1961	1962
United States:						
Production[1]	971	683	728	539	1,022	999
Shipment to consumers	889	723	790	552	787	741
Imports for consumption	172	184	224	162	117	159
Consumption, apparent[2]	1,061	907	1,014	714	904	900
Stocks, Dec. 31, producers	222	551	339	273	515	773
Price per pound, commercial grade	$5.75-$9.35	$7.00-$7.50	$7.00	$6.50-$7.00	$5.75-[3] $6.25	$5.75-$6.25
World: Production	1,776	1,462	[3] 1,650	[3] 1,671	[3] 2,097	2,126

[1] Includes small quantity of secondary selenium.
[2] Measured by shipments plus imports.
[3] Revised figure.

Consumption and Uses.—Shipments to consumers decreased to 741,000 pounds, 6 percent less than in 1961. The decrease in shipments of commercial-grade selenium more than offset increased shipments of the high-purity grade, ferroselenium, and compounds.

High-purity selenium was used primarily in electronic applications.

[54] Gschneider, K. A., Jr., R. O. Elliott, and R. R. McDonald. Effects of Alloying Additions on the Transformation of Cerium. Part II. Effects of Scandium, Thorium, and Plutonium Additions. Phys. and Chem. of Solids, v. 23, No. 9, September 1962, pp. 1191–1199.

[55] Prepared by John E. Shelton.

Small quantities were used in xerography and photoluminescence products. Ferroselenium improved the machinability of stainless steels.

Stocks.—Producers' stocks of marketable-grade selenium at yearend increased from 515,000 to 773,000 pounds. These stocks represented about 10 months' supply, according to apparent consumption during 1961. Total Government-owned inventories were 254,000 pounds, representing 63.4 percent of the maximum objective. Inventories showed 97,000 pounds in the National (strategic) stockpile and 157,000 pounds in the CCC and supplemental stockpile.

Prices.—Commercial-grade selenium was quoted at $5.75 to $6.25 per pound, and the high-purity grade was quoted at $6.75 in 1962. At yearend, ultra-high-purity selenium (99.999 plus percent) was quoted at $13.00 per pound and ferroselenium, at $5.75 per pound of contained selenium.

Foreign Trade.—Selenium content of imports for consumption of selenium metal and compounds totaled 159,300 pounds, 36 percent more than in 1961. Imports from Canada were 148,800 pounds valued at US$811,100. Imports from other countries were Japan, 3,400 pounds, Norway, 4,900 pounds, Sweden, 200 pounds, and the United Kingdom, 2,000 pounds. In addition, 1,100 pounds of selenium in selenium-bearing residues was imported from the Federation of Rhodesia and Nyasaland.

World Review.—*Canada.*—Production of selenium increased 18 percent. It was a byproduct of the electrolytic copper refineries of the International Nickel Company of Canada, Ltd., Copper Cliff, Ontario, and Canadian Copper Refiners, Ltd., Montreal East, Quebec.

Belgium.—Selenium was recovered from anode slimes resulting from the electrolytic refining of copper in the Republic of the Congo and the Federation of Rhodesia and Nyasaland.

Finland.—Output of selenium at Outokumpu Oy at Pori was down 11 percent.

Japan.—Selenium was produced at the Mitsubishi Metal Mining Co., Ltd., Osaka refinery, the Mitsui Mining & Smelting Co., Ltd., Takehara refinery, and Nippon Mining Co., Ltd., Hitachi and Saganoseki refineries as a byproduct of electrolytic-copper-refining operation. A minor quantity of selenium was a byproduct of sulfur and gold operations.

Mexico.—Selenium was a byproduct of lead flue dusts and was refined in the United States.

Peru.—Output of byproduct selenium increased 13 percent at the Cerro de Pasco Corp. Oroya electrolytic refinery.

Rhodesia and Nyasaland, Federation of.—Anode slimes (from the electrolytic refining of copper) containing selenium were shipped to Belgium and the United States for refining.

Technology.—The mineralogical and geochemical behavior of selenium and tellurium in ore deposits was studied.[56] The technical and economic aspects of concentrating selenium from sandstone ores by

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[56] Badalov, S. T., and S. Ruzmatov. (The Geochemistry of Selium and Tellurium in the Almalyk Ore Deposit.) Akad. Nauk SSSR, Inst. Mineral, Geokhim., i Kristallokhim. Redkikh Elementov, v. 4; 1960, pp. 24–27.

TABLE 5.—Free world production of selenium, by countries [1]

(Pounds)

Country	1953–57 (average)	1958	1959	1960	1961	1962
North America:						
Canada	332,953	306,990	368,107	521,638	430,612	506,015
Mexico	105,520	107,576	8,891	6,944	5,642	6,953
United States	970,505	683,000	728,000	539,000	1,022,000	999,000
South America:						
Argentina	[2] 845	(3)	(3)	(3)	(3)	(3)
Peru	[4] 5,573	8,419	8,155	10,681	16,305	18,382
Europe:						
Belgium-Luxembourg (exports)	58,775	48,942	124,560	72,531	52,910	[5] 30,900
Finland	7,599	13,051	13,196	11,358	13,296	11,797
Sweden	146,758	84,135	133,158	176,809	213,471	[5] 200,000
Asia: Japan	120,444	182,406	229,486	278,234	300,262	309,314
Africa: Rhodesia and Nyasaland, Federation of: Northern Rhodesia	23,437	24,388	33,448	50,119	39,362	40,526
Oceania: Australia	3,054	[5] 3,000	[5] 3,000	[5] 3,500	[5] 3,000	[5] 3,000
World total [1]	1,775,500	1,462,000	1,650,000	1,671,000	2,097,000	2,126,000

[1] This table incorporates a number of revisions of data published in previous Selenium chapters. Data do not add exactly to totals shown because of rounding.
[2] Average annual production 1955–57.
[3] Data not available; no estimate included in world total.
[4] Average annual production 1954–57.
[5] Estimate.

Compiled by Liela S. Price, Division of Foreign Activities.

froth flotation were discussed.[57] Flotation tests were made on ore samples containing 0.021 to 0.432 percent selenium, using kerosine, potassium amyl xanthate, and a frother. Recoveries and grade concentrate varied directly with the grade of the heads. Recoveries of selenium ranged from 76.1 to 93.6 percent, and the grades in the cleaner concentrate ranged from 2.9 to 16.3 percent selenium. Ammonium sulfide was used to extract selenium from copper anode slimes.[58] As much as 96 percent of the selenium was extracted from the slimes. After filtering, the selenium-rich solution was thermally decomposed in air to precipitate the selenium. Detection of selenium in parts per billion was accomplished by irradiating samples, followed by chemical separation, and counting of radioactive selenium.[59] This detection procedure was used to learn how selenium acts in muscular and nutritional processes.

Selenium additions to resulfurized carbon steels [60] and stainless steels [61] improved machinability.

Technical articles and reports concerning selenium and tellurium were compiled and abstracted.[62]

[57] Bhappu, Roshan B. Recovering Selenium From Sandstone Ores of New Mexico. J. Metals, v. 14, No. 6, June 1962, pp. 429–431.
[58] Karayev, Z. Sh., and G. Kh. Efendiyev. (Extracting Selenium With Ammonium Sulfide From Slimes as a Means of Obtaining Pure Selenium.) Azerb. Khim. Zhur., No. 5, 1961, pp. 119–123.
[59] Chemical and Engineering News. Activation Analysis Can Be Used to Detect Selenium and Other Materials at p.p.b. Levels. V. 39, No. 52, Dec. 25, 1961, p. 31.
[60] Journal of Metals. Super-Machining Steels. V. 14, No. 10, October 1962, p. 737.
[61] Iron Age. Selium for Stainless. V. 189, No. 8, Feb. 22, 1962, p. 15.
[62] Battelle Memorial Institute (Columbus, Ohio). Selenium and Tellurium Abstracts 1962. V. 3, pp. 525–718.

STAUROLITE [63]

Staurolite output and value decreased substantially in 1962, compared with 1961. This was the second consecutive year that production and value declined. E. I. du Pont de Nemours & Co., Inc., recovered staurolite at the Highland and Trail Ridge plants in Clay County, Fla. The mineral was used in the manufacture of portland cement.

TELLURIUM [64]

Production and shipments of tellurium metal and compounds increased, because demand rose for commercial-grade metal.

The Office of Minerals Exploration included tellurium among minerals and mineral products eligible for Government financial participation up to 50 percent of approved costs.

Domestic Production.—Production of tellurium increased 29 percent from 205,000 pounds in 1961 to 264,000 pounds in 1962. Output was as a byproduct of electrolytic copper refining and lead refining except for a small quantity from scrap. Companies reporting stocks, production, and shipments were American Metal Climax, Inc., Carteret, N.J.; American Smelting and Refining Company, Baltimore, Md.; International Smelting & Refining Co., Perth Amboy, N.J.; Penn Rare Metals, Inc., Revere, Pa.; Phelps Dodge Refining Corp., El Paso, Tex.; and United States Smelting, Refining and Mining Co., East Chicago, Ill.

TABLE 6.—Salient tellurium statistics

(Thousand pounds of contained tellurium)

	1953–57 (average)	1958	1959	1960	1961	1962
United States:						
Production, primary and secondary	156	123	177	271	205	264
Shipments to consumers	173	159	257	228	231	233
Stocks, Dec. 31, producers	120	131	58	126	64	87
Imports, general	(1)	6	16	15	(1)	(1)
Price per pound, commercial grade	$1.65–$1.75	$1.65–$1.75	$1.65–$3.00	$3.00–$4.00	$4.00–$5.25	$6.00
World: Production	184	176	255	389	[2] 366	398

[1] Data not available.
[2] Revised figure.

Consumption and Uses.—Shipments increased slightly to 233,000 pounds. Consumption of tellurium as additives in free-machining steels and for production of tellurium-copper alloys was greater than in 1961. The quantity used in the ceramic, chemical, and rubber industries showed little change. The use of tellurium for thermoelectric devices decreased.

Stocks.—Producers stocks of marketable-grade tellurium metal and compounds at yearend were 87,000 pounds, an increase of 36 percent over the end of 1961.

[63] Prepared by Henry Stipp.
[64] Prepared by John E. Shelton.

Prices.—Commercial-grade tellurium was raised from $5.25 to $6.00 per pound on January 2 and remained unchanged throughout 1962. High-purity tellurium (99.999 plus percent) was quoted at $21.50 to $30.00 per pound at yearend.

Foreign Trade.—Imports of tellurium metal and compounds were valued at approximately $50,000, but the quantity was not reported.

World Review.—*Canada.*—Tellurium production decreased 21 percent from 1961. Canadian production was a byproduct of electrolytic copper refining at The International Nickel Company of Canada, Ltd., Copper Cliff, Ontario; and Canadian Copper Refiners, Ltd., Montreal East, Quebec.

TABLE 7.—Free world production of tellurium, by countries [1]

(Pounds)

Country	1953–57 (average)	1958	1959	1960	1961	1962
North America:						
Canada	12,254	38,250	13,023	44,682	77,609	61,211
United States	155,968	123,000	177,000	271,000	205,000	264,000
South America: Peru	490	14,868	62,600	59,343	76,279	50,742
Asia: Japan	672	110	2,761	13,671	16,486	22,297
Free world total [1]	169,400	176,200	255,400	388,700	366,400	398,000

[1] This table incorporates a number of revisions of data published in previous Tellurium chapters. Data do not add exactly to totals shown because of rounding.

Compiled by Liela S. Price, Division of Foreign Activities.

Japan.—Tellurium was produced at the Osaka refinery, Mitsubishi Metal Mining Co., Ltd.; the Takehara refinery, Mitsui Mining & Smelting Co., Ltd.; and the Hitachi and Saganoseki refineries, Nippon Mining Co., Ltd.

Peru.—Tellurium was a byproduct at the Cerro de Pasco Corp. refinery at Oroya.

Technology.—Several articles were published on the extraction and refining of tellurium from ores and other tellurium-bearing materials.[65]

Research on the application of thermoelectric cooling devices continued. Prototypes of refrigerators, icemakers, and air conditioners, using bismuth telluride components, were produced for the homeowner, industry, and military services. A thermoelectric device attached to lathes and planers extended the life of cutting tools by cooling them.[66]

The effects on the machinability of steel from additions of tellurium were discussed.[67] Additions of minute quantities of tellurium changed gray cast iron to white cast iron by carbide stabilization.[68]

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[65] Koz'min, Yu. A., S. V. Zemskov, and A. I. Ryabinin. (Application of the Sulfide-Sulfite Method in the Processing of Tellurium-Containing Materials.) Metallurg. i Khim. Promst' Kazakhstana. Nauchno-tekhn. sb. (U.S.S.R.), No. 1 (11), 1961, pp. 23–25.
Rodzayevskiy, V. V., and A. I. Lazarev. (Preparation of High-Purity Tellurium.) Tsvetnyye metally (U.S.S.R.), No. 11, 1961, pp. 52–54.
Zelenov, V. I. (Selenium and Tellurium Behavior in Processing Some Types of Auriferous Ore.) Sb. Materialov po Gorn. Delu, Obogashcheniyu i Metallurgii, Tsentr. n.-i. Gornorazved. in-t (U.S.S.R.), No. 6, 1961, pp. 55–63.
Zelenov, V. I., and Z. M. Shtrineva. (Hydrometallurgical Extraction of Tellurium From Tellurium-Bearing Products.) Tsvetnyye metally (U.S.S.R.), No. 12, 1961, pp. 59–61.

[66] Iron Age. Tools Get Thermoelectric Chill. Dec. 13, 1962, p. 107.

[67] Spencer, R. C., C. D. Nagell, and Robert Richmond. How Tellurium Affects Machinability of Steel. Metal Prog., v. 82, No. 6, December 1962, pp. 73–78.
Steel. Steel Maker Still Striving for Freer Machining Metals. V. 150, No. 2, Jan. 8, 1962, pp. 90, 93.

[68] Iron Age. Tape Measures Trace Elements for Dual Iron Castings. V. 189, No. 17, Apr. 26, 1962, pp. 152–153.

Technical articles and reports concerning selenium and tellurium were compiled and abstracted.[69]

THALLIUM [70]

Domestic Production.—American Smelting and Refining Company at Denver, Colo., was the only domestic producer of thallium. This firm produced more, consumed less, and shipped much more of the metal than in 1961. Thallium sulfate production was smaller than in 1961, but shipments were larger.

Uses.—The largest use by far of thallium was as the sulfate, an odorless, tasteless, and very poisonous rodenticide and insecticide. Other uses for thallium were in low-melting alloys, in optical glass, and in glass seals for the protection of electronic components. Thallium-activated sodium iodide crystals were used in photomultiplier tubes. A new vapor lamp, reported to contain thallium, was being evaluated as a source of very white light.

Price.—Thallium was quoted at $7.50 per pound.

Technology.—A procedure for producing thallium-activated potassium iodide phosphor was patented.[71]

Preliminary measurements were made of the absorption of far-infrared radiation in the surface of a superconducting alloy containing lead and 10 atomic percent thallium at 1.4 K.[72]

The luminescence of thallium-activated zinc sulfide phosphors was studied.[73]

WOLLASTONITE [74]

Domestic production of wollastonite continued its upward trend; the tonnage was 9 percent greater than in 1961. Most of the output came from the Willsboro mine, Essex County, N.Y., operated by Cabot Minerals Division of Cabot Corp. Three firms recovered the remainder from four deposits in California.

Adirondack Development Corp., Keeseville, N.Y., began constructing a pilot plant late in the year at Willsboro, N.Y., to develop a process for producing ultrafine wollastonite, which reportedly was to have entirely different markets than existing wollastonite production. The work was made possible by a technical assistance contract with the Area Redevelopment Administration (ARA), U.S. Department of Commerce. ARA was to advance $89,504 of the total project cost of $109,504.

The following prices were quoted for wollastonite in Oil, Paint and Drug Reporter throughout 1962: Fine, paint grade, bags, carlots, works, $41 per ton, less than carlots, ex warehouse, $51 per ton; me-

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[69] Battelle Memorial Institute (Columbus, Ohio). Selenium and Tellurium Abstracts 1962. V. 3, pp. 525–718.

[70] Prepared by Donald E. Eilertsen.

[71] Alles, Francis Peter (assigned to E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.). Process for Making Thallium Activated Potassium Iodide Phosphor. U.S. Pat. 3,030,313, Apr. 17, 1962.

[72] Ginsbery, D. M., and J. D. Leslie. Far-Infrared Absorption in Lead-Thallium Super Conducting Alloy. IBM J. Res. and Devel., v. 6, No. 1, January 1962, pp. 55–57.

[73] Wachtel, A., Thallium-Activated Zn-S Phosphors. J. Electrochem. Soc., v. 109, No. 4, April 1962, pp. 306–309.

[74] Prepared by Milford L. Skow.

dium, paint grade, bags, carlots, works, $29 per ton, less than carlots, ex warehouse, $39 per ton. These prices were the same in 1961.

A California wollastonite deposit that had been worked commercially at times was described, and an average analysis of its product was reported.[75]

The use of wollastonite in the body of one-fire, glazed ceramic wall tile permitted a 9-hour firing schedule.[76]

YTTRIUM [77]

The commercial use of yttrium as an additive in nodular iron was problematical. Further testing by large consumers would depend partly upon the availability of lower cost material.

Domestic Production.—Nearly 2 tons of yttrium oxide valued at about $180,000 was shipped. Production was from monazite processing primarily for rare-earth values, and increased fourfold or fivefold to nearly 5 tons. This was commensurate with the greatly increased consumption of monazite during 1962.

Companies that recovered or refined yttrium oxide and compounds were American Potash & Chemical Corp., West Chicago, Ill.; Lunex Co., Pleasant Valley, Iowa; Michigan Chemical Corp., St. Louis, Mich., and Vitro Chemical Co., Chattanooga, Tenn.

Commercial producers of yttrium metal included American Potash & Chemical Corp., Lunex Co., Michigan Chemical Corp., and Research Chemicals Division, Nuclear Corporation of America, Phoenix, Ariz. Over 100 pounds of metal was produced, 35 pounds of which was shipped by Lunex Co.

Fused-salt electrolysis methods were used at the Bureau of Mines Metallurgy Research Center, Reno, Nev., to produce experimental quantities of high-purity yttrium metal.

Uses.—Most of the usage indicated by the processors for yttrium, usually either as the oxide or the metal, was in nuclear applications and in chemical processing. Microwave devices incorporated yttrium-iron garnets, which were used as transducers and transmitters. In fluoride processing, yttrium was considered as a structural material for ducts, pipes, and containers because of its resistance to hydrofluoric acid. The refractory oxide was used as a coating on low-cost graphite crucibles to prevent carbon contamination of molten alloys contained therein. Its resistance to oxidation at elevated temperatures made it valuable as an additive to steel and chromium-based alloys.

The greatest potential use of yttrium was considered to be in the preparation of nodular iron, in which it is one of the most effective spheroidizers of graphite.[78] Crane Company's Industrial Products Group planned to use yttrium nodular iron in its entire valve line by the end of the year. The material was said to be a substitute for malleable iron in castings, because it would contribute the strength

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[75] Troxel, B. W., and P. K. Morton. Mines and Mineral Resources of Kern County, California, California Div. of Mines and Geol., County Rept. 1, 1962, p. 344.

[76] Hoffman, M. S. Horse and Carriage Transportation—but Fine Ceramic Tile. Ceram. Age, v. 78, February 1962, pp. 42–44.

[77] Prepared by John G. Parker.

[78] Fisher, John. New Graphite Spheroid Theory Seen Iron Nodularizing Guide. Metalworking News, v. 3, Whole No. 90, June 25, 1962, pp. 1, 11.

and ductility of low-grade steels.[79] Although the use of yttrium nodular iron in engine blocks was reported to have been investigated by several automobile makers, one company indicated that the casting process was costly and that the metal produced had strength levels below those of comparable nodular iron. It was pointed out that the cost factor would be reduced considerably by using an yttrium alloy.[80]

Prices.—Some representative yttrium oxide prices were 20 and 23 cents per gram for material of 99- and 99.9-percent purity, respectively, in lots from 10 to 99 grams. Lots of 100 to 450 grams of the same purity were slightly lower. Pound-lot prices ranged from $50 to $70 per pound depending upon purity, while other large-lot prices were available from the companies. American Metal Market continued quoting small-lot prices with no changes from 1961. Lots of 10 to 99 grams and of 100 to 450 grams of 99.9-percent-pure metal sold for 81 and 54 cents per gram, respectively. Pound lots of yttrium metal sponge were priced from $240 to $300 per pound and of yttrium metal ingots, from $260 to $320 per pound for 98.8+ percent grade, 99.2+ percent grade, and 99.9+ percent grade (nuclear grade). Prices on larger quantities were furnished upon request.

World Review.—*Malaya, Federation of.*—Almost 6 short tons of xenotime (an yttrium phosphate mineral) worth US$1,300 was exported.[81]

Technology.—The second occurence of spencite, a metamict borosilicate of yttrium, thorium, and calcium, was found in a pegmatite near Cranberry Lake, Sussex County, N.J.[82] Apatite, with an abnormally high content of yttrium, was found in quartz in a Japanese pegmatite. The yttrium and rare-earth content is about the same as that in the abundant apatite found in iron-ore tailings in the Adirondack area (New York).[83]

Several patents disclosed chemical methods for the separation of yttrium.[84] Buffered DTPA (diethylenetrinitrilopentaacetic acid) was used as an eluant in the commercial ion-exchange isolation of yttrium compounds from mixed rare-earth oxide source material. The method offered greater specificity and minimized precipitation and recovery problems.[85]

Research was continued on the methods of growing single crystals containing yttrium. Yttrium borate crystals were formed by heating the components to about 1,200° C in a flux mixture of a molybdic oxide

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[79] Slattery, Tom. Crane Valves To Use Yttrium Nodular Iron. Metalworking News, v. 3, Whole No. 91 (sic), June 11, 1962, p. 11.

[80] Metalworking News. Yttrium Nodular Casting Called Costly for Ford. V. 3, Whole No. 89, June 18, 1962, p. 4.

[81] U.S. Embassy, Kuala Lumpur, Federation of Malaya. State Department Dispatch A-574, Apr. 9, 1963, p. 2.

[82] Jaffe, Howard W., and Victor J. Molinski. Spencite, The Yttrium Analogue of Tritomite From Sussex County, New Jersey. Am. Miner., v. 47, Nos. 1–2, January–February 1962, pp. 9–25.

[83] Omori, Keiichi, and Hiroshi Konno. A New Yttrian Apatite Enclosed in Quartz From Naegi, Gifu Prefecture, Japan. Am. Miner., v. 47, Nos. 9–10, September–October 1962, pp. 1191–1195.

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and a potassium compound and by slowly cooling the resulting melt.[86] Yttrium-aluminum garnet was grown using molten lead and boron oxides in the solvent. It was found that increasing boron oxide content in the solvent widened the field of stability of the garnet.[87] Other studies obtained phase equilibrium information that made possible an orderly method of selecting solvents for crystal growth. The percentage of iron in the crystallized phase varied directly with the boron oxide concentration in the solvent.[88]

Phase equilibria research was conducted on binary and ternary systems containing yttrium as a component. Pressure-temperature-composition studies in the range 900° to 1,350° C and 1 to 760 millimeters of mercury, confirmed by X-ray diffraction analysis and metallographic examination, showed the existence of an yttrium solid solution phase, an yttrium hydride phase approaching yttrium dihydride (YH_2) in composition, and a stable trihydride phase.[89] Solid solutions were formed in three yttrium-erbium silicate systems. It was believed that in all three systems continuous solubility was promoted by the small difference between the ionic radii but hindered by the structural difference between yttrium and erbium silicates.[90] Studies of the yttrium oxide-zirconium oxide system established the existence of cubic yttrium zirconate, which had the formula $Y_2Zr_2O_7$, a pyrochlore-type structure that suggested probable ferroelectric properties, and a melting point of about 2,530° C. It was resistant to concentrated hydrochloric, sulfuric, and hydrofluoric acids, aqua regia, and potassium and sodium hydroxides.[91] The yttrium-manganese system was shown to contain three intermetallic compounds and to have eutectics at 25.2, 60.9, and 82.0 weight-percent manganese, with respective melting points of 878° C, 1,100° C, and 1,075° C. Of the three intermetallic compounds, YMn_2 melted congruently, YMn_4 underwent syntectic decomposition, and YMn_{12} underwent peritectic decomposition.[92]

Binary systems of yttrium with titanium, zirconium, and hafnium were investigated through their entire composition range. In none of the systems were compounds formed and each system had only one eutectic reaction.[93] Alloy systems of yttrium-vanadium, yttrium-columbium, and yttrium-tantalum also were studied, and equilibrium diagrams were constructed. Regions of liquid immiscibility were common to all three systems, and in the yttrium-tantalum system complete immiscibility existed in the liquid and solid states.[94] The ternary sys-

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tem Fe_2O_3–FeO–$YFeO_3$ was investigated in ambient atmospheres of oxygen, air, and carbon dioxide at melting points. Depending upon the atmosphere, the temperature of coexistence of yttrium-iron garnet and oxide liquid decreased with decreasing oxygen partial pressure, ranging from 127° C in oxygen to 28° C in carbon dioxide. The garnet-phase composition changed with variation of temperature and oxygen pressure.[95]

It was found that yttrium may be used to reduce the oxygen content of beryllium. Deoxidation is accomplished at temperatures greater than 1,327° C, at which point the negative change of free energy of formation of yttrium oxide (Y_2O_3) is greater than that required for the formation of beryllium oxide (BeO).[96]

Bureau of Mines research on yttrium was summarized in reports involving heat decomposition of salts and thermodynamic data of the oxide.[97]

Pilot plant studies continued on yttrium nodular iron, but limitations of availability and high cost of the yttrium additive prevented development of what was thought to be its full potential.

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INDEX

The index consists of three parts: A commodity index, a company index, and a world review index. Because nearly all commodity chapters in Minerals Yearbook, volume I, follow a standard outline (Introductory Summary, Domestic Production, Consumption and Uses, Stocks, Prices (and specifications), Foreign Trade, World Review, World Reserves, and Technology), references to such data have been omitted under the various headings.

Readers seeking information on mine production for States, territories, or possessions should refer to tables in the Statistical Summary chapter, starting on page 137. 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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