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MINERALS YEARBOOK

1961

Volume I of Three Volumes

METALS AND MINERALS

(Except Fuels)

Prepared by the staff of the
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FOREWORD

MINERALS YEARBOOK, 1961, 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 chapter on "High-Purity Silicon," new in the 1960 volume, has been renamed "Silicon." This chapter has been enlarged to incorporate data on metallurgical silicon and its alloys with iron. Also, an additional chapter in the 1961 volume I compares Bureau of Mines mineral-commodity production data for 1958 with those presented in the 1958 Census of Mineral Industry reports published by the United States Department of Commerce.

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

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

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 Severance Tax Division, Mississippi State Tax Commission.
Missouri: Division of Geological Survey and Water Resources, Department of Business Administration.
Montana: Montana Bureau of Mines and Geology.
Nevada: Nevada Bureau of Mines.
New Hampshire: New Hampshire State Planning and Development Commission.
New Jersey: Bureau of Geology and Topography.
New York: New York State Science Service.
North Carolina: Geological Survey of North Carolina.
North Dakota: North Dakota Geological Survey.
Oklahoma: Oklahoma Geological Survey and Oil and Gas Conservation Department; Oklahoma Corporation Commission, Gross Production Division; Oklahoma Tax Commission.
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South Carolina: Geological Survey of South Carolina.
South Dakota: State Geological Survey.
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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.

Washingon: 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 five review chapters, this volume was prepared by the staff of the Division of Minerals. The following persons supervised preparation of the various chapters: Charles T. Baroch, chief, Branch of Nonmetallic Minerals; Frank J. Cservenyak, chief, Branch of Ferrous Metals; and Paul F. Yopes, chief, Branch of Nonferrous Metals. Preparation of this volume was supervised and the chapters were coordinated with those in volume III by Donald R. Irving, assistant to the chief, Division of Minerals.

The manuscripts upon which this volume is based have been reviewed to insure statistical consistency 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, 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 both by companies and individuals of these essential data.

CHARLES W. MERRILL,
Chief, Division of Minerals.

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Review of the Mineral Industries [1]

(Metals and Nonmetals Except Fuels)

By Kung-Lee Wang [2]



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THE U.S. economy in early 1961 emerged from the slackening in business and industrial activity that had been underway since mid-1960. A new peak of production and income was achieved by yearend. The mining industry, including fuels, kept up with the economy although the nonfuel mineral industry trailed and made no gain during the year. The nonfuel mineral industry opened 1961 buoyantly but immediately ebbed and drifted slowly downward, lagging behind the other sectors of the economy. By May, the nonfuel mining sector reached its year's low, began to recover gradually, and reapproached the January figure although the value of nonfuel mineral production increased to a very small extent, it achieved another record high. Nonmetal minerals increase compensated the metals reduction. A large decrease in iron ore production and the significant depletion of iron ore stocks were responsible for the wane.

Net supply of nonfuel minerals and metals generally subsided, but imports were able to hold to their previous share in the sources of supply, while exports made some gain. Consumption of nonfuel minerals rose slightly. That of nonferrous metals and concentrates increased the most, consumption of steel-associated minerals declined a little, and that of nonmetallic minerals was the same. Domestic production made an inappreciable gain. Prices were comparatively steady although somewhat weak. Value of mineral production was up slightly. Overall physical stocks diminished to a limited degree. The changes in stocks were affected principally by sulfur, whereas iron ore was mainly responsible in 1960.

Mining labor productivity continued the gradual upward trend. Average annual earnings for all employees increased, but total employ-

[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.

ment, and total wages and salaries earned in the mineral industries declined. Principal current mining expenses diminished meagerly, while mining machinery and equipment were relatively more expensive than in 1960.

Income generated by the nonfuel mineral industries was less contrary to the national economic trend. Income from metal mining lost significantly, while nonmetallic mineral income remained the same. Similar situations existed in the average annual profit rate for the nonfuel mineral industries.

Expenditure on new plant and equipment in the mining industry (including fuels) declined slightly but much less than in all manufacturing. For research and development in the mining industry as a whole, expenditure continued to be insignificant. However, the Federal Bureau of Mines made a marked contribution. Most of its funds for mining research and development were expended on applied research.

Activity under the Defense Mobilization Program was again at a low ebb. The U.S. Tariff Commission rejected the injury claim by the feldspar industry against some Canadian exports but sustained the injury claims of the cement industry against imports from Sweden, Belgium, and Portugal. It recommended no change in the lead and zinc import quotas.

World mineral industries generally improved over 1960. World mineral production made modest gains, while that of the United States rose inappreciably. The United States continued as the leading consumer and as an important producer of most minerals. Consumption increased at a faster rate worldwide than in the United States. World stocks were enlarged a little, but the United States stocks ebbed. World price movements matched those of the United States.

DOMESTIC PRODUCTION

Value of Mineral Production.—The production value of metals, nonmetals, and mineral fuels was 1.3 percent higher than in 1960 and achieved a new record high. This small increment was registered despite a 5-percent decline in metals resulting from the slackening of iron and steel output. Virtually all the changes in total value resulted from physical volume changes because unit prices were steady.

Minerals fuels output increased 1.8 percent over 1960 and was principally responsible for the overall minerals increment. Hydrocarbon fuels accounted for all the gain, but bituminous coal and anthracite declined.

Nonfuel mineral value increased .3 percent. It was registered as another record high, and it furnished 32 percent of the total value of mineral production. Nonmetals strengthened their position, with a 3-percent increase over 1960; fertilizer raw material and sodium compounds setting new records. Also, cement production, higher than in 1960, compensated for the decline in value of other chemical and construction materials. Metallic ores and concentrates decreased 4.6 percent, resulting from a 20-percent decline in iron ore production and a 9-percent depletion of iron ore stocks in 1961.

Volume of Mineral Production.—The Bureau of Mines index of physical volume of mineral production has been revised to a 1957–59

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

(Million dollars)

Mineral groups [2]	1952–56 (average)	1957	1958	1959	1960 [3]	1961	Change in 1961 from 1960 (percent)
Metals and nonmetals except fuels:							
Nonmetals	2,673	3,267	3,346	3,721	3,732	3,846	+3
Metals	1,872	2,137	1,594	1,570	2,022	1,927	−5
Total	4,545	5,404	4,940	4,291	5,754	5,773	[4]
Mineral fuels	10,463	12,709	11,589	11,950	12,142	12,358	+2
Grand total	15,008	18,113	16,529	16,241	17,896	18,131	+1

[1] Beginning with 1953 Alaska and Hawaii are included.
[2] For details see table 2 (Mineral production in the United States) in the Statistical Summary of Mineral Production Chapter.
[3] Revised figures.
[4] Increase of less than 0.5 percent.

base, whereas those published previously were on a 1947–49 base. The index increased 0.8 point in 1961, a 0.8-percent rise. The fuel index rose nearly a point and was principally responsible for the minute rise of the total index. Nonmetals made a 2.6-point gain a 2.7-percent rise. Chemical materials, increasing 3.5 points, led construction materials, which rose 2.7 points; both gains were more than equalized by the 5.2-point loss in other nonmetals. Metal index was reduced 4.2 points, equivalent to a 3.9-percent loss. Despite the gain of 7.9 points in the base nonferrous metals, the 19.6-point loss in the ferrous metal index plus the decline in both monetary and other nonferrous metal index caused the overall metals index to ebb by 4.2 points.

The Federal Reserve Board (FRB) 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 nonmetal mining.

TABLE 2.—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					
1952	92.1	115.8	119.8	113.3	109.8	111.7	146.1	73.0	67.7	85.1	102.8	93.8
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	108.7	113.4	93.7	91.5	110.6	110.9	112.0	97.9	101.2

[1] For description of index see Minerals Yearbook 1956, v. 1; Review of the Mineral Industries, pp. 2-5.

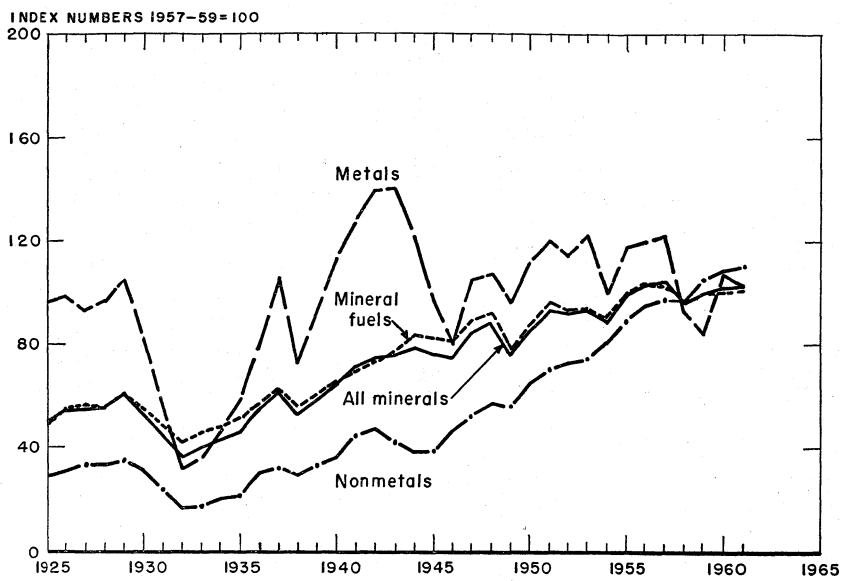


FIGURE 1.—Indexes of physical volume of mineral production in the United States, 1925–61, by groups.

TABLE 3.—Indexes of production of metal and mineral mining, metals, nonmetal products, and total industrial production, seasonally adjusted [1]

(1957=100)

Year	Metal, stone, and earth minerals mining	Iron and steel	Primary metals	Clay, glass, and stone products	Total industrial production
1954	79	80	81	85	85
1955	91	106	106	97	96
1956	98	103	104	102	99
1957	100	100	100	100	100
1958	91	75	78	95	93
1959	94	86	90	110	105
1960	105	88	[2] 90	110	108
1961 [3]	105	84	88	108	109

[1] Federal Reserve Bulletin, Industrial Production Indexes, March 1961, p. 350; May 1962, p. 628; previous issues.
[2] Revised figure.
[3] Preliminary figures.

The major advantage of the Bureau's index is that it is available on a comparable basis since 1880. However, FRB indexes are available monthly and on a seasonally adjusted basis.

The monthly indexes for all mining declined in the first quarter and then recovered fully and ended the year with a modest gain over 1960. The nonfuel (metal, stone and earth minerals) mining index started the year strongly, then eased, did not begin to recover until June, reached a lower peak in November, slacked off in December, and did not change for the year as a whole. Stone and earth minerals, reflecting the seasonal construction pattern, made no gain in 1961.

Metal mining generally followed the nonfuel mining pattern except for a strong gain in December and ended the year at a high point.

TABLE 4.—Monthly indexes of production, mining, metal mining and stone and earth minerals seasonally adjusted

(1957=100)

Month	Mining [1]			Metal mining			Stone and earth minerals		
	1960	1961	Change from 1960 (percent)	1960	1961	Change from 1960 (percent)	1960	1961	Change from 1960 (percent)
January	98	98	----------	87	109	+25.3	108	111	+2.8
February	96	96	----------	95	106	+11.6	106	106	----------
March	96	96	----------	104	106	+1.9	101	107	+5.9
April	98	97	−1.0	106	92	−13.2	115	110	−4.4
May	97	97	----------	103	86	−16.5	114	114	----------
June	97	98	+1.0	97	89	−8.2	116	116	----------
July	98	98	----------	94	90	−4.3	118	118	----------
August	98	99	+1.0	96	90	−6.2	116	114	−1.7
September	96	97	+1.0	92	94	+2.2	114	113	−.9
October	97	100	+3.1	88	99	+12.5	116	115	−.9
November	98	101	+3.1	95	106	+11.6	113	111	−1.8
December	98	101	+3.1	107	112	+4.7	109	104	−4.6
Annual average	97	[2] 98	+1.0	[3] 97	[2] 97	----------	112	[2] 112	----------

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

Source: Federal Reserve Bulletin. Industrial Production Indexes. March 1961, p. 350; March 1962, p. 346; May 1962, p. 628.

NET SUPPLY

Net Supply.—The net supply [3] of minerals and metals generally decreased in 1961. Nickel, lead, aluminum, cadmium, platinum, and phosphate rock were the major exceptions. The declines can be attributed to general increase of exports, inventory reductions of mineral-consuming industries, and general lessening of pig iron, steel ingot, and iron and steel casings production. Of the 34 commodities included in the net-supply tabulation, 26 decreased; 7 increased; and 1 remained unchanged. The net-supply analysis clearly showed 1961 to be a relatively poor year. The small increase of exports prevented a poorer year in the mineral industries.

Sources of Supply.—Imports continued as an important source of new supply, most markedly in the metals group. Of the commodities shown in table 5, the import contribution of 10 decreased; 13 increased; and 11 showed no change.

Sources of Imports.—Canada and Mexico expanded their share of U.S. imports for 12 principal commodities, lost in 8, and maintained their position in 4. The East and South Pacific areas maintained their share of the market, but other Western Hemisphere sources lost some. Other free world sources increased their share by increasing in 10, losing in 10, and maintaining their position in 3 principal commodities. The Soviet bloc made an appreciable increase in supplying platinum. Significant shifts in relative sources of imports

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

TABLE 5.—Net supply of principal minerals in the United States and components of gross supply [1]

(Thousand short tons unless otherwise stated)

Commodity	Net supply			Components as a percent of gross supply (gross supply=100)						Exports as a percent of gross supply	
				Primary shipments [2]		Secondary production [3]		Imports [4]			
	1960	1961	Change from 1960 (percent)	1960	1961	1960	1961	1960	1961	1960	1961
Ferrous ores, scrap, and metals:											
Iron (equivalent)[5]	103,222	89,779	−13	50	51	[6] 27	[6] 29	23	20	3	4
Manganese (content)	[7] 1,292	1,023	−20	7	4			[8] 93	[8] 96	1	1
Chromite (Cr_2O_3 content)	609	590	−3	7	5			93	95	(9)	1
Cobalt (content)—thousand pounds	[10] 12,410	[10] 10,673	−14	(11)	(11)	[12] 2	[12] 2	98	98	(9)	(9)
Molybdenum (content)—do	39,170	33,436	−15	100	100			(9)	(9)	44	52
Nickel (content)	[7] 122	146	+20	11	9	4	4	85	87	(13)	(13)
Tungsten ore and concentrate (W content)—short tons	4,999	4,917	−2	64	76			[8] 36	[8] 24	8	5
Other metallic ores, scrap, and metals:											
Copper (content)	1,585	1,593	+1	53	57	21	20	[8] 26	[8] 23	22	22
Lead (content)	1,068	1,133	+6	23	23	43	40	[8] 34	[8] 37	(9)	1
Zinc (recoverable content)	[7] 999	941	−6	[7] 43	46	[7] 7	6	[7 8] 50	[8] 48	[7] 1	6
Aluminum (equivalent)[14]	2,399	2,515	+5	[15] 17	[15] 10	2	4	[16] 81	[16] 86	[16] 12	[16] 8
Tin (content)—long tons	65,186	60,057	−8	(9)	(9)	19	19	81	81	1	1
Antimony (recoverable content)[17]—short tons	33,796	33,503	−1	3	5	58	56	[8] 39	[8] 39	3	(9)
Beryl ore (BeO content)—do	998	998		4	6			96	94	1	1
Cadmium (content)[18]—do	4,337	5,160	+19	41	37		(19)	[8] 59	[8] 63	22	6
Magnesium (content)	46,352	43,629	−6	[20] 79	[20] 82	20	16	1	2	9	12
Mercury—76-pound flasks	57,731	52,251	−9	[20] 57	60	9	16	[8] 34	[8] 24	1	1
Platinum-group metals—thousand troy ounces	716	951	+33	3	4	[21] 10	[21] 8	87	87	8	6
Titanium concentrate:											
Ilemenite and slag (TiO_2 content)	587	539	−8	71	76			29	24		
Rutile (TiO_2 content)	35	32	−9	25	22			75	78	3	4
Uranium concentrate (U_3O_8 content)—short tons	[7] 33,410	30,314	−9	[7] 52	57			53	42		
Nonmetals:											
Asbestos	709	666	−6	6	8			94	92	[22] 1	[22] 1
Barite, crude	[7] 1,356	1,407	+4	53	57			47	43		
Boron minerals and compounds, finished products (gross weight)	340	333	−2	[7] 99	100			[7] 1	(9)	47	45
Bromine and bromine in compounds—million pounds	[7] 165	170	+3	100	100			(9)	(9)	6	6
Clays	[7] 48,686	46,987	−3	100	100			(9)	(9)	1	1
Fluorspar, finished	767	724	−6	30	28			70	72	(9)	(9)
Gypsum, crude	[7] 14,209	14,197	(9)	[23] 63	65			37	35		(9)
Mica (except scrap)—thousand pounds	[7] 9,222	8,456	−8	6	5			94	95	7	4
Phosphate rock (P_2O_5 content)—thousand long tons	[7] 4,969	5,179	+4	99	99			[7] 1	1	[7] 8	7
Potash (K_2O equivalent)	2,337	2,268	−3	92	90			8	10	17	17
Salt (common)	26,118	26,115	(9)	96	96			4	4	2	2
Sulfur, all forms (content)[24]—thousand long tons	[7] 5,726	5,488	−4	90	88			10	12	24	20
Talc and allied minerals	686	705	+3	97	96			3	4	8	6

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

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

were made in iron, nickel, tungsten, copper, aluminum, beryl ore, cadmium, mercury, platinum, rutile, and fluorspar.

TABLE 6.—Percentage distribution of imports of principal minerals consumed in the United States, by country group of origin [1]

Commodity	Canada and Mexico		East and South Pacific [2]		Other Western Hemisphere		Other free world		Soviet bloc [3]	
	1960	1961	1960	1961	1960	1961	1960	1961	1960	1961
Ferrous ores, scrap, and metals:										
Iron (equivalent) [4]	30	37	20	15	46	44	4	4	(5)	(5)
Manganese (content)	8	7	1	1	32	32	59	60		
Chromite (Cr_2O_3 content)					2	(5)	97	98	1	2
Cobalt (content)	4	8		(5)			96	92		
Nickel (content)	71	89			16		13	11		
Tungsten ore and concentrate (W content)	3	1	13	16	18		66	83		
Other metallic ores, scrap, and metals:										
Copper (content)	26	22	56	67	1	(5)	17	11		
Lead (content)	38	42	38	37	2	3	22	18		
Zinc (recoverable content)	70	69	19	17	1	2	10	12		
Aluminum (equivalent) [6]	4	22			88	25	8	53		
Tin (content)	(5)	(5)	2	4	(5)	(5)	98	96		
Antimony (recoverable content) [7]	23	26	9	7	1	1	67	66		
Beryl ore (BeO content)				4	59	44	41	52		
Cadmium (content) [8]	[9] 97	57	1	8			2	35		
Mercury	13	25	1	1	(5)	(5)	86	74		
Platinum-group metals	29	18	(5)	(5)	5	3	50	53	16	26
Titanium concentrates: Rutile, ilmenite and slag (TiO_2 content)	39	56	20	25			41	19		
Uranium (U_3O_8 content) [10]	72	68	(11)	(11)			28	32		
Nometals:										
Asbestos	92	93	1	(5)	(5)		7	7		
Barite, crude	43	46	18	18	4	3	35	33		
Fluorspar, finished	55	69					45	31		
Gypsum, crude	89	90			11	10	(5)	(5)		
Mica (except scrap)	(5)	(5)	(5)	(5)	16	16	84	84		
Potash (K_2O equivalent)	2	(5)	2	1			91	96	5	3
Sulfur (content)	100	100					(5)	(5)		

[1] Data are based on imports for consumption and are classified like net new supply shown in table 5. U.S. Department of Commerce, Bureau of Census, United States Imports of Merchandise for Consumption—Commodity by Country of Origin 1960: Rept. FT 110, May 1961 and 1962. Imports that are less than 5 percent of net new supply are omitted.

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

[3] U.S.S.R., Bulgaria, East Germany, Albania, Czechoslovakia, Hungary, Estonia, Latvia, Lithuania, Poland, Rumania, China, 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 5.

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

[8] Metal and flue dust only.

[9] Revised figure.

[10] U.S. Atomic Energy Commission. Major Activities in Atomic Energy Program. January–December 1960, January 1961, p. 120.

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

CONSUMPTION

Patterns.—Domestic consumption of minerals generally increased slightly over 1960. Declines were marked (over 5 percent) in only 5 of the commodities in tables 7 and 8. Altogether, consumption of 14 commodities diminished, 17 rose, and 3 remained unchanged. The steel associated minerals, except nickel, generally declined owing to the slackening in iron and steel production. Consumption of most nonferrous minerals increased. Primary magnesium rose 23 percent; aluminum, 15 percent; refined copper, 8 percent; and slab zinc, 6 percent. Changes in nonmetallic minerals were mixed.

Estimated 1975 Consumption.—The Bureau of Mines estimated U.S. consumption of major mineral products for the year 1975.[4] 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 factors. New estimates have been added, and revisions have been made to adjust for new or additional information.

TABLE 7.—Reported consumption of principal metals and minerals in the United States

Commodity	1960	1961	Change from 1960 (percent)
Antimony [1]—short tons	[2] 13,271	12,697	−4
Barite, crude—thousand short tons	1,190	1,391	+17
Bauxite—thousand long tons, dried equivalent	8,883	8,621	−3
Beryl [3]—short tons	9,692	9,392	−3
Chromite—thousand short tons, gross weight	1,220	1,200	−2
Cobalt—thousand pounds	8,930	9,596	+7
Copper, refined—thousand short tons	1,350	1,463	+8
Fluorspar, finished—do	644	682	+6
Iron ore—thousand long tons, gross weight	108,050	99,254	−8
Lead—thousand short tons	1,021	1,027	+1
Magnesium, primary—short tons	37,100	45,533	+23
Manganese ore—thousand short tons, gross weight	1,946	1,718	−12
Mercury—76-pound flasks	51,167	55,763	+9
Mica splittings—thousand pounds	6,227	5,514	−11
Molybdenum, primary products [4]—thousand pounds, Mo content	31,837	32,621	+2
Nickel, exclusive of scrap—short tons	108,159	118,515	+10
Platinum-group metals (sales to consumers)—thousand troy ounces	775	823	+6
Tin—long tons	80,560	78,250	−3
Titanium concentrate:			
Ilmenite and slag—thousand short tons, estimated TiO_2 content	[2] 550	590	+7
Rutile—do	23	28	+22
Tungsten concentrate—thousand pounds of contained tungsten	11,605	11,128	−4
Zinc, slab—thousand short tons	878	931	+6

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

TABLE 8.—Apparent consumption of metals and minerals in the United States [1]

Commodity	1960	1961	Change from 1960 (percent)
Aluminum [2]—thousand short tons	[3] 2,016	2,321	+15
Asbestos, all grades [4]—do	709	666	−6
Boron minerals and compounds [5]—thousand short tons, gross weight	340	333	−2
Bromine and bromine in compounds—million pounds	166	171	+3
Cadmium, primary—thousand pounds, Cd content	[3] 10,127	10,117	([6])
Clays—thousand short tons	[3] 48,697	46,988	−4
Gypsum, crude [7]—do	14,231	14,217	([6])
Phosphate rock—thousand long tons, P_2O_5 content [8]	[3] 4,134	4,358	+5
Potash—thousand short tons, K_2O equivalent	2,337	2,274	−3
Salt, common—thousand short tons	[3] 26,118	26,115	([6])
Sulfur (all forms)—thousand long tons, S content	[3] 5,864	5,436	−7
Talc and allied minerals—thousand short tons	722	726	+1

[1] Covers commodities for which consumption is not reported.
[2] Includes 1960 shipments to Government of 37,000 short tons; 1961, 52,138 tons.
[3] Revised figure.
[4] No adjustments for national stockpile acquisitions.
[5] Reported as finished products.
[6] Less than 0.2 percent.
[7] Computed as crude mined plus crude imports for consumption less crude exports less the change in stocks.
[8] Estimated at 31 percent of gross weight.

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

The estimated 1975 steel ingot consumption has been revised downward from 180 million short tons to 160 million short tons. The reduction may appear contrary to the U.S. economic growth pattern. The trend toward increasing use of high-strength steel, which requires considerably less tonnage than regular-strength steel, and the changing pattern of material components of the U.S. defense, national security, and aerospace outlays, where, more and more, steel is being replaced by other materials, are the principal reasons for the downward revision. These factors are estimated to result in an overall reduction in consumption of steel-associated mineral products. Tungsten is a notable exception, where the consumption estimate has been increased over 80 percent.

The estimated refined copper consumption was revised upward 23 percent. Slab zinc was revised downward 15 percent.

TABLE 9.—Estimated United States consumption of major mineral products for year 1975

Mineral products	Quantity
Ferrous:	
Steel ingots, million short tons	[1] 160
Pig iron, do	[1] 108
Ferrous scrap, do	[1] 78
Iron ores, million long tons	[1] [2] 177
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	[3] 50–55
Tungsten, short tons	[1] 12,500
Nonferrous:	
Bismuth, thousand pounds	[1] 2,000
Copper, primary refined, thousand short tons	[1] 2,000
Lead, do	1,350
Zinc, slab, do	[1] 1,400
Aluminum, do	7,200
Alumina, do	12,000
Bauxite, do	25,000
Antimony, primary, short tons	[4] 18,000
Antimony, secondary, do	[4] 23,000
Silver, thousand troy ounces	[4] 1,550
Platinum, do	[4] 1,100
Titanium, ilmenite including titanium slag, thousand short tons	[4] 1,600
Titanium, rutile, do	[4] 150
Nonmetals:	
Asbestos, do	1,000
Phosphate rock (P_2O_5 content), do	[4] 9,000
Potash (K_2O content), do	[4] 6,000
Salt, million short tons	50
Crushed stone, do	[4] 1,400
Sand and gravel, do	[4] 1,500

[1] Revised figure.
[2] Estimated sources: U.S. (97 million long tons), Latin America (32 million), Canada (43 million), other (5 million).
[3] The estimated U.S. production would be 80 to 85 million pounds of which 30 million pounds would be for exports.
[4] Estimated.

Source: Bureau of Mines. Mineral Facts and Problems. Bull. 585, Outlook sections.

Sales and Orders.—Seasonally adjusted sales of primary metals increased gradually throughout the year, reversing the downward trend in the last half of 1960. Nonetheless, sales for the year decreased 4 percent from 1960, a decline of $1 billion. Sales of the stone, clay, and glass manufacturing industries rose 4 percent, or $340 million. Seasonally adjusted net new orders in the primary-metal industry continued the upward trend. The net new orders gained 16 percent over 1960, an increase of $3.7 billion.

TABLE 10.—Sales, primary metal industry and 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	
1957	27,852	25,504	8,489
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
1961:[1]			
January	1,760	1,810	690
February	1,810	1,750	700
March	1,790	1,880	730
April	1,950	2,190	690
May	2,130	2,190	720
June	2,070	2,200	740
July	2,200	2,330	760
August	2,220	2,410	790
September	2,210	2,310	790
October	2,160	2,320	810
November	2,190	2,330	830
December	2,270	2,820	800

[1] Seasonally adjusted data; therefore, will not add to 1961 total.

Source: U.S. Department of Commerce. Survey of Current Business. Office of Business Economics V. 42, No. 3, March 1962, pp. S–5, S–6.

STOCKS

Indexes of Stocks.—Bureau of Mines indexes of physical stocks held by mineral manufacturers, consumers, and dealers at yearend declined 16 points, or 11 percent, compared with 1960. The depletion of iron and lead stocks was the predominant factor in the decline. In contrast, stocks held by primary producers at yearend increased 17 points, or 11 percent, over 1960 and reached a new high. The increase was caused by a substantial rise in stocks of sulfur, potassium salts, and phosphate rock. All nonmetal stocks increased and compensated for the sharp decline of iron ore stocks.

TABLE 11.—Index of stocks of minerals of mineral manufacturers, consumers, and dealers at yearend

(1955=100)

Yearend	Total metals and nonmetals[1]	Metals					Nonmetals
		Total	Iron	Other ferrous	Base nonferrous	Other nonferrous	
1952	90	90	94	86	87	88	97
1953	105	105	105	108	106	103	112
1954	99	99	101	117	95	101	94
1955	100	100	100	100	100	100	100
1956	111	111	102	98	117	135	128
1957	130	129	126	122	122	180	161
1958	131	130	131	130	122	160	168
1959	128	127	127	147	116	157	173
1960	143	141	137	143	130	210	[2] 197
1961	127	125	127	131	105	205	199

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

The following commodities are included in the index of stocks of manufacturers, consumers, and dealers: Aluminum, arsenic, bauxite, bismuth, cadmium, cement, chromite, copper, ferrous scrap and pig iron, fluorspar, iron ore, lead, manganese ore and ferromanganese, mercury, molybdenum primary products, nickel, platinum-group metals, tin, titanium concentrates, tungsten concentrates, and zinc. The index of stocks of primary producers includes the following commodities: Antimony, bauxite, fluorspar, gypsum, iron ore, mercury, molybdenum, phosphate rock, potassium salts, sulfur, titanium concentrates, and tungsten. Primary market prices of each commodity were used as weights in the first index; average mine values were used in the second. All commodities were valued at 1955 prices or 1955 mine value, respectively. Movements in the indexes, therefore, reflect movements in the physical volume of stocks.

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

(1955=100)

Yearend	Total minerals [1]	Metals				Nonmetals
		Total	Iron ore	Other ferrous	Other	
1952	99	121	129	197	72	90
1953	105	135	133	326	73	93
1954	114	146	165	163	87	100
1955	100	100	100	100	100	100
1956	123	122	128	152	97	124
1957	144	158	158	405	72	138
1958	140	155	164	340	63	135
1959	128	155	172	246	74	117
1960	[2] 151	[2] 240	[2] 288	213	112	116
1961	168	217	248	246	119	149

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

TABLE 13.—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
1957: December	4,269	1,270
1958: December	4,111	1,200
1959: December	4,120	1,360
1960: December	4,490	1,440
1961: December	4,770	1,490
January	4,490	1,440
February	4,510	1,430
March	4,470	1,410
April	4,510	1,420
May	4,510	1,420
June	4,600	1,430
July	4,660	1,450
August	4,630	1,480
September	4,670	1,490
October	4,730	1,490
November	4,740	1,480

Source: U.S. Department of Commerce. Survey of Current Business. Office of Business Economics. V. 42, No. 2, February 1962, p. S-6.

Value of Inventories.—The value of seasonally adjusted inventories held by firms in the primary metal and in the stone, clay, and glass industries gained consistently throughout the year, and in December reached a record high for all months—$280 million above December 1960 for the primary-metal industry, and $50 million for the stone, clay, and glass industry.

LABOR AND PRODUCTIVITY

Employment.—Total 1961 employment in mineral industries continued the declining trend. Lessening activity in residential and public building, which contributed to the softening demand for construction materials, and reduction of iron mining activity highlighted the general decline. Employment in copper mining gained slightly, but that in iron mining continued to decline. The Bureau of Labor Statistics (BLS) ceased publication in 1961 of all employment and related statistics in lead and zinc mining. Nonmetal mining and quarrying employment followed the seasonal pattern but declined slightly.

Beginning November 1961, industry statistics on employment, hours and earnings, and labor turnover by BLS were revised and based on the 1957 Standard Industrial Classification and a March 1959 benchmark. Prior statistics are no longer comparable to the revised figures.[5] This comparison is applicable to all statistics published by BLS used in this section. The pattern in the mineral-manufacturing industries was mostly one of decline; employment in the cement, iron and steel, and nonferrous metal industries waned, while employment in the fertilizer industry did not change.

The following tabulation shows major changes in average total employment, compared with 1960:

	Percent
All industries	−½
Mining (including fuels)	−6
Metals and minerals (except fuels)	−5
Metal mining	−6
Nonmetal mining and quarrying	−4
Fuels	−6
Mineral manufacturing [1]	−7

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

Most mineral industries fared poorly, compared with all industries, reversing the 1960 trend. Copper mining, gaining 2 percent, was the only exception. The decline was attributed to ferrous mining and manufacturing and construction mineral materials.

Hours and Earnings.[6]—Average weekly hours of production workers in the mining industry, excluding lead and zinc mining, declined slightly in 1961. Hourly earnings gained a little, so that average weekly earnings were 2.4 percent higher than in 1960. All categories of mining increased quite similarly in their respective hours and earnings. Mineral manufacturing industries showed small increases in weekly and hourly earnings.

[5] Bureau of Labor Statistics. Employment and Earnings. V. 8, No. 5, November 1961, p. iii
[6] BLS ceased publication of lead and zinc mining employment and earnings data in 1961.

TABLE 14.—Total employment in the mineral industries (nonfuel) in the continental United States, by industry [1]

(In thousands)

Year and month	Mining				
	Total	Nonmetallic mining and quarrying	Metal		
			Total [2]	Iron	Copper
1958	208.1	114.9	93.2	31.8	27.7
1959	203.2	119.6	83.6	27.7	23.3
1960	212.8	119.5	93.3	33.2	28.3
1961:					
January	196.1	106.2	89.9	28.3	30.0
February	188.5	102.3	86.2	26.6	28.3
March	192.3	106.0	86.3	27.0	28.2
April	198.0	112.2	85.8	26.6	28.3
May	204.7	117.6	87.1	27.4	29.0
June	210.2	121.7	88.5	27.8	29.5
July	210.9	122.5	88.4	28.0	29.3
August	208.1	122.3	85.8	26.5	29.6
September	210.3	121.9	88.4	29.4	29.6
October	206.6	120.3	86.3	28.0	28.0
November	204.1	116.5	87.6	28.2	29.1
December	196.3	110.4	85.9	27.7	28.4
Year (average)	202.2	115.0	87.2	27.6	28.9

Year and month	Mineral manufacturing			
	Fertilizers	Cement, hydraulic	Blast furnaces, steel works, and rolling mills	Primary metals, nonferrous smelting and refining
1958	35.4	44.4	531.4	71.1
1959	36.2	43.9	515.3	68.0
1960	35.5	42.8	577.5	70.8
1961:				
January	34.9	38.0	488.1	68.0
February	35.9	36.5	490.4	66.0
March	41.6	37.5	496.7	65.5
April	44.8	40.1	507.6	65.0
May	41.8	40.9	527.3	65.7
June	33.4	42.2	539.0	67.8
July	30.5	42.4	545.5	68.0
August	31.3	41.7	550.0	68.3
September	33.5	41.3	559.7	67.7
October	33.7	40.6	554.7	68.7
November	32.0	40.3	550.0	68.9
December	33.0	38.8	554.0	68.8
Year (average)	35.5	40.1	530.3	67.4

[1] Employment statistics for lead and zinc mining and secondary nonferrous smelting and refining industries ceased publication by BLS in 1961.
[2] Includes other metal mining, not shown separately.

Source: U.S. Department of Labor, Employment and Earnings Statistics, Bureau of Labor Statistics, Bull. 1312. Revised on basis of the 1957 S.I.C., Employment and Earnings, v. 8, No. 5, November 1961; v. 8, No. 7, January 1962; v. 8, No. 8, February 1962; v. 8, No. 4, October 1961, table B. All prior employment statistics are not comparable to the revised statistics.

TABLE 15.—Average hours and gross earnings of production and related workers in the mineral industries (nonfuel) in continental United States, by industries

Year	Mining								
	Total [1]			Metal					
				Total [2]			Iron		
	Weekly		Hourly earnings	Weekly		Hourly earnings	Weekly		Hourly earnings
	Earnings	Hours		Earnings	Hours		Earnings	Hours	
1957	$91.38	42.2	$2.17	$97.27	40.7	$2.39	$102.05	39.1	$2.61
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]	105.68	42.8	2.48	113.44	41.4	2.74	115.12	38.5	2.99
	Metal—Continued			Nonmetallic mining and quarrying			Mineral manufacturing		
	Copper						Fertilizer		
1957	$96.88	41.4	$2.34	$85.65	43.7	$1.96	$71.14	42.6	$1.67
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	2.63	96.58	43.7	2.21	79.55	43.0	1.85
1961	119.03	43.6	2.73	99.86	43.8	2.28	81.37	42.6	1.91
	Mineral manufacturing—Continued								
	Cement, hydraulic			Blast furnaces, steel works, and rolling mills			Primary smelting and refining of nonferrous metals		
1957	$87.48	40.5	$2.16	$106.47	39.0	$2.73	[4]	[4]	[4]
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	123.45	38.7	3.19	109.89	40.7	2.70

[1] Weighted average of data computed, using figures for production workers as the weight.
[2] Includes other metal mining, not shown separately.
[3] 1961 statistics derived from U.S. Department of Labor. Employment and Earnings. Bureau of Labor Statistics, v. 8, No. 8, February 1962, table B–2.
[4] 1957 data not available.

Source: U.S. Department of Labor. Employment and Earnings Statistics for the United States, 1909–60. Bureau of Labor Statistics, Bull. 1312.

Labor Turnover Rates.[7]—Labor turnover rates in the mineral and related industries exhibited no striking or consistent trends during 1961. This lack of trend reflected a mild and rather incomplete recovery in economic activity. For the year as a whole, however, accessions increased (except in metal mining), and separations and layoffs decreased, compared with 1960.

TABLE 16.—Monthly labor-turnover rates in the mineral industries

(Per 100 employees)

Turnover rate	All manufacturing	Hydraulic cement products	Blast furnaces, steel works, and rolling mills	Primary smelting and refining of nonferrous metals	Total metal mining [1]	Iron mining	Copper mining
Total accession rate:							
1960 average	3.8	2.5	2.0	2.4	3.4	2.3	[2] 3.0
1961:							
January	3.7	2.9	4.0	1.7	3.8	6.9	1.1
February	3.2	3.7	3.4	2.3	2.5	3.8	1.5
March	4.0	6.7	3.5	2.1	1.9	2.3	1.6
April	4.0	4.5	5.1	2.5	3.1	4.6	2.7
May	4.2	3.8	5 4	4.4	2.8	3.1	2.2
June	5.0	3.0	3.9	4.2	3.9	3.6	3.5
July	4.4	2.3	3.0	2.2	2.1	1.7	2.3
August	5.3	1.6	3.3	3.2	2.3	2.0	2.0
September	4.6	1.5	3.2	1.7	3.4	4.5	1.9
October	4.3	1.9	2.2	3.0	2.7	2.2	1.9
November	3.3	1.3	2.0	1.8	2.7	3.3	1.4
December	2.5	1.3	3.7	1.4	2.0	3.0	1.1
Average	4.0	2.9	3.6	2.5	2.8	3.4	1.9
Total separation rate:							
1960 average	4.3	3.3	4.3	2.8	3.8	4.5	[2] 2.3
1961:							
January	4.7	5.7	3.6	4.9	5.1	5.6	6.0
February	3.9	4.9	2.7	4.2	2.4	2.0	2.4
March	3.9	2.0	2.5	2.3	2.8	3.4	2.3
April	3.4	1.4	1.7	2.1	2.2	2.2	1.6
May	3.5	1.2	1.9	1.9	2.4	2.8	1.6
June	3.6	1.5	1.8	2.1	1.8	1.2	1.6
July	4.1	2.5	1.7	1.9	2.3	1.1	1.8
August	4.1	3.2	2.1	2.8	2.9	1.9	2.6
September	4.8	3.2	2.7	3.5	4.0	4.7	2.4
October	4.1	2.8	3.1	2.1	2.9	3.8	2.3
November	4.0	1.9	3.2	2.4	4.3	8.0	1.8
December	3.8	7.0	1.7	2.4	3.3	3.9	3.4
Average	4.0	3.1	2.4	2.7	3.0	3.4	2.5
Layoff rate:							
1960 average	2.4	2.3	3.5	1.4	1.5	3.5	[2] .4
1961:							
January	3.2	4.9	2.8	3.9	3.4	4.8	4.7
February	2.6	4.3	1.9	3.4	1.1	1.4	1.3
March	2.3	1.4	1.7	1.4	1.3	2.7	.9
April	1.9	.7	1.0	1.0	.8	1.5	.6
May	1.8	.5	1.1	.7	.8	1.9	.2
June	1.7	.6	1.0	.8	.2	.1	.2
July	2.3	1.7	1.0	.8	.8	.6	.3
August	1.7	2.2	1.2	.8	.7	1.2	.4
September	1.9	1.1	1.2	1.2	1.1	2.5	.2
October	2.0	1.8	2.1	.9	1.3	3.1	.5
November	2.2	1.2	2.3	1.4	2.6	7.0	.3
December	2.4	6.4	1.1	1.6	2.1	3.4	2.5
Average	2.2	2.2	1.5	1.5	1.4	2.5	1.0

[1] Lead and zinc statistics have been discontinued.
[2] 10-month average.

Source: U.S. Department of Labor. Employment and Earnings Statistics for the United States, 1909–60. Bureau of Labor Statistics, Bull. 1312; Employment and Earnings. V. 8, No. 5, November 1961, table D-2; Employment and Earnings. V. 8, No. 7, January 1962, table D-2; Employment and Earnings. V. 8, No. 8. February 1962, table D-2.

[7] Work cited in footnote 6.

Wages and Salaries.—Wages and salaries in the mining industry continued the downward trend begun in 1960, contrary to the upward growth trend of all industries. Metal mining reached a peak in 1960 from the 1958 recession and declined in 1961 along with primary metal industries. Nonmetallic mining and quarrying increased slightly and kept up with the slow pace of construction activities; the stone, clay, and glass products industry declined inappreciably. The average annual earnings for full-time employees in the mineral industries increased modestly in 1961.

TABLE 17.—Wages and salaries in the mineral industries in the United States

(Million dollars)

Industry	1960	Change from 1959 (percent)	1961	Change from 1960 (percent)
All industries	[1] 271,308	+5.0	278,821	+2.8
All mining	3,832	−.1	3,740	−2.4
Nonfuel mining	1,165	+9.2	1,151	−1.2
Metal mining	568	+18.6	550	−3.2
Nonmetallic mining and quarrying	597	+1.5	601	+.7
Fuel mining	2,667	−3.6	2,589	−2.9
Manufacturing	87,411	+3.2	87,469	+.1
Primary metal industries	7,470	+3.2	7,199	−3.6
Stone, clay and glass products	3,042	+3.2	2,992	−1.6

[1] Revised figure.

Source: U.S. Department of Commerce, Survey of Current Business. Office of Business Economics, v. 42, July 1962.

TABLE 18.—Average annual earnings in the mineral industries in the United States

Industry	1960		1961	
	Average	Change from 1959 (percent)	Average	Change from 1960 (percent)
All industries	$4,705	+2.2	$4,843	+2.9
All mining	5,685	+2.6	5,885	+3.5
Nonfuel mining	[1] 5,676	+4.3	5,824	+2.6
Metal mining	6,108	+4.6	6,395	+4.7
Nonmetallic mining and quarrying	5,330	+3.3	5,414	+1.6
Fuel mining	[1] 5,685	+1.9	5,830	+2.6
Manufacturing	5,342	+2.4	5,509	+3.1
Primary metal industries	6,341	+.1	6,551	+3.3
Stone, clay and glass products	5,337	+2.5	5,470	+2.5

[1] Revised figure.

Source: U.S. Department of Commerce. Survey of Current Business. Office of Business Economics, v. 42, July 1962.

Productivity.—Productivity increased in metal mining. All indexes reached record highs. (Lead and zinc mining labor-productivity indexes previously derived by the Bureau of Mines were discontinued because BLS ceased publication of employment data for the industry). These indexes are on the 1957–59 base, while those published previously were on the 1947–49 base. BLS revised employment and man-hours statistics for the copper and iron mining industries along with other industries.[8] These revisions were primarily due to the

[8] U.S. Department of Labor. Employment and Earnings Statistics, Bureau of Labor Statistics Bull 1312.

periodic benchmark adjustments to unemployment insurance data and a change in the sampling technique for small firms. The revised employment figures and output indexes have been adjusted by BLS to benchmark levels computed from Census of Mineral Industries data for 1939, 1954, and 1958.

TABLE 19.—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
1952–56 (average) [2]	85.5	78.3	94.8	88.2
1957	94.1	93.4	104.9	100.9
1958	98.9	103.1	92.5	97.2
1959	110.0	105.8	100.9	101.6
1960	116.9	108.2	122.7	116.3
1961 [3]	117.9	111.1	135.8	132.4
	Recoverable metal [4] per—			
	Production worker	Man-hours	Production worker	Man-hours
1952–56 (average)	91.8	84.0	110.7	102.8
1957	94.8	94.1	110.9	106.7
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 [3]	116.2	109.5	112.8	110.0

[1] Indexes have been revised and adjusted to benchmark indexes derived from the Censuses 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 [9]

Index of Mine Value.—The average unit mine value of all minerals (including fuels) remained unchanged for the third successive year. However, the stability of the index was sustained by a 1-point rise in the fuels index over 1960; which equalized a 2-point decline in the metals index. The nonmetals index remained the same.

In the metals subgroup, despite general increases in ferrous and other nonferrous metals, the 11-point decrease of the base nonferrous metals carried the total metal index down. The nonmetal subgroup was unchanged as an increase in chemical minerals compensated for a decline in construction materials.

The stability of the average unit mine value of minerals index was in line with the trend for wholesale price indexes; the average unit value for wholesale prices was 100.7 in 1960 and 100.3 in 1961.

The difference between the average unit mine value index (table 20) and other published indexes is illustrated by the monetary-metal index. The Treasury price of gold and silver had not changed from

[9] The indexes are revised to the 1957–59 base, but those published previously were on the 1947–49 base.

TABLE 20.—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					
1951	88	83	66	105	110	91	79	87	92	81	83	89
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	96
1961	98	103	105	99	98	103	100	102	102	101	101	97

[1] For description of index see Review of Mineral Industries; Ch. in Minerals Yearbook, 1959. V. 1, 1960, pp. 22-24.

year to year, but the index did.[10] The variations were caused by movements in the differential between smelter purchase prices for ores and refined metal prices. The index of mine value is believed to reflect more accurately the actual per-unit mine return.

Index of Implicit Unit Value.—The index of implicit unit value [11] is presented for the first time in table 21. The index reflects 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 as published in the Statistical Summary chapter of the Minerals Yearbook. The implicit unit index number is found by dividing the index of value by the index of physical volume.

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

Unit value of all minerals declined slightly. Mineral fuels rose 1 point but not enough to counterbalance the lower metals and nonmetals indexes. The metals decreased 2 points, and nonmetals declined 2.7 points, 2 percent and 2.6 percent, respectively, from 1960.

Prices.—Prices of mineral commodities were generally steady, declining slightly except for large gains in iron and steel scrap, phosphate rock, and potash. Nonferrous metals, particularly slab zinc and pig lead, declin d the most in the annual average prices. Slab zinc decreased the most from January to December 1961. During the year most commodities listed showed greater variation in price than the average of all commodities.

[10] Starting in November 1961, the U.S. Treasury stopped selling silver on the open market.
[11] Designed by William A. Vogely, Chief economist.

TABLE 21.—Index of implicit unit value of minerals produced in the United States by group

(1957-59=100)

Year	All minerals	Total metals	Total nonmetals	Total mineral fuels
1925	55.3	42.3	117.0	48.4
1926	56.2	41.1	113.1	50.9
1927	49.0	37.6	105.8	42.4
1928	46.8	38.6	101.8	39.8
1929	47.2	42.9	97.1	40.0
1930	43.0	34.8	90.1	37.6
1931	33.3	28.9	79.9	27.7
1932	31.9	22.6	71.4	28.7
1933	29.8	31.9	70.6	25.3
1934	36.8	34.0	74.4	33.2
1935	36.6	35.1	77.0	32.6
1936	38.0	36.1	66.1	34.6
1937	40.3	40.5	64.2	36.9
1938	38.3	36.0	62.4	35.9
1939	37.4	38.5	64.8	33.3
1940	37.3	37.7	62.3	33.4
1941	41.3	39.3	63.8	38.1
1942	43.1	40.6	64.4	40.3
1943	44.7	39.9	63.3	43.1
1944	46.1	42.1	63.0	45.2
1945	47.1	44.7	66.5	45.8
1946	54.0	50.5	78.1	51.8
1947	65.7	58.7	73.4	66.6
1948	80.7	64.3	78.9	84.9
1949	80.0	64.4	81.2	83.0
1950	80.5	68.4	82.4	82.6
1951	83.6	78.5	85.7	84.5
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	101.1	105.6	100.9	101.8

Costs.—Most cost items as shown in table 23 increased moderately in price compared with 1960. Explosives showed the greatest increase; gas fuels and petroleum products gained slightly. Lumber prices declined 5 percent from 1960 and continued the downward trend begun in 1959. Industrial chemicals and coal declined much less.

In March 1962, BLS began publishing detailed construction, mining, material handling, and other machinery and equipment indexes. The relevant indexes are presented in table 24. In general, prices of mining, construction, and material-handling machinery and equipment increased over 1960. The changes from 1960 for major items are as follows:

	Percent
Mining machinery and equipment	+1.3
Construction machinery and equipment	+1.6
Power cranes, draglines, shovels, etc	+.3
Tractors, other than farm	+1.5

TABLE 22.—Price relatives for selected metals and mineral commodities, January and December 1961, and annual averages

(1957–59=100)

Commodity	1961		Change from January (percent)	Annual average		Change from 1960 (percent)
	January	December		1960	1961	
Metals and metal products	100.3	100.3	----------	101.3	100.7	−0.6
Iron and steel	100.2	100.2	----------	100.6	100.7	+.1
Iron ore	98.1	98.1	----------	97.1	98.1	+1.0
Iron and steel scrap	75.4	78.8	+4.5	79.9	84.7	+6.0
Semifinished steel products	101.8	101.8	----------	102.0	101.8	−.2
Finished steel products	101.9	101.5	−.4	102.1	101.7	−.4
Foundry and forge shop products	103.4	103.4	----------	103.1	103.4	+.3
Pig iron and ferroalloys	95.9	95.3	−.6	96.3	94.6	−1.8
Nonferrous metals	98.8	100.8	+2.0	103.9	100.4	−3.4
Primary metal refinery shapes	98.8	101.8	+3.0	103.6	100.9	−2.6
Aluminum, ingot	103.7	95.7	−7.7	103.8	101.7	−2.0
Copper, ingot, electrolytic	99.2	106.1	+7.0	111.2	103.7	−6.7
Lead, pig, common	84.7	78.9	−6.9	91.8	83.6	−8.9
Zinc, slab, prime western	104.0	108.3	+4.1	116.6	104.4	−10.5
Nonferrous scrap	92.6	99.9	+7.9	100.8	99.9	−.9
Nonmetallic mineral products	101.8	101.6	−.2	101.4	101.8	+.4
Concrete ingredients	102.7	101.8	−.9	102.7	102.8	+.1
Sand, gravel and crushed stone	102.0	102.7	+.7	101.8	102.4	+.6
Concrete products	102.4	102.4	----------	102.4	102.5	+.1
Structural clay products	103.3	103.3	----------	103.1	103.2	+.1
Gypsum products	102.9	105.0	+2.0	101.9	103.8	+1.9
Other nonmetallic minerals	102.3	101.7	−.6	102.8	102.2	−.6
Building lime	104.9	106.0	+1.0	104.7	105.2	+.5
Insulation materials	95.4	92.6	−2.9	100.7	95.1	−5.6
Asbestos cement shingles	110.6	110.6	----------	108.1	110.6	+2.3
Bituminous binders (1958=100)	100.0	100.0	----------	100.0	100.0	----------
Fuels and related products and power	102.6	100.6	−2.0	99.6	100.7	+1.1
Fertilizer materials	104.8	104.7	−.1	102.2	104.3	+2.1
Nitrogenates	101.7	101.6	−.1	100.6	101.2	+.6
Phosphates	107.3	108.8	+1.4	103.9	107.4	+3.4
Phosphate rock	116.3	120.4	+3.5	108.7	117.0	+7.6
Potash	114.9	113.7	−1.0	105.2	112.8	+7.2
Muriate, domestic	112.9	111.4	−1.3	103.6	110.8	+6.9
Sulfate	114.3	114.3	----------	106.1	112.3	+5.8
All commodities other than farm and food	101.2	100.9	−.3	101.3	100.8	−.5
All commodities	101.0	100.4	−.6	100.7	100.3	−.4

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

TABLE 23.—Price relatives for selected cost items in nonfuel mineral production, January and December 1961 and annual averages

(1957–59=100, unless otherwise specified)

Commodity	1961		Change from January (percent)	Annual average		Change from 1960 (percent)
	January	December		1960	[1] 1961	
Coal	100.1	98.6	−1.5	98.8	97.7	−1.1
Coke	103.6	103.6	----------	103.6	103.6	----------
Gas fuels (January 1958=100)	121.1	118.4	−2.2	116.6	118.7	+1.8
Petroleum and refined products	102.4	98.2	−4.1	97.6	99.3	+1.7
Industrial chemicals	99.5	97.1	−2.4	100.5	98.4	−2.1
Lumber	94.1	93.7	−.4	99.8	94.7	−5.1
Explosives	108.5	108.3	−.2	105.6	108.4	+2.7
Construction machinery and equipment	107.0	107.6	+.6	105.8	107.5	+1.6

[1] Preliminary figures.

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

TABLE 24.—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	Contractors air tools, hand-held	Mixers, pavers, spreaders, etc.	Tractors, other than farm
1947	54.2	45.9	60.4	55.3	61.8	58.9	56.0	55.4	61.9	48.5
1948	61.3	50.5	65.5	61.7	69.5	63.6	64.3	60.1	66.7	56.4
1949	65.3	53.9	69.2	65.3	71.5	66.3	68.5	63.1	71.8	61.0
1950	67.2	58.4	70.7	67.4	74.4	69.0	70.4	64.2	72.4	62.9
1951	74.5	66.1	77.9	75.0	80.8	78.5	80.6	71.3	78.8	69.2
1952	75.6	66.1	78.0	75.3	80.7	78.5	81.1	71.3	78.8	71.2
1953	77.9	69.8	81.3	77.7	83.0	78.5	81.2	73.6	81.0	75.3
1954	79.3	74.2	84.2	79.5	83.4	78.7	81.4	75.0	81.4	77.6
1955	82.6	77.9	87.7	83.9	84.5	83.8	83.8	76.2	85.3	80.6
1956	89.5	86.7	93.2	90.6	90.2	85.4	89.9	86.0	90.3	88.8
1957	96.3	94.9	99.6	97.2	96.2	95.3	96.3	93.0	95.7	95.8
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	108.6	108.0

Source: U.S. Department of Labor. Wholesale Price Index. Bureau of Labor Statistics, March 1962.

The index of labor costs per pound of recoverable metal decreased slightly in copper mining but remained unchanged in iron-ore mining. The index of labor costs per dollar of recoverable metal increased 5 points in copper mining and held steady in iron-ore mining. The index of value of recoverable metal per man-hour declined for copper but increased for iron ore.

TABLE 25.—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
1951	82	59	71	78	97	79
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

[1] Index computed from data in tables 15 and 19. All data has been rebased on the 1957–59 period.
[2] Index computed from data in table 19 multiplied by price of electrolytic copper and iron ore, and rebased.
[3] Index computed by author using index of value and data in table 15.

Source: U.S. Department of Labor, Indexes of Output Per Production Worker and Per Production Worker Man Hour. Bureau of Labor Statistics, Employment and Earnings. Bull. 1312.

Index of Principal Metal Mining Expenses.[12]—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 costs and productivity changes as well as changes in prices of

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

current supplies and fuels that are used by the mining industry. Reflecting the 1-point decline of both cost of labor (adjusted for gain in labor productivity) and cost of supplies, despite the slight increase of fuels cost, the index was 1 point lower than in 1960 and continued the mild downward trend since 1959. These indexes not only are on the 1957–59 base but also are reconstructed by using weights derived from 1958 Census of Mineral Industries, while those published previously were on the 1947–49 base using 1954 Census of Mineral Industries weights.

TABLE 26.—Index of principal metal mining expenses [1]

(1957–59=100)

Year	Total	Labor	Supplies	Fuels
1951	78	69	88	94
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

[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.

Fringe Benefits for Mine Workers.[13]—During the period, 1935–60, supplementary remuneration practices, a substantial part of employer expenditures for employee pay, increased in variety and complexity.

In the mining industry, employer expenditures for fringe benefits were accrued either directly to the employee or indirectly through the insurance companies, the Government, or private welfare funds. The direct payment in 1960 included paid leave amounting to 4.7 percent of the gross payroll for production, development, and related work in all establishments, and premium pay amounting to 5.5 percent. Indirect payments for legally required income security programs such as social security, unemployment compensation, and other insurance, amounted to 6.8 percent of gross payroll. In addition, private welfare plans provided 8.8 percent of gross payrolls. In terms of cents per production-man-hour paid for all establishments, paid leave came to 12.0 cents an hour; premium pay, to 14.0 cents; legally required payments, to 17.3 cents; and private welfare plans, to 22.4 cents.

Average expenditure for paid leave ranged from 7.3 percent of gross payroll in all establishments in iron-ore mining to 4.2 percent in mining and quarrying nonmetallic minerals except fuels, or 21.1 cents per hour to 9.1 cents, respectively.

Average expenditures for premium pay ranged from 6.0 percent of gross payroll of all establishments in mining and quarrying nonmetallic minerals except fuels to 3.7 percent in lead and zinc ores; average cents per hour paid ranged from 13.3 cents to 8.9 cents, respectively.

[13] U.S. Department of Labor. Bureau of Labor Statistics, Monthly Labor Review: Supplementary Remuneration for Mine Workers. v. 85, No. 6, June 1962, pp. 654–661.

TABLE 27.—Average expenditure for paid leaves, premium pay practices, and legally required payments in mining industries, United States, 1960

Industry[1]	All establishments									
	Percent of gross payroll					Cents per hour paid for—				
	Total	Vacation	Holiday	Sick leave	Other [2]	Total	Vacation	Holiday	Sick leave	Other [2]
Paid leave:										
All industries, average	4.7	3.1	1.2	0.4	(3)	12.0	7.8	3.0	1.1	0.1
Metal mining [4]	6.2	3.9	2.1	.2	(3)	17.1	10.7	5.8	.6	(3)
Iron ores	7.3	4.8	2.4	(3)	(3)	21.1	14.0	7.0	(3)	.1
Copper ores	6.2	3.5	2.0	.6	(3)	17.0	9.7	5.5	1.8	.1
Lead and zinc ores	5.7	3.8	1.7	.1	(3)	13.8	9.3	4.2	.2	(3)
Anthracite mining	3.2	3.0	.1	(3)	(3)	8.4	8.0	.3	.1	(3)
Bituminous coal and lignite mining	3.3	3.2	.1	(3)	(3)	9.8	9.6	.2	(3)	(3)
Crude petroleum and natural gas [4]	5.3	2.9	1.5	.9	0.1	12.8	6.9	3.6	2.1	.2
Crude petroleum and natural gas	8.2	4.4	2.2	1.4	.2	21.7	11.6	5.9	3.8	.4
Oil and gas field services	2.0	1.1	.6	.2	(3)	4.4	2.5	1.4	.5	(3)
Mining and quarrying of nonmetallic minerals, except fuels	4.2	2.7	1.3	.2	(3)	9.1	5.9	2.9	.3	(3)

Industry[1]	All establishments				
	Percent of gross payroll			Cents per hour paid for—		
	Total	Overtime, weekend, and holiday work	Shift	Total	Overtime, weekend, and holiday work	Shift
Premium pay:						
All industries, average	5.5	5.1	0.4	14.0	13.0	1.0
Metal mining [4]	4.4	3.4	1.0	12.3	9.5	2.8
Iron ores	3.8	2.5	1.3	10.9	7.2	3.7
Copper ores	4.9	4.0	.9	13.3	10.9	2.4
Lead and zinc ores	3.7	2.9	.7	8.9	7.1	1.8
Anthracite mining	3.3	3.0	.2	8.8	8.1	.7
Bituminous coal and lignite mining	3.8	3.3	.4	11.2	9.9	1.3
Crude petroleum and natural gas [4]	6.8	6.6	.2	16.5	16.0	.5
Crude petroleum and natural gas	3.2	2.9	.3	8.4	7.5	.9
Oil and gas field services	10.9	10.8	(3)	23.9	23.9	(3)
Mining and quarrying of nonmetallic minerals, except fuels	6.0	5.7	.3	13.1	12.4	.7

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	All establishments									
	Percent of gross payroll					Cents per hour paid for —				
	Total	Social security (OASDI)	Unemployment compensation	Workmen's compensation	Other [5]	Total	Social security (OASDI)	Unemployment compensation	Workmen's compensation	Other [5]
Legally required payments:										
All industries, average	6.8	2.5	1.3	3.0	(3)	17.3	6.4	3.4	7.5	(3)
Metal mining [4]	5.5	2.5	1.0	2.0	(3)	15.2	6.9	2.8	5.4	(3)
Iron ores	5.1	2.5	1.3	1.3	----	14.7	7.2	3.9	3.7	----
Copper ores	4.6	2.5	.7	1.5	----	12.8	6.8	1.8	4.2	----
Lead and zinc ores	7.0	2.7	.9	3.3	0.1	16.9	6.4	2.1	8.1	0.3
Anthracite mining	8.5	2.8	2.8	2.9	----	22.5	7.4	7.3	7.7	----
Bituminous coal and lignite mining	7.0	2.5	1.8	2.7	----	20.7	7.5	5.2	8.0	----
Crude petroleum and natural gas [4]	7.2	2.5	1.0	3.6	(3)	17.4	6.1	2.5	8.8	(3)
Crude petroleum and natural gas	4.1	2.3	.7	1.1	(3)	10.9	6.2	1.8	2.9	(3)
Oil and gas field services	10.5	2.7	1.5	6.4	(3)	23.4	5.9	3.2	14.2	(3)
Mining and quarrying of nonmetallic minerals, except fuels	6.8	2.6	1.5	2.6	(3)	14.8	5.6	3.4	5.7	.1

[1] The classification is based on the U.S. Bureau of the Budget, Standard Industrial Classification Manual, 1957.
[2] Includes military, jury, witness, voting, and personal leave.
[3] Less than 0.05 percent or 0.05 cent.
[4] Includes industries not shown separately.
[5] Consists of State temporary disability insurance.

Source: U.S. Department of Labor. Monthly Labor Review. Bureau of Labor Statistics, June 1962, v. 85, No. 6, pp. 657–659.

TABLE 28.—Average expenditures for private welfare plans in mining industries, United States, 1960

Industry [1]	Total	Health, accident, and life insurance	Pension and retirement plans	Vacation and holiday funds	Supplemental unemployment benefits	Severance or dismissal pay	Savings and thrift plans	Year-end and Christmas bonuses
	Percent of gross payroll							
	All establishments							
Metal mining [3]	7.0	3.5	2.9	--	.4	(2)	--	.1
Iron ores	10.0	4.6	4.3	--	.9	(2)	--	.1
Copper ores	6.6	3.5	2.9	--	--	(2)	--	.2
Lead and zinc ores	4.3	2.4	1.8	--	(2)	--	--	(2)
Anthracite mining	14.3	.4	13.9	--	--	--	--	(2)
Bituminous coal and lignite mining	18.1	8.2	9.9	--	--	--	--	(2)
Crude petroleum and natural gas [3]	5.7	1.0	3.0	(2)	--	.2	1.1	.4
Crude petroleum and natural gas	9.1	1.3	4.9	(2)	--	.5	1.9	.5
Oil and gas field services	2.0	.7	.8	(2)	--	(2)	.1	.3
Mining and quarrying of nonmetallic minerals, except fuels	4.6	2.0	1.8	--	.1	(2)	.2	.7
All industries, average	8.8	3.3	4.6	(2)	.1	.1	.4	.3
	Cents per hour paid							
Metal mining [3]	19.4	9.8	8.1	--	1.1	0.1	--	0.3
Iron ores	28.8	13.2	12.5	--	2.6	.1	--	.4
Copper ores	18.0	9.6	8.0	--	--	(2)	--	.5
Lead and zinc ores	10.5	5.9	4.4	--	.1	--	--	.1
Anthracite mining	38.1	1.2	36.8	--	--	--	--	.1
Bituminous coal and lignite mining	53.8	24.3	29.4	--	--	--	--	.1
Crude petroleum and natural gas [3]	13.8	2.4	7.2	(2)	--	.6	2.6	1.0
Crude petroleum and natural gas	23.8	3.5	12.8	(2)	--	1.3	5.0	1.3
Oil and gas field services	4.4	1.5	1.8	(2)	--	(2)	.2	.8
Mining and quarrying of nonmetallic minerals, except fuels	9.9	4.3	4.0	--	.1	(2)	.4	1.5
All industries, average	22.4	8.3	11.7	(2)	.2	.3	1.1	.8

[1] The classification is based on the U.S. Bureau of the Budget, Standard Industrial Classification Manual, 1957.
[2] Less than 0.05 percent or 0.05 cent.
[3] Includes industries not shown separately.

Source: U.S. Department of Labor. Bureau of Labor Statistics. Monthly Labor Review: Supplementary Renumeration for Mine Workers, 1960. June 1962, v. 85, No. 6, p. 660.

Average expenditures for legally required payments ranged from 7.0 percent of gross payroll of all establishments in lead and zinc mining to 4.6 percent in copper mining, or 16.9 cents per hour to 12.8 cents, respectively.

Average expenditures for private welfare plans ranged from 10.0 percent of gross payroll of all establishments in iron-ore mining to 4.3 percent in lead and zinc mining. The average expenditure in cents per hour paid ranged from 28.8 cents in iron-ore mining to 9.9 cents in mining and quarrying nonmetallic minerals except fuel.

INCOME

National Income Originated.—Contrary to the trend of all industries, income originated in all mining and related industries declined. Metal mining lost 10.7 percent, because of lesser demand for primary metal and significant depletion of stocks of metal ores.

TABLE 29.—National income originated in the mineral industries in the United States [1]

Industry	Income, million dollars			
	1959 [2]	1960 [2]	1961	Change from 1960 (percent)
All industries	400,481	415,480	427,829	+3.0
Metal mining	644	763	681	−10.7
Nonmetallic mining and quarrying	800	836	830	−.7
Total mining except fuels	1,444	1,599	1,511	−5.5
Total mining including fuels	5,283	5,207	4,977	−4.4
Manufacturing	119,929	121,987	121,704	−.2
Primary metal industries	10,527	10,624	9,979	−6.1
Stone, clay and glass products	4,450	4,334	4,247	−2.0
	Percent			
All industries	100.00	100.00	100.00	
Metal mining	.16	.18	.16	
Nonmetallic mining and quarrying	.20	.20	.19	
Total mining except fuels	.36	.38	.35	
Total mining including fuels	1.32	1.25	1.16	
Manufacturing	29.95	29.36	28.45	
Primary metal industries	2.63	2.56	2.33	
Stone, clay and glass products	1.11	1.04	.99	

[1] U.S. Department of Commerce. Survey of Current Business. Office of Business Economics, v. 42, July 1962. To arrive at national income, depletion charges are not deducted; this affects data for mining industries.
[2] Revised figures.

Profits and Dividends.—The annual rate of profit in 1961 on stockholders' equity (after corporate income taxes) was 10 percent less than in 1960 for mineral manufacturing corporations compared with a 4.4-percent decrease for all manufacturing. The rate of profit of mineral manufacturing continued the downward trend started in 1960. Although dividends distributed declined, except for the stone, clay, and glass products industry, they did not drop as sharply as profits. Minerals manufacturing again trailed behind all manufacturing in both rate of profit and dividends distributed.

TABLE 30.—Annual average profit rates on shareholder's equity, after taxes, and total dividends, mineral manufacturing corporations [1]

Corporations	Annual profit rate (percent)			Total dividends (million dollars)		
	1960	1961	Percent change 1961 from 1960	1960	1961	Percent change 1961 from 1960
All manufacturing [2]	9.2	8.8	−4.4	8,280	8,551	+3.3
Primary metals	7.2	6.5	−9.7	955	926	−3.0
Primary iron and steel [3]	7.2	6.2	−13.9	648	627	−3.3
Primary nonferrous metals [3]	7.1	7.1	----------	307	300	−2.3
Stone, clay, and glass products	9.9	8.8	−11.1	301	304	+1.0

[1] Federal Trade Commission and Securities and Exchange Commission, Quarterly Financial Reports for Manufacturing Coporations, 1st Quarter and 4th Quarter 1961, tables 4 and 8.
[2] Except newspapers.
[3] Included in primary metals.

Business Failures.—Mining failures continued to increase, and reached a record high, but current liabilities of the firms that failed decreased by 14 percent from 1960.

TABLE 31.—Industrial and commercial failures and liabilities

Industry	1959	1960	1961
Mining:[1]			
Number of failures	91	98	103
Current liabilities, thousand dollars	8,363	19,650	16,814
Manufacturing:			
Number of failures	2,374	2,514	2,722
Current liabilities, thousand dollars	199,373	269,985	308,468
All industrial and commercial industries:			
Number of failures	14,053	15,445	17,075
Current liabilities, thousand dollars	692,808	938,630	1,090,123

[1] Including fuels.

Source: Dun & Bradstreet, Inc. Monthly Business Failures. Business Economics Department, New York, N.Y., January issues, 1960, 1961, 1962.

INVESTMENT

New Plant and Equipment.—Expenditures for new plant and equipment by fuel- and nonfuel-mining firms declined $10 million in 1961 compared with 1960, and were $260 million under 1957. The decline was 1 percent in the mining industry compared with 6 percent in all manufacturing. The 29-percent, 14-percent, and 18-percent declines in expenditures for new plant and equipment by primary iron and steel, primary nonferrous metal, and stone, clay, and glass products manufacturing, respectively, were much more severe than the decline in all manufacturing.

Issues of Mining Securities.—The mining industry (including fuels) was the source for 2.0 percent of all new corporate securities offered in 1961, below the 2.5 percent and 2.1 percent for 1960 and 1958, respectively, but above the 1.7 percent figure in 1959. The percentage distribution between types of securities in mining followed a

TABLE 32.—Expenditures on new plant and equipment by firms in mining and selected mineral manufacturing industries[1]

(Billion dollars)

Industry	1959	1960	1961	1961			
				January-March	April-June	July-September	October-December
Mining[1]	0.99	0.99	0.98	0.21	0.26	0.25	0.26
Manufacturing	12.07	14.48	13.68	3.00	3.46	3.34	3.88
Primary iron and steel	1.04	1.60	1.13	.28	.28	.26	.30
Primary nonferrous metals	.31	.31	.26	.07	.07	.06	.07
Stone, clay, and glass products	.53	.62	.51	.11	.12	.12	.16
Chemicals and allied products	1.23	1.60	1.62	.33	.42	.40	.46
Petroleum and coal products	2.49	2.64	2.76	.56	.70	.70	.80

[1] Including fuels.

Source: U.S. Department of Commerce. Survey of Current Business. Office of Business Economics, v. 41, No. 3, March 1961, p. 14; v. 42, No. 3, March 1962, p. 7.

pattern similar to that in 1960. Total gross proceeds from all corporate offerings increased $2,988 million, compared with 1960; mining proceeds gained only $13 million. The 5-percent increase in proceeds in mining greatly lagged behind the 29-percent gain in total corporate offerings and 87-percent increase in manufacturing.

TABLE 33.—Estimated gross proceeds of new corporate securities offered for cash in the United States in 1961 [1]

Type of security	Total corporate		Manufacturing		Mining [2]	
	Million dollars	Percent	Million dollars	Percent	Million dollars	Percent
Bonds	9,425	72	3,371	82	166	63
Preferred stock	449	3	75	2	20	8
Common stock	3,273	25	666	16	76	29
Total	13,147	100	4,112	100	262	100

[1] U.S. Securities and Exchange Commission. Statistical Bulletin. V. 21, No. 4, April 1962, p. 18. 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 mining securities and the composite and manufacturing indexes gained over 1960. An increase in the mining index reversed the sharp decline in 1960. The index increased 19 percent, compared with a 16-percent gain in manufacturing and a 20-percent gain in the composite.

TABLE 34.—Indexes of common-stock annual average prices [1]

(1957-59=100)

Year	Composite [2]	Manufacturing	Mining [3]
1957	89.8	90.7	107.2
1958	93.2	92.5	97.9
1959	116.7	116.5	95.0
1960	113.9	110.9	73.8
1961	134.2	126.7	92.5

[1] Council of Economic Advisers. Economic Indicators (prepared for the Joint Economic Committee). April 1962, p. 30. 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.

TRANSPORTATION

Data on rail and water transportation were not available for 1961 because they are not published until the late fall of the year after the year reported. Therefore, the data in tables 35, 36, and 37 cover 1959 and 1960.

Rail Transportation.—All mineral products were 59 percent of total tonnage carried by rail during 1960, of which metal and other nonfuel minerals were 31 percent and mineral fuels, 28 percent. The overall tonnage carried by rail increased 9.2 million short tons over

1959; total mineral products increased 7.6 million short tons. The 14.6 million short-ton gain of metal and nonfuel minerals more than compensated for the 7.0 million-ton decrease of mineral fuels. In the metal and nonfuel mineral subgroup, iron and other metallic ores and concentrates increased; sand and gravel, crushed stone, and cement declined.

TABLE 35.—Indexes of average freight rates on carload traffic, 1959–60, and average revenue per ton, originated or terminated, 1958–60, in the United States

Item	Indexes [1] (1950=100)		Average revenue per ton [2] (dollars)		
	1959	1960	1958	1959	1960
Products of mines	117	115	3.16	3.13	3.03
Iron ore	138	138	2.39	2.46	2.34
Clay and bentonite	136	133	7.79	8.17	8.18
Sand, industrial	128	127	3.53	3.60	3.45
Gravel and sand, n.o.s	116	114	1.35	[3] 1.38	1.38
Stone and rock, broken, ground and crushed	116	115	1.72	1.69	1.67
Fluxing stone and raw dolomite	139	140	1.89	1.96	2.01
Salt	115	114	6.96	6.84	9.34
Phosphate rock	100	95	2.34	2.15	1.97
Mineral manufactures and miscellaneous [4]	118	115	11.85	11.54	11.66
Fertilizers, n.o.s	115	111	8.37	8.12	7.76
Iron, pig	135	133	5.30	5.33	5.17
Cement: Natural and portland	95	85	4.03	3.74	3.38
Lime, n.o.s	127	124	6.46	6.23	5.94
Scrap iron and scrap steel	129	127	4.39	4.43	4.06
Furnace slag	111	110	2.08	1.88	1.82
Nonmineral categories:					
Products of agriculture	114	112	8.66	8.39	7.93
Animals and products	118	116	24.21	23.92	24.22
Products of forests	125	124	8.35	8.33	8.22
Forwarder traffic	126	122	45.39	41.83	38.92
All commodities	118	116	6.96	6.94	6.67

[1] U.S. Interstate Commerce Commission. Index of Average Freight Rates on Railroad Carload Traffic 1952–60. Bureau of Transport Economics and Statistics, Statement RI–1, January 1962.
[2] U.S. Interstate Commerce Commission. Freight Commodity Statistics, Class I Steam Railways in the United States. Bureau of Transport Economics and Statistics, Statement 59100, 1958; 60100, 1959; and 6105, 1960.
[3] Revised figure.
[4] All manufacturers and miscellaneous.

Water Transportation.—All mineral products were 83 percent of total tonnage shipped on water during 1960, of which metal and other nonfuel minerals were 24 percent of the total, and mineral fuels were 59 percent. The overall tonnage shipped on water increased 33 million tons over 1959; total mineral products shipped increased 26 million tons. Metal and other nonfuel minerals rose 16.9 million tons in 1960. Iron ore increased 23.1 million tons to offset all other declines.

Great Lakes Shipping.—The Great Lakes had almost 85 percent of the dry-cargo tonnage of domestic water commerce; coastwise traffic had 90 percent of the tanker tonnage. The mineral commodities supplied 95 percent of the total Great Lakes traffic in 1960 compared with 91 percent in 1959. The change was attributed principally to increased shipments of iron ore.

TABLE 36.—Rail and water transportation of mineral products in the United States, by products

(Thousand short tons)

Product	Rail [1]			Water [2]		
	1959	1960	Change from 1959 (percent)	1959	1960	Change from 1959 (percent)
Metals and minerals, except fuels:						
Iron ore	69,473	96,847	+39.4	47,454	70,552	+48.7
Iron and steel scrap	20,353	20,279	−.4	1,744	1,739	−.3
Metals and alloys	10,995	10,133	−7.8			
Other ores and concentrates	16,497	20,626	+25.0	3,933	4,368	+11.1
Other scrap	1,977	2,332	+16.8			
Slag	6,193	5,776	−6.7	778	1,190	+53.0
Sand and gravel	70,036	61,967	−11.5	64,988	59,750	−8.1
Stone, crushed except limestone	54,613	50,705	−7.2			
Limestone, crushed	15,561	16,161	+3.9	27,188	28,886	+6.2
Cement	34,279	27,983	−18.4	5,683	5,563	−2.1
Phosphate rock	22,978	24,321	+5.8	2,589		
Clays	9,771	9,322	−4.6	2,197	2,024	−7.9
Sulfur	4,002	3,203	−20.0	4,680	4,007	−14.4
Other	26,193	27,904	+6.5	3,563	3,646	+2.3
Total	362,921	377,559	+4.0	164,797	181,725	+10.3
Mineral fuels and related products:						
Coal:						
Anthracite [3] [4]	20,358	16,839	−17.3	814	633	−22.2
Bituminous [3]	307,226	304,500	−.9	130,038	132,230	+1.7
Coke [3]	16,155	16,453	+1.8	285	448	+57.2
Crude petroleum	1,531	1,888	+23.3	72,356	74,138	+2.5
Gasoline	8,172	7,531	−7.8	93,011	92,618	−.4
Distillate fuel oil	8,066	7,279	−9.8	73,192	74,004	+1.1
Residual fuel oil				45,265	49,666	+9.7
Kerosene	18,761	18,747	−.1	9,325	9,255	−.8
Other				16,236	16,591	+2.2
Total	380,269	373,237	−1.9	440,522	449,583	+2.1
Total mineral products	743,190	750,796	+1.0	605,319	631,308	+4.3
Grand total, all products	1,223,397	1,232,670	+.8	726,732	760,573	+4.7
Mineral products, percent of grand total:						
Metals and minerals, except fuels	30	31		23	24	
Mineral fuels and related products	31	28		61	59	
Total mineral products	61	59		84	83	

[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, 1959 and 1960. Statements 605 and 6105.

[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 1959 and calendar year 1960, pt. 5, National Summaries.

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

[4] The rail statistics include anthracite to breakers and washeries (thousand short tons): 1959—8,601; 1960—6,940.

TABLE 37.—Great Lakes shipping

(Million short tons in dry cargo ships)

Commodity	1957	1958	1959	1960
Iron ore	85.6	52.7	45.9	68.4
Bituminous coal and lignite	38.2	32.2	32.6	33.1
Crushed limestone	28.3	20.4	23.9	25.5
Building cement	2.1	1.9	2.3	2.1
Sand and gravel	1.6	1.0	1.6	1.4
All other commodities	8.0	5.9	10.4	6.2
Total	163.8	114.1	116.7	136.7

Source: U.S. Department of Commerce. Maritime Commission, Domestic Oceanborne and Great Lakes Commerce of the United States. 1959, 1961, and summary for 1951-59.

FOREIGN TRADE

Value.—Value of nonfuel mineral imports decreased 5 percent from 1960. The reduction of iron ore and copper concentrates imports caused the decline. Value of exports increased 1 percent, another record high. The $112 million gain of ferrous scrap exports accounted for most of the increase.

Tariffs.—On January 26 the U.S. Tariff Commission reported the results of an investigation concerning the alleged injury to the U.S. feldspar industry by exports of nepheline syenite from Canada to the United States at less than fair value, under the meaning of section 201(a) of the Antidumping Act, 1921, as amended. It was decided that the U.S. industry was not being, and not likely to be, injured or prevented from being established by the importation.

Similar investigations were undertaken for portland cement imported from Sweden, Belgium, and Portugal.[14] In each case it was determined, in April, June, and October respectively, that the U.S. industry within the competitive market areas concerned was being injured because of importation at less than fair value and the resulting loss of a substantial volume of sales by the domestic industry.

TABLE 38.—Value of minerals and mineral products imported and exported by the United States, 1959–61, by commodity groups and commodities [1]

(Thousand dollars)

SITC No.	Group and commodity	Imports for consumption [2]			Exports of domestic merchandise [3]		
		1959	1960	1961	1959	1960	1961
	Metals (crude): [4]						
281-01	Iron ore and concentrates	312,415	321,713	250,254	33,824	57,575	53,823
282-01	Iron and steel scrap	11,639	6,386	7,696	167,239	244,579	356,509
	Ores of nonferrous base metals and concentrates:						
283-07	Manganese	74,810	82,262	78,430	819	719	1,054
283-11	Tungsten	4,235	3,478	1,994	5	1,251	250
283-06	Tin	23,282	31,104	21,923			
283-01	Copper	98,437	229,264	110,285	1,808	6,832	2,475
283-08	Chromium	31,853	24,239	21,444	3,084	320	516
283-05	Zinc	39,292	43,666	34,711	1	3	124
283-03	Bauxite (aluminum ore) and concentrates	73,203	78,065	88,821	2,672	2,588	12,189
283-04	Lead	27,019	27,911	24,385	54	168	448
[5] 283-19	Columbium	2,652	3,687	2,306	13	150	52
283-02	Nickel	1,770	2,275	93			495
[5] 283-19	Titanium						
	Ilmenite	7,991	5,066	4,604	} 290	167	190
	Rutile	2,943	3,611	2,544			
[5] 283-19	Cobalt				543	1,313	1,881
[5] 283-19	Molybdenum				24,778	39,843	48,758
[5] 283-19	Other	9,302	6,512	7,196	1,900	3,097	1,959
	Nonferrous metal scrap:						
284-01	Aluminum	3,299	1,598	1,738	10,485	26,905	26,452
	Old and scrap copper	1,654	3,524	874	5,292	31,384	18,031
	Old brass and bronze and clippings	698	184	174	[6] 12,497	[6] 52,220	[6] 52,226
	Other, not elsewhere included	3,277	3,804	1,884	3,494	6,081	4,916
285-02	Platinum-group metals	9,618	12,949	10,446			
	Total metals (crude)	739,389	891,298	671,802	268,798	475,195	582,348
	Metals (unwrought): [4] [7]						
681-01	Pig iron and sponge iron	36,621	18,992	21,199	773	5,354	19,400
681-02	Ferroalloys:						
	Ferromanganese	14,067	19,008	34,385	388	203	146
	Ferrochromium	29,750	14,313	7,612	2,096	5,249	838
	Other	2,390	1,876	1,369	4,024	4,977	9,726

See footnotes at end of table.

[14] Reports of injury cited in Federal Register, Doc. 61-3101, 61-5262, 61-10157.

TABLE 38.—Value of minerals and mineral products imported and exported by the United States, 1959–61 by commodity groups and commodities [1]—Con.

(Thousand dollars)

SITC No.	Group and commodity	Imports for consumption [2]			Exports of domestic merchandise [3]		
		1959	1960	1961	1959	1960	1961
	Metals—Continued						
682-01	Copper	146,805	117,763	142,181	93,142	273,757	252,262
687-01	Tin	103,298	87,854	98,205	1,890	1,294	1,264
684-01	Aluminum	111,259	75,808	91,187	53,518	128,199	57,638
683-01	Nickel (including scrap)	111,485	116,679	169,831			
686-01	Zinc	34,002	29,646	27,569	2,841	18,389	11,421
685-01	Lead	71,506	70,335	61,441	943	865	610
689-01	Cobalt	35,926	17,093	14,867	[8]	[8]	[8]
	Mercury	5,992	3,510		92	83	71
	Other nonferrous base metals	62,521	17,592	15,755	12,787	29,695	23,172
671-02	Platinum-group metals, including unworked and partly worked	27,295	21,185	[9]	2,563	4,840	[9]
	Total metals (unwrought)	792,917	611,654	685,601	175,057	472,905	378,548
	Total metals (crude and unwrought)	1,532,306	1,502,952	1,357,403	443,855	948,100	960,896
	Nonmetals (crude):						
	Diamonds:						
[5]672-01	Gems, rough or uncut	94,299	88,060	116,077	607	830	1,533
[5]272-07	Industrial	62,530	51,727	68,965	844	1,297	1,822
	Total	156,829	139,787	185,042	1,451	2,127	3,355
272-12	Asbestos, crude, washed or ground	65,007	63,345	58,942	763	845	708
271-02	Sodium nitrate	13,322	11,459	15,862			
272-13	Mica, unmanufactured (including scrap)	14,089	7,547	7,410	126	113	142
[5]272-14	Fluorspar	13,368	14,393	13,644	69	38	30
272-11	Stone for industrial uses, except dimension	12,927	9,443	9,555	641	687	731
272-06	Sulfur	13,901	15,457	17,173	42,000	42,262	36,624
271-03	Phosphates, natural, ground or unground	3,421	2,754	2,629	28,602	37,543	36,910
272-04	Clays	3,288	641	16,705	13,474	13,708	14,285
([10])	Other nonmetals (except fuels)	35,039	[11] 25,912	27,484	30,686	33,058	38,626
	Total nonmetals (crude)	331,191	[11] 290,738	354,446	117,812	130,381	131,411
	Grand total	1,863,497	[11] 1,793,690	1,711,849	561,667	1,078,481	1,092,307

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

As could be expected, individual commodities and groupings shown or omitted will not in all instances be in accord with usual Bureau of Mines practice as followed in individual commodity chapters in this Minerals Yearbook. In a few 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] Includes items entered for immediate consumption, items withdrawn from bonded storage warehouse for consumption, and ores, etc., smelted and refined under bond—included at time smelted or refined product is withdrawn for consumption or for export.

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

[4] Excludes gold and silver.

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

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

[7] Includes alloys.

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

[9] Information not available.

[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.

On October 2, in accordance with paragraph 1 of Executive Order 10401, the Tariff Commission submitted to the President the second report on trade in 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. Tariff rates for metals or minerals were not changed in 1961.

During the year, the Office of Civil and Defense Mobilization and its successor, the Office of Emergency Planning, had no application under consideration from any nonfuel mineral industry under section 8 of the Trade Agreements Act, the so-called national defense clause.

RESEARCH AND DEVELOPMENT

Sources of Funds.—Funds for the performance of research and development for all industries increased 46 percent from $6.5 billion in 1956 to $9.6 billion in 1959. Primary metals industries increased 48 percent from $93 million in 1956 to $138 million in 1959. The stone, clay, and glass products industry gained 41 percent. The petroleum refining and extracting industry increased only 21 percent.

Federal funds, only 39 percent of the total research and development performance, or $1.4 billion, in 1953, increased fourfold to $5.6 billion in 1959, or 59 percent of the total. Most Federal research and development expenditures were devoted to defense and national security. Consequently, 86 percent of the total research and development funds for the aircraft and parts industry and 70 percent of research and development funds for the electrical equipment and communications industry were Federal in 1959. The Government contributed 11 percent of the total research and development funds in the primary metals industry, 9 percent in petroleum refining and extraction, and 3 percent in stone, clay, and glass products during 1959.

Bureau of Mines.[15]—Bureau of Mines expenditures for research and development during fiscal year 1962 increased 6.8 percent over the previous years. During fiscal years 1960, 1961, and 1962, Bureau of Mines expenditures were 4.5, 5.0, and 4.6 percent of the total Federal expenditures for metallurgy and materials research as compiled by National Science Foundation of $97.5, $94.1, and $109.7 million, respectively. During the same years, the Department of Defense expended 76.5, 73.8, and 70.1 percent of the total, and the Atomic Energy Commission spent 17.3, 18.4, and 17.4 percent, respectively. In fiscal 1962, National Aeronautics and Space Administration (NASA) ranked third with 6.5 percent of the total Federal expenditure for metallurgy and materials research.

Basic Research, Applied Research, and Development.—The research and development programs of industrial firms are directed toward research with specific application rather than basic research which adds to scientific knowledge without specific commercial

[15] 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, (3) Metals and Nonmetal Mining Research in Bureau of Mines by Thomas E. Howard.

TABLE 39.—Sources of funds for research and development performance by industry 1958 and 1959

(Million dollars)

Industry and distribution	Company financed research and development			Federally financed research and development			Other sources		Total research and development		
	1958	1959	Change, percent, 1958–59	1958	1959	Change, percent, 1958–59	1958	1959	1958	1959	Change, percent, 1958–59
Chemicals and allied products	615	664	+8	190	284	+49	2	1	807	949	+18
Petroleum refining and extraction	232	243	+5	18	24	+33	3	6	253	272	+8
Stone, clay, and glass products	62	70	+13	2	2	(1)	(2)	(2)	64	72	+13
Primary metals	111	123	+11	15	15	(1)	(2)	1	126	138	+10
Primary ferrous products	65	73	+12	2	2	(1)	(2)	(2)	67	75	+12
Nonferrous and other metal products	46	50	+9	13	13	(1)	(2)	1	59	63	+7
Fabricated metal products	63	66	+5	64	58	−9	1	1	128	124	−3
Machinery	470	538	+14	331	404	+22	4	4	805	946	+18
Electrical equipment and communications	587	654	+11	1,336	1,575	+18	11	11	1,935	2,240	+16
Motor vehicles and other transportation equipment	532	616	+16	319	249	−22	1	1	852	866	+2
Aircraft and parts	367	399	+9	2,181	2,610	+20	3	19	2,551	3,028	+19
Professional and scientific instruments	153	174	+14	137	175	+28	5	4	295	353	+20
All other manufacturing industries	247	277	+12	108	145	+34	9	10	378	450	+19
Nonmanufacturing industries	(3)	(3)		(3)	(3)		18	19	101	115	+14
Total	3,479	3,867	+11	4,759	5,610	+18	57	76	8,295	9,553	+15

[1] Percentage of change was not computed for industries in which Federally Financed Research and Development Performance amounted to less than $25 million in 1958.
[2] Less than $0.5 million.
[3] Not separately available but included in total.

Source: National Science Foundation, Funds for Research and Development in Industry 1959, pp. 11, 14, 54, 55.

TABLE 40.—Bureau of Mines expenditures for mining and mineral research and development
(Thousand dollars)

Fiscal year	Applied research	Basic research	Development	Total
1958	11,862	2,610	5,809	20,281
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]	16,372	4,095	6,822	27,289

[1] Estimated figure.

Source: Budget Office, Bureau of Mines.

relevance. The primary metals and stone, clay, and glass products industries devoted a comparatively small part of research and development funds toward basic research, with $7 million and $4 million, respectively, in 1959. Private basic research averaged only 4 percent of the total research and development performance in each year from 1953 to 1959. Federal funds for basic research have been about three-fourths the annual volume of total basic research performance in the economy. From 1958 through 1961, the Bureau of Mines spent 15 percent in basic research, 60 percent in applied research, and 25 percent in development.

Research and Development and Size of Company.—As reported by the National Science Foundation, research and development was concentrated in the largest companies. In 1959, 406 companies with 5,000 or more employees (3 percent of the total number with research and development programs) composed 86 percent of the value of total research and development. Companies with 5,000 or more employees in petroleum refining and extraction spent 93 percent, the largest primary metal companies spent 79 percent, and the largest

TABLE 41.—Percentage of distribution of funds for the performance of basic research, applied research, and development, by industry, 1959

Industry	Total research and development funds, in millions	Percentage of distribution			
		Total	Basic research	Applied research	Development
Chemicals and allied products	$949	100	11	54	35
Petroleum refining and extraction	272	100	18	38	44
Stone, clay, and glass products	72	100	6	32	62
Primary metals	138	100	5	39	56
Primary ferrous products	75	100	7	(1)	(1)
Nonferrous and other metal products	63	100	3	45	52
Fabricated metal products	124	100	1	31	68
Machinery	946	100	3	13	84
Electrical equipment and communication	2,240	100	3	13	84
Motor vehicles and other transportation equipment	866	100	1	(1)	(1)
Aircraft and parts	3,028	100	1	11	88
Professional and scientific instruments	353	100	3	23	75
All other manufacturing industries	450	100	[2] 3	[2] 17	[2] 58
Nonmanufacturing industries	115	100	(1)	30	55
Total	9,553	100	4	20	76

[1] Not separately available but included in total.
[2] Includes some industries not separately available but included in total.

Source: National Science Foundation, Funds for Research and Development in Industry 1959, p. 25.

firms in the stone, clay, and glass products industry spent 77 percent of the total research and development funds for their respective industries.

Scientific and Technical Personnel.—Mineral related industries, including fuels, employed 11.6 percent of the total scientists and engineers in all industries in January 1960. Stone, clay, and glass products industries employed 1.3 percent of the total; primary metals industries employed 4.3 percent; the petroleum refining and extraction industry employed 6.0 percent of the total.

TABLE 42.—Scientists and engineers, by function and industry, January 1960 [1]

Industry	All scientists and engineers	Scientists and engineers primarily engaged in—				
		Research and development	Management and administration of research and development	Exploration	Production and operations	All other activities
	Number					
Chemicals and allied products	90,700	31,800	10,500	400	27,800	20,100
Petroleum products and extraction	48,600	8,100	6,100	11,200	16,800	6,400
Stone, clay, and glass products	10,200	2,500	1,800	100	4,800	1,000
Primary metal industries	35,100	4,900	5,900	300	19,400	4,800
Fabricated metal products	38,100	13,000	5,200	(2)	14,800	4,900
Machinery (except electrical)	71,400	22,000	12,500	100	23,000	14,000
Electrical equipment	101,400	54,900	12,100	500	19,600	13,900
Aircraft and parts	101,500	58,800	9,400	(2)	28,800	4,500
Professional and scientific instruments	26,300	12,100	3,400	(2)	6,700	4,000
Other manufacturing industries	84,300	27,500	13,100	100	38,200	5,500
Nonmanufacturing industries	205,200	21,700	32,800	1,600	110,000	38,800
Total, all industries	812,700	257,100	113,100	14,400	310,000	118,000
	Distribution, percent					
Chemicals and allied products	100	35.1	11.6	0.5	30.6	22.2
Petroleum products and extraction	100	16.6	12.5	23.1	34.6	13.2
Stone, clay, and glass products	100	24.5	17.7	1.4	46.6	9.8
Primary metal industries	100	13.8	16.8	.7	55.2	13.5
Fabricated metal products	100	34.1	13.8	(2)	39.0	12.8
Machinery (except electrical)	100	30.7	17.4	.1	32.3	19.5
Electrical equipment	100	54.2	12.3	.5	19.2	13.8
Aircraft and parts	100	58.0	9.2	(2)	28.4	4.4
Professional and scientific instruments	100	45.9	13.1	(2)	25.5	15.2
Other manufacturing industries	100	32.6	15.5	.1	45.3	6.5
Nonmanufacturing industries	100	10.6	16.0	.8	53.7	18.9
Average, all industries	100	31.6	13.9	1.8	38.2	14.5

[1] Totals and percents have been calculated on the basis of unrounded figures and therefore may not correspond exactly with those indicated by the rounded figures shown.
[2] Less than 50 cases.

Source: National Science Foundation. Scientific and Technical Personnel in Industry 1960. P. 25.

DEFENSE MOBILIZATION

Defense Production Act.[16]—The 86th Congress added $108 million to the $2,100 million borrowing authority of the Defense Production Act. Of this amount, $2,198,175,000 had been allocated by the Office

[16] Executive Office of the President. Report on Borrowing Authority. Office of Civil and Defense Mobilization, December 31, 1961, pp. 6-13.

of Civil and Defense Mobilization in December 1961 to carry out the DPA programs, leaving $9,825,000 undistributed. The probable ultimate net cost of the Defense Production Act metals and minerals programs was $795 million. Adding custodial, U.S. Treasury interest, other administrative expense, and loss on disposal of assets, depreciation, and other expenses not identified with specific commodities, this cost was $1,224 million.

TABLE 43.—Summary of Government inventories of raw materials, at acquisition cost and at market value

(Million dollars)

Type of acquisition	Inventory, June 30, 1960 [1]			Inventory, June 30, 1961 [2]		
	Total		Excess over stockpile objective	Total		Excess over stockpile objective
	Acquisition cost [3]	Market value [4]	Acquisition cost	Acquisition cost [3]	Market value [4]	Acquisition cost
National stockpile (Public Law 520):						
Stockpile grade	5,834	6,081	1,886	5,800	5,679	1,932
Nonstockpile materials	319	155	320	307	146	307
Total	6,153	6,236	2,206	6,107	5,825	2,239
DPA inventory (Public Law 744):						
Stockpile grade	978	791	838	1,090	840	850
Nonstockpile materials	471	143	471	392	120	392
Total	1,449	934	1,309	1,482	960	1,242
Supplemental stockpile (Public Law 480):						
Stockpile grade	719	696	580	929	878	777
Nonstockpile materials	35	28	36	22	20	22
Total	754	724	616	951	898	799
Commodity Credit Corporation inventory (Public Law 608):						
Stockpile grade	113	108	65	108	106	50
Nonstockpile materials	6	8	6	1	1	1
Total	119	116	71	109	107	51
Federal Facilities Corporation (Public Law 608): Stockpile grade tin	10	9	10	10	10	10
Totals:						
Stockpile grade	7,654	7,685	3,379	7,937	7,513	3,619
Nonstockpile materials	831	334	833	722	287	722
Total	8,485	8,019	4,212	8,659	7,799	4,341

[1] Joint Committee on Defense Production, 10th Ann. Rep. S. Rept. 1, 87th Cong., 1st Sess., Jan. 9, 1961, p. 31. Dec. 31, 1960 data not available.

[2] Joint Committeee on Defense Production, 11th Ann. Rep. S. Rept. 1, 87th Cong., 2nd Sess., Jan. 23, 1962, p. 23.

[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.

National (Strategic) Stockpile Program.[17] [18]—Metals and minerals delivered to the national stockpile during 1961 amounted to $5.3

[17] Executive Office of the President, Stockpile Report to Congress. Office of Civil and Defense Mobilization, January–June 1961, pp. vi–9; July–December 1961, pp. vi–12.

[18] The Joint Committee on Defense Production, 11th Ann. Report, 87th Congress, 2d sess. January 1962, pp. 11-35.

million, of which $3.3 million helped fulfill stockpile objectives. Government cash commitments for delivery of materials exceeding maximum stockpile objectives were reduced $13.5 million, involving mainly cobalt, copper, and nickel. Deliveries yet to be made under existing contracts to the national stockpile on December 31 were $4.8 million. Phlogopite block mica was added to the stockpile group, and crocidolite asbestos was removed.

TABLE 44.—National stockpile objectives and inventory

(Value in million dollars at market prices)

Objectives	Objectives, in effect Dec. 31		Applicable inventory, on hand Dec. 31	
	1960	1961	1960	1961
Basic	2,150	2,200	2,090	2,100
Maximum	2,240	2,200	1,880	1,900
Total objectives	4,390	4,400	3,970	4,000
Excess over objectives			1,580	1,600
Outstanding commitments			10	5

Source: Executive Office of the President. Stockpile Report to the Congress. OCDM, July–December 1960, p. vii; July–December 1961, p. vii.

The reduction of stockpile planning from a 5-year to a 3-year period, which was the basis of procurement policy from 1946 to 1958, caused the surplus position of many inventories. In March 1962, the Office of Emergency Planning declassified data for national stockpile inventories as of December 31, 1961. The details are presented in table 44.

Sales commitments for disposing of excess and offgrade materials from the strategic stockpile and the DPA inventory were about $51.5 million, of which $35 million came from the strategic stockpile. Of 71 draft stockpile disposal plans prepared by GSA, 11 required Congressional approval, and 5 had received Congressional approval. The plans for disposal of nickel-cobalt calcines and matt were approved on March 29, 1961.

Office of Minerals Exploration (OME).[19]—Of 97 applications received by OME for exploration assistance in 1961, 8 contracts and 24 amendments were completed. Government participation in the 8 contracts was not to exceed $252,133. Commodities covered were mercury, lead-zinc, silver-lead-zinc, lead-silver, copper, copper-cobalt, lead-zinc-copper, and nickel in 7 States. Eight contracts were terminated, and two were cancelled. At the end of 1961, 16 contracts remained in force with a maximum Government participation of $1.2 million.

Two changes occurred in OME regulations: (1) On July 27, gold, silver, iron ore, bismuth, sulfur, and tellurium were added to the list of materials eligible for exploration assistance; (2) on September 21 the financial eligibility requirements were modified and clarified by amendment.

[19] Department of the Interior. Office of Minerals Exploration Sixth and Seventh Semiannual Reports and 1961 Quarterly Reports of OME.

TABLE 45.—Strategic mineral materials in Government inventories in relation to strategic stockpile objectives as of December 31, 1961

(Specification grades)

Material	Unit (thousands)	Maximum objective	Government inventories					Surplus market value (thousands)
			Total	National (strategic) stockpile	DPA inventory	CCC and supplemental stockpile	Surplus	
Aluminum	Short tons	1,200	1,929	1,127	802		729	$349,920
Aluminum oxide, fused, crude	Short dry tons	200	378	200		178	178	25,632
Antimony metal (antimony content)	Short tons	70	45	30		15		
Asbestos:								
Amosite	do	45	25	12		13		
Chrysotile	Short dry tons	11	9	6		3		
Bauxite:								
Metal grade, Jamaica type	Long dry tons	2,600	6,494	880	1,370	4,244	3,894	45,482
Metal grade, Surinam type	do	6,400	6,985	4,965		2,020	585	8,980
Refractory grade	Long calcined tons	137	299	299			162	5,970
Beryl (11 percent oxide equivalent)	Short tons	23	36	23	2	11	13	4,898
Bismuth	Pounds	3,000	2,825	1,306	23	1,496		
Cadmium	do	6,500	16,766	9,719		7,047	10,266	16,426
Chromite:								
Metallurgical grade	Short dry tons	2,700	5,229	3,800	1	1,428	2,529	81,282
Chemical grade	do	475	961	559		401	485	8,551
Refractory grade	do	1,300	1,227	1,047		180		
Cobalt (cobalt content)	Pounds	19,000	97,048	76,974	18,997	1,077	78,048	117,072
Columbium	do	1,900	14,624	6,126	8,142	356	12,724	15,688,692
Copper	Short tons	1,000	1,142	1,009	122	11	142	88,040
Corundum	do	2	2	2				
Diamond, industrial:								
Crushing bort	Carats	30,000	35,637	31,113		4,524	5,637	15,784
Stones	do	18,000	22,627	9,165		13,462	4,623	59,174
Fluorspar:								
Acid grade	Short dry tons	280	1,100	458	20	622	820	36,900
Metallurgical grade	do	375	412	369		43	37	1,517
Graphite, natural:								
Ceylon, amorphous lump	do	4	6	5		1	2	446
Madagascar, crystalline	do	17	33	33			16	2,903
Other	do	2	5	5			3	915
Iodine	Pounds	4,300	3,280	2,977		303		
Kyanite-mullite	Short dry tons	5	10	10			5	658
Lead	Short tons	286	1,302	1,050	8	244	1,016	208,280
Magnesium	do	107	179	179			72	51,840
Manganese, battery grade:								
Natural ore	Short dry tons	50	274	145		129	224	25,536
Synthetic dioxide	do	20	25	21	4		5	3,100

Manganese, chemical grade:								
Type A ore	do	30	103	29		74	73	4,654
Type B ore	do	53	73	2		71	20	1,307
Manganese ore:								
Metallurgical grade	do	6,800	9,116	5,230	1,324	2,562	2,316	82,797
Mercury	Flasks	110	147	131		16	37	7,030
Mica:								
Muscovite block, stained A/B and better	Pounds	8,300	10,085	6,655	2,666	764	1,785	10,710
Muscovite film, 1st and 2d qualities	do	1,300	1,361	1,195	103	63	61	732
Muscovite splittings	do	21,200	44,856	40,030		4,826	23,656	28,387
Phlogopite block	do	17	17	17				
Phlogopite splittings	do	1,700	4,228	3,074		1,154	2,528	4,045
Molybdenum (molybdenum content)	do	59,000	84,305	84,305			25,305	35,427
Nickel (nickel content)	do	323,000	438,702	334,538	104,164		115,702	94,008
Platinum group metals:								
Iridium	Troy ounces	4	14	14			10	700
Palladium	do	340	746	90	8	648	406	9,744
Platinum	do	165	767	717		50	602	48,160
Quartz crystal	Pounds	650	5,044	4,812		232	4,394	79,092
Rare-earths and undisclosed materials	Short tons	28	15	10		5		
Rutile	Short dry tons	65	80	18	36	26	15	1,200
Sapphire and ruby	Carats	18,000	16,205	16,205				
Selenium	Pounds	400	254	97		157		
Silicon carbide, crude	Short tons	100	196	65		131	96	21,024
Talc, steatite, block and lump	do	0.3	1.2	1.2			0.9	293
Tantalum (tantalum content)	Pounds	2,420	3,036	1,566	1,470		616	8,125
Tin	Long tons	185	349	341		8	164	440,832
Tungsten (tungsten content)	Pounds	50,000	161,464	103,752	53,797	3,915	111,464	157,164
Vanadium (vanadium content)	do	2,000	15,930	15,930			13,930	24,795
Zinc	Short tons	178	1,580	1,256		324	1,402	336,480

Source: General Services Administration and Office of Emergency Planning.

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The program of the Defense Minerals Exploration Administration (DMEA) which terminated June 30, 1958, was administered by OME. Only 2 of 1,159 completed DMEA contracts were in force and unliquidated contract obligations at the end of 1961 were $157,885. Since the inception of the program, 394 discoveries and developments had been certified. The recoverable mineral commodities found in DMEA projects had an estimated gross value of approximately $1 billion at 1961 market prices. The net cost was about $30.8 million.

TABLE 46.—Commodities delivered under U.S. Government purchase regulations [1]

Commodity	Quantity delivered		Cumulation delivered as of Dec. 31, 1961	Total authorized purchases
	1960	1961		
Public Law 206, 83d Congress:				
Beryl ore----------short dry tons--	233	310	3,030	4,500
Mica [2] (hand-cobbed, mica or equivalent) short tons--	2,379	2,174	24,032	25,000

[1] General Services Administration. Report of Purchases under Purchase Regulations, as of December 31, 1960, and December 31, 1961. Defense Materials Service. Only commodities listed for which purchases and/or deliveries were made during 1961.
[2] The Government terminated by June 30, 1960, all DPAcontracts for the procurement of foreign mica.

Barter Program.[20] [21]—The value of barter contracts negotiated by the Commodity Credit Corporation (CCC) in 1961 was $163.5 million; the principal minerals were bauxite (Jamaican and Surinam), industrial diamond, lead, and manganese ore (metallurgical grade). End of the year CCC inventory awaiting transfer to stockpile amounted to $59 million. There were no additions to the list of materials eligible for barter during 1961.[22]

WORLD REVIEW [23]

World Production.—United Nations index of world mining production (including fuels) increased to 139 compared with 136 in 1960 (1953=100). The 2.2-percent increase was higher than the 0.8-percent rise for the United States. North America—Canada and United States—was the only area in the world where mining production declined; Latin America was unchanged, and Asia and Europe increased by 5 and 7 points, respectively. The Organization for European Economic Cooperation (OEEC) index of mining production paralleled that of the United Nations.

U.S. production and imports of principal minerals again were the major part of world supply, following closely the past historical trend. However, the U.S. total share of the supply of these commodities was slightly lower than in 1960.

[20] The Joint Committee on Defense Production. 11th Ann. Rept., 87th Cong., 2d sess., January 1962, pp. 19-40.
[21] Published and unpublished records of U.S. Department of Agriculture, Commodity Stabilization Service, Barter and Stockpiling Division.
[22] For details, see USDA reports and announcements on barter contracts and exports.
[23] Excluding Soviet-bloc countries.

TABLE 47.—Index of world metal-mining production

(1953=100)

Year	Free World	North America [1]	Latin America [2]	Asia: East and Southeast [3]	Europe [4]
1957	[5] 124	122	130	113	127
1958	116	107	[5] 121	[5] 98	124
1959	[5] 120	106	[5] 127	[5] 100	[5] 122
1960	[5] 136	124	[5] 154	[5] 117	[5] 134
1961	139	122	154	122	141
First quarter	133	111	149	117	142
Second quarter	139	123	154	122	144
Third quarter	141	130	157	126	133
Fourth quarter [6]	142	123	156	124	145

[1] Canada and the United States.
[2] Central and South America and Caribbean Islands.
[3] Afghanistan, Brunei, Burma, Ceylon, Singapore and 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.
[4] Excluding Albania, Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, Rumania, and U.S.S.R.
[5] Revised figure.
[6] Preliminary.

Source: United Nations Monthly Bulletin of Statistics. V. 16, May 1962, pp. 9–15.

TABLE 48.—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	Germany, West	Greece	Italy	Netherlands	Norway	Sweden	Turkey	United Kingdom
	Mining and quarrying												
1954	99	101	[1] 110	97	103	104	123	110	100	101	91	88	101
1955	108	105	[1] 115	100	110	110	132	123	101	111	104	97	100
1956	113	108	[1] 119	100	113	115	150	139	102	123	115	107	100
1957	115	[1] 111	[1] 123	98	120	119	195	156	105	124	120	110	100
1958	108	110	[1] 118	92	128	119	205	159	110	123	112	[2]	95
1959	112	[1] 110	[1] 113	79	147	115	214	171	114	[1] 119	110	[2]	93
1960	115	[1] 115	[1] 114	79	168	[1] 118	[2]	180	[1] 120	[1] 130	128	[2]	90
1961	122	119	[2]	77	187	122	[2]	194	124	127	139	[2]	89
	Basic metal industries												
1954	93	112	[1] 120	109	114	116	103	119	117	103	110	------	108
1955	111	131	[1] 143	127	133	141	98	148	133	127	125	------	117
1956	114	139	[1] 154	137	140	150	102	162	131	154	137	------	119
1957	114	145	[1] 170	131	153	154	120	182	135	167	140	------	120
1958	102	139	[1] 170	126	158	146	132	171	134	171	134	------	109
1959	113	148	[1] 180	136	158	160	126	184	156	[1] 191	153	------	114
1960	121	170	[1] 213	149	177	186	164	228	188	[1] 216	[1] 166	------	133
1961	[2]	[2]	[2]	148	186	187	[2]	248	[2]	227	181	------	124

[1] Revised figure.
[2] Data not available.

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

World Consumption.—The United Nations Commodity Survey reported world consumption of major minerals as mixed in 1961 in contrast to U.S. consumption. 1961 imports for consumption of iron ore by the six major steel producers in the free world—other than

TABLE 49.—Comparison of world and United States production and United States imports of principal metals and minerals, 1961

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	1961 U.S. total production and imports compared with 1960 total [1]
Fuels:					
Coal	2,880,338	15	(2)	15	Less.
Petroleum (crude)—thousand barrels	8,187,986	32	5	37	More.
Nonmetals:					
Asbestos	2,775	2	22	24	Less.
Cement [3]—thousand barrels	1,997,319	17	(2)	17	More.
Diamonds—thousand carats	33,700	----------	40	40	Do.
Feldspar [4]—thousand long tons	1,500	33	2	35	Less.
Fluorspar	2,300	9	22	31	Do.
Gypsum	43,035	22	12	34	Do.
Mica (including scrap) thousand pounds	355,000	56	4	60	Do.
Nitrogen, agricultural [3 4 5]	11,570	26	13	39	More.
Phosphate rock—thousand long tons	43,770	42	(2)	42	Do.
Potash (K_2O equivalent)	10,500	26	2	28	Do.
Salt [3]	96,400	27	1	28	Do.
Sulfur, elemental—thousand long tons	11,380	56	1	57	Do.
Metallic ores and concentrates:					
Bauxite—thousand long tons	29,040	4	32	36	Less.
Chromite	4,655	[6] 2	28	30	Do.
Copper (content of ore and concentrate)	4,850	24	(2)	25	More.
Iron ore—thousand long tons	497,610	14	5	19	Less.
Lead (content of ore and concentrate)	2,660	10	5	15	More.
Mercury—thousand 76-pound flasks	240	13	5	18	Less.
Molybdenum (content of ore and concentrate)—thousand pounds	87,900	76	(7)	76	Do.
Nickel (content of ore and concentrate)	396	3	32	35	More.
Platinum group (Pt, Pd, etc.). thousand troy ounces	1,190	4	48	52	Do.
Silver—do	231,800	15	15	30	Less.
Titanium concentrates:					
Ilmenite [4]	2,313	34	8	42	Do.
Rutile [4]	128	7	21	28	Do.
Tungsten concentrate (60 percent WO_3)—short tons	74,200	11	(2)	11	More.
Vanadium (content of ore and concentrate) [4]—short tons	8,650	62	(7)	62	Do.
Zinc (content of ore and concentrate)	3,720	12	10	22	Do.
Metals, smelter basis:					
Aluminum	5,195	37	1	38	Less.
Copper	5,060	24	7	31	More.
Iron, pig (including ferroalloys)	289,350	23	(2)	23	Less.
Lead	2,660	17	9	26	More.
Magnesium	115	35	1	36	Do.
Steel ingots and castings	392,400	25	1	26	Less.
Tin	190	[8] 5	21	26	Do.
Uranium oxide (U_3O_8) [6]—short tons	35,850	49	[9] 36	85	Do.
Zinc	3,550	24	4	28	More.

[1] Data on 1960 imports and production for the United States is available in the 1960 Minerals Yearbook, p. 131.
[2] Less than 1 percent.
[3] Including Puerto Rico.
[4] World total exclusive of U.S.S.R.
[5] Year ended June 30 of the year stated (United Nations).
[6] Produced for Federal Government only; excludes quantity consumed by American Chrome Company.
[7] Not imported.
[8] U.S. imports of tin concentrates (tin content).
[9] Percentage derived from data in the Atomic Energy Commission Annual Report, January 1962.

France, which is a net exporter of iron ore—decreased. The United States was responsible for most of the decline. Elsewhere, increases in imports into Japan and West Germany were not enough to offset reduced imports into Belgium, Canada, and the United Kingdom.

Free-world consumption of aluminum was higher than in 1960. The United States was primarily responsible for the increase. Free world consumption of copper was slightly lower than in 1960. The

U.S. consumption increased sharply; that of Western Europe and Japan decreased. Consumption outside the United States was generally less.

TABLE 50.—Apparent consumption of primary nonferrous metals—copper, lead, aluminum, zinc, and tin—in selected countries

Country	Copper			Lead			Aluminum		
	Thousand metric tons	Index (corresponding period of preceding year=100)		Thousand metric tons	Index (corresponding period of preceding year=100)		Thousand metric tons	Index (corresponding period of preceding year=100)	
	1959	1960	1961, first 9 months	1959	1960	1961	1959	1960	1961, first 9 months
United States	1,327.2	92	104	872.3	93	100	1,845.0	84	111
United Kingdom	486.5	115	95	257.0	111	96	293.5	123	77
Germany, West	445.7	116	115	210.8	114	98	228.5	133	99
France	188.1	128	103	159.1	104	99	167.8	127	94
Belgium	61.5	124	102	42.8	108	100	49.3	130	104
Italy	140.0	132	112	63.0	124	108	86.0	115	104
Sweden	78.7	117	101	37.5	117	101	30.5	121	90
Canada	117.8	91	117	41.1	89	126	80.5	129	[2]
Japan	219.9	136	[1] 123	71.2	134	135	112.6	134	[2]
India	53.9	116	107	280.0	88	107	22.9	107	[2]
World [3]	3,481.0	108	107	2,129.0	102	103	3,184.9	100	103

Country	Zinc			Tin		
	Thousand metric tons	Index (corresponding period of preceding year=100)		Thousand metric tons	Index (corresponding period of preceding year=100)	
	1959	1960	1961, preliminary	1959	1960	1961
United States	862.7	92	104	49.5	114	86
United Kingdom	251.6	110	93	21.7	107	94
Germany, West	264.6	112	103	17.7	165	129
France	170.5	101	109	11.1	107	97
Belgium	96.5	108	110	[4] 2.4	[4] 121	[4] 86
Italy	68.0	125	106	4.1	110	133
Sweden	24.6	125	88	[2]	[2]	[2]
Canada	62.0	82	109	4.3	100	100
Japan	154.4	122	126	11.8	131	107
India	47.5	131	113	4.4	93	97
World [3]	2,326.0	104	105	158.0	115	100

[1] Based on 6 months' data.
[2] Not available.
[3] Excluding the central planning countries.
[4] Belgium and Luxembourg.

Source: United Nations. Commodity Survey, 1961. April 1962, pp. 13–48.

World consumption of lead and zinc again increased. Western European consumption lagged slightly behind the United States, but consumption in Japan and Latin America increased sharply. World consumption of tin remained unchanged from 1960. The gain of Western European, Japanese, and Latin American consumption offset a substantial decline in U.S. consumption.

World Stocks.[24]—Free-world stocks generally increased again. Copper, lead, zinc, and sulfur stocks all increased moderately, but stocks of tin and iron ores declined.

An appreciable proportion of the free-world output of nonferrous metals in the 1950's went into various government stockpiles. Strategic stockpiles had been built and with the expansion in industry, consumer stocks had expanded and refilled. By the end of the decade when both governmental and consumer stocks had virtually ceased to increase, available production capacity was well above commercial requirements.

About 6 percent of the total 1950 through 1959 production of the free world's major nonferrous metals went into U.S. noncommercial stocks. The proportion of U.S. Government holdings as percentage of aggregate world production during 1950 through 1959 was as follows: Aluminum, 7.5 percent; copper, 3.2 percent; lead, 6.3 percent; zinc, 6.7 percent; and tin, 20.0 percent.

Since 1958, most stockpile objectives had been evaluated and lowered in line with changing assessments of defense needs. In several countries, government-held stocks were liquidated or greatly reduced. But at the end of 1961, U.S. official holdings of major nonferrous metals were still large. Copper holdings represented about 3 months' world output in 1960; aluminum and lead holdings, about 6 months'; zinc, about 7 months'; and tin, well over 2 years. The proportions of these U.S. surplus stockpile materials in relation to total 1960 free-world output were approximately as follows: Aluminum, 2 months; copper, 11 days; lead, 5½ months; zinc, 6½ months; and tin, 13 months.

World Prices.—Prices of metal ores remained unchanged from 1960, whereas the prices of total mineral and primary commodities declined slightly. Prices of metal ores and minerals were increasing in the second half of the year. Prices of nonferrous base metals declined in 1961. Zinc led the decline, followed closely by lead, and further down by copper, with no change in aluminum and an increase in tin.

Nonferrous base metals[25] price indexes [(1960=100)] were as follows in 1961:

Metals:	*Index (1960=100)*
Aluminum	100
Copper	94
Lead	87
Zinc	85
Tin	111
Aggregate total	98

Ocean Freight Rates.—Indexes of ocean freight rates again increased across the board. However, these indexes were still low compared with those of the 5 years preceding 1958.

[24] United Nations. Commodity Survey, 1961.
[25] Source: United Nations. Commodity Survey, 1961, Supplement in Nonagricultural Commodities. P. 14.

TABLE 51.—World trade price and freight-rate indexes

(1953=100)

Year	Price indexes			Trip charter freight-rate indexes [1]		
	Primary commodities	Total minerals	Metal ores	General cargo	Ore	Fertilizers
1957	102	114	107	145	138	131
1958	96	108	100	87	90	83
1959	94	[2] 102	99	93	90	75
1960	94	[2] 100	101	96	92	80
1961	92	99	101	102	93	87
First quarter	92	99	98	100	95	83
Second quarter	93	99	101	104	92	96
Third quarter	92	100	102	103	89	87
Fourth quarter	91	100	102	102	95	83

[1] United Kingdom indexes based upon weighted average of quotations by all nations on routes important to United Kingdom tramp fleet in 1951.
[2] Revised figure.

Source: United Nations. Monthly Bulletin of Statistics. March 1962, special tables A and C.

Review of Metallurgical Technology

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

A SEED seldom sprouts, grows, flowers, and bears fruit within one season. So it is with ideas. Usually it takes several years, sometimes decades, for an idea to be born, tested, developed, and adapted into a process or fabrication method. Therefore, the development of technical advancements often cannot be ascribed to a particular year.

Given the limited perspective of months, it is impossible to relate all the results of research and engineering investigations of 1961 that possibly may develop into technical "breakthroughs." Moreover, the significant details of processes and techniques that have been accepted for commercial practice have been described adequately in the current literature and need no further discussion here. This paper, therefore, reviews research accomplishments, presents brief operating notes, and points up important problems of the mineral industries. Included are significant changes and general trends noted during recent years. These all have been woven together in an effort to establish a pattern of current minerals and metals technology.

Probably the most outstanding scientific accomplishment of 1961 can be summarized with four names: Gagarin, Titov, Shepard, and Grissom. Certainly the year marked the beginning of the man-in-space era, and, in effect, marked the coming of age of those materials that make space flights possible.

Titanium, for example, demonstrated its reliability as an aerospace metal in its use as the basic structural material of the Mercury capsule, America' spaceman vehicle. Chosen for its light weight, ease of fabrication, and ability to retain strength and rigidity at high temperatures, titanium gave excellent performance. The capsule was designed to withstand 20 G's and high-temperature stiffness was a must. During the launch phase, the all-titanium adapter section reaches 600° F. The titanium stringers approach a like temperature, and even the inner skin becomes as hot as 200° F. Project Mercury also gave a dramatic answer to a question that has plagued some metallurgists for years—the reliability of titanium welding. The original Mercury capsule and the succeeding 20 production capsules each contained 45,000 inches of welding that had to be reliable.

Beryllium was used in heat shielding "shingles" fastened to the outside of the Mercury capsule. This metal has about the same weight

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

as magnesium, the strength of mild steel, and a stiffness factor greater than that of any other metal. Potentially it has many uses as a lightweight construction material in almost anything that flies. Restricting use, however, have been lack of ductility, indefinite knowledge of substantial resources, and high cost of processing and fabrication. Recently, it has been definitely established that when beryllium is sufficiently purified it has a degree of ductility not found in the ordinary commercial metal. Pieces of beryllium 1¼ inches in diameter and a foot long have been zone-refined and rolled with success. Investigations are continuing to determine if polycrystalline beryllium will be as plastic. The recently developed domestic deposits of beryllium-bearing material, coupled with the development of new processes such as that of Mineral Concentrates and Chemical Co., Inc., in Colorado, tend to relieve the worries about future resources. The cost of end-use items, however, is still high. About 70 percent of the cost is in fabrication, which stays expensive because of the difficulty of working brittle metal and the fact that most scrap is not reworked.

Steel, which has been overshadowed for several years by the more exotic metals, has started a comeback, especially in the field of ultrahigh strength. In the last decade improvements in aircraft design and production of higher quality steels have increased the ultimate strength of steel from 180,000 to 260,000 psi. In the past 3 years this has been pushed to over 300,000 psi in small plant lots. Extrapolated strength levels of 425,000 psi for conventional material have been reported in the laboratory. This has been accomplished by increasing the carbon content from 0.40 percent in the current ultrahigh-strength steels to about 0.60 percent and by adding 8 to 11 percent alloying elements. These strength increases are obtained at the expense of such properties as ductility and notch hardness, which vary inversely with strength for all steels. Vacuum melting has helped alleviate this problem by providing 25 to 50 percent improvement in longitudinal ductility and impact strength and up to 300 percent improvement in transverse ductility of larger sections.

Two new columbium alloys were announced by E. I. du Pont de Nemours & Co., Inc., during the year. One, containing 5 percent zirconium, had a strength of 75,000 psi at room temperature, 30,000 psi at 2,000° F., and 12,000 psi at 2,500° F. The second alloy (10 Ti-5 Zr-balance Cb) was considerably stronger at room temperature with a tensile strength of 80,000 psi, but maintained only 23,000 psi at 2,000° F. Such alloys would be intended for use on reentry vehicles to combat the extreme temperature rises encountered.

Explosive forming, also known as high-energy forming, can now be said to be established as a production method. Basically, the system uses shock waves or energy generated by the discharge of an explosive and transmitted by a fluid or semifluid medium to shape the metal part. This technique is employed primarily for special forming in the aircraft industries, but has been used for materials ranging from very soft to almost brittle. Its principal advantage lies in the fact that relatively inexpensive dies can be used and that there is no spring back after deformation. The disadvantage is that the method does not lend itself to high production rates or to the fabrication of large quantities of any one object. One interesting application of

the process was made by the Martin Co. of Baltimore, Md., in the construction of a scale model of torus tank. By simplifying the fabrication of large parts by explosive forming, the number of components was reduced from 40 to 12, with a consequent reduction in welding of almost 50 percent.

A process known as "dirty plating" received considerable attention during the year. The process consists of stirring a finely divided nonmetallic compound such as aluminum oxide in a normal plating solution and codepositing to form a composite material with a metallic matrix and nonmetallic inclusions. Several combinations of oxides, borides, nitrides, and carbides have been codeposited successfully, mostly with nickel or chromium metal. The coatings have shown promise in combating abrasion and wear and of having superior oxidation resistance. The most favorable results showed that a graphite rocket nozzle protected by one of these coatings would operate up to 1 minute at simulated firing conditions of about 4,000° F. Unprotected graphite failed in one-tenth that time.

Two research developments in physics may have significant consequences for the metallurgist. Bell Telephone Laboratories made an optical maser that produces a continuous coherent beam of infrared light. The new instrument promises to have revolutionary effects in communications. Several groups have been investigating the possibility of producing superconducting electromagnets for use in making better particle-accelerating machines and for study of the properties of materials. A definite contribution was made by J. K. Hulm of Westinghouse Electric Corp. with his columbium-zirconium magnet that produced a field of 43,000 oersteds and operated from only the local laboratory electricity supply. Bell Telephone Laboratories perfected a wire that continues to be superconducting in fields as large as 88,000 oersteds.

The mineral-producing industry for the past several years has been faced with the triple threat of processing ores that are increasingly lower in grade and more complex, spiraling costs, and the pressure of foreign competition. To meet these problems, much attention has been given to research and engineering investigations conducted to develop methods of shaving pennies from production costs and improving performance. The results of these studies are beginning to be seen in concentration plants built or remodeled in the last 2 years.

To keep pace with the increased tonnages being treated, there is a definite trend to larger and larger crushing and grinding units. Primary gyratory crushers with 54- to 60-inch feed openings are not unusual. Enlargement of secondary and tertiary units reflects the trend; a 10-foot-diameter cone crusher was announced recently. Rod milling often is employed to bridge the gap between crushing and ball milling and sometimes completely replaces the tertiary crushing step. Interest in larger grinding mills has continued. The 12½- by 16-foot ball mills and rod mills installed at The International Nickel Company of Canada, Ltd., Thompson project near Moak Lake, Manitoba, Canada, and at the Duval Sulphur & Potash Co. Esperanza concentrator near Tuscon, Ariz., are reported to be performing satisfactorily. Mills 10½ by 13 feet or 10 by 14 feet are common in other recent installations.

Autogenous grinding has received renewed attention in late years, and several new mining ventures are reportedly giving it serious consideration. Although most activity has resulted from testing specular hematite ores, some authorities predict that it will find even wider use for processing sulfide ores. Two major advantages are claimed: Ability to reduce run-of-mine ore to finished grind in one stage, and ability to approach grain boundary comminution, the ultimate of mineral liberation. Quebec Cartier Mining Co. is operating twelve 18-foot-diameter Cascade-type mills in its Lac Jeannine iron ore plant prior to spirial concentration. Two other large potential iron producers in northeast Canada have been experimenting with the method on a pilot-plant scale. The Vassbo concentrator in Sweden is using a 22- by 7-foot mill to grind lead ore.

Cyclones are generally accepted for the role of classification. They are used extensively to replace or supplement mechanical classifiers and are employed almost exclusively in middling regrind circuits. A recent trend is their use to handle extremely large circulating loads in grinding circuits; up to 1,000 percent returning loads have been reported.

General acceptance of the practice of regrinding middling products before final cleaning is in itself a relatively recent development and has improved the recovery at several installations. In line with the same effort to "get out the last drop," more and more attention is being given to byproduct recovery. One case in point is the application of cyanidation by San Manuel Copper Corp., for recovery of gold from molybdenum concentrate. Several groups have investigated the recovery of germanium, and one African company is reported to be employing magnetic separation for its removal from copper concentrate. Another African company recovers germanium from sulfide concentrates by a roast-leach method.

Significant in the new and remodeled plants has been the adoption of instrumentation and automation for control of segments of the beneficiation process. Although the primary aim of automatic control is to conserve manpower, most of the new plants report additional benefits in product uniformity and lower maintenance costs.

True automation implies use of sensing and control devices integrated by means of feedback systems and a computer control center. Such a system has been approached most closely by the segments of the minerals industry where process variables are relatively uncomplicated and where materials handling is an exceptionally large part of the total operation. Such operations as cement manufacture and coal washing are included in this category. Among the companies reporting reasonable success at incorporation of direct control of unit operations into centralized or electronic computer centers are Dundee Cement Co., Dundee, Mich., California Portland Cement Co., Mojave, Ariz., and Ideal Cement Co., Ada, Okla.

Modern design and instrumentation were successfully combined by Mountaineer Coal Co., Leaverage, W.Va., in constructing a plant to process raw coal from the Pittsburgh seam into a uniform product containing less than 7 percent ash and 3 percent total moisture. From the feeders (automatically controlled by a belt weigher) to the final dryers (controlled by exhaust temperature), the entire system was de-

signed to make the most efficient arrangement of conventional equipment coupled with maximum use of remote and automatic control. The result has been a 1,500-ton-per-day-capacity mill that employs only four operators from mine to finished product.

The sintering operation for processing iron ore concentrates lends itself readily to automatic control and is being accepted generally. Also, computers have been used widely to determine the optimum conditions for blast furnace operations.

In the field of nonferrous minerals, automation and computer control have grown at a slower rate. This has been primarily because of a lack of suitable sensing devices for measuring process variables. The problem, therefore, involves creating or tailoring instruments and controls for each particular situation. Appreciable strides have been made in this direction, however. Novel techniques, such as gamma ray absorption measurement to determine pulp density and X-ray fluorescence for continuous analysis of mill products, have been developed to a high degree of efficiency.

Probably the most fully automatic nonferrous mill constructed to date is Duval's Esperanza copper concentrator. A three-stage crushing circuit embodies control of feed rate to each crusher to effect operation at optimum capacity and delivery of desired product size from the tertiary unit. Feed to the wet grinding circuit is controlled manually, but instrument control of water and lime additions maintains desired pulp density and alkalinity.

Further, the pulp level in the flotation cells is controlled automatically, and addition of reagents is regulated and recorded by instrument. The copper flotation concentrate is treated in an instrument controlled steaming operation to depress minerals other than molybdenite, and the cleaned molybdenite concentrate is prepared for shipment with automatic weighing and packaging facilities.

The Mission copper mill near Sahuarita, Ariz., recently completed by American Smelting and Refining Company, includes centralized and automatic control of several of the unit operations. Similarly, the new Viburnum lead concentrator of St. Joseph Lead Co., in southeastern Missouri, also embodies continuous recorders for feed rate, recirculation load, and pulp density, central panel control of flotation circuits, and automatic weighing devices. The enlarged and modernized plant of Ray Mines Division, Kennecott Copper Corp., at Hayden, Ariz., features panelboard control of crushing, flotation, and leaching operations, and radiation-absorption regulation of the density of thickener underflow. None of the above, however, is a totally integrated automatic concentrator. The unsolved problems concerning the relationship of dependent variables retard full automation. The most optimistic of the prognosticators, however, predict realization of such a "dream mill" by 1970.

In the iron and steel industry major effort continues for the purpose of increasing blast furnace capacity. The record has been good. In 20 years the annual average capacity of a blast furnace has been boosted 53 percent. Since 1947 the requirements of iron ore and coal to make a ton of pig iron have been reduced about 13 percent; limestone needed has dropped more than 50 percent; scrap requirements have remained fairly constant. Current investigations both here

and in the U.S.S.R. are being directed to studies of the effect of supplementary fuels added at the tuyeres and the use of oxygen-enriched blast. Substantial coke savings and production increases have been reported.

The largest contributing factor to date for increased capacity and decreased raw material consumption has been the progress made in force feeding the blast furnace a richer diet of iron units in the form of upgraded ore or pelletized concentrates. This advance, however, was not accomplished without introducing new problems, as E. H. Rose pointed out in a much-talked-about article printed in two journals of the American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc. (AIME).[3]

Certain iron ores which qualified as commercial shipping ores only a few years ago are no longer marketable. Also, operators have found that with a high-grade burden in the blast furnace there is a problem of maintaining sufficient slag volume to scavenge the sulfur introduced by the coke, about 60 percent of which reports in the finished metal. This may place a limit on the capacity of furnaces unless methods are devoloped to further eliminate sulfur during the coking operation. Another problem has arisen in the pelletizing operation. The methods now in use have been developed primarily to utilize the minus 200-mesh concentrate obtained by treating low-grade magnetiferous taconites. These methods are not readily adaptable to concentrates from some of the new ore discoveries, notably those in Labrador. These latter, specular hematite ores, can be beneficiated at a relatively coarse 28-mesh grind. Thus, the operators are faced with the problem of expensive regrinding of the concentrates to minus 200-mesh for pelletizing or of developing a method of agglomerating coarse-grained material that will yield a pellet with acceptable green strength before heat treating. In any event, they will not have the 28-percent bonus of energy supplied by the exothermic reaction of magnetite transforming to hematite.

Interest is still evident in so-called direct reduction processes. Announcements were made during 1961 of the intention to use the much-publicized Strategic-Udy process commercially at Anaconda, Mont., and at two new Canadian plants. The Krupp-Renn process is being given a new look as a possibility for intermediate-grade Minnesota ores. One new technique was announced. The Allis-Chalmers Manufacturing Co. agglomeration-reduction process (ACAR), still in development, shows promise for treating high-grade pellets to yield a product suitable for electric furnace or cupola melting. Basically the ACAR system is two concentric kilns. Passing concurrently with pelletized feed through the inner kiln, fuel gas is reformed to an atmosphere consisting primarily of hydrogen and carbon monoxide. In this atmosphere 90 to 95 percent of the iron oxide is reduced to metallic iron. The unused gas proceeds to the annular section between the two shells and is burned to hold the reduction zone at a temperature of 1,900° F.

The use of "tonnage oxygen" to supplement air in the oxidation process in steelmaking is growing in popularity. About 20 million

[3] Rose, E. H., Iron Ore; The Big Picture; Min. Eng., v. 13, No. 9, September 1961, pp. 1052–1058; J. Metals, v. 13, No. 11, November 1961, pp. 814–819.

tons of steel was produced in 1961 by one of the various techniques based on this principle. This, too, has introduced a new problem. The vigorous reaction caused by oxygen on the molten bath creates extremely fine iron oxide dust which bring equally vigorous protests from neighboring communities unless adequate and expensive provision is made for trapping it. The city of Buffalo, N.Y., for example, has refused to put up with the red smoke nuisance even for a period of testing by Republic Steel Corp. As a result, Republic has abandoned the idea of oxygen steel processing rather than gamble that the increased capacity will justify the cost of a precipitator system.

The use of oxygen is increasing in other phases of production metallurgy. United States Steel Corp. is using oxygen to make ferromanganese. Using oxygen-enriched air in its fluidized roasters at the Rizdon Works, Electrolytic Zinc Co. of Australasia, Ltd., has reduced the sulfite content of its calcine while maintaining a high rate of oxidation. The technique has resulted in improved fuel economy, high zinc solubility, and low iron solubility in the furnaces. At the Consolidated Mining & Smelting Co. of Canada, Ltd., Trail, British Columbia, 1,200 to 1,400 cubic feet of oxygen is added daily to the 12,000 cubic feet of air feeding two lead blast furnaces. The company reported that the oxygen-enriched blast has increased capacity about 25 percent.

Renewed interest is being shown in hydraulic transportation of solids. The method has been used successfully in Florida since the early 1940's to transport phosphate rock matrix for relatively short distances—rarely exceeding 5 miles. Abundance of water, flat terrain, and beneficiation of the matrix by agitation while being pumped have been contributing factors to acceptability of this method. Pipelines generally in use today are 14 and 16 inches in diameter, with one as large as 20 inches.

Long-distance hydraulic transportation, although generally considered to hold promise of great economic benefits, has not been adopted on a broad scale, and until 1961 only two major long-distance solids pipelines were operating in the United States. Since 1957, a 72-mile-long, 6-inch-diameter pipeline of American Gilsonite Co. has been satisfactorily transporting 700 tons of gilsonite per day from the mine at Bonanza, Utah, to the processing plant at Grand Junction, Colo. Similarly, a 108-mile-long, 10-inch-diameter pipeline of Pittsburgh Consolidation Coal Co. has been used since January 1958 to transport 4,000 tons of finely crushed coal per day from the mine at Cadiz, Ohio, to a power plant at Cleveland.

Recently, the Anaconda Reduction Works of The Anaconda Company, Anaconda, Mont., has been conducting tests with a 16-inch-diameter pipeline designed to transport 20,000 tons of deslimed flotation tailings per day for more than 7 miles. The material is to be used for fill in a tailings dam construction project. At Anaconda's El Salvador project in Chile a 6-inch pipeline has been used since 1959 to transport 1,000 tons of copper concentrate per day for 14 miles, entirely by gravity, to the railroad for subsequent haulage to the smelter at Potrerillos. It is planned to extend the pipeline an additional 60 miles to the smelter. Tests indicate that the pipe will handle up to 2,000 tons of concentrate per day at a pulp density of 40 to 60 percent

solids. At another South American copper development, proposed treatment plans include transportation of 10,000 tons of ground ore daily from mine to concentrator by a 14-inch gravity pipeline and transportation of the mill concentrate 35 miles by a 4-inch gravity pipeline . Other contemplated installations of hydraulic transportation include a proposed 24-inch line to move coal 350 miles from West Virginia to the New York City area. This project has been moved nearer reality by the recent demonstration by The Babcock & Wilcox Co. that coal slurry can be burned directly in a modified cyclone burner. This development eliminates, at a saving of 60 cents per ton, the dewatering step now necessary before burning slurry.

The general belief that worldwide demands for fertilizer will continue to surge sharply upward during the foreseeable future has spurred a tremendous increase in potash, phosphate rock, and nitrogen production. Phosphate fertilizers, for example, are expected to rise from the present 15 million tons per year to 18 million tons by 1970. Similarly, annual potash fertilizer production is expected to climb from 2 million tons to 3 million tons in the same period. The economics of the fertilizer industry is linked closely to the cost of distribution. A decrease in production costs can be directly translated into the number of extra miles that the product can be shipped and marketed. Recently, the battle to break through the distance barrier has included manufacture of products of high nutrient content. There is, for example, an increasing output of liquid fertilizers derived from superphosphoric acid made from elemental phosphorous, as well as such highly concentrated products as diammonium phosphate and ammonium polyphosphate.

The basic fertilizer producers are trying other approaches, too, for keeping production costs at a minimum. There is a definite trend toward integration of production and marketing; more and more production firms have been corporatively wedded to bulk mixing operations and distribution outlets. Other producers have entered the direct distribution field by packaging and selling complete plant-food products such as the phosphate-nitrogen-potash mixtures. In addition, there is a significant use of new and better materials-handling techniques, including the sale of fertilizer to farmers by the truckload in bulk rather than in the more expensive bagged lots. Technological improvements have included development of methods for particle-size control of various nutrient components, thus allowing dry blending rather than chemical compounding of concentrated fertilizers.

A new route to copper production, bypassing smelting, has been announced for a proposed plant on Mindanao Island in the Philippines. The unit will use a high-pressure ammonia leach and hydrogen reduction method similar to that developed for copper-nickel-cobalt ore by Sherritt Gordon Mines, Ltd., at Fort Saskatchewan, Alberta, Canada. In addition, a technique developed by E. W. Bliss Co. will be used to press and roll the copper powder directly into strip, wire, tubing, and sheet. The plant is expected to produce 14,000 tons of copper, 500 tons of zinc, and 100,000 tons of ammonium sulfate annually.

Several reasons are given for not selecting the conventional smelter, electrolytic refinery, and fabrication route. First, capital investment is purported to be much lower. Also, the conventional process is not economic for such limited tonnage. In addition, the zinc-rich portion of much of the feed is amenable to leaching but not to smelting. Finally, the new method produces byproduct ammonium sulfate which is greatly needed in the Phillippines for fertilizer.

Another copper reduction process has proven to be feasible on a commercial scale. Research by the Bureau of Mines has demonstrated that the segregation process has promise for treating oxidized and mixed oxide-sulfide copper ores regardless of gangue constituents present. The laboratory results encouraged Transarizona Resources, Inc., to erect, in 1959, a 175-ton-per-day experimental plant to process highly calcareous and iron-bearing oxidized copper ore of the Lake Shore deposit near Komelik, Ariz. From ore containing 1.5 to 2.25 percent copper, approximately 85 percent of the copper is recovered in a 50-percent copper concentrate. Based on the pilot plant operation and results, Transarizona is expanding its operations to a 750-ton-per-day capacity.

A solvent extraction process developed by the Bureau of Mines has been employed by Vitro Chemical Co. at Salt Lake City, Utah, to recover scandium from plant-stripped uranium solvent analyzing less than 0.1 gram of scandium oxide (Sc_2O_3) per liter. The crude cake, containing thorium and scandium fluorides (10 percent Sc_2O_3), was refined at Vitro's Chattanooga, Tenn., facility. The product was high-purity scandium oxide assaying 99.99 percent Sc_2O_3. The success of this trial run indicates that adequate supplies of this element to satisfy any foreseeable use are available from waste leach liquors of uranium mills. The current price of about $2,700 per pound does not encourage wide use, however. Conversely, the cost is not likely to drop appreciably without a significant market.

A flotation process, yet too new for proper evaluation, was developed by Minerals & Chemicals Philipp Corp., Menlo Park, N.J. Called ultraflotation, the method is designed to recover particles in sizes smaller than 1 micron by employing a "mineral carrier" added to the feed. The larger carrier grains (often limestone) tend to collect tiny particles that ordinarily would not be attracted by air bubbles during frothing. Announcement has been made of a commercial trial at McIntyre, Ga., to remove titaniferous impurities from kaolin.

The intensification of research by the minerals industry was illustrated by three new laboratories announced during the year. Bethlehem Steel Co. opened its new Homer Research Laboratory at Bethlehem, Pa. This 450-employee facility will conduct research ranging from study of chemical reactions of steelmaking to preparation of refractory furnace linings. Of prime interest will be the development of high-strength steel and coatings or new alloy steels capable of meeting the strength-to-weight and corrosion requirements of space vehicles. The Anaconda American Brass Co. stepped up its research program nearly 10 times in a new laboratory at Waterbury, Conn. This effort will be devoted largely to fundamental studies of the properties of copper and its alloys. The Kennecott Copper Corp. announced construction of a new basic research laboratory expected to

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be completed in 1 year at Lexington, Mass. The research program at this laboratory will emphasize solid state physics investigations aimed toward contributing to basic knowledge and producing discoveries of a fundamental nature, which will result ultimately in new materials and products.

Of more than passing interest were two meetings sponsored by AIME in 1961, which were devoted to single technical fields. They were labeled as being the best organized and most efficiently run meetings in the history of AIME. The First International Symposium on Agglomeration, held in Philadelphia in mid-April, drew 595 industrial leaders to consider the advances and problems in the area of agglomeration. Three dominant points were consistently emphasized throughout the symposium: 1. Careful and complete premixing of materials prior to sintering or pelletizing is vital to improved production. 2. Updraft furnaces appear to be most effective for lead-zinc treatment and are preferred for some iron ores. 3. There is a lack of uniformity in quality testing of agglomerated products. At the 50th anniversary of Froth Flotation in the U.S.A., held in Denver, Colo., in September, 500 registrants gathered to discuss recent advances and current technology in the art of flotation. Although due respect was paid to the past achievements of flotation, the chief interest was in determining the role that flotation may play in future beneficiation and processing technology.

In short, there is a trend in the minerals industries toward production of specialized products. There is a tremendous drive toward cheaper and more efficient processing. And there is a wider acceptance of research as a tool to help achieve these goals.

Review of Mining Technology

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

THE SIGNIFICANCE of technologic developments during the year was overshadowed by the possible effects on world mining of political and economic events. The cold war that warmed up considerably several times during the year, rapid advance of industrialization in Europe and Japan, the tribulations attending emergence of new nations and negotiations toward international economic unions, all had direct or side effects on segments of the mining industry. In contrast, mining technology appeared to have reached a relatively stable plateau of trial and evaluation, rather than innovation. European longwall and hydraulic mining methods were being tried with relative success in the United States. Mechanized operations and ultra-large-capacity digging and hauling equipment were commonplace. The electronic computer and statistical mathematics were gradually being recognized as useful techniques for increasing efficiency in the industry. International symposia gained popularity as media for exchanging ideas and information on mining research.

EXPLORATION AND SAMPLING

Of importance to mineral exploration and almost certain to be reflected in future discoveries were large-scale geologic investigations in many parts of the world. These studies were conducted on a national scale and were related to increased nationalism and a drive for economic sufficiency in many nations. The Mamina area of Tarapaca Province was studied by Chile's Institute of Geological Investigations, Canada began aeromagnetic surveys of the Canadian Shield, which will be tied to extensive geologic field studies. An aerial survey was underway in the Kingdom of Jordan in hope of developing economic mineral deposits. Surinam was being resurveyed with highly sophisticated airborne geophysical equipment.[3] A virtual army of geologists was engaged in economic geologic investigations in the U.S.S.R. Methods used by the Northern Pacific Railway Co. during a geologic reconnaissance of a large area in the United States were described.[4] This trend of thinking is not restricted to regional land areas. A ter-

[1] Chief mining engineer.
[2] Assistant chief mining engineer.
[3] Engineering and Mining Journal, Geophysical Re-Survey for Surinam Jungle: V. 162, No. 4, Apr. 1, 1961, p. 91.
[4] Thurlow, Ernest E., Geologic Reconnaissance of Large Areas: Min. Cong. J., v. 47, No. 3, March 1961, pp. 33–35.

restrial approach was advocated [5] that would relate the earth's major structural features to the globe as a framework for economic geologic research. Increased thought was being given also to mineral resources in the oceans.[6] The British outlined some methods that could be applied in a oceanographic mineral exploration.[7] These methods included echo sounding, Sonar and Sparkler systems, variations of conventional geophysical methods, geological sampling, and, possibly, heat-flow measurements. The depths of the earth also were being subjected to continued probing. In addition to the well-known Mohole project,[8] the Canadians were participating in International Union of Geodesy and Geophysics (IUGG) research that is part of the Upper Mantle program.[9] The project envisioned a seismic network spaced at 500-mile intervals from the Atlantic to the Pacific to investigate the seismic characteristics of the earth's crust.

In a more prosaic field, efforts continued to establish mathematical principles that could be applied to exploration and sampling. Development of mathematical-statistical assessment, from borehole results, of the likely average grade of a South African gold mining property with approximate limits of error was reviewed.[10] Tests showed the practical utility of a modified lognormal model of the form log (inch-dwt. value +55) to the conditions found in these mines. A complementary report reviewed techniques for mine valuation by underground sampling.[11] Increased use of statistical techniques was indicated. An interesting device was the control chart used in detecting bias introduced by poor sampling or assay practice. Continuing its study of applying mathematical-statistical methods to mine sampling, the Bureau of Mines published results of investigations made to determine the reliability of these techniques.[12] The study involved four steps: (1) Determining the population moments for a given sample size, (2) determining total sampling moments for two or more stages of sampling, (3) using population-moment relations with sample size, and (4) establishing measures of reliability from a fitted continuous curve.

DEVELOPMENT

Developing a large-tonnage mine requires a high capital investment, making it imperative to bring the mine into production as soon as possible. The importance of development time coupled with ground conditions and increasing depth of the ore were major factors in

[5] Brock, B. B., A Philosophy of Mineral Exploration: Optima, vol. 10, No. 3, September 1960, pp. 143–158.

[6] Oceanography 1960 to 1970, 3-Ocean Resources: A Rept. by the Committee on Oceanography, Nat. Acad. Sci., Nat. Res. Council, 1961, 30 pp.

[7] Smith, D. Taylor, Prospecting the Underwater World: Min. Jour., pt. 1, v. 256, No. 6548, Feb. 17, 1961, pp. 182–185; pt. 2, v. 256, No. 6549, Feb. 24, 1961, pp. 208–210; pt. 3, v. 256, No. 6550, Mar. 3, 1961, pp. 239–243; pt. 4 v. 256, No. 6551, Mar. 10, 1961, p. 269.

[8] Undersea Technology, Why Mohole: V. 2, No. 3, May/June 1961, pp. 24–28.

[9] Saturday Review, Canada's Continent-Spanning Look Inside Earth: Feb. 4, 1961, pp. 35–40.

[10] Krige, D. G., Developments in the Valuation of Gold Mining Properties From Borehole Results: Trans. 7th Commonwealth Min. and Met. Cong., South Africa, v. 2, April–May 1961, pp. 536–561.

[11] Sichel, H. S., and R. St. J. Rowland, Recent Advances in Mine Sampling and Underground Valuation Practice in South African Gold Fields: Trans. 7th Commonwealth Min. and Met. Cong., South Africa, v. 2, April–May 1961, pp. 563–586.

[12] Becker, R. M., and Scott W. Hazen, Jr., Particle Statistics of Infinite Populations as Applied to Mine Sampling: BuMines Rept. of Inv. 5669, 1961, 79 pp.

promoting the efficient shaft-sinking methods used in South Africa. The methods developed were described at the Seventh Commonwealth Mining and Metallurgical Congress in South Africa, and might well be a preview of techniques to be adopted in other areas to mine the deeper ores.[13]

Some noteworthy developments were the use of large-diameter concrete-lined circular shafts, precementation through water-bearing strata, mechanical mucking, and the multideck sinking-stage design to accommodate mechanical equipment to allow concurrent sinking and lining. Introduction of the Blair stage hoist provided a means of solving the problem of increased weight of the multideck sinking stage.[14] The Blair hoist incorporates the principle of doubling down each rope of a double-fleeting wheel hoist, thus multiplying the ropes for suspending the load. An intermediate tensioning tower equalizes the tension in the compounded rope system. By these techniques and closely integrated cycling of the operations, sinking speeds in excess of 1,000 feet per month were achieved.

The success of bored shafts up to 90 inches in diameter in the Ambrosia Lake uranium district led to development of a 15-foot boring bit.[15]

DRILLING

Investigations by The International Nickel Company of Canada, Ltd., (Inco) guided its selection of equipment and drilling techniques used in more than 18.5 million feet of production drilling annually.[16] Most of the drilling was done with air-leg machines and 7/8-inch chisel-type tungsten carbide-insert integral steel, paralleling European rather than U.S. practice. A platform truck to serve five air-leg drills was designed and used in preference to early jumbos with boom mountings. Tests relating sharpening practice of the tungsten carbide insert to steel performance demonstrated that premature sharpening was a prime cause of low footage. Insert life increased 80 percent when inserts were sharpened only to the half-dull point; drilling speed decreased only 6 percent between the stages of relative dullness.

A new bit design for chisel-type tungsten carbide-tipped integral steel evolved from experiments at the University of Witwatersrand,[17] Johannesburg, Republic of South Africa. Called a saddleback tip, it was designed for more efficient transfer of energy to the rock. The new shape tends to focus the stress waves within the face of the cylin-

[13] Jamieson, D. M., M. P. Pearse, and E. R. A. Plumstead, The Evolution of Shaft Design and Sinking Technique in South Africa: Trans. 7th Commonwealth Min. and Met. Con., South Africa, v. 2, April–May 1961, pp. 589–625.
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[14] Waspe, L. A., The Blair Friction Hoist: Min. Mag., v. 95, No. 5, November 1956, pp. 265–271.
[15] Petroleum Week, Massive 15-Ft. Drill Bit Gets Trial Run: Jan. 20, 1961, pp. 33–34.
[16] Dewey, J. H., Underground Drilling at Inco: Min. Cong. J., v. 47, No. 1, January 1961, pp. 24–29.
[17] Engineering and Mining Journal, Concave Bit Increases Drilling Speed, Reduces Wear: v. 162, No. 5, May 1961, p. 108.

drical drill hole. The status of jet-piercing performance was outlined at the International Symposium on Mining Research at Rolla, Mo.[18] Efficiency of the operation depends on the "spallability" of the rock, for which a general relationship to rock characteristics has been established. Evolution of burner design has brought about improved performance and broadened the range of application. The ability of the jet piercer to bottom-chamber a hole provides control over location of the center of gravity of the charge, which can be used to advantage for some blasting conditions. Faced with a need to provide for removal of methane gas and additional escapement facilities, the Olga Coal Co. turned to the use of bored shafts about 11 years ago.[19] Since that time large-diameter shaft boring by the company has evolved through churn and Calyx drilling to rotary methods with oil-drilling-type bits. Seven shafts had been bored, three by churn drilling methods, two by the Calyx method, and two by rotary drilling. The first shaft, 30 inches in diameter and 630 feet deep, was drilled and cased in 10 months at a cost of $92.20 per foot. A 76-inch-diameter shaft was recently bored to a depth of 698 feet in 47 operating days at a cost of $104.50 per foot.

Variations from conventional vertical blasthole drilling in surface mines were applied successfully to some pit conditions. A new horizontal rotary air drill was used on overburden at the Power mine of Peabody Coal Co., Montrose, Mo.[20] The machine will drill 360 feet of 6¼-inch blasthole per hour in hard shale interlaced with pyrite. Angle drilling was used at the New Cornelia Branch open pit mine of Phelps Dodge Corp. at Ajo, Ariz., for the final slope line of holes. Use of angle holes resulted in less backbreak and better toe. Similar results were reported by the Sanford Hill mine of National Lead Co., at Tahawus, N.Y.

With the introduction of ladder drilling, Swedish practice appears to have made the full circle from mounted drills to air-leg drills and back to mounted air-leg drills.[21] An air-leg drill is mounted on a horizontal ladder supported by transverse bars. The pusher leg of the drill engages a rung on the ladder to advance and retract the machine. The method retains some of the advantages of air-leg and mounted drill operations.

Studies were continuing on various fundamental aspects of drilling to guide future developments. The Mining Research Establishment of the British National Coal Board completed a study of rotary drilling.[22] Abrasive bit wear remained the limiting feature determining final criterion of usefulness. Theory of the interactions between the drilling mechanism and rock face received further investigation.[23]

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[18] Coleman, J. J., and H. C. Rolseth, Technical Advances Expand Use of Jet-Piercing in Taconite Industry: Internat. Symposium on Min. Res., Univ. of Missouri Sch. of Mines and Met. and U.S. Dept. of Interior, BuMines, 1961, pp. 28–1, 28–41.

[19] Mauck, H. Eugene, and D. C. Ridenour, Developments in Large Borehole Drilling: Min. Cong. J., v. 47, No. 8, August 1961, pp. 77–80.

[20] Lewis, N. O., Horizontal Air Drilling: Min. Cong. J., v. 47, No. 7, July 1961, pp. 59–61.

[21] Mine and Quarry Engineering, Ladder Drilling: V. 27, No. 2, February 1961, pp. 82–84.

[22] Fish, B. G., The Basic Variables in Rotary Drilling: Mine and Quarry Eng., v. 27, No. 1, January 1961, pp. 29–34, v. 27, No. 2, February 1961, pp. 74–81.

[23] Fischer, H. C., The Computation and Measurement of Stress Pulses in Percussive Drilling: Paper presented at Internat. Symposium on Min. Res., Univ. of Missouri Sch. of Mines and Met. and U.S. Dept. of the Interior, BuMines, Rolla, Mo., February 1961, 14 pp.

Tandanand, Sathit, and Howard L. Hartman, Stress Distribution Beneath a Wedge-Shaped Drill Bit Loaded Statically: Paper presented at Internat. Symposium on Min. Res.,

The opportunity afforded by modern instrumentation techniques to measure energy transfer, wave mechanics, and fracture patterns has introduced a more quantitative appraisal of theoretical drilling actions.

FRAGMENTATION

While drilling and blasting continue as the primary means for fragmenting rock in mining, each year brings some advance toward mechanical methods to accomplish this purpose. Continuous-mining machines produced over 27 percent of the domestic bituminous coal mined underground. The Kentucky Oak Mining Co., Hazard, Ky., was using what was said to be the world's largest coal auger with a 7-foot cutting head.[24] The auger had produced coal at a rate of 25 tons per minute. A novel method of advancing a full-face mechanical boring machine was developed at the Suntrana mine, Healy, Alaska.[25] Called the Alkirk Cycle Miner, twin boring heads are advanced by pulling toward two pilots bored and anchored ahead of the face. Effective performance of the mechanical boring or fragmenting machines is still limited to the softer rock formations, but new designs and cutting actions are gradually expanding their use toward breaking harder formations. Bureau of Mines tests to cut bituminous and anthracite coal with a hydraulic jet were successful.[26] A pulsating hydrojet monitor operating at 1,000 to 10,000 (reported figure) atmospheres was described in a Soviet publication.[27] Photographs indicate that the monitor is electrically controlled and its operation programed.

Experimental models of other methods for mechanical fragmentation were being developed. A process called electrothermal forcing was developed by General Electric Co. in cooperation with the Montana School of Mines under a research grant from The Anaconda Company.[28] A high-frequency-current source (radiofrequency) forms a conducting path in the rock, allowing passage of a lower frequency current to heat and eventually break the rock. A similar development was reported in Soviet journals.[29] Electrohydraulic rock breaking also had been investigated in the United States and the U.S.S.R.[30] The method is based on an electric spark discharged under water (see Review of Mining Technology Chapter, v. I, Minerals Yearbook, 1958).

Univ. of Missouri Sch. of Mines and Met. and U.S. Dept. of the Interior, BuMines, Rolla, Mo., February 1961, 15 pp.

Hawkes, Ivor, and P. K. Chakravarty, Strain Wave Behavior in Percussive Drill Steels: Paper presented at Internat. Symposium on Min. Res., Univ. of Missouri Sch. of Mines and Met. and U.S. Dept. of the Interior, BuMines, Rolla, Mo., February 1961, 14 pp.

Fairhurst, C., Wave Mechanics of Percussive Drilling: Mine and Quarry Eng., v. 27, No. 3, March 1961, pp. 122–130; v. 27, No. 4, April 1961, pp. 169–178; v. 27, No. 7, July 1961, pp. 327–328.

[24] Mechanization, World's Largest Recovery Auger: Vol. 25, No. 5, May 1961, 55 pp.

[25] Engineering and Mining Journal, New Pilot-Pull Borer Draws Itself Into the Rock: Vol. 162, No. 11, 48 pp.

[26] Wallace, J. J., G. C. Price, and M. J. Ackerman, Hydraulic Coal Mining Research: Equipment and Preliminary Tests; BuMines Rept. of Inv. 5915, 1961, 25 pp.

[27] Sovietski Shaktner (Soviet Miner), The Power of Water: No. 12, December 1961, pp. 15–16.

[28] Wall Street Journal, GE Has Way To Break Rocks Using Radio Waves, Electricity, Sept. 13, 1961.

[29] Kravenko, V. S., A. P. Obrastsov, and V. V. Ustinov, Dustless Breaking of Rocks Electrically: Min. Cong. J., v. 47, No. 5, May 1961, pp. 53–55.

[30] Bergstrom, B. H., The Electrohydraulic Crusher: Eng. and Min. J., v. 163, No. 2 February 1961, pp. 134–140.

A review of the data on cratering by explosives presented established relationships between charge size, depth of burst, crater radii, and crater depth.[31] Crater tests to calculate bench and blast configuration were utilized in a Canadian open pit iron mine.[32] The controlled crater tests resulted in a more systematic blasting method, a 30-percent increase in broken-rock yield per foot of hole, and a 40-percent decrease in blasting cost.

Various methods termed "smooth blasting," "perimeter blast," and cushion blasting had been developed to minimize backbreak and provide a smoother blasted surface.[33] A technique of presplitting was added to accomplish this purpose.[34] Presplitting differs from the other methods in that a shear plane is broken in the solid rock prior to drilling and blasting within the proposed break line. It has been used to prepare surface rock excavations for engineered structures. The methods are relatively slow and expensive, but for specific conditions can result in ultimate economies in preparing an excavated site in rock.

The cost advantages demonstrated by using ammonium nitrate blasting agents for surface mining created a strong incentive to their introduction underground. Their use underground in salt and potash mines was described.[35] About 50 percent of production blasting in the Boliden mines in Sweden was being done with ammonium nitrate-fuel oil (AN-FO) blasting agents.[36] Tests indicated many of the important parameters for successful detonation of AN-FO mixtures in small-diameter holes underground.[37] Proper mix, drill density, moisture content, and adequate primer are essential. Failure occurred in holes less than 1¼ inches in diameter.

MATERIALS HANDLING: LOADING, TRANSPORTATION, HOISTING

Efforts continue toward automating materials-handling systems in mines. An automated chute loading system was installed at the "Sachtleben" AG in West Germany.[38] A system of electric eyes actuates the chute gate after a car is spotted. Sensing electrodes shut

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[31] Nordyke, Milo D., On Cratering, A Brief History, Analysis, and Theory of Cratering: UCRL–6578, Univ. of California Lawrence Radiation Lab., Aug. 22, 1961, 72 pp.

[32] Farnam, H. E., Jr., New Applications of Explosives: Skilling's Min. Rev., v. 50, No. 41, Oct. 14, 1961, pp. 4–5, 10.

[33] Jarman, Hugh G., Note on Perimeter Blasting: Min. Mag., v. 105, No. 2, August 1961, pp. 73–76.

[34] Paine, Rolf S., D. K. Holmes, and Harry E. Clark, Controlled Overbreak by Presplitting: Paper presented at Internat. Symposium on Min. Res., Univ. of Missouri Sch. of Mines and Met. and U.S. Dept. of the Interior, BuMines, Rolla, Mo., February 1961, pp. 13–1 to 13–9.

[35] Ryon, John L., Jr., Underground Use of Ammonium Nitrate-Fuel Oil Explosives: Min. Eng., v. 13, No. 4, April 1961, pp. 377–380.

Mitterer, Adolph V., and Ben T. Phillips, Jr., Underground Ammonium Nitrate Blasting: Min. Cong. J., v. 47, No. 4, April 1961, pp. 72–75.

[36] Henning, Ulf, Blasting With Ammonium Nitrate Fuel Oil Explosives Underground at Boliden: Paper presented at Internat. Symposium on Min. Res., Univ. of Missouri Sch. of Mines and U.S. Dept. of the Interior, BuMines, Rolla, Mo., February 1961.

[37] Maurer, William C., and John S. Rinehart, How To Detonate Ammonium Nitrate Underground in Small Drill Holes: Eng. and Min. J., v. 162, No. 11, November 1961, pp. 102–103, 108, 110.

Bullock, R. L., Lee Bilheimer, and J. J. Jancik, Research on the Underground Application of Ammonium Nitrate-Fuel Oil Mixtures in Small Diameter Holes: Paper presented at Internat. Symposium on Min. Res., Univ. of Missouri Sch. of Mines and U.S. Dept. of the Interior, BuMines, Rolla, Mo., February 1961.

[38] Engineering and Mining Journal, How "Sachtleben" AG Automated Underground Loading and Cut Costs: V. 162, No. 5, May 1961, pp. 98–99.

off the flow of ore when a car is filled. Interest in conveyor transport has developed partly because it is relatively automatic. Conversion from truck haulage to conveyor haulage at the United States Borax & Chemical Corp. and the Riverside Cement Co. mines in California is illustrative.[39] An idea of the large capacities of installed conveyor systems is given by a listing of 15 with terminal pulley centers at 4,000 feet and over, and 41 with drive motor power of 600 horsepower or over.[40]

The possibility of automating truck haulage was being investigated. On a test section of automatic highway at the General Motors Corp. proving grounds, cables buried in the middle of each lane were used to guide driverless vehicles. The possibility of installing an electronically controlled haul road in an iron mine was being explored.[41]

An automated haul road populated with 95-ton haulers (such as the one claimed by KW-Dart Truck Co. as the world's largest commercial truck) would provide a formidable transport system.

GROUND CONTROL

The foundation for solution of many ground-control problems in mining is the knowledge being developed through rock-mechanics studies. Notable advances were reported in measurement tools and in assessing the reliability of these tools.[42] Stress-relief techniques in which borehole gages are overdrilled to register the change in stress were providing valuable in situ measurements. A 10-year review of rock-mechanics research in South Africa indicated some of the practical results of the work.[43] Most studies and theoretical analysis had led to a concept of the fracture zone surrounding excavations and the stresses related thereto. These data, in turn, were related to control of rock burst and water inflow in the mines. In England studies had been conducted on the relation of rebound hardness tests to the compressive strength of rocks,[44] and the determination of rock behavior under pressure by the use of sonics at both audible and ultrasonic frequencies.[45] Practical devices to measure ground movement, one of the basic elements of rock mechanics, were developed by St. Joseph Lead Co.[46] Some of the practical interpretations of rock mechanics phenomena were explored.[47]

[39] Cooper, D. M., and P. B. Nallé, Economics of Truck vs. Belt Haulage: Min. Cong. J., v. 47, No. 7, July 1961, pp. 48–51.
Mining World, A Conveyor Takes Over at Boron: V. 23, No. 13, December 1961, pp. 23–25.

[40] Traxler, E. R., Conveyor Belt Horsepower and Operating Distances Continue To Increase: Eng. and Min. J., v. 162, No. 8, August 1961, pp. 86–87.

[41] Construction Methods, Methods Memo: V. 43, No. 10, October 1961, p. 218.

[42] Panek, Louis A., Measurement of Rock Pressure With a Hydraulic Cell: Min. Eng., v. 13, No. 3, March 1961, pp. 282–285.
Utter, Stephen, Stress Determinations Around an Underground Mine Opening. Paper presented at Internat. Symposium on Min. Res., Univ. of Missouri Sch. of Mines and U.S. Dept. of the Interior, BuMines, Rolla, Mo., February 1961, 9 pp.
Hast, Nils, The Measurement of Rock Pressures in Mines: Sveriges Geologiska Undersökning, Arshok 52, No. 3, Stockholm 1958, 183 pp.

[43] Hill, F. G., and H. G. Denkhaus, Rock Mechanics Research in South Africa, With Special Reference to Rockbursts and Strata Movement in Deep Level Gold Mines: Trans. 7th Commonwealth Min. and Met. Cong., South Africa, v. 2, April–May 1961, pp. 805–835.

[44] Greenland, Brian J., Rock Mechanics: Coll. Guard., v. 203, No. 5240, Sept. 21, 1961, pp. 346–348.

[45] Singh, B., The Behavior of Rocks Under Pressure: Coll. Guard., v. 201, No. 5201, Dec. 22, 1960, pp. 719–724; v. 201, No. 5202, Dec. 29, 1960, pp. 769–772.

[46] Reed, John J., and David C. Mann, St. Joseph Builds Practical Rock Mechanics Tools: Eng. and Min. J., v. 162, No. 3, March 1961, pp. 100–106.

[47] Woodruff, Seth D., Practical Use of Rock Mechanics: Min. Cong. J., v. 47, No. 7, July 1961, pp. 33–37, 55.

DRAINAGE AND WATER CONTROL

Water control in mines comprises three major phases, (1) control of inflow, (2) gathering and pumping inflow, and (3) disposal or use of outflow. An idea of the volume of water involved was given in a report on Transvaal and Orange Free State mines where 56 mines pumped 44,283 million gallons per year.[48] Removal and handling of contained grit and sludge and neutralizing a cleared water product for reuse constitute a major problem. Elaborate systems of settlers and clarifiers had been installed underground. At the Mufulira copper mine in Rhodesia, 60 percent of the mining department power requirements and 25 percent of the total mine power load were needed to pump 16 million gallons of water per day.[49] Plans were made to predrain mining blocks, desludge the mine water, and pump clear water and the sludge to the surface. Water from the mine supplied domestic and industrial water for the plant and townsites. Hydrologic studies of surface water and ground water started during exploration of the Grace Mine orebody at Morgantown, Pa., were used to guide dewatering efforts.[50] Seventeen 12¼-inch drill holes were equipped with submersible pumps to draw down the water level. The results of the pumping were observed through the exploratory diamond drill holes. Selected wells were later intercepted with a drift to obtain maximum water yield and eliminate the need for well pumps. The program materially helped shaft sinking through broken permeable ground and reduced the flow of water coming through the ore.

VENTILATION

The announced new ventilation project by Anaconda at the Steward mine, increasing circulation to 550,000 cubic feet of fresh air per minute, was indicative of interest in mine ventilation. A much needed text on the subject was added to mining literature.[51] Progress was reported in solving the problem of adequate dilution and removal of gas when using continuous miners.[52] The rapid advance and closure of the face by the continuous miner made conventional methods of ventilation inadequate. Exhaust and forcing methods with auxiliary fans and various methods of dust entrapment were tried, and although none of the methods was completely satisfactory, an exhaust system with wet-filtering of the dust gave the best results.

A review of ventilation practice in South Africa for mines lying below the "critical ventilation horizon," (90° F virgin rock temperature) indicated some of the problems introduced by high tempera-

[48] Dolan, John, Water Problems of the Transvaal and Orange Free State Mines: Trans. 7th Commonwealth Min. and Met. Cong., South Africa, v. 3, April–May 1961, pp. 1357–1388.

[49] Young, D., and P. B. Mattushek, Underground Drainage and Sludge Disposal at Mufulira: Trans. 7th Commonwealth Min. and Met. Cong., South Africa, April–May, 1961, 23 pp.

[50] Biemsderfer, G. K., and R. H. Leske, Ground Water Control at Grace Mine: Min. Cong. J., v. 47, No. 10, 1961, pp. 39–44.

[51] Hartman, Howard L., Mine Ventilation and Air Conditioning: Ronald Press Co., New York, N.Y., 399 pp.

[52] Patterson, C. H., Progress in Ventilating Continuous Mining Sections: Min. Cong. J., v. 47, No. 3, March 1961, pp. 29–32.

Robinson, R., Ventilation and Dust Extraction Systems: Coll. Guard., v. 202, No. 5228, June 29, 1961, pp. 761–765.

ture and humidity.[53] Although a definition of acceptable limits was not unanimously accepted, designed experiments demonstrated that above 87° F saturated, at a velocity of 100 fpm, work output drops rapidly. Air cooling was commonly resorted to, not primarily to make "hot" places "cool" but rather to make additional air available for reuse. The trend in recent years has been to place the cooling plants underground with the air-cooling coils as close as possible to the working faces.

HEALTH AND SAFETY

The use of water stemming was one of the subjects for discussion at the Directors of Safety in Mines Research Conference, held in Warsaw, Poland, during October. Used in the coal mines of Belgium, France, and England, the main advantage is reduced smoke and dust, although some improvement was reported in reducing the fumes from blasting. Plastic bags with self-sealing valves were generally used for water stemming in the European mines. The bags were generally filled with water at the working face. The method was tried without success in the South African gold mines.[54] The large amount of explosives and the small amount of stemming used in the gold mines compared to coal mines probably accounts for the poor results in the gold mines. The Bureau of Mines conducted tests on the relative effects of various stemming materials, including water, on reducing the incendivity of permissible explosives.[55]

An extraction plant to remove nitrous fumes and blasting dust and to allow multishift blasting was used in the South African mines.[56] The fumes were removed by passing return air down through a bed of vermiculite impreguated with a solution of potassium permanganate.

MINING PRACTICE AND PERFORMANCE

The use of computing an data-processing machines to approach the optima in mining conditions was a subject of much discussion.[57] The entire June issue of Mining World was devoted to the subject. The machine systems supply a powerful tool to digest and analyze bulk data; the major limitation is the amount and validity of data available for processing. A major side benefit may very well be to spur research, thus improving data collection and recording to provide reliable data

[53] Barcza, M., and J. de V. Lambrechts, Ventilation and Air Conditioning Practice in South African Gold Mines: Trans. 7th Commonwealth Min. and Met. Cong., South Africa, v. 2, April–May 1961, pp. 725–742.

[54] Kitto, P. H., Underground Dust Control and Research: Trans. 7th Commonwealth Min. and Met. Cong., South Africa, v. 2, April–May 1961, pp. 743–756.

[55] Van Dolah, R. W., N. E. Hanna, and R. L. Grant, Relative Efficacy of Stemming Materials in Reducing Incendivity of Permissible Explosives: BuMines Rept. of Inv. 5863, 1961. 8 pp.

[56] Robson, S. R., The Development of an Extraction Plant for the Elimination of Blasting Fumes: Trans. 7th Commonwealth Min. and Met. Cong., South Africa, v. 2, April–May, pp. 757–773.

[57] Hewlett, R. F., Calculating Ore Reserves Using a Digital Computer: Min. Eng., v. 13, No. 1, January 1961, pp. 37–42.

Hewlett, R. F., Mining and Computers: Min. Eng., v. 13, No. 2, February 1961, pp. 179–181.

Freeze, A. C., Use of Data Processing Machines for Calculating Ore Reserves at the Sullivan Mine: Min. Eng., v. 13, No. 4, April 1961, pp. 382–389.

Wilson, Robert L., Electronic Computations of Open Pit Tonnage and Ore Grade: Min. Eng., v. 13, No. 6, June 1961, pp. 587–591.

for machine processing. Experience with a punchcard data-processing system at the Roan Antelope copper mine in Rhodesia showed an apparent increase in measurable costs, compared with the manual system, but provided unmeasurable benefits difficult to evaluate in monetary terms.[58] An important result was to focus more attention on the need to coordinate methods and routines in the various departments of the company.

Mechanization has made selection of production equipment a major decision when a complete unit of underground coal mining equipment may cost a quarter million dollars. Comparative analysis of suitability, productivity, cost and integration with other phases of mining is essential. Some of the factors to be considered in the selection of new coal mining equipment were tabulated.[59] A related tabulation of large stripping equipment (12 cu. yd. and over) indicated relative performance.[60] If efficiency is measured on the rule-of-thumb basis of cubic yards of material handled per cubic yard of bucket or dipper capacity, the data show relatively constant efficiency for equipment in this size range.

A longwall mining system utilizing self-advancing hydraulic roof supports in conjunction with a coal planer had been applied successfully at the Keystone mine of Eastern Gas & Fuel Association, Keystone, W. Va.[61] Major benefits over the former system of room-and-pillar mining were better roof control, a 50-percent reduction in manpower, increased production, and minimum maintenance and supply costs. The coal seam averaged 52 inches high. The longwall face was 590 feet long. The system offers the possibility of full automation of a longwall face. At the Frood-Stobie mine of Inco, Sudbury, Ontario, Canada, a new method of undercut-and-fill stoping was replacing square-set stoping for mining pillars.[62] As each successive undercut slice was mined, laminated plank stringers were laid to support a timber mat, and sand filling was introduced. Specially designed blast rounds and fill methods were used.

An approach to open pit mine design was described.[63] The importance and interrelation of considerations such as margin of profit; life, depth, and size of ultimate pit; stripping ratio; pit slopes; and cutoff grades were examined. The importance of pit slope and related slope-stability determination was emphasized.

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[58] Hornibrook, J. T., and F. H. Thornton, Advantages Derived From the Application of the Punch-Card Data Processing System at Roan Antelope Copper Mines, Ltd.: Trans. 7th Commonwealth Min. and Met. Cong., South Africa, v. 2, April–May 1961, 14 pp.

[59] McCurdy, Wayne A., Selection of Production Equipment: Mechanization, v. 25, No. 6, June 1961, pp. 43–53.

[60] Geissel, R. L., R. A. Campbell, W. W. Dukes, and G. H. Utterback, Performance of Large Stripping Equipment: Min. Cong. J., v. 47, No. 3, March 1961, p. 79.

[61] Coal Age, Greater Efficiency, More TPM: V. 66, No. 12, December 1961, pp. 50–54.

[62] Mining World, Undercut-and-Fill Stoping Saves Money at International Nickel: V. 23, No. 10, pp. 28–30.

[63] Holt, W., Some Aspects of Open Pit Mining: Mine and Quarry Eng., v. 27, No. 9, September 1961, pp. 392–399.

Technologic Trends in the Mineral Industries

(Metals and Nonmetals except Fuels)

By Donald R. Irving [1]

MATERIAL handled at metal and nonmetal mines in the United States in 1961 was 2.7 billion tons, 3 percent less than the 2.8 billion tons (revised figure) reported in 1960. A larger percentage of the total was ore, 2.1 billion tons compared with 2.0 billion tons in 1960, as the quantity of waste removed at iron ore and uranium mines declined 80 million tons, and total ore and waste decreased 99 million tons.

Copper and iron ore producers reported three-fourths of the crude ore and waste handled at metals mines; sand and gravel and stone producers handled three-fourths of the nonmetals total. Almost half of the material was handled in seven States—Minnesota, Florida, Arizona, California, Utah, Michigan, and Texas. When the large-volume construction materials (sand and gravel and stone) were excluded from the totals, four States—Arizona, Minnesota, Florida, and Utah—supplied more than half the material handled.

For the first time, the relative values of surface and underground ores have been calculated; a breakdown shows the value attributable to principal and byproduct minerals. The value for surface ores including sand and gravel and stone averaged $1.80 a ton in 1961, and that for underground ores averaged $6.70 a ton. Corresponding values excluding sand and gravel and stone averaged $3.10 and $7.85 a ton, respectively.

Underground mining methods in 1961 were open stoping, 74 percent; caving, 25 percent; and other, 1 percent. Only 11 percent of the open stoping required artifical support. Virtually all the ore mined by surface methods was mechanically loaded; about half had been previously drilled and blasted.

In 1961, exploration and development totaled 29 million feet compared with slightly under 21 million feet in 1960. The increase was due almost entirely to a sharp rise in percussion drilling. Drilling provided 89 percent of the total exploration and development footage, as follows: Percussion drilling, 43 percent; rotary drilling, 22 percent; long-hole drilling, 12 percent; diamond drilling, 10 percent; and rotary drilling, 2 percent.

Four-fifths of the footage in 1961 was for metals, of which about 70 percent was for uranium, gold, and molybdenum. Clays and stone were 70 percent of the nonmetals footage.

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For the first time since 1935 data were collected by the Federal Bureau of Mines on froth flotation; these data enabled measurement of growth over a 25-year period. In that time, material treated rose from 26 to almost 200 million tons although the number of plants using flotation increased only from 184 to 202. The number of flotation reagents used in 1960 was triple the number used in 1935; the number of commodities treated increased fivefold; reagent consumption was ten times the 1935 figure. However, reagent consumption per ton of ore rose only from 3.282 to 4.297 pounds.

MINING

Material Handled.—Mineral producers in the United States handled 2.7 billion tons of ore and waste (excluding fuels), a 3-percent decrease from the 2.8 billion tons (revised figure) reported in 1960. The decline was attributed entirely to metal mining, for which the material-handled figure decreased from 938 million to 846 million tons. Material handled at iron-ore mines was 64 million tons less and at uranium mines declined 35 million tons.

Despite the decrease in total material handled, crude ore output of metals increased slightly. Gains reported for ores of beryllium, copper, ilmenite, manganese, mercury, molybdenum, rare-earths, tungsten, and uranium more than offset losses in output of bauxite, chromite, gold, lead, manganese, rutile, silver, and zinc ores. In 1961, copper and iron ore production was 70 percent of the crude ore and 78 percent of the total material handled, compared with 73 and 76 percent, respectively, in 1960.

Only about four-fifths as much waste was handled at nonmetals mines as in 1960, but crude-ore production increased 3 percent, and as a consequence total material handled was up slightly. However, the increase resulted mainly from sand and gravel and stone production.

Of the 2.7 billion tons of material handled in 1961, 1.9 billion tons (70 percent) was ore. Almost 17.5 million tons of the ore was net accruals to stockpiles; 12.9 million tons was net withdrawals from stockpiles; 6.6 million tons was material shipped from mine dumps and tailings.

Commodities for which major stockpile accruals were reported included crushed and broken stone (8.7 million tons), clays (2.0 million tons), copper (1.9 million tons), iron ore (1.5 million tons), and uranium (0.7 million tons). Stockpile accruals also were reported for beryllium, lode and placer gold, lead, manganese ore, manganiferous ore, mercury, and silver ores, and the following nonmetal ores: Aplite, barite, boron minerals, diatomite, feldspar, fluorspar, gypsum, scrap mica, olivine, perlite, phosphate rock, potassium salts, pumice, pyrites, salt, sodium carbonate (natural), dimension stone, and sulfur.

Commodities for which net stockpile withdrawals were reported included crushed and broken stone (7.0 million tons), iron ore (2.3 million tons), barite (0.8 million tons), clays (0.7 million tons), and salt (0.5 million tons). Lesser quantities were withdrawn from stockpiled metal ores of chromite, copper, manganiferous ore, mercury, silver, tungsten, uranium, and zinc; and from nonmetal ores, asbestos, boron minerals, diatomite, fluorspar, gypsum, magnesite, scrap mica,

phosphate rock, pumice, sodium carbonate (natural), dimension stone, sulfur, and talc.

Most of the dump and tailing material shipped was stone (2.3 million tons), copper (2.1 million tons), and iron ore (1.6 million tons). Small quantities of metal dump and tailing materials were handled for lode and placer gold, lead, manganese ore, silver, uranium, and zinc; and of nonmetal materials for clays, garnet, salt, and talc.

Material handled at nonmetal mines, excluding sand and gravel and stone, declined 6 percent; output of crude ore increased slightly.

Six commodities—copper, placer gold, ilmenite, iron ore, molybdenum, and uranium—supplied 92 percent of the crude ore and 95 percent of the ore and waste handled at metal mines, compared with 93 percent and 96 percent, respectively, in 1960. In both years, about 80 percent of the crude ore and more than 90 percent of the total material handled at metal mines came from surface operation. Of the total material handled, 45 percent was crude ore.

Clays, phosphate rock, salt, sand and gravel, and stone furnished 93 percent of the crude ore and 93 percent of the total material handled at nonmetal mines in both 1960 and 1961. Sand and gravel and stone supplied 83 percent of the nonmetal crude ore and 77 percent of the total material handled, compared with 82 and 76 percent, respectively, in 1960. Of the total nonmetal material handled, 90 percent was crude ore, compared with 87 percent in 1960.

In 1960, seven States—Minnesota, Florida, Arizona, California, Utah, Michigan, and Texas—reported handling more than 100 million tons of ore and waste, and together they handled 46 percent of the U.S. total. The same seven States also reported more than 100 million tons each in 1961 and supplied 48 percent of the total material handled in the United States. Minnesota, which led in 1960, declined to third place in 1961 because tonnage handled at iron mines decreased. California led in 1961; Arizona ranked second. When the two large-volume construction materials, sand and gravel and stone, were deducted from the 1961 totals, material handled exceeded 100 million tons in only four States. Arizona reported 201 million tons; Minnesota, 171 million; Florida, 153 million; and Utah, 140 million. These four States furnished 54 percent of the total material handled. The leading States in tonnage of crude ore mined were Minnesota, 141 million tons; Florida, 82 million; Arizona, 76 million; and California, 66 million.

Surface Versus Underground Mining.—An important analysis available for the first time in this chapter is that of the relative value of surface and underground ores, a breakdown shows value attributable to the principal mineral products and byproducts. The stage of measurement of value used in table 6 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.

TABLE 1.—Material handled at surface and underground mines, by commodities in 1960 [1]

(Thousand short tons)

Commodity	Surface			Underground			All mines		
	Crude ore	Waste	Total	Crude ore	Waste	Total	Crude ore	Waste	Total
Metals:									
Bauxite	2,494	3,808	6,302	208	----	208	2,702	3,808	6,510
Beryllium	44	20	64	6	7	13	50	27	77
Chromite	----	----	----	214	12	226	214	12	226
Copper	111,395	236,353	347,748	24,756	1,035	25,791	136,151	237,388	373,539
Gold:									
Lode	328	77	405	2,000	1,150	3,150	2,328	1,227	3,555
Placer	53,857	4,259	58,116	4	4	8	53,861	4,263	58,124
Iron ore	147,503	164,616	312,119	24,812	2,085	26,897	172,315	166,701	339,016
Lead	26	40	66	6,800	631	7,431	6,826	671	7,497
Manganese ore	368	436	804	55	28	83	423	464	887
Manganiferous ore	1,231	74	1,305	203	----	203	1,434	74	1,508
Mercury	105	239	344	160	32	192	265	271	536
Molybdenum	----	----	----	11,684	57	11,741	11,684	57	11,741
Nickel	1,103	323	1,426	----	----	----	1,103	323	1,426
Rare-earth metals and thorium	20	8	28	----	----	----	20	8	28
Silver	92	4	96	406	155	561	498	159	657
Titanium:									
Ilmenite	8,887	13,181	22,068	----	----	----	8,887	13,181	22,068
Rutile	1,046	1,130	2,176	----	----	----	1,046	1,130	2,176
Tungsten	61	1	62	449	25	474	510	26	536
Uranium	2,967	81,114	84,081	5,628	2,059	7,687	8,595	83,173	91,768
Zinc	476	1,561	2,037	8,246	920	9,166	8,722	2,481	11,203
Other [2]	3,493	985	4,478	----	----	----	3,493	985	4,478
Total metals	335,496	508,229	843,725	85,631	8,200	93,831	421,127	516,429	937,556
Nonmetals:									
Abrasives [3]	129	62	191	34	----	34	163	62	225
Asbestos	853	1,155	2,008	79	4	83	932	1,159	2,091
Barite	1,769	2,986	4,755	196	1	197	1,965	2,987	4,952
Boron minerals	2,126	----	2,126	11	----	11	2,137	----	2,137
Clays	46,627	35,984	82,611	1,896	22	1,918	48,523	36,006	84,529
Feldspar	1,386	100	1,486	24	----	24	1,410	100	1,510
Fluorspar	60	44	104	446	13	459	506	57	563
Gypsum	7,546	7,440	14,986	2,496	34	2,530	10,042	7,474	17,516
Magnesite	555	1,226	1,781	----	----	----	555	1,226	1,781
Magnesium compounds	42,700	----	42,700	----	----	----	42,700	----	42,700
Mica:									
Scrap	1,273	381	1,654	8	1	9	1,281	382	1,663
Sheet	78	----	78	182	1	183	260	1	261
Perlite	384	2	386	3	----	3	387	2	389

Phosphate rock	59,939	108,746	168,685	1,039	----	1,039	60,978	108,746	169,724
Potassium salts	15,210	----	15,210	14,442	50	14,492	29,652	50	29,702
Pumice	2,249	161	2,410	----	----	----	2,249	161	2,410
Pyrites	93	1,027	1,120	177	----	177	270	1,027	1,297
Salt	45,331	2	45,333	6,902	----	6,902	52,233	2	52,235
Sand and gravel	707,254	----	707,254	----	----	----	707,254	----	707,254
Sodium carbonate (natural)	2,568	----	2,568	931	----	931	3,499	----	3,499
Sodium sulfate (natural)	3,545	----	3,545	----	----	----	3,545	----	3,545
Stone:									
Crushed and broken	592,308	68,761	661,069	27,628	365	27,993	619,936	69,126	689,062
Dimension	6,348	637	6,985	286	----	286	6,634	637	7,271
Sulfur:									
Frasch-process mines	5,581	----	5,581	----	----	----	5,581	----	5,581
Other mines	424	313	737	----	----	----	424	313	737
Talc, soapstone, and pyrophyllite	341	117	458	484	48	532	825	165	990
Vermiculite	1,017	1,817	2,834	----	----	----	1,017	1,817	2,834
Other [4]	3,829	4,740	8,569	50	6	56	3,879	4,746	8,625
Total nonmetals	1,551,523	235,701	1,787,224	57,314	545	57,859	1,608,837	236,246	1,845,083
Grand total	1,887,019	743,930	2,630,949	142,945	8,745	151,690	2,029,964	752,675	2,782,639

[1] This table incorporates a number of revisions.
[2] Magnesium chloride for metal, platinum-group metals, and zircon.
[3] Emery, garnet, tripoli, grinding pebbles; millstones, grindstones, oilstones and other sharpening stones; and tubemill liners.
[4] Aplite, calcium magnesium chloride, diatomite, graphite, greensand marl, kyanite, lithium, olivine, staurolite, and wollastonite.

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TABLE 2.—Material handled at surface and underground mines, by commodities in 1961

(Thousand short tons)

Commodity	Surface			Underground			All mines		
	Crude ore	Waste	Total	Crude ore	Waste	Total	Crude ore	Waste	Total
Metals:									
Bauxite	1,408	1,309	2,717	240		240	1,648	1,309	2,957
Beryllium	45	26	71	11	26	37	56	52	108
Chromite				159		159	159		159
Copper	119,017	235,214	354,231	26,258	684	26,942	145,275	235,898	381,173
Gold:									
Lode	82	828	910	1,996	1,169	3,165	2,078	1,997	4,075
Placer	48,537	3,300	51,837	11	5	16	48,548	3,305	51,853
Iron ore	132,163	119,537	251,700	20,697	2,336	23,033	152,860	121,873	274,733
Lead	48	154	202	6,363	648	7,011	6,411	802	7,213
Mercury	123	231	354	149	33	182	272	264	536
Molybdenum				12,274	18	12,292	12,274	18	12,292
Nickel	1,078	360	1,438				1,078	360	1,438
Rare-earth metals and thorium	21	28	49		2	2	21	30	51
Silver	81	48	129	406	326	732	487	374	861
Titanium:									
Ilmenite	20,316	6,089	26,405				20,316	6,089	26,405
Rutile	343	375	718				343	375	718
Tungsten	66	343	409	542	26	568	608	369	977
Uranium	3,364	46,858	50,222	5,532	1,232	6,764	8,896	48,090	56,986
Zinc	242	46	288	8,307	960	9,267	8,549	1,006	9,555
Other [1]	13,163	229	13,392	110	6	116	13,273	235	13,508
Total	340,097	414,975	755,072	83,055	7,471	90,526	423,152	422,446	845,598
Nonmetals:									
Abrasives [2]	126	105	231	33		33	159	105	264
Asbestos	839	912	1,751	45		45	884	912	1,796
Barite	5,566	3,335	8,901	192	4	196	5,758	3,339	9,097
Boron minerals	8,148	12	8,160	18		18	8,166	12	8,178
Clays	51,148	37,832	88,980	7,977	33	8,010	59,125	37,865	96,990
Feldspar	1,190	55	1,245	20	11	31	1,210	66	1,276
Fluorspar	120	28	148	500	2	502	620	30	650
Gypsum	7,121	4,242	11,363	2,545	59	2,604	9,666	4,301	13,967
Magnesite	604	819	1,423				604	819	1,423
Mica:									
Scrap	566	291	857	2	9	11	568	300	868
Sheet	26	7	33	171	17	188	197	24	221
Perlite	414	9	423				414	9	423
Phosphate rock	69,156	78,123	147,279	956	61	1,017	70,112	78,184	148,296
Potassium salts	19,715		19,715	15,654	144	15,798	35,369	144	35,513
Pumice	2,465	89	2,554				2,465	89	2,554

Pyrites	107	1,160	1,267	169	----	169	276	1,160	1,436
Salt	59,696	56	59,752	6,824	266	7,090	66,520	322	66,842
Sand and gravel	751,573	----	751,573	----	----	----	751,573	----	751,573
Sodium carbonate (natural)	6,421	----	6,421	882	15	897	7,303	15	7,318
Stone:									
Crushed and broken	591,870	54,570	646,440	27,954	504	28,458	619,824	55,074	674,898
Dimension	5,323	1,196	6,519	149	----	149	5,472	1,196	6,668
Sulfur:									
Frasch-process mines	6,260	----	6,260	----	----	----	6,260	----	6,260
Other mines	502	43	545	----	----	----	502	43	545
Talc, soapstone, and pyrophyllite	332	125	457	462	17	479	794	142	936
Vermiculite	1,185	1,398	2,583	----	----	----	1,185	1,398	2,583
Other [3]	1,710	3,961	5,671	61	3	64	1,771	3,964	5,735
Total	1,592,183	188,368	1,780,551	64,614	1,145	65,759	1,656,797	189,513	1,846,310
Grand total	1,932,280	603,343	2,535,623	147,669	8,616	156,285	2,079,949	611,959	2,691,908

[1] Cobalt, magnesium chloride for metal, manganese ore, manganiferous ore, and platinum-group metals.
[2] Emery, garnet, grinding pebbles, and tripoli.
[3] Aplite, calcium magnesium chloride, diatomite, greensand marl, kyanite, lithium minerals, magnesium compounds, olivine, sodium sulfate (natural), and wollastonite.

TABLE 3.—Material handled at surface and underground mines, by States in 1960

(Thousand short tons)

State	Surface			Underground			All mines		
	Crude ore	Waste	Total	Crude ore	Waste	Total	Crude ore	Waste	Total
Alabama	29,795	4,713	34,508	3,738	----------	3,738	33,533	4,713	38,246
Alaska	29,304	3,857	33,161	11	4	15	29,315	3,861	33,176
Arizona	73,265	117,621	190,886	14,067	888	14,955	87,332	118,509	205,841
Arkansas	22,553	5,101	27,654	830	----------	830	23,383	5,101	28,484
California	169,420	30,394	199,814	1,629	86	1,715	171,049	30,480	201,529
Colorado	22,529	13,558	36,087	13,720	1,153	14,873	36,249	14,711	50,960
Connecticut	11,945	43	11,988	13	----------	13	11,958	43	12,001
Florida	108,282	111,413	219,695	----------	----------	----------	108,282	111,413	219,695
Georgia	22,973	11,407	34,380	928	----------	928	23,901	11,407	35,308
Idaho	11,313	8,913	20,226	1,091	383	1,474	12,404	9,296	21,700
Illinois	74,717	4,189	78,906	3,343	3	3,346	78,060	4,192	82,252
Indiana	41,082	2,819	43,901	887	----------	887	41,969	2,819	44,788
Iowa	39,187	10,258	49,445	914	----------	914	40,101	10,258	50,359
Kansas	24,099	2,248	26,347	2,088	341	2,429	26,187	2,589	28,776
Kentucky	17,960	1,134	19,094	3,908	1	3,909	21,868	1,135	23,003
Louisiana	34,627	59	34,686	2,007	----------	2,007	36,634	59	36,693
Maine	11,037	19	11,056	26	----------	26	11,063	19	11,082
Maryland	18,702	440	19,142	6	----------	6	18,708	440	19,148
Massachusetts	21,201	167	21,368	----------	----------	----------	21,201	167	21,368
Michigan	90,648	9,347	99,995	18,862	1,053	19,915	109,510	10,400	119,910
Minnesota	156,780	125,732	282,512	2,475	167	2,642	159,255	125,899	285,154
Mississippi	20,609	2,272	22,881	----------	----------	----------	20,609	2,272	22,881
Missouri	32,006	4,521	36,527	14,677	376	15,053	46,683	4,897	51,580
Montana	24,007	24,707	48,714	4,873	426	5,299	28,880	25,133	54,013
Nebraska	14,320	4,260	18,580	----------	----------	----------	14,320	4,260	18,580
Nevada	19,782	26,323	46,105	222	43	265	20,004	26,366	46,370
New Hampshire	6,801	----------	6,801	53	----------	53	6,854	----------	6,854
New Jersey	44,853	86	44,939	1,059	----------	1,059	45,912	86	45,998
New Mexico	17,695	28,006	45,701	17,870	717	18,587	35,565	28,723	64,288
New York	72,224	7,858	80,082	5,188	83	5,271	77,412	7,941	85,353
North Carolina	27,598	207	27,805	607	19	626	28,205	226	28,431
North Dakota	8,818	----------	8,818	----------	----------	----------	8,818	----------	8,818
Ohio	76,922	10,614	87,536	3,378	----------	3,378	80,300	10,614	90,914
Oklahoma	21,625	83	21,708	491	----------	491	22,116	83	22,199
Oregon	36,448	477	36,925	5	----------	5	36,453	477	36,930
Pennsylvania	57,964	14,732	72,696	5,010	659	5,669	62,974	15,391	78,365
Rhode Island	3,390	8	3,398	----------	----------	----------	3,390	8	3,398
South Carolina	12,119	1,762	13,881	----------	----------	----------	12,119	1,762	13,881
South Dakota	17,174	1,037	18,211	1,806	1,076	2,882	18,980	2,113	21,093
Tennessee	28,956	3,383	32,339	5,217	161	5,378	34,173	3,544	37,717
Texas	93,487	3,514	97,001	5,853	----------	5,853	99,340	3,514	102,854

Utah	57,374	72,205	129,579	1,982	522	2,504	59,356	72,727	132,083
Vermont	5,487	1,140	6,627	232	1	233	5,719	1,141	6,860
Virginia	28,531	4,509	33,040	2,617	33	2,650	31,148	4,542	35,690
Washington	39,931	1,431	41,362	1,070	188	1,258	41,001	1,619	42,620
West Virginia	12,828	892	13,720	1,457	----------	1,457	14,285	892	15,177
Wisconsin	52,445	253	52,698	2,361	138	2,499	54,806	391	55,197
Wyoming	10,048	66,213	76,261	1,955	224	2,179	12,003	66,437	78,440
Other [1]	6,577	5	6,582	----------	----------	----------	6,577	5	6,582
Total	1,881,438	743,930	2,625,368	148,526	8,745	157,271	2,029,964	752,675	2,782,639

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

TABLE 4.—Material handled at surface and underground mines (including sand and gravel and stone), by States in 1961

(Thousand short tons)

State	Surface			Underground			All mines		
	Crude ore	Waste	Total	Crude ore	Waste	Total	Crude ore	Waste	Total
Alabama	41,409	21,718	63,127	3,388	121	3,509	44,797	21,839	66,636
Alaska	20,975	3,253	24,228	11	18	29	20,986	3,271	24,257
Arizona	86,937	125,007	211,944	14,364	701	15,065	101,301	125,708	227,009
Arkansas	24,226	2,751	26,977	779	1	780	25,005	2,752	27,757
California	209,604	29,674	239,278	1,425	108	1,533	211,029	29,782	240,811
Colorado	21,938	6,580	28,518	14,431	761	15,192	36,369	7,341	43,710
Connecticut	13,087	70	13,157	13		13	13,100	70	13,170
Florida	119,590	71,435	191,025				119,590	71,435	191,025
Georgia	25,169	19,239	44,408	934	3	937	26,103	19,242	45,345
Idaho	11,683	8,317	20,000	1,469	368	1,837	13,152	8,685	21,837
Illinois	67,745	4,275	72,020	3,301	5	3,306	71,046	4,280	75,326
Indiana	39,181	2,132	41,313	924		924	40,105	2,132	42,237
Iowa	36,732	7,239	43,971	1,053	10	1,063	37,785	7,249	45,034
Kansas	26,290	1,298	27,588	2,068	335	2,403	28,358	1,633	29,991
Kentucky	17,901	1,077	18,978	5,715		5,715	23,616	1,077	24,693
Louisiana	32,168	123	32,291	1,874	3	1,877	34,042	126	34,168
Maine	10,102	4	10,106	11		11	10,113	4	10,117
Maryland	23,808	466	24,274	61		61	23,869	466	24,335
Massachusetts	23,736	129	23,865				23,736	129	23,865
Michigan	97,486	7,381	104,867	17,461	1,455	18,916	114,947	8,836	123,783
Minnesota	137,546	65,875	203,421	1,919	168	2,087	139,465	66,043	205,508
Mississippi	8,012	864	8,876				8,012	864	8,876
Missouri	35,308	4,368	39,676	12,763	430	13,193	48,071	4,798	52,869
Montana	26,829	2,434	29,263	4,313	241	4,554	31,142	2,675	33,817
Nebraska	13,896	630	14,526	7		7	13,903	630	14,533
Nevada	23,068	29,174	52,242	198	54	252	23,266	29,228	52,494
New Hampshire	7,881		7,881	39	1	40	7,920	1	7,921
New Jersey	24,153	34	24,187	943		943	25,096	34	25,130
New Mexico	23,506	22,948	46,454	18,974	571	19,545	42,480	23,519	65,999
New York	63,443	5,756	69,199	4,350	38	4,388	67,793	5,794	73,587
North Carolina	29,702	475	30,177	774	38	812	30,476	513	30,989
North Dakota	9,735		9,735				9,735		9,735
Ohio	73,498	5,904	79,402	9,781	17	9,798	83,279	5,921	89,200
Oklahoma	21,182		21,182	614		614	21,796		21,796
Oregon	31,849	520	32,369	3	9	12	31,852	529	32,381
Pennsylvania	56,526	12,087	68,613	5,435	711	6,146	61,961	12,798	74,759
Rhode Island	2,383	38	2,421				2,383	38	2,421
South Carolina	11,652	2,333	13,985				11,652	2,333	13,985
South Dakota	14,589	493	15,082	1,828	1,026	2,854	16,417	1,519	17,936
Tennessee	33,593	3,366	36,959	4,348	164	4,512	37,941	3,530	41,471
Texas	107,596	3,212	110,808	266		266	107,862	3,212	111,074
Utah	69,620	84,870	154,490	1,953	400	2,353	71,573	85,270	156,843

Vermont	6,238	1,053	7,291	163	4	167	6,401	1,057	7,458
Virginia	34,372	2,778	37,150	2,689	106	2,795	37,061	2,884	39,945
Washington	31,277	783	32,060	1,120	262	1,382	32,397	1,045	33,442
West Virginia	12,385	944	13,329	2,070	2	2,072	14,455	946	15,401
Wisconsin	53,692	157	53,849	1,755	156	1,911	55,447	313	55,760
Wyoming	12,608	39,950	52,558	2,077	310	2,387	14,685	40,260	54,945
Other [1]	6,372	131	6,503				6,372	131	6,503
Total [2]	1,932,280	603,343	2,535,623	147,669	8,616	156,285	2,079,949	611,959	2,691,908

[1] Delaware, District of Columbia, and Hawaii.
[2] Detail may not add to total owing to rounding.

TABLE 5.—Material handled at surface and underground mines (excluding sand and gravel and stone), by States in 1961

(Thousand short tons)

State	Surface			Underground			All mines		
	Crude ore	Waste	Total	Crude ore	Waste	Total	Crude ore	Waste	Total
Alabama	20,323	21,512	41,835	3,363	121	3,484	23,686	21,633	45,319
Alaska	15,455	3,253	18,708	11	18	29	15,466	3,271	18,737
Arizona	61,452	124,857	186,309	14,364	701	15,065	75,816	125,558	201,374
Arkansas	3,160	2,217	5,377	427	1	428	3,587	2,218	5,805
California	65,125	19,667	84,792	502	84	586	65,627	19,751	85,378
Colorado	1,152	3,390	4,542	14,391	759	15,150	15,543	4,149	19,692
Connecticut	276	41	317	13	----------	13	289	41	330
Florida	81,991	71,027	153,018	----------	----------	----------	81,991	71,027	153,018
Georgia	6,902	19,043	25,945	43	1	44	6,945	19,044	25,989
Idaho	2,477	8,297	10,774	1,469	386	1,855	3,946	8,683	12,629
Illinois	2,032	67	2,099	1,097	5	1,102	3,129	72	3,201
Indiana	1,355	473	1,828	672	----------	672	2,027	473	2,500
Iowa	2,152	508	2,660	135	----------	135	2,287	508	2,795
Kansas	3,481	143	3,624	922	49	971	4,403	192	4,595
Kentucky	962	315	1,277	141	----------	141	1,103	315	1,418
Louisiana	15,337	45	15,382	1,874	3	1,877	17,211	48	17,259
Maine	64	4	68	4	----------	4	68	4	72
Maryland	597	22	619	5	----------	5	602	22	624
Massachusetts	104	----------	104	----------	----------	----------	104	----------	104
Michigan	13,427	3,562	16,989	17,458	1,455	18,913	30,885	5,017	35,902
Minnesota	102,875	65,874	168,749	1,919	168	2,087	104,794	66,042	170,836
Mississippi	1,181	675	1,856	----------	----------	----------	1,181	675	1,856
Missouri	7,226	2,556	9,782	5,914	427	6,341	13,140	2,983	16,123
Montana	10,615	2,378	12,993	4,313	241	4,554	14,928	2,619	17,547
Nebraska	147	----------	147	----------	----------	----------	147	----------	147
Nevada	15,296	29,174	44,470	198	54	252	15,494	29,228	44,722
New Hampshire	59	----------	59	39	1	40	98	1	99
New Jersey	686	14	700	943	----------	943	1,629	14	1,643
New Mexico	9,129	22,917	32,046	18,974	571	19,545	28,103	23,488	51,591
New York	10,097	5,399	15,496	4,268	38	4,306	14,365	5,437	19,802
North Carolina	4,014	442	4,456	774	38	812	4,788	480	5,268
North Dakota	336	----------	336	----------	----------	----------	336	----------	336
Ohio	7,316	1,068	8,384	7,779	17	7,796	15,095	1,085	16,180
Oklahoma	1,367	----------	1,367	80	----------	80	1,447	----------	1,447
Oregon	1,803	491	2,294	3	9	12	1,806	500	2,306
Pennsylvania	2,620	4,669	7,289	3,478	692	4,170	6,098	5,361	11,459
South Carolina	1,742	1,954	3,696	----------	----------	----------	1,742	1,954	3,696
South Dakota	415	404	819	1,828	1,026	2,854	2,243	1,430	3,673
Tennessee	4,739	2,577	7,316	3,664	164	3,828	8,403	2,741	11,144
Texas	40,566	2,653	43,219	266	----------	266	40,832	2,653	43,485
Utah	53,749	84,074	137,823	1,953	400	2,353	55,702	84,474	140,176
Vermont	850	1,035	1,885	94	4	98	944	1,039	1,983

Virginia	2,750	76	2,826	1,227	99	1,326	3,977	175	4,152
Washington	825	765	1,590	1,120	262	1,382	1,945	1,027	2,972
West Virginia	1,134	----------	1,134	253	2	255	1,387	2	1,389
Wisconsin	126	2	128	1,755	156	1,911	1,881	158	2,039
Wyoming	3,610	39,918	43,528	1,829	160	1,989	5,439	40,078	45,517
Other [1]	419	23	442	----------	----------	----------	419	23	442
Total [2]	583,517	547,577	1,131,094	119,564	8,112	127,676	703,081	555,689	1,258,770

[1] Delaware, District of Columbia, and Hawaii.
[2] Detail may not add to total owing to rounding.

TABLE 6.—Value of principal mineral products and byproducts of surface and underground ores mined in the United States in 1961

(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	$8.45		$8.45	$8.35		$8.35	$8.40		$8.40
Beryllium	2.80	$0.45	3.25	7.35		7.35	3.60	$0.35	3.95
Chromite				18.70		18.70	18.70		18.70
Copper	4.10	.20	4.30	6.55	$0.75	7.30	4.55	.30	4.85
Gold:									
Lode	8.85	.95	9.80	12.60	.45	13.05	12.50	.45	12.95
Placer	.15		.15	3.10		3.10	.15		.15
Iron ore	3.65		3.65	6.90	.10	7.00	4.10		4.10
Lead	6.10	7.00	13.10	5.95	3.15	9.10	5.95	3.15	9.10
Mercury	15.60		15.60	32.90		32.90	26.40		26.40
Molybdenum				5.20	.15	5.35	5.20	.15	5.35
Nickel	4.80		4.80				4.80		4.80
Rare-earth metals and thorium	19.00		19.00				19.00		19.00
Silver	2.50	1.30	3.80	29.10	7.40	36.50	24.60	6.40	31.00
Titanium:									
Ilmenite	.65	.25	.90				.65	.25	.90
Rutile	1.95	.10	2.05				1.95	.10	2.05
Tungsten	19.60		19.60	17.35	2.20	19.55	17.60	1.95	19.55
Uranium	16.35	2.40	18.75	18.90	2.30	21.20	18.00	2.35	20.35
Zinc	15.00	3.40	18.40	10.40	3.00	13.40	10.50	3.00	13.50
Other	1.20	.05	1.25	20.35	.35	20.70	1.25	.05	1.30
Total	3.20	.10	3.30	8.10	.90	9.00	4.15	.25	4.40
Nonmetals:									
Abrasives	11.15	.25	11.40	4.00		4.00	9.65	.20	9.85
Asbestos	4.50	.05	4.55	13.05		13.05	4.90	.05	4.95
Barite	1.65		1.65	2.90		2.90	1.70		1.70
Boron	5.45	1.75	7.20	43.70		43.70	5.50	1.75	7.25
Clays	3.00		3.00	1.55		1.55	2.80		2.80
Feldspar	4.20	.30	4.50	4.15		4.15	4.20	.30	4.50
Fluorspar	14.90	1.20	16.10	17.25	5.25	22.50	16.70	4.30	21.00
Gypsum	3.50		3.50	4.20		4.20	3.70		3.70
Magnesite	5.20		5.20				5.20		5.20
Mica:									
Scrap	3.60	.05	3.65	10.50		10.50	3.60	.05	3.65
Sheet	13.90	.10	14.00	17.05	.20	17.25	16.65	.15	16.80
Perlite	7.30		7.30				7.30		7.30
Phosphate rock	1.80		1.80	5.35		5.35	1.85		1.85

Potassium salts	.10		.10	5.45	·05	5.50	2.65		2.65
Pumice	2.75		2.75				2.75		2.75
Pyrites	6.40	.70	7.10	4.25		4.25	5.00	.25	5.25
Salt	1.90		1.90	6.85		6.85	2.40		2.40
Sand and gravel	1.00		1.00				1.00		1.00
Sodium carbonate (natural)	.85	.75	1.60	13.30		13.30	2.35	.65	3.00
Stone:									
Crushed and broken	1.35		1.35	1.85		1.85	1.40		1.40
Dimension	16.75	.30	17.05	39.75	1.25	41.00	17.45	.30	17.75
Sulfur:									
Frasch-process mines	20.70		20.70				20.70		20.70
Other mines	2.80		2.80				2.80		2.80
Talc, soapstone, and pyrophyllite	5.95		5.95	7.10		7.10	6.60		6.60
Vermiculite	2.20		2.20				2.20		2.20
Other	24.95	.20	25.15	19.80		19.80	24.70	.15	24.85
Total	1.45		1.45	3.85	.05	3.90	1.55		1.55
Grand total	1.75	.05	1.80	6.20	.50	6.70	2.10	.05	2.15
Total nonmetals (excluding stone and sand and gravel)	2.70	.10	2.80	5.20	.05	5.25	3.05	.10	3.15
Total metals and nonmetals (excluding stone and sand and gravel)	3.00	.10	3.10	7.20	.65	7.85	3.70	.20	3.90

Byproducts contribute to the value of salable mineral products for about half of the mineral commodities. The value of byproducts is a significant part of the value, however, only for the metal ores of lead, silver, tungsten, and zinc, and for the nonmetals, boron, fluorspar, and natural sodium carbonate minerals.

In almost all instances, the unit value of underground ores is greater than that of surface ores, and when the low-value construction materials (sand and gravel and stone) were excluded from the totals, underground ores averaged $7.85 a ton, compared with $3.10 a ton for surface ores. Value of metal ores mined by surface methods ranged from $0.15 a ton for placer gold to $19.60 a ton for tungsten; value of metal ores mined underground ranged from $3.10 for placer gold to $36.50 for silver. Value of surface-mined nonmetals ranged from $0.10 a ton for potassium salts (brine) to $20.70 a ton for Frasch-process sulfur; value of nonmetal ores mined underground ranged from $1.55 a ton for clays to $43.70 a ton for boron minerals.

In 1961, 93 percent of the total crude ore mined (80 percent of the metals, and 96 percent of the nonmetals) came from surface operations. Only three commodities, chromite, cobalt, and molybdenum, were mined entirely underground. Other metal commodities mined substantially from underground sources included lode gold (97 percent), lead (99 percent), silver (99 percent), tungsten (89 percent), and zinc (99 percent). Among nonmetals only fluorspar (91 percent), sheet mica (87 percent), and wollastonite (86 percent) were mined predominantly underground. Mining methods were little changed from those reported in 1960. The tonnage of ore mined underground exceeded 40 percent only in New Mexico, where it was 45 percent in 1961 compared with 50 percent in 1960. From 25 to 40 percent of the ore was mined underground in Colorado, Kentucky, and Missouri in 1960 and 1961.

The relationship between crude ore and marketable product is shown in tables 11 and 12; that between total material handled and marketable product, in tables 13 and 14.

TABLE 7.—Crude ore and total material handled at surface and underground mines, by commodities in 1960

(Percent)

Commodity	Crude ore		Total material	
	Surface	Underground	Surface	Underground
Metals:				
Bauxite	92	8	97	3
Beryllium	88	12	83	17
Chromite	----	100	----	100
Copper	82	18	93	7
Gold:				
Lode	14	86	11	89
Placer	100	----	100	----
Iron ore	86	14	92	8
Lead	(1)	99+	1	99
Manganese ore (35 percent or more manganese)	87	13	91	9
Manganiferous ore (5 to 35 percent manganese)	86	14	86	14
Mercury	40	60	64	36
Molybdenum	----	100	----	100
Silver	18	82	15	85
Tungsten	12	88	12	88
Uranium	34	66	92	8
Zinc	6	94	18	82
Other [2]	100	----	100	----
Nonmetals:				
Abrasives [3]	79	21	85	15
Asbestos	92	8	96	4
Barite	90	10	96	4
Boron minerals	99	1	99	1
Clays	96	4	98	2
Feldspar	98	2	98	2
Fluorspar	12	88	18	82
Gypsum	75	25	86	14
Magnesite	100	----	100	----
Magnesium compounds	100	----	100	----
Mica:				
Scrap	99	1	99	1
Sheet	30	70	30	70
Perlite	99	1	99	1
Phosphate rock	98	2	99	1
Potassium salts	51	49	51	49
Pumice	100	----	100	----
Pyrites	34	66	86	14
Salt	87	13	87	13
Sand and gravel	100	----	100	----
Sodium carbonate (natural)	73	27	73	27
Sodium sulfate (natural)	100	----	100	----
Stone:				
Crushed and broken	95	5	96	4
Dimension	96	4	96	4
Sulfur:				
Frasch-process mines	100	----	100	----
Other mines	100	----	100	----
Talc, soapstone, and pyrophyllite	41	59	46	54
Vermiculite	100	----	100	----
Other [4]	99	1	99	1

[1] Less than 0.5 percent.
[2] Magnesium chloride for metal, nickel, platinum-group metals, rare-earth metals and thorium, titanium, and zircon.
[3] Emery, garnet, grinding pebbles, millstones, grindstones, pulpstones, sharpening stones, tube-mill liners, and tripoli.
[4] Aplite, calcium chloride, diatomite, graphite, greensand marl, iodine, kyanite, lithium minerals, olivine, staurolite, and wollastonite.

TABLE 8.—Crude ore and total material handled at surface and underground mines, by commodities in 1961

(Percent)

Commodity	Crude ore		Total material	
	Surface	Underground	Surface	Underground
Metals:				
Bauxite	85	15	92	8
Beryllium	80	20	66	34
Chromite		100		100
Cobalt		100		100
Copper	82	18	93	7
Gold:				
Lode	3	97	22	78
Placer	100	(1)	100	(1)
Iron ore	87	13	92	8
Lead	1	99	3	97
Manganese ore	93	7	95	5
Manganiferous ore	52	48	64	36
Mercury	45	55	66	34
Molybdenum		100		100
Nickel	100		100	
Platinum-group metals	100		100	
Rare-earth metals and thorium	100		100	
Silver	1	99	15	85
Titanium:				
Ilmenite	100		100	
Rutile	100		100	
Tungsten	11	89	42	58
Uranium	36	64	88	12
Zinc	1	99	3	97
Total metals	80	20	89	11
Nonmetals:				
Aplite	100		100	
Asbestos	95	5	98	2
Barite	96	4	98	2
Boron minerals	100	(1)	100	(1)
Clays	86	14	92	8
Diatomite	100		100	
Emery	100		100	
Feldspar	98	2	98	2
Fluorspar	9	91	23	77
Garnet	100		100	
Graphite	100		100	
Grinding pebbles	100		100	
Greensand marl	100		100	
Gypsum	74	26	81	19
Kyanite	100		100	
Lithium minerals	100		100	
Magnesite	100		100	
Mica:				
Scrap	100	(1)	99	1
Sheet	13	87	15	85
Olivine	83	17	82	18
Perlite	100		100	
Phosphate rock	99	1	99	1
Potassium salts	56	44	56	44
Pumice	100		100	
Pyrites	39	61	88	12
Salt	90	10	89	11
Sand and gravel	100		100	
Sodium carbonate (natural)	88	12	88	12
Sodium sulfate (natural)	100		100	
Stone:				
Crushed and broken	95	5	96	4
Dimension	97	3	98	2
Sulfur:				
Frasch-process mines	100		100	
Other mines	100		100	
Talc, soapstone, and pyrophyllite	41	59	41	59
Vermiculite	100		100	
Wollastonite	14	86	14	86
Total nonmetals	96	4	96	4
Grand total	93	7	94	6

[1] Negligible.

TABLE 9.—Crude ore and total material handled at surface and underground mines, by States in 1960

(Percent)

State	Crude ore		Total material	
	Surface	Underground	Surface	Underground
Alabama	89	11	90	10
Alaska	100		100	
Arizona	84	16	93	7
Arkansas	97	3	97	3
California	99	1	99	1
Colorado	62	38	71	29
Connecticut	99+	[1]	99+	[1]
Delaware	100		100	
District of Columbia	100		100	
Florida	100		100	
Georgia	96	4	97	3
Hawaii	100		100	
Idaho	91	9	93	7
Illinois	96	4	96	4
Indiana	98	2	98	2
Iowa	98	2	98	2
Kansas	92	8	92	8
Kentucky	82	18	83	17
Louisiana	95	5	95	5
Maine	99+	[1]	99+	[1]
Maryland	100		100	
Massachusetts	100		100	
Michigan	83	17	83	17
Minnesota	98	2	99	1
Mississippi	100		100	
Missouri	69	31	71	29
Montana	83	17	90	10
Nebraska	100		100	
Nevada	99	1	99	1
New Hampshire	99	1	99	1
New Jersey	98	2	97	3
New Mexico	50	50	71	29
New York	93	7	94	6
North Carolina	98	2	98	2
North Dakota	100		100	
Ohio	96	4	96	4
Oklahoma	98	2	98	2
Oregon	110		100	
Pennsylvania	92	8	93	7
Rhode Island	100		100	
South Carolina	100		100	
South Dakota	91	9	86	14
Tennessee	85	15	86	14
Texas	94	6	94	6
Utah	97	3	98	2
Vermont	96	4	97	3
Virginia	92	8	93	7
Washington	97	3	97	3
West Virginia	90	10	90	10
Wisconsin	96	4	96	4
Wyoming	84	16	97	3

[1] Less than 0.5 percent.

Methods.—Open-stoping and caving methods were used to mine 99 percent of the underground ore produced in the United States. Almost two-thirds of the ore came from naturally supported open stopes; one-quarter, from caving; and less than one-tenth, from artificially supported stopes; only minor variations occurred between data for 1960 and 1961. In both years, all the bauxite and natural sodium carbonates mined underground came from naturally supported open stopes; all of the chromite, from artificially supported stopes; and all of the molybdenum, from caving stopes. Some ore was mined underground in 42 of the 50 States. Virtually all the ore mined by surface methods in 1961 was loaded mechanically; only a minor quantity of the output, by hand methods.

Exploration and Development.—Four-fifths of the exploration and development footage reported in 1960 and 1961 was for metals. Uranium development supplied 42 percent of the footage in 1960, but only 26 percent in 1961. Molybdenum development furnished 2 percent of the 1960 footage and ranked second in 1961 with 19 percent. Uranium, stone, lead, iron ore, clays, and zinc supplied 80 percent of the 1960 footage; the same six commodities and gold supplied 75 percent in 1961.

More than four-fifths of the exploration and development footage—82 percent in 1960 and 87 percent in 1961—was diamond, rotary, long-hole, and percussion drilling. In 1960, rotary drilling led, followed in decreasing order by percussion, diamond, and long-hole drilling. In 1961, percussion drilling was 43 percent of the footage, followed by rotary, long-hole, and diamond drilling.

TABLE 10.—Crude ore and total material handled at surface and underground mines, by States in 1961

(Percent)

State	Crude ore		Total material	
	Surface	Underground	Surface	Underground
Alabama	92	8	95	5
Alaska	100	(1)	100	(1)
Arizona	86	14	93	7
Arkansas	97	3	97	3
California	99	1	99	1
Colorado	60	40	65	35
Connecticut	100	(1)	100	(1)
Delaware	100		100	
District of Columbia	100		100	
Florida	100		100	
Georgia	96	4	98	2
Hawaii	100		100	
Idaho	89	11	92	8
Illinois	95	5	96	4
Indiana	98	2	98	2
Iowa	97	3	98	2
Kansas	93	7	92	8
Kentucky	76	24	77	23
Louisiana	94	6	95	5
Maine	100	(1)	100	(1)
Maryland	100	(1)	100	(1)
Massachusetts	100		100	
Michigan	85	15	85	15
Minnesota	99	1	99	1
Mississippi	100		100	
Missouri	73	27	75	25
Montana	86	14	87	13
Nebraska	100	(1)	100	(1)
Nevada	99	1	99	1
New Hampshire	100	(1)	100	(1)
New Jersey	95	5	96	4
New Mexico	55	45	70	30
New York	94	6	94	6
North Carolina	97	3	97	3
North Dakota	100		100	
Ohio	88	12	89	11
Oklahoma	97	3	97	3
Oregon	100	(1)	100	(1)
Pennsylvania	91	9	92	8
Rhode Island	100		100	
South Carolina	100		100	
South Dakota	89	11	84	16
Tennessee	89	11	89	11
Texas	100	(1)	100	(1)
Utah	97	3	98	2
Vermont	97	3	98	2
Virginia	93	7	93	7
Washington	97	3	96	4
West Virginia	86	14	87	13
Wisconsin	97	3	97	3
Wyoming	86	14	96	4
Total	93	7	94	6

[1] Negligible.

TABLE 11.—Crude ore mined per unit of marketable product at surface and underground mines in the United States, by commodities in 1960

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 to units of marketable product	Crude ore mined (thousand short tons)	Marketable product, units	Ratio of units of crude ore to units of marketable product	Crude ore mined (thousand short tons)	Marketable product, units	Ratio of units of crude ore to units of marketable product
Metals:										
Bauxite	Long tons	2,494	1,843	1.4:1	208	155	1.3:1	2,702	1,998	1.4:1
Chromite	Short tons				214	108	2.0:1	214	108	2.0:1
Copper	do	110,891	769	144.2:1	24,562	248	99.0:1	135,453	1,017	133.2:1
Gold: Lode	Troy ounces	328	35	9.4:1	2,000	753	2.7:1	2,328	788	3.0:1
Iron ore	Long tons	137,276	64,303	2.1:1	23,253	18,202	1.3:1	160,529	82,505	1.9:1
Lead	Short tons	27	1	27.0:1	6,827	177	38.6:1	6,854	178	38.5:1
Magnesium chloride for magnesium metal	do	247	145	1.7:1				247	145	1.7:1
Manganese ore	do	367	73	5.0:1	55	10	5.5:1	422	83	5.1:1
Manganiferous ore	do	1,004	475	2.1:1	186	181	1.0:1	1,190	656	1.8:1
Mercury	Flasks	103	9	11.4:1	160	24	6.7:1	263	33	8.0:1
Molybdenum	Pounds				11,684	51,615	0.2:1	11,684	51,615	0.2:1
Nickel	Short tons	1,103	13	84.8:1				1,103	13	84.8:1
Rare-earth metals and thorium	do	7						7		
Silver	Troy ounces	92	218	0.4:1	404	9,952	.04:1	496	10,170	.05:1
Titanium:										
Ilmenite	Short tons	8,887	789	11.3:1				8,887	789	11.3:1
Rutile	do	1,075	9	119.4:1				1,075	9	119.4:1
Tungsten	do	61	1	61.0:1	449	6	74.8:1	510	7	72.9:1
Uranium	do	2,606	2,604	1,0:1	5,319	5,302	1.0:1	7,925	7,906	1.0:1
Zinc	do	478	22	21.7:1	8,189	352	23.3:1	8,667	374	23.2:1
Zircon	do	1,715	53	32.4:1				1,715	53	32.4:1
Total		268,805			83,515			352,320		
Nonmetals:										
Abrasives	Short tons	105	20	5.3:1				105	20	5.3:1
Barite	do	1,246	620	2.0:1	97	94	1.0:1	1,343	714	1.9:1
Clays	do	45,909	44,035	1.0:1	1,888	1,879	1.0:1	47,797	45,914	1.0:1
Feldspar	Long tons	1,389	481	2.9:1	24	14	1.7:1	1,413	495	2.9:1
Fluorspar	Short tons	60	47	1.3:1	404	155	2.6:1	464	202	2.3:1
Gypsum	do	7,351	7,317	1.0:1	2,488	2,488	1.0:1	9,839	9,805	1.0:1
Magnesite	do	551	499	1.1:1				551	499	1.1:1
Magnesium compounds	do	42,700	62	688.7:1				42,700	62	688.7:1

Mica:										
Scrap	do	1,273	98	13.0:1	8	2	4.0:1	1,281	100	12.8:1
Sheet	Pounds	81	84	1.0:1	182	212	0.9:1	263	296	0.9:1
Perlite	Short tons	385	310	1.2:1	3	3	1.0:1	388	313	1.2:1
Phosphate rock	Long tons	59,938	16,751	3.6:1	1,039	766	1.4:1	60,977	17,517	3.5:1
Potassium salts	Short tons	15,210	54	281.7:1	15,071	2,440	6.2:1	30,281	2,494	12.1:1
Pumice	do	2,257	2,210	1.0:1				2,257	2,210	1.0:1
Pyrites	Long tons	93	83	1.1:1	177	116	1.5:1	270	199	1.4:1
Salt	Short tons	45,376	15,507	2.9:1	6,769	6,185	1.1:1	52,145	21,692	2.4:1
Sodium carbonate (natural)	do	2,568	174	14.8:1	931	495	1.9:1	3,499	669	5.2:1
Sodium sulfate (natural)	do	3,545	222	16.0:1				3,545	222	16.0:1
Stone:										
Crushed and broken	do	592,308	590,180	1.0:1	27,628	24,591	1.1:1	619,936	614,771	1.0:1
Dimension	do	6,348	2,189	2.9:1	286	68	4.2:1	6,634	2,257	2.9:1
Sulfur:										
Frasch-process mines	Long tons	5,647	5,002	1.1:1				5,647	5,002	1.1:1
Other mines	do	320	182	1.8:1				320	182	1.8:1
Talc, soapstone, pyrophyllite	Short tons	342	282	1.2:1	485	442	1.1:1	827	724	1.1:1
Tripoli	do	24	24	1.0:1	33	33	1.0:1	57	57	1.0:1
Vermiculite	do	1,017	199	5.1:1				1,017	199	5.1:1
Other [1]	do	6,565	1,276	5.1:1	104	35	3.0:1	6,669	1,311	5.1:1
Total		842,608			57,617			900,225		
Grand total		1,111,413			141,132			1,252,545		

[1] Aplite, asbestos, boron minerals, calcium magnesium chloride, diatomite, graphite, greensand marl, kyanite, olivine, staurolite, and wollastonite.

TABLE 12.—Crude ore mined per unit of marketable product at surface and underground mines in the United States, by commodities in 1961

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	1,408	1,041	1.4:1	240	181	1.3:1	1,648	1,222	1.3:1
Beryllium	Short tons	41	(1)	194.1:1	9	1	9.0:1	50	1	50.0:1
Chromite	do				159	83	1.9:1	159	83	1.9:1
Copper	do	116,921	799	146.3:1	26,259	287	91.5:1	143,180	1,086	131.8:1
Gold:										
Lode	Troy ounces	72	18	4.0:1	1,990	718	2.8:1	2,062	736	2.8:1
Placer	do	48,914	199	245.8:1	11	1	11.0:1	48,925	200	244.6:1
Iron ore	Long tons	138,841	57,186	2.4:1	20,390	14,843	1.4:1	159,231	72,029	2.2:1
Lead	Short tons	17	(1)	39.5:1	6,338	183	34.6:1	6,355	183	34.7:1
Mercury	Flasks	89	7	12.7:1	148	24	6.2:1	237	31	7.6:1
Molybdenum	Pounds				12,274	48,000	.25:1	12,274	48,000	.25:1
Nickel	Short tons	1,078	13	82.9:1				1,078	13	82.9:1
Platinum-group metals	Troy ounces	(2)	(2)	110.2:1				(2)	(2)	110.2:1
Rare-earth metals and thorium	Short tons	6	(1)	15.0:1				6	(1)	15.0:1
Silver	Troy ounces	81	223	.36:1	401	12,623	.03:1	482	12,846	.03:1
Titanium:										
Ilmenite	Short tons	20,046	781	25.7:1				20,046	781	25.7:1
Rutile	do	343	7	49.0:1				343	7	49.0:1
Tungsten	do	66	1	66.0:1	534	7	76.3:1	600	8	75.0:1
Uranium	do	2,749	2,749	1.0:1	5,419	5,239	1.0:1	8,168	7,988	1.0:1
Zinc	do	243	16	15.2:1	8,314	375	22.2:1	8,557	391	21.9:1
Other [3]	do	(2)	(2)	32.9:1	(2)	(2)	1.3:1	(2)	(2)	31.1:1
Nonmetals:										
Abrasives [4]	do	(2)	(2)	1.0:1	(2)	(2)	1.0:1	54	54	1.0:1
Asbestos	do	839	51	16.5:1	45	2	22.5:1	884	53	16.7:1
Barite	do	5,274	708	7.4:1	192	87	2.2:1	5,466	795	6.9:1
Boron minerals	do	8,148	565	14.4:1	10	7	1.4:1	8,158	572	14.3:1
Clays	do	47,975	45,122	1.1:1	7,935	1,841	4.3:1	55,910	46,963	1.2:1
Feldspar	Long tons	1,184	479	2.5:1	19	10	1.9:1	1,203	489	2.5:1
Fluorspar	Short tons	117	48	2.4:1	383	137	2.8:1	500	185	2.7:1
Gypsum	do	6,985	6,973	1.0:1	2,539	2,528	1.0:1	9,524	9,501	1.0:1
Magnesite	do	604	604	1.0:1				604	604	1.0:1
Mica:										
Scrap	do	564	78	7.2:1	2	1	2.0:1	566	79	7.2:1
Sheet	Pounds	26	(1)	483.4:1	171	(1)	339.6:1	197	(1)	353.7:1

Perlite	Short tons	366	310	1.2:1				366	310	1.2:1
Phosphate rock	Long tons	69,005	17,908	3.9:1	946	671	1.4:1	69,951	18,579	3.8:1
Potassium salts	Short tons	19,715	61	323.2:1	17,614	2,523	7.0:1	37,329	2,584	14.4:1
Pumice	do	2,443	2,451	1.0:1	13	13	1.0:1	2,456	2,464	1.0:1
Pyrites	do	93	76	1.2:1	168	102	1.6:1	261	178	1.5:1
Salt	do	59,563	18,866	3.2:1	6,307	6,280	1.0:1	65,870	25,146	2.6:1
Sand and gravel	do	751,611	751,611	1.0:1				751,611	751,611	1.0:1
Sodium carbonate (natural)	do	6,134	181	33.9:1	857	484	1.8:1	6,991	665	10.5:1
Stone:										
Crushed and broken	do	583,084	578,868	1.0:1	27,892	27,779	1.0:1	610,976	606,647	1.0:1
Dimension	do	4,877	2,162	2.3:1	149	43	3.5:1	5,026	2,205	2.3:1
Sulfur:										
Frasch-process mines	Long tons	5,692	5,083	1.1:1				5,692	5,083	1.1:1
Other mines	do	608	178	3.4:1				608	178	3.4:1
Talc, soapstone, and pyrophyllite	Short tons	331	327	1.0:1	463	429	1.1:1	794	756	1.1:1
Vermiculite	do	867	127	6.8:1				867	127	6.8:1
Other [5]	do	1,183	671	1.7:1	60	32	1.9:1	1,243	703	1.7:1

[1] Less than 1,000 tons.
[2] Figures withheld to avoid disclosing individual company confidential data.
[3] Manganese ore, manganiferous ore, and magnesium chloride for magnesium metal.
[4] Emery, garnet, grinding pebbles, and tripoli.
[5] Aplite, diatomite, graphite, greensand marl, epsomite, kyanite, lithium, olivine, sodium sulfate (natural), and wollastonite.

TABLE 13.—Material handled per unit of marketable product at surface and underground mines in the United States, by commodities in 1960

Commodity	Unit of marketable product (thousands)	Surface			Underground			All mines		
		Material handled (thousand short tons)	Marketable product, units	Ratio of units of material handled to units of marketable product	Material handled (thousand short tons)	Marketable product, units	Ratio of units of material handled to units of marketable product	Material handled (thousand short tons)	Marketable product, units	Ratio of units of material handled to units of marketable product
Metals:										
Bauxite	Long tons	6,302	1,843	3.4:1	208	155	1.3:1	6,510	1,998	3.3:1
Chromite	Short tons				226	108	2.1:1	226	108	2.1:1
Copper	do	315,870	769	410.8:1	25,480	248	102.7:1	341,350	1,017	335.6:1
Gold: Lode	Troy ounces	403	35	11.5:1	3,131	753	4.2:1	3,534	788	4.5:1
Iron ore	Long tons	299,797	64,303	4.7:1	25,338	18,202	1.4:1	325,135	82,505	3.9:1
Lead	Short tons	67	1	67.0:1	7,443	177	42.1:1	7,510	178	42.2:1
Manganese ore	do	801	73	11.0:1	82	10	8.2:1	883	83	10.6:1
Manganiferous ore	do	1,079	475	2.3:1	186	181	1.0:1	1,265	656	1.9:1
Mercury	Flasks	343	9	3.8:1	192	24	8.0:1	535	33	16.2:1
Molybdenum	Pounds				11,715	51,615	0.2:1	11,715	51,615	0.2:1
Nickel	Short tons	1,426	13	109.7:1				1,426	13	109.7:1
Silver	Troy ounces	92	218	0.4:1	559	9,952	0.1:1	651	10,170	0.1:1
Titanium:										
Ilmenite	Short tons	22,068	789	28.0:1				22,068	789	28.0:1
Rutile	do	2,205	9	245.0:1				2,205	9	245.0:1
Tungsten	do	61	1	61.0:1	474	6	79.0:1	535	7	76.4:1
Uranium	do	77,665	2,604	29.8:1	7,334	5,302	1.4:1	84,999	7,906	10.8:1
Zinc	do	2,039	22	92.7:1	9,040	352	25.7:1	11,079	374	29.6:1
Other [1]	do	3,003	198	15.2:1	9			3,012	198	15.2:1
Total		733,221			91,417			824,638		
Nonmetals:										
Abrasives (includes natural abrasives, emery and garnet).	Short tons	166	20	8.3:1				166	20	8.3:1
Barite	do	4,232	620	6.8:1	98	94	1.0:1	4,330	714	6.1:1
Clays	do	81,818	44,035	1.9:1	1,916	1,879	1.0:1	83,734	45,914	1.8:1
Feldspar	Long tons	1,488	481	3.1:1	24	14	1.7:1	1,512	495	3.1:1
Fluorspar	Short tons	101	47	2.1:1	418	155	2.7:1	519	202	2.6:1
Gypsum	do	14,792	7,317	2.0:1	2,523	2,488	1.0:1	17,315	9,805	1.8:1
Magnesite	do	1,776	499	3.6:1				1,776	499	3.6:1
Magnesium compounds	do	42,700	62	688.7:1				42,700	62	688.7:1

Mica:										
Scrap	do	1,654	98	16.9:1	8	2	4.0:1	1,662	100	16.6:1
Sheet	Pounds	77	84	0.9:1	183	212	0.9:1	260	296	0.9:1
Perlite	Short tons	386	310	1.2:1	3	3	1.0:1	389	313	1.2:1
Phosphate rock	Long tons	168,459	16,751	10.1:1	1,039	766	1.4:1	169,498	17,517	9.7:1
Potassium salts	Short tons	15,210	54	281.7:1	15,121	2,440	6.2:1	30,331	2,494	12.2:1
Pumice	do	2,419	2,210	1.1:1				2,419	2,210	1.1:1
Pyrites	Long tons	1,120	83	13.5:1	177	116	1.5:1	1,297	199	6.5:1
Salt	Short tons	45,378	15,507	2.9:1	6,769	6,185	1.1:1	52,147	21,692	2.4:1
Sodium carbonate (natural)	do	2,568	174	14.8:1	931	495	1.9:1	3,499	669	5.2:1
Sodium sulfate (natural)	do	3,545	222	16.0:1				3,545	222	16.0:1
Stone:										
Crushed and broken	do	661,069	590,180	1.1:1	27,993	24,591	1.1:1	689,062	614,771	1.1:1
Dimension stone	do	6,985	2,189	3.2:1	286	68	4.2:1	7,271	2,257	3.2:1
Sulfur: Other mines	Long tons	6,280	5,184	1.2:1				6,280	5,184	1.2:1
Talc, soapstone, and pyrophyllite	Short tons	459	282	1.6:1	534	442	1.2:1	993	724	1.4:1
Tripoli	do	24	24	1.0:1	33	33	1.0:1	57	57	1.0:1
Vermiculite	do	2,834	199	14.2:1				2,834	199	14.2:1
Other [2]	do	12,323	1,276	9.7:1	114	35	3.2:1	12,437	1,311	9.5:1
Total		1,077,863			58,170			1,136,033		
Grand total		1,811,084			149,587			1,960,671		

[1] Beryllium concentrate, magnesium chloride for magnesium metal, rare-earth metals and thorium and zircon.
[2] Aplite, asbestos, boron minerals, calcium magnesium chloride, diatomite, graphite, greensand marl, kyanite, olivine, staurolite, and wollastonite.

TABLE 14.—Material handled per unit of marketable product at surface and underground mines in the United States, by commodities in 1961

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	2,717	1,041	2.6:1	240	181	1.3:1	2,957	1,222	2.4:1
Beryllium	Short tons	67	(1)	316.1:1	34	1	34.0:1	101	1	101.0:1
Chromite	do				159	83	1.9:1	159	83	1.9:1
Copper	do	352,134	799	440.7:1	26,943	287	93.9:1	379,077	1,086	349.1:1
Gold:										
Lode	Troy ounces	900	18	50.0:1	3,160	718	4.4:1	4,060	736	5.5:1
Placer	do	52,214	199	262.4:1	16	1	16.0:1	52,230	200	261.2:1
Iron ore	Long tons	258,378	57,186	4.5:1	22,726	14,843	1.5:1	281,104	72,029	3.9:1
Lead	Short tons	171	(1)	392.5:1	6,986	183	38.2:1	7,157	183	39.1:1
Mercury	Flasks	319	7	45.6:1	181	24	7.5:1	500	31	16.1:1
Molybdenum	Pounds				12,292	48,000	.3:1	12,292	48,000	.3:1
Nickel	Short tons	1,437	13	110.5:1				1,437	13	110.5:1
Platinum-group metals	Troy ounces	(2)	(2)	110.2:1				(2)	(2)	110.2:1
Rare-earth metals and thorium	Short tons	33	(1)	87.7:1	1			34	(1)	92.0:1
Silver	Troy ounces	129	223	.6:1	726	12,623	0.1:1	855	12,846	0.1:1
Titanium:										
Ilmenite	Short tons	25,760	781	33.0:1				25,760	781	33.0:1
Rutile	do	718	7	102.6:1				718	7	102.6:1
Tungsten	do	409	1	409.0:1	559	7	79.9:1	968	8	121.0:1
Uranium	do	49,607	2,749	18.0:1	6,650	5,239	1.3:1	56,257	7,988	7.0:1
Zinc	do	288	16	18.0:1	9,273	375	24.7:1	9,561	391	24.5:1
Other [3]	do	(2)	(2)	33.5:1	(2)	(2)	1.6:1	(2)	(2)	31.7:1
Nonmetals:										
Abrasives [4]	do	(2)	(2)	5.8:1	(2)	(2)	1.0:1	255	73	3.5:1
Asbestos	do	1,750	51	34.3:1	45	2	22.5:1	1,795	53	33.9:1
Barite	do	8,608	708	12.2:1	196	87	2.3:1	8,804	795	11.1:1
Boron minerals	do	8,160	565	14.4:1	10	7	1.4:1	8,170	572	14.3:1
Clays	do	85,806	45,122	1.9:1	7,968	1,841	4.3:1	93,774	46,963	2.0:1
Feldspar	Long tons	1,238	479	2.6:1	30	10	3.0:1	1,268	489	2.6:1
Fluorspar	Short tons	145	48	3.0:1	384	137	2.8:1	529	185	2.9:1
Gypsum	do	11,226	6,973	1.6:1	2,597	2,528	1.0:1	13,823	9,501	1.5:1
Magnesite	do	1,422	604	2.4:1				1,422	604	2.4:1

Mica:										
Scrap	do	854	78	10.9:1	11	1	11.0:1	865	79	10.9:1
Sheet	Pounds	(1)	(1)	620.2:1	(1)	(1)	313.2:1	(1)	(1)	396.2:1
Perlite	Short tons	375	310	1.2:1				375	310	1.2:1
Phosphate rock	Long tons	147,128	17,908	8.2:1	1,006	671	1.5:1	148,134	18,579	8.0:1
Potassium salts	Short tons	19,715	61	323.2:1	17,757	2,523	7.0:1	37,472	2,584	14.5:1
Pumice	do	2,532	2,451	1.0:1		13	0.0:1	2,532	2,464	1.0:1
Pyrites	do	1,253	76	16.5:1	168	102	1.6:1	1,421	178	8.0:1
Salt	do	59,618	18,866	3.2:1	6,573	6,280	1.0:1	66,191	25,146	2.6:1
Sand and gravel	do	751,611	751,611	1.0:1				751,611	751,611	1.0:1
Sodium carbonate (natural)	do	6,134	181	33.9:1	872	484	1.8:1	7,006	665	10.5:1
Stone:										
Crushed and broken	do	637,654	578,868	1.1:1	28,395	27,779	1.0:1	666,049	606,647	1.1:1
Dimension	do	6,073	2,162	2.8:1	149	43	3.5:1	6,222	2,205	2.8:1
Sulfur:										
Frasch-process mines	Long tons	5,692	5,083	1.1:1				5,692	5,083	1.1:1
Other mines	do	650	178	3.7:1				650	178	3.7:1
Talc, soapstone, and pyrophyllite	Short tons	455	327	1.4:1	480	429	1.1:1	935	756	1.2:1
Vermiculite	do	2,265	127	17.8:1				2,265	127	17.8:1
Other [5]	do	5,144	671	7.7:1	62	32	2.0:1	5,206	703	7.4:1

[1] Less than 1,000 tons.
[3] Figures withheld to avoid disclosing individual company confidential data.
[3] Manganese ore, manganiferous ore, and magnesium chloride for magnesium metal.
[4] Emery, garnet, grinding pebbles, and tripoli.
[5] Aplite, diatomite, graphite, greensand marl, epsomite, kyanite, lithium, olivine, sodium sulfate (natural), and wollastonite.

TABLE 15.—Mining methods used in underground operations, by commodities

(Percent)

Commodity	Open stoping				Caving		Other and unspecified	
	Natural support		Artificial support					
	1960	1961	1960	1961	1960	1961	1960	1961
Metals:								
Bauxite	100.0	100.0						
Beryllium	100.0	45.5		54.5				
Chromite			100.0	100.0				
Copper	29.0	33.8	9.2	9.7	61.8	56.5		
Gold:								
Lode	4.0	3.6	94.2	96.1		.3	1.8	
Placer		54.5		9.1				36.4
Iron ore	45.5	47.0	6.4	6.5	47.2	44.6	.9	1.9
Lead	86.8	83.5	12.9	16.5			.3	
Manganese ore	78.8	86.4	20.0	13.6	.8		.4	
Mercury	4.4	3.4	94.4	96.6	.6		.6	
Molybdenum					100.0	100.0		
Silver	16.8	11.3	83.2	88.7				
Tungsten	55.9	39.9	44.1	60.1				
Uranium	89.1	81.8	7.4	11.5	2.8	6.7	.7	
Zinc	82.7	80.7	17.0	19.3			.3	
Nonmetals:								
Asbestos		95.5		4.5				
Barite	1.0		99.0	98.9				1.1
Boron minerals		100.0						
Clays	87.5	97.2	4.3	1.0	8.2	1.8		(1)
Feldspar	100.0	70.0		30.0				
Fluorspar	40.3	35.5	56.0	59.3	3.7	5.2		
Gypsum	99.2	99.1	.8	.9				
Mica:								
Scrap	25.0	33.3	75.0	66.7				
Sheet	67.2	52.0	32.8	48.0				
Perlite	100.0							
Phosphate rock	37.0	33.5	60.2	63.9	2.8	2.6		
Potassium salts	99.8	97.0				3.0	.2	
Pyrites	83.1	79.9	16.9	20.1				
Salt	94.6	92.8					5.4	7.2
Sodium carbonates (natural)	100.0	100.0						
Stone:								
Crushed and broken	95.7	95.8	1.6	1.4		.1	2.7	2.7
Dimension	98.9	95.3	1.1			4.7		
Talc, soapstone, and pyrophyllite	70.9	83.1	18.8	15.2	9.5	.2	.8	1.5
Total	64.1	65.5	7.8	8.1	27.0	25.3	1.1	1.1

[1] Less than 0.05 percent.

TABLE 16.—Mining methods used in underground operations, by States

(Percent)

State	Open stoping				Caving		Other and unspecified	
	Natural support		Artificial support					
	1960	1961	1960	1961	1960	1961	1960	1961
Alabama	97.8	97.8			2.2	2.2		
Alaska			90.9	100.0			9.1	
Arizona	3.1	3.9	9.6	9.4	87.2	86.7	.1	
Arkansas	78.6	76.3	21.4	23.7				
California	78.8	77.2	20.7	21.0	.1	1.0	.4	0.8
Colorado	8.3	7.5	6.2	7.2	85.4	85.3	.1	
Connecticut	100.0	100.0						
Georgia	98.7	99.8	1.3	.2				
Idaho	.8	5.0	99.2	95.0				
Illinois	94.3	93.3	5.2	5.9	.5	.8		
Indiana	100.0	100.0						
Iowa	100.0	100.0						
Kansas	100.0	100.0						
Kentucky	98.3	98.5	1.7	1.5				
Louisiana	100.0	100.0						
Maine	100.0	36.4				63.6		
Maryland	100.0	100.0						
Michigan	66.5	73.9	4.4	5.8	28.4	18.1	.7	2.2
Minnesota	.6		8.0	11.3	88.6	88.7	2.8	
Missouri	100.0	99.9						.1
Montana	10.5	11.0	25.9	34.1	63.1	54.9	.5	
Nebraska		100.0						
Nevada	64.2	66.5	33.5	31.5	1.4		.9	2.0
New Hampshire	100.0	100.0						
New Jersey	28.0	64.8	72.0	35.2				
New Mexico	97.2	92.6	2.5	3.5	.2	3.9	.1	
New York	92.2	89.1	.1		.4	.5	7.3	10.4
North Carolina	24.3	19.0	75.7	81.0				
Ohio	83.9	100.0					16.1	
Oklahoma	100.0	100.0						
Oregon	57.1	100.0	42.9					
Pennsylvania	57.8	41.3	.5	.5	41.4	47.9	.3	10.3
South Dakota	1.6	2.4	96.0	97.4	.4	.2	2.0	
Tennessee	99.9	100.0	.1					
Texas	100.0	100.0						
Utah	48.3	56.3	43.8	38.9	6.0	4.8	1.9	
Vermont	79.4	100.0	.9		19.7			
Virginia	90.5	89.7	1.9	2.1			7.6	8.2
Washington	93.5	93.2	6.5	6.8				
West Virginia	100.0	100.0						
Wisconsin	47.4	32.7			52.6	67.3		
Wyoming	60.5	53.4	17.2	14.2	22.3	32.4		
Total	64.1	65.5	7.8	8.1	27.0	25.3	1.1	1.1

TABLE 17.—Mining methods used in open-pit mining, by commodities in 1961

(Percent)

Commodity	Mechanical loading		Other	Explanation of other
	Preceded by drilling and blasting	Not preceded by drilling and blasting		
Metals:				
Bauxite	96	4		
Beryllium	96		4	Unspecified.
Copper	96	2	2	Leaching.
Iron ore	77	23		
Lead	83	17		
Mercury	67	31	2	Unspecified.
Manganese ore	84	16		
Manganiferous ore	88	12		
Nickel	30	70		
Rare-earth metals and thorium	100			
Tungsten	100			
Uranium	44	55	1	Drilled or cut without blasting.
Zinc	100			
Nonmetals:				
Aplite	47	53		
Asbestos	99	1		
Barite	15	84	1	Mechanical excavation and nonfloat washing.
Clays	25	73	2	Dredging (1 percent), unspecified (1 percent).
Diatomite		100		
Emery	100			
Feldspar	78	18	4	Unspecified.
Fluorspar	63	37		
Garnet	100			
Graphite	17	83		
Greensand marl		100		
Gypsum	83	16	1	Drilled or cut without blasting.
Kyanite	87	13		
Lithium minerals	100			
Magnesite	100			
Mica:				
Scrap	16	78	6	Hydraulicking.
Sheet	15	62	23	Hand methods (4 percent), unspecified (19 percent).
Olivine	100			
Perlite	36	64		
Phosphate rock	1	98	1	Dredging.
Potassium salts			100	Pumping.
Pumice	3	97		
Pyrites	90	10		
Sand and gravel		95	5	Dredging.
Sodium carbonate (natural)			100	Pumping.
Sodium sulfate (natural)		100		
Stone:				
Crushed and broken	91	5	4	Dredging.
Dimension	22	4	74	Hand methods (1 percent), drilled or cut without blasting (73 percent).
Sulfur:				
Frasch-process mines			100	Pumping.
Other mines	99	1		
Talc, soapstone, and pyrophyllite	64	30	6	Drilled or cut without blasting.
Vermiculite	7	93		
Wollastonite		71	29	Hand methods.

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

Commodity	1960		1961	
	Feet	Percent of total	Feet	Percent of total
Metals:				
Beryllium	16,079	0.1	76,472	0.3
Copper	1,203,632	5.8	1,104,712	3.8
Gold	386,741	1.9	5,677,277	19.4
Iron ore	1,603,689	7.8	2,252,869	7.7
Lead	1,834,226	8.4	1,363,933	4.7
Manganese ore	14,025	.1	4,090	(1)
Mercury	97,691	.5	32,320	.1
Molybdenum	231,915	1.1	2,636,116	9.1
Nickel	20,973	.1	12,060	(1)
Rare-earth metals and thorium	9,871	.1	1,360	(1)
Silver	39,116	.2	86,225	.3
Titanium	74,785	.4	39,483	.1
Tungsten	631,549	3.1	689,956	2.4
Uranium and vanadium	8,707,918	42.1	7,660,885	26.3
Zinc	1,476,993	7.2	1,611,870	5.5
Zircon	3,692	(1)		
Other [2]	8,243	.1	36,721	.1
Total	16,361,138	79.0	23,286,349	79.8
Nonmetals:				
Asbestos	62,568	.3	45,313	.2
Barite	77,828	.4	41,026	.2
Boron minerals	7,829	(1)	9,592	(1)
Clays	1,417,981	6.9	1,602,154	5.5
Feldspar	6,960	(1)	81,833	.3
Fluorspar	33,750	.2	45,795	.2
Gypsum	233,697	1.1	474,574	1.6
Mica:				
Scrap	4,210	(1)	385	(1)
Sheet	23,045	.1	2,426	(1)
Phosphate rock	146,364	.7	231,456	.8
Potassium salts	43,790	.2	356,640	1.2
Pumice	6,931	(1)	2,000	(1)
Pyrites	7,100	(1)	1,316	(1)
Salt	23,933	.1	41,648	.1
Sodium carbonate (natural)	44,963	.2	27,532	.1
Sodium sulfate (natural)	13,124	.1		
Stone	1,914,078	9.3	2,462,579	8.4
Sulfur:				
Frasch-process mines	238,723	1.2	157,642	.5
Other mines	919	(1)	2,191	(1)
Talc, soapstone, and pyrophyllite	27,749	.1	86,859	.3
Other [3]	16,244	.1	232,976	.8
Total	4,351,786	21.0	5,905,937	20.2
Grand total	20,712,924	100.0	29,192,286	100.0

[1] Less than 0.05 percent.
[2] Antimony (1961), bauxite, chromite (1960), cobalt (1961), and platinum-group metals.
[3] Aplite (1961), calcium-magnesium chloride, diatomite, greensand marl (1961), kyanite, magnesite (1961), olivine (1961), perlite (1961), staurolite, tripoli, vermiculite (1961), and wollastonite.

TABLE 19.—Exploration and development activity in the United States, by methods

Method	1960					
	Metals		Nonmetals		Total	
	Feet	Percent of total	Feet	Percent of total	Feet	Percent of total
Shaft sinking	24,732	0.1	2,772	0.1	27,504	0.1
Raising	325,282	2.0	23,587	.5	348,869	1.7
Winzing	20,031	.1	466	(1)	20,497	.1
Tunneling	81,764	.5	47,438	1.1	129,202	.6
Drifting	1,166,922	7.1	90,376	2.1	1,257,298	6.1
Crosscutting	111,800	.7	10,787	.2	122,587	.6
Diamond drilling	3,286,657	20.1	322,144	7.4	3,608,801	17.4
Churn drilling	538,423	3.3	113,473	2.6	651,896	3.2
Rotary drilling	3,785,317	23.2	2,430,318	55.9	6,215,635	30.0
Long-hole drilling	2,313,212	14.1	53,620	1.2	2,366,832	11.4
Percussion drilling	4,062,048	24.8	828,797	19.1	4,890,845	23.6
Trenching	139,947	.9	56,231	1.3	196,178	1.0
Other	505,003	3.1	371,777	8.5	876,780	4.2
Total	16,361,138	100.0	4,351,786	100.0	20,712,924	100.0

	1961					
	Metals		Nonmetals		Total	
	Feet	Percent of total	Feet	Percent of total	Feet	Percent of total
Shaft sinking	23,712	0.1	5,393	0.1	29,105	0.1
Raising	288,706	1.2	16,117	.3	304,823	1.0
Winzing	6,363	(1)	500	(1)	6,863	(1)
Tunneling	52,389	.2	29,011	.5	81,400	.3
Drifting	922,766	4.0	364,597	6.2	1,287,363	4.4
Crosscutting	240,039	1.0	9,788	.2	249,827	.9
Diamond drilling	2,568,807	11.0	276,323	4.7	2,845,130	9.8
Churn drilling	403,105	1.7	203,734	3.4	606,839	2.1
Rotary drilling	3,011,159	13.0	3,430,804	58.1	6,441,963	22.1
Long-hole drilling	3,186,652	13.7	362,761	6.1	3,549,413	12.1
Percussion drilling	11,710,474	50.3	913,688	15.5	12,624,162	43.2
Trenching	72,986	.3	71,589	1.2	144,575	.5
Other	799,191	3.5	221,632	3.7	1,020,823	3.5
Total	23,286,349	100.0	5,905,937	100.0	29,192,286	100.0

[1] Less than 0.05 percent.

TABLE 20.—Exploration and development by methods and selected metals in 1960

(Feet)

Metal	Method						
	Shaft sinking	Raising	Winzing	Tunneling	Drifting	Crosscutting	Diamond drilling
Beryllium			36	888	320	195	3,300
Copper	7,243	71,888	14,695	6,733	216,161	5,211	650,797
Gold	1,869	16,802	392	6,103	39,831	21,029	109,440
Iron ore	3,756	142,982	63	28,512	196,852	16,222	653,989
Lead	1,128	14,954	767	4,617	70,791	6,498	797,458
Manganese ore	120	850			1,590	100	
Mercury	647	6,156	42	1,287	5,334	1,262	7,760
Molybdenum	329	488		250	12,008	1,542	35,385
Nickel					500		17,483
Rare-earth metals and thorium	35			20	156	50	470
Silver	426	4,559	140	1,285	8,471	4,976	15,867
Titanium							40,157
Tungsten		6,301			6,430	440	16,458
Uranium and vanadium	5,350	32,737	703	29,348	522,125	39,260	679,185
Zinc	3,819	27,565	3,193	2,721	86,292	14,874	258,358
Zircon	10						500
Other[1]					61	141	50
Total	24,732	325,282	20,031	81,764	1,166,922	111,800	3,286,657

Metal	Method						
	Churn drilling	Rotary drilling	Long-hole drilling	Percussion drilling	Trenching	Other	Total
Beryllium					11,340		16,079
Copper	80,724	134,356	5,346	873	1,445	8,160	1,203,632
Gold	3,095	8,812	35,552	73,741	65,751	4,324	386,741
Iron ore	102,254	275,974	53,363	21,052	4,610	104,060	1,603,689
Lead	280,597	68,488	12,747	527,098	5,985	43,098	1,834,226
Manganese ore	450	5,000	535		1,700	3,680	14,025
Mercury	3,000	21,020	6,450	14,440	25,012	5,281	97,691
Molybdenum			181,913				231,915
Nickel	2,990						20,973
Rare-earth metals and thorium	1,200				7,940		9,871
Silver			1,490	260	1,360	282	39,116
Titanium	4,920	14,962				14,746	74,785
Tungsten			150,620	450,900	400		631,549
Uranium and vanadium	8,466	3,250,707	1,758,249	2,079,995	12,295	289,498	8,707,918
Zinc	46,887	490	106,947	893,689	1,534	30,624	1,476,993
Zircon	2,040	817			325		3,692
Other[1]	1,800	4,691			250	1,250	8,243
Total	538,423	3,785,317	2,313,212	4,062,048	139,947	505,003	16,361,138

[1] Bauxite, chromite, and platinum-group metals.

TABLE 21.—Exploration and development by methods and selected nonmetals in 1960

(Feet)

Nonmetal	Method						
	Shaft sinking	Raising	Winzing	Tunneling	Drifting	Crosscutting	Diamond drilling
Asbestos		270		850	275		25,843
Barite	55	385		138	3,888	60	1,730
Boron minerals		208			230	330	1,145
Clays		140		7,403	1,284	1,621	88,915
Feldspar				60			
Fluorspar	372	1,663	210	150	4,825	880	21,875
Gypsum	350	1,500			7,000		14,659
Mica:							
Scrap	30				170	30	
Sheet	750			330	1,515	90	
Phosphate rock		10,707		2,901	9,491	3,375	5,871
Potassium salts	990				800		16,000
Pumice						100	1,050
Pyrites		1,057			2,733	348	2,943
Salt				200			
Sodium carbonate (natural)					41,764		
Sodium sulfate (natural)							
Stone	85	3,568		34,961	12,568	3,194	130,042
Sulfur:							
Frasch-process mines							
Other mines							
Talc, soapstone and pyrophyllite	140	3,729	256	445	3,433	759	5,087
Other [1]		360			400		6,984
Total	2,772	23,587	466	47,438	90,376	10,787	322,144

Nonmetal	Method						
	Churn drilling	Rotary drilling	long-hole drilling	Percussion drilling	Trenching	Other	Total
Asbestos		8,000		3,000	15,950	8,380	62,568
Barite	3,800	54,064		5,040		8,668	77,828
Boron minerals		5,916					7,829
Clays	19,918	1,053,329	7,500	14	4,254	233,603	1,417,981
Feldspar		6,800	100				6,960
Fluorspar	1,495		980	250	1,050		33,750
Gypsum	1,000	201,840	45	3,000		4,303	233,697
Mica:							
Scrap		580			2,000	1,400	4,210
Sheet		20,000			360		23,045
Phosphate rock	19,300	91,522			1,800	1,397	146,364
Potassium salts		26,000					43,790
Pumice	2,500	475			206	2,600	6,931
Pyrites	19						7,100
Salt	4,300	17,273				2,160	23,933
Sodium carbonate (natural)		860	2,339				44,963
Sodium sulfate (natural)	10,644	2,480					13,124
Stone	44,557	695,737	36,156	817,293	26,651	109,266	1,914,078
Sulfur:							
Frasch-process mines		238,723					238,723
Other mines		919					919
Talc, soapstone and pyrophyllite	900	5,000	6,500		1,500		27,749
Other [1]	5,040	800		200	2,460		16,244
Total	113,473	2,430,318	53,620	828,797	56,231	371,777	4,351,786

[1] Calcium-magnesium chloride, diatomite, kyanite, staurolite, tripoli, and wollastonite.

TABLE 22.—Exploration and development by methods and States in 1960

(Feet)

State	Method							
	Shaft sinking	Raising	Winzing	Tunneling	Drifting	Crosscutting	Diamond drilling	Churn drilling
Alabama							9,672	34,710
Alaska	170	3,974		20	2,177	982	53,555	6,125
Arizona	6,043	67,993	76	7,424	144,035	9,920	373,732	56,372
Arkansas		385			3,488		1,530	1,800
California	1,353	8,221	327	4,820	11,723	3,245	56,021	5,565
Colorado	1,895	13,396	538	17,016	116,697	12,173	577,867	5,861
Connecticut				60			1,000	
Florida								12,000
Georgia	100						16,250	
Hawaii							600	
Idaho	320	9,430	315	1,950	17,296	11,204	38,423	23,600
Illinois	80	1,115	285	4,900	2,066	380	24,148	5,920
Indiana							8,180	1,756
Iowa				4,021			4,230	1,354
Kansas					150		816	4,931
Kentucky	65			18,020	2,390		2,560	5,200
Louisiana				200				
Maine							13,833	
Maryland							2,071	500
Massachusetts								
Michigan	2,347	99,460	60	22,142	153,308	8,375	157,791	3,400
Minnesota		2,946	3	2,320	12,224	372	76,007	41,139
Missouri	2,125	1,038		1,152	40,756	1,205	944,134	324,111
Montana	747	3,903	16,883	5,382	68,467	4,545	16,596	15,447
Nebraska								
Nevada	1,248	3,056	469	3,562	8,105	1,575	120,554	12,365
New Jersey		528			14			
New Mexico	3,889	28,030	441	1,589	375,033	25,301	199,885	1,397
New York	384	19,847		3,262	23,514	853	87,698	
North Carolina	1,471	3,771	15	330	6,743	892	11,788	100
Ohio				200	200		4,691	1,976
Oklahoma						150		
Oregon	128	540	55	280	330	25	3,669	2,990
Pennsylvania		28,380		9,450	27,579	1,987	92,172	1,838
South Carolina								135
South Dakota		8,068		1,116	17,747	17,743	75,381	365
Tennessee	2,088	6,266	36	688	36,625	896	137,700	20,478
Texas							4,283	10,644
Utah	1,015	20,620	888	13,122	77,673	8,478	325,881	6,790
Vermont		900	106	350	500		15,543	
Virginia	350	6,953		1,200	17,427	1,508	68,623	4,819
Washington	72	3,916		765	17,684	4,727	25,851	1,567
West Virginia				1,100				
Wisconsin	1,354	3,066		460	7,961	5,849	37,104	36,341
Wyoming	260	3,067		2,301	65,386	202	18,962	300
Total	27,504	348,869	20,497	129,202	1,257,298	122,587	3,608,801	651,896

TABLE 22.—Exploration and development by methods and States in 1960—Con.

(Feet)

State	Method						
	Rotary drilling	Long-hole drilling	Percussion drilling	Trenching	Other	Total	Percent of total
Alabama	54,950			2,250	3,794	105,376	0.5
Alaska		2,517		23,010	5,231	97,761	.5
Arizona	212,621	38,925	791,758	13,331	510	1,722,740	8.3
Arkansas	3,530					10,733	.1
California	255,903	194,539	622,229	28,022	16,086	1,208,054	5.8
Colorado	269,283	378,454	90,332	3,010	266,137	1,752,659	8.3
Connecticut					2	1,062	(1)
Florida	106,167			11,000	8,147	137,314	.7
Georgia	72,546	50				88,946	.4
Hawaii	100,000					100,600	.5
Idaho	40,535	4,790	1,359,867	10,365	454	1,518,549	7.3
Illinois	2,313	3,500	22,500			67,207	.3
Indiana	60,000		158,412	4	1,090	229,442	1.1
Iowa	41,420				800	51,825	.3
Kansas	55,891	10			108	61,906	.3
Kentucky	14,221			2,200	1	44,657	.2
Louisiana	179,302					179,502	.9
Maine				1,000		14,833	.1
Maryland					1	2,572	(1)
Massachusetts		2,932				2,932	(1)
Michigan	2,663	45,235	7,669		2,160	504,610	2.4
Minnesota	138,377		8,473		198,860	480,721	2.3
Missouri	800,108	1,938	409,124	4,510	41,726	2,571,927	12.4
Montana	814	1,695		6,745	675	141,899	.7
Nebraska	51,000					51,000	.3
Nevada	152,270	9,227	4,550	48,850	13,825	379,656	1.8
New Jersey					18,494	19,036	.1
New Mexico	696,577	1,430,561	1,152,501	2,286	17,087	3,934,577	19.0
New York	13,900	100	16		5	149,579	.7
North Carolina	28,800			1,050		54,960	.3
Ohio	15,463		1,000		3,001	26,531	.1
Oklahoma			48,650	2,460		51,260	.3
Oregon	5,000			22,596	3,880	39,493	.2
Pennsylvania	77,501	9,637	14	300	2,126	250,984	1.2
South Carolina	70,399		200			70,734	.4
South Dakota	29,150	300		85	180	150,135	.7
Tennessee	111,412	22,247	41,263		202,968	582,667	2.8
Texas	219,560		79,000		4,749	318,236	1.5
Utah	75,419	72,819	68,171	3,080	18,297	692,253	3.4
Vermont	5,445	6,500		240		29,584	.2
Virginia	108,673	110	110			209,773	1.0
Washington		101,307	11,580	1,270	26,119	194,858	1.0
West Virginia	1,283					2,383	(1)
Wisconsin	11,116	7,128	10,426	444	200	121,449	.6
Wyoming	2,132,023	32,311	3,000	8,070	20,067	2,285,949	11.0
Total	6,215,635	2,366,832	4,890,845	196,178	876,780	20,712,924	100.0

[1] Less than 0.05 percent.

TABLE 23.—Exploration and development by methods and selected metals in 1961

(Feet)

Metal	Shaft sinking	Raising	Winzing	Tunneling	Drifting	Crosscutting	Diamond drilling	Churn drilling
Beryllium	120	610	40	400	5,489	230	8,376	
Copper	5,584	90,455	425	1,083	182,746	6,041	615,487	30,780
Gold:								
Lode	1,936	19,119	455	5,131	54,172	3,610	161,597	2,142
Placer	112	200		1,036	315	235		6,014
Iron ore	1,905	86,754		16,589	143.394	10,960	386,752	51,367
Lead	1,885	13,034	623	3,034	60,425	8,378	542,373	110,228
Manganese ore		330			475		425	200
Mercury	192	3,529	313	1,022	3,822	826	2,776	6,494
Molybdenum	423	417		6	24,957	513	55,208	360
Nickel							5,350	5,410
Rare-earth metals and thorium				420				800
Silver	3,387	6,317	25	3,153	26,129	5,338	26,719	650
Titanium							3,165	
Tungsten	110	7,331		3,107	9,583	620	18,322	
Uranium and vanadium	6,518	33,892	2,035	13,447	331,454	196,094	541,355	111,126
Zinc	1,480	26,718	2,447	3,959	79,805	7,194	187,914	60,826
Other [1]	60			2			12,988	16,708
Total	23,712	288,706	6,363	52,389	922,766	240,039	2,568,807	403,105

	Rotary drilling	Long-hole drilling	Percussion drilling	Trenching	Other	Total	Percent of total
Beryllium	49,929	4,200	200	6,878		76,472	0.3
Copper	138,767	26,008	1,407	3,109	2,820	1,104,712	4.7
Gold:							
Lode	4,434	42,442	5,337,742	4,034	15,160	5,651,974	24.3
Placer	1,384	30		13,637	2,340	25,303	.1
Iron ore	589,565	384,493	314,756	920	265,414	2,252,869	9.7
Lead	39,004	12,376	532,898	6,278	33,397	1,363,933	5.9
Manganese ore	1,000	1.200	460			4,090	
Mercury	2,105	10,125	616	500		32,320	.1
Molybdenum		542,108	1,972,409	600	39,115	2,636,116	11.3
Nickel				1,300		12,060	.1
Rare-earth metals and thorium				140		1.360	
Silver		3,375	1,500	9,050	582	86,225	.4
Titanium	36,318					39,483	.2
Tungsten		91,453	559,130	300		689.956	3.0
Uranium and vanadium	2,141,690	1,972,923	1,994,049	26,240	290,062	7,660,885	32.9
Zinc		95,919	995,307		150,301	1,611,870	6.9
Other [1]	6,963					36,721	.1
Total	3,011,159	3,186,652	11,710,474	72,986	799,191	23,286,349	100.0

[1] Antimony, bauxite, cobalt, and platinum-group metals.

TABLE 24.—Exploration and development by methods and selected nonmetals in 1961

(Feet)

Nonmetals	Shaft sinking	Raising	Winzing	Tunneling	Drifting	Crosscutting	Diamond drilling	Churn drilling
Asbestos							5,109	
Barite		490		3,517	380	32		8,384
Boron minerals		150			500	150	731	
Clays	129	96		5,390	2,250	400	72,222	2,700
Feldspar					130		1,604	
Fluorspar	606	1,015			3,588		28,021	350
Gypsum	265	2,000		7,550	7,500	2,000	14,564	
Mica:								
Scrap	15	70			240			
Sheet	500			725	365	251	300	
Phosphate rock		4,316	500	422	11,567	1,554	3,821	525
Potassium salts	946				295,288		4,337	
Pumice								
Pyrites				50			1,266	
Salt	1,092				2,000	575		4,850
Sodium carbonate (natural)	1,700				25,832			
Stone	40	4,143		9,625	11,920	2,283	138,858	186,925
Sulfur:								
Frasch-process mines								
Other mines								
Talc, soapstone, and pyrophyllite	100	3,747		1,552	2,917	543	600	
Other [1]		90		180	120	2,000	4,890	
Total	5,393	16,117	500	29,011	364,597	9,788	276,323	203,734

Nonmetals	Rotary drilling	Long-hole drilling	Percussion drilling	Trenching	Other	Total	Percent of total
Asbestos	904			35,800	3,500	45,313	0.8
Barite	8,892		100	5,400	13,831	41,026	.7
Boron minerals	8,061					9,592	.2
Clays	1,325,226	1,500	1,142	4,255	186,844	1,602,154	27.1
Feldspar	18,075		60,000	24	2,000	81,833	1.4
Fluorspar	9,765	1,000	150	1,300		45,795	.8
Gypsum	379,427		51,268			474,574	8.0
Mica:							
Scrap				60		385	
Sheet				285		2,426	.1
Phosphate rock	200,252			7,955	544	231,456	3.9
Potassium salts	56,069					356,640	6.0
Pumice					2,000	2,000	
Pyrites						1,316	
Salt	33,131					41,648	.7
Sodium carbonate (natural)						27,532	.5
Stone	1,225,572	357,861	497,309	15,130	12,913	2,462,579	41.7
Sulfur:							
Frasch-process mines	157,642					157,642	2.7
Other mines	2,191					2,191	
Talc, soapstone, and pyrophyllite		2,400	75,000			86,859	1.5
Other [1]	5,597		218,719	1,380		232,976	3.9
Total	3,430,804	362,761	913,688	71,589	221,632	5,905,937	100.0

[1] Aplite, diatomite, greensand marl, magnesite, olivine, perlite, vermiculite, and wollastonite.

TABLE 25.—Exploration and development by methods and States in 1961

(Feet)

State	Shaft sinking	Raising	Winzing	Tunneling	Drifting	Crosscutting	Diamond drilling	Churn drilling
Alabama	60						23,678	5,201
Alaska	111	1,804	4	42	623		62,849	5,304
Arizona	3,756	83,591	280	4,074	153,564	21,539	453,274	28,672
Arkansas		450		3,257	368	32		
California	1,357	10,555	638	4,790	16,791	5,909	72,472	6,345
Colorado	5,792	14,684	1,277	9,532	137,924	6,571	529,212	4,907
Connecticut							500	26,277
Florida							3,892	2,000
Georgia	100			2,600			500	114,500
Hawaii								1,012
Idaho	2,962	11,287	2,015	722	28,607	12,731	45,584	
Illinois	406	1,100	200	700	3,040	250	26,343	9,065
Indiana				6,000		2,000	16,257	692
Iowa							3,054	358
Kansas							1,000	
Kentucky				1,570	1,148		13,659	350
Louisiana	264							
Maine							13,867	
Massachusetts							180	
Michigan	3,040	53,561		13,981	114,399	3,388	101,773	10
Minnesota		2,459			10,119	502	85,864	16,698
Mississippi								
Missouri	842	1,484		7	30,842		662,851	154,046
Montana	1,147	3,044	754	2,521	15,391	2,153	6,018	
Nebraska							10	
Nevada	1,251	1,542	224	1,474	10,403	686	40,797	9,235
New Hampshire	105			40	65	30		
New Jersey		228			855	665	625	
New Mexico	447	24,600	456	1,461	482,608	174,374	84,259	108,147
New York	360	12,949		4,894	14,339	944	52,133	80
North Carolina	495	3,967		3,782	3,742	753	4,270	
North Dakota								
Ohio	828				2,200	575	14,856	1,264
Oregon		75			1,567	210	1,130	5,410
Pennsylvania		24,858		7,980	24,145	1,214	91,884	16,128
South Carolina								
South Dakota		10,203		670	33,306		92,757	
Tennessee	43	5,152	27	1,400	32,852		66,895	14,988
Texas							1,130	3,000
Utah	2,969	16,370	988	5,591	73,004	6,855	153,445	850
Vermont	69	1,900		450	500		6,509	
Virginia	250	6,453		700	19,935	900	77,531	4,725
Washington		4,389		250	19,769	827	30,046	
West Virginia								
Wisconsin	271	2,456		1,522	8,095	6,020	672	67,345
Wyoming	2,180	5,662		1,390	47,162	699	3,354	230
Total	29,105	304,823	6,863	81,400	1,287,363	249,827	2,845,130	606,839

TABLE 25.—Exploration and development by methods and States in 1961—Con.

(Feet)

State	Rotary drilling	Long-hole drilling	Percussion drilling	Trenching	Other	Total	Percent of total
Alabama	60				39,895	68,894	0.2
Alaska		3,783		8,152	2,500	85,172	.3
Arizona	251,567	48,052	7,709	3,284	100	1,059,462	3.6
Arkansas	4,500					8,607	
California	117,256	158,172	633,055	52,330	19,146	1,098,816	3.8
Colorado	351,262	778,285	2,103,518	26,026	190,595	4,159,585	14.2
Connecticut				20		26,797	.1
Florida	36,470			4,500	2,844	49,706	.2
Georgia	318,239	600			27,773	464,312	1.6
Hawaii	53,000				20	54,032	.2
Idaho	85,103	9,337	1,445,588	5,870	146,025	1,795,831	6.2
Illinois	922	3,744			6	45,776	.2
Indiana	444		214,766		6,290	246,449	.8
Iowa	45,219				2,000	50,631	.2
Kansas	72,656					73,656	.2
Kentucky	216.065	18		1,600		234,410	.8
Louisiana	147,901					148,165	.5
Maine						13,867	
Massachusetts						180	
Michigan	232,346	384,193	309,918			1,216,609	4.2
Minnesota	29,847	300	3,531		221,418	370,738	1.3
Miss'ssippi	500					500	
Missouri	1,347,271	650	19,020	5,000	49,819	2,271,832	7.8
Montana		5,250	430	6,820	260	43,788	.1
Nebraska	4,636					4,646	
Nevada	235,178	9,063	251,199	4,671	4,644	570,367	2.0
New Hampshire				30		270	
New Jersey	32,460					34,833	.1
New Mexico	631,221	1,538,683	1,513,732	940	41,796	4,602,724	15.8
New York	70,544	29			2,100	158,372	.5
North Carolina	237,495		60,560	2,115		317,179	1.1
North Dakota	8,500					8,500	
Ohio	7,677	40		5		27,445	.1
Oregon	1,150	76,000	52,504	3,748	5,850	147,644	.5
Pennsylvania	6,750	237,378	113,661		510	524,508	1.8
South Carolina	53,039			80		53,119	.2
South Dakota	6,100	5,612	4,782,299	222	2,000	4,933,169	16.9
Tennessee	159,818	4,081	66,162	6,255	153,628	511,301	1.8
Texas	246,736		10,948		1,500	263,314	.9
Utah	144,393	93,508	5,453	6,760	45,163	555,349	1.9
Vermont		1,800	75,000		2,217	88,445	.3
Virginia	79,004	250	10,000	300		200,048	.7
Washington	2,518	80,461	516,528	5,147	731	660,666	2.3
West Virginia		14				14	
Wisconsin	155,587	4,278	74,967		322	321,535	1.1
Wyoming	1,048,529	105,832	353,614	700	51,671	1,621,023	5.5
Total	6,441,963	3,549,413	12,624,162	144,575	1,020,823	29,192,286	100.0

TABLE 26.—Exploration and development of barite, by States

State	1960		1961	
	Feet	Percent of total	Feet	Percent of total
Arkansas	5,403	7.0	4,107	10.0
Georgia	15,000	19.3	15,000	36.6
Idaho	3,800	4.9		
Missouri	8,668	11.1	19,215	46.8
New Mexico	460	.6		
Tennessee	39,152	50.3		
Texas	4,000	5.1		
Other [1]	1,345	1.7	2,704	6.6
Total	77,828	100.0	41,026	100.0

[1] California, Montana, Nevada, and Washington (1961).

TABLE 27.—Exploration and development of copper, by States

State	1960		1961	
	Feet	Percent of total	Feet	Percent of total
Arizona	674,911	56.1	833,104	75.4
California	21,145	1.8	16,978	1.5
Colorado	14,026	1.2	2,105	.2
Michigan	83,474	6.9	43,771	4.0
Minnesota	23,442	1.9		
Montana	98,591	8.2	1,409	.1
Nevada	92,219	7.7	17,130	1.6
New Mexico	71,129	5.9	51,025	4.6
North Carolina	7,762	.6	2,803	.2
Tennessee	46,450	3.9	45,085	4.1
Utah	36,378	3.0	84,701	7.7
Wisconsin	32,841	2.7		
Other [1]	1,264	.1	6,601	.6
Total	1,203,632	100.0	1,104,712	100.0

[1] Idaho, Maine, Washington, and Wyoming (1961).

TABLE 28.—Exploration and development of iron ore, by States

State	1960		1961	
	Feet	Percent of total	Feet	Percent of total
Alabama	83,877	5.2	65,493	2.9
Alaska	28,876	1.8	18,488	.8
Arizona			17,490	.8
California	5,000	.3	28,480	1.3
Michigan	411,603	25.7	926,290	41.1
Minnesota	359,279	22.4	342,378	15.2
Missouri	127,756	8.0	602,034	26.7
Nevada	110,000	6.9	36,495	1.6
New York	24,332	1.5	7,175	.3
Pennsylvania	111,422	7.0	93,067	4.1
Texas	48,721	3.0	69,176	3.1
Utah	245,680	15.3	4,374	.2
Wisconsin	30,977	1.9	19,775	.9
Wyoming	14,284	.9	16,063	.7
Other [1]	1,882	.1	6,091	.3
Total	1,603,689	100.0	2,252,869	100.0

[1] Colorado, New Jersey, North Carolina (1960), South Dakota, and Virginia (1961).

TABLE 29.—Exploration and development of lead and zinc, by States

State	1960		1961	
	Feet	Percent of total	Feet	Percent of total
Arizona	23,907	0.7	13,818	0.5
Colorado	39,667	1.2	38,576	1.3
Idaho	1,390,645	42.0	1,643,445	55.2
Illinois	10,203	.3	18,605	.6
Kansas	4,931	.2		
Missouri	1,141,034	34.5	686,104	23.1
Montana	13,630	.4	9,258	.3
Nevada	54,487	1.7	34,417	1.1
New Mexico	34,072	1.0	26,372	.9
New York	58,310	1.8	47,587	1.6
North Carolina	6,646	.2		
Pennsylvania	10,560	.3	19,691	.7
Tennessee	203,189	6.1	135,553	4.5
Utah	126,886	3.8	82,889	2.8
Virginia	35,553	1.1	68,992	2.3
Washington	113,780	3.4	89,334	3.0
Wisconsin	40,499	1.2	58,955	2.0
Other [1]	3,220	.1	2,207	.1
Total	3,311,219	100.0	2,975,803	100.0

[1] Alaska (1960), Arkansas (1960), California, New Jersey (1961), and Oregon (1961).

TABLE 30.—Exploration and development of phosphate rock, by States

State	1960		1961	
	Feet	Percent of total	Feet	Percent of total
Florida	8,979	6.1	18,911	8.2
Idaho	48,840	33.4	76,285	32.9
Montana	17,179	11.7	14,360	6.2
Tennessee	60,000	41.0	116,780	50.5
Utah	11,366	7.8	5,120	2.2
Total	146,364	100.0	231,456	100.0

TABLE 31.—Exploration and development of sulfur, by States

State	1960		1961	
	Feet	Percent of total	Feet	Percent of total
California	919	0.4	2,191	1.4
Louisiana	179,302	74.8	144,101	90.1
Texas	59,421	24.8	13,541	8.5
Total	239,642	100.0	159,833	100.0

TABLE 32.—Exploration and development of uranium, by States

State	1960		1961	
	Feet	Percent of total	Feet	Percent of total
Arizona	1,004,450	11.5	188,392	2.5
Colorado	1,463,553	16.8	1,486,329	19.4
New Mexico	3,769,535	43.3	4,152,242	54.2
South Dakota	31,956	.4	6,770	.1
Utah	251,833	2.9	280,295	3.7
Wyoming	2,147,891	24.7	1,520,466	19.8
Other [1]	32,500	.4	25,191	.3
Total	8,701,718	100.0	7,659,685	100.0

[1] California, Idaho, Montana (1960), Nevada, Oregon, and Washington.

TABLE 33.—Exploration and development in Alaska, by methods

(Feet)

Method	Gold, lode	Gold, placer	Iron ore	Mercury	Other [1]	Total
1960:						
Shaft sinking		92		78		170
Raising	95			3,879		3,974
Tunneling	20					20
Drifting	695			782	700	2,177
Crosscutting	755			227		982
Diamond drilling	17,024		24,081		12,450	53,555
Churn drilling		1,330	4,795			6,125
Long-hole drilling				2,517		2,517
Percussion drilling	1,040	1,420		18,200	2,350	23,010
Other				5,231		5,231
Total	19,629	2,842	28,876	30,914	15,500	97,761
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

[1] Antimony (1961), lead (1960), molybdenum (1961), nickel, platinum-group metals, silver (1960), and stone.
[2] Includes winzing.

TABLE 34.—Exploration and development in Arizona, by methods

(Feet)

Method	Copper	Gold	Lead-zinc	Uranium	Other [1]	Total
1960:						
Shaft sinking	4,522	135	534	782	70	6,043
Raising	63,487	80	1,552	2,604	270	67,993
Winzing				45	31	76
Tunneling	100	1,060	585	4,056	1,623	7,424
Drifting	126,167	145	5,784	11,658	281	144,035
Crosscutting	2,620		3,957	3,343		9,920
Diamond drilling	354,779		11,495	7,247	211	373,732
Churn drilling	56,372					56,372
Rotary drilling	62,755			149,866		212,621
Long-hole drilling	1,876			37,049		38,925
Percussion drilling	873	85		787,800	3,000	791,758
Trenching	850				12,481	13,331
Other	510					510
Total	674,911	1,505	23,907	1,004,450	17,967	1,722,740
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	100					100
Total	833,104	3,674	13,818	188,392	20,474	1,059,462

[1] Asbestos (1960), beryllium (1960), feldspar (1961), iron ore (1961), mercury (1960), rare-earth metals and thorium (1961), silver (1961), stone, and tungsten.

TABLE 35.—Exploration and development in California, by methods

(Feet)

Method	Asbestos	Clays	Copper	Gold, lode and placer	Lead-zinc	Mercury	Potash, soda, and borate minerals	Stone	Talc, soapstone, and pyrophyllite	Tungsten	Uranium	Other [1]	Total
1960:													
Shaft sinking				1,059		208			40		21	25	1,353
Raising			1,150	3,122	150	142	208			3,443	6		8,221
Winzing				140	30	7			150				327
Tunneling			420	2,245		850		840	95		250	120	4,820
Drifting			600	3,609	240	2,352	230	380	80	4,192	40		11,723
Crosscutting			900	585		985	330	349		46	20	30	3,245
Diamond drilling	12,000		5,575	400		5,700	1,145	5,907	1,500	15,104	22	8,668	56,021
Churn drilling		200	800	865								3,700	5,565
Rotay drilling	8,000	6,550	9,800	60		9,300	5,916	116,226			3,200	96,851	255,903
Long-hole drilling		7,500	1,900	668		1,433		32,373		150,620		45	194,539
Percussion drilling				73,260				98,069		450,900			622,229
Trenching	15,950			4,495		6,312		200	300		440	325	28,022
Other	8,380			956		50		2,500				4,200	16,086
Total	44,330	14,250	21,145	91,464	420	27,339	7,829	256,844	2,165	624,305	3,999	113,964	1,208,054
1961:													
Shaft sinking		60	310	748	75	69		40				55	1,357
Raising		96	2,440	1,885	50	1,093	150	990	300	3,506		45	10,555
Winzing				237	95	301						5	638
Tunneling			563	2,308	100	967		475	159			218	4,790
Drifting		1,050	1,260	2,762	165	2,871	500	242	762	7,082		97	16,791
Crosscutting			410	2,021	40	426	150	289	100	213	200	2,060	5,909
Diamond drilling	800	7,819	10,945	853		2,776	731	890		16,052		31,606	72,472
Churn drilling				4,812		608						925	6,345
Rotary drilling	904	8,206	300	384		505	8,061	21,233			20,000	57,563	117,156
Long-hole drilling		1,500	750	560	110	3,799		60,000		91,453			158,172
Percussion drilling				72,165				2,300		558,570		20	633,055
Trenching	35,500			3,560	40	400		10,530			910	1,390	52,330
Other	3,500			15,616	30								19,146
Total	40,704	18,731	16,978	107,911	705	13,815	9,592	96,989	1,321	676,876	21,110	93,984	1,098,716

[1] Barite, beryllium, diatomite, gypsum, iron ore, mica, pumice (1960), pyrites, rare-earth metals and thorium, salt (1961), silver (1961), sulfur (1961), and zirconium (1960).

TABLE 36.—Exploration and development in Colorado, by methods

(Feet)

Method	Beryllium	Clays	Copper	Gold, lode and placer	Lead-zinc
1960:					
Shaft sinking			10	114	25
Raising			107	1,657	6,569
Winzing				45	120
Tunneling	90	1,073	4,670	235	953
Drifting	170	600	757	5,593	12,964
Crosscutting	70		1,032	208	2,502
Diamond drilling		245	7,073	1,708	12,067
Churn drilling					
Rotary drilling		2,218			
Long-hole drilling			337	50	480
Percussion drilling				346	
Trenching	415	200	40		
Other				3,076	3,987
Total	745	4,336	14,026	13,032	39,667
1961:					
Shaft sinking	120		25	245	56
Raising	340		215	1,795	5,234
Winzing	40			44	150
Tunneling		190		705	1,625
Drifting	510	1,000	615	5,127	14,227
Crosscutting			85	266	2,828
Diamond drilling		268		1,180	9,755
Churn drilling					105
Rotary drilling				1,000	
Long-hole drilling	4,200		1,000	174	3,106
Percussion drilling	200			560	750
Trenching	1,300		165	1,156	740
Other					
Total	6,710	1,458	2,105	12,252	38,576

Method	Molybdenum	Stone	Uranium	Other [1]	Total
1960:					
Shaft sinking	329		1,303	114	1,895
Raising	367	320	3,633	743	13,396
Winzing			373		538
Tunneling	250		9,725	20	17,016
Drifting	8,924	403	84,099	3,187	116,697
Crosscutting			7,561	800	12,173
Diamond drilling	15,085		540,595	1,094	577,867
Churn drilling			5,861		5,861
Rotary drilling		750	264,474	1,841	269,283
Long-hole drilling	181,913	520	195,154		378,454
Percussion drilling			89,986		90,332
Trenching		100	1,715	540	3,010
Other			259,074		266,137
Total	206,868	2,093	1,463,553	8,339	1,752,659
1961:					
Shaft sinking	423		4,813	110	5,792
Raising	185	350	6,350	215	14,684
Winzing			1,023	20	1,277
Tunneling			5,229	1,903	9,652
Drifting	21,957	350	93,736	402	137,924
Crosscutting		80	3,193	119	6,571
Diamond drilling	23,000	2,564	490,680	1,765	529,212
Churn drilling			4,802		4,907
Rotary drilling		1,160	346,202	2,900	351,262
Long-hole drilling	542,108	700	226,997		778,285
Percussion drilling	1,972,409		129,299	300	2,103,518
Trenching			22,525	180	26,066
Other	39,115		151,480		190,595
Total	2,599,197	5,204	1,486,329	7,914	4,159,745

[1] Fluorspar (1960), gypsum, iron ore, mica (1960), pyrites, rare-earth metals and thorium, silver (1961), and tungsten (1961).

TABLE 37.—Exploration and development in Idaho, by methods

(Feet)

Method	Copper	Gold, lode and placer	Lead	Phosphate rock	Silver
1960:					
Shaft sinking		95	50		175
Raising	20	200	2,883		4,354
Winzing	20		55		
Tunneling	33	462	1,279		
Drifting		442	6,328		6,589
Crosscutting		216	4,488		4,741
Diamond drilling			10,105	3,800	14,667
Churn drilling			500	19,300	
Rotary drilling				23,940	
Long-hole drilling		125	2,285		1,175
Percussion drilling		50	525,994		
Trenching		1,515	100	1,800	100
Other		107	140		207
Total	73	3,212	554,207	48,840	32,008
1961:					
Shaft sinking		40	105		2,817
Raising		220	2,895		5,937
Winzing			40		
Tunneling	100	135	57		430
Drifting	300	365	7,423		14,362
Crosscutting		110	6,817		4,910
Diamond drilling	400	300	11,135	3,000	22,754
Churn drilling					
Rotary drilling				71,885	
Long-hole drilling	600		5,139		1,875
Percussion drilling			532,469		
Trenching		540		1,400	3,430
Other		450	130		132
Total	1,400	2,160	566,210	76,285	56,647

	Uranium	Zinc	Other [1]	Total
1960:				
Shaft sinking				320
Raising		1,973		9,430
Winzing		240		315
Tunneling		86	90	1,950
Drifting	646	3,291		17,296
Crosscutting		1,759		11,204
Diamond drilling		8,801	1,050	38,423
Churn drilling			3,800	23,600
Rotary drilling	595		16,000	40,535
Long-hole drilling	300	905		4,790
Percussion drilling		819,383	14,440	1,359,867
Trenching			6,850	10,365
Other				454
Total	1,541	836,438	42,230	1,518,549
1961:				
Shaft sinking				2,962
Raising	80	2,115	40	11,287
Winzing		1,975		2,015
Tunneling				722
Drifting	180	5,947	30	28,607
Crosscutting		764	130	12,731
Diamond drilling		7,995		45,584
Churn drilling				
Rotary drilling			13,218	85,103
Long-hole drilling	100	1,623		9,337
Percussion drilling		911,503	1,616	1,445,588
Trenching	500			5,870
Other		145,313		146,025
Total	860	1,077,235	15,034	1,795,831

[1] Barite (1960), clays, mercury, mica (1960), pumice (1960), rare-earth metals and thorium (1960), stone, and tungsten (1961).

TABLE 38.—Exploration and development in Missouri, by methods

(Feet)

Method	Clay	Iron ore	Lead-zinc	Stone	Other [1]	Total
1960:						
Shaft sinking		2,007	118			2,125
Raising		34	1,004			1,038
Tunneling		152		1,000		1,152
Drifting		2,656	38,100			40,756
Crosscutting		1,205				1,205
Diamond drilling	72,351	83,149	773,531	15,103		944,134
Churn drilling	11,626	34,043	277,430	1,012		324,111
Rotary drilling	772,881		15,871	11,356		800,108
Long-hole drilling			1,898	40		1,938
Percussion drilling			1,104	408,020		409,124
Trenching		4,510				4,510
Other			31,978	1,080	8,668	41,726
Total	856,858	127,756	1,141,034	437,611	8,668	2,571,927
1961:						
Shaft sinking		842				842
Raising		297	1,187			1,484
Tunneling		7				7
Drifting		196	30,646			30,842
Crosscutting						
Diamond drilling	62,210	77,723	509,930		12,988	662,851
Churn drilling		31,068	108,413	107	14,458	154,046
Rotary drilling	853,000	490,000	2,791	1,480		1,347,271
Long-hole drilling				650		650
Percussion drilling				19,020		19,020
Trenching					5,000	5,000
Other		1,901	33,137	950	13,831	49,819
Total	915,210	602,034	686,104	22,207	46,277	2,271,832

[1] Barite and cobalt (1961).

TABLE 39.—Exploration and development in New Mexico, by methods

(Feet)

Method	Copper	Gold	Lead	Molybdenum	Potash
1960:					
Shaft sinking	232	90	345		990
Raising	1,789		39	121	
Winzing	421				
Tunneling	20	27	752		
Drifting	2,655	38		3,084	800
Crosscutting	235			1,542	
Diamond drilling	60,535			9,193	14,000
Churn drilling			897		
Rotary drilling	5,142				26,000
Long-hole drilling			600		
Percussion drilling					
Trenching	100	80			
Other					
Total	71,129	235	2,633	13,940	41,790
1961:					
Shaft sinking	314	17	40		
Raising	1,381			232	
Winzing	300		14		
Tunneling	215	82	185		
Drifting	3,421		30	3,000	295,288
Crosscutting	143		750	513	
Diamond drilling	41,943	2,300		15,318	2,925
Churn drilling	2,053				
Rotary drilling	655				40,705
Long-hole drilling	250		2,500		
Percussion drilling	300		429		
Trenching	50	385	80		
Other					
Total	51,025	2,784	4,028	19,063	338,918

	Uranium	Zinc	Other [1]	Total
1960:				
Shaft sinking	2,217		15	3,889
Raising	23,904	2,147	30	28,030
Winzing			20	441
Tunneling	640		150	1,589
Drifting	364,911	2,795	750	375,033
Crosscutting	23,060	279	185	25,301
Diamond drilling	94,511	20,976	670	199,885
Churn drilling	500			1,397
Rotary drilling	665,435			696,577
Long-hole drilling	1,427,520	2,441		1,430,561
Percussion drilling	1,149,700	2,801		1,152,501
Trenching	50		2,056	2,286
Other	17,087			17,087
Total	3,769,535	31,439	3,876	3,934,577
1961:				
Shaft sinking		56	20	447
Raising	22,215	772		24,600
Winzing	142			456
Tunneling	579		400	1,461
Drifting	179,593	1,276		482,608
Crosscutting	172,295	473	200	174,374
Diamond drilling	3,696	16,577	1,500	84,259
Churn drilling	106,094			108,147
Rotary drilling	589,861			631,221
Long-hole drilling	1,535,819	114		1,538,683
Percussion drilling	1,499,927	3,076	10,000	1,513,732
Trenching	225		200	940
Other	41,796			41,796
Total	4,152,242	22,344	12,320	4,602,724

[1] Barite (1960), beryllium, manganese ore (1960), perlite (1961), pumice (1960), rare-earth metals and thorium (1960), silver, and stone (1961).

TABLE 40.—Exploration and development in Utah, by methods

(Feet)

Method	Clays	Copper	Fluorspar	Iron ore	Lead-zinc
1960:					
Shaft sinking			50		368
Raising	100	200	220		9,937
Winzing		6	50		547
Tunneling					1,641
Drifting	384	6	420		31,560
Crosscutting	371	40			3,436
Diamond drilling		34,096	1,500	240,500	19,007
Churn drilling	5,000				450
Rotary drilling		1,970		5,180	10,324
Long-hole drilling					7,304
Percussion drilling					30,242
Trenching		60	1,000		1,090
Other					10,980
Total	5,855	36,378	3,240	245,680	126,886
1961:					
Shaft sinking					853
Raising		100			10,563
Winzing		6			332
Tunneling					2,047
Drifting			100		22,716
Crosscutting					1,603
Diamond drilling		84,135		3,042	15,259
Churn drilling	200				
Rotary drilling			100	1,332	12,183
Long-hole drilling					17,333
Percussion drilling					
Trenching		460			
Other					
Total	200	84,701	200	4,374	82,889

	Phosphate rock	Stone	Uranium	Other [1]	Total
1960:					
Shaft sinking			577	20	1,015
Raising	8,489		1,599	75	20,620
Winzing			285		888
Tunneling			11,421	60	13,122
Drifting	2,877	11	42,355	60	77,673
Crosscutting			4,631		8,478
Diamond drilling		5,921	24,857		325,881
Churn drilling			1,340		6,790
Rotary drilling			53,657	4,288	75,419
Long-hole drilling			65,515		72,819
Percussion drilling			37,929		68,171
Trenching		580	350		3,080
Other			7,317		18,297
Total	11,366	6,512	251,833	4,503	692,253
1961:					
Shaft sinking			1,170	946	2,969
Raising	3,707		1,925	75	16,370
Winzing			650		988
Tunneling			2,964	580	5,591
Drifting	1,413		39,524	9,251	73,004
Crosscutting			5,252		6,855
Diamond drilling		2,187	39,034	9,788	153,445
Churn drilling				650	850
Rotary drilling			64,985	65,793	144,393
Long-hole drilling			75,675	500	93,508
Percussion drilling		2,000	3,453		5,453
Trenching			500	5,800	6,760
Other			45,163		45,163
Total	5,120	4,187	280,295	93,383	555,349

[1] Asbestos (1961), beryllium (1961), gold (1960), gypsum, potash (1961), and silver (1961).

TABLE 41.—Exploration and development in Wyoming, by methods

(Feet)

Method	Bentonite	Iron ore	Stone	Uranium	Other [1]	Total
1960:						
Shaft sinking				260		260
Raising		1,486	1,000	581		3,067
Tunneling		636		1,665		2,301
Drifting		5,026	850	17,746	41,764	65,386
Crosscutting		27		175		202
Diamond drilling	1,400	7,109		10,453		18,962
Churn drilling				300		300
Rotary drilling	45,163		13,030	2,073,830		2,132,023
Long-hole drilling				32,311		32,311
Precussion drilling				3,000		3,000
Trenching	200			7,570	300	8,070
Other	20,067					20,067
Total	66,830	14,284	14,880	2,147,891	42,064	2,285,949
1961:						
Shaft sinking				480	1,700	2,180
Raising		3,849	900	913		5,662
Tunneling				1,390		1,390
Drifting		9,029	1,000	11,301	25,832	47,162
Crosscutting		205		494		699
Diamond drilling		2,980		374		3,354
Churn drilling				230		230
Rotary drilling	54,814			993,715		1,048,529
Long-hole drilling				105,832		105,832
Percussion drilling				353,614		353,614
Trenching				500	200	700
Other			48	51,623		51,671
Total	54,814	16,063	1,948	1,520,466	27,732	1,621,023

[1] Beryllium, copper (1961), gold, mica (1960), silver (1960), and sodium carbonate (natural).

FROTH FLOTATION [2]

The growth of flotation in the United States was measured by data collected for 1960, the 50th anniversary of froth flotation. Similar data previously were compiled in 1935 [3] and 1930–34 [4] but were limited to copper, copper-lead, lead, lead-zinc, zinc, and gold and silver ores, whereas the 1960 data included 34 commodities. In 1960, 198 million tons of material was treated at 202 froth flotation plants; in 1935, 26.1 million tons was treated at 184 plants using flotation alone or a combination of gravity-flotation methods.

The quantity of sulfide ore concentrated in 1960 (155.4 million tons) was about 6 times the 1935 total (26.1 million tons). The major part of the increase in treated ore resulted from installing large flotation plants for concentrating low-grade copper ores. For example, copper ore production rose from 20 million tons in 1935 to 135 million tons in 1960. Of the 20 million tons produced in 1935, 83 percent was concentrated—90 percent by straight flotation and the remainder by combined gravity-flotation methods. In 1960, 99.5 percent of the 135 million tons was concentrated, virtually all by

[2] Merrill, Charles W., and James W. Pennington, The Magnitude and Significance of Flotation in the Mineral Industries of the United States. AIME, 50th Anniversary of Froth Flotation in the United States. (Scheduled for publication in 1962).

[3] Miller, T. H., and R. L. Kidd. Ore Concentration in 1935. Manuscript Rept. 2, BuMines, April 1937, 30 pp. Available only in the U.S. Dept. of the Interior Library, Washington, D.C., and BuMines libraries. San Francisco, Calif., and Pittsburgh, Pa.

Weinig, Arthur J., and Clark B. Carpenter. The Trend of Flotation. Colorado School of Mines Quarterly, v. 32, No. 4, October 1937, pp. 27–48.

[4] Miller, T. H. and R. L. Kidd. Ore Concentration. Ch. in BuMines Minerals Yearbook 1935, Statistical Appendix, 1936, pp. 47–62.

TABLE 42.—Froth flotation plants in the United States, by States in 1960

State	Number	State	Number
Alabama	6	New Jersey	3
Arizona	20	New Mexico	12
Arkansas	2	New York	6
California	10	North Carolina	8
Colorado	13	Ohio	2
Florida	14	Oklahoma	1
Georgia	2	Pennsylvania	12
Idaho	12	South Carolina	3
Illinois	6	Tennessee	6
Kentucky	1	Utah	7
Maryland	3	Vermont	1
Michigan	7	Virginia	8
Minnesota	1	Washington	5
Missouri	7	West Virginia	9
Montana	5	Wisconsin	5
Nevada	4	Wyoming	1
		Total	202

TABLE 43.—Froth flotation in 1960

Type	Plants: Number	Plants: Capacity (tons per day)	Ore treated (tons)	Concentrates produced (tons)	Energy used (kilowatt-hours): Total (millions)	Energy used (kilowatt-hours): Per ton	Water used (gallons): Total (millions)	Water used (gallons): Per ton
Copper	18	158,200	44,156,140	1,520,119	693.3	15.7	41,948.3	950
Copper-molybdenum	12	297,500	95,083,900	2,235,463	1,749.5	18.4	72,263.8	760
Copper-lead-zinc	29	28,400	5,437,300	560,719	124.0	22.8	3,969.2	730
Copper-zinc-iron-sulfur	8	10,000	2,378,400	999,877	44.0	18.5	2,827.5	1,190
Gold-silver	4	1,600	132,180	3,360	2.8	21.0	142.1	1,075
Lead-zinc	25	50,700	8,195,100	537,050	109.8	13.4	4,548.3	555
Barite	5	2,500	444,100	285,392	5.8	13.0	546.2	1,230
Bastnaesite, calcite, garnet, kyanite and talc	7	2,100	466,530	113,120	7.4	16.0	793.1	1,700
Clay, feldspar, mica, quartz and spodumene	10	5,600	1,030,940	434,073	28.9	28.0	3,092.8	3,000
Fluorspar	6	2,050	484,000	179,459	24.2	50.0	677.6	1,400
Glass sand	5	3,200	799,300	735,400	2.9	3.6	959.2	1,200
Ilmenite and magnesite	4	3,200	617,300	274,875	8.7	14.1	617.3	1,000
Iron oxide	4	5,700	1,530,360	599,461	30.6	20.0	1,423.2	930
Manganese and tungsten	4	3,500	448,600	64,893	11.9	26.5	471.0	1,050
Phosphate	15	88,700	20,981,900	7,023,544	199.3	9.5	83,927.6	4,000
Potash	7	39,800	11,984,350	3,116,518	137.8	11.5	3,115.9	260
Anthracite	5	5,000	800,000	425,000	5.6	7.0	----------	------
Bituminous coal	26	21,500	3,312,000	2,370,000	23.2	7.0	----------	------
Waste paper	3	90	25,400	21,580	.3	11.1	685.0	25,000
Chicle-naphthalene-oil	5	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Total	202	729,340	198,307,800	21,499,903	3,210.0	16.2	222,008.1	1,140

[1] Data not available.

flotation alone. A striking example of the effect of efficient large-scale flotation on grade of copper ore mined is that, during the 25-year period, the average recoverable copper content of ore treated decreased from 1.57 to 0.72 percent.

In the concentration of lead and zinc ores, the part treated solely by flotation increased from 15 percent in 1935 to 40 percent in 1960. The grade of lead and zinc ores also was influenced by flotation, and the average recoverable metal content of the ores decreased from 1.95 percent lead and 3.70 percent zinc in 1935 to 1.35 percent lead and 2.68 percent zinc in 1960.

Comparison of flotation-reagent data for 1960 with those for 1935 showed tremendous differences in the number and quantity of reagents used. Almost 100 different reagents were used in 1960, compared with 35 in 1935. Also, reagent consumption in 1960 was 850.3 million pounds compared with 85.5 million pounds, in 1935. Although average reagent consumption per ton of ore rose from 3.282 to 4.297 pounds, the change was due largely to flotation of nonmetal commodities which use larger quantities than sulfide flotation and which were not reported in 1935. For sulfide flotation only, the total reagent consumption increased from 85.5 million pounds in 1935 to 544 million pounds in 1960. This was only a small change in consumption per ton, from 3.282 to 3.501 pounds, and probably resulted from more extensive use of selective flotation and increased byproduct recovery.

Flotation reagents were classified as follows:

Modifiers—reagents used to control alkalinity and to eliminate harmful effects of colloidal material and soluble salts.

Activators—reagents used to assist or improve the flotation of minerals that do not respond to a simple collector-froth combination.

Depressants—reagents used to improve the selective separation of minerals by lowering the floatability of specific minerals.

Collectors—reagents used to provide a water-repellent surface on the mineral to be floated so that adherence of the mineral to the air bubbles was improved.

Frothers—reagents used to produce a froth of adequate durability to permit removal of mineral-carrying bubbles from the flotation machine.

Flocculants—reagents used to flocculate solids in aqueous suspension and thereby facilitate thickening and filtering operations.

Whenever possible, the chemical names rather than the trade names of reagents are reported. For those reagents whose chemical compositions are unknown or too complex for simple presentation, the

TABLE 44.—Consumption of reagents by types and plants in froth flotation in 1960

Type of plant	Reagent consumption (pounds)							
	Modifiers		Activators		Depressants		Collectors	
	Total	Per ton	Total	Per ton	Total	Per ton	Total	Per ton
Copper	86,105,637	2.403			75,476	0.008	5,710,483	0.129
Copper-molybdenum	359,077,552	4.306	181,868	0.025	2,334,093	.048	17,129,028	.180
Copper-lead-zinc	11,247,321	2.514	2,598,701	.586	2,841,984	.801	1,014,868	.194
Copper-zinc-iron-sulfur	16,608,695	7.201	1,929,716	.837	507,952	.222	706,470	.297
Gold-silver	925	.250	10,148	.150	351	.043	32,145	.243
Lead-zinc	3,049,537	3.647	3,459,005	.469	348,175	.060	777,607	.102
Barite	597,262	3.602					168,413	1.016
Bastnaesite, calcite, garnet, kyanite and talc	577,380	1.945			116,160	5.500	381,039	1.067
Clay, feldspar, mica, quartz and spodumene	3,041,580	2.950			1,086,732	1.702	3,540,802	3.435
Fluorspar	1,213,042	2.506	357,033	.801	1,243,113	2.790	515,469	1.065
Glass sand	525,985	.658					1,320,865	1.653
Ilmenite and magnesite	1,064,892	1.877			306,181	.557	1,049,974	1.851
Iron oxide	4,593,996	3.002			210,600	.600	3,309,775	2.163
Manganese and tungsten	882,436	4.583	1,280,205	5.000	2,678	.230	18,188,426	40.547
Phosphate	76,500,661	3.672					155,773,582	7.504
Potash			2,630,552	.900	6,785,052	.610	2,267,207	.189
Anthracite							1,485,000	2.001
Bituminous coal	1,609,352	2.058					6,657,058	3.372
Waste paper	857,750	146.000					97,180	16.541
Total	567,554,003	3.716	12,447,228	.496	15,858,547	.191	220,125,391	1.125

Type of plant	Reagent consumption (pounds)					
	Frothers		Flocculants		Total	Per ton
	Total	Per ton	Total	Per ton		
Copper	3,595,125	0.082	13,717,450	1.560	109,204,171	2.473
Copper-molybdenum	7,214,610	.076	1,922,680	.056	387,859,831	4.079
Copper-lead-zinc	551,916	.106	9,182	.005	18,263,972	3.359
Copper-zinc-iron-sulfur	313,214	.132	50,507	.023	20,116,554	8.458
Gold-silver	9,029	.068			52,598	.398
Lead-zinc	750,383	.099	77,412	.044	8,462,119	1.035
Barite	2,640	.200	267	.050	768,582	4.635
Bastnaesite, calcite, garnet, kyanite and talc	41,860	.125			1,116,439	2.888
Clay, feldspar, mica, quartz and spodumene	1,040,865	1.010	804,378	1.747	9,514,357	9.229
Fluorspar	62,078	.128	2,710	.010	3,393,445	7.011
Glass sand	39,400	.250			1,886,250	2.360
Ilmenite and magnesite	10,089	.024	373,103	.679	2,804,239	4.943
Iron oxide					8,114,371	5.302
Manganese and tungsten	1,311,456	4.007			21,665,201	48.295
Phosphate	17,468	.012	12,780	.020	232,304,491	11.072
Potash	1,270,726	.111	54,839	.010	13,008,376	1.085
Anthracite	270,500	.338			1,755,500	2.194
Bituminous coal	314,298	.124	393,885	.321	8,974,593	2.710
Waste paper	39,528	7.200			994,458	87.502
Total	16,855,185	.097	17,419,193	.303	850,259,547	4.297

TABLE 45.—Consumption and value of reagents in froth flotation in 1960

Function and reagent	Consumption, pounds	
	Total	Per ton
Modifier:		
Caustic soda	20,613,880	00.931
Lime	461,118,435	3.650
Phosphates	1,082,550	.016
Soda ash	2,799,806	.293
Sodium silicate	5,029,312	.159
Sulfuric acid	76,101,720	3.070
Other	808,300	1.768
Total:		
Pounds	567,554,003	3.716
Value	$5,979,271	$0.039
Activator:		
Copper sulfate	7,603,710	.674
Sodium sulfide	612,212	.051
Sulfur dioxide	1,600,754	.934
Other	2,630,552	.900
Total:		
Pounds	12,447,228	.496
Value	$1,474,663	$0.059
Depressant:		
Aerodepressants (610, 620, 633)	42,991	.056
Calcium cyanide	806,285	.071
Guar	136,347	.100
Hydrofluoric acid	1,086,732	1.702
Lignin sulfonate	158,632	.161
Quebracho	426,080	1.192
Sodium cyanide	2,805,900	.052
Sodium ferrocyanide	514,467	.028
Sodium fluoride	502,381	.664
Sodium hydrosulfite	90,350	.350
Sodium silico fluoride	10,560	.500
Sodium sulfite	764,346	.630
Starch	6,888,222	.690
Tannic acid	27,812	.280
Zinc hydrosulfite	171,455	.577
Zinc sulfate	1,036,783	.296
Other	389,204	.556
Total:		
Pounds	15,858,547	.191
Value	$1,644,085	$0.020
Collector:		
Aerofloats (31, 242)	405,521	.089
Aerofloats (sodium, 208, 211, 238)	1,776,631	.032
Aeropromoters (404, 425)	383,009	.028
Aeropromoters (710,765)	389,160	1.255
Aeropromoters (801, 825, 899)	2,180,006	1.257
Amines	4,327,625	.143
Dow Z-200	579,283	.031
Fatty acids	51,377,283	2.206
Fuel oil	120,314,341	1.485
Kerosine	14,977,729	.986
Minerec	799,708	.033
Petroleum sulfonate	324,912	1.085
Sodium oleate	2,572,160	9.821
Tall oil	1,130,247	1.286
Thiocarbanilide	5,773	.088

TABLE 45.—Consumption and value of reagents in froth flotation in 1960—Con.

Function and reagent	Consumption, pounds	
	Total	Per ton
Collector—Con.		
Thionocarbamate	29,735	0.022
Potassium amyl xanthate	495,089	.044
Potassium ethyl xanthate	25,445	.091
Potassium isopropyl xanthate	2,480	.080
Potassium secondary butyl xanthate	1,968	.030
Sodium ethyl xanthate	1,734,222	.106
Sodium isopropyl xanthate	2,067,191	.045
Sodium secondary butyl xanthate	637,224	.080
Xanthates	249,553	.133
Other	13,339,096	.610
Total:		
Pounds	220,125,391	1.125
Value	$8,737,999	$0.045
Frother:		
Aerofroth 65	245,972	.017
Aerofroths (70, 73, 77)	220,145	.047
Barrett oil	452,724	.068
Creosote oil	1,250,892	.135
Cresylic acid	2,793,744	.060
Dowfroth	826,499	.025
Hardwood creosote	367,794	.080
Methyl amyl alcohol	2,952,057	.066
Methyl isobutyl carbinol	1,903,478	.048
Oleate	38,430	7.000
Oronite	1,280,205	5.000
Pine oil	4,523,245	.053
Total:		
Pounds	16,855,185	.097
Value	$2,444,635	$0.014
Flocculant:		
Aerofloes (550, 3171)	16,733	.008
Alum	4,695	.058
Guar	92,907	.060
Kylo	3,819	.024
Lime	14,731,871	2.814
Nalco 600	21,780	.060
Separan	1,066,519	.026
Starch	340,850	1.783
Sulfuric acid	1,091,600	3.165
Superfloc 16	48,419	.013
Total:		
Pounds	17,419,193	.303
Value	$1,508,752	$0.026
Total reagents:		
Pounds	850,259,547	4.297
Value	$21,789,405	$0.110

trade names are shown. Included in those categories are Aerodepressants, Aerofloats, Aerofroths, Aeropromoters, Aeroflocs, and Superflocs (products of American Cyanamid Co.); Dowfroth, Dow Z–200, and Separan (products of The Dow Chemical Co.); Kylo (product of Minnesota Mining and Manufacturing Co.); Minerec (product of the Minerec Corp.); Nalco 600 (product of Nalco Chemical Co.); and Oronite (product of Oronite Chemical Co.). Also, to avoid disclosing confidential information, some reagents are not identified but are included under "Other" classification, or the data on two or more reagents are combined.

Operating flotation plants used 3,210 million kilowatt-hours of energy, an average of 16.2 kilowatt-hours per ton of material treated. Energy consumption included all that necessary to service the plants, such as crushing, grinding, classification, flotation, filtering, and materials handling.

Water used in the plants totaled 222 billion gallons and averaged 1,140 gallons per ton of raw material. The figures are for total water used and include recirculated and makeup water.

The Bureau of Mines plans to canvass froth-flotation plants at 5-year intervals in subsequent years and to compare results with the 1960 data.

TABLE 46.—Materials treated and reagents consumed in froth flotation, by Eastern States in 1960

Function and reagent	Alabama, Florida, Georgia		Kentucky, Virginia, West Virginia		Maryland, Ohio, Pennsylvania		North Carolina, South Carolina, Tennessee		New Jersey, New York, Vermont	
	Ore treated (tons)	Reagents used (pounds)	Ore treated (tons)	Reagents used (pounds)	Ore treated (tons)	Reagents used (pounds)	Ore treated (tons)	Reagents used (pounds)	Ore treated (tons)	Reagents used (pounds)
Modifier:										
Caustic soda	20,362,818	18,890,430	(1)	(1)	(1)	(1)	(1)	(1)		
Lime			233,684	100,758	(1)	(1)	1,746,890	4,062,416	799,851	2,134,564
Phosphates							200,900	401,800	(1)	(1)
Soda ash			218,894	502,912			44,200	53,100	(1)	(1)
Sodium silicate	19,890	27,846					1,470,240	966,876	(1)	(1)
Sulfuric acid	15,806,578	57,852,813	(1)	(1)			2,338,465	13,099,493	1,087,452	1,648,927
Other			200,000	156,152	803,972	705,163	(1)	(1)	5,875	857,750
Total	20,480,131	76,771,089	652,578	759,822	803,972	705,163	(1)	(1)	1,806,178	4,641,241
Activator:										
Copper sulfate			737,473	330,660	1,192,372	979,069	3,165,757	1,901,871	712,851	822,685
Other							1,457,040	320,549		
Total			737,473	330,660	1,192,372	979,069	3,165,757	2,222,420	712,851	822,685
Depressant:										
Hydrofluoric acid [2]	(1)	(1)					455,400	903,617	756,252	502,381
Quebracho [3]			(1)	(1)						
Sodium cyanide [4]			649,349	24,500	1,192,372	42,243	2,033,649	508,695	(1)	(1)
Starch			(1)	(1)						
Other	(1)	(1)	209,124	99,061					(1)	(1)
Total	(1)	(1)	858,473	123,561	1,192,372	42,243	2,489,049	1,412,312	(1)	(1)
Collector:										
Aerofloats			(1)	(1)	1,192,372	211,752	1,944,847	295,593	919,311	533,020
Amines	19,954,458	1,969,534			(1)	(1)	969,775	853,503		
Dow Z-200										
Fatty acids [5]	20,362,818	48,850,203	362,894	505,270	(1)	(1)	(1)	(1)	756,252	945,282
Fuel oil	20,673,591	92,455,368	704,580	2,623,700	1,453,110	2,117,910	759,375	2,061,861	843,252	491,892
Kerosine	14,759,923	13,783,501	(1)	(1)	(1)	(1)			(1)	(1)
Sodium oleate									(1)	(1)
Xanthates			526,789	59,626	(1)	(1)	1,899,890	556,304	712,851	72,818
Other			266,684	29,284	351,816	311,182	210,400	250,000	35,208	60,510
Total	20,799,481	157,058,606	1,739,823	3,217,880	2,777,698	2,640,844	4,469,632	4,017,261	1,835,511	2,103,522

Frother:										
Aerofroths			136,500	16,313	149,512	37,446	928,803	38,276	(1)	(1)
Creosote oil [6]							2,400,398	378,176		
Dowfroth					(1)	(1)	(1)	(1)		
Methyl amyl alcohol	(1)	(1)	137,124	11,107	(1)	(1)			(1)	(1)
Methyl isobutyl carbinol			859,602	41,039	613,200	148,788	652,445	353,128		
Pine oil	1,604,799	66,463	826,119	84,540	1,605,876	315,527	1,053,985	760,295	712,852	98,925
Other	(1)	(1)			657,510	45,142	(1)	(1)	529,992	6,733
Total	(1)	(1)	1,959,345	152,999	2,944,898	546,903	(1)	(1)	1,118,104	105,658
Flocculant:										
Aeroflocs			(1)	(1)			(1)	(1)		
Guar							(1)	(1)		
Lime									(1)	(1)
Separan			457,202	20,620	665,572	6,355	514,829	3,332		
Starch			191,220	340,850						
Sulfuric acid			(1)	(1)			200,900	803,600		
Other			209,124	288,651			1,488,040	45,261	(1)	(1)
Total			801,546	650,121	665,572	6,355	2,203,769	852,193	(1)	(1)
Grand total	20,799,481	234,016,971	2,604,745	5,235,043	3,006,898	4,920,577	4,469,632	28,939,914	1,835,511	8,294,112

[1] Included in grand total to avoid disclosing individual company confidential data.
[2] Includes sodium fluoride and sodium silicafluoride.
[3] Includes tannic acid.
[4] Includes calcium cyanide and sodium ferrocyanide.
[5] Includes tall oil.
[6] Includes Barret oil.

TABLE 47.—Materials treated and reagents consumed in froth flotation, by Central States in 1960

Function and reagent	Arkansas, Missouri, Oklahoma		Illinois	
	Ore treated (tons)	Reagents used (pounds)	Ore treated (tons)	Reagents used (pounds)
Modifier:				
Caustic soda	(1)	(1)		
Lime	(1)	(1)	258,500	222,905
Phosphates			(1)	(1)
Soda ash			380,395	743,043
Sodium silicate	225,801	874,187	(1)	(1)
Sulfuric acid	39,380	141,768		
Other	389,799	184,872	(1)	(1)
Total	527,571	1,200,827	638,895	1,086,595
Activator:				
Copper sulfate	1,620,980	321,673	638,895	513,944
Sodium sulfide	3,151,634	230,021		
Total	3,840,311	551,694	638,895	513,944
Depressant:				
Aerodepressants			428,923	33,644
Quebracho [2]			380,395	366,553
Sodium cyanide [3]	4,102,701	513,478	539,423	383,863
Sodium sulfite [4]			297,190	171,455
Starch			(1)	(1)
Zinc sulfate	932,303	33,563		
Other			(1)	(1)
Total	4,102,701	547,041	(1)	(1)
Collector:				
Aerofloats	2,144,646	253,433	540,423	127,308
Fatty acids [5]	(1)	(1)	305,356	190,944
Fuel oil				
Kerosine				
Xanthates	3,512,416	221,320	445,190	59,703
Other	(1)	(1)		
Total	4,491,386	(1)	638,895	377,955
Frother:				
Aerofroths	3,963,815	138,309		
Creosote oil [6]	3,151,634	120,097		
Dowfroth				
Methyl amyl alcohol			158,244	2,414
Methyl isobutyl carbinol	360,782	54,130	555,690	55,966
Pine oil			(1)	(1)
Other			(1)	(1)
Total	4,324,597	312,536	(1)	(1)
Flocculant:				
Aerofloes	1,257,413	12,863	(1)	(1)
Guar	(1)	(1)		
Lime				
Separan	(1)	(1)	205,884	2,059
Other	(1)	59,035	(1)	(1)
Total	1,257,413	71,898	(1)	(1)
Grand total	4,491,386	3,286,158	638,895	3,222,334

See footnotes at end of table.

TABLE 47.—Materials treated and reagents consumed in froth flotation, by Central States in 1960—Continued

Function and reagent	Michigan, Minnesota		Wisconsin	
	Ore treated (tons)	Reagents used (pounds)	Ore treated (tons)	Reagents used (pounds)
Modifier:				
Caustic soda				
Lime			242,215	134,920
Phosphates				
Soda ash				
Sodium silicate	1,089,000	871,200		
Sulfuric acid	1,139,976	2,984,328		
Other				
Total	1,139,976	3,855,528	242,215	134,920
Activator:				
Copper sulfate			242,215	155,462
Sodium sulfide				
Total			242,215	155,462
Depressant:				
Aerodepressants				
Quebracho [2]				
Sodium cyanide [3]			242,215	8,673
Sodium sulfite [4]				
Starch				
Zinc sulfate				
Other				
Total			242,215	8,673
Collector:				
Aerofloats	1,089,000	1,415,700	242,215	26,655
Fatty acids [5]	1,089,000	326,700		
Fuel oil	7,235,601	2,865,908		
Kerosine			(1)	(1)
Xanthates	8,018,390	1,402,810		
Other	50,973	152,928	(1)	(1)
Total	9,158,366	6,164,046	247,705	65,085
Frother:				
Aerofroths			114,215	4,227
Creosote oil [6]				
Dowfroth	6,095,625	362,688		
Methyl amyl alcohol				
Methyl isobutyl carbinol			128,000	3,443
Pine oil	6,494,390	577,033	73,505	2,397
Other			5,490	38,430
Total	8,018,390	939,721	247,705	48,497
Flocculant:				
Aeroflocs			128,000	1,855
Guar				
Lime	(1)	(1)		
Separan				
Other	(1)	(1)		
Total	(1)	(1)	128,000	1,855
Grand total	9,158,366	24,674,170	247,705	414,492

[1] Included in grand total to avoid disclosing individual company confidential data.
[2] Includes tannic acid.
[3] Includes calcium cyanide and sodium ferrocyanide.
[4] Includes sodium hydrosulfite and zinc hydrosulfite.
[5] Includes tall oil.
[6] Includes Barrett oil.

TABLE 48.—Materials treated and reagents consumed in froth flotation, by Western States in 1960

Function and reagent	Arizona, New Mexico		California, Nevada		Colorado, Utah		Idaho, Washington		Montana, Wyoming	
	Ore treated (tons)	Reagents used (pounds)	Ore treated (tons)	Reagents used (pounds)	Ore treated (tons)	Reagents used (pounds)	Ore treated (tons)	Reagents used (pounds)	Ore treated (tons)	Reagents used (pounds)
Modifier:										
Caustic soda			252,830	48,524	733,556	1,275,717				
Lime	73,371,524	323,496,009	7,679,306	68,387,648	29,137,374	46,514,555	399,440	104,755	12,139,143	15,236,679
Phosphates	67,521,160	612,485					(1)	(1)		
Soda ash	(1)	(1)	360,736	269,085	53,145	175,614	1,172,515	333,197	180,894	422,935
Sodium silicate			272,916	80,594	28,060,300	1,162,012	(1)	(1)	180,894	410,126
Sulfuric acid	(1)	(1)	71,132	65,036						
Other	11,520,462	420,873			363,000	399,300	250,088	90,589		
Total	73,371,524	324,529,367	8,048,174	68,850,887	29,538,869	49,527,198	1,192,436	528,541	12,320,037	16,069,740
Activator:										
Copper sulfate	681,409	837,123	(1)	(1)	1,077,074	784,649	1,618,376	776,339	(1)	(1)
Sodium sulfide	8,602,173	198,196					(1)	(1)		
Other	2,922,835	2,630,552	270,241	1,287,305			(1)	(1)	(1)	(1)
Total	12,206,417	3,665,871	270,241	1,287,305	1,077,074	784,649	1,618,376	(1)	(1)	(1)
Depressant:										
Aerodepressants	323,865	8,996	(1)	(1)						
Guar	(1)	(1)								
Hydrofluoric acid [2]			86,922	76,362						
Lignin sulfonate			(1)	(1)			959,822	53,032		
Quebracho [3]			(1)	(1)						
Sodium cyanide [4]	30,640,242	1,061,053	(1)	(1)	29,137,374	1,431,929	546,592	57,389	(1)	(1)
Sodium sulfite [5]			(1)	(1)	981,459	705,796	464,405	58,550		
Starch	9,762,983	6,648,705								
Zinc sulfate	681,409	303,391	(1)	(1)	861,182	383,145	1,090,248	300,927	(1)	(1)
Other	(1)	(1)	327,476	206,789	28,060,300	389,204			(1)	(1)
Total	41,786,065	8,158,492	379,078	283,151	29,137,374	2,910,074	1,872,480	469,898	173,135	69,254
Collector:										
Aerofloats	35,273,111	889,513	652,344	466,153	28,550,316	727,306	1,384,892	166,182	(1)	(1)
Amines	8,730,918	1,311,012	(1)	(1)	(1)	(1)				
Dow Z-200	6,269,687	81,327	(1)	(1)	736,556	20,267			(1)	(1)
Fatty acids [6]			38,095	49,315	(1)	(1)	(1)	(1)	819,894	1,009,669
Fuel oil	12,847,935	630,632	7,676,449	15,751,363	28,060,300	740,607			(1)	(1)
Kerosine	(1)	(1)			264,030	975,750				
Minerec	23,770,223	781,677			(1)	(1)	19,366	473	208,635	10,432

Xanthates	39,148,856	1,539,990	7,638,817	586,424	29,556,789	306,929	1,858,391	267,049	12,139,143	128,049
Other	11,621,809	1,452,288	324,972	2,626,681	12,231,526	12,135,724	(1)	(1)	12,726,286	1,151,118
Total	85,056,477	6,686,439	8,312,384	19,479,936	41,873,436	14,906,583	2,013,084	(1)	12,959,037	2,299,268
Frother:										
Aerofroths	13,449,853	218,493	89,316	6,440	409,226	6,364				
Creosote oil [7]	14,350,986	1,520,190			(1)	(1)	639,596	42,824		
Cresylic acid	17,657,705	2,048,735			28,074,950	708,621	(1)	(1)		
Dowfroth	25,110,398	406,493	(1)	(1)	458,659	12,604	243,657	4,490		
Methyl amyl alcohol	12,984,502	1,086,029			29,324,410	1,734,694	1,567,508	92,921	(1)	(1)
Methyl isobutyl carbinol	23,080,623	932,814	(1)	(1)	592,441	40,715	362,071	14,327	12,103,643	248,998
Pine oil	24,321,339	1,524,454	7,612,748	663,084	39,961,226	380,228	303,974	15,885	95,116	31,046
Other			273,370	1,283,911	(1)	(1)	(1)	(1)	(1)	(1)
Total	84,529,177	7,737,208	7,975,461	1,953,435	42,276,436	(1)	2,013,084	208,635	12,198,759	(1)
Flocculant:										
Aerofloes	3,832,189	38,724			(1)	(1)	(1)	(1)		
Lime			(1)	(1)						
Separan	41,074,372	1,001,668	263,472	1,300	218,153	4,182	280,269	4,029	674,500	13,135
Other	112,140	4,726	(1)	(1)	(1)	(1)	(1)	(1)		
Total	44,937,761	1,045,118	263,472	(1)	1,038,023	(1)	(1)	(1)	674,500	13,135
Grand total	85,056,477	351,822,495	8,312,384	92,787,907	42,276,436	71,059,868	2,054,519	2,677,380	12,969,037	18,907,476

[1] Included in grand total to avoid disclosing individual company confidential data.
[2] Includes sodium fluoride and sodium silicafluoride.
[3] Includes tannic acid.
[4] Includes calcium cyanide and sodium ferrocyanide.
[5] Includes sodium hydrosulfite and zinc hydrosulfite.
[6] Includes tall oil.
[7] Includes Barrett oil.

Statistical Summary of Mineral Production

By Kathleen J. D'Amico [1]

THIS SUMMARY is shown in Minerals Yearbook volumes I and III of this series on mineral production in the United States, its island possessions, the Canal Zone, and the Commonwealth of Puerto Rico, and on the principal minerals imported into and exported from the United States. 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 operations at or near mines.

TABLE 1.—Value of mineral production in the United States,[1] 1925–61, 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] 2,630	1,518	14,067
1936	2,405	685	516	3,606	1955	10,780	[3] 2,957	2,055	15,792
1937	2,798	711	756	4,265	1956	11,741	[3] 3,266	2,358	17,365
1938	2,436	622	460	3,518	1957	12,709	[3] 3,267	2,137	18,113
1939	2,423	754	631	3,808	1958	11,589	[3] 3,346	1,594	16,529
1940	2,662	784	752	4,198	1959	11,950	[3] 3,721	1,570	17,241
1941	3,228	989	890	5,107	1960	[4] 12,142	[3] 3,732	[4] 2,022	[4] 17,896
1942	3,568	1,056	999	5,623	1961	12,358	[3] 3,846	1,927	18,131
1943	4,028	916	987	5,931					

[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] Total adjusted to eliminate duplicating value of raw materials used in manufacturing cement and/or lime.
[4] Revised figure.

[1] Statistical officer.

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

Data for clays and stone, 1954–61, included output used in making cement and lime. Mineral-production totals have been adjusted to eliminate duplicating these values.

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

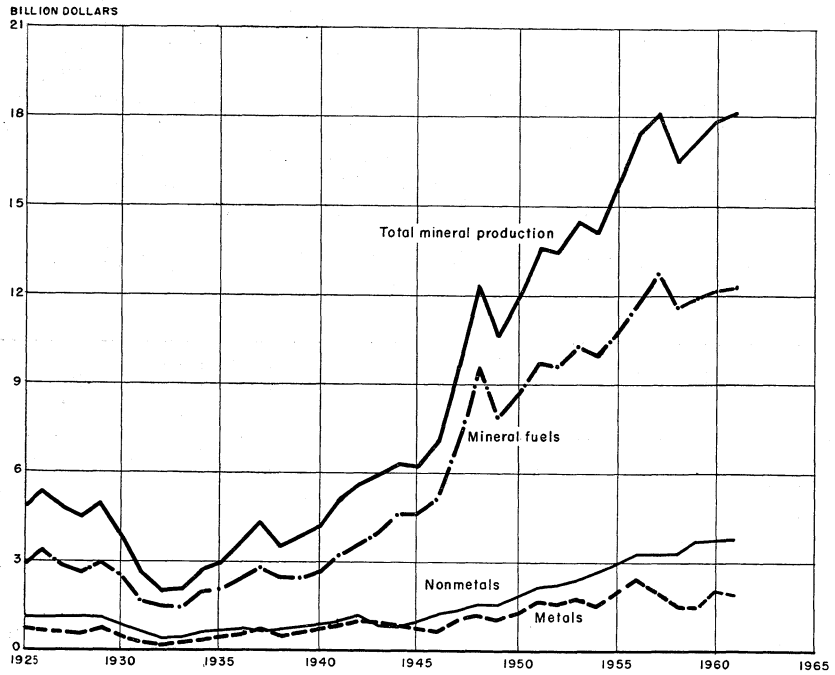


FIGURE 1. Value of mineral production in the United States, 1925–61.

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

Mineral	1958		1959		1960		1961	
	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	1,326,493	$3,343	1,518,765	$3,868	1,242,874	$3,070	1,558,792	$12,818
Gilsonite—do	317,280	4,864	379,362	9,385	383,037	10,020		
Carbon dioxide, natural (estimate)—thousand cubic feet	722,615	102	485,179	71	521,169	99	545,354	82
Coal:								
Bituminous and lignite [2]—thousand short tons	410,446	1,996,281	412,028	1,965,607	415,512	1,950,425	402,977	1,844,563
Pennsylvania anthracite—do	21,171	187,898	20,649	172,320	18,817	147,116	17,446	140,338
Helium—thousand cubic feet	352,134	5,741	375,408	6,144	475,179	7,768	551,785	10,263
Natural gas—million cubic feet	11,030,298	1,317,492	12,046,115	1,556,800	12,771,038	1,789,970	13,254,025	1,996,241
Natural gas liquids:								
Natural gasoline and cycle products—thousand gallons	5,596,458	393,139	5,597,102	408,694	5,842,507	416,819	6,105,463	412,019
LP gases—do	6,783,000	296,571	7,874,706	349,802	8,444,074	391,566	9,085,465	370,186
Peat—short tons	327,813	3,446	419,460	4,372	470,889	5,138	524,695	4,991
Petroleum (crude)—thousand 42-gallon barrels	2,449,016	7,380,065	2,574,590	7,473,336	2,574,933	7,420,181	[3] 2,621,758	[3] 7,566,945
Total mineral fuels		11,589,000		11,950,000		12,142,000		12,358,000
Nonmetals (except fuels):								
Abrasive stone [4]—short tons	4,023	305	3,672	315	2,539	240	2,495	238
Aplite—long tons	(5)	(5)	(5)	(5)	(5)	(5)	97,465	651
Asbestos—short tons	43,979	5,127	45,459	4,391	45,223	4,231	52,814	4,347
Barite—do	605,402	7,508	901,815	10,301	[6] 714,276	[6] 8,574	798,785	9,315
Boron minerals—do	528,209	38,310	619,946	46,150	640,591	47,550	602,613	46,936
Bromine—thousand pounds	176,397	46,689	195,483	51,508	175,010	44,637	180,798	44,517
Cement:								
Portland—thousand 376-pound barrels	317,263	1,038,672	346,675	1,144,867	321,646	1,089,134	314,821	1,048,832
Masonry—thousand 280-pound barrels							19,275	55,737
Natural and slag—thousand 376-pound barrels							269	968
Clays—thousand short tons	43,750	143,487	49,383	159,659	[6] 49,069	[6] 162,411	47,389	156,829
Emery—short tons	7,687	126	8,555	150	8,169	142	6,180	106
Feldspar—long tons	469,738	4,278	548,390	5,372	502,380	4,779	496,808	5,120
Fluorspar—short tons	319,513	15,071	185,091	8,680	229,782	10,391	205,083	9,275
Garnet (abrasive)—do	12,303	869	14,568	1,211	10,522	986	12,057	1,036
Gem stones (estimate)	(7)	1,006	(7)	1,184	(7)	1,188	(7)	1,309
Gypsum—thousand short tons	9,600	32,495	10,900	39,231	9,825	35,690	9,500	34,950
Lime—do	9,203	120,921	12,498	163,890	[6] 12,935	[6] 172,731	15,192	210,127
Magnesite—short tons	492,982	2,409	594,307	2,401	498,528	2,051	603,656	3,129
Magnesium compounds from sea water and brine (except for metals)—short tons, MgO equivalent	207,053	16,419	276,309	21,636	293,454	21,903	356,384	25,545

See footnotes at end of table.

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

Mineral	1958		1959		1960		1961	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Nonmetal (except fuels)—Continued								
Mica:								
Scrap—short tons	93,347	$2,065	101,541	$2,665	[6] 97,912	[6] $2,698	99,044	$2,417
Sheet—pounds	661,344	2,845	706,395	3,419	[6] 571,108	[6] 3,183	480,494	3,308
Perlite—short tons	291,994	2,463	324,669	2,737	312,153	2,665	310,338	2,664
Phosphate rock—thousand long tons	14,879	93,693	15,869	98,758	17,516	117,041	18,559	130,535
Potassium salts—thousand short tons, K_2O equivalent	2,147	75,000	2,383	80,393	2,638	[6] 89,676	2,732	104,464
Pumice—thousand short tons	1,973	5,287	2,276	5,863	2,210	5,569	2,463	6,799
Pyrites—thousand long tons	974	7,987	1,057	8,148	1,016	7,936	988	7,418
Salt—thousand short tons	21,911	141,486	25,160	155,839	25,479	161,140	25,707	160,223
Sand and gravel—do	684,498	652,789	730,205	728,712	[6] 709,792	[6] 720,432	751,784	751,301
Sodium carbonate (natural)—short tons	628,619	17,032	735,261	19,078	808,624	20,865	805,828	20,444
Sodium sulfate (natural)—do	347,445	6,716	402,743	7,689	449,631	8,706	465,814	9,296
Stone [8]—thousand short tons	535,923	826,685	584,163	911,982	[6] 616,784	[6] 952,555	615,388	950,560
Sulfur:								
Frasch process mines—thousand long tons	4,644	109,272	5,222	121,777	5,003	115,494	5,082	117,884
Other mines—long tons	153,574	1,505	151,932	1,418	181,422	1,732	177,549	1,694
Talc, soapstone, and pyrophyllite—short tons	718,165	4,718	791,558	5,641	734,473	5,378	761,318	5,267
Tripoli—do	47,044	183	52,968	219	57,713	247	54,641	225
Vermiculite—thousand short tons	191	2,728	207	3,082	199	3,108	206	3,350
Value of items that cannot be disclosed: Brucite (1958–59), calcium-magnesium chloride, diatomite, epsom salts from epsomite (1961), graphite, iodine, kyanite, lithium minerals, greensand marl, nitrogen compounds (1958), olivine, staurolite (1958, 1960–61), strontium minerals (1958–59), wollastonite, and values indicated by footnote 5		[6] 39,642		[6] 42,322		[6] 42,664		44,743
Total nonmetals [9]		3,346,000		3,721,000		3,732,000		3,846,000
Metals:								
Antimony ore and concentrate—short tons, antimony content	716	[10]	688	[10]	635	[10]	689	[10]
Bauxite—long tons, dried equivalent	1,310,685	12,815	1,700,235	17,725	1,997,827	21,107	1,228,032	13,937
Beryllium concentrate—short tons, gross weight	505	243	425	179	509	162	[11] 1,122	[10]
Chromite—do	143,795	6,187	[12] 105,000	[12] 3,765	[12] 107,000	[12] 3,813	[12] 82,000	[12] 2,939
Cobalt (content of concentrate)—thousand pounds	4,832	[10]	2,944	[10]	[10]	[10]	[10]	[10]
Columbium-tantalum concentrate [13]—pounds	428,347	[10]	189,263	[10]				
Copper (recoverable content of ores, etc.)—short tons	979,329	515,127	824,846	506,455	1,080,169	693,468	1,165,155	699,093
Gold (recoverable content of ores, etc.)—troy ounces	1,739,249	60,874	1,602,931	56,103	1,666,772	58,336	1,548,270	54,189
Iron ore, usable (excluding byproduct iron sinter) thousand long tons, gross weight	66,288	569,154	59,164	514,067	[6] 82,963	[6] 724,131	72,378	650,501
Lead (recoverable content of ores, etc.)—short tons	267,377	62,566	255,586	58,786	246,669	57,722	261,921	53,956

Manganese ore (35 percent or more Mn) short tons, gross weight	327,309	23,637	229,199	17,904	80,021	5,352	46,088	3,264
Manganiferous ore (5 to 35 percent Mn) do	520,601	3,532	470,600	3,153	658,455	4,466	225,004	1,480
Mercury 76-pound flasks	38,067	8,720	31,256	7,110	33,223	7,002	31,662	6,257
Molybdenum (content of concentrate) thousand pounds	42,328	50,371	51,603	64,655	69,941	87,406	66,753	87,925
Nickel (content of ore and concentrate) short tons	13,489	(10)	13,374	(10)	14,079	(10)	13,133	(10)
Rare-earth and thorium concentrates do	2,021	286	1,143	206	(10)	(10)	(10)	(10)
Silver (recoverable content of ores, etc.) thousand troy ounces	34,111	30,872	31,194	28,233	30,766	27,846	34,794	32,166
Tin (content of ore and concentrate) long tons			50	60	10	12	(10)	(10)
Titanium concentrate:								
Ilmenite short tons, gross weight	565,164	11,152	637,263	12,106	[6] 789,237	14,655	782,629	13,320
Rutile do	1,863	210	8,648	877	[6] 9,226	[6] 957	7,664	778
Tungsten ore and concentrate short tons, 60-percent WO_3 basis	3,788	3,991	3,649	4,502	7,325	9,815	8,245	10,565
Uranium ore short tons	5,178,315	116,397	6,934,927	141,349	7,970,211	152,188	8,041,329	148,299
Vanadium (recoverable in ore and concentrate) do	3,030	10,817	3,719	13,278	4,971	17,749	5,343	19,076
Zinc (recoverable content of ores, etc.) do	412,005	84,113	425,303	97,787	435,427	112,365	464,390	106,848
Value of items that cannot be disclosed: Chromite,[12] magnesium chloride for magnesium metal, manganiferous residuum, platinum-group metals (crude), zirconium concentrate, and values indicated by footnote 10		23,245		21,763		23,078		22,582
Total metals		1,594,000		1,570,000		2,022,000		1,927,000
Grand total mineral production		16,529,000		17,241,000		17,896,000		18,131,000

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

TABLE 3.—Minerals produced in the United States and principal producing States in 1961

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	Ark., Mo., Nev., Ga.	Calif., Idaho, Ky., Mont., N. Mex., N.C., S.C., Tenn., Tex., Utah, Wash.
Bauxite	Ark., Ga., Ala.	
Beryllium	Colo., S. Dak., N. Mex., N.H.	Ariz., Conn., Maine, N.Y., Wyo.
Boron	Calif.	
Bromine	Mich., Tex., Ark., Calif.	W. Va.
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.
Chromite	Mont.	
Clays	Ohio, Tex., Ga., Calif.	All other States except Alaska, Hawaii, 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., Mo.	
Copper	Ariz., Utah, Mont., N. Mex.	Alaska, Calif., Colo., Idaho, Mich., Mo., Nev., N.C., Oreg., Pa., Tenn., Wash., Wyo.
Diatomite	Calif., Nev., Wash., Oreg.	Ariz.
Emery	N.Y.	
Feldspar	N.C., Calif., Conn., Ga.	Ariz., Colo., Maine, N.H., S.C., S. Dak., Tex., Va.
Fluorspar	Ill., Ky., Nev., Colo.	Calif., Mont., Utah.
Garnet, abrasive	N.Y., Idaho.	
Gold	S. Dak., Utah, Ariz., Wash.	Alaska, Calif., Colo., Idaho, Mont., Nev., N. Mex., N.C., Oreg., Pa., Tenn., Wyo.
Graphite	Tex., Pa.	
Gypsum	Calif., Mich., Iowa, Tex.	Ariz., Ark., Colo., Ind., Kans., La., Mont., Nev., N. Mex., N.Y., Ohio, Okla., S. Dak., Utah Va., Wash., Wyo.
Helium	Okla., Tex., N. Mex., Kans.	
Iodine	Calif., Mich.	
Iron ore	Minn., Mich., Ala., Utah	Ariz., Calif., Colo., Ga., Idaho, Mo., Mont., Nev., N.J. N. Mex., N.Y., N.C., Oreg., Pa., S. Dak., Tenn., Tex., Va., Wis., Wyo.
Kyanite	Va., S.C.	
Lead	Mo., Idaho, Utah, Colo.	Alaska, Ariz., Calif., Ill., Kans., Ky., Mont., Nev., N. Mex., N.Y., N.C., Okla., Oreg., Va., Wash., Wis.
Lime	Ohio, Mich., Mo., Pa.	Ala., Ariz., Ark., Calif., Colo., Conn., Fla., Hawaii, Idaho, Ill., Iowa, Kans., Ky., 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.	
Magnesite	Nev., Wash., Calif.	
Magnesium chloride	Tex.	
Magnesium compounds	Mich., Calif., Fla., N.J.	Miss., N. Mex., Tex.
Manganese ore	Nev., Mont.	
Manganiferous ore	Minn., N. Mex., Mich., Mont.	Ariz., Ga.
Marl, greensand	N.J., Md.	
Mercury	Calif., Nev., Alaska, Idaho.	Ariz., Oreg.
Mica:		
Scrap	N.C., Ga., Ala., 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., Mont., S.C., Va., Wyo.
Molybdenum	Colo., Utah, Ariz., N. Mex.	Calif., Nev.
Natural gas	Tex., La., Okla., N. Mex.	Ala., Alaska, Ark., Calif., Colo., Fla., Ill., Ind., Kans., Ky., Md., Mich., Miss., Mo., Mont., Nebr., N.Y., N. Dak., Ohio, Pa., Tenn., Utah, Va., W. Va., Wyo.

TABLE 3.—Minerals produced in the United States and principal producing States in 1961—Continued

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

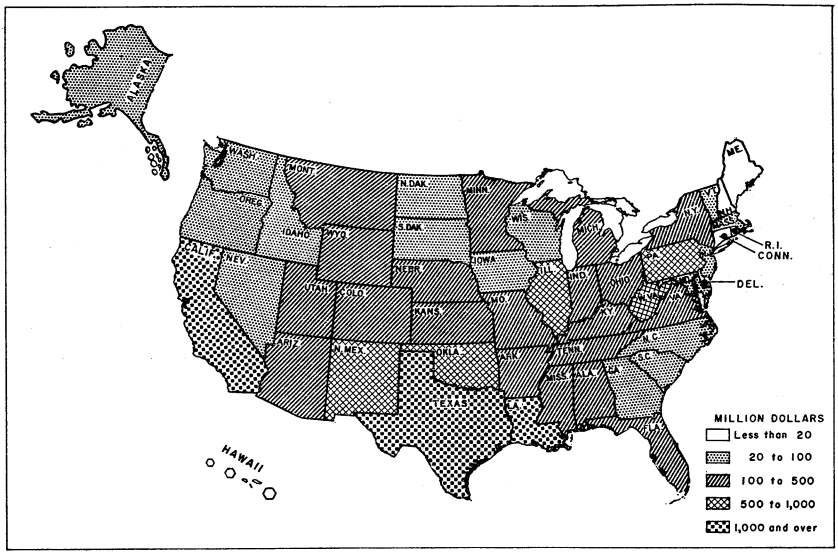


FIGURE 2.—Value of mineral production in the United States, 1961, by States.

TABLE 4.—Value of mineral production in the United States, and principal minerals produced in 1961

(Thousand dollars)

State	1958	1959	1960	1961			
				Value	Rank	Percent of U.S. total	Principal minerals in order of value
Alabama	$188,938	$200,847	$217,507	$214,411	20	1.18	Coal, cement, stone, iron ore.
Alaska	21,450	20,495	21,860	34,733	41	.19	Petroleum, coal, sand and gravel, gold.
Arizona	314,520	326,862	415,512	432,614	13	2.39	Copper, sand and gravel, cement, zinc.
Arkansas	132,520	140,594	158,263	149,138	25	.82	Petroleum, bauxite, stone, cement.
California	1,500,367	1,433,626	1,404,665	1,420,749	3	7.84	Petroleum, natural gas, cement, sand and gravel.
Colorado	306,566	314,677	343,104	343,256	17	1.89	Petroleum, molybdenum, coal, uranium.
Connecticut	13,128	12,930	15,255	16,501	45	.09	Stone, sand and gravel, lime, feldspar.
Delaware	1,142	1,284	989	1,053	50	.01	Sand and gravel, stone, clays, gem stones.
District of Columbia	72	75	71	68	----------	(1)	Clays.
Florida	142,114	163,446	176,923	190,933	23	1.05	Phosphate rock, stone, cement, clays.
Georgia	75,106	86,262	91,203	95,256	29	.53	Clays, stone, cement, sand and gravel.
Hawaii	6,298	7,630	9,254	14,588	47	.08	Stone, cement, sand and gravel, pumice.
Idaho	64,648	70,209	57,441	68,900	35	.38	Silver, lead, zinc, phosphate rock.
Illinois	576,862	572,275	586,364	571,605	8	3.15	Petroleum, coal, stone, sand and gravel.
Indiana	197,677	206,359	208,247	197,965	22	1.09	Coal, cement, petroleum, stone.
Iowa	85,356	88,557	95,030	90,674	30	.50	Cement, stone, sand and gravel, gypsum.
Kansas	503,788	508,077	483,952	485,872	9	2.68	Petroleum, natural gas, cement, stone.
Kentucky	402,121	418,821	413,525	386,013	15	2.13	Coal, petroleum, stone, natural gas.
Louisiana	1,523,370	1,766,269	1,987,967	2,173,442	2	11.99	Petroleum, natural gas, natural gas liquids, sulfur.
Maine	12,574	13,278	13,677	14,969	46	.08	Cement, stone, sand and gravel, mica.
Maryland	45,735	53,189	55,527	62,264	36	.34	Stone, cement, sand and gravel. coal.
Massachusetts	23,887	25,916	27,588	30,234	42	.17	Sand and gravel, stone, lime, clays.
Michigan	343,487	381,297	429,737	442,696	12	2.44	Iron ore, cement, petroleum, sand and gravel.
Minnesota	395,880	347,178	515,255	450,509	11	2.48	Iron ore, sand and gravel, stone, cement.
Mississippi	151,411	186,116	198,449	210,242	21	1.16	Petroleum, natural gas, cement, sand and gravel.
Missouri	144,120	157,189	156,041	145,365	27	.80	Cement, stone, lead, lime.
Montana	176,728	167,328	178,854	183,354	24	1.01	Petroleum, copper, sand and gravel, cement.
Nebraska	90,047	97,130	101,957	103,060	28	.57	Petroleum, cement, sand and gravel, stone.
Nevada	68,291	70,164	80,335	80,565	32	.44	Copper, sand and gravel, iron ore, lime.
New Hampshire	3,919	4,722	5,514	5,388	48	.03	Sand and gravel, mica, stone, feldspar.
New Jersey	50,380	59,479	56,409	59,208	37	.33	Stone, sand and gravel, iron ore, magnesium compounds.
New Mexico	559,777	592,535	653,226	688,908	6	3.80	Petroleum, potassium salts, natural gas, uranium.
New York	205,338	234,642	255,368	228,983	18	1.26	Cement, stone, salt, sand and gravel.
North Carolina	39,891	40,789	45,096	50,124	39	.28	Stone, sand and gravel, copper, tungsten.
North Dakota	59,445	67,342	78,378	84,697	31	.47	Petroleum, sand and gravel, coal, natural gas liquids.
Ohio	344,856	397,326	391,150	368,315	16	2.03	Coal, cement, stone, lime.
Oklahoma	761,936	765,439	780,941	785,973	5	4.34	Petroleum, natural gas, natural gas liquids, cement.

See footnote at end of table.

TABLE 4.—Value of mineral production in the United States, and principal minerals produced in 1961—Continued

(Thousand dollars)

State	1958	1959	1960	1961			
				Value	Rank	Percent of U.S. total	Principal minerals in order of value
Oregon	$45,190	$49,842	$54,520	$54,922	38	.30	Stone, sand and gravel, cement, nickel.
Pennsylvania	882,040	862,150	823,360	791,648	4	4.37	Coal, cement, stone, natural gas.
Rhode Island	2,249	2,333	5,727	3,079	49	.02	Sand and gravel, stone, gem stones.
South Carolina	22,412	30,598	30,001	30,136	43	.17	Stone, cement, clays, sand and gravel.
South Dakota	41,534	48,553	46,780	42,980	40	.24	Gold, cement, sand and gravel, stone.
Tennessee	124,934	140,738	143,475	147,262	26	.81	Stone, cement, coal, zinc.
Texas	4,033,311	4,219,757	4,116,664	4,224,909	1	23.30	Petroleum, natural gas, natural gas liquids, cement.
Utah	367,232	373,515	431,383	406,617	14	2.24	Copper, petroleum, coal, uranium.
Vermont	21,443	23,359	22,879	24,283	44	.13	Stone, asbestos, sand and gravel, talc.
Virginia	203,277	222,501	203,887	221,835	19	1.22	Coal, stone, cement, sand and gravel.
Washington	60,896	63,894	70,485	73,006	33	.40	Cement, sand and gravel, stone, lime.
West Virginia	749,747	737,616	720,601	687,903	7	3.80	Coal, natural gas, natural gas liquids, stone.
Wisconsin	71,334	71,959	77,171	72,886	34	.40	Sand and gravel, stone, iron ore, cement.
Wyoming	369,938	393,841	438,733	466,983	10	2.58	Petroleum, uranium, natural gas, sodium carbonates, and sulfates.
Total	16,529,000	17,241,000	17,896,000	18,131,000	----------	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	1958		1959		1960		1961	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
ALABAMA								
Cement: [2]								
Portland—thousand 376-pound barrels	13,588	$42,930	14,819	$46,639	12,931	$42,706	12,445	$39,027
Masonry—thousand 280-pound barrels							2,006	6,156
Clays [3]—thousand short tons	1,548	1,787	1,786	2,089	1,840	2,170	1,787	2,068
Coal (bituminous)—do	11,182	72,360	11,947	78,212	13,011	92,439	12,915	90,903
Iron ore (usable)—thousand long tons, gross weight	3,659	23,393	4,165	23,922	4,068	23,511	3,597	20,510
Lime—thousand short tons	520	5,851	579	6,847	[4] 536	[4] 6,593	579	6,871
Mica (sheet)—pounds	(5)	(5)	818	7	(5)	(5)	(5)	(5)
Natural gas—million cubic feet	323	30	172	17	57	4	56	[4]
Petroleum (crude)—thousand 42-gallon barrels	5,887	(5)	5,524	(5)	7,329	(5)	[7] 6,932	[7] 19,063
Sand and gravel—thousand short tons	4,128	4,210	4,352	4,594	4,359	4,759	5,800	6,452
Stone [3]—do	11,080	17,068	11,886	18,728	13,503	19,970	13,651	19,909
Value of items that cannot be disclosed: Native asphalt, bauxite, slag cement, clays (kaolin), scrap mica, salt, stone (dimension limestone and marble, shell, 1959–61, crushed sandstone 1959–61), talc, and values indicated by footnote 5		26,508		25,401		[4] 29,650		7,919
Total Alabama [9]		188,938		200,847		[4] 217,507		214,411
ALASKA								
Clays—thousand short tons			(10)	$1	1	$10		
Coal (bituminous)—do	759	$6,931	660	5,869	722	6,318	737	$5,868
Copper (recoverable content of ores, etc.)—short tons	5	3	36	22	41	26	92	55
Gem stones	(11)	(5)	(11)	18	(11)	(5)	(11)	(5)
Gold (recoverable content of ores, etc.)—troy ounces	186,435	6,525	178,918	6,262	168,197	5,887	114,216	3,998
Lead (recoverable content of ores, etc.)—short tons	2	(5)			(5)	(5)	(5)	
Mercury—76-pound flasks	3,380	774	3,743	852	4,459	940	4,129	816
Natural gas—million cubic feet	50	6	133	16	246	30	631	129
Peat—short tons					376	(5)		
Petroleum (crude)—thousand 42-gallon barrels	29	(5)	187	295	559	1,230	[7] 6,325	[7] 17,647
Sand and gravel—thousand short tons	4,255	3,871	5,859	5,265	6,013	5,483	5,241	4,185
Silver (recoverable content of ores, etc.)—thousand troy ounces	24	22	21	19	26	23	18	17
Stone—thousand short tons	615	2,065	89	377	275	852	(5)	(5)
Value of items that cannot be disclosed: Platinum-group metals, uranium ore, and values indicated by footnote 5		1,253		1,499		[4] 1,061		2,018
Total Alaska		21,450		20,495		[4] 21,860		34,733

See footnotes at end of table.

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

Mineral	1958		1959		1960		1961	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
ARIZONA								
Beryllium concentrate—short tons, gross weight	18	$10			(12)	(6)	8	$4
Clays [3]—thousand short tons	119	179	120	$179	173	$260	165	240
Coal (bituminous)—thousand short tons	8	54	7	63	6	58		
Copper (recoverable content of ores, etc.)—short tons	485,839	255,551	430,297	264,202	538,605	345,784	587,053	352,232
Gem stones	(11)	86	(11)	88	(11)	120	(11)	119
Gold (recoverable content of ores, etc.)—troy ounces	142,979	5,004	124,627	4,362	143,064	5,007	145,959	5,109
Lead (recoverable content of ores, etc.)—short tons	11,890	2,782	9,999	2,300	8,495	1,988	5,937	1,223
Lime—thousand short tons	126	1,817	123	1,666	148	2,430	167	2,686
Manganese ore (35 percent or more Mn)—short tons gross weight	62,279	5,220	68,183	5,727	1,626	40		
Manganiferous ore (5 to 35 percent Mn)—do	1,455	32	10,693	234	8,677	190	(5)	(5)
Mercury—76-pound flasks	53	12	(5)	(5)	(5)	(5)	148	29
Mica (scrap)—short tons	1,717	25	3,069	55	(5)	(5)	(5)	(5)
Molybdenum (content of concentrate)—thousand pounds	2,320	2,827	3,181	4,019	4,359	5,211	4,878	6,232
Petroleum (crude)—thousand 42-gallon barrels	12	(5)	25	(5)	73	(5)	[7] 67	(5)
Pumice—thousand short tons	401	1,025	487	1,153	703	1,164	745	1,893
Sand and gravel—do	12,208	9,526	13,458	11,966	14,490	14,235	21,953	24,706
Silver (recoverable content of ores, etc.)—thousand troy ounces	4,685	4,240	3,898	3,528	4,775	4,322	5,120	4,733
Stone—thousand short tons	1,528	2,731	2,468	3,998	4,249	5,107	3,582	4,626
Uranium ore—short tons	257,756	7,049	253,390	6,309	283,684	6,219	228,225	4,965
Zinc (recoverable content of ores, etc.)—do	28,532	5,821	37,325	8,585	35,811	9,239	29,585	6,804
Value of items that cannot be disclosed: Asbestos, cement, clays (bentonite, fire clay 1961), diatomite (1961), feldspar, fluorspar (1958), gypsum, helium (1961), iron ore (1961), nitrogen compounds (1958), perlite, pyrites, tungsten (1959–60), vanadium, and values indicated by footnote 5		11,734		9,811		[4] 15,851		18,910
Total Arizona [9]		314,520		326,862		[4] 415,512		432,614
ARKANSAS								
Barite—short tons	182,779	$1,668	338,539	$3,097	277,851	$2,578	277,855	$2,630
Bauxite—long tons, dried equivalent	1,257,916	[8] 12,311	1,631,643	17,048	1,932,071	20,469	1,178,898	13,462
Clays—thousand short tons	578	1,578	782	2,406	815	2,456	773	1,758
Coal (bituminous)—do	364	2,744	441	3,482	409	3,116	395	2,888
Gem stones	(11)	23	(11)	18	(11)	38	(11)	19
Gypsum—thousand short tons	(5)	(5)	(5)	(5)	67	208	167	531
Lead (recoverable content of ores, etc.)—short tons			38	9				

Lime—thousand short tons	(5)	(5)	(5)	(5)	(5)	(5)	192	3,168
Manganese ore (35 percent or more Mn)—short tons, gross weight	22,221	1,737	17,742	1,398				
Natural gas—million cubic feet	32,890	2,664	40,674	3,539	55,451	6,599	59,547	8,039
Natural gas liquids:								
Natural gasoline and cycle products—thousand gallons	37,197	2,574	40,730	2,523	34,558	2,148	27,889	1,640
LP gases—do	53,518	2,743	55,731	3,048	73,252	3,735	75,157	3,286
Petroleum (crude)—thousand 42-gallon barrels	28,700	80,934	26,329	72,931	30,117	83,424	[7] 29,249	[7] 80,435
Sand and gravel—thousand short tons	8,644	7,039	11,696	11,857	8,192	10,262	9,389	9,074
Stone—do	8,461	10,178	8,824	10,424	10,939	13,555	12,029	12,402
Zinc (recoverable content of ores, etc.)—short tons			49	11	50	13	37	9
Value of items that cannot be disclosed: Abrasive stones, bromine, cement, soapstone, and values indicated by footnote 5		7,241		10,042		10,918		10,906
Total Arkansas [9]		132,520		140,594		[4] 158,263		149,138

CALIFORNIA

Barite—short tons	24,812	$272	28,143	$326	16,157	$181	21,203	$295
Boron minerals—do	528,209	38,310	619,946	46,150	640,591	47,550	602,613	46,936
Cement [2]—thousand 376-pound barrels	39,583	124,367	43,635	138,506	39,712	128,826	41,090	129,836
Chromite—short tons, gross weight	20,588	1,646	(5)	(5)				
Clays—thousand short tons	2,394	5,012	2,726	5,646	2,899	5,663	3,041	6,405
Copper (recoverable content of ores, etc.)—short tons	749	394	663	407	1,087	698	1,382	829
Feldspar—long tons	71,193	624	76,489	824	76,010	886	(5)	(5)
Gem stones	(11)	150	(11)	150	(11)	150	(11)	200
Gold (recoverable content of ores, etc.)—troy ounces	185,385	6,489	145,270	5,084	123,713	4,330	97,644	3,418
Gypsum—thousand short tons	1,423	3,184	1,686	3,788	1,616	3,687	1,574	3,673
Lead (recoverable content of ores, etc.)—short tons	140	33	227	52	440	103	103	21
Lime—thousand short tons	262	4,470	358	5,817	345	5,628	518	9,412
Magnesium compounds from sea water and bitterns (partly estimated) short tons, MgO equivalent	74,132	4,854	87,968	6,336	86,532	6,233	90,534	6,467
Manganese ore (35 percent or more Mn)—short tons, gross weight	17,644	1,516	19,354	1,663				
Manganiferous ore (5 to 35 percent Mn)—do			129	(5)	96	(5)		
Mercury—76-pound flasks	22,365	5,123	17,100	3,890	18,764	3,955	18,688	3,693
Mica, scrap—short tons	(5)	(5)			(5)	(5)	950	12
Natural gas—million cubic feet	465,582	108,481	485,655	119,471	517,535	138,182	556,241	157,416
Natural gas liquids:								
Natural gasoline and cycle products—thousand gallons	853,045	68,485	834,258	68,023	794,657	62,496	762,878	57,645
LP gases—do	342,992	18,678	396,331	21,260	408,378	21,482	424,767	21,805
Peat—short tons	28,617	374	34,604	449	33,091	481	46,348	501
Perlite—do	14,883	114	(5)	(5)	(5)	(5)	(5)	(5)
Petroleum (crude)—thousand 42-gallon barrels	313,672	909,649	308,946	787,812	305,352	751,166	[7] 300,062	[7] 729,151
Pumice—thousand short tons	377	1,670	574	2,162	427	1,895	610	2,202
Salt—do	1,297	(5)	1,388	(5)	1,443	(5)	1,601	(5)
Sand and gravel—do	84,137	95,340	87,945	108,009	87,679	107,503	110,181	124,111

See footnotes at end of table.

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

Mineral	1958		1959		1960		1961	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
CALIFORNIA—Continued								
Silver (recoverable content of ores, etc.)—thousand troy ounces	188	$170	173	$156	180	$163	93	$86
Stone—thousand short tons	32,423	48,345	32,134	49,090	33,075	49,842	33,850	50,327
Talc, soapstone, and pyrophyllite—short tons	129,638	1,339	144,816	1,490	130,539	1,396	161,068	1,524
Wollastonite—do	1,652	17	(5)	(5)	(5)	(5)	4,075	42
Zinc (recoverable content of ores, etc.)—do	51	10	78	18	465	120	304	70
Value of items that cannot be disclosed: Asbestos, bromine, calcium-magnesium chloride, carbon dioxide (1959–61), masonry cement, coal (lignite), diatomite, fluorspar (1958, 1960–61), iodine, iron ore, lithium minerals, magnesite, molybdenum, platinum-group metals (crude), potassium salts, pyrites, rare-earth metal concentrates, sodium carbonates and sulfates, strontium minerals (1959), sulfur ore, tungsten concentrate, uranium ore (1958–60), and values indicated by footnote 5		68,564		73,397		[4] 79,471		81,051
Total California [9]		1,500,367		1,433,626		[4] 1,404,665		1,420,749
COLORADO								
Beryllium concentrate—short tons, gross weight	176	$63	221	$67	304	$53	[13] 819	(5)
Carbon dioxide, natural—thousand cubic feet	(5)	(5)	175,223	(5)	155,871	20	167,872	$19
Clays—thousand short tons	449	1,111	417	1,160	490	1,424	556	1,241
Coal (bituminous)—do	2,974	19,305	3,294	21,034	3,607	21,090	3,678	22,787
Columbium-tantalum concentrate [14]—pounds	2,280	7						
Copper (recoverable content of ores, etc.)—short tons	4,193	2,206	2,940	1,805	3,247	2,085	4,141	2,485
Feldspar—long tons	34,648	237	(5)	(5)	(5)	(5)	14,129	99
Gem stones	(11)	38	(11)	43	(11)	45	(11)	36
Gold (recoverable content of ores, etc.)—troy ounces	79,539	2,784	61,097	2,138	61,269	2,144	67,515	2,363
Gypsum—thousand short tons	103	341	106	385	82	296	85	320
Iron ore (usable)—thousand long tons, gross weight	(5)	(5)	11	78	11	80	27	190
Lead (recoverable content of ores, etc.)—short tons	14,112	3,302	12,907	2,969	18,080	4,231	17,755	3,658
Lime—thousand short tons	(5)	(5)	(5)	(5)	(5)	(5)	75	1,319
Manganese ore (35 percent or more Mn)—short tons, gross weight	210	17	1,218	102				
Mica, scrap—short tons	387	6	68	1	340	4	600	10

Natural gas—million cubic feet	82,464	8,659	99,899	10,989	107,404	12,781	108,142	12,544
Natural gas liquids:								
Natural gasoline—thousand gallons	49,505	3,410	47,424	2,811	73,179	4,138	76,880	3,627
LP gases—do	68,027	3,343	77,637	3,671	104,275	4,938	115,410	5,498
Peat—short tons	7,143	41	6,674	35	9,384	37	9,894	44
Petroleum (crude)—thousand 42-gallon barrels	48,736	145,721	46,440	134,676	47,469	137,660	[7] 46,746	[7] 134,628
Pumice—thousand short tons	34	65	40	66	32	70	44	60
Pyrites—thousand long tons	67	359	(5)	(5)	(5)	(5)	(5)	(5)
Rare-earth and thorium concentrates—short tons	650	35	9	1	(12)	(6)		
Sand and gravel—thousand short tons	20,626	17,842	20,897	18,817	19,053	16,882	18,360	16,946
Silver (recoverable content of ores, etc.)—thousand troy ounces	2,056	1,860	1,341	1,213	1,659	1,502	1,965	1,817
Stone—thousand short tons	2,930	4,943	2,824	5,537	2,442	4,651	2,451	5,301
Tin (content of ore and concentrate)—long tons			50	60	10	12	(5)	(5)
Uranium ore—short tons	939,706	22,486	1,044,089	22,546	1,149,583	23,462	1,282,462	21,509
Vanadium (recoverable in ore and concentrate)—do	2,396	(5)	2,949	(5)	4,026	(5)	4,149	(5)
Zinc (recoverable content of ores, etc.)—do	37,132	7,575	35,388	8,139	31,278	8,070	42,647	9,809
Value of items that cannot be disclosed: Cement, fluorspar, molybdenum, perlite, salt, tungsten, and values indicated by footnote 5		62,855		79,229		99,743		99,860
Total Colorado [9]		306,566		314,677		[4] 343,104		343,256
CONNECTICUT								
Beryllium concentrate—short tons, gross weight	(5)	(5)	13	$8	16	$9	2	$1
Clays—thousand short tons	199	$299	280	368	207	308	[3] 149	[3] 260
Gem stones	(11)	3	(11)	5	(11)	7	(11)	9
Lime—thousand short tons	29	464	(5)	(5)	35	616	33	589
Peat—short tons	1,764	11	2,090	13	(5)	(5)	(5)	(5)
Sand and gravel—thousand short tons	5,019	5,479	4,749	4,912	6,575	5,960	7,499	6,633
Stone—do	4,223	6,863	4,462	7,088	5,057	8,313	5,206	8,616
Value of items that cannot be disclosed: Clay (kaolin 1961), feldspar, sheet mica (1958, 1960–61), and values indicated by footnote 5		89		636		140		491
Total Connecticut [13]		13,128		12,930		15,255		16,501
DELAWARE								
Sand and gravel—thousand short tons	1,090	$962	1,241	$1,071	1,084	$907	961	$970
Value of items that cannot be disclosed: Nonmetals		180		213		82		83
Total Delaware		1,142		1,284		989		1,053

See footnotes at end of table.

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

Mineral	1958		1959		1960		1961	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
FLORIDA								
Clays—thousand short tons	450	$5,808	[3] 245	[3] $6,171	[3] 252	[3] $6,357	513	$7,202
Gem stones			(11)	3	(11)	(6)	(11)	(6)
Lime—thousand short tons	(5)	(5)	111	1,238	151	2,611	213	3,555
Natural gas—million cubic feet	35	5	34	5	30	5	29	5
Peat—short tons	36,438	165	34,446	158	39,275	162	24,573	149
Petroleum (crude)—thousand 42-gallon barrels	449	(5)	424	(5)	368	(5)	[7] 371	(5)
Phosphate rock—thousand long tons	10,851	68,951	11,564	71,208	12,321	82,530	13,789	95,590
Sand and gravel—thousand short tons	5,490	4,389	6,674	5,177	6,757	5,559	6,530	5,577
Stone [8]—do	23,549	30,983	26,917	35,940	27,629	37,419	28,855	36,305
Titanium concentrate—thousand short tons, gross weight	190	5,495	262	7,196	286	7,489	(5)	(5)
Zirconium concentrate—short tons	30,302	1,018	(5)	(5)	(5)	(5)	(5)	(5)
Value of items that cannot be disclosed: Cement, clays (kaolin and miscellaneous clay 1959–60), magnesium compounds (1959–61), rare-earth metals concentrates (1958–59, 1961), staurolite, stone (dimension limestone 1958–59, 1961, calcareous marl 1960), and values indicated by footnote 5		28,510		40,034		[4] 38,154		44,797
Total Florida [9]		142,114		163,446		[4] 176,923		190,933
GEORGIA								
Barite—short tons	(5)	(5)	(5)	(5)	(5)	(5)	106,914	$2,046
Clays—thousand short tons	2,942	$31,253	3,352	$36,232	3,519	$40,160	3,569	42,025
Coal—do	9	44	7	34	4	21	4	22
Feldspar—long tons	(5)	(5)	(5)	(5)	(5)	(5)	31,128	692
Iron ore (usable)—thousand long tons, gross weight	209	1,008	186	945	128	613	162	835
Manganese ore (35 percent of more Mn)—short tons, gross weight	(5)	(5)	1,547	(5)				
Mica (sheet)—pounds	15,102	82	18,461	119	10,218	89	349	3
Peat—short tons	4,491	(5)	4,288	(5)	6,904	73	1,032	(5)
Sand and gravel—thousand short tons	2,631	2,693	2,909	2,982	3,338	3,047	3,150	3,049
Stone—do	12,129	31,108	13,771	35,973	14,297	37,033	15,854	38,077
Talc and soapstone—short tons	(5)	(5)	53,692	107	40,200	88	47,950	98
Value of items that cannot be disclosed: Bauxite, cement, gem stones, iron ore (pigment material, 1958–60), manganiferous ore, scrap mica, and values indicated by footnote 5		10,145		10,979		11,181		9,454
Total Georgia [9]		75,106		86,262		91,203		95,256

HAWAII

Cement—thousand 376-pound barrels					113	$571	1,077	$5,574
Gem stones	(11)	(5)	(11)	(5)	(11)	(5)	(11)	18
Lime—thousand short tons	8	$260	(5)	(5)	(5)	(5)	14	354
Pumice—do	260	481	276	$548	361	676	324	626
Salt—do	(10)	(5)					(10)	4
Sand and gravel—do	438	1,112	463	1,253	490	1,324	416	758
Stone—do	2,377	4,446	3,034	5,480	3,535	6,443	4,429	7,656
Value of items that cannot be disclosed: Other nonmetals and values indicated by footnote 5		13		363		353		
Total Hawaii [16]		6,298		7,630		9,254		14,588

IDAHO

Antimony ore and concentrate—short tons, antimony content	677	(5)	678	(5)	635	(5)	689	(5)
Clays [3]—thousand short tons	27	$20	39	$33	36	$29	27	$20
Cobalt (content of concentrate)—thousand pounds	3,078	(5)	1,141	(5)				
Columbium-tantalum concentrate—pounds	422,612	(5)	189,263	(5)				
Copper (recoverable content of ores, etc.)—short tons	9,846	5,179	8,713	5,350	4,208	2,702	4,328	2,597
Gold (recoverable content of ores, etc.)—troy ounces	15,896	556	10,479	367	6,135	215	5,718	200
Iron ore (usable)—thousand long tons	1	14	6	56	9	(5)	12	70
Lead (recoverable content of ores, etc.)—short tons	53,603	12,543	62,395	14,351	42,907	10,040	71,476	14,724
Lime—thousand short tons							[17] 47	[17] 658
Mercury—76-pound flasks	2,625	601	1,961	446	1,538	324	1,073	212
Mica:								
Scrap—short tons	1	(5)						
Sheet—pounds	1,968	14	(5)	(5)	(5)	(5)		
Nickel (content of ore and concentrate)—short tons	29	(5)	(5)	(5)				
Phosphate rock—thousand long tons	1,291	5,652	1,610	7,412	2,177	11,044	1,440	7,984
Pumice—thousand short tons	108	172	93	137	56	88	60	95
Rare-earth metals concentrates—short tons	692	(5)	522	80				
Sand and gravel—thousand short tons	6,879	6,404	9,184	8,080	7,088	6,594	7,305	6,793
Silver (recoverable content of ores, etc.)—thousand troy ounces	15,953	14,438	16,637	15,057	13,647	12,351	17,576	16,249
Stone—thousand short tons	1,391	1,794	1,079	1,931	1,318	2,141	1,873	3,111
Titanium concentrate—short tons, gross weight	2,223	(5)	(5)	(5)	2,014	30	1,873	28
Uranium ore—short tons	(5)	(5)	3,374	30	(5)	(5)	(5)	(5)
Zinc (recoverable content of ores, etc.)—do	49,725	10,144	55,699	12,811	36,801	9,495	58,295	13,408
Value of items that cannot be disclosed: Barite, cement, clays (fire clay, bentonite 1958, 1960–61, kaolin 1961), abrasive garnet, gem stones, gypsum (1958–59), lime (recycled 1961), peat, perlite (1961), tungsten concentrate (1958, 1961), vanadium (1961), zirconium concentrate (1958), and values indicated by footnote 5. Excludes value of raw materials used in manufacturing cement		7,117		4,068		2,388		2,751
Total Idaho		64,648		70,209		57,441		68,900

See footnotes at end of table.

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

Mineral	1958		1959		1960		1961	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
ILLINOIS								
Cement:								
Portland—thousand 376-pound barrels	9,618	$30,858	9,925	$31,794	9,139	$30,732	8,595	$28,301
Masonry—thousand 280-pound barrels							461	1,420
Clays—thousand short tons	2,335	5,910	2,229	4,950	2,357	5,479	1,982	4,166
Coal (bituminous)—do	43,912	176,614	45,466	184,412	45,977	184,087	45,246	177,070
Fluorspar—short tons	152,087	7,931	112,469	5,908	134,529	6,936	116,908	5,956
Gem stones	(11)	1	(11)	1	(11)	(5)	(11)	(5)
Lead (recoverable content of ores, etc.)—short tons	1,610	377	2,570	591	3,000	702	3,430	707
Natural gas—million cubic feet	12,983	1,921	13,739	1,910	11,666	1,458	9,970	1,276
Natural gas liquids:								
Natural gasoline and cycle products—thousand gallons	22,380	1,645	(5)	(5)	16,496	1,313	16,956	1,311
LP gases—do	353,129	20,866	(5)	(5)	358,366	19,941	340,284	16,495
Peat—short tons	11,588	72	9,117	72	6,179	28	6,597	30
Petroleum (crude)—thousand 42-gallon barrels	80,275	240,825	76,727	229,414	77,341	228,929	[7] 79,387	[7] 237,367
Sand and gravel—thousand short tons	29,866	33,453	30,241	33,717	33,138	36,255	31,353	35,098
Stone—do	35,016	44,245	35,294	45,081	41,721	55,593	36,361	47,939
Zinc (recoverable content of ores, etc.)—short tons	24,940	5,088	26,815	6,167	29,550	7,624	26,795	6,163
Value of items that cannot be disclosed: Lime, tripoli, and values indicated by footnote 5		9,573		30,897		[4] 10,797		11,775
Total Illinois [9]		576,862		572,275		[4] 586,364		571,605
INDIANA								
Abrasive stones—short tons	10	$10	5	$13	(5)	(5)	5	$14
Cement—thousand 376-pound barrels	[2] 14,730	[2] 48,858	14,245	47,231	14,052	$48,310	(5)	(5)
Clays—thousand short tons	1,370	2,477	1,692	2,915	1,822	3,396	1,362	2,446
Coal (bituminous)—do	15,022	58,506	14,804	59,954	15,538	61,570	15,106	58,815
Natural gas—million cubic feet	378	59	484	92	342	61	382	77
Peat—short tons	12,106	145	15,393	202	27,486	290	57,146	502
Petroleum (crude)—thousand 42-gallon barrels	11,864	35,711	11,554	34,315	12,054	35,439	[7] 11,152	[7] 33,233
Sand and gravel—thousand short tons	16,862	15,045	20,357	17,924	20,752	18,377	19,577	16,898
Stone—do	15,394	31,974	18,544	37,682	18,956	34,920	18,001	33,062
Value of items that cannot be disclosed: Cement (masonry and natural cement 1958), gem stones (1961), gypsum, and values indicated by footnote 5.		7,539		8,817		8,569		55,461
Total Indiana [9]		197,677		206,359		[4] 208,247		197,965

IOWA

Cement:									
Portland	thousand 376-pound barrels	12,675	$41,741	13,170	$44,048	12,517	$44,204	12,108	$41,718
Masonry	thousand 280-pound barrels							557	1,843
Clays	thousand short tons	[3] 837	[3] 1,054	912	1,168	1,022	1,345	1,044	1,426
Coal (bituminous)	do	1,179	4,147	1,180	4,214	1,068	3,845	927	3,323
Gypsum	do	1,230	4,491	1,318	5,587	1,283	5,428	1,239	5,276
Sand and gravel	do	12,411	10,965	13,484	11,658	14,692	13,516	13,391	11,651
Stone	do	21,045	26,138	20,501	25,759	23,185	30,321	22,018	28,916
Value of items that cannot be disclosed: Fire clay (1958), gem stones (1960–61), lime, and peat (1958, 1960–61)			633		520		660		845
Total Iowa [9]			85,356		88,557		95,030		90,674

KANSAS

Cement:									
Portland	thousand 376-pound barrels	9,600	$30,047	10,405	$32,282	8,162	$26,373	8,028	$25,605
Masonry	thousand 280-pound barrels							379	1,156
Clays	thousand short tons	875	1,145	1,021	1,271	894	1,224	954	1,225
Coal (bituminous)	do	823	3,711	772	3,607	888	4,197	664	3,102
Gem stones				[11]	1	[11]	[6]		
Helium	thousand cubic feet	27,888	432	21,643	343	21,696	350	23,251	434
Lead (recoverable content of ores, etc.)	short tons	1,299	304	481	111	781	183	1,449	298
Lime	thousand short tons							15	193
Natural gas	million cubic feet	561,816	64,047	604,410	72,529	634,410	74,226	649,083	81,135
Natural gas liquids:									
Natural gasoline	thousand gallons	110,293	6,229	107,814	5,576	115,868	6,694	132,180	5,790
LP gases	do	115,175	5,193	124,874	6,658	127,270	6,343	135,643	5,916
Petroleum (crude)	thousand 42-gallon barrels	119,942	359,826	119,543	347,870	113,453	329,014	[7] 112,241	[7] 324,376
Salt	thousand short tons	1,073	11,348	1,123	13,670	1,213	14,109	[18] 914	[18] 11,409
Sand and gravel	do	10,317	6,769	11,334	7,937	9,710	6,808	11,366	7,781
Stone [8]	do	12,424	15,036	13,999	17,108	11,814	15,031	12,328	16,411
Zinc (recoverable content of ores, etc.)	short tons	4,421	902	1,017	234	2,117	546	2,446	563
Value of items that cannot be disclosed: Natural cement, gypsum, pumice, salt (brine 1961), stone (dimension 1958–59 and crushed sandstone), and values indicated by footnote 5			1,627		2,012		1,436		3,204
Total Kansas [9]			503,788		508,077		[4] 483,952		485,872

See footnotes at end of table.

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

Mineral	1958		1959		1960		1961	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
KENTUCKY								
Barite—short tons			26,598	$335	(5)	(5)	3,304	$30
Clays—thousand short tons	737	$2,957	984	3,595	[3] 951	[3] $2,646	[3] 906	[3] 2,406
Coal (bituminous)—do	66,312	289,385	62,810	270,139	66,846	282,395	63,032	256,158
Fluorspar—short tons	25,861	1,201	18,579	887	25,855	1,173	38,898	1,755
Lead (recoverable content of ores, etc.)—do	516	121	409	94	558	131	656	135
Natural gas—million cubic feet	72,248	17,412	73,504	17,420	75,329	18,380	70,937	17,592
Natural gas liquids:								
Natural gasoline—thousand gallons	37,926	2,165	35,868	2,133	(5)	(5)	(5)	(5)
LP gases—do	150,655	8,491	213,171	12,267	(5)	(5)	(5)	(5)
Petroleum (crude)—thousand 42-gallon barrels	17,509	51,652	27,272	76,634	21,147	60,268	[7] 18,643	[7] 55,370
Sand and gravel—thousand short tons	4,685	4,835	5,081	5,568	5,113	5,763	5,582	5,540
Silver (recoverable content of ores, etc.)—thousand troy ounces	(5)	(5)	(5)	(5)			2	2
Stone—thousand short tons	12,597	17,360	[8] 16,063	[8] 22,215	[8] 15,810	[8] 21,493	17,085	23,309
Zinc (recoverable content of ores, etc.)—short tons	1,258	257	673	155	869	224	1,147	264
Value of items that cannot be disclosed: Cement, ball clay (1960–61), gem stones (1960–61), lime (1961), stone (crushed sandstone 1959–60), and values indicated by footnote 5		7,059		8,202		22,080		24,463
Total Kentucky [9]		402,121		418,821		[4] 413,525		386,013
LOUISIANA								
Clays—thousand short tons	[3] 755	[3] $755	[3] 904	[3] $904	749	$749	645	$645
Lime—do	(5)	(5)	(5)	(5)	(5)	(5)	927	11,893
Natural gas—million cubic feet	2,451,587	316,255	2,670,271	411,222	2,988,414	511,019	3,271,857	611,837
Natural gas liquids:								
Natural gasoline and cycle products—thousand gallons	783,099	50,371	846,110	60,295	875,567	66,214	931,176	61,714
LP gases—do	410,869	21,435	540,046	25,877	606,023	28,147	806,559	33,214
Petroleum (crude)—thousand 42-gallon barrels	313,891	1,023,517	362,666	1,145,569	400,832	1,258,138	[7] 424,962	[7] 1,339,905
Salt—thousand short tons	3,442	18,960	4,807	20,918	4,792	21,959	4,722	23,357
Sand and gravel—do	15,061	17,119	16,052	20,111	14,319	19,106	12,042	14,833
Stone—do	5,453	9,532	5,670	10,874	[8] 4,691	[8] 8,882	[8] 4,641	[8] 7,656
Sulfur (Frasch-process)—thousand long tons	2,028	47,651	2,252	52,779	2,256	52,639	2,352	55,164
Value of items that cannot be disclosed: Cement, clay (bentonite 1958–59), gypsum, stone (crushed miscellaneous 1960–61), and values indicated by footnote 5		20,475		20,286		24,042		15,807
Total Louisiana [10]		1,523,370		1,766,269		[4] 1,987,967		2,173,442

MAINE

Beryllium concentrate	short tons, gross weight	(12)	(6)	3	$2	(5)	(5)	5	$3
Clays	thousand short tons	23	$26	25	26	41	$50	43	51
Feldspar	long tons	13,034	83	(5)	(5)	(5)	(5)	(5)	(5)
Gem stones		(11)	5	(11)	10	(11)	15	(11)	20
Mica:									
Scrap	short tons	104	3	157	4	171	6	80	2
Sheet	pounds	20,097	278	22,360	237	26,842	4 303	7,373	88
Sand and gravel	thousand short tons	8,941	3,746	9,452	3,644	9,833	3,892	8,921	3,796
Stone	do	880	2,760	819	2,766	1,012	3,851	998	4,694
Value of items that cannot be disclosed: Cement, lime (1958), peat (1958–59), and values indicated by footnote 5			6,363		7,050		5,991		6,961
Total Maine [16]			12,574		13,278		4 13,677		14,969

MARYLAND

Clays	thousand short tons	3 605	3 $815	3 661	3 $944	3 612	3 $853	581	$997
Coal (bituminous)	do	838	3,161	842	3,188	748	2,799	757	2,868
Gem stones		(11)	2	(11)	2	(11)	2	(11)	3
Lime	thousand short tons	(5)	(5)	(5)	(5)	(5)	(5)	96	1,302
Natural gas	million cubic feet	4,266	1,148	4,373	1,181	4,065	1,081	3,578	973
Sand and gravel	thousand short tons	8,513	11,368	10,034	12,983	10,076	13,221	12,404	16,894
Stone	do	6,721	14,387	7,445	15,476	7,944	16,962	10,671	21,203
Value of items that cannot be disclosed: Cement, ball clay (1958–60), greensand marl, peat (1961), potassium salts, talc and soapstone, and values indicated by footnote 5			16,224		21,416		22,779		20,153
Total Maryland [9]			45,735		53,189		55,527		62,264

MASSACHUSETTS

Clays	thousand short tons	85	$111	101	$229	83	$71	104	$85
Gem stones		(11)	(6)	(11)	1	(11)	1	(11)	2
Lime	thousand short tons	139	2,121	144	2,289	154	2,370	145	2,307
Peat	short tons	1,014	(5)	773	(5)	(5)	(5)	(5)	(5)
Sand and gravel	thousand short tons	10,620	10,035	13,210	11,786	14,789	13,013	18,061	14,958
Stone	do	4,649	12,354	5,102	12,375	5,247	12,782	5,210	13,399
Value of items that cannot be disclosed: Nonmetals and values indicated by footnote 5			9		6		8		38
Total Massachusetts [16]			23,887		25,916		27,588		30,234

See footnotes at end of table.

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

Mineral	1958		1959		1960		1961	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
MICHIGAN								
Cement:								
Portland—thousand 376-pound barrels	20,912	$70,432	23,026	$77,324	22,361	$77,694	21,948	$75,172
Masonry—thousand 280-pound barrels							1,515	4,467
Clays—thousand short tons	1,663	1,813	1,771	1,937	1,738	1,904	1,817	1,975
Copper (recoverable content of ores, etc.)—short tons	58,005	30,511	55,300	33,954	56,385	36,199	70,245	42,147
Gypsum—thousand short tons	1,331	4,824	1,721	6,595	1,463	5,609	1,295	5,095
Iron ore (usable)—thousand long tons, gross weight	8,111	69,845	7,247	62,921	10,792	95,791	9,384	87,604
Lime—thousand short tons	(5)	(5)	862	11,748	1,177	15,730	1,211	15,960
Manganiferous ore (5 to 35 percent Mn)—short tons, gross weight	112,536	(5)			180,460	(5)	17,083	(5)
Natural gas—million cubic feet	14,243	2,649	18,916	4,350	20,790	4,449	27,697	5,844
Peat—short tons	107,342	1,684	191,661	2,357	214,402	2,755	209,266	2,002
Petroleum (crude)—thousand 42-gallon barrels	9,308	27,366	10,439	30,691	15,899	46,266	[7] 18,898	[7] 55,182
Salt—thousand short tons	4,267	33,018	4,485	35,725	4,088	33,759	3,885	31,284
Sand and gravel—do	39,871	34,616	48,052	41,193	46,910	39,304	54,603	47,790
Stone—do	27,188	26,846	30,095	30,379	31,256	32,274	28,731	30,103
Value of items that cannot be disclosed: Bromine, calcium-magnesium chloride, gem stones, iodine (1961), magnesium compounds, natural gas liquids, potassium salts, and values indicated by footnote 5		45,558		49,371		45,864		46,186
Total Michigan [9]		343,487		381,297		[4] 429,737		442,696
MINNESOTA								
Clays—thousand short tons	92	$150	153	$267	[3] 125	[3] $163	176	$241
Iron ore (usable)—thousand long tons, gross weight	42,503	354,528	36,109	306,920	54,723	470,874	44,699	407,152
Manganiferous ore (5 to 35 percent Mn)—short tons, gross weight	370,603	(5)	429,102	(5)	441,028	(5)	181,835	(5)
Peat—short tons	(5)	(5)			1,465	72	11,091	181
Sand and gravel—thousand short tons	29,634	21,680	28,486	20,726	30,302	24,611	30,690	24,143
Stone—do	3,519	9,560	3,639	9,461	4,234	10,034	3,957	9,975
Value of items that cannot be disclosed: Abrasive stones, cement, fire clay (1960–61), gem stones, lime, and values indicated by footnote 5		10,154		9,993		[4] 9,767		9,223
Total Minnesota [10]		395,880		347,178		515,255		450,509

MISSISSIPPI

Clays	thousand short tons	576	$3,338	747	$4,064	1,017	$4,786	1,104	$5,034
Natural gas	million cubic feet	160,143	22,260	162,095	25,125	172,478	32,426	172,543	32,092
Natural gas liquids:									
Natural gasoline and cycle products	thousand gallons	25,738	1,658	23,207	1,495	23,648	1,552	25,135	1,625
LP gases	do	9,208	503	8,141	465	10,151	564	15,510	700
Petroleum (crude)	thousand 42-gallon barrels	39,512	113,004	49,620	140,921	51,673	146,235	[7] 54,492	[7] 153,667
Sand and gravel	thousand short tons	6,545	6,240	7,520	7,743	6,181	5,568	5,920	5,903
Stone	do	[8] 102	[8] 92	[8] 126	[8] 114	807	808	913	1,044
Value of items that cannot be disclosed: Certain metals and nonmetals			4,820		6,751		7,271		11,070
Total Mississippi [16]			151,411		186,116		[4] 198,449		210,242

MISSOURI

Barite	short tons	199,268	$2,666	296,093	$3,924	180,702	$2,588	227,323	$3,052
Cement:									
Portland	thousand 376-pound barrels	12,116	40,657	13,947	46,974	12,183	42,330	11,839	41,142
Masonry	thousand 280-pound barrels							437	1,398
Clays	thousand short tons	2,060	5,986	2,635	6,898	2,540	7,207	2,132	5,040
Coal (bituminous)	do	2,592	11,111	2,748	11,937	2,890	12,450	2,938	12,567
Copper (recoverable content of ores, etc.)	short tons	1,429	752	1,065	654	1,087	698	1,479	887
Iron ore (usable)	thousand long tons, gross weight	387	3,820	349	3,278	365	3,760	341	3,633
Lead (recoverable content of ores, etc.)	short tons	113,123	26,471	105,165	24,188	111,948	26,196	98,785	20,350
Lime	thousand short tons	1,173	14,136	1,324	15,714	1,254	14,701	1,173	13,873
Natural gas	million cubic feet					75	19	90	
Nickel (content of ore and concentrate)	short tons	763	(5)	(5)	(5)	(5)	(5)	(5)	(5)
Petroleum (crude)	thousand 42-gallon barrels	84	(5)	75	(5)	75	(5)	[7] 108	(5)
Sand and gravel	thousand short tons	8,972	9,728	10,279	11,406	10,207	11,601	9,371	10,688
Silver (recoverable content of ores, etc.)	thousand troy ounces	251	227	340	308	16	14	12	11
Stone	thousand short tons	24,276	32,878	26,939	36,435	27,180	37,878	25,631	36,577
Zinc (recoverable content of ores, etc.)	short tons	362	74	92	21	2,821	728	5,847	1,345
Value of items that cannot be disclosed: Native asphalt, cobalt, gem stones, manganese ore (1958), and values indicated by footnote 5			2,037		2,288		[4] 2,074		792
Total Missouri [9]			144,120		157,189		[4] 156,041		145,365

See footnotes at end of table.

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

Mineral	1958		1959		1960		1961	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
MONTANA								
Chromite—short tons, gross weight	119,057	(5)	[19] 105,000	[19] $3,765	[19] 107,000	[19] $3,813	[19] 82,000	[19] $2,939
Clays [3]—thousand short tons	23	$19	46	48	63	77	55	76
Coal (bituminous and lignite)—do	305	1,475	345	1,478	313	1,188	371	1,207
Copper (recoverable content of ores, etc.)—short tons	90,683	47,699	65,911	40,469	91,972	59,046	104,000	62,400
Fluorspar—do	53,654	(5)	18,542	(5)	31,273	(5)	14,905	(5)
Gold (recoverable content of ores, etc.)—troy ounces	26,003	910	28,551	999	45,922	1,607	35,377	1,238
Iron ore (u able)—thousand long tons, gross weight	14	(5)	50			293	34	209
Lead (recoverable content of ores, etc.)—short tons	8,434	1,974	7,672	1,765	4,879	1,142	2,643	544
Lime—thousand short tons	(5)	(5)	(5)	(5)	(5)	(5)	118	986
Manganese ore (35 percent or more Mn)—short tons, gross weight	53,123	4,036	21,604	1,520	29,036	1,996	17,515	1,412
Manganiferous ore (5 to 35 percent Mn)—do	(5)	(5)	2,415	34	676	11	2,236	33
Natural gas—million cubic feet	27,989	1,903	30,743	2,306	33,418	2,373	33,901	2,509
Peat—short tons							7,385	112
Petroleum (crude)—thousand 42-gallon barrels	27,957	74,086	29,857	76,434	30,240	72,878	[7] 30,907	[7] 74,795
Sand and gravel—thousand short tons	13,432	12,593	10,930	12,587	12,589	11,657	14,702	13,506
Silver (recoverable content of ores, etc.)—thousand troy ounces	3,630	3,286	3,420	3,096	3,607	3,265	3,490	3,227
Stone—thousand short tons	1,786	2,468	1,186	1,691	1,183	1,576	1,512	1,849
Uranium ore—short tons	689	20	2,890	(5)	1,726	29	729	10
Zinc (recoverable content of ores, etc.)—do	33,238	6,781	27,848	6,405	12,551	3,238	10,262	2,360
Value of items that cannot be disclosed: Barite, cement, chromite,[19] clays (bentonite 1958–59, fire clay), gem stones, gypsum, sheet mica, natural gas liquids, pyrites (1958–59), phosphate rock, rare-earth metal concentrates (1958–59), talc, tungsten (1960–61), vermiculite, and values indicated by footnote 5		20,318		15,248		15,217		14,854
Total Montana [16]		176,728		167,328		178,854		183,354
NEBRASKA								
Clays—thousand short tons	108	$110	131	$133	108	$109	146	$148
Gem stones	(11)	2	(11)	3	(11)	4	(11)	5
Natural gas—million cubic feet	11,405	1,711	13,128	2,087	15,258	2,670	15,743	2,629
Natural gas liquids:								
Natural gasoline—thousand gallons	10,870	727	(5)	(5)	(5)	(5)	(5)	(5)
LP gases—do	31,178	1,565	(5)	(5)	(5)	(5)	(5)	(5)

Petroleum (crude) thousand 42-gallon barrels	20,373	59,897	22,881	65,897	23,825	68,378	24,396	[7] 69,529
Sand and gravel thousand short tons	10,441	7,945	11,202	8,301	10,876	8,746	10,094	8,250
Stone do	3,555	4,747	3,236	5,235	3,336	5,651	3,622	6,324
Value of items that cannot be disclosed: Cement, lime (1961), pumice, and values indicated by footnote 5		14,603		17,679		18,384		18,637
Total Nebraska[3]		90,047		97,130		[4] 101,957		103,060

NEVADA

Antimony ore and concentrate short tons, antimony content	39	$8	10	$2				
Barite short tons	59,407	403	91,298	623	[4] 86,061	[4] $591	129,524	$863
Copper (recoverable content of ores, etc.) do	66,137	34,788	57,375	35,228	77,485	49,745	78,022	46,813
Fluorspar do	12,338	340	16,743	407	18,505	388	18,129	357
Gem stones	(11)	100	(11)	100	(11)	100	(11)	100
Gold (recoverable content of ores, etc.) troy ounces	105,087	3,678	113,443	3,971	58,187	2,037	54,165	1,896
Gypsum thousand short tons	686	2,306	818	2,738	802	2,721	729	2,625
Iron ore (usable) thousand long tons, gross weight	594	3,149	698	3,712	[4] 740	[4] 3,683	845	4,608
Lead (recoverable content of ores, etc.) short tons	4,150	971	1,357	312	987	231	1,791	369
Manganese ore (35 percent or more Mn) short tons, gross weight	127,322	7,566	56,611	3,918	49,076	3,301	28,573	1,852
Manganiferous ore (5 to 35 percent Mn) do			200	(5)	(5)	(5)		
Mercury 76-pound flasks	7,336	1,681	7,156	1,628	7,821	1,648	7,486	1,480
Perlite short tons	(5)	(5)	(5)		35,214	286	29,544	240
Petroleum (crude) thousand 42-gallon barrels	40	69	32	(5)	27	(5)	[7] 152	(5)
Sand and gravel thousand short tons	5,503	5,311	6,436	7,522	4,085	5,224	7,095	7,443
Silver (recoverable content of ores, etc.) thousand troy ounces	933	844	611	553	707	640	388	359
Stone thousand short tons	813	1,335	840	1,587	579	1,350	677	1,576
Talc and soapstone short tons	5,391	41	5,824	50	4,882	30	3,090	33
Zinc (recoverable content of ores, etc.) do	91	19	217	50	420	108	453	104
Value of items that cannot be disclosed: Brucite (1958–59), clays, diatomite, lime, magnesite, molybdenum, pumice, salt, sulfur ore, tungsten, uranium ore, and values indicated by footnote 5		6,020		8,458		[4] 8,809		10,811
Total Nevada [16]		68,291		70,164		[4] 80,335		80,565

NEW HAMPSHIRE

Beryllium concentrate short tons, gross weight	14	$8	20	$12	14	$8	23	$14
Clays thousand short tons	26	26	26	26	27	27	30	30
Feldspar long tons	(5)	(5)	(5)	(5)	(5)	(5)	10,290	62
Gem stones	(11)	5	(11)	10	(11)	15	(11)	(5)
Mica:								
Sheet pounds	81,472	646	119,163	1,133	[4] 72,188	[4] 1,101	62,737	931
Scrap short tons	314	12	(5)	(5)	415	14	669	20
Peat do	100	(5)	25	(5)	23	(5)	15	(5)
Sand and gravel thousand short tons	4,940	2,620	5,124	2,887	6,621	3,687	7,701	3,627
Stone do	(5)	(5)	82	488	104	594	117	684
Value of items that cannot be disclosed: Values indicated by footnote 5		602		166		68		20
Total New Hampshire		3,919		4,722		[4] 5,514		5,388

See footnotes at end of table.

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

Mineral	1958		1959		1960		1961	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
NEW JERSEY								
Clays—thousand short tons	684	$2,181	700	$1,895	664	$1,597	657	$1,681
Gem stones	(11)	4	(11)	6	(11)	7	(11)	9
Peat—short tons	18,397	185	28,300	278	25,100	192	21,257	212
Sand and gravel—thousand short tons	9,877	16,145	11,033	18,620	11,594	19,511	12,257	20,895
Stone—do	8,229	19,193	10,079	22,133	10,202	22,814	11,315	24,539
Zinc (recoverable content of ores, etc.)[20]—short tons	607	125					112	26
Value of items that cannot be disclosed: Iron ore, lime, magnesium compounds, manganiferous residuum, greensand marl, and uranium ore (1960). Excludes limestone used in manufacturing lime		12,547		16,547		12,288		11,846
Total New Jersey		50,380		59,479		56,409		59,208
NEW MEXICO								
Barite—short tons	(5)	(5)	320	$6	492	$10	600	$10
Beryllium concentrate—short tons, gross weight	27	$16	11	6			24	12
Carbon dioxide, natural—thousand cubic feet	(5)	(5)	(5)	(5)	230,115	(5)	242,903	(5)
Clays [3]—thousand short tons	40	73	45	77	56	132	67	165
Coal (bituminous)—do	117	719	149	837	295	1,747	412	2,477
Copper (recoverable content of ores, etc.)—short tons	55,540	29,214	39,688	24,369	67,288	43,199	79,606	47,764
Fluorspar—do			200	7				
Gem stones	(11)	28	(11)	39	(11)	40	(11)	46
Gold (recoverable content of ores, etc.)—troy ounces	3,378	118	3,155	110	5,423	190	6,201	217
Gypsum—thousand short tons					55	193	105	386
Helium—thousand cubic feet	29,793	502	16,903	264	43,494	684	42,224	762
Iron ore (usable)—thousand long tons, gross weight	(21)	(5)	(21)	(5)	1	27	(21)	(5)
Lead (recoverable content of ores, etc.)—short tons	1,117	261	829	191	1,996	467	2,332	480
Lime—thousand short tons	21	260	16	209	36	496	25	350
Manganese ore (35 percent or more Mn)—short tons, gross weight	28,866	2,333	27,528	2,248				
Mica:								
Scrap—short tons	787	24	210	7	235	7	1,800	52
Sheet—pounds	1,791	18	247	2	(5)	(5)		

Natural gas	million cubic feet	761,446	79,190	739,660	73,966	798,928	85,485	789,662	86,073
Natural gas liquids:									
Natural gasoline and cycle products	thousand gallons	258,312	15,131	264,133	16,859	321,667	20,412	301,404	18,619
LP gases	do	458,178	17,331	552,257	22,320	645,116	28,788	656,751	24,154
Perlite	short tons	202,046	1,790	240,642	2,121	240,593	2,119	245,654	2,159
Petroleum (crude)	thousand 42-gallon barrels	98,515	293,974	105,692	301,394	107,380	305,895	[7] 112,083	[7] 320,784
Potassium salts	thousand short tons, K_2O equivalent	1,978	69,106	2,189	74,117	2,440	[4] 82,645	2,523	96,380
Pumice	thousand short tons	507	959	493	1,023	365	827	339	879
Salt	do	31	275	36	322	39	331	33	284
Sand and gravel	do	13,205	11,413	12,460	13,332	7,419	7,459	12,523	10,049
Silver (recoverable content of ores, etc.)	thousand troy ounces	159	144	159	144	304	275	283	261
Stone	thousand short tons	1,730	1,507	461	542	1,277	1,692	1,853	2,206
Uranium ore	short tons	1,888,499	32,264	3,269,826	53,463	3,793,494	61,827	3,631,036	62,482
Zinc (recoverable content of ores, etc.)	do	9,034	1,843	4,636	1,066	13,770	3,553	22,900	5,267
Value of items that cannot be disclosed: Cement (1960–61) fire clay, molybdenum, magnesium compounds, manganiferous ore, vanadium, and values indicated by footnote 5			1,345		3,771		5,266		7,237
Total New Mexico [16]			559,777		592,535		[4] 653,226		688,908
NEW YORK									
Clays	thousand short tons	1,085	$1,419	1,309	$1,714	1,172	$1,717	1,037	$1,373
Emery	short tons	7,687	126	8,555	150	8,169	142	6,180	106
Gem stones		(11)	8	(11)	8	(11)	9	(11)	10
Gypsum	thousand short tons	834	3,869	919	4,663	755	3,928	663	3,441
Iron ore (usable)	thousand long tons, gross weight	1,944	25,683	2,044	28,050	2,484	[4] 32,977	1,973	25,548
Lead (recoverable content of ores, etc.)	short tons	579	135	481	111	775	181	879	181
Natural gas	million cubic feet	2,808	859	2,915	889	4,990	1,542	5,742	1,694
Peat	short tons	13,606	117	12,875	138	10,042	146	11,209	123
Petroleum (crude)	thousand 42-gallon barrels	1,763	7,457	1,970	8,353	1,813	8,412	[7] 1,715	[7] 8,163
Salt	thousand short tons	3,896	30,609	4,011	30,958	4,008	30,763	4,149	30,761
Sand and gravel	do	24,730	27,541	27,943	31,415	30,687	35,152	28,043	30,471
Silver (recoverable content of ores, etc.)	thousand troy ounces	67	60	52	47	49	45	41	37
Stone	do	22,598	38,219	28,640	46,556	29,802	46,955	26,951	43,734
Zinc (recoverable content of ores, etc.)	short tons	53,014	10,815	43,464	9,997	66,364	17,122	54,763	12,595
Value of items that cannot be disclosed: Beryllium concentrate (1960–61), cement, abrasive garnet, iron oxide pigments (1958), lime, talc, titanium concentrate, and wollastonite			61,859		76,904		81,831		76,219
Total New York [9]			205,338		234,642		[4] 255,368		228,983

See footnotes at end of table.

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

Mineral	1958		1959		1960		1961	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
NORTH CAROLINA								
Abrasive stones—short tons	(11)	[22] $2	[23] 191	[23] $5	(11)	[22] $2	(11)	[22] $3
Clays [3]—thousand short tons	2,046	1,187	2,524	1,522	2,476	1,548	2,603	1,669
Feldspar—long tons	(5)	(5)	(5)	(5)	270,761	2,781	251,858	2,477
Gem stones	(11)	1	(11)	9	(11)	4	(11)	6
Gold (recoverable content of ores, etc.)—troy ounces	876	31	965	34	1,826	64	2,094	73
Iron ore—thousand long tons			(5)	(5)	(5)	(5)	(5)	1
Lead (recoverable content of ores, etc.)—short tons					424	99	318	66
Mica:								
Scrap—do	50,897	1,041	47,736	1,212	47,281	1,100	53,615	1,010
Sheet—pounds	521,701	1,722	505,623	1,755	430,193	[4] 1,539	390,870	2,237
Sand and gravel—thousand short tons	7,044	5,880	8,580	7,426	8,801	7,453	9,779	8,467
Silver (recoverable content of ores, etc.)—thousand troy ounces	15	14	16	15	212	192	170	157
Stone—thousand short tons	12,385	19,132	12,859	20,302	14,721	23,296	15,921	25,262
Talc and pyrophyllite—short tons	126,158	614	127,296	647	100,593	549	90,711	367
Value of items that cannot be disclosed: Abrasive stone (grinding pebbles and tube-mill liners, 1958, millstones 1959), asbestos, barite (1961), beryllium concentrate (1958), clay (kaolin), copper, lithium minerals, olivine, tungsten concentrate, and values indicated by footnote 5		10,267		7,862		6,469		8,329
Total North Carolina		39,891		40,789		[4] 45,096		50,124
NORTH DAKOTA								
Clays—thousand short tons	[3] 54	[3] $66	[3] 61	[3] $79	[3] 102	[3] $129	(5)	(5)
Coal (lignite)—do	2,314	5,409	2,413	5,426	2,525	5,790	2,726	$6,141
Gem stones	(11)	1	(11)	1	(11)	1	(11)	1
Natural gas—million cubic feet	17,325	1,672	17,915	1,774	19,483	2,221	20,100	2,533
Petroleum (crude)—thousand 42-gallon barrels	14,259	42,634	17,824	49,907	21,992	59,598	[7] 23,568	[7] 64,105
Pumice—thousand short tons	11	11						
Sand and gravel—do	11,464	6,605	9,883	6,516	8,648	6,904	9,395	7,507
Stone—do	23	35	48	84	28	44	40	40
Value of items that cannot be disclosed: Clays (bentonite 1958–60, fire clay 1960), natural gas liquids, salt (1960–61) and values indicated by footnote 5		3,012		3,555		3,691		4,370
Total North Dakota		59,445		67,342		[4] 78,378		84,697

OHIO

Abrasive stones, grindstones and pulpstones—short tons	852	$83	1,081	$101	(5)	(5)	(5)	(5)
Cement:								
Portland—thousand 376-pound barrels	15,700	53,043	18,994	63,935	17,480	$61,478	15,303	$53,251
Masonry—thousand 280-pound barrels							846	2,604
Clays—thousand short tons	5,220	13,082	5,478	15,346	5,165	14,325	4,923	13,790
Coal (bituminous)—do	32,028	126,241	35,112	135,729	33,957	130,877	32,226	121,343
Gem stones	(11)	(5)	(11)	2	(11)	3	(11)	4
Lime—thousand short tons	2,411	32,471	3,190	45,121	3,117	44,403	3,123	42,158
Natural gas—million cubic feet	31,786	6,802	34,664	8,042	36,074	8,477	36,423	9,069
Peat—short tons	5,660	104	5,813	73	6,755	93	9,113	123
Petroleum (crude)—thousand 42-gallon barrels	6,260	18,091	5,978	17,157	5,405	16,053	[7] 5,161	[7] 15,947
Salt—thousand short tons	2,443	17,443	2,858	20,486	3,108	24,149	3,465	25,037
Sand and gravel—do	29,624	36,619	38,604	45,139	37,943	44,979	33,688	41,272
Stone—do	29,122	49,782	[8] 36,155	[8] 59,326	[8] 35,856	[8] 59,479	33,652	55,701
Value of items that cannot be disclosed: Gypsum, natural gasoline (1958), stone (dimension limestone 1960, and calcareous marl 1959–60), and values indicated by footnote 5		1,905		2,027		1,826		1,566
Total Ohio [9]		344,856		397,326		[4] 391,150		368,315

OKLAHOMA

Clays [3]—thousand short tons	576	$579	966	$970	734	$739	792	$801
Coal (bituminous)—do	1,629	10,858	1,525	10,272	1,342	9,113	1,032	6,784
Helium—thousand cubic feet			98,749	1,619	289,068	4,691	313,244	5,872
Lead (recoverable content of ores, etc.)—short tons	3,692	864	601	138	936	219	980	202
Natural gas—million cubic feet	696,504	70,347	811,508	81,151	824,266	98,088	892,697	108,016
Natural gas liquids:								
Natural gasoline and cycle products—thousand gallons	440,798	26,029	448,353	29,443	531,995	33,074	521,237	33,358
LP gases—do	657,114	25,822	675,869	27,070	762,258	32,409	817,082	30,141
Petroleum (crude)—thousand 42-gallon barrels	200,699	594,069	198,090	578,423	192,913	563,306	[7] 191,834	[7] 558,237
Salt—thousand short tons	4	41	(5)	(5)	3	16	3	19
Sand and gravel—do	7,232	5,859	6,002	5,927	6,424	7,468	5,310	5,513
Stone—do	10,794	12,232	12,683	14,980	[8] 14,054	[8] 16,098	14,981	16,561
Zinc (recoverable content of ores, etc.)—short tons	5,267	1,074	1,049	241	2,332	602	3,148	724
Value of items that cannot be disclosed: Native asphalt (1958–60), clay (bentonite), cement, gem stones (1959–61), gypsum, lime, pumice, stone (crushed granite 1960), tripoli, and values indicated by footnote 5		16,022		18,156		16,756		21,920
Total Oklahoma [9]		761,936		765,439		[4] 780,941		785,973

See footnotes at end of table.

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

Mineral	1958		1959		1960		1961	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
OREGON								
Chromite—short tons, gross weight	4,133	(5)						
Clays—thousand short tons	252	$293	294	$308	318	$370	294	$357
Copper (recoverable content of ores, etc.)—short tons	10	5			6	4	(5)	(5)
Gold (recoverable content of ores, etc.)—troy ounces	1,423	50	686	24	835	29	1,054	37
Lead (recoverable content of ores, etc.)—short tons	1	(6)					(5)	(5)
Lime—thousand short tons	(5)	(5)			(5)	(5)	221	5,157
Mercury—76-pound flasks	2,276	521	1,224	278	513	108	138	27
Nickel (content of ore and concentrate)—short tons	12,697	(5)	12,374	(5)	13,115	5,246	12,860	(5)
Pumice—thousand short tons	138	331	(5)	(5)	(5)	(5)	203	461
Sand and gravel—do	10,464	10,265	18,087	15,506	17,673	16,170	12,299	13,680
Silver (recoverable content of ores, etc.)—thousand troy ounces	3	2	(24)	(6)	(24)	(6)	2	2
Stone—thousand short tons	15,077	15,621	13,341	16,126	[4] 16,913	[4] 19,721	17,272	20,939
Uranium ore—short tons					(5)	(5)	2,160	66
Zinc (recoverable content of ores, etc.)—do							3	1
Value of items that cannot be disclosed: Asbestos (1959–61), carbon dioxide, (1958–60), cement, diatomite, gem stones, iron ore (pigment material, 1959, 1961), and values indicated by footnote 5		19,311		18,607		14,124		15,557
Total Oregon [9]		45,190		49,842		[4] 54,520		54,922
PENNSYLVANIA								
Cement:								
Portland—thousand 376-pound barrels	42,115	$142,399	43,356	$150,918	38,320	$131,763	36,635	$124,506
Masonry—thousand 280-pound barrels							2,678	7,232
Clays—thousand short tons	[3] 3,318	[3] 17,051	3,466	17,196	[3] 3,557	[3] 16,536	[3] 2,999	[3] 14,402
Coal:								
Anthracite—do	21,171	187,898	20,649	172,320	18,817	147,116	17,446	140,338
Bituminous—do	67,771	373,812	65,347	345,332	65,425	345,971	62,652	323,758
Cobalt (content of concentrate)—thousand pounds	564	(5)	280	(5)	(5)	(5)	(5)	(5)
Gem stones	(11)	2	(11)	3	(11)	4	(11)	5
Lime—thousand short tons	1,003	14,161	1,263	18,261	1,120	16,277	1,124	16,896

Natural gas—million cubic feet	95,869	27,131	99,366	29,015	113,928	36,229	100,427	29,526
Natural gas liquids:								
Natural gasoline—thousand gallons	1,608	107	2,884	184	1,399	85	1,272	74
LP gases—do	1,363	123	1,484	36	1,580	138	1,453	115
Peat—short tons	23,623	203	26,948	262	30,837	325	27,993	291
Petroleum (crude)—thousand 42-gallon barrels	6,472	26,535	6,160	25,872	6,009	27,341	[7] 5,622	[7] 26,480
Sand and gravel—thousand short tons	11,825	19,180	14,257	23,233	13,011	21,204	12,594	19,766
Stone—do	40,049	69,694	43,682	77,421	42,136	74,168	41,834	71,344
Zinc (recoverable content of ores, etc.)[20]—short tons	10,812	2,229	16,718	3,828	13,746	3,559	23,428	5,408
Value of items that cannot be disclosed: Clays (kaolin 1958, 1960–61), copper, gold, graphite (1959–61), iron ore, scrap mica, pyrites, pyrophyllite and soapstone, silver, tripoli, and values indicated by footnote 5		15,960		15,812		17,430		25,355
Total Pennsylvania [9]		882,040		862,150		[4] 823,360		791,648

RHODE ISLAND

Sand and gravel—thousand short tons	2,038	$1,883	1,740	$1,588	1,535	$1,355	1,726	$1,666
Stone—do	[8] 3	[8] 8	(5)	(5)	1,810	4,372	(5)	(5)
Value of items that cannot be disclosed: Nonmetals and values indicated by footnote 5		358		745				1,413
Total Rhode Island		2,249		2,333		5,727		3,079

SOUTH CAROLINA

Clays—thousand short tons	929	$5,157	1,160	$5,920	1,297	$6,201	1,346	$6,169
Mica (sheet)—pounds	1,144	8	251	3	101	1	12	(6)
Peat—short tons	4,865	(5)	4,194	(5)	(5)	(5)	(5)	(5)
Sand and gravel—thousand short tons	2,946	2,858	3,104	3,077	3,029	3,048	2,904	3,067
Stone—do	[8] 3,637	[8] 5,229	[8] 6,248	[8] 8,647	7,327	10,593	6,752	9,827
Zirconium concentrate—short tons	141	5						
Value of items that cannot be disclosed: Barite, cement, feldspar (1959–61), gem stones (1958), kyanite, scrap mica, pyrites (1960–61), rare-earth metal concentrates (1958), staurolite (1958), stone (crushed limestone 1958–59, crushed sandstone 1959, calcareous marl 1958–59), titanium (1958), vermiculite, and values indicated by footnote 5		9,586		13,640		[4] 11,144		12,311
Total South Carolina [16]		22,412		30,598		30,001		30,136

See footnotes at end of table.

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

Mineral	1958		1959		1960		1961	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
SOUTH DAKOTA								
Beryllium concentrate—short tons, gross weight	240	$129	156	$84	167	$88	238	$130
Clays [3]—thousand short tons	155	155	227	227	202	202	249	249
Coal (lignite)—do	20	78	22	88	20	83	18	75
Columbium-tantalum concentrate—pounds	4,294	10						
Copper (recoverable content of ores, etc.)—short tons					1	1		
Feldspar—long tons	23,229	145	30,825	196	45,588	292	29,354	186
Gem stones	(11)	16	(11)	20	(11)	20	(11)	18
Gold (recoverable content of ores, etc.)—troy ounces	570,830	19,979	577,730	20,221	554,771	19,417	557,855	19,525
Gypsum—thousand short tons	12	49	19	78	22	89	22	89
Iron ore (usable)—thousand long tons					(5)	(5)	22	100
Mica:								
Scrap—short tons	1,003	24	158	5	205	10	1,054	32
Sheet—pounds	16,772	68	38,775	158	30,887	145	18,086	37
Petroleum (crude)—thousand 42-gallon barrels	58	(5)	151	(5)	281	(4)	[7] 234	(5)
Sand and gravel—thousand short tons	14,705	9,179	17,775	11,058	13,548	9,359	11,324	7,336
Silver (recoverable content of ores, etc.)—thousand troy ounces	153	138	124	113	108	98	127	118
Stone—thousand short tons	1,395	4,095	2,721	7,243	3,149	7,909	2,806	6,642
Uranium ore—short tons	35,489	530	45,734	606	41,104	586	43,588	495
Value of items that cannot be disclosed: Cement, clays (bentonite), lime, lithium minerals (1958–60), vanadium (1960–61), and values indicated by footnote 5		7,555		9,401		9,376		8,978
Total South Dakota [9]		41,534		48,553		46,780		42,980
TENNESSEE								
Cement:								
Portland—thousand 376-pound barrels	8,375	$26,408	9,153	$28,934	8,246	$27,384	8,357	$26,964
Masonry—thousand 280-pound barrels							1,018	2,753
Clays—thousand short tons	935	4,210	1,146	4,952	1,270	4,537	[8] 1,040	[8] 4,190
Coal (bituminous)—do	6,785	25,969	5,913	23,581	5,930	21,154	5,860	20,681
Copper (recoverable content of ores, etc.)—short tons	9,109	4,791	11,490	7,055	12,723	8,168	12,272	7,363
Gem stones	(11)	1	(11)	(5)	(11)	1	(11)	1

Gold (recoverable content of ores, etc.)—troy ounces	124	4	99	3	123	4	152	5
Iron ore (usable)—thousand long tons, gross weight	(5)	(5)	21	111	(5)	(5)	(5)	(5)
Manganese ore (35 percent or more Mn)—short tons, gross weight	5,935	452	7,586	589	283	15	----	----
Manganiferous ore (5 to 35 percent Mn)—do	----	----	56	1	(5)	(5)	----	----
Natural gas—million cubic feet	54	9	52	9	63	11	71	13
Petroleum (crude)—thousand 42-gallon barrels	7	(5)	6	(5)	20	(5)	[7] 18	(5)
Phosphate rock—thousand long tons	1,903	13,041	1,755	13,255	1,939	15,424	2,235	18,675
Sand and gravel—thousand short tons	5,612	6,671	6,221	7,570	6,293	7,655	6,232	8,046
Silver (recoverable content of ores, etc.)—thousand troy ounces	44	40	60	54	65	58	83	77
Stone—thousand short tons	[8] 16,850	[8] 26,814	18,767	29,094	20,074	29,942	23,940	35,906
Zinc (recoverable content of ores, etc.)—short tons	59,130	12,062	89,932	20,684	91,394	23,579	81,734	18,799
Value of items that cannot be disclosed: Barite, clay (fuller's earth 1961), lime, scrap mica (1958–60), pyrites, stone (crushed sandstone 1958, dimension limestone 1958) and values indicated by footnote 5	----	6,884	----	7,392	----	[4] 7,606	----	7,241
Total Tennessee [9]	----	124,934	----	140,738	----	[4] 143,475	----	147,262

TEXAS

Cement:								
Portland—thousand 376-pound barrels	25,875	$79,756	27,991	$88,067	23,365	$76,577	25,101	$80,808
Masonry—thousand 280-pound barrels							851	2,529
Clays [8]—thousand short tons	3,720	5,424	3,870	5,703	3,302	5,058	3,786	5,737
Gem stones	(11)	100	(11)	100	(11)	100	(11)	150
Gypsum—thousand short tons	1,240	4,120	1,351	4,770	1,131	3,960	1,074	3,846
Helium—thousand cubic feet	294,452	4,807	238,113	3,918	120,921	2,044	173,066	3,196
Lime—thousand short tons	691	7,146	809	8,530	821	9,087	880	9,736
Natural gas—million cubic feet	5,178,073	517,807	5,718,993	617,651	5,892,704	665,876	5,963,605	733,523
Natural gas liquids:								
Natural gasoline and cycle products—thousand gallons	2,871,589	204,501	2,790,155	209,238	2,880,906	207,583	3,111,427	214,279
LP gases—do	3,786,575	151,896	4,353,368	181,148	4,476,142	200,478	4,768,222	185,558
Petroleum (crude)—thousand 42-gallon barrels	940,166	2,872,389	971,978	2,893,146	927,479	2,748,735	[7] 938,017	[7] 2,787,925
Salt—thousand short tons	3,843	15,115	4,519	17,498	4,756	18,222	4,695	17,682
Sand and gravel—do	32,871	30,808	35,295	34,726	29,844	30,754	27,398	30,691
Stone—do	36,076	40,912	42,172	47,787	39,029	45,088	38,316	45,874
Sulfur (Frasch-process)—thousand long tons	2,616	61,621	2,970	68,998	2,747	62,855	2,730	62,720
Talc and soapstone—short tons	60,827	168	60,945	283	67,031	336	78,214	376
Value of items that cannot be disclosed: Abrasive stones (1959), native asphalt, barite (1961), bromine, clay (fuller's earth), coal (lignite), feldspar, graphite, iron ore, magnesium chloride (for metal), magnesium compounds (except for metal), mercury (1958–60), pumice (1958, 1961), sodium sulfate, and uranium ore	----	46,891	----	48,544	----	49,666	----	50,923
Total Texas [9]	----	4,033,311	----	4,219,757	----	[4] 4,116,664	----	4,224,909

See footnotes at end of table.

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

Mineral	1958		1959		1960		1961	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
UTAH								
Asphalt and related bitumens, native: Gilsonite—short tons	317,280	$4,864	379,362	$9,385	383,037	$10,020	(8)	(8)
Carbon dioxide, natural—thousand cubic feet	90,207	6	69,625	5	60,425	4	78,136	$5
Clays—thousand short tons	[3] 157	[3] 488	[3] 185	[3] 484	[3] 143	[3] 416	143	1,080
Coal (bituminous)—do	5,328	30,340	4,545	27,982	4,955	31,458	5,159	31,126
Copper (recoverable content of ores, etc.)—short tons	189,184	99,511	144,715	88,855	218,049	139,987	213,534	128,120
Fluorspar—do	16,109	564	(8)	(8)	1,912	51	610	18
Gem stones	(11)	40	(11)	134	(11)	72	(11)	73
Gold (recoverable content of ores, etc.)—troy ounces	307,824	10,774	239,517	8,383	368,255	12,889	342,988	12,005
Iron ore (usable)—thousand long tons, gross weight	3,514	25,202	2,842	19,979	3,334	23,862	3,533	25,493
Lead (recoverable content of ores, etc.)—short tons	40,355	9,443	36,630	8,425	39,398	9,219	40,894	8,424
Lime—thousand short tons	80	1,513	90	1,773	127	2,672	142	2,626
Manganese ore (35 percent or more Mn)—short tons, gross weight	1,043	84	1,511	124				
Mica (sheet)—pounds	12	(8)						
Natural gas—million cubic feet	19,247	2,829	38,921	5,527	51,040	9,187	57,175	8,976
Natural gasoline—thousand gallons	240	15	(8)	(8)	(8)	(8)	(8)	(8)
Petroleum (crude)—thousand 42-gallon barrels	24,811	74,185	39,959	114,283	37,594	103,008	[7] 33,118	[7] 91,075
Pumice—thousand short tons	41	84	39	81	60	134	60	95
Salt—do	184	2,275	209	2,453	231	3,092	249	3,187
Sand and gravel—do	25,304	14,379	8,843	6,436	6,848	6,182	14,060	8,448
Silver (recoverable content of ores, etc.)—thousand troy ounces	5,278	4,777	3,734	3,380	4,783	4,329	4,798	4,435
Stone—thousand short tons	13,126	13,949	3,338	4,048	1,837	3,087	1,808	3,219
Uranium ore—short tons	1,239,767	38,583	1,210,654	37,310	1,089,757	27,843	1,098,783	25,734
Vanadium (recoverable in ore and concentrate)—do	376	(8)	536	(8)	462	(8)	514	(8)
Zinc (recoverable content of ores, etc.)—do	44,982	9,176	35,223	8,101	35,476	9,153	37,239	8,565
Value of items that cannot be disclosed: Barite (1959–61), cement, clay (kaolin 1958–60), gypsum, molybdenum, LP gases (1959–61), perlite, phosphate rock, potassium salts, pyrites (1959–60), and values indicated by footnote 5		25,214		27,396		36,047		45,554
Total Utah [10]		367,232		373,515		[4] 431,383		406,617
VERMONT								
Copper (recoverable content of ores, etc.)—short tons	475	$250						
Gem stones	(11)	1	(11)	$1	(11)	$1	(11)	$2
Sand and gravel—thousand short tons	1,882	1,316	2,320	1,590	1,809	1,218	2,232	1,567
Silver (recoverable content of ores, etc.)—thousand troy ounces	5	5						
Stone—thousand short tons	808	15,789	944	17,372	2,114	17,444	2,731	18,715
Value of items that cannot be disclosed: Asbestos, clays, lime, and talc		4,106		4,420		4,240		4,012
Total Vermont [10]		21,443		23,359		22,879		24,283

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VIRGINIA

Aplite—long tons	(5)	(5)	(5)	(5)	(5)	(5)	97,465	$651
Clays—thousand short tons	1,153	$1,143	1,346	$1,396	1,348	$1,395	1,406	1,332
Coal (bituminous)—do	26,826	130,319	29,769	139,224	27,838	122,723	30,332	126,121
Gem stones	(11)	3	(11)	4	(11)	5	(11)	6
Lead (recoverable content of ores, etc.)—short tons	2,934	687	2,770	637	2,152	504	3,733	769
Lime—thousand short tons	471	5,533	765	8,168	711	8,028	739	8,596
Manganese ore (35 percent or more Mn)—short tons, gross weight	8,128	647	6,232	499				
Manganiferous ore (5 to 35 percent Mn)—do	56	1	(5)	(5)				
Mica, sheet—pounds	147	2	108	1	103	1	(5)	(5)
Natural gas—million cubic feet	2,521	681	2,280	597	2,227	604	2,466	668
Petroleum (crude)—thousand 42-gallon barrels	4	(5)	6	(5)	2	(5)	[7] 6	(5)
Sand and gravel—thousand short tons	7,158	10,834	8,452	12,369	7,666	11,432	9,839	14,697
Silver (recoverable content of ores, etc.)—thousand troy ounces	2	2	1	1				
Stone—thousand short tons	15,413	27,504	17,787	31,447	19,358	33,019	22,934	39,206
Zinc (recoverable content of ores, etc.)[20]—short tons	18,472	3,808	20,334	4,662	19,885	5,142	29,163	6,726
Value of items that cannot be disclosed: Cement, feldspar, gypsum, iron ore (pigment materials 1960–61), kyanite, pyrites, salt, talc and soapstone, titanium concentrate, and values indicated by footnote 5		25,471		28,848		[4] 26,027		27,757
Total Virginia [9]		203,277		222,501		[4] 203,887		221,835

WASHINGTON

Abrasive stone: Pebbles (grinding)—short tons	18	(6)	(5)	(6)	(5)	(5)	(5)	(6)
Barite—do	(5)	(5)	(5)	(5)	(4)	(4)	5,100	42
Chromite—short tons, gross weight	17	$2						
Clays [3]—thousand short tons	196	183	180	$171	169	$162	145	$138
Coal (bituminous)—do	252	1,968	242	1,841	228	1,721	191	1,381
Copper (recoverable content of ores, etc.)—short tons	52	27	49	30	78	50	66	40
Gem stones	(11)	75	(11)	(5)	(11)	(5)	(11)	(5)
Iron ore (usable)—thousand long tons	4	(5)	4	5				
Lead (recoverable content of ores, etc.)—short tons	9,020	2,111	10,310	2,371	7,725	1,808	8,053	1,659
Lime—thousand short tons							[17] 349	[17] 8,481
Manganese ore (35 percent or more Mn)—short tons, gross weight			83	(5)				
Peat—short tons	34,642	116	32,884	124	27,770	121	55,543	359
Petroleum (crude)—thousand 42-gallon barrels	4	(5)	1	(5)	1	(5)	(25)	(5)
Pumice—thousand short tons	(5)	(5)	9	112	(5)	(5)	(5)	(5)
Sand and gravel—do	24,389	20,086	21,360	18,576	[4] 25,594	[4] 19,459	18,994	16,145
Stone—do	7,837	9,991	12,278	13,587	13,897	15,796	11,464	14,758
Talc and soapstone—short tons	4,000	21	4,073	23	2,406	12	2,927	23
Uranium ore—do	(5)	(5)	152,336	(5)	171,255	3,223	175,327	3,582
Zinc (recoverable content of ores, etc.)—do	18,797	3,835	17,111	3,936	21,317	5,500	20,217	4,650
Value of items that cannot be disclosed: Carbon dioxide, cement, fire clay, diatomite, epsom salts (1961), gold, lime (recycled 1961), magnesite, mercury (1958), olivine, silver, strontium minerals (1958–59), tungsten (1961), and values indicated by footnote 5		24,128		25,054		24,552		23,666
Total Washington [9]		60,896		63,894		[4] 70,485		73,006

See footnotes at end of table.

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

Mineral	1958		1959		1960		1961	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
WEST VIRGINIA								
Clays—thousand short tons	510	$1,960	596	$2,492	626	$2,639	475	$2,193
Coal (bituminous)—do	119,468	635,201	119,692	621,003	118,944	597,222	113,070	558,525
Gem stones			(11)	1	(11)	1	(11)	1
Natural gas—million cubic feet	204,581	50,734	204,633	53,205	208,757	54,694	210,556	57,692
Natural gas liquids:								
Natural gasoline—thousand gallons	27,917	5,643	29,242	1,808	23,211	1,513	34,095	2,296
LP gases—do	235,524	12,806	308,316	15,534	329,874	16,527	342,646	17,826
Petroleum (crude)—thousand 42-gallon barrels	2,186	7,629	2,184	7,862	2,300	9,361	[7] 2,703	[7] 11,190
Salt—thousand short tons	627	2,784	811	3,305	920	3,673	899	3,510
Sand and gravel—do	5,253	11,729	4,854	10,513	4,506	9,802	4,882	10,152
Stone—do	[8] 5,599	[8] 9,990	[8] 5,923	[8] 10,482	[8] 8,001	[8] 14,001	7,628	13,244
Value of items that cannot be disclosed: Bromine, calcium-magnesium chloride, cement, lime, stone (crushed sandstone 1958, dimension sandstone 1959–60, calcareous marl 1959)		13,067		13,318		13,195		13,385
Total West Virginia [9]		749,747		737,616		[4] 720,601		687,903
WISCONSIN								
Abrasive stones—short tons	858	$26	770	$27	397	$12	560	$17
Clays—thousand short tons	154	167	178	192	144	156	126	130
Iron ore (usable)—thousand long tons, gross weight	867	(5)	701	(5)	1,502	(5)	1,122	(5)
Lead (recoverable content of ores, etc.)—short tons	800	187	745	171	1,165	273	680	140
Lime—thousand short tons	141	2,193	(5)	(5)	(5)	(5)	161	2,480
Peat—short tons	(5)	(5)	7,500	(5)	8,500	(5)	(5)	(5)
Sand and gravel—thousand short tons	39,383	25,845	41,999	27,535	35,681	25,648	39,978	28,457
Stone—do	13,722	23,334	13,522	23,782	16,486	22,302	13,418	19,686
Zinc (recoverable content of ores, etc.)—short tons	12,140	2,477	11,635	2,676	18,410	4,750	13,865	3,189
Value of items that cannot be disclosed: Cement, gem stones, and values indicated by footnote 5		18,083		18,541		25,619		19,649
Total Wisconsin [9]		71,334		71,959		77,171		72,886

Beryllium concentrate	short tons, gross weight	17	$9	1	(6)	5	$2	2	$1
Clays [3]	thousand short tons	1,075	9,968	764	$9,449	788	9,571	859	10,301
Coal	do	1,629	5,820	1,977	6,669	2,024	6,992	2,529	8,573
Copper (recoverable content of ores, etc.)	short tons	(12)	(6)	----------	----------	----------	----------	1	1
Gem stones		(11)	52	(11)	76	(11)	68	(11)	83
Gold (recoverable content of ores, etc.)	troy ounces	117	4	----------	----------	40	1	1	(6)
Gypsum	thousand short tons	6	19	9	31	13	46	(5)	(5)
Iron ore (usable)	thousand long tons, gross weight	557	(5)	503	2,923	(5)	(5)	(5)	(5)
Natural gas	million cubic feet	121,682	10,221	156,978	12,715	181,610	21,793	194,674	24,334
Natural gas liquids:									
Natural gasoline	thousand gallons	49,451	3,052	64,586	4,003	72,195	4,535	76,349	4,705
LP gases	do	54,496	2,614	90,314	3,951	120,693	5,279	132,831	5,451
Petroleum (crude)	thousand 42-gallon barrels	115,572	301,643	126,050	315,125	133,910	336,114	[7] 142,589	[7] 356,473
Phosphate rock	thousand long tons	124	937	(5)	(5)	(5)	(5)	(5)	(5)
Pumice	thousand short tons	45	40	94	77	33	30	20	20
Sand and gravel	do	5,333	4,760	4,692	3,982	5,928	5,356	6,669	5,356
Stone	do	1,099	1,472	1,317	1,791	1,401	2,302	2,594	3,315
Uranium ore	short tons	651,790	13,286	864,582	17,610	1,357,225	27,387	1,521,064	28,218
Value of items that cannot be disclosed: Cement, clays (fire clay 1958–59, 1961, miscellaneous clay 1959–61), feldspar (1958), lime (1961), sheet mica (1959–61), silver (1958, 1960–61), sodium carbonates and sulfates, vanadium (1958, 1960–61), vermiculite (1961), and values indicated by footnote 5		----------	16,760	----------	15,970	----------	[4] 19,780	----------	21,046
Total Wyoming [9]		----------	369,938	----------	393,841	----------	[4] 438,733	----------	466,983

[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] Revised figure.
[5] Figure withheld to avoid disclosing individual company confidential data.
[6] Less than $500.
[7] Preliminary figure.
[8] Excludes certain stone, included with "Value of items that cannot be disclosed."
[9] Total adjusted to eliminate duplicating value of clays and stone.
[10] Less than 500 short tons.
[11] Weight not recorded.
[12] Less than 0.5 ton.
[13] Includes 805 tons of low-grade beryllium ore.
[14] Total weight of columbite-tantalite plus $(Cb\text{-}Ta)_2O_5$ content of euxenite.
[15] Total value adjusted to eliminate duplicating value of stone.
[16] Total has been adjusted to eliminate duplicating value of raw materials used in manufacturing cement and/or lime.
[17] Excludes recycled lime, included with "Value of items that cannot be disclosed."
[18] Excludes salt in brine, included with "Value of items that cannot be disclosed."
[19] Excludes quantity consumed by American Chrome Co.
[20] 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.
[21] Less than 500 long tons.
[22] Millstones only.
[23] Grinding pebbles and tubemill liners.
[24] Less than 500 troy ounces.
[25] Less than 500 barrels.

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

Area and mineral	1958		1959		1960		1961	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
American Samoa: Stone—thousand short tons	30	$59	178	$219	523	$261	362	$286
Canal Zone:								
Sand and gravel—do	41	34	14	21	65	68	75	73
Stone (crushed)—do	140	237	223	270	203	306	163	271
Total Canal Zone		271		291		374		344
Canton:								
Sand and gravel—thousand short tons			[3]	[4]				
Stone (crushed)—do			[3]	1				
Guam:								
Sand and gravel—do	9	23	28	20	1	1	38	49
Stone—do	684	751	568	1,109	962	2,194	292	591
Total Guam		774		1,129		2,195		640
Johnston:								
Sand and gravel—thousand short tons					1	4	1	1
Stone—do					2	5	1	2
Total Johnston						9		3
Midway: Stone (crushed)—thousand short tons	175	476					11	34
Virgin Islands: Stone (crushed)—do	25	81	14	51	15	51	20	75
Wake: Stone (crushed)—do	10	37	32	34	36	49	24	62

[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	1958		1959		1960		1961	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement—thousand 376-pound barrels	4,748	$15,175	5,392	$16,982	5,441	$14,546	5,931	$16,946
Clays—thousand short tons	165	83	167	83	160	102	184	112
Lime—do	(2)	(2)	10	321	1	15	1	15
Salt—do	1	14	3	38				
Sand and gravel—do	476	763	530	888	8,996	8,669	11,370	10,385
Stone—do	1,986	2,768	2,063	2,878	4,219	7,661	5,049	7,284
Value of items that cannot be disclosed: Other nonmetals and values indicated by footnote 2		272				74		
Total Puerto Rico [4]		17,689		19,700		[3] 29,603		33,805

[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.
[4] Total adjusted to eliminate duplicating value of raw materials used in manufacturing cement.

TABLE 8.—U.S. imports for consumption of principal minerals and products

Mineral	1960		1961	
	Quantity	Value (thousands)	Quantity	Value (thousands)
Metals:				
Aluminum:				
Metal—short tons	154,706	$75,808	199,223	$91,187
Scrap—do	5,042	1,598	6,002	1,738
Plates, sheets, bars, etc—do	36,677	25,872	49,310	33,062
Antimony:				
Ore (antimony content)—do	6,455	1,214	6,713	1,389
Needle and liquated—do	24	11	13	6
Metal—do	5,437	2,495	4,912	2,347
Oxide—do	2,368	972	1,980	935
Arsenic: White (As_2O_3 content)—do	12,825	1,046	19,483	1,422
Bauxite: Crude—thousand long tons	[1] [2] 8,739	[1] 78,024	[2] 9,206	88,821
Beryllium ore—short tons	8,943	2,864	8,516	2,786
Bismuth (general imports)—pounds	1,167,019	2,131	798,518	1,498
Boron carbide—do	85,965	172	11,992	37
Cadmium:				
Metal—thousand pounds	942	1,157	1,079	1,473
Flue dust (cadmium content)—do	1,861	778	239	112
Calcium:				
Metal—pounds	12,618	15	17,266	23
Chloride—short tons	1,570	62	3,022	103
Chromate:				
Ore and concentrate (Cr_2O_3 content)—do	[1] 571,067	[1] 24,313	563,140	21,444
Ferrochrome (chromium content)—do	34,186	14,313	18,698	7,611
Metal—do	908	1,645	692	1,150
Cobalt:				
Metal—thousand pounds	10,801	17,093	10,036	14,867
Oxide (gross weight)—do	1,459	1,520	681	663
Salts and compounds (gross weight)—do	230	104	159	59
Columbium ore—pounds	[2] 5,066,514	[2] 3,696	[2] 2,973,769	[2] 2,527
Copper: (copper content)				
Ore—short tons	3,503	2,016	2,587	1,526
Concentrates—do	20,935	12,391	21,914	12,516
Regulus, black, coarse—do	185	80	95	57
Unrefined, black, blister—do	486	311	5,929	3,508
Refined in ingots, etc—do	171,021	[1] 109,490	87,206	51,852
Old and scrap—do	1,836	1,106	1,643	870
Old brass and clippings—do	309	184	390	173
Ferroalloys: Ferrosilicon (silicon content)—short tons	4,972	1,533	2,307	803
Gold:				
Ore and base bullion—troy ounces	460,579	16,080	456,139	15,938
Bullion—do	8,861,716	318,952	1,159,320	40,273
Iron ore:				
Ore—thousand long tons	[1] 34,578	[1] 321,919	25,805	250,226
Pyrites cinder—long tons	5,884	20	3,504	18
Iron and steel:				
Pig iron—short tons	330,847	18,351	377,180	20,511
Iron and steel products (major):				
Iron products—do	[1] 41,356	[1] 8,688	31,157	5,794
Steel products—do	[1] 3,528,459	[1] 485,802	3,277,319	418,268
Scrap—do	138,687	5,281	235,350	8,315
Tinplate scrap—do	[1] 40,714	[1] 992	33,039	770
Lead:				
Ore, flue dust, matte (lead content)—do	[1] 137,303	27,816	136,860	24,347
Base bullion (lead content)—do	293	[2] 62	236	[2] 51
Pigs and bars (lead content)—do	[1] 213,347	[1] 45,065	247,327	45,863
Reclaimed, scrap, etc. (lead content)—do	5,598	1,034	3,894	592
Sheets, pipe, and shot—do	2,855	696	2,845	641
Babbitt metal and solder (lead content)—short tons	1,512	16,024	1,409	14,207
Type metal and antimonial lead (lead content)—short tons	[1] 3,915	[1] 970	5,765	1,340
Manufactures—do	2,097	710	2,319	807
Magnesium:				
Metallic and scrap—do	401	202	1,005	483
Alloys (magnesium content)—do	28	288	31	170
Sheets, tubing, ribbons, wire, and other forms (magnesium content)—short tons	4	61	5	80
Manganese:				
Ore (35 percent or more manganese) (manganese content)—short tons	[1] 1,082,362	[1] 82,307	1,031,062	78,144
Ferromanganese (manganese content)—short tons	92,594	19,008	[2] 170,199	[2] 34,396

See footnotes at end of table.

TABLE 8.—U.S. imports for consumption of principal minerals and products—Con.

Mineral	1960		1961	
	Quantity	Value (thousands)	Quantity	Value (thousands)
Metals—Continued				
Mercury:				
Compounds—pounds	114,305	$ 302	90,724	$228
Metal—76-pound flasks	19,488	3,510	12,313	2,048
Minor metals: Selenium and salts—pounds	175,761	972	127,482	738
Nickel:				
Ore and matte—short tons	184	73	(3)	(4)
Pigs, ingots, shot, cathodes—do	79,662	116,567	115,985	169,656
Scrap—do	135	113	278	175
Oxide—do	[2] 24,584	[2] 27,650	14,613	14,137
Platinum group:				
Unrefined materials:				
Ore and concentrates—troy ounces	401	30	568	39
Grains and nuggets, including crude, dust, and residues—troy ounces	30,338	2,201	29,997	2,181
Sponge and scrap—do	3,095	212	11,550	689
Osmiridium—do			2,601	66
Refined metal:				
Platinum—do	238,307	18,917	236,859	18,165
Palladium—do	368,256	8,189	571,693	12,672
Iridium—do	4,253	283	4,366	286
Osmium—do	277	17	466	26
Rhodium—do	31,722	4,126	17,394	2,328
Ruthenium—do	3,997	156	8,969	388
Radium:				
Radium salts—milligrams	23,333	364	12,947	185
Radioactive substitutes	(5)	1,394	(5)	1,509
Rare earths: Ferrocerium and other cerium alloys—pounds	21,391	78	22,955	63
Silver:				
Ore and base bullion—thousand troy ounces	43,404	38,164	34,559	30,832
Bullion—do	17,253	15,797	15,697	14,173
Tantalum: Ore—pounds	[2] 695,222	[2] 1,127	[2] 808,082	[2] 1,780
Tin:				
Ore (tin content)—long tons	14,026	31,104	8,917	21,923
Blocks, pigs, grains, etc—do	[1] 39,538	[1] 86,334	39,898	96,909
Dross, skimmings, scrap, residues, and tin alloys, n.s.p.f—long tons	809	1,642	612	1,299
Tinfoil, powder, flitters, etc	(5)	839	(5)	676
Titanium:				
Ilmenite—short tons	265,645	5,067	195,836	4,604
Rutile—do	29,235	3,611	27,497	2,544
Metal—pounds	4,461,737	4,866	4,980,356	5,352
Ferrotitanium—do	166,053	41	364,721	93
Compounds and mixtures—do	12,258,035	2,413	18,044,423	3,536
Tungsten: (tungsten content)				
Ore and concentrate—thousand pounds	3,525	3,478	[2] 2,123	[2] 1,983
Metal—pounds	159,759	370	55,613	139
Ferrotungsten—thousand pounds	167	207	340	422
Other alloys—pounds	36,666	62	9,955	15
Zinc:				
Ore (zinc content)—short tons	[1] 382,938	[1] 38,704	357,653	31,920
Blocks, pigs, and slabs—do	120,925	29,639	125,186	27,540
Sheets—do	04	302	1,183	354
Old, dross, and skimmings—do	1,205	189	1,410	178
Dust—do	19	7	86	28
Manufactures	(6)	837	(6)	787
Zirconium: Ore, including zirconium sand—short tons	34,280	1,234	33,805	873
Nonmetals:				
Abrasives: Dimonds (industrial)—carats	[1] 13,146,094	[1] 51,836	14,209,446	68,545
Asbestos—short tons	669,496	63,345	616,552	58,942
Barite:				
Crude and ground—do	[1] 641,728	[1] 5,008	615,128	5,690
Witherite (crude)—do	[1] 1,344	59	[2] 1,716	67
Chemicals—do	4,986	576	4,565	543
Bromine—pounds	145,943	111	300,491	196
Cement—376-pound barrels	[1] 4,108,273	10,306	3,620,685	9,225
Clays:				
Raw—short tons	153,349	2,985	153,833	2,955
Manufactured—do	6,666	118	2,339	105
Cryolite—do	17,246	1,670	13,814	1,194
Feldspar: Crude—long tons	44	5	24	2
Fluorspar—short tons	534,020	14,393	505,759	13,644

See footnotes at end of table.

TABLE 8.—U.S. imports for consumption of principal minerals and products—Con.

Mineral	1960		1961	
	Quantity	Value (thousands)	Quantity	Value (thousands)
Nonmetals—Continued				
Gem stones:				
Diamonds—carats	2,167,474	[1] $165,555	3,114,073	$193,275
Emeralds—do	81,207	1,463	227,284	2,090
Other—do	(5)	25,470	(5)	27,350
Graphite—short tons	48,324	1,755	29,748	1,332
Gypsum:				
Crude, ground, calcined—do	[1] 5,302,383	[1] 9,038	4,968,188	9,094
Manufactures	(5)	1,388	(5)	1,212
Iodine, crude—thousand pounds	1,894	1,425	3,017	2,852
Kyanite—short tons	6,052	265	5,415	244
Lime:				
Hydrated—do	[1] 676	15	950	22
Other—do	18,445	369	31,418	491
Dead-burned dolomite—do	[2] 12,932	[2] 550	4,256	233
Magnesium:				
Magnesite—do	[2] 118,780	7,789	56,521	3,839
Compounds—do	14,971	546	15,435	518
Mica:				
Uncut sheet and punch—pounds	1,088,021	2,081	852,648	1,841
Scrap—short tons	6,240	86	3,024	41
Manufactures—do	4,266	6,139	3,823	6,117
Mineral-earth pigments: Iron oxide pigments:				
Natural—do	2,976	132	2,248	114
Synthetic—do	7,516	1,100	4,806	777
Ocher, crude and refined—do	230	14	91	5
Siennas, crude and refined—do	649	64	546	57
Umber, crude and refined—do	2,894	98	2,685	93
Vandyke brown—do	195	14	168	13
Nitrogen compounds (major), including urea—do	[1] 1,214,088	[1] 55,631	1,434,926	63,924
Phosphate, crude—long tons	129,290	3,754	134,004	3,629
Phosphatic fertilizers—do	[1] 17,450	[1] 1,079	32,467	2,453
Pigments and salts:				
Lead pigments and salts—short tons	15,729	3,224	18,155	3,498
Zinc pigments and salts—do	15,582	3,052	12,608	2,354
Potash—do	[1 6] 414,803	[1 6] 15,370	[6] 465,057	[6] 17,327
Pumice:				
Crude or unmanufactured—do	6,556	58	6,907	69
Wholly or partly manufactured—do	3,916	103	4,063	116
Manufactures, n.s.p.f.	(5)	36	(5)	19
Quartz crystal (Brazilian pebble)—pounds	1,193,257	615	1,173,560	798
Salt—short tons	1,057,028	4,484	1,050,084	3,755
Sand and gravel:				
Glass sand—do	10,765	37	2	2
Other sand—do	379,673	516	335,005	441
Gravel—do	3,752	5	43,287	44
Sodium sulfate—thousand short tons	167	3,473	196	4,153
Stone, including slate and whiting	(5)	11,344	(5)	12,268
Strontium: Mineral—short tons	[1] 6,186	150	9,931	244
Sulfur and pyrites:				
Sulfur:				
Ore—long tons	[1] 103,281	[1] 2,268	94,181	1,934
Other forms, n.e.s—do	[1] 638,089	13,185	737,336	15,218
Pyrites—do	[1] 306,216	[1] 1,075	281,604	742
Talc: Unmanufactured—short tons	23,975	849	27,355	[2] 1,054
Fuels:				
Carbon black:				
Acetylene—pounds	6,785,095	1,303	8,073,544	1,482
Gas black and carbon black—do	719,164	134	557,327	111
Coal:				
Anthracite—short tons	1,476	16	792	10
Bituminous, slack, culm, and lignite—do	260,495	1,844	164,259	1,360
Briquets—do	[1] 5,529	[1] 375	7,338	370
Coke—do	[1] 126,345	[1] 1,498	126,518	1,543
Peat:				
Fertilizer grade—do	254,794	13,011	243,834	12,620
Poultry and stable grade—do	9,083	498	8,603	558

See footnotes at end of table.

TABLE 8.—U.S. imports for consumption of principal minerals and products—Con.

Mineral	1960		1961	
	Quantity	Value (thousands)	Quantity	Value (thousands)
Fuels—Continued				
Petroleum:				
Crude—thousand barrels	400,846	[1] $895,055	411,968	$933,310
Gasoline [7]—do	[1] 19,350	[1] 64,667	16,313	52,478
Kerosine [8]—do	70	224	425	1,524
Distillate oil [8]—do	9,792	[1] 30,798	13,661	39,617
Residual oil [8]—do	230,396	[1] 482,471	229,468	500,286
Unfinished oils—do	20,430	55,847	25,802	69,978
Asphalt—do	6,257	14,379	6,728	15,646
Miscellaneous [8]—do	76	631	20	465

[1] Revised figure.
[2] Adjusted by Bureau of Mines.
[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 naphtha but excludes benzol, 1960—[1] 907,649 barrels ([1] $9,181,905); 1961—460,839 barrels ($5,476,518).
[8] Includes quantities imported free of duty for supplies of vessels and aircraft.

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	1960		1961	
	Quantity	Value (thousands)	Quantity	Value (thousands)
Metals:				
Aluminum:				
Ingots, slabs, crude—short tons	284,979	$128,199	128,861	$57,638
Scrap—do	79,513	26,905	82,005	26,452
Plates, sheets, bars, etc—do	18,098	16,266	25,241	23,975
Castings and forgings—do	1,190	2,849	1,203	3,560
Antimony: Metals and alloys, crude—do	59	47	34	21
Arsenic: Calcium arsenate—pounds	289,700	21	669,932	58
Bauxite, including bauxite concentrates—long tons	29,317	2,588	150,683	12,189
Aluminum sulfate—short tons	12,286	451	14,213	535
Other aluminum compounds—do	35,144	5,503	55,610	8,060
Beryllium—pounds	131,648	1,344	123,349	645
Bismuth: Metals and alloys—do	156,636	276	167,166	268
Cadmium—thousand pounds	2,448	3,014	702	983
Calcium chloride—short tons	26,792	1,068	22,047	1,091
Chrome:				
Ore and concentrate:				
Exports—do	5,184	320	10,465	516
Reexports—do	19,927	721	40,483	1,560
Chromic acid—do	982	546	1,068	604
Ferrochrome—do	15,588	5,249	7,844	2,838
Cobalt—pounds	1,798,218	1,313	2,075,243	1,881
Columbium metals, alloys, and other forms—short tons	159,309	157	69,863	151
Copper:				
Ore, concentrate, composition metal, and unrefined copper (copper content)—do	11,111	6,832	4,478	2,475
Refined copper and semimanufactures—do	[1] 510,494	[1] 327,936	486,359	295,397
Other copper manufactures—do	5,181	4,006	7,362	5,260
Copper sulfate or blue vitriol—do	14,841	3,377	7,575	1,542
Copper base alloys—do	[1] 130,140	[1] 69,564	124,938	70,240
Ferroalloys:				
Ferrosilicon—pounds	11,002,848	867	69,528,561	6,105
Ferrophosphorus—do	95,794,790	2,095	60,120,159	1,307
Gold:				
Ore and base bullion—troy ounces	9,196	322	13,717	480
Bullion, refined—do	37,676	1,326	22,132,692	774,521
Iron ore—thousand long tons	[1] 5,273	[1] 57,899	4,916	53,823

See footnotes at end of table.

TABLE 9.—U.S. exports of principal minerals and products—Continued

Mineral	1960		1961	
	Quantity	Value (thousands)	Quantity	Value (thousands)
Metals—Continued				
Iron and steel:				
Pig iron—short tons	111,773	$5,174	415,668	$19,243
Iron and steel products (major):				
Semimanufactures—do	[1] 2,336,969	[1] 445,167	1,428,367	274,888
Manufactured steel mill products—short tons	[1] 910,115	[1] 258,444	798,005	253,073
Advanced products	[2]	157,686	[2]	160,126
Iron and steel scrap: Ferrous scrap, including rerolling materials—short tons	[1] 8,039,668	[1] 241,572	9,715,755	354,017
Lead:				
Ore, matte, base bullion (lead content)—short tons	1,297	168	4,437	448
Pigs, bars, anodes—do	1,967	748	2,133	518
Scrap—do	2,579	361	5,163	940
Magnesium:				
Metal and alloys and semifabricated forms, n.e.c.—short tons	5,125	3,695	6,648	4,519
Powder—do	7	23	33	78
Manganese:				
Ore and concentrate—do	5,139	719	7,528	1,054
Ferromanganese—do	751	202	469	146
Mercury:				
Exports—76-pound flasks	357	83	285	71
Reexports—do	317	62	180	33
Molybdenum:				
Ore and concentrate (molybdenum content)—pounds	30,244,496	39,847	35,661,001	48,758
Metals and alloys, crude and scrap—do	295,004	368	440,849	433
Wire—do	9,639	278	12,488	376
Semifabricated forms, n.e.c.—do	4,940	74	7,362	135
Powder—do	9,620	32	11,816	40
Ferromolybdenum—do	424,819	489	358,523	501
Nickel:				
Ore—short tons	1	4	1,766	495
Alloys and scrap (including Monel metal), ingots, bars, sheets, etc.—short tons	52,468	27,128	51,631	24,969
Catalysts—do	761	1,240	805	1,456
Nickel-chrome electric resistance wire—short tons	235	969	254	1,079
Semifabricated forms, n.e.c.—do	644	2,322	1,037	3,980
Platinum:				
Ore, concentrate, metal and alloys in ingots, bars, sheets, anodes, and other forms, including scrap—troy ounces	49,497	3,212	41,385	2,089
Palladium, rhodium, iridium, osmiridium, ruthenium, and osmium (metal and alloys including scrap)—troy ounces	15,652	504	20,460	820
Platinum group manufactures, except jewelry	[2]	2,978	[2]	2,983
Radium metal (radium content)—milligrams	712	17	334	18
Rare earths:				
Cerium ore, metal, and alloys—pounds	15,410	15	6,563	30
Lighter flints—do	27,517	118	20,338	89
Silver:				
Ore and base bullion—thousand troy ounces	291	266	654	597
Bullion, refined—do	26,302	24,236	39,174	36,361
Tantalum:				
Ore, metal, and other forms—pounds	49,965	555	232,088	1,041
Powder [3]—do	1,174	49	5,585	189
Tin:				
Ingots, pigs, bars, etc.:				
Exports—long tons	608	1,294	543	1,264
Reexports—do	249	549	257	626
Tin scrap and other tin bearing material except tinplate scrap—long tons	4,397	1,355	10,506	3,352
Tin cans finished or unfinished—do	32,875	17,362	30,929	15,093

See footnotes at end of table.

TABLE 9.—U.S. exports of principal minerals and products—Continued

Mineral	1960		1961	
	Quantity	Value (thousands)	Quantity	Value (thousands)
Metals:—Continued				
Titanium:				
Ore and concentrate—short tons	1,260	$167	1,436	$190
Sponge (including iodide titanium) and scrap—short tons	879	869	886	927
Intermediate mill shapes—do	359	2,038	336	1,929
Mill products, n.e.c—do	67	1,200	48	773
Ferrotitanium—do	245	157	212	93
Dioxide and pigments—do	33,655	10,001	31,104	9,216
Tungsten: Ore and concentrate:				
Exports—short tons	633	1,251	207	250
Reexports—do	[1] 229	[1] 343	689	791
Vanadium ore and concentrate, pentoxide, etc. (vanadium content)—pounds	7,379,432	14,124	[3] 4,161,978	[3] 7,658
Zinc:				
Ore and concentrate (zinc content) short tons	13	3	1,670	124
Slabs, pigs, or blocks—do	75,144	18,122	50,055	11,196
Sheets, plates, strips, or other forms, n.e.c. short tons	3,324	2,443	3,219	2,271
Scrap (zinc content)—do	12,169	1,499	5,900	871
Dust—do	777	267	717	224
Semifabricated forms, n.e.c—do	2,569	1,195	3,036	1,317
Zirconium:				
Ore and concentrate—do	1,382	317	1,277	278
Metals and alloys and other forms pounds	[1] 384,406	[1] 2,595	178,873	1,472
Nonmetals:				
Abrasives:				
Grindstones—short tons	319	56	123	46
Diamond dust and powder—carats	321,373	845	490,327	1,357
Diamond grinding wheels—do	264,942	1,567	285,425	1,708
Other natural and artificial metallic abrasives and products	(2)	24,082	(2)	26,084
Asbestos: Unmanufactured:				
Exports—short tons	5,461	845	3,572	708
Reexports—do	64	12	227	51
Boron: Boric acid, borates, crude and refined pounds	601,211,757	25,576	538,542,810	23,212
Bromine, bromides, and bromates—do	10,241,178	2,898	11,120,085	2,980
Cement—376-pound barrels	187,304	1,135	285,816	1,387
Clays:				
Kaolin or china clay—short tons	79,965	2,044	98,785	2,395
Fire clay—do	177,578	3,305	155,166	3,391
Other clays—do	[1] 272,158	[1] 8,365	304,858	8,499
Cryolite—do	226	66	167	41
Fluorspar—do	458	38	338	30
Graphite:				
Amorphous—do	1,377	181	1,328	186
Crystalline flake, lump or chip—do	164	51	91	34
Natural, n.e.c—do	314	57	139	37
Gypsum:				
Crude, crushed or calcined thousand short tons	17	687	20	731
Manufactures, n.e.c	(2)	606	(2)	568
Iodine, iodide, iodates—thousand pounds	251	353	176	282
Kyanite and allied minerals—short tons	3,255	210	4,000	318
Lime—do	61,056	992	29,969	921
Mica:				
Unmanufactured—pounds	701,926	113	334,221	142
Manufactured:				
Ground or pulverized—do	7,077,245	370	7,074,850	396
Other—do	243,354	828	190,320	689
Mineral-earth pigments: Iron oxide, natural and manufactured—short tons	3,862	1,113	3,213	855
Nitrogen compounds (major)—do	623,370	33,063	445,930	30,480
Phosphate rock—long tons	[1] 4,250,970	[1] 37,584	4,122,732	36,910
Phosphatic fertilizers (superphosphates) long tons	416,931	19,882	469,197	23,695
Pigments and salts (lead and zinc):				
Lead pigments—short tons	2,118	705	2,302	764
Zinc pigments—do	2,327	694	2,791	759
Lead salts—do	944	355	464	183

See footnotes at end of table.

TABLE 9.—U.S. exports of principal minerals and products—Continued

Mineral		1960		1961	
		Quantity	Value (thousands)	Quantity	Value (thousands)
Nonmetals—Continued					
Potash:					
Fertilizer	do	815,521	$23,508	776,827	$29,673
Chemical	do	17,372	2,418	29,740	2,995
Quartz crystal (raw)		(2)	354	(2)	518
Radioactive isotopes, etc	curie	146,983	1,286	202,769	1,741
Salt:					
Crude and refined	short tons	[1] 420,322	2,548	641,966	3,876
Shipments to noncontiguous Territories	short tons	14,311	1,042	10,164	793
Sodium and sodium compounds:					
Sodium sulfate	do	30,724	940	32,259	992
Sodium carbonate	thousand short tons	155	5,143	132	4,045
Stone:					
Limestone, crushed, ground, broken	short tons	[1] 926,197	[1] 1,780	790,912	1,596
Marble and other building and monumental	cubic feet	431,262	1,250	435,173	1,596
Stone, crushed, ground, broken	short tons	153,106	2,659	128,149	3,027
Manufactures of stone		(2)	477	(2)	430
Sulfur:					
Crude	long tons	1,775,526	40,880	1,585,531	35,370
Crushed, ground, flowers of	do	11,017	1,413	10,512	1,254
Talc:					
Crude and ground	short tons	59,457	1,801	47,912	1,721
Manufactures, n.e.c	do	158	92	134	84
Powders-talcum (face and compact)		(2)	1,378	(2)	1,396
Fuels:					
Carbon black	thousand pounds	[1] 543,047	[1] 49,602	522,331	48,166
Coal:					
Anthracite	short tons	[1] 1,440,400	[1] 22,903	1,546,488	22,354
Bituminous	do	[1] 36,541,075	[1] 331,616	34,969,825	319,034
Briquets	do	21,126	305	12,731	176
Coke	do	353,016	6,885	445,232	8,213
Petroleum:					
Crude	thousand barrels	3,087	8,032	3,219	8,541
Gasoline [4]	do	12,380	82,615	8,209	56,481
Kerosine	do	590	3,148	210	1,462
Distillate oil	do	[1] 9,843	[1] 35,348	6,838	23,594
Residual oil	do	18,695	43,412	14,023	34,575
Lubricating oil	do	[1] 15,314	207,200	16,607	218,388
Asphalt	do	[1] 788	4,501	510	3,928
Liquefied petroleum gases	do	2,989	9,646	3,549	13,322
Wax	do	1,334	26,445	1,238	24,694
Coke	do	6,858	27,009	7,271	29,234
Petroleum	do	258	6,182	246	6,098
Miscellaneous	do	500	14,719	476	14,292

[1] Revised figure.
[2] Weight not recorded.
[3] Adjusted by Bureau of Mines.
[4] Includes naphtha, but excludes benzol: 1960—561,193 barrels ($8,951,625); 1961—1,106,390 barrels ($16,877,309).

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 United States production of principal metals and minerals

Mineral	1960			1961		
	World	United States		World	United States	
	Thousand short tons (unless otherwise stated)		Percent of world	Thousand short tons (unless otherwise stated)		Percent of world
Fuels:						
Coal:						
Bituminous	2,007,957	412,766	21	1,962,276	399,959	20
Lignite	706,214	2,746	(1)	727,262	3,018	(1)
Pennsylvania anthracite	192,300	18,817	10	190,800	17,446	9
Coke (excluding breeze):						
Gashouse [2]	51,300	(3)	(3)	50,430	(3)	(3)
Oven and beehive	308,209	57,229	19	305,961	51,711	17
Fuel briquets and packaged fuel	118,700	769	(1)	121,300	591	(1)
Natural gas (marketable) million cubic feet	(4)	12,771,038	(4)	(4)	(4)	(4)
Peat	68,500	471	(1)	69,700	525	(1)
Petroleum (crude) thousand barrels	7,674,493	2,574,933	34	8,187,986	2,621,758	32
Nonmetals:						
Asbestos	2,440	45	2	2,770	53	2
Barite	3,100	771	25	3,000	731	24
Cement [5] thousand barrels	1,866,277	334,130	18	1,997,319	338,628	17
Corundum	9			8		
Diamonds thousand carats	27,700			33,700		
Diatomite	1,000	450	45	1,030	450	44
Feldspar thousand long tons	1,470	502	34	1,500	497	33
Fluorspar	2,190	230	11	2,300	205	9
Graphite	465	(3)	(3)	450	(3)	(3)
Gypsum	43,200	9,825	23	43,035	9,500	22
Magnesite	7,200	499	7	8,600	604	7
Mica (including scrap) thousand pounds	365,000	196,395	54	355,000	198,568	56
Nitrogen, agricultural [5 6]	10,800	2,804	26	11,570	2,954	26
Phosphate rock thousand long tons	40,870	17,516	43	43,770	18,559	42
Potash (K_2O equivalent)	10,000	2,639	26	10,500	2,733	26
Pumice [7]	11,900	2,210	19	13,400	2,463	18
Pyrites thousand long tons	19,300	1,016	5	19,400	987	5
Salt [5]	93,900	25,481	27	96,400	25,707	27
Strontium [7]	13			11		
Sulfur, elemental thousand long tons	10,290	5,804	56	11,380	6,333	56
Talc, pyrophyllite, and soapstone	2,750	734	27	2,890	761	26
Vermiculite [7]	269	199	74	279	207	74
Metals, mine basis:						
Antimony (content of ore and concentrate) short tons	61,000	637	1	60,000	689	1
Arsenic, white [7]	57	(3)	(3)	59	(3)	(3)
Bauxite thousand long tons	26,980	1,998	7	29,040	1,228	4
Beryllium concentrate short tons	9,300	509	5	8,600	1,122	13
Bismuth thousand pounds	5,300	(3)	(3)	5,500	(3)	(3)
Cadmium do	22,100	10,180	46	20,100	9,943	49
Chromite	4,930	[8] 107	2	4,655	[8] 82	2
Cobalt (contained) [7] short tons	16,800	(3)	(3)	16,100	(3)	(3)
Columbium-tantalum concentrate [7] thousand pounds	6,850			7,370		
Copper (content of ore and concentrate)	4,640	1,080	23	4,850	1,165	24
Gold thousand troy ounces	45,400	1,680	4	47,700	1,567	3
Iron ore thousand long tons	512,329	88,784	17	497,610	71,329	14
Lead (content of ore and concentrate)	2,610	247	9	2,660	262	10
Manganese ore (35 percent or more Mn)	15,006	80	(1)	14,933	46	(1)
Mercury thousand 76-pound flasks	242	33	14	240	32	13
Molybdenum (content of ore and concentrate) thousand pounds	89,500	68,237	76	87,900	66,563	76
Nickel (content of ore and concentrate)	359	13	4	396	11	3
Platinum groups (Pt, Pd, etc.) thousand troy ounces	1,250	24	2	1,190	43	4
Silver do	240,200	36,800	15	231,800	34,900	15
Tin (content of ore and concentrate) long tons	181,500	10	(1)	188,000	(3)	(3)
Titanium concentrate:						
Ilmenite [7]	2,205	786	36	2,313	782	34
Rutile [7]	114	9	8	128	9	7
Tungsten concentrate (60 percent WO_3) short tons	69,400	7,325	11	74,200	8,245	11
Vanadium (content of ore and concentrate) [7] short tons	7,090	4,971	70	8,650	5,343	62
Zinc (content of ore and concentrate)	3,590	435	12	3,720	464	12

See footnotes at end of table.

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

Mineral	1960			1961		
	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						
Metals, smelter basis:						
Aluminum	4,985	2,014	40	5,195	1,904	37
Copper	4,950	1,234	25	5,060	1,207	24
Iron, pig (incl. ferroalloys)	285,000	68,620	24	289,350	66,717	23
Lead	2,550	382	15	2,660	450	17
Magnesium—short tons	102,600	40,070	39	115,400	40,745	35
Selenium [7]—thousand pounds	1,667	539	32	2,056	1,022	50
Steel ingots and castings	381,400	99,282	26	392,400	98,014	25
Tellurium [7]—thousand pounds	389	271	70	394	205	52
Tin—thousand long tons	192	[9] 14	7	190	[9] 9	5
Uranium oxide (U_3O_8) [7]—short tons	40,740	17,760	44	35,850	17,399	49
Zinc	3,280	800	24	3,550	847	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 Co.
[9] U.S. imports of tin concentrates (tin content).

Compiled by Augusta W. Jann, Division of Foreign Activities.

Employment and Injuries in the Metal and Nonmetal Industries

By John C. Machisak [1]

THIS CHAPTER of the Minerals Yearbook is confined to injury experience and employment data in the 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. The 1961 figures are a summation of actual company reports received by the Bureau of Mines by May 31, 1962. The reports are furnished voluntarily in response to an annual canvass requesting injury and employment data for individual operations. The information for 1961 is preliminary and subject to revision. Combined statistical data on all mineral industries are included in volume III.

METAL MINES

The reports received for the metal-mining industry in 1961 indicated a decline in the safety record from the preceding year. The preliminary injury-frequency rate per million man-hours of worktime for metal mines was 4 percent higher than the rate in 1960. The greatest improvement in injury experience was made in the uranium industry, having a 33-percent decline in the overall injury-frequency rate. Iron mines also showed improvement; the injury-frequency rate declined 5 percent. The frequency rate of injuries rose, however, at copper, gold-silver, lead-zinc, and miscellaneous metal mines as well as at gold placer-mining operations. Hours of work per man during the year averaged 2,030, an increase of 55 hours, or 3 percent over 1960. An average 8.1-hour shift was maintained throughout the year, approximately the same as in 1960.

Copper.—The injury experience in the copper-mining industry, as reflected by the injury-frequency rate, was not as good as in 1960. Preliminary data indicated an increase of nearly 3 percent in the frequency rate when compared with 1960. Days active remained the same (275) as in the preceding year, and employees worked an average 8.4-hour shift, accumulating a median total of 2,301 hours of work each.

Gold Placer.—Preliminary data for placer operations indicated a sharp increase in the injury-frequency rate (fatal and nonfatal) compared with 1960. The average days worked at placer mines in-

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creased from 165 in 1960 to 194. Employees averaged 1,572 hours of worktime each and worked an 8.1-hour average daily shift.

Gold-Silver.—The safety record of gold-silver mines was not as favorable as in 1960, as shown by the overall injury-frequency rate increase of 29 percent from 32.48 to 41.96 per million man-hours of worktime. The days active increased by 15 over 1960. The length of work shifts was approximately the same, but hours worked per man per year increased 6 percent from 1,888 in 1960 to 2,006 in 1961.

Iron.—The combined injury-frequency rate at iron mines in 1961 was 14.45—a 5-percent decline from the rate of 15.21 in the preceding year. The mines were operated 17 days less than in 1960, and the same length of shift was maintained in both years. Owing to lessened activity, employees accumulated 1,806 hours average worktime each in 1961 compared with 1,944 in 1960—a decline of 7 percent.

Lead-Zinc.—A less favorable safety record than in 1960 was indicated at lead-zinc mines. The overall (fatal and nonfatal) injury-frequency rate of 90.15 was 37 percent higher than the rate of 65.83 in 1960 and marked the third consecutive year in which the injury-frequency rate increased. The number of fatalities reported by May 31, 1962, indicated a sharp decline in the number of fatal injuries in lead-zinc mines in 1961. The mines were operated 26 more days than in 1960. The men worked the same length of shift in both years, and averaged 2,022 hours of worktime each compared with 1,813 man-hours each in 1960 (a 12-percent increase).

Uranium-Vanadium Mines.—Employment in the uranium-vanadium industry had increased rapidly during the past few years. Although peaceful uses of uranium [2] were being investigated and developed, uranium was used chiefly for military applications. Because vanadium is produced in conjunction with mining uranium ores, no separation of injury and employment data was available for vanadium mining. This industry had grown rapidly in recent years and is shown separately in this chapter for the first time. In previous publications in this series, it was included with the miscellaneous metals group. Preliminary figures indicated an improvement in the safety record for uranium-vanadium mines over 1960. The combined (fatal and nonfatal) injury-frequency rate of 43.31 showed a 33-percent decline from the rate of 64.63 in 1960. The mines operated 15 more days in 1961, and workers averaged 2,003 hours of worktime each during the year, a 6-percent increase over 1960.

Miscellaneous Metals.—This group includes mines producing antimony, bauxite, beryl, chromite, cobalt, manganese, mercury, molybdenum, nickel, rare-earth metals, titanium, tungsten, zirconium, and other miscellaneous metals. The rate of occurrence of fatal and nonfatal injuries increased, resulting in a 14-percent rise in the overall injury-frequency rate when compared with 1960. The mines were active 29 more days in 1961 than in 1960. The length of shift was about the same in both years, but the number of hours of worktime averaged 11 percent more in 1961.

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[2] Baker, Don H., Jr. Uranium. BuMines Minerals Yearbook 1960, v. 1, 1961, p. 1153.

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		Injury rate per million man-hours
					Fatal	Nonfatal	
Copper:							
1952–56 (average)	16,405	304	4,993	39,878	27	1,287	32.95
1957	17,664	294	5,188	41,452	19	1,276	31.24
1958	14,972	261	3,912	31,295	20	911	29.75
1959	14,201	232	3,289	26,382	16	714	27.67
1960	16,077	275	4,421	35,388	17	828	23.88
1961 [1]	14,408	275	3,960	33,157	12	802	24.55
Gold placer:							
1952–56 (average)	1,983	213	422	3,437	1	139	40.74
1957	1,551	186	288	2,380	2	140	59.67
1958	1,793	172	309	2,549	1	120	47.48
1959	1,648	160	263	2,200	1	109	50.61
1960	1,224	165	202	1,688	2	68	41.47
1961 [1]	797	194	154	1,253	1	63	51.07
Gold-silver:							
1952–56 (average)	3,079	258	795	6,346	8	599	95.65
1957	3,411	267	910	7,276	6	327	45.77
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 [1]	3,290	251	826	6,601	3	274	41.96
Iron:							
1952–56 (average)	28,455	244	6,947	55,728	19	882	16.17
1957	25,669	252	6,480	51,958	13	617	12.13
1958	21,382	206	4,411	35,374	14	432	12.61
1959	22,099	179	3,966	31,823	14	482	15.59
1960	21,170	242	5,131	41,158	16	610	15.21
1961 [1]	16,402	225	3,694	29,625	10	418	14.45
Lead-zinc:							
1952–56 (average)	12,740	261	3,319	26,549	26	1,905	72.73
1957	11,777	246	2,897	23,168	14	1,320	57.58
1958	8,298	244	2,023	16,160	19	834	52.79
1959	7,665	253	1,939	15,515	10	869	56.65
1960	8,137	227	1,845	14,750	12	959	65.83
1961 [1]	5,530	253	1,398	11,181	1	1,007	90.15
Uranium-vanadium: [2]							
1960	7,329	233	1,710	13,832	32	862	64.63
1961	5,395	248	1,337	10,806	9	459	43.31
Miscellaneous: [3]							
1952–56 (average)	6,774	247	1,674	13,482	12	1,019	76.47
1957	8,385	237	1,988	15,946	17	874	55.88
1958	9,476	221	2,094	16,840	14	898	54.16
1959	9,352	231	2,161	17,580	24	768	45.05
1960	2,989	246	736	5,908	1	246	41.81
1961 [1]	2,222	275	611	4,893	5	228	47.62
Total: [4]							
1952–56 (average)	69,436	261	18,151	145,420	93	5,831	40.74
1957	68,457	259	17,751	142,181	71	4,554	32.53
1958	59,608	229	13,665	109,523	70	3,499	32.59
1959	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 [1]	48,044	249	11,980	97,515	41	3,251	33.76

[1] Preliminary figures.
[2] Uranium-vanadium included with miscellaneous metals before 1960.
[3] Includes antimony, bauxite, beryl, chromite, cobalt (excludes 1960), columbite-tantalite (excludes 1960 and 1961), magnesium (excludes 1961), manganese, mercury, molybdenum, nickel, pyrite (excludes 1957, 1959, 1960 and 1961), rare-earths, titanium, tungsten, zircon, and other miscellaneous metals.
[4] Metals do not always add to totals because figures are rounded.

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, pyrophyllite, and other miscellaneous nonmetals. The injury-frequency rate for 1961 in the nonmetal mine group declined 22 percent over 1960. Days active increased by 15, or 6 percent. The same

average length of work shift (8.2 hours) was maintained in both years, and the median man-hours worked per employee in 1961, was 2,101—an increase of 6 percent over the 1,973 hours worked in 1960.

Nonmetal Mills.—The safety record in nonmetal mills was not quite as favorable in 1961, as shown by the overall injury-frequency rate of 21.06, compared with 20.92 in 1960. Work shifts averaged 8.02 hours in 1961, compared with 8.09 hours in 1960. The average number of hours worked per man per year was 2,183 in 1960 and 2,151 in 1961.

Clay Mines and Mills.—Clay mines in this chapter cover the principal industrial clays: Kaolin or china clay, bentonite, fuller's earth, ball clay, and fire clay. Injury experience and employment data are shown in table 4. The preliminary injury-frequency rate for fatal and nonfatal injuries decreased 30 percent, from 28.73 in 1960 to 20.00 per million man-hours worked in 1961. Days active, however, increased from 192 to 209. The average number of hours worked per man was 1,681 compared with 1,552 in 1960, an increase of 8 percent. The preliminary injury-frequency rate in clay mills was approximately the same as in 1960, as shown in table 4. Days active at clay mills increased slightly over 1960 and were reflected in increased accumulated hours of worktime per worker in 1961.

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	
1952-56 (average)	13,624	278	3,793	30,813	16	1,148	37.78
1957	17,921	262	4,691	37,877	9	1,112	29.60
1958	17,800	239	4,258	34,648	15	955	28.00
1959 [2]	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 [3]	14,645	257	3,758	30,766	11	688	22.72

[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] Revised figures.
[3] Preliminary figures.

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

Year	Men working daily	Average active mill days	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rate per million man-hours
					Fatal	Nonfatal	
1957	27,031	274	7,415	59,765	10	1,512	25.47
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 [1]	30,558	268	8,196	65,719	6	1,378	21.06

[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:							
1957	5,024	203	1,046	8,355	3	320	38.66
1958	5,880	193	1,134	9,277	6	322	35.36
1959 [1]	5,914	191	1,132	9,184	5	271	30.05
1960	6,203	192	1,193	9,638	5	272	28.73
1961 [2]	4,076	209	850	6,851	2	135	20.00
Mill:							
1957	15,516	258	3,996	32,079	5	949	29.74
1958	16,530	255	4,221	34,096	5	896	26.43
1959	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 [2]	16,215	253	4,106	32,898	2	901	27.45

[1] Revised figures.
[2] Preliminary figures.

SAND AND GRAVEL PLANTS

Preliminary data on employment at commercial and noncommercial sand and gravel plants in 1961 represented about 56 percent of the number of men employed in 1960. The combined (fatal and nonfatal) injury-frequency rate of 18.01 per million man-hours of worktime in 1961 indicated a decrease of 11 percent from the preceding year. The plants were active 217 days, and employees averaged 1,848 hours of work each in 1961.

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	
1957 [1]	31,531	221	6,954	59,764	35	1,763	30.09
1958	51,122	211	10,763	92,456	25	1,698	18.64
1959	59,492	(2)	(2)	109,830	21	2,161	19.87
1960	52,352	(2)	(2)	95,749	25	1,919	20.30
1961 [3]	29,203	217	6,347	53,959	21	951	18.01

[1] Employment data from Branch of Nonmetallic Minerals, Division of Minerals.
[2] Not available.
[3] Preliminary figures.

SLAG (IRON BLAST-FURNACE) PLANTS

Final data compiled as the result of the Bureau of Mines canvass of slag (iron blast-furnace) plants for 1961 revealed almost the same number of men working as in 1960; however, the number of man-hours worked decreased 7 percent. No fatal injuries were reported, and the number of nonfatal injuries declined 12 percent. The injury-frequency rate was 5 percent lower than in 1960.

Employees worked an average of 1,998 hours each, a decline of 7 percent compared with the 2,150 work hours each in 1960.

TABLE 6.—Employment and injury experience at slag (iron blast-furnace) plants in the United States [1]

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	
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	(2)	(2)	3,613	----------	34	9.41
1961	1,682	246	415	3,361	----------	30	8.93

[1] All data are final.
[2] Data not available.

METALLURGICAL PLANTS

Reports received from metallurgical plants (ore-dressing mills and primary nonferrous reduction and refinery plants) for 1961 indicated in preliminary figures compiled that the overall injury-frequency rate per million man-hours of work was 19 percent higher than in 1960. The two additional days active reported in 1961 were reflected in a slight increase in the average hours worked per man (2,491 in 1961 and 2,474 in 1960).

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	
1952–56 (average)	56,427	317	17,913	142,974	15	2,698	18.98
1957	65,212	322	21,003	167,489	21	2,280	13.74
1958	52,109	302	15,733	125,773	12	1,698	13.60
1959	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 [1]	45,786	311	14,253	114,073	8	1,384	12.20

[1] Preliminary figures.

ORE-DRESSING PLANTS

Ore-dressing plants include those performing the crushing, screening, washing, jigging, magnetic separation, flotation, and other milling operations of metallic ores. Approximately the same overall frequency rate was maintained in 1961 as in 1960. Days active, also, were approximately the same for both years. Copper, gold-silver, lead-zinc, uranium, and miscellaneous metal mills had reported no fatalities when these data were compiled. The uranium mills formerly included in the miscellaneous metals group, are shown separately as a commodity for the first time in this chapter, reflecting the growth of this industry.

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:							
1952–56 (average)	6,477	328	2,124	17,035	2	237	14.03
1957	7,083	319	2,261	18,095	4	279	15.64
1958	6,468	283	1,828	14,618	1	140	9.65
1959	5,588	250	1,394	11,156	----	82	7.35
1960	5,255	314	1,648	13,188	3	111	8.64
1961 [1]	5,686	317	1,804	14,428	----	106	7.35
Gold-silver:							
1952–56 (average)	466	292	138	1,099	----	36	32.76
1957	468	267	125	1,001	----	20	19.99
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 [1]	312	248	77	617	----	11	17.83
Iron:							
1952–56 (average)	4,335	238	1,033	8,331	2	80	9.84
1957	5,218	262	1,367	11,004	1	67	6.18
1958	5,857	246	1,441	11,536	2	60	5.37
1959	6,324	196	1,240	10,035	1	56	5.68
1960	6,413	258	1,653	13,320	----	79	5.93
1961 [1]	5,183	270	1,399	11,218	3	60	5.62
Lead-zinc:							
1952–56 (average)	3,605	254	917	7,355	1	162	22.16
1957	3,280	252	826	6,609	----	104	15.74
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]	1,047	249	261	2,089	----	60	28.72
Uranium-vanadium: [2]							
1960	2,578	321	826	6,610	1	138	21.03
1961 [1]	2,135	319	682	5,480	----	68	12.41
Miscellaneous metals: [3]							
1952–56 (average)	3,776	308	1,161	9,296	1	282	30.44
1957	5,517	296	1,635	13,087	4	273	21.17
1958	4,573	270	1,236	9,886	----	192	19.42
1959	5,442	300	1,632	13,107	3	146	11.37
1960	6,416	323	2,073	16,605	1	88	5.36
1961 [1]	1,887	310	585	4,682	----	48	10.25
Total: [4]							
1952–56 (average)	18,659	288	5,373	43,116	6	796	18.60
1957	21,566	288	6,214	49,795	9	743	15.10
1958	19,677	266	5,225	41,799	3	467	11.24
1959	19,423	248	4,808	38,621	5	353	9.27
1960	22,529	297	6,689	53,638	5	488	9.19
1961 [1]	16,250	296	4,808	38,514	3	353	9.24

[1] Preliminary figures.
[2] Uranium-vanadium included with miscellaneous metals before 1960.
[3] Includes alumina, antimony, bauxite, chromite, columbite-tantalite, manganese, mercury, molybdenum, nickel, rare-earths, titanium, tungsten, uranium-vanadium (excludes 1960 and 1961), and other miscellaneous metals.
[4] Metals do not always add to totals because figures are rounded.

NONFERROUS REDUCTION PLANTS AND REFINERIES

The plants and refineries that compose this section of the mineral industries are engaged in the primary extraction of nonferrous metals from ores and concentrates and in refining crude primary nonferrous metals. The combined (fatal and nonfatal) injury-frequency rate per million man-hours of worktime in these plants increased 25 percent from 10.93 for 1960 to 13.71. Days worked averaged approximately the same, and the average number of hours worked per man per year was 2,558 in 1961, compared with 2,532 hours each in 1960. Data on injury experience and employment at primary aluminum smelters

and reduction plants and refineries are shown separately. These data were formerly included in the miscellaneous metals group.

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:							
1952-56 (average)	11,387	317	3,611	28,985	4	378	13.18
1957	11,826	323	3,821	30,583	5	375	12.43
1958	10,801	312	3,370	26,966	4	426	15.95
1959	11,204	262	2,939	23,516	4	230	9.95
1960	11,805	313	3,693	29,445	3	370	12.67
1961 [1]	11,414	329	3,750	29,999	3	420	14.10
Lead:							
1952-56 (average)	3,583	304	1,091	8,726	2	111	12.95
1957	3,439	314	1,079	8,629	1	137	15.99
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 [1]	2,493	300	747	5,975	----	116	19.41
Zinc:							
1952-56 (average)	9,389	342	3,211	25,554	2	743	29.15
1957	9,263	326	3,023	24,083	4	632	26.41
1958	7,323	322	2,361	18,891	2	379	20.17
1959	7,243	327	2,370	18,951	----	361	19.05
1960	7,392	293	2,169	17,354	2	279	16.19
1961 [1]	6,518	328	2,138	17,107	2	360	21.16
Aluminum: [2]							
1960	12,630	346	4,365	34,920	1	214	6.16
1961 [1]	7,522	316	2,378	19,027	----	117	6.15
Miscellaneous metals: [3]							
1952-56 (average)	13,408	345	4,627	36,593	2	670	18.36
1957	19,118	359	6,866	54,398	2	393	7.26
1958	11,309	344	3,886	30,998	1	308	9.97
1959	14,695	359	5,280	42,239	1	232	5.52
1960	1,551	315	489	3,913	----	28	7.16
1961 [1]	1,589	271	431	3,451	----	18	5.22
Total: [4]							
1952-56 (average)	37,768	332	12,540	99,858	9	1,902	19.14
1957	43,646	339	14,789	117,694	12	1,537	13.16
1958	32,432	324	10,508	83,974	9	1,231	14.77
1959	36,232	312	11,287	90,291	6	952	10.61
1960	36,160	317	11,459	91,572	7	994	10.93
1961 [1]	29,536	320	9,445	75,559	5	1,031	13.71

[1] Preliminary figures.
[2] Aluminum included with miscellaneous metals before 1960.
[3] Includes aluminum (excludes 1960 and 1961), antimony, bauxite, chromite, cobalt, magnesium, tin, titanium, and other miscellaneous metals.
[4] Metals do not always add to totals because figures are rounded.

STONE QUARRIES

The safety record of the stone-quarrying industry, as indicated by preliminary figures derived from actual company data, improved in 1961. The overall injury-frequency rate (fatal and nonfatal combined) per million man-hours of worktime decreased approximately 10 percent from 23.26 in 1960 to 21.05. The average hours worked per man per year was approximately the same as in 1960.

Cement.—Injury experience in the cement industry (quarries and mills) improved. Preliminary figures indicated a 16-percent decline in the overall injury-frequency rate from 4.79 in 1960 to 4.03. The average hours of worktime per man was 2,455—approximately the same as the 2,457 hours worked in 1960.

Granite.—A decline of 5 percent was noted in the granite industry's preliminary injury-frequency rate (fatal and nonfatal) of 31.75, compared with the final rate of 33.39 in 1960. The average hours of worktime per man increased 2 percent from 1,941 in 1960 to 1,980.

Lime.—Incomplete coverage of injury experience and employment in the lime industry in 1961 indicated a decline of 13 percent in the injury-frequency rate from that in 1960. Employees worked an average of 2,350 hours each in 1961, an approximate 3-percent decline from the average of 2,415 hours in 1960.

Limestone.—The limestone industry's preliminary injury-frequency rate was less favorable than that in 1960. The frequency of injuries per million man-hours rose 2 percent over 1960. The average hours worked per man during 1961 declined 3 percent—from 1,980 in 1960 to 1,930.

Marble.—The combined injury-frequency rate (preliminary) in the marble industry was 50.84, or 6 percent higher than the rate of 48.01 for 1960. The hours worked per man averaged 2,019, compared with 2,088 in 1960, a 3-percent decline.

Sandstone.—Preliminary figures indicated an improvement in the safety record of sandstone and associated operations in 1961 as shown by a 7-percent decline in the overall injury-frequency rate. Workers accumulated an average of 1,579 hours of work each in 1961, a 4-percent decrease from the 1,653 work-hour average in 1960.

Slate.—The injury-frequency rate for the slate industry was not as favorable as in 1960. The rates were based on nonfatal injuries as no fatal injuries were reported in either 1961 or 1960. Each employee accumulated an average of 2,043 hours worktime during the year, an increase of 6 percent over the 1,925 hours recorded in 1960.

Traprock.—The combined (fatal and nonfatal) injury-frequency rate for the traprock industry improved, as shown by a 7-percent decline from the 1960 rate. The hours worked per man averaged 1,793—an increase of 6 percent over the 1,697 hours worked in 1960.

Miscellaneous Stone.—Preliminary 1961 figures revealed a decline of 58 percent in the overall injury-frequency rate for the miscellaneous stone group. Each employee averaged 1,650 hours worktime in 1961—almost identical with the 1960 average (1,651).

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

Industry and year	Men working daily	Average active mine days	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rate per million man-hours
					Fatal	Nonfatal	
Cement: [1]							
1952–56 (average)	28,418	325	9,247	73,868	12	359	5.02
1957	29,167	317	9,254	73,940	14	277	3.94
1958	29,908	296	8,864	70,910	9	297	4.32
1959	28,253	(2)	(2)	71,261	7	339	4.86
1960	28,837	(2)	(2)	70,846	5	334	4.79
1961 [3]	22,569	307	6,919	55,397	2	221	4.03
Granite:							
1952–56 (average)	6,375	242	1,546	12,818	6	509	40.18
1957	7,017	238	1,668	13,890	8	592	43.20
1958	7,522	242	1,824	14,590	4	708	48.80
1959	8,512	(2)	(2)	18,003	3	717	39.99
1960	8,532	(2)	(2)	16,563	2	551	33.39
1961 [3]	5,933	238	1,412	11,749	4	369	31.75
Lime: [1]							
1952–56 (average)	8,767	293	2,566	20,643	6	470	23.06
1957	8,220	284	2,332	18,683	1	447	23.98
1958	6,948	292	2,027	16,216	1	354	21.89
1959	7,800	(2)	(2)	18,686	7	354	19.32
1960	8,295	(2)	(2)	20,036	8	372	18.97
1961 [3]	7,056	292	2,059	16,583	3	272	16.58
Limestone:							
1952–56 (average)	26,340	237	6,240	52,397	20	1,799	34.72
1957	28,692	230	6,603	55,637	21	1,960	35.61
1958	29,649	245	7,266	58,128	23	2,026	35.25
1959	31,939	(2)	(2)	63,184	26	2,060	33.01
1960	33,453	(2)	(2)	66,250	13	2,072	31.47
1961 [3]	20,870	230	4,790	40,285	12	1,283	32.15
Marble:							
1952–56 (average)	2,424	263	610	5,061	1	183	36.36
1957	3,160	258	814	6,750	1	188	28.00
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]	2,591	246	637	5,232	2	264	50.84
Sandstone:							
1952–56 (average)	3,692	239	881	7,200	2	339	47.36
1957	2,980	206	613	4,989	1	259	52.12
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 [3]	2,374	192	457	3,748	2	168	45.36
Slate:							
1952–56 (average)	1,560	260	406	3,387	1	176	52.26
1957	1,357	254	345	2,871	1	169	59.21
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 [3]	1,089	252	275	2,225	----	127	57.07
Traprock:							
1952–56 (average)	2,977	226	673	5,868	3	235	40.56
1957	2,883	215	620	5,332	6	277	53.08
1958	4,130	230	950	7,597	6	331	44.36
1959	4,808	(2)	(2)	8,746	3	443	51.00
1960	5,207	(2)	(2)	8,835	4	411	46.97
1961 [3]	3,026	213	645	5,426	4	234	43.86
Miscellaneous stone: [4]							
1957	650	248	161	1,302	----	41	31.49
1958	2,232	240	535	4,284	----	228	53.22
1959	1,949	(2)	(2)	3,476	3	170	49.78
1960	1,913	(2)	(2)	3,158	2	129	41.48
1961 [3]	1,173	204	240	1,935	----	34	17.57
Total: [5]							
1952–56 (average)	80,552	275	22,169	181,240	51	4,070	22.74
1957	84,126	266	22,410	183,394	53	4,210	23.25
1958	88,448	264	23,353	186,821	45	4,572	24.71
1959	91,523	(2)	(2)	199,321	52	4,790	24.29
1960	95,304	(2)	(2)	202,366	39	4,668	23.26
1961 [3]	66,681	261	17,434	142,580	29	2,972	21.05

[1] Includes burning or calcining and other mill operations.
[2] Not available.
[3] Preliminary figures.
[4] Not compiled before 1957.
[5] Stones do not always add to totals because figures are rounded.

Mineral Production

(Comparison of Bureau of Mines and Bureau of the Census 1958 Data)

By Mary S. Lanier[1]

THE BUREAU OF MINES collects annually from mineral producers, processors, and users—on a voluntary basis—information on mineral commodities at various stages in their progression from mine to end use. For some minerals there are monthly or quarterly canvasses as well. Production data are tabulated and published on a commodity basis; that is, the total of a mineral commodity produced is available regardless of the industry classification of the producer.

The Bureau of the Census in its economic census program, which includes the Census of Mineral Industries, collects data on expenses, capital expenditures, horsepower of equipment, energy use, and secondary production, as well as on selected production and shipments. These data are collected on an establishment basis; each establishment is then classified for purposes of tabulation and publication according to its major activity into an industry as defined by the Standard Industrial Classification Manual.

This chapter compares Bureau of Mines mineral production data for 1958 with those of the Bureau of the Census, U.S. Department of Commerce, as presented in its reports of the 1958 Census of Mineral Industries. The two agencies cooperated in conducting the 1958 Census of Mineral Industries so that comparable coverage and, so far as feasible, unduplicated results, would be obtained. Joint forms were not used in 1958.

Prior to the 1958 canvass, the Bureau of Mines provided the Bureau of the Census with supplemental mailing lists to (1) assure that coverage would be identical and (2) provide Census with a list of establishments having no employees. Also, the Bureau of Mines played an important role in designing the 1958 census questionnaires so that duplication of requested data would be minimized. At the same time, items to be included by both agencies for relating the more detailed statistics were determined.

The Bureau of Mines and the Bureau of the Census cooperated in developing a table comparing the basic statistics tabulated by the separate agencies. The comparison of quantity and value data for each mineral or mineral commodity has been designed and explained where necessary so that users of the statistics can understand any major differences. The comparison also provides an approximate measure of the extent to which coverages of the two agencies match.

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TABLE 1.—Comparison of the Bureau of Mines and

Mineral	Commodity data			
	Bureau of Mines			Bureau of the Census
	Measurement stage	Quantity (thousand short tons unless otherwise specified)	Value (thousand dollars)	Measurement stage
Mineral fuels:				
Asphalt and related bitumens (native):				
Bituminous limestone and sandstone.	Production	1,326	3,343	Production Shipments
Gilsonite	do	317	4,864	Production Shipments
Carbon dioxide, natural, estimate (thousand cubic feet).	do	722,616	102	
Coal:				
Bituminous	do	408,019	1,990,575	Production Net shipments
Lignite	do	2,427	5,706	Production Net shipments
Pennsylvania anthracite	do Shipments	21,171 20,976	187,898 186,665	Production Net shipments
Crude petroleum (thousand 42-gallon barrels).	Production	2,449,016	7,380,065	Production Shipments
Field condensate and drips (thousand barrels).				Shipments
Helium (thousand cubic feet)	Production	352,134	5,741	
Natural gas (million cubic feet)	Gross withdrawals. Marketed production.	13,146,635 11,030,298	(1) 1,317,492	Production Shipments
Natural gas liquids (thousand 42-gallon barrels).	Production Shipments	294,749 292,128	689,710 (1)	Production Shipments
Peat	Production Shipments	328 (1)	3,446 (1)	Production Shipments
Nonmetals:				
Abrasive stone	Production	(1)	183	
Natural abrasives, except sand				Production Shipments
Asbestos: Crude and prepared	Sold or used	44	5,127	Production Shipments
Barite:				
Crude	do Mine or plant output.	605 486	7,508 (1)	Production Shipments
Prepared	Production Sales	1,014 1,027	(1) 28,352	Shipments
Boron minerals	Sold or used	528	38,310	Shipments
Bromine (thousand pounds)	Sales	176,397	46,689	do
Cement (thousand 376-pound barrels).	Production Shipments	321,490 317,263	(1) 1,038,672	Production do

See footnotes at end of table.

Bureau of the Census mineral production data for 1958

Commodity data—Con.		Industry data, Bureau of the Census					
Bureau of the Census—Continued							
Quantity (thousand short tons unless otherwise specified)	Value (thousand dollars)	Industry code	Total industry value of shipments and receipts (thousand dollars)	Primary products, net shipments			Secondary products, services, and resales (thousand dollars)
				Total produced in all industries (thousand dollars)	Produced in specified industry (thousand dollars)	Produced in other industries (thousand dollars)	
1,298	(1)						
1,298	3,327	1,494	8,041	8,027	8,027	----------	14
317	(1)						
321	4,700						
(2)	(2)	3 2813	(2)	(2)	(2)	(2)	(2)
413,580	(1)	1211	2,390,677	2,055,042	2,054,067	435	26,986
417,075	2,062,140						
4,231	(1)	1212	11,035	11,021	11,021	----------	14
4,231	11,021						
22,258	(1)	1111	290,342	196,425	196,425	----------	7,749
22,341	196,425						
2,319,162	(1)						
2,317,565	6,934,158	1311	7,809,998	7,082,194	6,899,121	183,073	910,777
48,647	148,036						
(2)	(2)	3 2813	(2)	(2)	(2)	(2)	(2)
12,152,585	(1)	1311	576,008	1,294,271	432,565	861,706	143,443
10,134,236	1,294,271						
294,192	(1)	1321	1,625,098	699,328	699,328	----------	7,587
294,887	699,328						
366	(1)	1498	4,379	4,253	(2)	(2)	59
365	4,253						
(2)	(2)	----------	----------	----------	----------	----------	----------
66	(1)						
65	3,510	1497	3,373	3,510	(2)	(2)	(2)
44	(1)						
44	4,900	3 1499	5,061	4,900	(2)	(2)	16
608	(1)						
148	1,402						
(2)	(2)	1472	13,768	31,868	13,434	18,434	(2)
1,120	30,466						
559	32,275	3 1474	(2)	32,275	(2)	(2)	(2)
10,000	2,306	3 2819	(2)	2,306	(2)	(2)	(2)
319,000	(1)						
320,000	1,038,613	3241	1,073,494	1,062,849	1,059,967	2,882	13,527

TABLE 1.—Comparison of the Bureau of Mines and Bureau

Mineral	Commodity data			
	Bureau of Mines			Bureau of the Census
	Measurement stage	Quantity (thousand short tons unless otherwise specified)	Value (thousand dollars)	Measurement stage
Nonmetals—Continued				
Clays	Sold or used	43,750	143,487	
Ball clay and kaolin:				
Crude	do	2,619	41,924	Production Net shipments
Prepared		(1)	(1)	Shipments
Ball clay	Sold or used	397	5,503	
Kaolin	do	2,222	36,421	
Bentonite				
Crude	Sold or used	1,291	15,317	Production Net shipments
Prepared				do
Common clay and shale				Shipments
Crude	Sold or used	30,674	38,217	Production Shipments
Prepared				do
Fire clay	Sold or used	8,808	40,420	Production
Crude				Shipments
Prepared				do
Fuller's earth	Sold or used	358	7,609	Net shipments
Diatomite: Prepared	do	438	20,216	Production Shipments
Emery	do	8	126	
Feldspar:				
Crude	do	526	4,278	Production Shipments
Prepared	do	470	6,540	do
Fluorspar:				
Crude	Production	818	(1)	Production Shipments
Prepared	Production	311	(1)	Production Shipments
	Net shipments	320	15,071	Net shipments
Garnet (abrasive)	Sold or used	12	869	
Gem stones	Production	(4)	1,006	
Gypsum:				
Crude	do	9,600	32,495	Production Shipments
Prepared				do
Lime	Sold or used	9,211	121,193	do
Magnesite and brucite	(5)	(5)		Production
	(5)	(5)	(5)	Shipments
Aplite, kyanite, laterite, and olivine				do
Magnesium compounds, seawater, and brine (except for metals) (MgO equivalent).	Sold or used	207	16,419	Shipments
Mica:				
Scrap (or flake) mica	do	93	2,065	Production Shipments
Sheet mica (thousand pounds)	do	661	2,844	Production Shipments
Ground mica	do	98	5,560	do

See footnotes at end of table.

of the Census mineral production data for 1958—Continued

Commodity data—Con.		Industry data, Bureau of the Census					
Bureau of the Census—Continued							
Quantity (thousand short tons unless otherwise specified)	Value (thousand dollars)	Industry code	Total industry value of shipments and receipts (thousand dollars)	Primary products, net shipments			Secondary products, services, and resales (thousand dollars)
				Total produced in all industries (thousand dollars)	Produced in specified industry (thousand dollars)	Produced in other industries (thousand dollars)	
3,044	(1)						
314	3,066	1455	42,434	47,664	(2)	(2)	463
2,311	44,598						
(2)	(2)	(2)					
(2)	(2)	(2)					
1,705	(1)						
396	1,394	1452	16,843	23,207	16,505	6,702	240
1,343	21,813						
1,558	16,505						
31,683	(1)						
2,044	3,034	1459	22,004	68,202	21,741	46,461	263
3,649	26,191						
8,724	(1)						
3,517	13,389	1453	18,606	33,497	17,559	15,938	871
1,033	6,070						
285	6,778	1454	8,692	6,778	6,778	----	(2)
458	(1)						
452	20,114	[3] 1499	20,212	(2)	(2)	(2)	(2)
(2)	(2)	1497	(2)	(2)	(2)	(2)	(2)
506	(1)						
120	866	1456	6,889	7,018	5,772	1,246	661
465	6,608						
836	(1)						
96	1,785						
368	(1)	1473	19,977	15,443	15,443	----	1,196
366	16,966						
275	15,443						
(2)	(2)	1497	(2)	(2)	(2)	(2)	(2)
(2)	(2)	[3] 1499	(2)	(2)	(2)	(2)	(2)
9,384	(1)						
737	1,414	1492	7,048	34,160	7,036	27,124	12
3,829	15,939						
8,259	108,976	3274	130,948	108,976	103,663	5,313	27,285
508	(1)	1457	7,270	7,270	7,270	----	----
154	7,270						
234	2,777	[3] 1459	(2)	(2)	(2)	(2)	(2)
(1)	12,768	[3] 2819	(2)	12,768	(2)	(2)	(2)
106	(1)						
48	989						
407	(1)	1493	6,221	10,490	6,103	4,387	118
406	2,702						
115	5,950						

TABLE 1.—Comparison of the Bureau of Mines and Bureau

Mineral	Commodity data			
	Bureau of Mines			Bureau of the Census
	Measurement stage	Quantity (thousand short tons unless otherwise specified)	Value (thousand dollars)	Measurement stage
Nonmetals—Continued				
Perlite:				
Crude	Production	372	(1)	Production, Shipments
Prepared	Sold or used	292	2,464	Production, Shipments
Phosphate rock:				
Crude ore or matrix (thousand long tons).	Production	46,459	(1)	Production, Shipments
Washed or concentrated	do	[6] 12,360	(1)	Production, Shipments
Dried, calcined or sintered	do	[6] 11,486	(1)	Production, Shipments
Net shipments by industry	Sold or used	14,879	93,693	Net shipments
Potassium salts:				
Crude	Production	12,224	(1)	Production
Marketable	Sold or used	3,650	75,000	do
K_2O equivalent	do	2,147		
Crude and prepared		(1)	(1)	Shipments
Pumice	Sold or used	1,973	5,287	Production, Shipments
Pyrites (thousand long tons)	Production	974	7,987	Production, Shipments
Salt	Sold or used	21,912	141,500	
Rock salt	do	5,407	37,125	Shipments
Evaporated salt	do	3,762	62,373	do
Salt in brine	do	12,743	42,002	
Sand and gravel	do	684,498	652,789	
Common sand	do	230,451	220,386	Production, Shipments
Commercial sand	do	200,371	203,428	
Government-and-contractor sand.	do	30,080	16,958	
Glass sand	do	5,575	17,858	Production, Shipments
Molding sand	do	5,632	12,827	Production, Shipments
Gravel	do	442,840	401,718	Production, Shipments
Commercial gravel	do	277,716	291,170	
Government and contractor gravel.	do	165,124	110,548	
Sodium carbonate (natural)	do	629	17,032	Shipments
Sodium sulfate (natural)	do	347	6,716	do
Stone, total	do	535,923	826,685	Net shipments
Dimension, total	do	2,522	80,254	do
Rough	do	1,220	18,152	do
Dressed	do	1,302	62,102	do
Limestone, total	do	979	18,757	do
Rough	do	542	4,239	do
Dressed	do	437	14,518	do
Granite, total	do	621	24,059	do
Rough	do	281	9,419	do
Dressed	do	340	14,640	do
Stone, n.e.c., total	do	922	37,438	do
Rough	do	397	4,494	do
Dressed	do	525	32,944	do

See footnotes at end of table.

of the Census mineral production data for 1958—Continued

Commodity data—Con.		Industry data, Bureau of the Census					
Bureau of the Census—Continued							
Quantity (thousand short tons unless otherwise specified)	Value (thousand dollars)	Industry code	Total industry value of shipments and receipts (thousand dollars)	Primary products, net shipments: Total produced in all industries (thousand dollars)	Primary products, net shipments: Produced in specified industry (thousand dollars)	Primary products, net shipments: Produced in other industries (thousand dollars)	Secondary products, services, and resales (thousand dollars)
364	(1)						
18	92						
278	(1)	[3] 1499	2,604	2,604	(2)	(2)	(2)
265	2,512						
46,031	(1)						
3,162	8,922						
12,636	(1)						
8,492	41,607	1475	132,094	99,036	99,036	----------	125
11,747	(1)						
11,817	81,440						
15,605	99,036						
12,224	(1)						
3,710	(1)	[3] 1474	(2)	(2)	(2)	(2)	(2)
(1)	----------						
4,002	82,468						
2,093	(1)	1495	5,002	5,006	(2)	(2)	(2)
2,073	5,486						
1,025	(1)	[3] 1479	(2)	2,392	(2)	(2)	(2)
377	2,392						
(1)	(1)	1476	41,813	40,525	(1)	(1)	4,190
5,447	40,525						
3,815	86,544	[3] 2899	(2)	(2)	(2)	(2)	(2)
(1)	(1)						
----------	----------	1441	560,806	591,188	518,457	72,731	41,479
232,708	(1)						
219,407	219,246	[3] 1441	(2)	(2)	(2)	(2)	(2)
(1)	(1)						
(1)	(1)						
7,446	(1)	[3] 1441	28,343	21,955	19,442	2,513	8,901
7,421	21,955						
7,763	(1)	[3] 1441	16,373	19,021	14,319	4,702	2,054
7,709	19,021						
306,042	(1)						
292,516	309,606	[3] 1441	(2)	(2)	(2)	(2)	(2)
(1)	(1)						
(1)	(1)						
639	17,175	[3] 1474	(2)	(2)	(2)	(2)	(2)
344	6,495	[3] 1474	(2)	(2)	(2)	(2)	(2)
(1)	(1)	----------	----------	----------	----------	----------	----------
2,957	80,559						
1,662	18,613	[3] 1411	15,864	22,154	15,275	6,879	589
1,295	61,946	[3] 3281	72,597	(2)	(2)	(2)	(2)
1,129	18,331						
705	7,009	[3] 1411	4,174	7,139	4,128	3,011	46
424	11,322	[3] 3281	16,243	(2)	(2)	(2)	(2)
807	29,827						
333	3,711	[3] 1411	5,577	5,864	5,166	698	411
474	26,116	[3] 3281	28,831	(2)	(2)	(2)	(2)
1,021	32,401						
624	7,893	[3] 1411	6,113	9,151	5,979	3,172	134
397	24,508	3281	28,523	(2)	(2)	(2)	(2)

TABLE 1.—Comparison of the Bureau of Mines and Bureau

Mineral	Commodity data			
	Bureau of Mines			Bureau of the Census
	Measurement stage	Quantity (thousand short tons unless otherwise specified)	Value (thousand dollars)	Measurement stage
Nonmetals—Continued:				
Stone, total—Continued				
Crushed and broken, total	Sold or used	533,401	746,431	Production Shipments
Commercial	do	483,634	694,801	
Government-and-contractor	do	49,767	51,630	
Limestone	do	390,468	516,765	Net production Net shipments
Granite	do	31,337	45,432	Net production Net shipments
Stone, n.e.c.	do	111,596	184,234	Net production Net shipments
Sulfur:				
Frasch process sulfur (thousand long tons).	Production	4,643	(1)	Production
	Shipments	4,644	109,272	Shipments
Other	Production	6	(1)	Production
	Shipments	154	1,505	Shipments
Elemental	Production	642	(1)	Production Shipments
Talc, soapstone, and pyrophyllite:				
Crude	do	718	4,718	Production Net shipments
Prepared	do	633	13,856	Shipments
Crude and prepared	Sold or used	694	14,206	
Tripoli	do	47	183	
Vermiculite: Crude	do	191	2,728	
Other nonmetals n.e.c.:				
Crude	Production	(1)	21,958	Production Shipments
Prepared				Production Shipments
Metals:				
Antimony ore and concentrate (antimony, content) (short tons).	Production	716	(1)	Shipments
Bauxite (thousand long tons):				
Crude	do	1,584	12,815	Production
	Shipments	1,649	13,984	Shipments
Prepared	Production	137	(1)	Production Shipments
Net shipments				Net shipments
Beryllium concentrate (short tons)	Production	505	(1)	Production
	Shipments	505	243	Shipments
Chromite:				
Crude chromium ores				Production
Chromium concentrate	Shipments	144	6,187	Shipments (crude ore and concentrate)
Cobalt (content of concentrate) (thousand pounds).	Production	4,844	(1)	
Columbium-tantalum concentrate (thousand pounds).	Shipments	428	(1)	

See footnotes at end o

of the Census mineral production data for 1958—Continued

Commodity data—Con.		Industry data, Bureau of the Census					
Bureau of the Census—Continued							
Quantity (thousand short tons unless otherwise specified)	Value (thousand dollars)	Industry code	Total industry value of shipments and receipts (thousand dollars)	Primary products, net shipments			Secondary products, services, and resales (thousand dollars)
				Total produced in all industries (thousand dollars)	Produced in specified industry (thousand dollars)	Produced in other industries (thousand dollars)	
484,592	(1)						
405,240	616,649	1421	616,076	731,642	580,851	150,791	33,037
(1)	(1)						
388,360	(1)	[3] 1421	459,037	577,004	430,007	146,997	26,971
309,491	459,564						
33,812	(1)	[3] 1421	49,596	49,961	48,467	1,494	1,129
33,812	49,961						
62,420	(1)	[3] 1421	107,443	104,677	99,247	5,430	8,067
61,397	107,124						
4,642	----						
4,607	105,995	1477	106,202	106,200	106,200	----	2
12	(1)						
12	205						
669	(1)	[3] 1479	(2)	(2)	(2)	(2)	(2)
628	16,465						
726	----						
237	1,574	1496	14,908	19,167	(2)	(2)	301
600	17,593						
----	----						
(2)	(2)	[3] 1497	(2)	(2)	(2)	(2)	(2)
(1)	(1)	[3] 1499	(2)	(2)	(2)	(2)	(2)
206	----						
2	35	[3] 1499	(2)	(2)	(2)	(2)	(2)
204	----						
209	3,696						
(1)	3,157	[3] 1099	(2)	(2)	(2)	(2)	(2)
1,612	(1)						
1,662	15,607						
136	(1)	1051	18,174	17,355	17,355	----	19
137	2,548						
1,658	17,089						
474	(1)	[3] 1099	(2)	213	(2)	(2)	(2)
474	213						
300	(1)						
		[3] 1069	6,001	(1)	5,970	(1)	----
150	6,001						
(2)	(2)	[3] 1069	(2)	(2)	(2)	(2)	(2)
(2)	(2)	[3] 1069	(2)	(2)	(2)	(2)	(2)

TABLE 1.—Comparison of the Bureau of Mines and Bureau

Mineral	Commodity data			
	Bureau of Mines			Bureau of the Census
	Measurement stage	Quantity (thousand short tons unless otherwise specified)	Value (thousand dollars)	Measurement stage
Metals—Continued				
Copper:				
Crude ore mined in the copper ores industry.	Production	114,824	(1)	Production
Copper concentrate (thousand pounds of metal contained).	Sold or treated	1,819,465	(1)	Shipments
Copper precipitate (thousand pounds of metal contained).	do	198,000	(1)	do
Recoverable content of copper-bearing materials (short tons).	Mine production.	979,329	515,127	Production
Copper, lead, zinc, gold, and silver ores.	do	134,516	(1)	do Shipments
Gold:				
Lode:				
Crude ore mined in the industry.	do	2,518	(1)	do
Concentrate (thousand troy or fine ounces of contained metal).	Shipments	[6] 110.4	(1)	Production Shipments
Mill bullion (thousand troy or fine onces).	Production	692.3	(1)	do
Placer (thousand troy or fine ounces).	do	371	12,984	Production Shipments
Metal content of gold-bearing materials (thousand troy or fine ounces).	do	1,739	60,874	Production
Iron ore, except manganiferous iron ore:				
Crude (thousand long tons)	Production	109,815	(1)	Production Shipments
Direct-shipping ore, concentrate and agglomerate (thousand long tons).	Net production	66,959	(1)	Net production
	Net shipments	66,288	569,154	Net shipments
Lead (short tons, recoverable metal content).	Production	267,377	62,566	Production
Lead ore (short tons, metal contained).	Shipments	257,909	(1)	Shipments
Lead concentrates				Production
Lead and zinc ores:				
Crude ore mined in the industries.	Production	16,534	(1)	do
Manganese ores (thousand long tons):				
Crude				do Shipments Net shipments
35% or more manganese	Shipments	288	23,637	Shipments

See footnotes at end of table.

of the Census mineral production data for 1958—Continued

Commodity data—Con.		Industry data, Bureau of the Census					
Bureau of the Census—Continued				Primary products, net shipments			
Quantity (thousand short tons unless otherwise specified)	Value (thousand dollars)	Industry code	Total industry value of shipments and receipts (thousand dollars)	Total produced in all industries (thousand dollars)	Produced in specified industry (thousand dollars)	Produced in other industries (thousand dollars)	Secondary products, services, and resales (thousand dollars)
111,957	21,622						
1,792,489	316,147	1021	457,644	369,419	357,244	12,175	17,234
174,868	31,650						
996,955	(1)						
129,216	(1)						
4,384	29,417						
2,358	(1)						
28	(1)						
91.4	3,790	1042	29,506	29,072	28,164	908	70
680.3	24,090						
362.1	(1)						
362.5	12,580	1043	6,326	6,314	6,314		12
1,739	(1)						
108,384	(1)						
50,586	311,292						
66,993	(1)	[3] 1011	(1)	621,799	(1)	(1)	(1)
68,121	621,799						
285,916	(1)						
281,485	5,184	[3] 1031	75,603	59,941	54,094	5,847	14,050
383	54,813						
14,405	(1)	1031	120,561	102,676	99,702	2,974	4,141
1,395	(1)						
508	17,448						
336	27,156	1062	39,385	32,776	(2)	(2)	(2)
460	32,776						

TABLE 1.—Comparison of the Bureau of Mines and Bureau

Mineral	Commodity data			
	Bureau of Mines			Bureau of the Census
	Measurement stage	Quantity (thousand short tons unless otherwise specified)	Value (thousand dollars)	Measurement stage
Metals—Continued				
Manganiferous iron ore (thousand long tons):				
Crude				Production
Direct-shipping ore, concentrates, and agglomerates.	Net production and shipments.	465	3,532	Net production Shipments
Mercury:				
Crude ore	Production	328	(1)	Production
Mercury metal, 76-pound flasks	do	38,067	8,720	do Shipments
Molybdenum (content of concentrate).	do	21	50,371	Production
	Shipments			Shipments
Nickel (content of ore and concentrate, short tons).	Production	13,490	(1)	
Rare-earth and thorium concentrates (short tons).	Production	2,021	286	
Thorite, crude (short tons)				Production Shipments
Bastnaesite and monazite concentrates (short tons).	Shipments	987	(1)	Production Shipments
Silver:				
Crude ore mined in the industry	Production	639	(1)	Production
Silver concentrate and mill bullion (thousand troy or fine ounces).	Shipments	12,910	(1)	Net shipments Shipments
Metal content of silver-bearing materials (thousand troy or fine ounces).	Production	34,111	30,872	Production
Titanium ore:				
Crude ore				Production
Titanium concentrate	Production	571	(1)	do
	Shipments	567	11,365	Shipments
Ilmenite	do	565	11,155	
Rutile	do	2	210	
Tungsten ore:				
Crude ore				Production
Tungsten concentrate	Shipments	4	3,991	Shipments

See footnotes at end of table.

of the Census mineral production data for 1958—Continued

Commodity data—Con.		Industry data, Bureau of the Census					
Bureau of the Census—Continued							
Quantity (thousand short tons unless otherwise specified)	Value (thousand dollars)	Industry code	Total industry value of shipments and receipts (thousand dollars)	Primary products, net shipments: Total produced in all industries (thousand dollars)	Primary products, net shipments: Produced in specified industry (thousand dollars)	Primary products, net shipments: Produced in other industries (thousand dollars)	Secondary products, services, and resales (thousand dollars)
882	(1)						
437	(1)	[3] 1011	(1)	3,042	(1)	(1)	(1)
409	3,042						
400	(1)						
33,812	(1)	1092	8,607	8,402	8,402	----------	(2)
37,144	8,402						
36	(1)						
37	49,933	[3] 1069	(2)	(2)	(2)	(2)	(2)
(2)	(2)	[3] 1069	(20)	(2)	(2)	(2)	(2)
(2)	(2)						
702	(1)						
702	34	[3] 1099	(2)	(2)	(2)	(2)	(2)
5,663	(1)						
1,074	250						
496	(1)						
(1)	1,419						
13,234	11,674	1044	12,557	13,093	12,177	916	244
35,577	(1)						
13,244	(1)						
606	(1)						
598	12,365	1093	17,158	12,365	(2)	(2)	(2)
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----------	----------						
188	(1)						
6	13,675	1064	14,430	13,675	(2)	(2)	(2)

TABLE 1.—Comparison of the Bureau of Mines and Bureau

Mineral	Commodity data			
	Bureau of Mines			Bureau of the Census
	Measurement stage	Quantity (thousand short tons unless otherwise specified)	Value (thousand dollars)	Measurement stage
Metals—Continued				
Uranium ore	Mine production.	5,178	116,515	
Uranium concentrate	Mill production.	13	238,000	
Uranium-vanadium ore		(1)	(1)	Production
Uranium-vanadium concentrate		(1)	(1)	Production and shipments.
Vanadium (recoverable in ore and concentrate).	Mine production.	7	(1)	
	Mill production.	3	10,817	
Zinc (short tons, recoverable metal content).	Mine production.	412,005	84,113	Production
Zinc ore (short tons, metal contained)	Shipments	384,107	(1)	Shipments
Zinc concentrate				Production
Zirconium concentrate (short tons)	Production	30,443	1,024	Production Shipments
Value of items that cannot be disclosed: Magnesium chloride for magnesium metal, manganiferous residuum, platinum-group metals.			23,245	

[1] Data not available.
[2] Data not available separately.
[3] Mineral or minerals designated in subject column represent 1 or more of those included in 4-digit industry code specified.
[4] Weight not recorded.
[5] Figure withheld to avoid disclosing individual company confidential data.
[6] Not published separately by Bureau of Mines.

The comparative table also includes industry shipments and receipts data from the Census reports to afford readers (1) an approximate measure of the extent to which a particular commodity is produced in the industry to which it is primary and (2) information of the extent to which that industry produces other commodities. "Total industry value of shipments and receipts" are in excess of the sum of the total shown for "Primary products" and for "Secondary products, services, and resales," because of the inclusion in the former of all intercompany transfers.

To avoid duplicating Bureau of Mines product detail, the 1958 census questionnaires requested less detail on quantity and value of shipments. The Census data are primarily product-class statistics which provide a benchmark for relating more detailed Bureau of Mines data to Bureau of the Census statistics on operating cost and capital expenditures. Unless otherwise stated, Bureau of the Census industry data, in general, are based on the 1957 Standard Industrial

of the Census mineral production data for 1958—Continued

Commodity data—Con.		Industry data, Bureau of the Census					
Bureau of the Census—Continued							
Quantity (thousand short tons unless otherwise specified)	Value (thousand dollars)	Industry code	Total industry value of shipments and receipts (thousand dollars)	Primary products, net shipments			Secondary products, services, and resales (thousand dollars)
				Total produced in all industries (thousand dollars)	Produced in specified industry (thousand dollars)	Produced in other industries (thousand dollars)	
(2)	(2)						
(2)	(2)						
5,480	(1)						
59	243,080	1094	336,451	224,931	(2)	(2)	(2)
(2)	(2)						
(2)	(2)						
463,703	(1)						
462,037	(1)	3 1031	44,958	42,735	28,531	14,204	7,168
758	42,679						
36,458	(1)	3 1099	(2)	(2)	(2)	(2)	(2)
40,734	1,678						

Classification for nonmanufacturing industries. For each mineral, the industry code used in determining the Bureau of Mines value of mineral production is shown; however, in some instances it was necessary or desirable to compare with Census data at another measurement stage.

Other factors pertinent to comparability of mineral statistics published by the two agencies are as follows:

1. The Bureau of Mines usually obtains data on commodities sold or used, whereas the Bureau of the Census collects information on production and shipments and calculates net shipments. Net figures (net production and net shipments) reported by Census usually exclude minerals produced for preparation at other establishments; they are the net of transfers to cleaning or preparation plants but not of all interplant transfers. Shipments or gross shipments as defined by Census include interplant transfers, and net shipments mean (a) shipments of crude direct-shipping material plus concentrates or (b) gross shipments less receipts of minerals for preparation. Differences between these measurement stages account for significant differences between Census and Mines figures.

2. Different objectives for collecting mineral statistics result in differences in coverage of certain areas by both agencies.

3. The Bureau of Mines includes reports of all respondents, regardless of size; the Bureau of the Census excludes establishments whose value of products and reported costs are below $500.

4. The Bureau of Mines data on prepared products and concentrates represent only those prepared from domestic materials; Bureau of the Census data on prepared products include those prepared from foreign materials. In addition, the stage of preparation at which the products are measured and valued is different for the two agencies in some instances.

Explanations of major variations in the quantities and values of many minerals or mineral commodities listed in the comparative table are presented in the summaries that follow. These explanatory notes, however, are of interest only to the user of the table and not to the general reader. Specific problems and questions of the user of these commodity data probably can be resolved by reference to the commodity chapters of the Bureau of Mines Minerals Yearbook and to the Census of Mineral Industries and Census of Manufactures, 1958, of the Bureau of the Census.

MINERAL FUELS

Anthracite.—The Bureau of Mines statistics on both production and shipments are based primarily on data reported by breakers, washeries, and dredges but also include some coal sold for use without preparation. The quantity and value of the coal so reported is then distributed among the counties from which the coal originated. The Census statistics are on an establishment basis and take into account the actual location and type of product of the establishment as reported by the respondent, making a distinction between "net production" and "net shipments." The Bureau of Mines statistics therefore are comparable by county only with the Census statistics for "net production" and are not comparable with the Census county figures for "net shipments."

Both agencies collect information on coal shipped for use as raw coal and on raw coal shipped for preparation, as well as on the prepared product. The Census figures for coal shipped for use as raw coal are much larger than those known to the Bureau of Mines. Reports to the Bureau of Mines indicate that much of this coal is shipped for preparation before final shipment to the consumer.

Bituminous Coal and Lignite.—The Bureau of Mines statistics on both production and shipments are based primarily on data furnished by producers. These data are supplemented, however, by data from various State mine department records and, in a few instances, from railroad carloadings, in order to obtain coverage of production not directly reported. The Bureau of Mines figures represent the quantity and value of net marketable coal produced, excluding washery and other refuse. The Census statistics are on an establishment basis, making a distinction between "net production" and "net shipments."

Both the Bureau of Mines and the Bureau of the Census collect information on mechanical cleaning of coal. However, the Bureau of

Mines credits the clean coal to the location or locations at which the coal was mined, whereas the Census statistics show the clean coal shipped according to the location of the cleaning plant. The Census clean-coal statistics represent mechanical cleaning at plants operated in conjunction with mines and at separately operated cleaning plants (these are included in the bituminous coal industry) and exclude figures for coal cleaning at preparation plants operated as parts of coke ovens or other manufacturing establishments. The Bureau of Mines includes data for these consumer-operated plants in its statistics on mechanical cleaning.

Both agencies obtain information on mechanical crushing, and Census, in addition, obtains data for screening and sizing. The Bureau of Mines figures for mechanical crushing show all coal crushed at mines, including that which was both crushed and mechanically cleaned. The Census figures represent coal prepared only by mechanical crushing, screening, and sizing.

The Bureau of Mines commodity statistics include data for State-owned or State-operated mines producing coal, with inmate labor, for use at State institutions. Government institutions, in general, are out of scope of the Census. The Bureau of the Census, for the first time in 1958, collected information on coal purchased and resold without further processing. Data for such resales are not collected by the Bureau of Mines.

Natural Gas.—The Bureau of Mines figure that is equivalent to the Bureau of the Census figure for production is "gross withdrawals"; that is, marketed production plus quantities used in repressuring and quantities vented and wasted. The Bureau of Mines figure that is equivalent to the Bureau of the Census figure for shipments is "marketed production," comprising gas sold or consumed by producers, including losses in transmission, amounts added to storage, and increases in gas in pipelines. The Bureau of the Census has shown 562,371 million cubic feet of gas produced and used in the same establishment in lease operations and net increase in underground storage of 12,368 million cubic feet; these figures are not included for Census shipments.

Peat.—The difference in the values of peat of the two agencies may be that the Bureau of the Census includes the value of containers where the product is sold at the mine or preparation plant in containers.

NONMETALS

Abrasive Stone.—The Bureau of Mines figure of $183,000 for abrasive stone represents values of grindstones, pulpstones, millstones, grinding pebbles, and tube-mill liners but does not include sharpening stones, emery, garnet, and tripoli. Values for sharpening stones are included with nonmetal items that cannot be disclosed. Weight of millstones is not recorded. The Bureau of Mines reports emery, abrasive garnet, and tripoli as individual items, but figures for these minerals are included as natural abrasives by the Bureau of the Census.

Asbestos.—The Bureau of the Census reported quantity and value of shipments (gross shipments less receipts from other establishments for preparation) of crude and prepared asbestos. For the Bureau of

Mines data, 44,000 short tons of asbestos was recovered from 1 million tons of rock mined. The Bureau of Mines reports production value of marketable asbestos.

Barite.—The Bureau of Mines production figure of 486,000 short tons represents mine or plant output of primary barite, and the figures for prepared barite cover crushed and ground barite sold or used by producers. For Bureau of the Census purposes, net shipments (value, $13,434,000) by the barite industry are equivalent to gross shipments less receipts from other establishments for preparation and include some barite that was prepared by washing only. Industry 1472 excludes separately operated barite-preparation plants; such plants are classified as industry 3295.

Boron Minerals.—Bureau of the Census data represent net shipments (gross shipments less receipts from other establishments for preparation) of boron compounds. Total value of net shipments, $32,275,000, contains a high proportion of refined borates.

Bromine.—Bureau of Mines figures represent a calculation of theoretical bromine present in compounds sold by primary producers. Bureau of the Census data are for elemental bromine only.

Cement.—"Shipments from mills" of the Bureau of Mines do not include interplant transfers as do the figures on cement of the Bureau of the Census described as "Total shipments including interplant transfers" in the Census of Manufactures. The cost of containers is excluded by both the Bureau of Mines and the Bureau of the Census in the value of cement f.o.b. mill, but the cost of containers of $24,236,000 is included in the industry data of the Bureau of the Census.

Clays.—Some respondents may report clay as one type to the Bureau of Mines and as another type to the Bureau of the Census, which may be reflected in small variations in figures between the two Bureaus. Production figures of the Bureau of the Census for crude ball clay and kaolin, crude bentonite, crude fireclay, and common clay and shale represent quantity mined and used in the same establishment in making cement, clay products, and prepared clay, plus quantity of crude net shipments. Quantity and value figures for shipments of crude ball clay and kaolin and crude bentonite represent net shipments by mineral industries. Census excludes Hawaiian production from common clay and shale. Net shipments by the bentonite industry include shipments by other mineral industries. Industries 1452, 1453, 1454, 1455, and 1459 exclude separately operated clay-preparation plants. These plants are classified as industry 3295.

Gypsum.—For the Bureau of Mines, $32,495,000 represents the value of production. The production figure of 9,384,000 short tons reported by Census as mined for shipment in crude or prepared form includes 5,581 tons of gypsum valued at approximately $21,174,000 produced and used in the same establishment in the manufacture of calcined gypsum products. Industry 1492 excludes gypsum mining at establishments classified in manufacturing industry 3275.

Lime.—Selling value f.o.b. plant, excluding cost of containers, is reported by the Bureau of Mines. The figures are incomplete because all captive lime could not be accounted for. Bureau of the Census data for 1958 are reported in the Census of Manufactures rather than in the Census of Mineral Industries and include production and

shipments wherever made. The cost of containers is included in the value figure of Census. Census quantity excludes lime valued at $5,070,000, for which no quantity data were reported.

Mica.—The 661,000 pounds of sheet mica production, valued at $2,845,000, reported by the Bureau of Mines includes full-trimmed equivalent of hand-cobbed mica. Industry 1493 excludes separately operated mica-grinding plants; such plants are classified as industry 3295.

Perlite.—Prepared perlite is perlite treated by simple preparation methods, such as drying and crushing, but not expansion. The Bureau of Mines "crude" perlite is valued f.o.b. producer's plant and is crushed, cleaned, and sized. This probably is equivalent to Census' "prepared" perlite. The production figure of 372,000 short tons actually represents crude ore, but the 292,000 tons of "sold or used" perlite is not crude ore.

Sand and Gravel.—The Bureau of the Census excludes operations of Federal, State, and local governments. Census figures for common sand in Hawaii and Alaska are included with those for sand and gravel. Census includes all commercial operations and operations by contractors and subcontractors in government projects. In a specially designed inquiry, a total of 24 million tons of sand and gravel was reported to Census by such contractors. Although the Census total figure of 553 million tons of sand and gravel produced exceeds the Bureau of Mines total of 489 million tons by 13 percent, when the Census total is adjusted to exclude the 24 million tons for own use or government projects the Census total excess is reduced to 8 percent.

Stone.—For Bureau of Mines data, figures for rough monumental marble are included with those for dressed monumental marble. The Bureau of Mines reports totals for all stone sold or used by commercial, Government, and contractor operations. Bureau of the Census statistics exclude Federal, State, and local government operations. Also Census production for limestone, granite, and stone not elsewhere classified represents stone shipments plus stone mined and used in the same establishment in making cement, lime, and other manufactured products. Figures for a small tonnage of granite mined and used in the same establishment are excluded from the granite figures and included with those for stone not elsewhere classified. For Alaska and Hawaii, Census figures on granite are included with those for limestone. For Hawaii, Census shipments figures include the quantity and estimated value of limestone mined and used in the same establishment in making lime. For dimension stone, the Bureau of the Census figures represent shipments of rough dimension stone from separately operated quarries as well as shipments of rough dimension stone and dressed dimension stone from quarries with associated dressing plants located at the quarry site. No figures are included in the Census tabulations shown here for shipments of dressed dimension stone from dressing plants not operated in conjunction with a quarry, even though such a dressing plant may be an integral part of a company engaged in quarrying and dressing stone. Bureau of Mines production data are compiled on the basis of quantities and values of both rough blocks and finished products by primary producers. These

Bureau of Mines figures are compiled on a company basis. For example, in the case of a stone company having three establishments, (1) a quarry with no dressing plant, (2) a quarry with a dressing plant, and (3) a separately operated dressing plant, the Census figures include only the first two types of establishments, whereas the Bureau of Mines compiles its figures on output of stone for this company on the basis of the figures reported by all three types of establishments. Thus, the Bureau of Mines shows less rough dimension stone shipped than shown by the Bureau of the Census. There is a considerable tonnage loss in fabricating dressed stone from rough blocks. Accordingly, it would be expected that the aggregate Bureau of Mines tonnage would be less than that of the Bureau of the Census even though the operations of the same companies were covered by both agencies. Net production of crushed and broken stone reported by Census excludes stone produced for preparation at another establishment.

Talc, Soapstone, and Pyrophyllite.—The production and value figures of the Bureau of Mines for these three mineral commodities exclude dimension soapstone. The uniform approach of Census to crude material as that loaded at mine site and to prepared material as that including milling, washing, grinding, and sizing may cause differences in figures for talc, soapstone, and pyrophyllite. Industry 1496 excludes separately operated talc, soapstone, and pyrophyllite preparation plants; such plants are classified in industry 3295.

Other Nonmetals.—The Bureau of Mines value figure of $21,958,000 includes aplite, brucite, calcium magnesium chloride, epsom salts, graphite, iodine, kyanite, lithium minerals, magnesite, marl, nitrogen compounds, olivine, staurolite, sharpening stones, and wollastonite. Bureau of the Census data cover other nonmetals not elsewhere classified.

METALS

Antimony Ore and Concentrate.—The Bureau of Mines reports antimony content of antimony ore and concentrate in short tons. The Bureau of the Census combines antimony concentrates, platinum, and thorium concentrates, and, for Alaska, mercury. Thus, the data reported in the table are not comparable.

Bauxite.—The net shipments figures and values thereof reported by Census represent, in the first instance, gross shipments less receipts from other establishments for preparation and, in the second, shipments of direct-shipping ore, concentrates to consumers, and agglomerates. The Bureau of Mines value is computed from selling prices and values assigned by producers and estimate when such data are not available. The Bureau of Mines figure of 1,584,000 long tons of crude bauxite produced (value $12,815,000) reported in the comparison is equivalent to the 1,311,000 long tons of bauxite (dried equivalent) published in other tables.

Copper.—Bureau of Mines figures for production of crude ores are determined on a commodity basis and represent copper ores sold or treated, irrespective of where these ores are produced. Bureau of the Census figures represent all ores mined by establishments classi-

fied in the copper ores industry, f.o.b. mine or mill. Quantity of copper concentrate, as presented by the Bureau of Mines, includes some metal recovered from old tailings smelted or retreated and also some copper recovered from a copper-zinc ore. Census figures for metals contained in ores and concentrates represent gross metal content. The Bureau of Mines publishes statistics representing recoverable metal content of the ores.

Gold.—Lode gold produced as reported by the Bureau of Mines includes gold ore and gold-silver ore. Shipments represent recoverable metal content of gold ore, gold-silver ore, and gold concentrates produced, less mill bullion produced. Shipments of mill bullion also represent production. The quantity figure of metal content of gold-bearing materials represents recoverable metal content of mine production, and the value of shipments of gold-bearing materials and placer gold has been estimated from the quantity of mine production and the price authorized by the Gold Reserve Act of January 31, 1934. Census quantity figures of gold-bearing material produced represent gross metal content and exclude Alaska. Figures for placer gold in Alaska are included by the Bureau of the Census.

Iron Ore.—The Bureau of Mines excludes manganiferous iron ores (5 to 35 percent), although a figure is given in its report on iron ores. Census includes manganiferous iron ore in the quantity and value figures for shipments, including interplant transfers, of crude iron ore. Shipments mean gross shipments less receipts from other establishments for preparation. Net shipments represent direct-shipping ore, concentrates to consumers, and agglomerates.

Lead.—Bureau of Mines figures represent recoverable metal content of the ores; Census figures represent gross metal content.

Lead and Zinc.—Bureau of Mines figures represent lead ore, zinc ore, lead-zinc ores, and copper-lead, copper-zinc, and copper-lead-zinc ores. Shipments are in terms of recoverable content of lead and zinc. For concentrates, Census quantity figures represent production, but value figures represent shipments.

Manganese Ore.—Shipments and value of manganese ore reported by the Bureau of Mines cover ores of 35 percent or more manganese and ferruginous manganese ore except for Minnesota. These shipments represent marketable ores from the consumer's standpoint; besides direct-shipping ore, they include without duplication concentrates and nodules made from domestic ores. For the Bureau of the Census, "net shipments" of ores of 35 percent manganese represent gross shipments less receipts from other establishments for preparation; shipments represent direct-shipping ore, concentrates to consumers, and agglomerates. The Bureau of Mines excludes shipments of low-grade manganese ores shipped to U.S. Government purchase depots. Bureau of the Census statistics include such ores.

Manganiferous Ore.—Bureau of Mines shipments figures and values thereof represent manganiferous iron ore (5 to 35 percent manganese) and include Minnesota ferruginous manganese ore. Bureau of the Census data represent shipments of direct-shipping ore, concentrates to consumers, and agglomerates. Census shipments figures for manganiferous iron ore are included with "iron ore, except manganiferous iron ore."

Mercury.—Crude ore production figures of the Bureau of Mines cover mercury ores treated. Alaska's production of 3,380 flasks also is included. Mercury metal produced and value thereof include mercury from placer operations and from cleanup activity at furnaces and other plants. Mines' value of mercury metal was obtained by multiplying quantity produced by the average 1958 price per flask in New York. The Bureau of the Census excludes figures from Alaska but includes value of mercury metal produced in Alaska with the value of antimony concentrates, platinum, and thorium concentrates.

Molybdenum.—The Bureau of Mines reports molybdenum content of concentrates, as compared with Census' molybdenum concentrates.

Rare Earth and Thorium Concentrates.—Figures of the Bureau of Mines represent only concentrates prepared from domestic materials. Bureau of the Census data include products prepared from foreign material.

Silver.—Crude ores from sources not classed in "silver ores industry" are included in Bureau of Mines production figures. Quantity of shipments represents recoverable metal content of silver ores and mill bullion. Value is determined by the Treasury buying price for newly mined silver. Bureau of the Census data represent gross metal content and reported value f.o.b. mine or mill.

Titanium Concentrate.—Bureau of Mines figures cover concentrates from domestic ores only; the Bureau of the Census includes concentrates produced in the United States from imported material. Data from establishments which engage only in preparing or grinding titanium products are included by the Bureau of the Census and excluded by the Bureau of Mines.

Tungsten Ore and Concentrate.—The Bureau of Mines figures cover concentrates from domestic ores only; the Bureau of the Census includes concentrates produced in the United States from imported material.

Uranium Ores.—Bureau of Mines figures represent domestic mine production of uranium-vanadium ores; value is based on total U_3O_8 content (in pounds) at base price of $3.50 per pound. Uranium-vanadium concentrate production represents mill production and is valued at a considerably higher unit price. For uranium-vanadium concentrates, Bureau of the Census figures include low-grade concentrates shipped to preparation plants for upgrading; Bureau of Mines figures do not.

Zinc.—The value of $84,113,000 represents an estimate by the Bureau of Mines from the quantity of mine production and an average price, and also represents the weighted average unit price of domestic refined metals delivered to purchasers. Shipments of zinc concentrates represent recoverable content of zinc ores, lead-zinc ores, copper-zinc ores, and copper-lead-zinc ores. Bureau of the Census figures for zinc contained in ores and concentrates represent gross metal content.

Zirconium Concentrate.—Bureau of Mines data represent domestic mine production valued at the yearend price of zircon concentrates at Jacksonville, Fla. Bureau of the Census data include products prepared from foreign material.

Abrasive Materials

By James D. Cooper [1] and Gertrude E. Tucker [2]

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NATURAL abrasives sold or used in the United States in 1961 declined 5 percent in volume and 1 percent in value from 1960. Production and value of crude artificial abrasives in the United States and Canada were down about 15 percent from 1960. The value of imports, exports, and reexports of abrasive materials showed substantial gains. Grinding-wheel sales were down 5 percent in value, and coated abrasives were down 1 percent in value.

TABLE 1.—Salient abrasive statistics in the United States

Kind	1952–56 (average)	1957	1958	1959	1960	1961
Natural abrasives (domestic) sold or used by producers:						
Tripoli short tons	[1] 47,336	50,717	47,044	52,968	57,713	54,641
Value thousands	[1] $208	$195	$183	$219	$247	$225
Special silica-stone products [3] short tons	6,731	5,847	4,023	3,672	2,539	2,495
Value thousands	$401	$331	$305	$315	[3] $241	$238
Garnet short tons	11,548	9,776	12,303	14,568	10,522	12,057
Value thousands	$1,041	$1,080	$869	$1,211	$986	$1,036
Emery short tons	10,712	11,893	7,687	8,555	8,169	6,180
Value thousands	$149	$184	$126	$150	$142	$106
Artificial abrasives [4] short tons	431,991	484,702	334,483	417,569	441,508	372,192
Value thousands	$49,745	$65,634	$48,806	$62,928	$64,594	$54,937
Foreign trade (natural and artificial abrasives):						
Imports for consumption (value) thousands	$81,396	$85,097	$60,733	$91,560	[3] $84,488	$96,219
Exports (value) do	$22,042	$27,589	$22,469	$23,100	$26,550	$29,195
Reexports (value) do	[5] $6,821	$8,702	$12,964	$13,700	$10,409	$17,814

[1] Average for 1955–56.
[2] See table 7 for kinds of products.
[3] Revised figure.
[4] Production of silicon carbide and aluminum oxide (United States and Canada); shipments of metallic abrasives (United States).
[5] Average for 1954–56.

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

STOCKS

At the end of 1961 the Government stockpiles contained abrasive materials in excess of the maximum objectives for all stockpiled items except corundum. The excesses ranged from 18.8 percent for crushing bort to 96 percent for crude silicon carbide.

Available data on producer stocks of abrasive materials are included elsewhere in the chapter.

TABLE 2.—Status of the Government stockpiles with respect to abrasive materials on Dec. 31, 1961

Material	Unit (thousands)	Maximum stockpile objective	Government inventories			Surplus over maximum objective (percent)
			National (strategic) stockpile	CCC and supplemental stockpiles	Total	
Aluminum oxide, fused, crude	Short tons	200	200	178	378	89.0
Silicon carbide, crude	do	100	65	131	196	96.0
Corundum	do	2	2		2	
Industrial diamond, crushing bort	Carats	30,000	31,113	4,524	35,637	18.8
Industrial diamond, stones	do	18,000	9,165	13,462	22,627	25.7

FOREIGN TRADE [3]

The total value of imports of abrasive materials was 14 percent higher than in 1960; industrial diamond showed the greatest increase of any major category—32 percent. Imports of artificial abrasives declined. Exports increased 10 percent in value over 1960, with most items showing gains.

Reexports of abrasive materials increased 71 percent in value compared with 1960; industrial diamond stones accounted for virtually all of the increase.

TRIPOLI [4]

Combined sales of processed tripoli, amorphous silica, and rottenstone decreased 6 percent in both quantity and value from 1960. No tripoli was imported. Abrasive uses accounted for 71 percent of the processed tripoli sold in both 1960 and 1961.

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

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

TABLE 3.—U.S. imports for consumption of abrasive materials (natural and artificial), by kinds

Kind	1960		1961	
	Quantity	Value	Quantity	Value
Burrstones: Bound up into millstones---short tons	1	$292		
Hones, oilstones, and whetstones---number	124,850	61,668	319,740	$68,715
Corundum (including emery):				
Corundum ore---short tons	2,654	77,243	2,396	54,856
Emery ore---do			1,120	10,000
Grains, ground, pulverized, or refined---do	4	411	16	3,744
Paper and cloth coated with sand, emery, or corundum	(1)	1,458,130	(1)	1,251,633
Wheels, files, and other manufactures of emery or garnet, and wheels of corundum or silicon carbide---short tons	176	230,367	185	232,539
Tripoli, rottenstone, diatomaceous earth, and burrstones, in blocks, unmanufactured---short tons	38	1,604	(2)	(2)
Diamonds:				
Diamond dies, pierced or partially pierced, mounted or unmounted---number	[3] 13,580	[3] 241,535	10,422	178,247
Crushing bort (including all types of bort suitable for crushing)---carats	[3] 6,605,850	[3] 17,279,350	5,065,021	13,010,244
Other industrial diamond (including glaziers' and engravers' diamond, unset, and miners')---carats	[3] 5,418,254	31,476,967	8,395,771	53,308,869
Carbonado and ballas---do	749	21,039	1,947	30,195
Dust and powder---do	[3] 1,121,241	[3] 3,059,338	746,707	2,195,799
Flint, flints, and flintstones, unground---short tons	14,579	321,257	12,109	286,443
Grit, shot, and sand, of iron and steel---do	1,304	537,747	1,353	576,996
Artificial abrasives:				
Crude, not separately provided for:				
Carbides of silicon (carborundum, crystalon, carbolon, and electrolon)---short tons	88,546	12,603,242	73,727	10,826,925
Aluminous abrasives, Alundum, Aloxite, Exolon, and Lionite---short tons	160,495	16,341,428	124,143	13,549,098
Other---do	1,113	136,542	128	16,700
Manufactures:				
Grains, ground, pulverized, refined, or manufactured---short tons	1,998	527,464	2,181	545,322
Wheels, files, and other manufactures, not separately provided for---short tons	181	112,873	76	72,565
Total		[3] 84,488,497		96,218,890

[1] Quantity not recorded.
[2] Adjusted by Bureau of Mines to none.
[3] Revised figure.

Source: Bureau of the Census.

Price quotations on tripoli in E&MJ Metal and Mineral Markets 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, 2.6 to 2.75 cents; and air-floated through 200-mesh, 2.75 to 3 cents.

SPECIAL SILICA-STONE PRODUCTS

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

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TABLE 4.—U.S. exports of abrasive materials, by kinds

Kind	1960		1961	
	Quantity	Value	Quantity	Value
Natural abrasives:				
Diamond grinding wheels, sticks, hones, and laps carats	264,942	$1,566,547	285,425	$1,708,151
Diamond dust and powder do	321,373	844,640	490,327	1,356,574
Diamond suitable only for industrial use do	306,331	1,297,096	475,211	1,822,383
Grindstones and pulpstones short tons	319	56,254	123	45,966
Emery powder, grains, and grits (natural) pounds	2,245,599	203,905	2,319,019	202,775
Corundum grains and grits (natural) do	109,078	33,202	191,870	50,923
Whetstones, sticks, etc. (natural) do	371,609	160,187	199,716	161,810
Natural abrasives not elsewhere classified do	20,709,234	1,098,352	22,712,491	1,297,121
Manufactured abrasives:				
Aluminum oxide, fused, crude, and grains do	21,934,978	3,411,213	23,576,230	3,441,468
Silicon carbide, fused, crude, and grains do	16,387,510	3,101,161	24,462,739	4,058,367
Alumina, unfused do	217,902	78,786	173,021	87,465
Manufactured abrasives, not elsewhere classified pounds	221,709	72,909	290,212	80,503
Abrasive pastes, compounds, and cake (except chemical) pounds	658,151	198,468	680,839	180,773
Grinding wheels, except diamond wheels do	3,441,572	4,040,291	3,509,752	4,376,134
Pulpstones of manufactured abrasives do	3,627,385	957,776	3,322,701	866,126
Whetstones, etc., of manufactured abrasives do	371,765	970,821	407,066	1,067,113
Abrasive paper and cloth (natural abrasives) reams	34,362	752,852	32,347	685,231
Abrasive paper and cloth (artificial abrasives) do	175,434	6,450,662	182,384	6,427,814
Metallic abrasives (except steel wool) pounds	13,072,035	1,255,224	15,478,787	1,278,764
Total		26,550,346		29,195,461

Source: Bureau of the Census.

TABLE 5.—U.S. reexports of abrasive materials, by kinds

Kind	1960		1961	
	Quantity	Value	Quantity	Value
Natural abrasives:				
Diamond grinding wheels, sticks, hones, and laps carats	655	$7,820	1,077	$22,426
Diamond dust and powder do	312,557	866,546	55,733	190,659
Diamond suitable only for industrial use do	1,619,553	9,486,827	2,601,349	17,582,881
Emery powder, grains, and grits (natural) pounds	13,600	1,632		
Whetstones, sticks, etc. (natural) do	1,584	1,292		
Manufactured abrasives:				
Aluminum oxide, fused, crude, and grains do	25,460	2,148	37,182	6,891
Grinding wheels, except diamond wheels do	14,043	10,870	4,015	8,406
Abrasive paper and cloth (natural abrasives) reams			20	2,320
Abrasive paper and cloth (artificial abrasives) do	76	3,262		
Whetstones, etc., of manufactured abrasives pounds	7,116	4,664	58	562
Manufactured abrasives, not elsewhere classified pounds	49,412	23,761		
Total		10,408,822		17,814,145

Source: Bureau of the Census.

TABLE 6.—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)
1952–56 (average)	29,390	$1,105	7,468	$173	[3] 3,857	[3] $134	40,715	$1,412
1957	31,326	1,300	7,429	171	5,533	194	44,288	1,665
1958	29,994	1,257	7,385	178	4,778	159	42,157	1,594
1959	34,389	1,527	8,199	192	5,061	169	47,649	1,888
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

[1] Includes amorphous silica and Pennsylvania rottenstone.
[2] Partly estimated.
[3] Includes some tripoli for filter block in 1955.

TABLE 7.—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)
1952–56 (average)	2,821	$198	2,692	$83	1,218	$120	6,731	$401
1957	1,505	132	2,902	86	1,440	113	5,847	331
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	[3] 66	1,407	175	2,539	[3] 241
1961	[2]	[2]	[2]	[2]	2,495	238	2,495	238

[1] Includes grindstones (1960–61), pulpstones (1952 only), oilstones and other sharpening stones (1952–61 except 1957 data), tube-mill liners (1952–61), grinding pebbles (1961), and value of millstones (1952–61).
[2] Included with "Other products" to avoid disclosing individual company confidential data.
[3] Revised figure.

NATURAL SILICATE ABRASIVES

Garnet.—Sales of domestic garnet increased 15 percent in quantity and 5 percent in value over 1960. There were six producers: 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.

Occurrences of garnet in the Keskin-Celebidag region in Turkey were described. The garnet grain size was less than 0.3 cm for andradite, and from 0.5 to 1.0 cm for grossularite. A second Turkish source of garnet, the Uludag scheelite deposits near Bursa, contained 15- to 180-mesh garnet that could be obtained as a byproduct.[5]

[5] Bureau of Mines. Mineral Trade Notes. V. 15, No. 3, March 1961, p. 4. Yilmaz, Sabit. Garnet Stone Occurrences in the Keskin-Celebidag Region. Bull. of the Turkish Miner. Res. and Exploration Inst. (MTA), No. 54, April 1960, pp. 66–68.

TABLE 8.—Abrasive garnet sold or used by producers in the United States

Year	Short tons	Value (thousands)	Year	Short tons	Value (thousands)
1952-56 (average)	11,548	$1,041	1959	14,568	$1,211
1957	9,776	1,080	1960	10,522	986
1958	12,303	869	1961	12,057	1,036

NATURAL ALUMINA ABRASIVES

Corundum.—No production of corundum was reported in the United States or Canada during 1961. Imports decreased 10 percent in quantity and 29 percent in value from 1960.

A Canadian Journal article briefly described major corundum and emery deposits of the world and included data on mining, processing and marketing methods, physical properties, and uses.[6]

A brief description of the producing corundum mine at Concession, 25 miles north of Salisbury, Southern Rhodesia, was published. The ore body consists of massive corundum in schist, which was mined by jet piercing, blasting, and hand sorting. The plus 4-inch material was used by a refractories plant in the Union of South Africa, and most of the minus 4- plus 3-inch material was exported to the United States.[7]

TABLE 9.—World production of corundum, by countries[1 2]

(Short tons)

Country[1]	1952-56 (average)	1957	1958	1959	1960	1961
Argentina	37					
Australia	14					
India	453	497	435	236	268	363
Malaya, Federation of	[3] 21					
Mozambique	2					
Rhodesia and Nyasaland, Federation of:						
Nyasaland	18					
Southern Rhodesia	1,860	4,507	4,593	2,799	3,843	2,792
Union of South Africa	2,078	1,539	2,118	622	123	159
World total (estimate)[1 2]	10,000	10,000	11,000	8,000	9,000	8,000

[1] Corundum is produced in 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 Helen L. Hunt, Division of Foreign Activities.

[6] Anderson, L. Corundum and Emery. Canadian Min. J., v. 82, No. 8, August 1961, pp. 73–75.

[7] Bureau of Mines. Mineral Trade Notes. V. 53, No. 5, November 1961, p. 3.

Emery.—Production of emery in the United States declined 24 percent in quantity and 25 percent in value in 1961. Emery imports were equal to those of 1959; no imports were reported in 1960.

TABLE 10.—Emery sold or used by producers in the United States

Year	Short tons	Value (thousands)	Year	Short tons	Value (thousands)
1952–56 (average)	10,712	$149	1959	8,555	$150
1957	11,893	184	1960	8,169	142
1958	7,687	126	1961	6,180	106

INDUSTRIAL DIAMOND

World production of industrial diamond reached a record high, following 2 years of declining output in 1959 and 1960. Production in the Republic of the Congo achieved a new high, following a year in which civil disturbances had closed the large producing mine at Bakwanga for 2 months. Production records were also attained by the Union of South Africa and Sierra Leone. The combined output of all other producing countries was approximately the same as in 1960.

With production capacity for manufactured diamond increasing, and new producers entering the field, an intense campaign of research and promotion to develop and encourage new large-scale uses of industrial diamond was under way. Emphasis was on plate-glass grinding and polishing and concrete sawing and finishing.

World Review: *Africa.*—A production goal of 12 million carats of diamond was established for 1961 in the Republic of the Congo. The figure seemed too high to some, considering unsettled conditions in the country,[8] but, final figures for the year showed that production was 50 percent above the goal, a record high.

TABLE 11.—U.S. imports for consumption of industrial diamond (excluding diamond dust and manufactured bort)

(Thousand carats and thousand dollars)

Year	Quantity	Value	Year	Quantity	Value
1952–56 (average)	14,233	$56.996	1959	12,605	$60,975
1957	12,220	50,063	1960	[1] 12,025	[1] 48,777
1958	9,500	37,596	1961	13,463	66,349

[1] Revised figure.

Source: Bureau of the Census.

[8] Mining World. International News, Africa, Congo Republic. V. 12, No. 2, February 1961, p. 61.

TABLE 12.—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
1960:								
North America:								
Canada	[1] 117,459	[1] $458,363	[1] 482,836	[1] $2,676,417			4,366	$6,344
Mexico			306	954				
Total	[1] 117,459	[1] 458,363	[1] 483,142	[1] 2,677,371			4,366	6,344
South America:								
Brazil			36,310	447,674	649	$20,286		
British Guiana			795	17,995				
Venezuela			8,630	219,796				
Total			45,735	685,465	649	20,286		
Europe:								
Belgium-Luxembourg	654	1,864	1,122,977	8,294,157			7,576	20,616
Denmark	2,000	5,715						
France			49,787	337,822				
Germany, West	[1] 63	[1] 190	15,564	172,852			[1] 3,538	[1] 11,548
Netherlands	243,678	657,370	83,557	582,777			26,028	72,870
Spain			64	1,280				
Switzerland	[1] 1,165,442	[1] 3,100,078	5,015	35,975			410,240	1,079,296
United Kingdom	[1] 4,014,417	[1] 10,195,284	[2] 2,865,691	[1] 15,277,754	100	753	72,330	227,959
Total	[1] 5,426,254	[1] 13,960,501	[1] 4,142,655	[1] 24,702,617	100	753	[1] 519,712	[1] 1,412,289
Asia:								
Israel			4,495	39,607				
Japan			730	10,304				
Total			5,225	49,911				
Africa:								
Congo, Republic of the, and Ruanda-Urundi	[1] 52,081	[1] 165,707	90,771	321,284			[1] 20,915	[1] 64,553
Ghana			48,520	410,432				
Liberia			176	3,528				
Union of South Africa	1,010,056	2,694,779	594,542	2,469,744			576,248	1,576,152
Western Africa, n.e.c.			7,488	156,615				
Total	[1] 1,062,137	[2] 2,860,486	741,497	3,361,603			[1] 597,163	[1] 1,640,705
Grand total	[1] 6,605,850	[1] 17,279,350	[1] 5,418,254	[1] 31,476,967	749	21,039	[1] 1,121,241	[1] 3,059,338
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		

See footnote at end of table.

TABLE 12.—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
1961:								
Europe:								
Belgium-Luxembourg	6,028	$32,339	2,131,579	$13,707,905	-------	-------	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

[1] Revised figure.

Source: Bureau of the Census.

The diamond-prospecting monopoly in Tanganyika ended on January 1, 1961, and 24 blocks, containing approximately 15,000 square miles each, were made available to reputable mining companies willing to invest $84,000 annually per block. Williamson Diamonds Ltd., in which the Government of Tanganyika has one-half interest, was given first choice of four of the blocks. Companies meeting the requirements were to have exclusive prospecting rights for diamond and nonexclusive prospecting rights for other minerals.[9]

Alluvial diamond mining was expected to be implemented by diversion of the Bafi River near Daudiadu, Kovo District, by the Mines Department in Sierra Leone. Reserves for 10 years were to be exposed in a strip of river bed 8,000 feet long.[10]

[9] Bureau of Mines. Mineral Trade Notes. V. 52, No. 4, April 1961, pp. 15–19.
[10] Bureau of Mines. Mineral Trade Notes. V. 53, No. 6, December 1961, p. 11. Mining Journal (London). Mining Miscellany. V. 257, No. 6584, Oct. 27, 1961, p. 427.

TABLE 13.—World production of natural industrial diamond, by countries

(Thousand carats)

Country	1960 [1]	1961
Africa:		
Angola	400	460
Central African Republic	50	70
Republic of the Congo	13,040	17,740
Republic of Ghana	2,500	2,300
Republic of Guinea	670	730
Republic of Ivory Coast	120	330
Sierra Leone [2] [3]	1,450	1,550
South-West Africa	50	90
Tanganyika	250	345
Union of South Africa:		
"Pipe" mines:		
Premier	1,000	1,200
De Beers Group	580	760
Others	100	80
"Alluvial" mines	160	160
Total Africa	20,370	25,815
Other areas:		
Brazil [3]	175	175
British Guiana	[4] 40	45
Venezuela	57	73
Australia, Borneo, India, and U.S.S.R. [3]	[4] 360	420
World total [3]	21,000	26,500

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

The Diamond Workers Co-operative Union, representing the Ghanaian mines, agreed to give up its license as a diamond dealer in return for a 1-percent commission from the eight remaining dealers for handling the cooperative members' diamonds.[11] Because of an impending shutdown, the Government of Ghana took over the property and concessions of the Holland Syndicate near Akwatia. The Ghana State Mining Corp. was appointed to manage the operations.[12] The second section of the Aninchecke treatment plant of Consolidated African Selection Trust, near Akwatia, was completed. Lateritic terrace gravels were to be treated on a 3-shift basis, with annual production of 150,000 carats.[13]

Geologists from the U.S.S.R. reportedly led field parties exploring for diamonds and gold in Guinea.[14]

A U.S.S.R. grant of 40 million rubles was made to the Government of Mali to explore for diamond and other minerals.[15]

At the end of 1961, two private operating companies were engaged in large-scale diamond prospecting in the ocean off the coast of South-West Africa. The concessions extend from the low-water mark to the 3-mile limit, and cover several hundred square miles.[16]

[11] Mining Journal (London). Metals and Minerals—Accra Diamond Market. V. 257, No. 6581, Oct. 6, 1961, p. 349.
[12] Mining Journal (London). Mining Finance—Ghana Diamonds. V. 258, No. 6594, Jan. 5, 1962, p. 21.
[13] Bureau of Mines. Mineral Trade Notes. V. 50, No. 4, April 1961, pp. 14, 15.
[14] Queensland Government Mining Journal. Russians in Search for Diamonds and Gold in Guinea. V. 62, No. 717, July 1961, p. 334.
[15] Mining Journal (London). Mining Miscellany. V. 256, No. 6559, May 1961, p. 513.
[16] Engineering and Mining Journal. This Month in Mining—Submerged Deposits May Yield Diamonds. V. 162, No. 9, September 1961, p. 128. Mining Journal (London). Mining Miscellany—Offshore Diamond Recovery. V. 257, No. 6586, Nov. 10, 1961, p. 485.

Plans to reopen the De Beers mine in the Union of South Africa, which had been closed since 1908, were announced. The mine was to be in full operation by 1966, and production was to offset declining output from other mines which were becoming deeper. An additional recovery plant to process 500,000 loads of ore per month was planned for the Premier mine, to assure an adequate supply of industrial stones.[17]

Commercial production of manufactured diamond in the Union of South Africa began in October 1961, by Ultra High Pressure Units, Ltd., at a new plant at Springs, near Johannesburg. The company claimed the plant could supply the total world requirements of diamond for resinoid-bonded diamond wheels.[18]

Other Areas.—According to Soviet reports, scientists from the U.S.S.R. discovered evidence of large deposits of diamonds and other valuable minerals in Queen Maud Land, Antarctica.[19]

A group of U.S. investors, known as Diamonds of Brazil, Inc., was reported to be reopening an old mine, the Boa Vista, in Minas Gerais State, Brazil.[20]

According to sales figures released by the Central Selling Organization, sales of industrial diamond in Europe increased from 1.8 million carats in 1958 to 4.4 million carats in 1960. Sales for the first three quarters of 1961 indicated that the upward trend was continuing.[21] Total gem and industrial diamond sales for 1961 by the Central Selling Organization reached a new record of $268 million. The previous high, set in 1959, was $255 million.[22]

The Indian Government's National Mineral Development Corp. announced that it would prospect for diamond in the Panna region of Madhya Pradesh State. The Corporation hoped to produce 40,000 to 50,000 carats annually by 1963; as much as 65 percent may be gem-quality diamond and the balance industrial.[23]

The Soviet Yakut Diamond Trust reported a new diamond discovery, named Aihal, in the Yakut Republic. This was the 11th major deposit reported since 1956 in the central Siberian plateau. The Mir deposit, under development, reportedly was scheduled to reach full production capacity by 1965. Another major deposit, the Udachuaya pipe, was to be at full capacity by 1970.[24]

A 100-cubic-yard dry-washing and concentrating plant was installed at the Arkansas Diamond mine near Murfreesboro, Ark.[25] Data on production were not available.

Technology.—A new brochure on industrial diamond was reviewed in an English technical journal. The brochure, "Diamonds in Industry—an Introduction," briefly covers diamond formation, diamond

[17] Mining World and Engineering Record. De Beers Well Equipped To Meet Difficult Times Ahead in Africa. V. 177, No. 4551, June 1961, p. 243.
[18] The South African Mining and Engineering Journal. Synthetic Diamonds by the Pound. V. 72, pt. 2, No. 3586, Oct. 27, 1961, pp. 973, 975, 977.
[19] Canadian Mining Journal. Outside Canada, Antarctica. V. 82, No. 4, April 1961, p. 150.
[20] Jewelers' Circular-Keystone. American Investors Seek Diamonds in Brazil Mine. V. 131, No. 9, June 1961, pp. 95–96.
[21] Mining Journal (London). Diamond Sales. V. 257, No. 6584, Oct. 27, 1961, p. 435.
[22] Mining Journal (London). Metals and Minerals—Record Diamond Sales in 1961. V. 258, No. 6595, Jan. 12, 1962, p. 45.
[23] Engineering and Mining Journal. In India. V. 162, No. 10, October 1961, p. 182.
[24] Mining World. What's Going on in Mining, Europe, Russia. V. 23, No. 3, March 1961, p. 71.
[25] Mining World. Central. V. 23, No. 10, September 1961, p. 60.

uses, and the diamond-marketing system. The type of diamond best suited for each type of industrial application is described.[26]

An improved process, said to be 95- to 99-percent efficient, was developed for salvaging industrial diamond from industrial wiping cloths. The process was reported to be faster, safer, and more economical than conventional methods.[27]

Natural Diamond.—The last article in a series on African methods of mining and processing diamond reviewed the history of diamond-recovery processes, with emphasis on new developments since 1950. Heavy-medium, high-tension, optical, belt-flotation, attrition-grinding, and other methods were described.[28]

Three diamond-recovery flowsheets, designed for different types of ore and operations of various sizes, were published and the latest equipment and methods were depicted.[29]

Details of diamond grinding of mirror pencil edges and bevels were described. The various grinding and polishing operations employed automatic and hand-operated wheels of natural diamond grit ranging from 60- to 600-mesh. Wheel life of the finer mesh beveling wheels was reported to be about 4.5 million linear inches. Advantages claimed over older methods included increased production, improved quality, and less waste.[30]

Expansion joints in two runways at the new Dulles International Airport near Washington, D.C., were sawed by metal-bonded diamond wheels. A total of 88 miles of joints, one-fourth inch wide and 2 to 3 inches deep, were cut at an average cutting speed of 6 feet per minute.[31]

Natural diamond drilling stones for Project "Mohole" were donated by a South African company. Approximately 2,500 stones, with a combined weight of 3,000 carats, were received for the project for use in drill crowns which would cut a 1¾-inch core.[32]

A new device utilizing radiation from thulium 170 was reported to detect diamonds, other gem stones, and metal ores. The equipment, developed in the U.S.S.R., was portable and economical to operate.[33]

Data were made available by a producer of a new blocky type of natural diamond grit. Among claims for the new material were longer life, smoother cutting, and closer grading, as compared with conventional natural diamond grit.[34]

Manufactured Diamond.—The U.S.S.R. reportedly devised a technique for producing manufactured diamond and planned to produce sufficient diamond to supply all industrial needs in the country.[35]

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[26] Mining Journal (London). Book Reviews. V. 257, No. 6582, Oct. 13, 1961, p. 383.
[27] South African Mining and Engineering Journal. Engineering Digest-Industrial Diamond Reclamation. V. 72, pt. 1, No. 3566, June 9, 1961, p. 1339.
[28] Mining World. How New Methods and New Equipment Increase Diamond Recovery in Africa. V. 12, No. 2, February 1961, pp. 30–35, 66.
[29] Deco Trefoil. Concentration of Diamonds. Bull. M7–F74, January–February 1961, pp. 13–16.
[30] Glass Industry. Diamond Grinding Wheels—Boon to Mirror Industry. V. 42, No. 11, November 1961, pp. 630–631.
[31] Purchasing Week. V. 4, No. 32, August 1961, p. 36. Industrial Diamond Abstracts, October 1961, p. A260.
[32] Mining Journal (London). Machinery and Equipment—Diamonds for Project "Mohole." V. 256, No. 6556, Apr. 14, 1961, p. 417.
[33] Mining Journal (London). Machinery and Equipment—Detecting Diamonds and Metals. V. 256, No. 6553, Mar. 24, 1961, p. 337.
[34] Ceramic Age. New Products—Natural Diamond Grit. V. 77, No. 3, March 1961, p. 56.
[35] Mining Journal (London). Mining Miscellany, Russian Output of Artificial Diamond. V. 257, No. 6588, Nov. 24, 1961, p. 546.

General Electric Co. produced semiconducting diamond of the p-type (receptor) by two methods—incorporation of boron and other impurities in the raw material used in producing manufactured diamond, and diffusion of impurities into natural and manufactured diamond at high temperature and pressure. Research to produce n-type (donor) semiconducting diamond also was underway.[36]

A new laboratory was opened in the United States to test and evaluate manufactured diamond for new and improved uses. Initial work was to be concentrated on such uses as grinding special steels, cutting masonry, and grinding plate glass.[37]

Radioactive diamond was produced in experimental quantity by adding a radioactive metal to the carbon-catalyst mixture used to make the diamond. The radioactive diamond does not retain static electric charges and therefore will not collect dust and metal particles as does normal industrial diamond.[38]

Presses capable of exerting pressures as high as 3 million psi were described.[39]

Research indicated that bearing surfaces impregnated with diamond dust have potential applications where ultrahard bearings are required.[40]

Diamonds over 1 carat in size were produced at General Electric Co. Research Laboratory, Schenectady, N.Y. Because of structural imperfections these first large stones did not have sufficient mechanical strength for industrial use. Stones of excellent quality one-tenth carat in size were produced at the laboratory, but were not available in commercial quantity.[41]

Diamond was formed from graphite by explosive shock at approximately 3 million psi in an experiment designed to demonstrate how diamonds were formed in meteors that have crashed into the earth.[42]

ARTIFICIAL ABRASIVES

Crude artificial abrasives production in the United States and Canada declined 16 percent in total tonnage and 15 percent in value from 1960. Most of the crude artificial abrasives produced in Canada were processed in the United States. None were processed in Canada. Aluminum oxide output included 17,328 tons of white, high-purity product, valued at $3,060,315. Silicon carbide production was at 86 percent of capacity; aluminum oxide, at 46 percent; and metallic abrasives, at 41 percent. Approximately 26 percent of the silicon carbide and 6 percent of the aluminum oxide were sold for nonabrasive uses.

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[36] Electronic News. GE Diamond Semicons. V. 6, No. 280, Sept. 11, 1961, p. 52.
[37] Mining Engineering. News from Mine and Mill—New G.E. Laboratory Studies Diamonds. V. 13, No. 12, December 1961, p. 1303.
[38] Chemical Age. Overseas News—Radioactive Industrial Diamonds. V. 86, No. 2216, Dec. 30, 1961, p. 1028.
[39] Peckver, Donald. Ultra High Pressures Create New Materials. Mat. in Design Eng., v. 54, No. 3, September 1961, pp. 111–117. Wentorf, Robert H., Jr. High Pressure Chemistry. Chem. Eng., v. 68, No. 21, Oct. 16, 1961, pp. 177–186.
[40] South African Mining and Engineering Journal. The Editor's Notebook—Industrial Diamond Developments. V. 72, pt. 2, No. 3587, Nov. 3, 1961, p. 1033.
[41] Missiles and Rockets. Man-Made Diamonds Cross One Carat Mark at G.E. V. 8, No. 2, Jan. 9, 1961, p. 30.
[42] Newsweek. Space and the Atom, Meteors: Dirt Cheap. May 29, 1961, p. 94.

Graded abrasive grain of all types sold to domestic users and manufacturers increased 2 percent over 1960, while sales to foreign manufacturers and users decreased 3 percent. The value of bonded grinding wheels sold by domestic producers was $152.5 million, down 5 percent from 1960. Vitrified wheels accounted for 43 percent of total sales; resin- and shellac-bonded wheels, for 39 percent; rubber-bonded wheels, for 5 percent; and all others, including diamond wheels, for 13 percent. Coated-abrasive sales by domestic manufacturers totaled 2,207,836 reams valued at $114,622,239, an increase of 2 percent in quantity but a 1-percent decrease in value compared with 1960. Based on the number of reams sold, aluminum oxide accounted for 41 percent of the total volume; silicon carbide, for 32 percent; garnet, for 13 percent; flint, for 11 percent; and emery, for 3 percent. Glue was used as the adhesive on 63 percent of the coated abrasives sold; waterproof bonds, on 19 percent; and resin bonds, on 18 percent—all unchanged from 1960.

TABLE 14.—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)
1952–56 (average)	78,277	$10,997	206,974	$21,747	146,740	$17,001	431,991	$49,745
1957	124,688	19,152	228,511	28,202	131,593	18,280	484,702	65,634
1958	110,456	17,597	122,868	16,870	101,159	14,339	334,483	48,806
1959	132,458	21,987	158,392	22,072	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

[1] Figures include material used for refractories and other nonabrasive purposes.
[2] Shipments from U.S. plants only.

TABLE 115.—Production, shipments, and stocks of metallic abrasives in the United States, by products

Year and product	Manufactured		Sold or used		Stocks Dec. 31		Annual capacity (short tons)
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	
1960:							
Chilled iron shot and grit	38,891	$4,086	38,974	$4,195	7,404	$790	157,789
Annealed iron shot and grit	32,190	4,151	32,342	4,178	1,517	191	[1] 65,744
Steel shot [2]	[3] 40,708	[3] 7,672	[3] 41,067	[3] 8,474	6,302	1,311	100,925
Other types (including cut wire shot)					343	63	4,355
Total	111,789	15,909	112,383	16,847	[4] 15,566	[4] 2,355	263,069
1961:							
Chilled iron shot and grit	36,841	3,849	35,494	3,773	8,751	938	162,684
Annealed iron shot and grit	28,827	3,667	29,056	3,698	1,288	160	[1] 68,802
Steel shot [2]	[3] 45,211	[3] 7,840	[3] 44,965	[3] 8,653	6,683	1,009	98,425
Other types (including cut wire shot)					208	39	4,310
Total	110,879	15,356	109,515	16,124	16,930	2,146	265,419

[1] Included in capacity of chilled iron shot and grit.
[2] Includes steel grit.
[3] Combined to avoid disclosing individual company confidential data.
[4] Includes revisions in product detail.

Interest of U.S. producers in establishing manufacturing outlets in foreign countries remained high in 1961; new plants were completed or under construction in Mexico,[43] Chile,[44] Australia,[45] and Luxembourg.[46] One major company announced that 40 percent of its sales in 1960 were outside the United States.[47]

Technology.—Pads made of unwoven nylon fabric impregnated with fine silicon carbide abrasive were used for deburring small precision parts made of aluminum and stainless steel. The pliable pads, conforming to the shape of the area being ground, were less likely to damage the parts than methods previously used. Available in 30-foot strips, the fabric was die-punched to the desired shapes as needed.[48]

A new abrasive-impregnated "sponge" material was announced. Wheels made of this material were said to adapt to the shape of the product being ground, thereby grinding complex shapes in a single operation. The wheels operated either dry or wet and did not require high contact pressure for efficient grinding.[49]

Cost of blast cleaning with metal abrasives at one plant was cut 55 percent through a simple method of measuring operating time and abrasive consumption for each abrasive tested, with no interference with plant operation.[50]

The abrasive-wheel marking system used by U.S. manufacturers was described in a series of five articles covering grain types, grain sizes, wheel grade, wheel structure, and bond types.[51] Specifications on sizes and shapes of grinding wheels for various industrial applications were published in American Standard Specifications for Shapes and Sizes of Grinding Wheels.[52]

A review of the abrasive-wheel safety regulations or codes of the United States was published. As of August 15, 1961, 14 States had adequate safety codes, 23 had some codes or regulations, and 15 had no legal regulations. (The District of Columbia and Puerto Rico were considered as States in the survey for convenience.) [53]

A new film on grinding wheels was made available. The film depicts the historic importance of grinding wheels, the safety features built into the wheels by the manufacturers, and applications in which grinding wheels can be used to advantage.[54]

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[43] Chemical Engineering. CPI News Briefs—International, Mexico. V. 68, No. 12, June 12, 1961, p. 285.
[44] Mining World. International News—Latin America, Chile. V. 23, No. 4, April 1961, p. 47.
[45] Steel. Plans Australian Plant. V. 148, No. 11, Mar. 13, 1961, p. 110.
[46] Steel. Metalworkers Urged To Increase Foreign Investments and Trade. V. 149, No. 11, Sept. 11, 1961, p. 85.
[47] Wall Street Journal. Carborundum Co. Says Its Sales Abroad Are Increasing. V. 157, No. 101, May 24, 1961, p. 9.
[48] Iron Age. Nylon Pads Deburr Fine Parts. V. 188, No. 23, Dec. 7, 1961, p. 126.
[49] Metal Industry (London). Industrial News. V. 98, No. 20, May 19, 1961, pp. 401–402.
[50] Grinding and Finishing. Metal Abrasive Selection in Blasting Saves 55 Percent. V. 7, No. 10, October 1961, pp. 56–57.
[51] McKee, Richard L. Standard Marking System. Grinding and Finishing, v. 7, Nos. 2–6, February–June 1961.
[52] Grinding and Finishing. Grinding Wheel Shapes and Sizes Specifications. V. 7, No. 8, August 1961, p. 42.
[53] Grinding and Finishing. Industry News—Connecticut Adopts ASA Wheel Safety Code. V. 7, No. 10, October 1961, p. 86. McKee, Richard L. What Are the Facts On State Safety Codes? Grinding and Finishing, v. 7, No. 3, March 1961, pp. 36–37.
[54] Grinding and Finishing. "Tools That Shaped America." V. 7, No. 12, December 1961, p. 43.

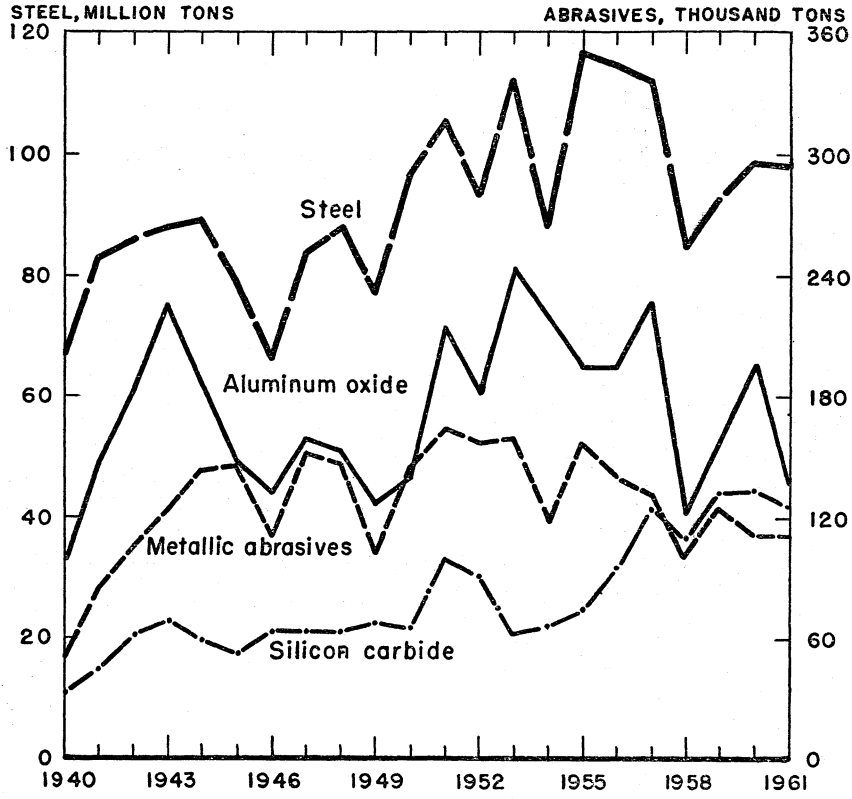


FIGURE 1.—Relationship between ingot steel and artificial abrasives production, 1940–61.

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.

A new cerium oxide mirror polish for blocking and beveling reportedly reduced production costs and increased output.[55] A cutting tool for wood, cement, and plastics, with potential applications for cutting metals and other hard materials, utilized a fine stream of liquid under several thousand pounds of pressure as the cutting head.[56] Glass beads were used as a blasting medium for cleaning and peening metals. Regular and high-density beads were available in sizes ranging from 10 to 840 microns.[57]

[55] Chemical & Engineering News. Briefs. V. 39, No. 39, Sept. 25, 1961, p. 58.
[56] Purchasing Week. Abrasi-Jet Machine Tool Co. V. 4, No. 25, June 19, 1961, p. 27. Industrial Diamond Abstracts, v. 18, September 1961, p. A240.
[57] Prismo Potters. Size Data Sheets. Industrial Division of the Prismo Safety Corp.

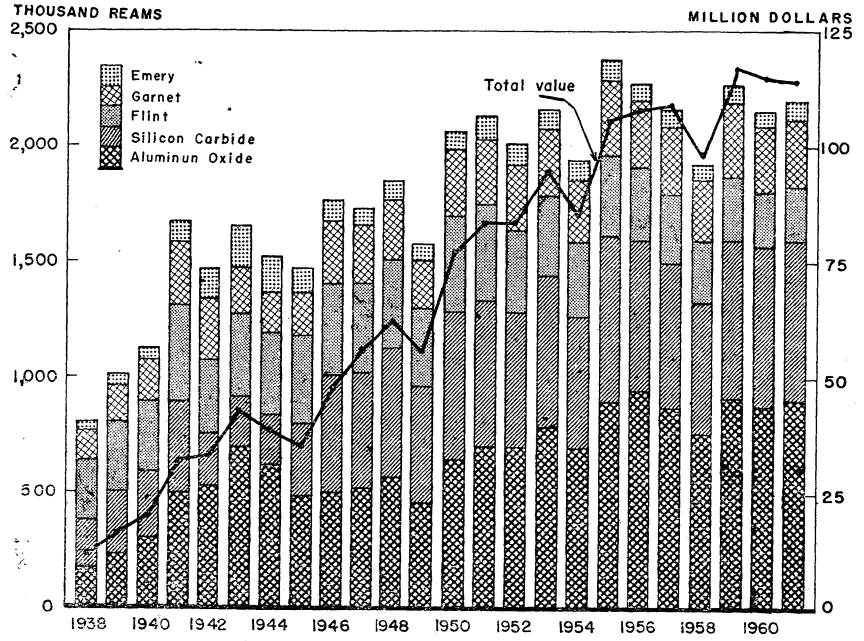


FIGURE 2.—Coated-abrasives industry in the United States, 1938–61.

TABLE 16.—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
1952–56 (average)	18.6	116.0	38.8	274.8	13.4	243.6
1957	14.0	131.9	36.7	298.7	16.5	255.0
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	16.9	265.4

[1] United States only.

Improved, lower cost titanium diboride offered promise as an abrasive grinding medium and as abrasive grain for finishing hard materials.[58]

[58] Materials in Design Engineering. Titanium Diboride Now Available as Large, High Strength Parts. V. 53, No. 1, January 1961, pp. 10–11.

Aluminum

By Kenneth B. Higbie,[1] Clarke I. Wampler,[2] and Mary E. Trought[2]

PRODUCTION of primary aluminum in the United States in 1961 was 5 percent less than in the record year 1960 and was the third highest figure in the history of the industry. Shipments of primary metal exceeded production and were only 32,000 short tons less than in the peak year 1959. World production was 5.2 million tons, 4 percent above 1960. Domestic production capacity remained virtually unchanged, and foreign capacity for producing the metal increased only 4 percent. Most companies were making plans for future expansion, but little or no expansion was taking place during the year. Consumption of aluminum increased as new markets were captured.

TABLE 1.—Salient aluminum statistics

(Thousand short tons and thousand dollars)

	1952–56 (average)	1957	1958	1959	1960	1961
United States:						
Primary production	1,379	1,648	1,566	1,954	2,014	1,904
Value	$584,658	$836,944	$773,610	$955,190	$1,030,007	$949,768
Price: Ingot, average cents per pound	22.4	27.5	26.9	26.9	26.0	25.5
Secondary recovery [1]	328	362	290	360	329	340
Imports for consumption (crude and semicrude)	252	258	293	302	196	255
Exports (crude and semicrude)	36	63	82	164	384	238
Consumption, apparent [2]	1,904	2,137	2,092	2,488	[3] 2,016	2,321
World: Production	3,070	[3] 3,710	[3] 3,865	[3] 4,480	[3] 4,985	5,195

[1] The 1952–53 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., shipped aluminum ingot to the Government Defense Production Administration inventory under a supply contract negotiated during 1950–52. Total metal delivered was 41 percent greater than that supplied during 1960. Quantities of aluminum metal in various government stockpiles are given in the section on stocks.

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

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Congress approved legislation to continue for another year suspension of a duty on imports of aluminum scrap. This duty had been suspended on an annual basis for each of the past 5 years.

Tariff discussions among the United States and European nations were held at Geneva, Switzerland, under the General Agreement on Tariffs and Trade. No changes were made in the tariffs on aluminum.

The Department of Justice brought antimerger charges against Kaiser Aluminum & Chemical Corp., seeking to force it to give up ownership of the U.S. Rubber Co. wire and cable department in Bristol, R.I. In April 1960 the Justice Department had brought a similar antitrust action against Aluminum Company of America (Alcoa) for its 1959 acquisition of Rome Cable Corp. The latter case was scheduled to be tried late in 1961, but was delayed until after the end of the year.

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	----------	324,211
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
Total	202,495	212,076	278,222	117,021	809,814

[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 was less than the record year of 1960. The 1,904,000 short tons produced was the third highest quantity in the history of the industry. Shipments exceeded production by 52,000 tons and were 5 percent or 90,000 tons greater than the 1960 shipments. During the year the industry operated at an average of 77 percent of installed capacity, with the highest quarterly rate, 80 percent, attained during the last quarter.

Cerro Corp. purchased United Pacific Aluminum Corp. and obtained in the merger the existing contract with Bonneville Power Administration (BPA) for sufficient electric power to operate an aluminum reduction plant with a 40,000-ton annual capacity. A possible site on the Columbia River near Wauna, Oreg., was optioned. Cerro later joined with Bridgeport Brass Co. Division of National Distillers & Chemical Corp. to study jointly the feasibility of building a reduction plant of 56,000-ton annual capacity, but no firm construction plans were released during the year.

Harvey Aluminum announced its intention to build an additional 75,000-ton-per-year aluminum reduction plant in the Pacific North-

west, but by the end of the year firm plans had not been released. Harvey had a contract with BPA, which expired in November 1961, for electric power for the plant.

Harvey announced it was planning to build in the Caribbean area an alumina plant which would have a production capacity of 150,000 tons of alumina per year. Completion early in 1961 of the installation of an additional 60 cells in Harvey's reduction plant at The Dalles, Oreg., increased plant capacity from 60,000 tons to 75,000 tons. The additional 15,000 tons brought the total U.S. primary ingot production capacity to 2,483,750 short tons.

Kaiser placed five refining sells for producing superpurity aluminum in operation at its Mead plant during April. The addition of these cells increased by 55 percent Kaiser's capacity for producing aluminum of greater than 99.99 percent purity and brought Kaiser's total capacity for the special metal to more than 5.3 million pounds annually. Each cell had a rated capacity in excess of 380,000 pounds per year.

Alcoa announced its entry into the superpure aluminum field with the development of new quality-control techniques which permitted the production of extra-pure metal. These and other minor changes in the superpure-metal industry increased the total U.S. capacity for the metal to approximately 6,780 tons a year representing about 22 percent of the world total which was estimated at 30,200 tons annually.[3]

A modernization and expansion program at Alcoa's Badin, N.C., reduction plant continued during 1961. Old potlines were removed and were to be replaced with new facilities.

The Government sold its aluminum-extrusion plant at Adrian, Mich., to Harvey Aluminum Co., Torrance, Calif., for $3,626,100. The former defense plant was estimated to have an annual capacity of more than 25,000 tons of aluminum forgings and extrusions.

Reynolds Metals Co. expanded its foil printing plant at Bellwood, Va., by 50 percent. Three additional presses brought the plant's total to nine with capacity to print more than 600 miles of foil per day. Reynolds purchased the Ford assembly plant in Chester, Pa., and announced that it planned to convert the property into a facility for fabricating insulated wire and cable products.

A second rolling mill installed by Kaiser at Ravenswood, W. Va. was capable of roll forming and welding aluminum tubing in 0.031- to 0.049-inch gages at a rate of 300 feet per minute in ¾- and 1-inch diameters. Construction of a new five-stand tandem cold-rolling mill at the Ravenswood plant was begun.

As an effort to improve small-business relationships, several of the primary producers announced that they would not accept orders for standard size sheet and plate in quantities of less than 4,000 pounds and would also decline orders at the mills for nonstandard lots of sheet and plate of less than 2,000 pounds except in a few special categories.[4]

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[3] American Metal Market. Super Purity Metal. V. 68, No. 72, Apr. 17, 1961, p. 9; New Super Purity Source. V. 68, No. 223, Nov. 21, 1961, p. 11.

[4] American Metal Market. Alcoa To Aid Distributors. V. 68, No. 214, Nov. 8, 1961, pp. 1, 10.

A $2 million expansion of Kaiser's aluminum-processing facilities at Chalmette, La., to produce extrusion billet was completed in 1961. The plant capacity for casting billet was increased approximately 50 percent.

Reynolds set up a can-making plant in Orlando, Fla. This plant and assembly lines installed in plants of three Florida frozen-juice packers were capable of producing 70 million cans a month. A new foil rolling mill, capable of producing foil 84 inches wide, was installed by Reynolds in its Louisville, Ky., foil plant.

The new mill was to be employed for rolling light-gage aluminum sheet ranging from 0.020 to 0.003 inch in thickness and up to 48 inches in width.

Several major aluminum reduction and alumina production facilities along the Gulf Coast were badly damaged in September when Hurricane Carla passed through the area. Portions of the production operations at Point Comfort and San Patricio, Tex., were closed for as long as a month as a result of the storm, which interrupted power, destroyed buildings, and damaged dock facilities.[5]

TABLE 3.—Production and shipments of primary aluminum in the United States[1]

(Short tons)

Quarter	1960		1961	
	Production	Shipments	Production	Shipments
First	491,536	488,190	452,010	433,601
Second	515,815	460,789	461,271	491,362
Third	513,419	457,555	491,344	483,406
Fourth	493,728	459,717	499,086	547,798
Total	2,014,498	1,866,251	1,903,711	1,956,167

[1] Quarterly production and shipments adjusted to final annual totals.

SECONDARY

The secondary aluminum industry operated at a level about 5 percent higher than in 1960. According to reports to the Bureau of Mines, domestic recovery of aluminum alloys (including all constituents) from 498,000 tons of nonferrous scrap totaled 416,000 tons. Recovery from new scrap was 282,500 tons, a decline of less than 1 percent. Recovery from old scrap and sweated pig increased to 133,400 tons, 91 percent above the preceding year. An additional 1,470 tons of aluminum was recovered from copper-base, zinc-base, and magnesium-base scrap. The value of 340,000 tons of aluminum recovered from processed scrap was $174 million, computed from the average price of primary aluminum ingot of 25.5 cents per pound.

Purchased aluminum-base scrap and sweated pig reported used by all consumers totaled 498,100 tons. Independent secondary smelters used 331,700 tons or 67 percent. Primary producers used 44,600 tons or 9 percent, and foundries, fabricators, and other consumers used 121,800 tons or 24 percent.

[5] American Metal Market. Hurricane Damage in the Millions. V. 68, No. 179, Sept. 18, 1961, p. 9.

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 1961	Being built in 1961	Total, actual and planned
Aluminum Company of America:			
Alcoa, Tenn	157,100	----------	157,100
Badin, N.C	47,150	----------	47,150
Massena, N.Y	118,000	32,000	150,000
Point Comfort, Tex	140,000	----------	140,000
Rockdale, Tex	150,000	----------	150,000
Vancouver, Wash	97,500	----------	97,500
Wenatchee, Wash	108,500	----------	108,500
Evansville, Ind	35,000	140,000	175,000
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	----------	60,050
San Patricio, Tex	95,000	----------	95,000
Troutdale, Oreg	91,500	----------	91,500
Massena, N.Y	[1] 100,000	----------	100,000
Total	701,000	----------	701,000
Kaiser Aluminum & Chemical Corp.:			
Chalmette, La	247,500	----------	247,500
Mead, Wash	176,000	----------	176,000
Tacoma, Wash	41,000	----------	41,000
Ravenswood, W. Va	145,000	----------	145,000
Total	609,500	----------	609,500
Anaconda Aluminum Co.: Columbia Falls, Mont	65,000	----------	65,000
Harvey Aluminum, Inc.: The Dalles, Oreg	75,000	----------	75,000
Ormet Corp.: Clarington, Ohio	180,000	----------	180,000
Grand total	2,483,750	172,000	2,655,750

[1] At end of 1961 the plant was complete, but only two potlines of 33,300 tons each were operating.

TABLE 5.—Aluminum recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

Kind of scrap	1960	1961	Form of recovery	1960	1961
New scrap:					
Aluminum-base	[1] 266,141	[2] 237,765	As metal	16,684	21,552
Copper-base	32	55	Aluminum alloys	308,318	316,396
Zinc-base	[3] 285	230	In brass and bronze	[3] 258	142
Magnesium-base	289	123	In zinc-base alloys	[3] 1,970	720
			In magnesium alloys	228	330
Total	[3] 266,747	238,173	In chemical compounds	1,992	1,328
			Total	[3] 329,450	340,468
Old scrap:					
Aluminum-base	[1] 61,769	[2] 101,233			
Copper-base	104	87			
Zinc-base	[3] 565	600			
Magnesium-base	265	375			
Total	[3] 62,703	102,295			
Grand total	[3] 329,450	340,468			

[1] Aluminum alloys recovered from aluminum-base scrap in 1960, including all constituents, amounted to 283,305 tons from new scrap and 69,784 tons from old scrap; total, 353,089 tons.
[2] Aluminum alloys recovered from aluminum-base scrap in 1961, including all constituents, amounted to 282,564 tons from new scrap and 133,366 tons from old scrap and sweated pig; total, 415,930 tons.
[3] Revised figure.

TABLE 6.—Stocks and consumption of new and old aluminum scrap and sweated pig in the United States in 1961 [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 [4]	Total	
Secondary smelters: [3]						
New scrap:						
Segregated 2S sheet and clips	500	6,658	6,638	----------	6,638	520
Segregated 3S sheet and clips	471	6,229	6,134	----------	6,134	566
Segregated 51S, 52S, 61S, etc., sheet and clips, less than 0.6 percent Cu	461	27,462	26,562	----------	26,562	1,361
Segregated 14S, 17S, 24S, 25S, etc., sheet and clips, more than 0.6 percent Cu	506	6,294	6,354	----------	6,354	446
Segregated 75S, 76S, 77S, 78S, 80S type sheet and clips, more than 0.6 percent Cu	618	5,416	5,425	----------	5,425	609
Mixed low Cu clips, 0.6 percent maximum Cu	990	24,932	24,409	----------	24,409	1,513
Mixed clips, more than 0.6 percent Cu	985	23,946	22,957	----------	22,957	1,974
Cast scrap	459	5,452	5,557	----------	5,557	354
Borings and turnings:						
Segregated 14S, 17S, 24S, 25S	526	8,457	8,743	----------	8,743	240
Segregated 75S, 76S, 77S, 78S, 80S type	526	9,801	9,929	----------	9,929	398
Segregated other	35	14,499	13,821	----------	13,821	713
Mixed, Zn 1.0 percent maximum	1,184	23,831	24,012	----------	24,012	1,003
Mixed, Zn over 1.0 percent	1,335	23,678	23,820	----------	23,820	1,193
Dross and skimmings	3,824	43,717	42,991	----------	42,991	4,550
Foil (includes both new and old)	163	2,976	2,848	----------	2,848	291
Miscellaneous	687	10,461	10,640	----------	10,640	508
Old scrap:						
Wire and cable	274	1,600	----------	1,661	1,661	213
Pots and pans	1,121	17,847	----------	17,990	17,990	978
Mixed alloy sheet	291	4,967	----------	4,957	4,957	301
Aircraft	253	4,039	----------	3,984	3,984	308
Castings and forgings	1,034	19,973	----------	19,696	19,696	1,311
Pistons	124	3,119	----------	2,710	2,710	533
Irony aluminum	438	9,299	----------	9,075	9,075	662
Miscellaneous	1,430	7,774	----------	8,006	8,006	1,198
Purchased pig	1,032	25,060	----------	22,786	22,786	3,306
Total	19,267	337,487	240,840	90,865	331,705	25,049
Primary producers:						
New and old scrap:						
Segregated 2S sheet and clips	139	3,408	3,404	----------	3,404	143
Segregated 3S sheet and clips	170	6,163	6,224	----------	6,224	109
Segregated 51S, 52S, 61S, etc., sheet and clips, less than 0.6 percent Cu	682	16,515	16,949	----------	16,949	248
Segregated 14S, 17S, 24S, 25S, etc., sheet and clips, more than 0.6 percent Cu	91	2,615	2,595	----------	2,595	111
Segregated 75S, 76S, 77S, 78S, 80S type sheet and clips, more than 0.6 percent Cu	111	2,573	2,684	----------	2,684	0
Mixed low Cu clips, 0.6 percent maximum Cu	111	3,191	3,241	----------	3,241	61
Mixed clips, more than 0.6 percent Cu	116	657	773	----------	773	0
Cast scrap	19	1,126	1,123	----------	1,123	22
Borings and turnings:						
Segregated 14S, 17S, 24S, 25S	3	137	130	----------	130	10
Segregated 75S, 76S, 77S, 78S, 80S	3	24	21	----------	21	6
Segregated other	0	500	456	----------	456	44
Mixed, Zn 1.0 percent maximum	7	18	23	----------	23	2
Mixed, Zn over 1.0 percent	9	34	31	----------	31	12
Foil (includes both new and old)	438	2,883	3,158	----------	3,158	163
Miscellaneous	113	3,365	3,411	----------	3,411	67
Wire and cable	15	88	----------	78	78	25
Castings and forgings	0	3	----------	3	3	0
Miscellaneous	0	1	----------	1	1	0
Purchased pig	0	267	----------	267	267	0
Total	2,027	43,568	44,223	349	44,572	1,023

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 1961—Continued

(Short tons, gross weight)

Class of consumer and type of scrap	Stocks, Jan. 1 [1] [2]	Receipts	Consumption			Stocks, Dec. 31
			New scrap	Old scrap [4]	Total	
Founderies, fabricators, and chemical plants:						
New scrap:						
Segregated 2S sheet and clips	329	1,754	1,969	----------	1,969	114
Segregated 3S sheet and clips	600	20,843	20,735	----------	20,735	708
Segregated 51S, 52S, 61S, etc., sheet and clips, less than 0.6 percent Cu	319	12,801	12,682	----------	12,682	438
Segregated 14S, 17S, 24S, 25S, etc., sheet and clips, more than 0.6 percent Cu	6	149	124	----------	124	31
Segregated 75S, 76S, 77S, 78S, 80S sheet and clips, more than 0.6 percent Cu	8	40	48	----------	48	0
Mixed low Cu clips, 0.6 percent maximum Cu	312	6,434	6,195	----------	6,195	551
Mixed clips, more than 0.6 percent Cu	323	827	651	----------	651	499
Cast scrap	142	1,102	949	----------	949	295
Borings and turnings:						
Segregated 14S, 17S, 24S, 25S	0	52	52	----------	52	0
Segregated other	1	26	27	----------	27	0
Mixed, Zn over 1.0 percent	1	1	2	----------	2	0
Dross and skimmings	10	37	43	----------	43	4
Foil (includes both new and old)	563	2,551	2,641	----------	2,641	473
Miscellaneous	205	4,318	3,886	----------	3,886	637
Old scrap:						
Wire and cable	0	98	----------	81	81	17
Pots and pans	0	98	----------	98	98	0
Mixed alloy sheet	0	4	----------	4	4	0
Aircraft	2	48	----------	49	49	1
Castings and forgings	46	476	----------	489	489	33
Pistons	0	219	----------	218	218	1
Irony aluminum	0	1	----------	0	0	1
Miscellaneous	10	51	----------	33	33	28
Purchased pig	14	75,482	----------	70,863	70,863	4,633
Total	2,891	127,412	50,004	71,835	121,839	8,464
Grand total of all scrap consumed:						
New scrap:						
Segregated 2S sheet and clips	968	11,820	12,011	----------	12,011	777
Segregated 3S sheet and clips	1,241	33,235	33,093	----------	33,093	1,383
Segregated 51S, 52S, 61S, etc., sheet and clips, less than 0.6 percent Cu	1,462	56,778	56,193	----------	56,193	2,047
Segregated 14S, 17S, 24S, 25S, etc., sheet and clips, more than 0.6 percent Cu	603	9,058	9,073	----------	9,073	588
Segregated 75S, 76S, 77S, 78S, 80S sheet and clips, more than 0.6 percent Cu	737	8,029	8,157	----------	8,157	609
Mixed low Cu clips, 0.6 percent maximum Cu	1,413	34,557	33,845	----------	33,845	2,125
Mixed clips, more than 0.6 percent Cu	1,424	25,430	24,381	----------	24,381	2,473
Cast scrap	620	7,680	7,629	----------	7,629	671
Borings and turnings:						
Segregated 14S, 17S, 24S, 25S	529	8,646	8,925	----------	8,925	250
Segregated 75S, 76S, 77S, 78S, 80S	529	9,825	9,950	----------	9,950	404
Segregated other	36	15,025	14,304	----------	14,304	757
Mixed, Zn 1.0 percent maximum	1,191	23,849	24,035	----------	24,035	1,005
Mixed, Zn over 1.0 percent	1,345	23,713	23,853	----------	23,853	1,205
Dross and skimmings	3,834	43,754	43,034	----------	43,034	4,554
Foil (includes both new and old)	1,164	8,410	8,647	----------	8,647	927
Miscellaneous	1,005	18,144	17,937	----------	17,937	1,212
Old scrap:						
Wire and cable	289	1,786	----------	1,820	1,820	255
Pots and pans	1,121	17,945	----------	18,088	18,088	978
Mixed alloy sheet	291	4,971	----------	4,961	4,961	301
Aircraft	255	4,087	----------	4,033	4,033	309
Castings and forgings	1,080	20,452	----------	20,188	20,188	1,344
Pistons	124	3,338	----------	2,928	2,928	534
Irony aluminum	438	9,300	----------	9,075	9,075	663
Miscellaneous	1,440	7,826	----------	8,040	8,040	1,226
Purchased pig	1,046	100,809	----------	93,916	93,916	7,939
Total	24,185	508,467	335,067	163,049	498,116	34,536

[1] Includes imported scrap.
[2] Revised figure.
[3] Excludes secondary smelters owned by primary aluminum companies.
[4] Includes purchased sweated pig.

TABLE 7.—Production and shipments of secondary aluminum alloys by independent smelters

(Short tons) [1]

Product	1960		1961	
	Production [2]	Shipments [3]	Production [2]	Shipments [3]
Pure aluminum (Al minimum, 97.0 percent)	16,684	16,488	21,552	21,188
Aluminum-silicon (maximum Cu, 0.6 percent)	23,947	23,903		
95/5 Al,-Si, 356, etc. (0.6 percent Cu maximum)			11,130	10,364
13 percent Si, 360, etc. (0.6 percent Cu maximum)			23,006	23,573
Aluminum-silicon (Cu, 0.6 to 2 percent)	5,706	6,011	6,498	6,513
No. 12 and variations	4,011	3,862	4,033	4,136
Aluminum-copper (maximum Si, 1.5 percent)	1,000	1,117	1,404	1,379
No. 319 and variations	36,683	36,519	32,174	32,334
Nos. 122, 138			2,927	2,991
AX8-679 and variations	111,735	110,568	113,814	114,375
Aluminum-silicon-copper-nickel	15,348	15,312	16,106	16,146
Deoxidizing and other destructive uses	29,098	29,527		
Grades 1 and 2			9,626	9,229
Grades 3 and 4			14,747	15,181
Aluminum-base hardeners	9,333	9,147	11,146	11,163
Aluminum-magnesium	1,993	2,032	1,441	1,556
Aluminum-zinc	9,545	9,362	5,093	4,614
Miscellaneous	16,881	16,494	20,279	20,901
Total	281,964	280,342	294,976	295,643

[1] Gross weight, including copper, silicon, and other alloying elements, at independent secondary smelters; total secondary aluminum and aluminum alloy ingot contained 14,105 tons primary aluminum in 1960 and 10,294 tons in 1961.
[2] No allowance was made for consumption by producing plants.
[3] No allowance was made for receipts by producing plants.

The Bureau of Mines estimated that full coverage of the industry during 1961 would show a total scrap consumption of 579,000 tons and a secondary ingot production of 345,000 tons. Calculated aluminum recovery based on full coverage would total 451,000 tons, and the metallic aluminum-alloy recovery would total 485,000 tons.

Aluminum-alloy ingot production, as reported to the Bureau of Mines, totaled 295,000 tons, 5 percent more than in 1960. Data on remelt ingots excluded alloys produced from purchased scrap by the primary producers. Shipments of many casting alloys increased in 1961.

The data obtained through a Bureau of Mines canvass are combined with data made available to the Bureau by the Aluminum Smelters Research Institute, which covers the operations of its members. The combined coverage is estimated to represent about 83 percent of the secondary aluminum industry.

In October, George Salls Metals Co. of Philadelphia, Pa., announced plans to expand its nonferrous smelting and other facilities. About 20,000 square feet of space would be added to the existing plant. Additional equipment would include a 100,000-pound-capacity aluminum reverberatory furnace with modern metallurgical controls. A quantometer was to be added to the research laboratory.

CONSUMPTION AND USES

Sales of primary aluminum by producers increased 5 percent in 1961. Secondary alumimum recovered from old nonferrous scrap increased 63 percent; that from new nonferrous scrap decreased 11 percent.

Net shipments of aluminum wrought products and castings increased 8 percent to 2,053,000 tons. Compared with 1960, shipments of extruded shapes increased 10 percent, rolled structural shapes increased 16 percent, and sand casting decreased 4 percent. Wrought products continued to represent about 80 percent of all shipments.

It was estimated by the aluminum industry that 1961 shipments of aluminum by product were as follows: Ingot, 31 percent; sheet and plate, 31 percent; extrusions and tubes, 21 percent; electrical wire and cable, 6 percent; foil, 6 percent; and other, 5 percent.

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
1952-56 (average)	1,360,042	215,443	71,648	256,530	1,903,663
1957	1,579,063	195,644	72,459	289,360	2,136,526
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	[4] 62,703	[4] 266,747	[4] 2,015,644
1961	1,956,167	24,004	102,295	238,173	2,320,639

[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.
[2] Crude and semicrude. Includes ingot equivalent of scrap imports and exports (weight × 0.9). Includes some shipments to Government stockpiles: Figures not available.
[3] The 1952-53 data are recoverable aluminum-alloy content; data for subsequent years are recoverable aluminum content.
[4] Revised figure.

The following distribution for wrought products was obtained from the figures published by the Bureau of the Census:

	Percent 1960	1961
Plate, sheet, and foil:		
Non-heat-treatable	39.5	37.6
Heat-treatable	6.0	7.0
Foil	8.2	8.1
Rolled rod, bar, and wide:		
Rod, bar, etc.[1]	3.1	3.0
Bare wire, conductor and nonconductor	1.8	1.6
Bare cable (including steel-reinforced)	6.0	7.0
Wire and cable, insulated or covered	2.0	2.0
Extruded shapes:		
Alloys other than 2000 and 7000 series	26.6	26.4
Allloys in 2000 and 7000 series	1.3	1.5
Tubing:		
Drawn	2.0	1.9
Welded non-heat-treatable [2]	.8	1.1
Powder, flake, and paste:		
Atomized	.4	.4
Flaked	.2	.2
Paste	.5	.5
Forgings (including impact extrusions)	1.6	1.7
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)

	1960	1961
Wrought products:		
Plate, sheet, and foil	818,628	881,968
Rolled structural shapes, rod, bar, and wire	[2] 195,900	227,418
Extruded shapes, rod, bar, tube blooms, and tubing	[2] 468,555	516,927
Powder, flake, and paste	[2] 16,424	17,942
Forgings	25,027	28,224
Total	[2] 1,524,534	1,672,479
Castings:		
Sand	[2] 64,902	62,311
Permanent mold	[2] 129,021	130,317
Die	[2] 181,505	187,932
Other	(3)	(3)
Total	[2] 375,970	390,910
Grand total	[2] 1,900,504	2,053,389

[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.

The Aluminum Association survey compared percentage distribution of all millwrought and foundry-casting shipments, exclusive of die castings, to consuming industries as reported by its members.[6] In the fourth quarter of 1961, 18 percent of the shipments went to the building products industry, 18 percent to transportation, 12 percent to electrical, 11 percent to containers and packaging, and 9 percent to consumer durable goods. Slightly over 16 percent went to distributors and jobbers, and the remainder to other industries.

Use of aluminum in the building and construction industry expanded, with many new applications developed in addition to expansion of past applications. Curtain walls of aluminum products comprised 18 percent of the total wall area of nonresidential buildings, an increase of 3 percent over 1960.[7] An estimated 124,000 pounds of metal was consumed in framing and panels of the curtain walls. The weight of the steel framework required was reduced at least 30 percent by the use of aluminum curtain walls.

The use of aluminum in new houses increased an estimated 15 pounds per dwelling unit, raising use of aluminum to an average of about 230 pounds per house. Kaiser's residential market development survey indicated the average new home used 369 pounds of aluminum in 1961 in comparison to 185 pounds in 1960.[8] Some housing projects involving two-story homes utilized as much as 650 pounds of aluminum per home. Prefabricated houses using over 1,200 pounds per house were produced in volume.

Use of an expandable aluminum beam as a support member for laying concrete floors helped speed the construction of buildings. The lightweight aluminum beams were easily installed and removed,

[6] American Metal Market. Building Still Largest Market. V. 69, No. 80, Apr. 26, 1962, p. 10.
[7] Light Metal Age. Aluminum in Curtain Walls. V. 19, No. 7, 8, August 1961, pp. 6–7.
[8] Iron Age. Aluminum for Home Pushed. V. 188, No. 21, Nov. 23, 1961, p. 61.

with one man required to carry the beams on and off the job and two carpenters and a laborer needed to set and strip them.[9]

Several bridges were constructed employing triangular-shaped aluminum beams bolted together edge to edge to form the roadway base. The quantity of aluminum required weighed about one-third that of a comparable steel bridge. Spans of 97 feet were constructed.[10] More than 27,000 feet of aluminum tubing was employed as railing on the new lower level of the George Washington Bridge spanning the Hudson River. This resulted in a weight saving of 370,000 pounds compared with the weight of steel railings used on the upper deck.[11]

Development of tapered aluminum plates 11 feet wide by 20 feet long, tapered lengthwise and varying from 0.250 inch to 1.000 inch in thickness, permitted the construction of storage tanks 70 feet in diameter and 48 feet high with a capacity of 25,000 to 33,000 gallons.[12]

The use of aluminum in truck trailers increased, partly because of the increased number of trailers produced and partly because the industry expanded its capability of making extra-wide trailer roofing sheet and extruded flooring systems. These new products, together with aluminum wheels and engines, help reduce dead weight while increasing payload and gas mileage.

Shipments of mobile homes and travel trailers amounted to approximately 125,000 units in 1961, a decrease of 13 percent from 1960.[13] Some 90 percent of all mobile homes built had aluminum sheathing.

Railroads turned to aluminum for an increasing number of boxcars, open hopper cars, gondola cars, tank cars, Pullman cars, covered hopper cars, and many special-use cars.[14] The use of the lighter metal permitted larger payloads. It was estimated that 10,000 tons of the metal was consumed in the manufacture of all type of cars. Aluminum was utilized for one-piece roofs, extruded floor planking, movable bulkheads, doors, walls, and framework. Railway cars for the Minuteman missile used aluminum for lightweight removable roofs. The design of the full-door boxcar would not have been possible without aluminum.

Despite an 18-percent decrease in the number of passenger cars built in 1961, the quantity of aluminum used by the automotive industry increased about 15 percent to an estimated 270,000 tons. On the basis of an industry wide survey, it was reported that the 1961 models contained an average of 62.7 pounds of aluminum per car and that the 1962 models would contain an average of 66.5 pounds.[15] Use of aluminum has increased each year since 1954, when an average of 25.0 pounds per car was used. Figures for 1955–60 were as follows: 1955, 29.6 pounds of aluminum per car; 1956, 35.2 pounds; 1957,

[9] Engineering News-Record. Lightweight Beams Cut Flooring Costs. V. 167, No. 24, Dec. 14, 1961, p. 45.
[10] Iron Age. New Aluminum Use. V. 187, No. 23, June 8, 1961, p. 66. Steel, v. 148, No. 16, Apr. 17, 1961, p. 17. Modern Metals, v. 17, No. 6, July 1961, p. 44.
[11] Modern Metals, v. 17, No. 6, July 1961, p. 87.
[12] American Metal Market, v. 68, No. 120, June 23, 1961, p. 11.
[13] Mobile Home and Travel Trailer Industry. Business and Defense Services Administration. Rept. ER–61–74. Jan. 17, 1962, 2 pp.
Iron Age, v. 189, No. 3, Jan. 18, 1962, p. 41.
[14] Modern Metals. On The Railroads. V. 17, No. 9, October 1961, pp. 28, 30, 32.
[15] Iron Age. Aluminum in Cars—A Growing Market. V. 189, No. 2, Jan. 11, 1962, p. 39. American Metal Market. Aluminum Shows Further Gain in Autos. V. 69, No. 6, Jan. 9, 1962, pp. 1, 8.

40.5 pounds; 1958, 47.3 pounds; 1959, 50.7 pounds; and 1960, 54.4 pounds.

Of the domestic car production in the 1961 model year, 10.3 percent had aluminum engines. This percentage was expected to remain stable for the 1962 model year. The total production of aluminum engines since use of the metal started in 1959 exceeded 1 million during 1961.

Kaiser contracted with General Motors Corp. to supply molten aluminum metal to a GM foundry at Reliance, Ohio, from Kaiser's Ravenswood, W. Va., reduction plant, a distance of about 285 miles. The metal was to be used primarily in casting motor blocks for the Buick Special and Oldsmobile F–85. Kaiser was the third company to enter the molten metal business. General Motors previously had contracted with Reynolds to supply the Chevrolet foundry at Massena, N.Y., for Corvair motor blocks; with Reynolds for metal from the Jones Mills, Ark. plant; and with Alcoa to supply a foundry at Bedford, Ind.[16]

Various aluminum companies engaged in research to develop new alloys and fabrication techniques for use in other automotive applications.[17] One company was investigating die casting of aluminum rear-axle housings. Others were trying aluminum in wheel mountings where the metal's ability to dissipate heat generated by friction of the brake lining against the drum insert is outstanding. Automobile bumpers made from new aluminum alloys were being tested.

Several of the aluminum companies began aluminum-can manufacturing in an effort to capture a larger portion of the market. Machines were produced that were capable of preparing thin-wall tubing in excess of 1,000 feet per minute and others that could produce aluminum or tin-coated steel cans three times as fast as conventional machines.[18]

Total use of aluminum for cans in 1961 according to the Bureau of the Census was 21,749 short tons, up 43 percent over the 1960 quantity of 15,226 tons. However, its share of the total metal-can industry was relatively small, only 0.4 percent, a rise of 0.1 percent from 1960. An aluminum can was defined as a single-walled container constructed of either aluminum sheet or impact extrusions (slugs). This excluded containers of all types produced from aluminum foil (under 0.006 inch) or collapsible tubes.

One of the aluminum-metal producers estimated the number of aluminum cans produced in 1961 (in millions) as follows: Frozen juice concentrate, 900; motor oil, 300; aerosols, 25; beer; 40; tuna and other drawn cans, 100.[19] Corresponding estimates for 1960 were (in millions) 200, 300, 25, 30, and 0, respectively. These five uses were estimated to comprise a total for 14 billion cans annually. Aluminum's penetration of the entire 44-billion-unit metal-can market was 1 percent in 1960 and 3 percent in 1961. It was estimated that aluminum

[16] American Metal Market. Hot Metal Use Expands. V. 68, No. 63, Apr. 4, 1961, p. 8.
[17] Iron Age. Aluminum Axle Housing Next. V. 187, No. 22, June 1, 1961, p. 51.
American Metal Market. Wheels Viewed as Next Major Aluminum Use in Automobiles. V. 68, No. 77, Apr. 24, 1961, p. 9.
American Metal Market. Auto Bumper Light Ore. V. 68, No. 89, May 10, 1961, pp. 1, 2.
[18] Iron Age. Canmaking Speed Is Tripled. V. 188, No. 13, Sept. 28, 1961, p. 60.
[19] American Metal Market. Aluminum Can Forecast. V. 69, No. 17, Jan. 24, 1962, p. 11.

was used for 51 percent of the cans produced for frozen juice concentrate, 18 percent of the motor oil containers, 3 percent of aerosol cans, 0.5 percent of the beer cans, and 10 percent of the tuna and other drawn-type cans.

The corrosion resistance of many aluminum alloys to hot ammonium nitrate solutions led to their utilization in pressure vessels, storage tanks, and piping systems.[20] Alloys 1060, 1100, 3003, 3004, and 6061 were considered satisfactory for containing solutions above 150° F and at nitrate concentrations greater than 40 percent. The magnesium content of the alloy was found to be critical as temperature and concentration increased.

Aluminum helped make possible the mounting of 105-mm guns on M–60 tanks because of the saving in weight obtained by using aluminum in armored plate, fuel tanks, wheels, ammunition racks, turret platform, and other items.[21] Over 6,000 pounds of the metal was used in the M–60 tank.

A disk-shaped aluminum reflector weighing less than 0.2 pound was utilized as a radio-signal collector for the Ranger spacecraft designed to travel to the moon's surface. Signals collected by the reflector would activate the mechanism to detach a payload capsule as it approached the moon. The reflector was a honeycomb sandwich structure made from foil and thin plate.[22]

Another planned space probe involved the use of a 10-foot-diameter aluminum mirror which consisted of 36 blades. The surface skin of each blade was foil 0.005 inch thick, preformed to an accurate parabolic contour by explosive forming.[23]

The electrical industry moved from fourth to third place among aluminum markets because of the increased use of the metal in substation structures, enclosures for switch gear, reactors, and related electrical equipment. In cases of extreme atmospheric corrosion, all-aluminum towers were used to reduce maintenance costs. In other towers, the uppermost (hot) sections were aluminum, or aluminum structural components were used with wooden uprights.

Aluminum sheeting coated with vinyl was produced for broad applications in luggage, appliances, furniture, mobile homes, and other products. Other metal sheet was coated with Teflon and stainless steel for cooking utensil applications. Special leakproof packages were made possible through development of a polyethylene-laminated foil.

Several new alloys were placed on the market by the aluminum companies. Extrusion alloy C–914 possessed a better combination of mechanical properties and extrusion speed, having special advantage in matte finish applications. Extrusion alloy C–58 was especially receptive to porcelain enameled type of finishes. Alloy 6563 was designed for anodizing to a brighter, more uniform, and more reflective finish than the usual alloys. Alloy 4543 was designed for architectural extrusion requiring a gray finish.[24]

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[20] Haines, R. H. Considerations in Building Aluminum Pressure Vessels. Modern Metals, v. 17, No. 11, Dec. 1961, pp. 44, 46.
[21] Materials in Design Engineering. Lightweight Ordnance Equipment. V. 54, No. 1, July 1961, pp. 100–106.
[22] American Metal Market, v. 69, No. 19, Jan. 16, 1962, p. 10.
[23] Iron Age. Explosives Shape Solar Mirror. V. 188, No. 18, Nov. 2, 1961, p. 79.
[24] American Metal Market. Extrusion Product Progress. V. 68, No. 191, Oct. 4, 1961, p. 11.

New applications for aluminum pipe included its use in underground pipeline systems for connecting gas mains to home lines. The aluminum pipe was fabricated in continuous coils 300 feet or more in length, thus eliminating the need for intermediate joints. The exterior was protected against corrosion by vinyl-butyl rubber laminate, covered with inexpensive insulation.[25]

Aluminum plate made from 5083 high-strength alloy was employed in building a 35-foot liquid hydrogen storage tank. The tank held 90,000 gallons of high-energy propellant at a temperature of 423° F.

Aluminum was utilized in the new Yankee Atomic Electric Co. 485,000-kilowatt reactor for specially constructed water-storage tanks where water purity was of primary importance. Aluminum metal also was utilized in cable and bus bar equipment throughout the plant.[26]

The U.S. Navy authorized the consumption of 40 million pounds of aluminum metal for various uses in new vessels planned for construction during 1961. Almost 75 percent of this amount was to be used in constructing guided missile cruisers, destroyers, and frigates; 20 percent in attack aircraft carriers; and the remainder in escort vessels, amphibious docks, assault ships, and minesweepers.[27]

U.S.S. Enterprise, the first U.S. nuclear-powered aircraft carrier and the world's largest ship, utilized some 3 million pounds of aluminum, largely in the gaint elevators that raise the aircraft to the carrier deck. Each elevator has room for 2,000 people.

Use of aluminum metal in the Nation's space program include its first spaceship, Ranger I, which was designed to land instruments on the moon.[28] Metal sheet, tubing, and castings formed structural components. A 50-inch-diameter aluminum antenna was to receive and transmit messages to the earth. Solar panels mounted on an aluminum alloy honeycomb structure will convert solar energy into electricity. Aluminum is especially qualified for spacecraft particularly in missions over extended periods because of its low evaporation rate at the vacuum condition of outer space.

The Titan missile carried 16,000 pounds of aluminum aloft in the form of aluminum fuel tanks. The Bomarc missile utilized aluminum alloys for ramjet fuel tanks.[29]

An 8-pound aluminum sphere was a memory drum for airborne computers. The sphere operates under extremely adverse conditions and allows a computer to operate reliably aloft for years. It can hold 358,000 bits of information, about 6 times the capability of a comparable commercial drum.[30]

The skin plate of the upper stage of the Saturn S–IV liquid hydrogen rocket was to be made of aluminum alloy 2014. Bulkheads were to be of aluminum sheet and plate. Forgings and extrusions of the same metal were incorporated into the rocket's structural framework.[31]

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[25] Mining Journal. Optimism in the U.S. Aluminum Industry. V. 257, No. 6579, Sept. 22, 1961, p. 297.
[26] American Metal Market, v. 68, No. 222, Nov. 20, 1961, p. 22.
[27] Chemical Engineering, v. 68, No. 3, Feb. 6, 1961, p. 48.
[28] American Metal Market. Aluminum Dominant in Craft Designed for Look at Moon. V. 68, No. 157, Aug. 16, 1961, p. 16.
[29] Nelson, R. H. Materials and Fabrication Methods for the Bomarc. Metal Prog., v. 79, No. 3, March 1961, pp. 107, 113, 142, 144, 146, 148.
[30] Technical Survey. Airborne Computers. V. 17, No. 7, Feb. 18, 1961, p. 111.
[31] Missiles and Rockets. Saturn S–IV Stage Goes Aluminum. V. 9, No. 7, Aug. 14, 1961, p. 21.

Aluminum also was found useful as construction material for a large aircore aluminum electromagnet to be built by the National Aeronautics and Space Administration for experiments in plasma heating and acceleration. The magnets were to be cryogenically cooled by neon at a temperature of −410° F.[32]

STOCKS

The amount of aluminum metal in the national (strategic) stockpile as of December 31, 1961, was announced as 1,127,000 short tons. An additional 802,000 short tons was in the DPA inventory. Thus, a total of 1,929,000 tons was available for governmental use—729,000 tons or 61 percent in excess of the estimated maximum objective required to meet the essential needs in a limited war or a general war of 3-year duration.

Inventories of aluminum ingot at the primary reduction plants varied from 259,500 short tons at the beginning of 1961 to 207,100 tons on December 31. The highest quantity of metal in stock during the year was a record 291,400 tons at the end of January. Stocks slowly decreased during the year, with minor increases taking place during July, August, and October. Based on December's production rate, 1961 closing stocks were equivalent to 38 days' output. In addition to the primary aluminum stocks reported, reduction plants also had inventories of ingot and aluminum in process.

Secondary alloy inventories varied from a high of 24,500 tons to a low of 21,300 tons during the year. At the beginning of the year, inventory was 23,300 tons, and at yearend inventory amounted to 22,400 tons. Extensive accumulation during June resulted in an increase of 2,800 tons over the previous month-end inventory and was the second highest for the year. Inventories reached their low in November.

Aluminum-base scrap inventories closed out the year at 34,500 tons, 10,400 tons above stocks at the beginning of the year. Three times during the year, in April, July, and December, stocks tended to be held high. The buildup in inventories took place during the first 4 months. Consumers' yearend inventories of scrap represented a 29-day supply, based on the December consumption rate.

PRICES

The base price of primary aluminum was 26 cents per pound throughout the first 8 months of 1961. On September 25 the base price dropped 2 cents to 24 cents per pound. A decrease in the price of aluminum to U.S. customers was first announced by Aluminium, Ltd., in Canada. The U.S. producers then announced a reduction to meet the new price.

There were three changes in the price of superpure aluminum during 1961. Effective March 6, 1961, the price was 45.50 to 47.50 cents per pound. According to the American Metal Market, the

[32] Steel. Supercool Aluminum Magnet Lowers Power Consumption. V. 149, No. 24, Dec. 11, 1961, pp. 110–111.

closing market prices for September 28 and December 14 were 43.50 to 45.50 and 43.50 cents per pound, respectively.

There were few price changes during 1961 in the secondary aluminum industry. According to American Metal Market, aluminum-base scrap was in plentiful supply despite exports which totaled about 82,000 tons. Smelter's buying prices for scrap aluminum changed infrequently, and the changes did not exceed 1 cent per pound. Finished alloy prices, however, changed more frequently. It was stated that competition rather than a retarded market resulted in price drops which ranged from ¼ cent to 2¼ cents per pound. These reductions affected the most popular casting and deoxidizing grades at various times during the year. Closing market prices on December 29, 1961, according to the American Metal Market were alloy 195, 23.75 to 24.25 cents per pound; No. 12, 20.75 to 21.25 cents per pound; and No. 380 (1 percent Zn), 21.00 to 22.00 cents per pound. Compared with prices quoted on December 30, 1960, these prices decreased 2 to 2½ cents per pound. Scrap prices at yearend were 2S, 3S, 51S, and 52S clips, 15.00 to 15.50 cents per pound; 75S clips, 11.00 to 11.50 cents per pound; and aluminum borings and turnings, 12.50 to 13.50 cents per pound. All these prices were ½ cent less than at the end of 1960.

FOREIGN TRADE [33]

Imports.—Total imports of crude and semicrude aluminum amounted to 15.50 cents per pound; 75S clips, 11.00 to 11.50 cents per pound; quantity exceeded total exports by 16,000 tons and contrasted with 1960, when a net export balance of 188,000 tons existed. Value of imports of crude, semicrude, and manufactured aluminum products amounted to $148 million, up 17 percent over the 1960 value and $24 million greater than the value of comparable exported products.

Canada supplied 53 percent of the aluminum imports, with France and Norway supplying 18 and 15 percent, respectively.

Exports.—Exports of crude and semicrude aluminum dropped 146,000 tons or 38 percent compared with 1960. Exports of manufactured products increased 37 percent. However, total value of crude, semicrude, and manufactured aluminum exports was $125 million, a decrease of approximately $60 million from 1960.

Principal export destinations for crude and semicrude metal were West Germany, United Kingdom, Japan, and Italy, which received 22, 17, 16, and 7 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, discs, plates, rectangle, rods, sheets, squares, and strips were subject to a duty of 2.50 cents-per-pound. Suspension of the 1.50 cents-per-pound duty on scrap was extended through June 30, 1962. There was no quota for aluminum scrap.

[33] 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 aluminum, by classes

Class	1960		1961	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Crude and semicrude:				
Metal and alloys, crude	154,706	$75,808	199,223	$91,187
Circles and disks	4,509	3,139	4,687	3,267
Plates, sheets, etc., n.e.s.	26,131	19,052	35,804	24,842
Rods and bars	6,037	3,681	8,819	4,953
Scrap	5,042	1,598	6,002	1,738
Total	196,425	103,278	254,535	125,987
Manufactures:				
Foil less than 0.006 inch thick	4,830	6,118	4,952	6,283
Folding rules	(1)	(2)	(1)	1
Leaf (5½ by 5½ inches)	(3)	14	(3)	19
Powder and powdered foil (aluminum bronze)	66	62	90	109
Table, kitchen, hospital utensils, etc.	3,128	4,753	3,191	5,837
Other manufactures	(4)	12,014	(4)	10,048
Total	(4)	22,961	(4)	22,288
Grand total	(4)	126,239	(4)	148,275

[1] Number: 1960, 1,584; 1961, 3,566; equivalent weight not recorded.
[2] Less than $1,000.
[3] Leaves: 1960, 3,702,448; 1961, 5,243,066.
[4] Quantity not recorded.

Source: Bureau of the Census.

TABLE 11.—U.S. imports for consumption of aluminum, by classes and countries

(Short tons)

Country	1960			1961		
	Metal and alloys, crude	Plates, sheets, bars, etc.[1]	Scrap	Metal and alloys, crude	Plates, sheets, bars, etc.[1]	Scrap
North America:						
Canada	104,070	7,647	4,403	119,004	9,924	5,930
Other			46			44
Total	104,070	7,647	4,449	119,004	9,924	5,974
Europe:						
Austria	3,364	1,518		885	1,188	
Belgium-Luxembourg	24	7,805	3	10	12,809	
France	10,221	3,818	205	40,183	5,758	
Germany, West	110	2,000		2	1,333	
Italy	1,109	3,613			3,595	
Norway	31,430	567		37,820	166	
Spain	891	912			1,168	
Sweden		1,091	28	90	1,313	6
United Kingdom	6	1,181	25	6	4,355	22
Yugoslavia	340	1,540		230	1,883	
Other	1	652	332	1	689	
Total	47,496	24,697	593	79,227	34,257	28
Asia:						
Japan		4,204			5,036	
Taiwan		107		992	71	
Other		22			20	
Total		4,333		992	5,127	
Africa	3,140					
Oceania					2	
Grand total:						
Short tons	154,706	36,677	5,042	199,223	49,310	6,002
Value, thousands	$75,808	$25,872	$1,598	$91,187	$33,062	$1,738

[1] Includes plates, sheets, etc.; bars and rods; and circules and disks.

Source: Bureau of the Census.

TABLE 12.—U.S. exports of aluminum, by classes

Class	1960		1961	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Crude and semicrude:				
Ingots, slabs, and crude	284,979	$128,199	128,861	$57,638
Scrap	79,513	26,905	82,005	26,452
Plates, sheets, bars, etc	18,098	16,266	25,241	23,975
Castings and forgings	1,190	2,849	1,203	3,560
Semifabricated forms, n.e.c	149	195	821	966
Total	383,929	174,414	238,131	112,591
Manufactures:				
Foil and leaf	1,318	1,787	1,697	2,130
Powders and pastes (aluminum and aluminum bronze) (aluminum content)	338	424	298	422
Cooking, kitchen, and hospital utensils	1,030	2,573	800	2,133
Sash sections, frames (door and window)	1,376	2,175	1,592	2,524
Venetian blinds and parts	1,504	1,852	1,230	1,437
Wire and cable	2,641	1,895	5,602	3,317
Total	8,207	10,706	11,219	11,963
Grand total	392,136	185,120	249,350	124,554

Source: Bureau of the Census.

WORLD REVIEW

The year 1961 marked the 75th anniversary of the development of the modern aluminum industry. The basic cell had been almost simultaneously discovered by Hall in America and Héroult in France in 1886. A résumé of developments in North and South America was presented at the International Light Metals Congress, Leoben, Austria, June 22, 1961.[34]

World production of aluminum was estimated at 5.2 million short tons—210,000 tons or 4 percent above 1960—and was 86 percent of rated capacity. Additional capacity, added either by new installations or by more efficient operation of older plants, was noted in the United States, France, Norway, India, Japan, and Taiwan.

The potential for increased use of aluminum throughout the world was illustrated by the fact that 23 pounds of aluminum metal per person was used in the United States compared with 15 in Great Britain, less than 10 in most European countries, 8 in Australia, and less than 4 in Japan.

[34] Light Metals (London). The Aluminium Industry in North and South America. V. 24, No. 279, August 1961, pp. 207–209.

TABLE 13.—U.S. exports of aluminum, by classes and countries

(Short tons)

Destination	1960			1961		
	Ingots, slabs, and crude	Plates, sheets, bars, etc.[1]	Scrap	Ingots, slabs, and crude	Plates, sheets, bars, etc.[1]	Scrap
North America:						
Canada	681	5,230	893	793	5,987	1,162
Cuba	100	251				
Mexico	5,231	159	16	4,855	337	4
Other	176	655	61	109	936	92
Total	6,188	6,295	970	5,757	7,260	1,258
South America:						
Argentina	6,228	68	314	11,470	127	
Brazil	943	115		2,285	87	34
Colombia	2,919	340		3,274	459	
Venezuela	668	729	[2]	879	663	31
Other	343	127		579	496	
Total	11,101	1,379	314	18,487	1,832	65
Europe:						
Belgium-Luxembourg	6,147	153	523	3,210	274	757
France	10,522	405		1,602	1,088	208
Germany, West	75,650	368	28,736	16,310	1,326	35,429
Italy	6,512	156	22,758	3,875	713	12,889
Netherlands	8,239	141	334	8,089	435	701
Switzerland	8,620	63	91	2,917	20	356
United Kingdom	118,109	6,233	9,073	25,207	9,810	4,475
Other	11,172	1,071	399	11,258	2,170	604
Total	244,971	8,590	61,914	72,468	15,836	55,419
Asia:						
India	915	954	1	937	202	67
Israel	719	64	55	2,954	62	2
Japan	8,774	216	16,152	13,243	367	24,837
Philippines	3,185	205		3,458	182	39
Other	2,029	289	14	4,838	242	206
Total	15,622	1,728	16,222	25,430	1,055	25,151
Africa	707	498	84	1,032	627	
Oceania	6,390	947	9	5,687	655	112
Grand total:						
Short tons	284,979	19,437	79,513	128,861	27,265	82,005
Value, thousands	$128,199	$19,310	$26,905	$57,638	$28,501	$26,452

[1] Includes plates, sheets, bars, extrusions, castings, forgings, and unclassified "semifabricated forms."
[2] Less than 1 ton.

Source: Bureau of the Census.

World demand for superpure aluminum (99.99 percent) had steadily increased until capacity of the 10 producing countries reached an estimated 30,200 short tons.[35]

Tables 15 and 16 show world capacity for production of aluminum and superpure metal. These were prepared by the Federal Bureau of Mines from various official and semiofficial sources.

[35] Revue de l'Aluminium. La Production d'Aluminium Raffiné dans le Monde. V. 38, No. 287, May 1961, pp. 599–602.

TABLE 14.—World production of aluminum by countries [1]

(Short tons)

Country [2]	1952–56 (average)	1957	1958	1959	1960	1961
North America:						
Canada	567,793	556,715	634,102	593,630	762,012	663,173
United States:	1,378,917	1,647,709	1,565,557	1,954,112	2,014,498	1,903,711
Total	1,946,710	2,204,424	2,199,659	2,547,742	2,776,510	2,566,884
South America: Brazil	2,577	9,794	13,102	19,950	20,034	[3] 20,000
Europe:						
Austria	53,970	62,125	62,716	72,271	74,924	74,578
Czechoslovakia	[4] 17,550	18,400	29,100	28,700	[3] 44,000	[3] 55,000
France	136,264	176,290	186,107	190,712	259,263	307,765
Germany:						
East	22,112	[3] 38,100	[3] 37,500	[3] 38,600	[3] 44,000	[3] 60,600
West	136,918	169,576	150,759	166,631	186,221	190,212
Hungary	34,595	27,650	43,560	50,400	54,564	56,328
Italy	64,132	72,981	70,603	82,658	92,206	91,881
Norway	72,593	105,430	133,777	160,881	181,662	189,487
Poland	[5] 17,400	22,443	24,738	25,143	28,640	52,488
Spain	6,329	16,721	17,769	24,959	26,429	31,085
Sweden (includes alloys)	11,258	14,958	15,113	17,086	18,409	18,436
Switzerland	31,288	34,238	34,723	37,886	43,795	46,297
U.S.S.R. [3]	390,000	550,000	605,000	690,000	745,000	990,000
United Kingdom	31,932	32,933	29,517	27,462	32,390	36,169
Yugoslavia	7,718	19,989	23,899	21,214	27,635	30,211
Total [3]	1,035,000	1,360,000	1,465,000	1,635,000	1,860,000	2,230,000
Asia:						
China [3]	[5] 8,500	22,000	30,000	77,600	88,100	110,000
India	5,803	8,718	9,167	19,131	20,123	20,263
Japan [6]	58,372	74,934	93,231	110,385	146,864	169,424
Taiwan	6,978	9,104	9,455	8,251	9,106	9,938
Total [2 3]	79,700	114,800	141,900	215,400	264,200	309,600
Africa: Cameroun		8,300	35,121	46,644	48,436	52,446
Oceania: Australia	[7] 5,819	11,899	12,173	12,734	13,054	14,789
World total (estimate) [1 2]	3,070,000	3,710,000	3,865,000	4,480,000	4,985,000	5,195,000

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[2] In addition to countries listed, North Korea produced a negligible quantity of aluminum.
[3] Estimate.
[4] Average annual production 1953–56.
[5] Average annual production 1954–56.
[6] Includes superpurity: 1952–56 (average), 217 tons; 1957, 650; 1958, 514; 1959, 1,122; 1960, 2,187; and 1961 1,293.
[7] Average annual production 1955–56.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

TABLE 15.—Producers of aluminum

(Short tons)

FREE WORLD

Country, company, and plant location	Annual capacity, 1961	Participants
North America:		
Canada:		
Aluminum Company of Canada, Ltd.	----------	Subsidiary of Aluminium, Ltd. (Canadian).
Arvida (Quebec)	373,000	
Shawinigan Falls (Quebec)	70,000	
Isle Maligne (Quebec)	115,000	
Kitimat (British Columbia)	192,000	
Chryslum, Ltd.: Beauharnois (Quebec)	38,000	Aluminum Company of Canada, Ltd. and Chrysler Corp. of Canada
Canadian British Aluminium Co. Ltd.:		
Baie Comeau (Quebec)	90,000	Subsidiary of British Aluminium Co. Ltd.
Total	878,000	
United States total [1]	2,483,750	
Total North America	3,361,750	
South America:		
Brazil:		
Aluminio Minas Gerais, S. A.	----------	Subsidiary of Aluminium, Ltd. (Canadian).
Ouro Preto (Minas Gerais)	14,300	
Companhia Brasileira do Aluminio: São Paulo	11,000	Industrias Votorantim, S. A., 80 percent, and other Brazilian interests, 20 percent.
Total South America	25,300	
Europe:		
Austria:		
Salzburger Aluminium G.m.b.H.: Lend	11,000	Subsidiary of Aluminium-Industrie, A. G. (AIAG), Swiss.
Vereinigte Aluminium Werke A. G.:		
Ranshofen	74,000	Government-owned.
Total	85,000	
France:		
Péchiney, Compagnie de Produits Chimique et Electrometallurgiques.	----------	Privately owned (French).
Chedde (Haute-Savoie)	5,600	
La Praz (Savoie)	3,000	
La Saussaz (Savoie)	9,500	
St. Jean de Maurienne (Savoie)	73,300	
L'Argentiere (Hautes-Alpes)	17,500	
Riouperoux (Isère)	11,700	
Auzat (Ariège)	18,000	
Sabart (Ariège)	17,600	
Noguères (Hautes-Pyrennés)	99,200	
Soc. d'Electro-Chimie, d'Electro-Métallurgie et des Acieries Electriques d'Ugine.	----------	Do.
Venthon (Savoie)	17,600	
Lannemezan (Hautes-Pyrennés)	41,900	
Total	314,900	
Germany, West:		
Aluminium G.m.b.H.: Rheinfelden (Baden)	49,500	Subsidiary of Swiss AIAG.
Vereinigte Aluminium Werke A. G.	----------	Government owned.
Erftwerk, Grevenbroich	31,000	
Innwerk, Toging	58,300	
Lippewerke, Lunen	42,000	
Total	180,800	
Italy:		
Montecatini, Soc. Generale per l'Industria Mineraria e Chimica.	----------	Privately owned (Italian).
Mori	13,200	
Bolzano	45,700	
Soc. Alluminio Veneto per Azioni (SAVA): Porto Marghera.	30,000	Subsidiary of Swiss AIAG.
Soc. dell'Alluminio Italiano (SAI): Borgofranco, d'Ivrea.	6,100	Subsidiary of Aluminium, Ltd (Canadian).
Total	95,000	

See footnotes at end of table.

TABLE 15.—Producers of aluminum—Continued

(Short tons)

FREE WORLD

Country, company, and plant location	Annual capacity, 1961	Participants
Europe—Continued		
Norway:		
A/S Aardal og Sunndal Verk		Government-owned.
Aardal	108,100	
Sunndalsora	55,000	
Det Norske Nitrid A/S		Aluminium, Ltd. (Canadian), 50 percent, and British Aluminium Co., 50 percent.
Eydehavn	10,200	
Tyssedal	19,300	
Norsk Aluminium A/S, Hoyanger	15,400	Aluminium, Ltd. (Canadian), 50 percent, and privately owned (Norwegian), 50 percent.
Mosjøen Aluminium A/S, Mosjøen	35,300	Swiss AIAG, 33⅓ percent, and A/S Elektrochemisk (Norwegian), 66⅔ percent.
Total	243,300	
Spain:		
Empresa Nacional del Aluminio, S. A		Spanish companies with majority government participation.
Valladolid	12,100	
Aviles	8,200	
Aluminio Español, S. A.: Sabinanigo (Huesca).	6,600	Pèchiney (French), 85 percent, and Kaiser Aluminum & Chemical Corp. (American), 15 percent.
Aluminio de Galicia, La Coruna	8,800	Péchiney (French) and Kaiser (American), 30 percent, and Spanish interests, 70 percent.
Total	35,700	
Sweden:		
A/B Svenska Aluminiumkompaniet		Privately owned (Swedish), 50 percent, and Aluminium, Ltd. (Canadian), 50 percent.
Mansbo	2,400	
Kubikenborg	14,300	
Total	16,700	
Switzerland:		
Aluminium Industrie A.G. (AIAG): Chippis	30,800	Privately owned (Swiss).
Usine d'Aluminium de Martigny, S.A.: Martigny.	5,500	Do.
Total	36,300	
United Kingdom:		
British Aluminium Co., Ltd		Tube Investments, Ltd. (British), 47 percent; Reynolds Metals Co. (American), 45 percent; Reynolds Tube Investments, Ltd., 4 percent; and miscellaneous shareholders 4 percent.
Kinlochleven	11,200	
Lochaber	28,000	
Total	39,200	
Yugoslavia:		
State concerns		Government-owned.
Razine	4,500	
Lozovac	4,000	
Strnisce (Kidricevo)	33,000	
Total	41,500	
Total Europe	1,088,400	
Asia:		
India:		
Aluminium Corp. of India, Ltd.: Asansol	2,800	Privately owned (Indian).
Indian Aluminium Co., Ltd		Aluminium, Ltd. (Canadian), 65 percent, and Indian-owned, 35 percent.
Alwaye	11,000	
Hirakud	22,400	
Hindustan Aluminium Corp. Ltd.: Rihand	22,400	Birla interests (Indian), 73 percent, and Kaiser Aluminum & Chemical Corp. (American), 27 percent.
Total	58,600	

See footnotes at end of table.

TABLE 15.—Producers of aluminum—Continued

(Short tons)

FREE WORLD

Country, company, and plant location	Annual capacity, 1961	Participants
Asia—Continued		
Japan:		
Showa Denko K.K. (Showa Electro-Chemical Industry Co., Ltd.)	----------	Privately owned (Japanese).
Kitikata	37,500	
Omachi	13,300	
Nippon Keikinzoku K.K. (Japan Light Metals Co.)	----------	Aluminium, Ltd. (Canadian), 50 percent, and privately owned (Japanese), 50 percent.
Kambara	62,600	
Niigata	34,200	
Sumitomo Kagaku K.K. (Sumitomo Chemical Co. Ltd.)	----------	Privately owned (Japanese).
Kikumoto	34,200	
Nagoya	15,800	
Total	197,600	
Taiwan: Taiwan Aluminium Corp.: Takao	15,400	Government-owned.
Total Asia	271,600	
Africa: Cameroun: Cie. Camerounaise de l'Aluminium Péchiney-Ugine (ALUCAM): Edea.	49,500	Péchiney-Ugine (French), Caisse Centrale de la France d'Outremer (French), and Cameroun Government.
Oceania: Australia: Comalco Industries, Pty., Ltd.: Bell Bay, Tasmania.	14,500	Tasmanian government, ⅓; Consolidated Zinc Corp. Ltd. (Australian), ⅔.
Total free world	4,811,050	

SOVIET BLOC [2]

U.S.S.R.: Soviet Aluminium Trust	----------	Government-owned.
Kamensk-Uralskiy	132,000	
Kandalakaha	27,500	
Krasnotourinsk-Bogoslovsk	137,500	
Stalinsk	132,000	
Volkhov	49,500	
Yerevan (Erivan)	27,500	
Zaporozhye (Dneprovskiy)	110,000	
Sumgait	77,000	
Nadvoitsy	22,000	
Stalingrad	220,500	
Total U.S.S.R.	935,500	
Czechoslovakia: Ziar Aluminium Works: Svaty Kriz.	55,000	Do.
Germany: East: Elektrochemisches Kombinat: Bitterfeld.	38,500	Do.
Hungary: Magyarsoviet Bauxit Ipar	----------	Do.
Felsogalla-Totis	16,500	
Ajka	16,500	
Inota	33,000	
Total	66,000	
Poland: Skawina Aluminium Works	50,000	Do.
China: Nationalized plants	77,600	Do.
North Korea	(3)	
Total, Soviet bloc	1,222,600	
Total, world	6,033,650	

[1] For breakdown of companies and plants, see table 4 of this chapter.
[2] In a number of instances it was impossible to confirm the data on plants of the Soviet bloc.
[3] Data not available.

TABLE 16.—World capacity of superpure aluminum

(Short tons)

Country and company	Location	Capacity
North America:		
Canada: Aluminum Company of Canada, Ltd	Arvida, Quebec	[1] 1,100
United States:		
Consolidated Aluminum Corp	Jackson, Tenn	2,100
Kaiser Aluminum & Chemical Corp	Mead, Wash	2,580
Reynolds Metals Co	Listerhill, Ala	600
Aluminum Company of America	Badin, N.C	1,500
Total		6,780
Europe:		
France: Péchiney, Cie. de Produits Chimiques et Electrométallurgiques.	Mercus	4,079
Germany:		
Aluminium G.m.b.H	Rheinfelden	1,929
Vereinigte Aluminium Werke, A. G	Erftwerk	3,858
Total		5,787
Italy: Soc. Alluminio Veneto per Azioni	Porto Marghera	183
Norway: A/S Vigeland Brug	Vigeland	2,976
Switzerland: Aluminium Industrie, A.G	Chippis	2,205
United Kingdom: British Aluminium Co., Ltd	Foyers	1,000
U.S.S.R.: Soviet Aluminum Trust	Volkhov	3,300
Asia: Japan:		
Nippon Keikinzoku K.K	Kambara	2,756
Sumitomo Kagaku K.K	Kikumoto	
Total		30,166

[1] Estimate.

NORTH AMERICA

Canada.—Aluminum Company of Canada, Ltd. (Alcan), operated at 73 percent of capacity compared with 85 percent in 1960. A rockslide within the Kemano water tunnel caused the closing of the Kitimat smelter from June to September. Normal production at the plant was not reached again until November.

Canadian British Aluminium Co., Ltd., announced that construction of an additional 45,000-ton potline at the Baie Comeau smelter was to start in 1963, in order to bring the additional capacity into operation by July 1965. The Aluminium, Ltd., contract for the exchange of alumina with Canadian British Aluminium Co., Ltd., expired by cancellation on December 31.

Mexico.—Construction of an aluminum plant by Reynolds Alumino, S.A., was begun in June 1961 and was scheduled for completion in 1962. The plant was to have a capacity of 22,000 short tons.

SOUTH AMERICA

Argentina.—The Argentine Government authorized Kaiser to build a 22,000-ton aluminum plant at Puerto Madryn in Patagonia.[36] Fabrica Argentina de Alumina, S.A., was formed by Kaiser to operate the plant. Alumina was to be imported for the plant which was scheduled for completion within 2½ years. Natural gas was to be used as fuel. Alcoa and Reynolds also were interested in establishing aluminum plants in Argentina.

[36] Metal Bulletin (London). Kaiser Aluminum in Patagonia. No. 4651, Dec. 1, 1961, p. 17.

Industrias Siderugicas Grassi, S.A., announced plans to build alumina and aluminum plants in southern Mendoza Province. The aluminum plant was to have a capacity of 11,000 short tons a year.

EUROPE

Consumption of aluminum in the countries of the Organisation for European Economic Cooperation increased 16 percent in 1960 over 1959. Of the four principal consumers, West Germany showed an increase of 28 percent; Italy, 25 percent; the United Kingdom, 14 percent; and France, 11 percent. Virtually the same use pattern was followed in 1960, with transportation accounting for 28 percent of the aluminum consumed; electrical engineering, 13 percent; packaging, machinery and equipment, building and construction, each 10 percent; and home and office appliances, 8 percent.

TABLE 17.—Aluminum consumption, by end use, 1960 [1]

(Short tons)

	West Germany	France	Italy	United Kingdom	All other [2]	Total
Transportation	108,026	74,201	62,832	122,769	16,336	384,164
Machinery and equipment	52,029	22,073	10,472	29,379	18,722	132,675
Electrical engineering	64,926	34,169	11,574	38,883	25,376	174,928
Building and construction	26,896	16,861	15,432	34,751	40,582	134,522
Packaging	43,541	24,026	14,881	32,226	20,086	134,760
Home and office appliances	17,417	22,967	12,126	40,792	19,713	113,015
All other [3]	97,114	46,441	23,259	88,585	22,611	278,010
Total	409,949	240,738	150,576	387,385	163,426	1,352,074

[1] Organisation for European Economic Cooperation and Development. Non-Ferrous Metal Statistics. November 1961, pp. 138–139.
[2] Includes Netherlands, Austria, Norway, Belgium, and Switzerland.
[3] Includes chemical, food, and agricultural appliances; powder; iron, steel, and other metal-producing industries; metal industries not elsewhere specified; and miscellaneous.

Hungary.—Three articles tracing the development of the aluminum industry in Hungary were published.[37] Information was presented pertaining to the alumina-production facilities, electrolytic aluminum reduction plants, and aluminum-fabrication facilities.

Italy.—Aluminum production was less than 1 percent below that of 1960, but imports of primary aluminum declined 27 percent from 32,777 short tons to 23,948 tons and exports declined 98 percent from 1,002 to 19 tons. Imports included 8,250 tons from Canada, 5,408 tons from Norway, 4,266 tons from the United States, 2,491 tons from France, and 2,809 tons from Austria.

Montecatini, Soc. Generale per l'Industria Mineraria e Chimica, considered building a 110,000-short-ton aluminum plant in Sardinia at a cost of US $60 million.[38] Kaiser also was interested in building a

[37] Metal Bulletin (London). Aluminium in Hungary: 1. The Alumina Industry. No. 4603, June 13, 1961, pp. i, iv; 2. Hungarian Smelters. No. 4609, July 4, 1961, pp. i, iv; and 3. The Semis Industry. No. 4613, July 18, 1961, pp. i, iv.
[38] American Metal Market. Italy Maps Major Aluminum Expansion. V. 68, No. 231, Dec. 4, 1961, pp. 1, 21.
Metal Bulletin (London). Italian Aluminium Smelters. No. 4650, Nov. 28, 1961, p. 21.

plant in Sardinia. Reynolds and the State-controlled Finmeccanica group were negotiating for the construction of an aluminum plant in Trieste.

Norway.—A/S Aardal og Sunndal Verk produced a record 125,700 short tons of aluminum in 1961 in spite of a power shortage at one of its plants. Expansion of the Aardal plant from 69,600 tons to 110,000 tons was nearly complete at yearend. Thirty-six of the 168 new furnaces were operating, and the remaining furnaces were to begin as power became available. Capacity of the Sunndal plant was being increased by technical improvements rather than by expansion.[39]

The proposed aluminum plant to be built by Norsk Hydro Elektrisk on the island of Karmoy was to be completed in several stages, the first of which would have a capacity of 33,000 short tons a year and cost US$28 million.

Expansion of the Mosjøen plant from 35,000 tons to 56,000 tons a year was scheduled for completion by mid-1963.

Poland.—Péchiney signed a contract with Centrozap, the Polish State body, to assist in building an aluminum plant at Konin. The plant, with a capacity of 105,000 short tons a year, was to be built in two stages, with production beginning in 1965 and completion of the plant by 1968.[40] Although capacity of the Skawina plant was rated at 50,000 short tons, it was stated that it could produce as high as 55,000 tons a year.

Sweden.—Svenska Aluminium Co. planned to double capacity of its Kubikenborg plant to 29,000 short tons a year by 1963. Aluminium Industrie, A.G., of Switzerland, agreed to make available to the company plans of its latest electrolytic cells and to give technical advice.[41]

ASIA

India.—The Planning Commission revised the original Third Plan aluminum-production target from 98,000 short tons to 159,000 tons.[42] The original plan included doubling the annual capacity of the Indian Aluminium Co., Ltd., Alwaye plant to 11,200 short tons and the Hirakud plant to 22,400 tons; the trebling of the Aluminium Corp. of India, Ltd., capacity to 8,400 tons; completion of the Hindustan Aluminium Corp., Ltd., project at Pipri, near Rihand in Uttar Pradesh, 22,400 tons; installation of the Koyna plant in Maharashtra, 22,400 tons; and installation of the Madras Aluminium Company plant near Mettur in Madras State, 11,200 tons. The revised plan provided for the installation of two new plants, one at Dandeli in Mysore State, 33,600 tons annually, and the other at Madhya Pradesh, 28,000 tons.

Preliminary work on the Madras plant was started in March 1961, with production scheduled to begin in 1963. Madras Aluminium Co., Ltd., which will operate the plant, was formed through the joint participation of the Indian Government, private groups, and Montecatini.

The Hirakud plant of Indian Aluminium Co., Ltd., completed increasing annual capacity from 11,200 tons to 22,400 tons in Novem-

[39] American Metal Market. Norwegian State-Owned Works Had Record Output in 1961. V. 69, No. 5, Jan. 8, 1962, p. 11.
[40] Metal Bulletin (London). Péchiney in Poland. No. 4640, Oct. 24, 1961, p. 23.
[41] Metal Bulletin (London). Swiss/Swedish Cooperation. No. 4649, Nov. 24, 1961, p. 23.
[42] Bureau of Mines. Mineral Trade Notes. V. 54, No. 4, April 1962, pp. 3–4.

ber 1961, but only 40 of the 80 cells installed were operating because of insufficient power.

Japan.—Production of primary aluminum totaled 169,400 short tons, of which 1,293 tons was superpure aluminum, compared with 146,900 and 2,188 tons respectively, in 1960. The Sumitomo Kagaku K.K. (Sumitomo Chemical Co., Ltd.) plant at Nagoya began producing in October 1961 at the rate of 600 tons monthly.

Mitsubishi Chemical Industries, Ltd., began constructing an aluminum plant with an annual capacity of 55,100 short tons at Naoyetsu, Niigata Prefecture, in northern Japan. The plant was to be built in two stages—the first to be completed by September 1962 and the other by September 1964. The company concluded contracts with Péchiney of France and Eletrokemisk A/S of Norway for technical assistance. Bauxite was to be imported from Western Mining Corp., Ltd. in Australia. The Japanese Government approved a joint venture of Mitsubishi Chemical Industries, Ltd., and Reynolds to establish an aluminum company, Mitsubishi Reynolds Aluminum Co. An aluminum plant with a monthly production of 2,750 to 3,300 tons of aluminum products was to be built in Saitama Prefecture by the end of 1963.

Nissho Steel Manufacturing Co., Ltd., Yawata Iron and Steel Co., Ltd., Kinoshita Sansho Co., and Kaiser were seeking approval for the establishment of an aluminum plant at Tsurusaka, Kyushu. Kaiser was to supply technical assistance and 25 to 30 percent of the capital.

An article listed the following problems facing the Japanese aluminum industry: (1) Geographical disadvantage and price competition, (2) expansion programs, and (3) effect of new capacity upon the industry.[43]

AFRICA

Ghana.—Shortly before the end of 1961, the United States, after receiving guarantees that the investment would be protected against future expropriation, agreed to guarantee loans to Ghana for building the Volta River Dam and an aluminum plant. The United Kingdom would provide $14 million, the United States, $34 million, and the International Bank for Reconstruction and Development, $28 million. Ghana would provide the remaining $84 million.

The Government also signed an agreement with the Soviet Union to build a smaller dam at Bui.[44]

OCEANIA

Australia.—Alcoa of Australia, Pty., Ltd., was created by Alcoa (51 percent), Western Mining Corp. (20 percent), Broken Hill South, Ltd. (17 percent), and North Broken Hill, Ltd. (12 percent), to establish and operate a $100 million aluminum project. The program called for mining bauxite in the Darling Ranges, an alumina plant at Kwinana, Western Australia, and an aluminum plant of Geelong,

[43] Industrial Bank of Japan, Ltd. Problems of the Japanese Aluminum Industry. Survey of Japanese Finance and Industry, v. 8, No. 6, November/December 1961, pp. 9–14.
[44] West African Review (London). Volta—Ghana's Power House. V. 32, No. 407, November 1961, pp. 12–17.

Victoria. The company was scheduled to begin operations in mid-1963.[45]

Comalco Industries, Pty., Ltd., reported improved operating efficiencies which raised production of aluminum to over 14,000 short tons a year. Expansion underway would bring annual capacity by 1963 to 35,800 short tons. Conversion of the Soderberg furnace to the prebaked anode type being installed may add a further 11,200 tons a year to the capacity.

Developments planned by three major groups, Alcoa, British Aluminum/Alcan, and Comalco, for the aluminum industry in Australia and New Zealand were summarized.[46]

TECHNOLOGY

Information relating to a new aluminum extraction and reduction process was released by Péchiney in Paris. The new process involves the carbothermic reduction of aluminum oxide yielding a metal of normal purity, but with a much lower titanium content than that obtained by normal practice.[47] The process consists of two stages: (1) Production of pure corundum in an electric furnace by carbothermic reduction of bauxite; and (2) further reduction of the corundum to aluminum metal in an electric furnace in the presence of carbon. The aluminum is separated from the metal carbide mixture, and the aluminum carbide remaining can be recycled for subsequent reduction. A pilot plant had been expected to be in full operation during 1961 at an annual capacity of 3,000 to 5,000 tons, but by the end of the year no announcement had been made confirming operation of the plant.

A review of patent literature related to various electrothermal processes for production of aluminum was published.[48] The review covered aspects of the subhalide, carbide, and nitride processes and provided background information on chemical reaction, principles, raw materials, equipment design, and methods of preparing the aluminum compounds involved. Each of these processes was known to have been scheduled for investigation by various aluminum companies on pilot plant scale during 1961; however, only general details of the processes were issued during the year.

Another investigation, utilizing the subhalide reaction for recovering aluminum from crude aluminum-silicon alloys, was reported by the Federal Bureau of Mines.[49] Aluminum contained in the crude material was reacted at low pressure (6 mm) and high temperature (1,100° C) with vaporized aluminum trichloride, forming aluminum monochloride vapor, which reverts to aluminum and aluminum trichloride when cooled to 900° C or less.

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[45] Mining Journal (London). Another Aluminium Complex for Australia. V. 256, No. 6566, June 23, 1961, pp. 713, 715.

[46] Wardrop, Robert. Survey of Aluminium Industry. Min. & Chem. Eng. Rev., Melbourne, Australia, v. 54, No. 1, Oct. 16, 1961, pp. 52–61.

[47] Journal of Metals, v. 13, No. 1, January 1961, p. 16.

[48] Herrmann, E. Die Elektrothermische Gewinnung von Aluminium im Lichte des Patentschrifttuns [The Electrothermal Production of Aluminum in the Light of Patent Literature]. Aluminium, v. 37, No. 3, March 1961, pp. 143–149; v. 37, No. 4, April 1961, pp. 215–221.

[49] Yerkes, Leland A., and Oliver C. Fursman. Refining Crude Aluminum by the Subhalide Reaction. BuMines Rept. of Inv. 5773, 1961, 19 pp.

Molten zinc condensed from zinc vapor was used to leach aluminum from an aluminum-silicon alloy made by carbothermic reduction of silicious aluminum ores.[50] Extraction efficiency increased as the system pressure was reduced. Zinc vapor was proved to be a better extracting agent than molten zinc.

Refining of aluminum using an organoaluminum electrolyte was described.[51] Mass spectroscopic investigations indicated that the aluminum prepared by this method was the purest ever obtained. However, the low conductivity of the electrolyte limited the rate at which the metal could be produced.

A review of the properties of superpure aluminum prepared by zone-melting technique was published.[52]

Kaiser Aluminum & Chemical Corp. and British Aluminium Co., Ltd., announced the successful joint development of a modified type of aluminum reduction cell which utilized refractory hard metal compounds as electrodes.[53] The development could lead to an improvement of up to 15 percent in cell operation, either by a decrease in the energy consumption per pound of metal or by an increase in metal output per pot. Typical refractory hard metals considered for this application were the carbides and diborides of titanium and zirconium. Another technique that was reported which could result in increased production from the Hall cell was the use of an electrolyte containing lithium fluoride.[54] If both the refractory hard metals and improved electrolyte prove satisfactory the total increase in production capability per cell could be as high as 55 percent when operating at a high rate of production.

A newly designed plant for production of an improved form of carbon pitch for use in prebaked anodes (used in producing aluminum) was constructed by Koppers Co., Inc., and began operating in Fontana, Calif., in 1961.[55] In the plant, carbon pitch derived from coal tar is extruded into pencil shapes which are added to calcined petroleum coke, made into a paste, and baked into an anode for electrolytic cell operation.

A method permitting recovery of fluorine and aluminum compounds from aluminum plant residues through application of mineral beneficiation techniques was reported.[56]

Research and technical progress in the various aspects of aluminum metallurgy in the United States and the United Kingdom during 1961 were reviewed.[57] Particular attention was given to production,

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[50] Caldwell, H. S., Jr., and M. J. Spendlove. Using Molten Zinc to Extract Aluminum From Aluminum-Silicon Alloys. A Progress Report. BuMines Rept. of Inv. 5781, 1961, 15 pp.

[51] Boehm, A., H. Ginsberg, and W. Reuter. Electrolytic Refining of Aluminum Using an Organoaluminum Electrolyte. Aluminium, v. 37, No. 5, May 1961, pp. 267–273.

[52] Chandron, Gedraes. Propriétés nouvelles de l'aluminium de très haute Pureté, Revue de L'Aluminium, No. 288, June 1961, pp. 755–762.

[53] Metallurgia, v. 64, No. 386, December 1961, pp. 289–290.
Iron Age, v. 188, No. 24, Dec. 14, 1961, p. 162.
American Metal Market, v. 68, No. 233, Dec. 6, 1961, pp. 1, 10.

[54] American Metal Market. Aluminum Producers Studying Process To Lift Production 55%. V. 68, No. 236, Dec. 11, 1961, pp. 1, 20.

[55] Modern Metals. Carbon Pitch in New Form Aids Aluminum Producers. V. 17, No. 9, October 1961, p. 76.

[56] McClain, R. S., G. V. Sullivan, and W. A. Stickney. Recovering Aluminum and Fluorine Compounds from Aluminum Plant Residues. BuMines Rept. of Inv. 5777, 1961, 16 pp.

[57] Elliott, E. Aluminum and Its Alloys in 1961. Part 1. Metallurgia, v. 65, No. 388, February 1962, pp. 59–64, 73; Part 2, v. 65, No. 389, March 1962, pp. 112–123.

melting and casting, working, joining, alloy systems, properties, corrosion and protection, applications and standards. Nearly 300 references were included in the bibliography.

As the technology of casting aluminum advanced, numerous articles were published describing diecasting, permanent mold, sand and plaster mold, and low-pressure casting techniques.[58]

Descriptions of types of gating and risering systems for permanent mold and die casting of aluminum were reviewed.[59]

Casting of superpure aluminum metal under vacuum produced a die-cast product that was successfully color anodized.[60]

A systematic investigation to determine the optimum refining procedures for producing hyper-eutectic aluminum-silicon casting alloys was carried out and the results published.[61] Factors which would affect the production of castings with satisfactory microstructures and mechanical strength were given.

Furnaces, alloys, and techniques employed in continuous casting of aluminum alloys were discussed.[62] Basic aspects of the vertical fixed-mold, direct-chill casting process for the production of good quality, high-strength aluminum-alloy ingots up to 36 inches in diameter and rectangular slabs up to 40 by 10 inches were given.

The fourth revision of a manual on aluminum fabrication was published.[63] It presented data on mechanical, physical, and other properties of the metal; standard tolerances and other useful information on standard aluminum alloys and the mill products normally produced from these allowances also were included.

Guides for selection of proper alloy, temper, and processing procedures for producing aluminum bumpers, wheel covers, trim, and automotive body components were released.[64] Suggested processes and finish specifications for preparing aluminum alloys were given.

The use of ultrasonics in casting and aging of aluminum alloys was reported by Russian researchers.[65] Hot shrinkage cracking was reduced by vibrating the mold in the 50- to 800-cycle-per-second range. An increase in hardness also was noted. Ultrasonic aging at room temperature resulted in reducing the aging period from 60 minutes to 5 minutes.

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[58] Butler, W. R., and S. L. Fahnestock. Which Aluminum Casting Process. Modern Metals, v. 17, No. 5, June 1961, pp. 42, 44, 46. Eshelman, R. H. Aluminum Casting Processes Vie for Automotive Jobs. Iron Age, v. 88, No. 23, Dec. 7, 1961. Foss, F. William. Aluminum Diecastings. Foundry, v. 89, No. 8, August 1961, pp. 56–59. Foundry. Aluminum Castings. V. 89, No. 5, May 1961, pp. 124–129. Le Jeune, F. H. Low Pressure Casting Process Produces Integral Wheel-Brake Drum Assembly. Modern Metals, v. 17, No. 5, June 1961, pp. 64–66. Miske, Jack C. Automatic Pouring of Aluminum Sand Casting. Foundry, v. 89, No. 1, January 1961, pp. 78–81. Modern Metals. How General Motors Casts Aluminum V–8 Engine Blocks. V. 17, No. 10, November 1961, pp, 68, 70.

[59] Foundry. Gating. V. 89, No. 8, August 1961, pp. 38–41. Foundry. Risering. V. 89, No. 9, September 1961, pp. 71–73. Metal Industry. Gating Aluminum Die-Castings. V. 97, No. 27, Dec. 30, 1960, pp. 542–543.

[60] Modern Metals. Vacuum Process Produces Super Purity Die-Castings That Can Be Anodized. V. 17, No. 5, June 1961, pp. 58, 60, 62–63.

[61] Ashton, S. J., J. Muir, and W. M. Doyle. Hyper-Eutectic Aluminum Silicon Casting Alloys. Metal Industry (London), v. 98, No. 7, Feb. 17, 1961, pp. 123–125; No. 8, Feb. 24, 1961, pp. 143–146; No. 9, Mar. 3, 1961, pp. 171–172.

[62] Doyle, W. M. Continuous Casting of Aluminum Alloys. Part I. Metal Ind., v. 99, No. 5, Aug. 4, 1961, pp. 82–85; Part II. V. 99, No. 6, Aug. 11, 1961, pp. 102–104; Part III. V. 99, No. 7, Aug. 18, 1961, pp. 132–133.

[63] Aluminum Association. Standards for Wrought Aluminum Mill Prdoucts. New York, N.Y., 4th rev., August 1961, 107 pp.

[64] Metal Progress. Forming and Finishing Aluminum Auto Trim. V. 80, No. 1, July 1961, pp. 67–72. Phipps, Harry E. Aluminum in Automotive Parts. Modern Metals, v. 17, No. 8, September 1961, pp. 56, 58, 62, 64.

[65] Tesmen, Arthur B. How the Russians Are Using Ultrasonics in Metallurgy. Metal Prog., v. 79, No. 1, January 1961, pp. 79–83.

Factors affecting the formability of aluminum were discussed and advances in press brake bending and magnetic metal-forming processes were explained.[66] Developments in the forming of aluminum sheet into complex shapes by metal spinning, deep drawing, pressing, high-energy forming, and stretch forming were reviewed.[67]

Several varieties of aluminum sheet were developed. Sheets coated with vinyl, cardboard, stainless steel, and rubber, and pre-enameled sheets were prepared for a variety of applications.[68]

A technique was developed that permitted commercial production of foamed aluminum.[69] The new material floats on water and is 12 times lighter than solid aluminum. The basic procedure for making the foamed aluminum consisted of adding a suitable foaming agent to a pool of molten metal, mixing thoroughly, and pouring into a mold to obtain the required shape. The industrial producers were licensed by the originators of the process, Bjorksten Research Laboratories, Inc., Madison, Wis.

Sintered aluminum materials containing boron or rare earth oxides for use in atomic reactors were produced in various fabricated forms.[70] Physical properties of the powder-metallurgy product equaled or exceeded those of cast and wrought alloy of the same composition.

The potential roles of aluminum and its alloys in rockets and satellites for space exploration were discussed.[71] The strength-to-weight ratio at ordinary temperatures, no diminution of desirable properties at very low temperatures, and a combination of useful physical and chemical characteristics, together with reworkable versatility when fabricated, emphasized the advantages the metal has for these applications. Pressure vessels for liquid propellants and rocket casings largely were made of aluminum alloys.

Very fine aluminum powder provided propellant energy for various rocket systems, including the Polaris, Pershing, Scout, and Mace.[72] Addition of aluminum powder to the solid fuel mixes greatly increased the propellant's thrust. Powder ranging from 5 to 8 microns in particle size was employed.

Information on safety precautions necessary during the production and storage of powders of aluminum and magnesium and their alloys was released.[73] Advice was given on the layout and construction of buildings, the use of explosion reliefs, and preparation or handling of the dusts in an inert atmosphere.

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[66] Ridout, Robert A. Factors Affecting the Formability of Aluminum. Modern Metals, v. 17, No. 11, December 1961, pp. 50, 52, 54–55, 57.

[67] Eldridge, G. W. Developments in the Forming of Aluminum Sheet. Metallurgia, v. 63, No. 376, February 1961, pp. 71–77.

[68] American Metal Market, v. 68, No. 58, Mar. 27, 1961, pp. 1, 20; No. 76, Apr. 21, 1961, pp. 1, 16; No. 92, May 15, 1961, p. 8; No. 174, Sept. 11, 1961, p. 10. Modern Metals. Stainless Clads Aluminum Via Molecular Bonding. V. 17, July 1961, p. 86.

[69] Industrial and Engineering Chemistry. Structural Foams. V. 53, No. 1, January 1961, pp. 64A–66A.

[70] Metal Industry. Sintered Reactor Materials. V. 98, No. 3, January 1961, pp. 49–50.

[71] Metal Industry. Metals in Space Technology. V. 99, No. 26, Dec. 29, 1961, pp. 519–520, 522.

[72] Modern Metals. Aluminum Powder Used in Solid Rocket Fuel. V. 17, No. 8, September 1961, p. 84.

[73] Metal Industry. Aluminum and Magnesium Powders. V. 99, No. 13, Sept. 29, 1961, p. 253.

Apex Smelting Co. announced development of new refining and alloying procedures which produce an aluminum die casting ingot with superior physical properties.[74]

A new type scrap-melting furnace was described[75] into which an entire aluminum fuselage could be inserted and heated to a temperature at which the aluminum would melt and the ferrous and other nonferrous parts would fall to the floor of the furnace separated from the aluminum. The average length of the fuselage sections was 23 feet, and they weighed between 3,000 and 3,500 lbs.

A text was published summarizing elevated-temperature tensile and creep-rupture properties of commercially available aluminum and magnesium alloys that would normally be used at elevated temperatures.[76] It included designations, chemical compositions, and pertinent specifications under which various forms of the material were supplied in both wrought and cast alloys.

Tensile properties of several aluminum alloys were found to increase as the temperature of application was reduced from room temperature to as low as −423°F. (liquid hydrogen).[77] All the alloys tested had good ductility and notch toughness at cryogenic temperatures. They did not reveal a transition from ductile to brittle behavior as the temperature was lowered. On the basis of yield strength-to-density ratios, the aluminum alloys showed some advantage over annealed stainless steel at very low temperatures.

A compilation of 22 properties of metals, alloys, and nonmetallic materials at cryogenic temperatures was released.[78] The paper included aluminum metal and aluminum alloys containing copper, magnesium, and manganese.

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[74] Schiffer, D. A. Aluminum Smelter Must Learn To Live With Conditions. Scrap Age, v. 18, No. 12, December 1961, pp. 64, 66.

[75] Iron Age. Lift Truck Speeds Reclamation of Scrap-Aluminum Aircraft. V. 187, No. 12, Mar. 23, 1961, p. 86–87.

[76] Materials in Design Engineering. Cryogenic Strength of Aluminum. V. 54, No. 6, November 1961, p. 49.

[77] Rice, L. F., J. E. Campbell, and W. F. Simmons. Tensile Behavior of the 5000 Series Aluminum Alloys at Room and Cryogenic Temperatures. Light Metal Age, v. 19, No. 9, 10, October 1961, pp. 9–10.

[78] Eldridge, E. A., and H. W. Deem. Report on Physical Properties of Metals and Alloys From Cryogenic to Elevated Temperatures. ASTM Special Technical Publication 296, April 1961, 206 pp.

Antimony

By Richard N. Spencer [1] and Edith E. den Hartog [2]

PRIMARY smelter production of antimony increased in 1961, secondary smelter production decreased, imports and exports declined, mine production remained nearly constant, and consumption decreased slightly. The net effect of these actions was a decrease in stocks. Prices increased during the year.

Antimony remained on the list of commodities eligible for barter acquisition for the supplemental stockpile through the Commodity Credit Corporation (CCC), and 4,695 short tons of antimony was received in exchange for surplus agricultural commodities.

DOMESTIC PRODUCTION

MINE PRODUCTION

Domestic mines produced 689 tons of antimony, most of which was recovered in the form of impure cathode metal as a byproduct of processing silver-lead ores by the Sunshine Mining Co., Shoshone County, Idaho.

SMELTER PRODUCTION

Primary.—Smelter production of antimony was 11,300 short tons, and represented an increase of 14 percent over the corresponding 1960 production. The increase was the result of higher output of byproduct antimony from primary lead smelting. Smelter output was recovered from source materials as follows: 6 percent from domestic mines, 78 percent from foreign ores and concentrates, and 16 percent as byproduct antimony recovered from domestic lead ores. Byproduct antimony production from domestic and foreign ores was 32 percent of total production.

Of the domestic smelter output, 2,490 short tons or 22 percent of total production was recovered from domestic ores. Companies reporting primary antimony production were American Smelting & Refining Co., Foote Mineral Co., Harshaw Chemical Co., Hummel Chemical Co., McGean Chemical Co., National Lead Co., and Sunshine Mining Co.

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

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TABLE 1.—Salient antimony statistics

(Short tons)

	1952-56 (average)	1957	1958	1959	1960	1961
United States:						
Production:						
Primary:						
Mine	904	709	705	678	635	689
Smelter [1]	11,239	11,400	8,557	8,748	9,954	11,329
Secondary	23,123	22,565	19,515	20,043	20,104	19,466
Imports, general (antimony content)	11,739	15,265	9,878	13,273	[3] 14,519	13,942
Exports	101	68	86	174	906	44
Consumption [2]	16,896	12,389	11,880	13,317	[3] 13,271	12,697
Price: New York, average cents per pound	35.50	35.09	31.76	31.30	31.30	33.89
World: Production	52,400	56,000	51,000	59,000	61,000	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.
[3] Revised figure.

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
1952-56 (average)	3,885	22.2	904	[1]
1957	3,022	23.5	709	253
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

[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	
1952-56 (average)	2,633	5,286	109	887	2,324	11,239
1957	4,658	4,210	107	510	1,915	11,400
1958	2,833	3,825	84	319	1,496	8,557
1959	2,667	4,411	70	430	1,170	8,748
1960	3,665	5,188	60	385	656	9,954
1961	4,558	4,609	84	355	1,723	11,329

Secondary.—The recovery of secondary antimony was 19,500 short tons, compared with 20,100 tons in 1960. All secondary antimony was recovered from antimony-containing lead and tin scrap largely by secondary smelters. So far as is known, secondary metallic antimony was not produced in the United States; all secondary antimony was recovered in alloys. Primary and secondary lead smelters recovered 18,700 short tons of antimony from scrap, and manufacturers and

foundries reclaimed the remaining 800 tons. Battery plate scrap supplied 10,970 tons; type metal scrap, 3,300 tons; drosses, 2,600 tons; bearing metals, 1,200 tons; and antimonial lead scrap, 900 tons. Antimonial lead was produced from most of the battery-plate scrap. Secondary lead smelters used 1,525 tons of primary metallic antimony, in addition to antimony recovered from scrap, to make 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	1960	1961	Form of recovery	1960	1961
New scrap:			In antimonial lead [1]	12,594	12,418
Lead-base	2,590	2,638	In other lead alloys	7,483	7,017
Tin-base	67	72	In tin-base alloys	27	31
Total	2,657	2,710	Total	20,104	19,466
Old scrap:			Value (millions)	$12.6	$13.2
Lead-base	17,405	16,715			
Tin-base	42	41			
Total	17,447	16,756			
Grand total	20,104	19,466			

[1] Includes 919 tons of antimony recovered in antimonial lead from secondary sources at primary plants in 1960 and 171 tons in 1961.

TABLE 5.—Byproduct antimonial lead produced at primary lead refineries in the United States

(Short tons)

Year	Antimonial lead produced at primary lead refineries					
	Gross weight	Antimony content				
		From domestic ores [1]	From foreign ores [2]	From scrap	Total	
					Quantity	Percent
1952–56 (average)	62,264	1,564	760	1,547	3,871	6.3
1957	67,786	1,300	615	1,149	3,064	4.5
1958	50,246	811	685	1,307	2,803	5.6
1959	37,487	676	494	754	1,924	5.1
1960	30,230	456	200	919	1,575	5.2
1961	35,080	1,010	713	171	1,894	5.4

[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 12,700 tons, 4 percent below 1960 consumption. Consumption was fairly high during the first quarter, declined sharply during the second quarter, remained low during the third quarter, and increased abruptly in the fourth quarter. Consumption for all major uses followed the above trend. Antimonial lead was the largest consumption outlet. Bearings, type metal, sheet and pipe, and cable covering used appreciable

quantities of metallic antimony. The use of antimony oxide by the plastics industry again showed a substantial increase and was 21 percent over 1960 consumption for that use. The use of antimony oxides and compounds in ceramics and glass decreased 25 percent to 1,200 tons, and use in flameproofing chemicals and compounds decreased slightly.

TABLE 6.—Industrial consumption of primary antimony in the United States

(Shorts tons, antimony content)

Year	Class of material consumed						Total
	Ore and concentrate	Metal [1]	Oxide	Sulfide	Residues	Byproduct antimonial lead	
1952-56 (average)	1,257	5,710	6,608	110	887	2,324	16,896
1957	677	4,055	5,129	103	510	1,915	12,389
1958	515	4,179	5,283	88	319	1,496	11,880
1959	270	5,420	5,948	79	430	1,170	13,317
1960	226	[2] 5,892	6,033	78	386	656	[2] 13,271
1961	106	4,994	5,450	69	355	1,723	12,697

[1] Includes antimony in imported alloys.
[2] Revised figure.

TABLE 7.—Industrial consumption of primary antimony in the United States, by class of material produced

(Short tons, antimony content)

Product	1952-56 (average)	1957	1958	1959	1960	1961
Metal products:						
Ammunition	6	12	(1)	(1)	(1)	(1)
Antimonial lead [2]	6,584	4,233	3,698	4,141	[3] 4,398	4,708
Bearing metal and bearings	969	944	644	886	803	737
Cable covering	119	183	208	157	146	141
Castings	71	106	82	84	72	53
Collapsible tubes and foil	35	20	37	33	17	24
Sheet and pipe	187	258	273	202	202	147
Solder	153	90	100	113	130	97
Type metal [2]	1,215	607	877	883	580	448
Other	121	153	147	130	148	152
Total [2]	9,460	6,606	6,066	6,629	[3] 6,496	6,507
Nonmetal products:						
Ammunition primers	22	14	10	11	11	15
Fireworks	36	37	33	28	33	20
Flameproofing chemicals and compounds	1,567	760	758	1,033	1,177	1,138
Ceramics and glass	1,788	1,611	1,570	1,727	1,640	1,223
Matches	18	26	18	19	17	(1)
Pigments	1,406	1,085	1,047	1,167	1,282	845
Plastics	711	748	841	1,034	1,013	1,228
Rubber products	74	284	265	217	238	287
Other	1,814	1,218	1,272	1,452	1,364	1,434
Total	7,436	5,783	5,814	6,688	6,775	6,190
Grand total	16,896	12,389	11,880	13,317	[3] 13,271	12,697

[1] Included with "Other" to avoid disclosing individual company confidential data.
[2] Includes antimony content of imported antimonial lead consumed.
[3] Revised figures.

STOCKS

Yearend industrial stocks of antimony totaled 6,400 tons, 700 tons lower than those of the end of 1960. Government stocks of antimony metal on December 31, 1961, included 1,577 tons in the CCC inventory, 12,754 tons in the supplemental stockpile, and 30,301 tons in the national strategic stockpile, totaling 44,632 tons in all Government stockpiles. The basic stockpile objective was 44,000 tons and the maximum objective 70,000 tons. Total Government inventory of antimony was 101.4 percent of basic objectives and 63.3 percent of maximum objectives.

TABLE 8.—Industry stocks of primary antimony in the United States, Dec. 31

(Short tons, antimony content)

Stocks	1957	1958	1959	1960	1961
Ore and concentrate	2,337	3,052	2,884	2,356	850
Metal	1,300	1,232	1,422	1,346	1,680
Oxide	2,510	1,889	1,659	2,187	2,398
Sulfide	160	143	115	94	107
Residues and slags	746	565	685	938	873
Antimonial lead [1]	329	371	373	242	538
Total	7,382	7,252	7,138	7,163	6,446

[1] Inventories from primary sources at primary lead smelters only.

PRICES

The quoted price of RMM brand antimony metal, in cases, was 29.50 cents per pound f.o.b., Laredo, Tex., until April 3 at which time the price advanced to 33.00 cents. The New York equivalent prices were 31.30 cents and 34.75 cents, respectively. Foreign antimony prices increased steadily throughout the year on all classes of material and in close harmony with metal prices.

TABLE 9.—Antimony price ranges in 1961

Type of antimony:		*Price*
Domestic metal [1]	cents per pound	29.00–34.75
Foreign metal [2]	do	25.75–31.50
Antimony trioxide [3]	do	26.50–31.50
Antimony ore, [3] 50–55 percent	dollars per short-ton unit	2.70– 3.25
Antimony ore, minimum 60 percent	do	3.45– 4.25
Antimony ore, minimum 65 percent	do	3.60– 4.50

[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 13,900 short tons, compared with 14,500 tons during 1960, a decrease of 4 percent.

[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.

Imports of ore and concentrate and antimonial lead increased; all other classes of imports decreased slightly. Mexico supplied 51 percent of ore and concentrate imports; the Union of South Africa, 40 percent; and Bolivia, 5 percent. The major suppliers of metal were: Yugoslavia, 44 percent; the United Kingdom, 26 percent; Belgium-Luxembourg, 20 percent; and Peru, 6 percent. The antimony content of antimony oxide imports was 1,643 short tons; the United Kingdom and Belgium-Luxembourg were the principal suppliers. Government barter acquisitions accounted for 37 percent of general antimony imports.

TABLE 10.—U.S. imports[1] of antimony, by countries

Year and country	Antimony ore			Needle or liquated antimony		Antimony metal		Antimony oxide	
	Short tons (gross weight)	Antimony content		Short tons (gross weight)	Value (thousands)	Short tons	Value (thousands)	Short tons (gross weight)	Value (thousands)
		Short tons	Value (thousands)						
1952-56 (average)	16,418	6,906	$2,033	35	$17	3,441	$1,882	1,647	$769
1957	21,374	8,198	1,973	38	17	5,052	2,413	1,893	[2] 790
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:									
North America:									
Canada						[3]	15		
Guatemala	174	119	22						
Mexico	10,221	2,699	346			603	395		
Nicaragua	12	6	1						
Total	10,407	2,824	369			603	410		
South America:									
Bolivia [4]	1,528	974	216						
Chile [4]	269	177	34						
Peru [4]	99	57	14			90	31		
Total	1,896	1,208	264			90	31		
Europe:									
Belgium-Luxembourg				2	1	492	222	329	139
France						205	93	268	112
Germany, West						6	2	92	36
Netherlands								112	46
United Kingdom				22	10	1,868	795	1,567	639
Yugoslavia						2,140	928		
Total				24	11	4,711	2,040	2,368	972
Asia: Japan						[3]	[5]		
Africa:									
Algeria						33	14		
Mozambique	224	132	29						
Union of South Africa	3,879	2,291	552						
Total	4,103	2,423	581			33	14		
Grand total	16,406	6,455	1,214	24	11	5,437	2,495	2,368	972

See footnotes at end of table.

TABLE 10.—U.S. imports of antimony, by countries—Continued

Year and country	Antimony ore			Needle or liquated antimony		Antimony metal		Antimony oxide	
	Short tons (gross weight)	Antimony content		Short tons (gross weight)	Value (thousands)	Short tons	Value (thousands)	Short tons (gross weight)	Value (thousands)
		Short tons	Value (thousands)						
1961:									
North America:									
Canada						50	52	[3]	[5]
Guatemala	113	71	18						
Mexico	10,674	3,411	527			93	61		
Total	10,787	3,482	545			143	113	[3]	[5]
South America:									
Bolivia [4]	585	362	87			22	9		
Chile [4]	221	134	49						
Peru [4]	109	65	19			272	104		
Total	915	561	155			294	113		
Europe:									
Belgium-Luxembourg				1	[5]	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

[1] Data are general imports, that is, include antimony imported for immediate consumption plus material entering the country under bond. Table does not include antimony contained in lead-silver ores.
[2] Data known to be not comparable with other years.
[3] Less than 1 ton.
[4] Imports shown from Chile probably were mined in Bolivia or Peru and shipped from a port in Chile.
[5] Less than $1,000.

Source: Bureau of the Census.

TABLE 11.—U.S. imports for consumption of antimony [1]

Year	Antimony ore			Needle or liquated antimony		Antimony metal		Type metal and antimonial lead [2] (short tons)	Antimony oxide	
	Short tons (gross weight)	Antimony content		Short tons (gross weight)	Value (thousands)	Short tons	Value (thousands)		Short tons (gross weight)	Value (thousands)
		Short tons	Value (thousands)							
1952–56 (average)	16,418	6,906	$2,033	35	$18	3,351	$1,839	1,205	1,645	$769
1957	21,374	8,198	1,973	38	17	5,412	2,587	417	1,893	[3] 790
1958	8,203	3,427	643	136	58	4,282	1,871	645	1,634	643
1959	15,307	6,466	1,236	177	79	4,422	2,039	592	2,056	825
1960	16,406	6,455	1,214	24	11	5,437	2,495	[4] 645	2,368	972
1961	16,204	6,713	1,389	13	6	4,912	2,347	665	1,980	935

[1] Does not include antimony contained in lead-silver ore.
[2] Estimated antimony content; for gross weight and value, see "Lead chapter" of this volume.
[3] Known to be not comparable with other years.
[4] Revised figure.

Source: Bureau of the Census.

Exports.—Exports of antimony in 1961 were 44 short tons, only 5 percent of 1960 exports and the smallest quantity exported since 1954. Most of these exports were in the form of antimony metal, alloys, needles, and antimony-bearing scrap metal. Panama, Venezuela, and Guatemala were the largest purchasers.

WORLD REVIEW

Bolivia.—Antimony exports were reported in terms of production because they were considered more reliable, and all production was exported. Production was 7,400 tons, an increase of 27 percent over 1960. La Unificada, S.A., a privately owned mine, was the largest producer. A small quantity of antimonial lead was produced, type metal was produced for domestic consumption, and a small quantity of impure lead-silver-antimony bullion was produced for export.

Canada.—Canadian production of antimony, 654 tons, was 21 percent less than that of 1960. All the antimony output was recovered as a byproduct of processing lead and silver ores by the Consolidated Mining & Smelting Co. of Canada, Ltd., of Trial, British Columbia. Canadian production was supplemented with imports to satisfy domestic requirements.

China.—China was still the world's largest producer of antimony. Considerable Chinese antimony was traded on the London Metal Exchange, and long-term contracts were being negotiated to supply Japan with its entire requirements.

Mexico.—Antimony production was 4,000 tons, 85 percent of 1960 output. Most of the production was exported to the United States as ore and intermediate smelter products. Domestic consumption remained low but did show a fair percentage gain.

Union of South Africa.—Consolidated Murchison (Transvaal) Goldfields & Development Co., Ltd., was the only antimony producer. Antimony continued to be recovered from an antimony-containing gold ore. All the output was exported and the principal market was the United Kingdom. Production was 11,800 tons, which was a decrease of 13 percent from that of 1960.

TECHNOLOGY

Organic compounds containing antimony were used to reduce the flammability of polyester resins.[4]

A new indium-antimonide infrared transducer provided better and more rapid detection and more precise measurements and was expected to be useful in new guidance and communications applications.[5]

Small additions of antimony substantially increased the hardness and wear resistance of gray cast iron.[6]

The U.S.S.R. installed an automated plant to produce antimony metal. Ore is roasted in a fluidized bed at over 1,000° C. to sublimate the antimony minerals and convert them to the lower oxides. A later

[4] Boake, Roberts & Co. Antimony-Containing Organic Compounds. British Patent 854,961.

[5] LaFond, Charles D. Ir. Transducer Brings New Advantages. Missiles and Rockets, v. 8, No. 12, Mar. 20, 1961, pp. 25–26.

[6] Current Review Soviet Technical Press, Feb. 23, p. 21 (OTS, Department of Commerce). Abs. in Tech. Survey, v. 17, No. 4, Jan. 28, 1961, p. 67 (8V).

process step converts these oxides to metal. Increased extraction was claimed for the process, and both sulfide and oxide ores can be treated.[7]

Recrystallization was observed in the semiconductor, indium antimonide.[8]

TABLE 12.—World production of antimony (content of ore except as indicated) by countries [1]

(Short tons)

Country	1952–56 (average)	1957	1958	1959	1960	1961
North America:						
Canada [2]	928	680	430	829	826	654
Guatemala (U.S. imports)	----	13	47	97	119	71
Mexico [3]	4,801	5,734	3,029	3,622	4,664	3,977
United States	904	709	705	678	637	689
Total	6,633	7,136	4,211	5,226	6,246	5,391
South America:						
Argentina	26	7	11	----	----	----
Bolivia (exports) [3]	6,896	7,026	5,818	6,065	5,872	7,429
Peru [3]	925	920	964	793	901	790
Total	7,847	7,953	6,793	6,858	6,773	8,219
Europe:						
Austria	476	430	514	631	676	668
Czechoslovakia [4]	1,800	1,800	1,800	1,800	1,800	1,800
France	241	----	42	----	----	----
Greece	220	----	----	----	----	----
Italy	439	224	188	231	340	500
Portugal	33	11	7	7	----	----
Spain	225	220	220	180	243	[5] 200
U.S.S.R. [4]	5,500	5,500	6,600	6,600	6,600	6,600
Yugoslavia (metal)	1,653	1,950	1,835	2,514	2,657	2,715
Total [5]	10,600	10,100	11,200	12,000	12,300	12,500
Asia:						
Burma [3]	88	70	90	240	180	175
China [5]	11,900	15,400	16,500	16,500	19,000	18,500
Iran [6]	106	[5] 110	160	[5] 160	[5] 55	[5] 55
Japan	370	474	298	340	298	215
Ryukyu Islands	[7] 18	6	----	26	159	112
Thailand	55	2	----	10	----	36
Turkey	1,242	1,232	[8] 1,687	[8] 1,380	[8] 1,507	[8] 1,508
Total [5]	13,800	17,300	18,700	18,700	21,200	20,600
Africa:						
Algeria	2,081	1,547	1,106	1,135	785	720
Morocco	721	360	203	252	310	[5] 400
Rhodesia and Nyasaland, Federation of Southern Rhodesia	100	83	151	104	100	68
Union of South Africa	10,363	11,021	7,904	13,619	13,538	11,804
Total	13,265	13,011	9,364	15,110	14,733	12,992
Oceania: Australia	263	543	775	703	175	131
World total (estimate)	52,400	56,000	51,000	59,000	61,000	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] Includes antimony content of smelter products derived from mixed ores.
[4] Estimate according to the annual issues of Minerais et Metaux (France), except 1961.
[5] Estimate.
[6] Year ended Mar. 20 of year following that stated.
[7] Average annual production, 1955–56.
[8] Exports.

Compiled by Augusta W. Jann, Division of Foreign Activities.

[7] Engineering and Mining Journal, v. 162, No. 6, June 1961, p. 367.
[8] Abrahams, M. S., and G. W. Neighbor. Determination of the Glide Elements and Recrystallization in InSb. Trans. Metal Soc. of AIME, v. 221, No. 5, October 1961, pp. 947–951.

Arsenic

By Don H. Baker, Jr.[1] and Gertrude N. Greenspoon[2]

PRODUCTION of white arsenic in the United States fell 17 percent in 1961. The volume of shipments decreased 31 percent but was substantially below production, and thus stocks at year-end were more than double those on January 1. Imports totaled 19,500 short tons, an increase of 52 percent over 1960. World production was estimated at 59,000 tons compared with 57,000 tons (revised) in 1960.

TABLE 1.—Salient white arsenic statistics

(Short tons)

	1952–56 (average)	1957	1958	1959	1960	1961
United States:						
Production	12,539	10,493	11,508	5,189	(1)	(1)
Shipments	12,526	12,785	10,931	7,239	(1)	(1)
Imports for consumption	5,538	10,135	9,524	19,386	12,825	19,483
Stocks Dec. 31: Producer	10,189	2,535	3,112	1,058	(1)	(1)
Consumption, apparent [2]	18,065	22,920	20,455	26,625	(1)	(1)
Price: Refined, carlots [3] cents per pound	6	5½	5½	4–5	4–5	4
World: Production	42,000	45,000	41,000	47,000	[4] 57,000	59,000

[1] Figure withheld to avoid disclosing individual company confidential data.
[2] Producers' shipments, plus imports, minus exports; no exports were reported by producers, 1952–61.
[3] E&MJ Metal and Mineral Markets.
[4] Revised figure.

DOMESTIC PRODUCTION

Domestic production of white arsenic decreased 17 percent in 1961 and was a byproduct of smelting arsenic-containing copper ores. Two plants accounted for the entire production: The Anaconda,

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
1952–56 (average)	11,883	11,898	$547,641	656	628	$52,346	12,539	12,526	$599,987
1957	9,814	11,980	475,629	679	805	54,721	10,493	12,785	530,350
1958	11,121	10,544	421,777	387	387	37,884	11,508	10,931	459,661
1959	4,897	6,922	293,940	292	317	27,315	5,189	7,239	321,255
1960–61	(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.

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

Mont., smelter of The Anaconda Company and the Tacoma, Wash., smelter of American Smelting and Refining Company. Arsenic metal was not produced in 1961.

CONSUMPTION AND USES

Most of the white arsenic produced in 1961 was consumed in manufacturing lead and calcium arsenate insecticides. Arsenic compounds also were used in weedkillers, glass manufacture, cattle and sheepdips, dyestuffs, and wood preservatives. Apparent consumption of white arsenic rose 13 percent in 1961.

Shipments of calcium arsenate, which had dropped steadily from 1955, may begin an upward trend.[3] Some companies stated that calcium arsenate already is being included in chemical crab grass killers without danger of toxicity.

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
1952–56 (average)	7,063	4,853	967	426	1,393
1957	5,960	9,739	1,068	1,167	2,235
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	(3)	(3)	[4] 1,044	[4] 1,187	[4] 2,231

[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

The total new supply of white arsenic was 4,000 tons greater in 1961 despite substantial decreases in production and shipments. As a result, producer yearend stocks more than doubled and were the largest in 5 years.

PRICES

White arsenic was quoted at 4 to 5 cents per pound (powdered, in barrels, carlots) until late January when the price was lowered to 4 cents; it was unchanged at the end of 1961. According to the Oil, Paint and Drug Reporter, lead arsenate (carlots, packed in 3-pound bags) was quoted at 30½ cents throughout the year.

The London price in 1961 for white arsenic, per long ton, 98-percent minimum purity, was £40 to £45 (equivalent to 5.00 to 5.63 cents per pound). Arsenic metal on the London market sold for £400 per long ton (50 cents per pound).

[3] Oil, Paint and Drug Reporter. Calcium Arsenate Set for Comeback. Producers Search for New Markets. V. 180, No. 7, Aug. 14, 1961, p. 41.

FOREIGN TRADE [4]

Imports.—White arsenic imported for consumption in 1961 totaled 19,500 tons, 52 percent more than in 1960 and the largest since these data have been recorded separately (1909). Mexico continued to be the principal supplier with 72 percent of the total imports, followed by France with 21 percent and Sweden with 5 percent.

Sixty-six tons of arsenic metal was received in 1961, of which 65 tons came from Sweden and 1 ton from Poland. Additional very small quantities were received from Canada, United Kingdom, and West Germany. Belgium-Luxembourg supplied 28 tons of arsenic sulfide. Of the 105 tons of sodium arsenate imported in 1961, 61 tons came from the United Kingdom and 44 tons from France.

TABLE 4.—U.S. imports for consumption of white arsenic (As_2O_3 content), by countries

Country	1952–56 (average)		1957		1958	
	Short tons	Value	Short tons	Value	Short tons	Value
North America:						
Canada	446	$36,323	1,508	$119,427	800	$63,353
Mexico	5,021	592,500	6,851	604,932	6,052	541,795
Total	5,467	628,823	8,359	724,359	6,852	605,148
Europe:						
France	57	5,400	981	34,770	1,201	49,532
Sweden	13	1,074	779	34,317	1,471	64,932
Other countries [1]	1	115	16	989	----------	----------
Total	71	6,589	1,776	70,076	2,672	114,464
Grand total	5,538	635,412	10,135	794,435	9,524	719,612

	1959		1960		1961	
	Short tons	Value	Short tons	Value	Short tons	Value
North America:						
Canada	607	$49,116	503	$40,249	192	$12,022
Mexico	12,528	962,894	9,857	856,327	14,058	1,068,164
Total	13,135	1,012,010	10,360	896,576	14,250	1,080,186
Europe:						
France	3,504	153,336	2,252	129,724	4,188	262,470
Sweden	2,746	176,043	213	19,357	1,042	74,406
Other countries [2]	1	122	(3)	382	3	4,654
Total	6,251	329,501	2,465	149,463	5,233	341,530
Grand total	19,386	1,341,511	12,825	1,046,039	19,483	1,421,716

[1] Includes Poland-Danzig and the United Kingdom.
[2] Includes Netherlands and the United Kingdom.
[3] Negligible.

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 5.—U.S. imports and exports of arsenicals, by classees

(Pounds)

Class	1952-56 (average)	1957	1958	1959	1960	1961
Imports for consumption: [1]						
White arsenic (As_2O_3 content)	11,076,897	20,270,069	19,048,920	38,771,199	25,649,095	38,966,394
Metallic arsenic	127,281	136,745	61,660	84,769	145,085	132,389
Sulfide	39,726	42,094	126,354	41,872	30,352	55,116
Sheepdip	64,386	67,763		116,785		
Calcium arsenate	58,950				4,001	
Sodium arsenate	144,019	328,049	173,337	152,769	209,956	211,034
Exports:						
Calcium arsenate	2,797,271	2,779,954	1,274,000	122,920	289,700	669,932
Lead arsenate	982,345	1,216,158	2,099,960	1,398,900	1,888,149	928,797

[1] Lead arsenate and paris green last received in 1952.

Source: Bureau of the Census.

Exports.—No exports of white arsenic were reported. Exports of calcium arsenate totaled 335 tons valued at $57,869, of which 160 tons went to Nicaragua, 110 to Peru, 39 to Canada, 17 to Jamaica, 4 to Hong Kong, 3 to Israel, and 2 to Colombia.

Exports of lead arsenate totaled 464 tons valued at $182,872. Peru received 333 tons, Canada 28, Costa Rica 23, Guatemala 20, Jamaica 14, France 13, and nine other countries the remainder (in lots of less than 10 tons each).

Tariff.—White arsenic, arsenic sulfide, paris green, and sheepdip containing arsenic were free of duty. 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 1961. Compounds of arsenic not specified in the Tariff Act were subject to a duty of 12½ percent of their foreign market value.

WORLD REVIEW

World production of white arsenic was estimated at 59,000 tons in 1961, 4 percent more than in 1960 (57,000 tons, revised). The increase resulted from higher world output of other metals, chiefly copper, with which arsenic is mineralogically and metallurgically associated.

France.—Except for 1960, France has been the third largest producer since 1955. Exports trended upward from 1956 but fell from 9,500 tons in 1959 to 8,700 in 1960. A 55-percent increase over 1960 was recorded in 1961 shipments.

Mexico.—Production of arsenic in Mexico rose from 11,100 tons in 1960 to 14,600 tons in 1961. Most of the output came to the United States.

TABLE 6.—Free world production of white arsenic, by countries [1] [2]

(Short tons)

Country [1]	1952–56 (average)	1957	1958	1959	1960	1961
North America:						
Canada	765	1,849	1,162	789	862	153
Mexico	2,842	5,075	3,411	11,536	11,078	[3] 14,600
United States	12,539	10,493	11,508	5,189	([4])	([4])
South America:						
Brazil	950	188	292	367	233	[3] 220
Peru	30	22	369	524	433	[3] 450
Europe:						
Belgium (exports)	2,065	2,280	543	3,161	([5])	([5])
France	5,957	7,627	8,354	8,800	9,400	[3] 13,500
Germany, West (exports)	401	216	205	180	110	[3] 140
Greece	51	11	13	11	[3] 11	[3] 11
Italy	1,394	927	688	1,254	654	[3] 660
Portugal	[6] 1,517	[6] 1,314	[6] 1,172	596	810	[3] 770
Spain	51		285	320	435	[3] 300
Sweden	11,152	12,282	11,194	12,100	[6] 15,114	[3] 12,000
Asia: Japan	1,690	1,521	1,429	1,186	1,247	[3] 1,200
Africa: Rhodesia and Nyasaland, Federation of: Southern Rhodesia	606	883	683	528	204	[3] 200
World total (estimate) [1] [2]	42,000	45,000	41,000	47,000	57,000	59,000

[1] Arsenic may be produced in Argentina, Austria, China, Czechoslovakia, Finland, East Germany, Hungary, U.S.S.R., and United Kingdom, but there is too little information to estimate production.
[2] This table incorporates a number of revisions 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 Augusta W. Jann, Division of Foreign Activities.

Sweden.—All of Sweden's output was produced by Boliden Mining Co., the leading world producer. Production in 1961 was estimated at 12,000 tons, 21 percent below 1960.

TECHNOLOGY

The Russians reported that sulfuric dioxide could be used commercially to reduce arsenic acid to arsenic trioxide in the purification of hydrometallurgical solutions from the acid leaching of polymetallic ores.[5]

A doctorate study of the phase relations in the nickel-arsenic systems will be useful for interpreting mineral associations, textures, and fine structures found in natural assemblages. The changes in the composition of coexisting phases are of fundamental importance in determining the physical-chemical conditions at the time of mineral formation.[6]

[5] Buzur-Ool, D. B. Crude Purifications of Solutions of Arsenic Using Sulfur Dioxide. Soviet J. of Nonferrous Metals, v. 2, No. 2, February 1961, pp. 49–51 (in English).
[6] Yund, R. A. Phase Relations in the System Ni–As[1]. Econ. Geol., v. 56, No. 7, November 1961, pp. 1273–1296.

Asbestos

By J. M. West [1] and Victoria R. Schreck [2]

ALTHOUGH the United States consumed 24 percent of the world production of asbestos, it supplied only 8 percent of its own requirements. The Nation ranked seventh among world producers, contributing 2 percent of the total output.

LEGISLATION AND GOVERNMENT PROGRAMS

Nearly one-half of the Arizona No. 2 fiber scheduled under contract with General Services Administration for the national stockpile was delivered by one producer. Contracts signed in 1960 for the purchase of 500 short tons were extended into 1962 to permit the completion of deliveries. Testing followed a simplified procedure and was carried out by Arizona Testing Laboratories, Phoenix, Ariz. Shipments were accepted at the Globe, Ariz., inspection depot as meeting requirements of National Stockpile Purchase Specification P-3-R2, dated June 10, 1953, which called for a minimum of 85 weight-percent of fiber 3/8 inch in length. This specification was superseded by a revised issue of June 2, 1961, which provided for more uniform grading requirements and more rigid testing; the source of fiber was not designated.

TABLE 1.—Salient asbestos statistics

	1952-56 (average)	1957	1958	1959	1960	1961
United States:						
Production (sales)—short tons	48,364	43,653	43,979	45,459	45,223	52,814
Value—thousands	$4,699	$4,918	$5,127	$4,391	$4,231	$4,347
Imports for consumption (unmanufactured)—short tons	702,087	682,732	644,331	713,047	[1] 669,496	616,552
Value—thousands	$60,023	$60,104	$58,314	$65,006	$63,345	$58,942
Exports (unmanufactured) [2] short tons	4,286	2,893	3,026	4,461	5,525	3,799
Value—thousands	$839	$350	$424	$793	$857	$759
Exports of asbestos products (value) [2] thousands	$12,436	$15,223	$13,233	$12,921	$13,703	$13,825
Consumption, apparent [3] short tons	746,165	723,492	685,284	754,045	[1] 709,194	665,567
World: Production—do	1,750,000	2,080,000	[1] 2,055,000	[1] 2,270,000	[1] 2,440,000	2,770,000

[1] Revised figure.
[2] Includes reexports.
[3] Measured by quantity produced, plus imports, minus exports.

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.

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DOMESTIC PRODUCTION

Asbestos production in the United States increased 17 percent in quantity compared with 1960, but it gained only 3 percent in value. Most of the increased production was from California deposits, where short-fiber and waste grades were recovered. An estimated 1.1 million tons of rock was mined to produce the 53,000 tons of fiber sold.

Vermont Asbestos Mines Division of Ruberoid Co., at Belvedere Mountain near Hyde Park, Vt., continued as the major domestic producer of asbestos. The small quantity of spinning-length fiber recovered was used in electrolytic cells.

Four companies reported shipments of asbestos from mines in the Globe district of Arizona: Jaquays Mining Corp., Metate Asbestos Corp., Pan American Fiber Corp., and Phillips Asbestos Mines. Jaquays was the principal Arizona producer. Best fiber from one plant was sold in Switzerland to be made into filter pads.

California production and shipments of fiber were reported by Asbestos Bonding Co., from the Phoenix Mine, Napa County, and by Todd Industries, Inc., from a mine in San Benito Co., near Coalinga. Two companies reported small amounts of asbestos produced for experimental purposes: Union Carbide Nuclear Co., from a deposit near Coalinga in Fresno County; and Rawhide Asbestos Corp., from the Chaparral Hill mine in Tuolumne County. Jefferson Lake Asbestos Corp., a subsidiary of Jefferson Lake Sulphur Co., completed exploration and clearing of its chrysotile deposit near Copperopolis in Calaveras Co. in preparation for mining. Construction was begun on a $5 million mill with a planned initial annual capacity of 15,000 tons of fiber. Coalinga Asbestos Co., Inc., neared completion of a mill on Pine Creek near Coalinga; it was expected to produce 12,000 or more tons of asbestos annually. Hidden Splendor Mining Co. announced plans to construct a 15,000-ton-per-year asbestos plant at its deposit in San Benito County, also near Coalinga.

Powhatan Mining Co. produced amphibole asbestos from its Burnsville mine, Yancey County, N.C.

Coast Asbestos Co. reported a small production of chrysotile from its property in Grant County, Oreg.

CONSUMPTION AND USES

Consumption of chrysotile asbestos decreased from 670,000 tons in 1960 to 633,000 tons. Part of the decrease was attributable to a slowdown of business activities early in the year. More than 97 percent of the chrysotile consumed was short fiber used mainly in asbestos-cement and asbestos-asphalt building materials. Nearly 9 percent of the short-fiber chrysotile consumed was from domestic mines.

Consumption of crocidolite, as represented by imports, decreased from 20,000 tons in 1960 to 18,000 tons.

Manufacture of asbestos-cement pipe was augmented by the opening of a new plant at Denison, Tex.,[3] and plans were announced for another plant to be built at Ravenna, Ohio.[4]

[3] Hegarty, A. Asbestos-Cement Pipe Plant. Min. Mag. (London), v. 104, No. 3, March 1961, pp. 152–155.

[4] Mining Engineering. Flintkote to Build Cement Pipe Plant. V. 13, No. 9, September 1961, p. 1023.

Main intended uses for newly established asbestos production from expanding California facilities included vinyl and asphalt tiles, asbestos-cement products, and stuccos. Foreign and domestic markets west of the Mississippi River were being contemplated.

STOCKS

Government stockpiles contained 25,000 tons of amosite and 8,800 tons of chrysotile at yearend—20,000 and 2,200 tons, respectively, less than maximum strategic objectives. Of the stockpiled material, 12,000 tons of amosite and 6,000 of chrysotile were in the national strategic stockpile; the remainder was in Commodity Credit Corporation (CCC) and supplemental stockpiles. Nonstrategic crocidolite held on inventory was 10,900 tons.

Deliveries in 1961 to the supplemental stockpile on contracts back to 1959 were as follows: Amosite, 6,562 tons; crocidolite, 3,999 tons; and chrysotile, 1,010 tons. CCC let contracts under the barter program in 1961 for 5,000 tons of amosite and 10,000 tons of crocidolite to be delivered by 1963 in exchange for surplus agricultural commodities.

PRICES

Canadian (Quebec) chrysotile asbestos prices, f.o.b. mine, were unchanged as follows:

Grade:	*Per short ton*
Crude No. 1	Can$1,410–Can$1,475
Crude No. 2—Crude run of mine and sundry	610– 875
No. 3—Spinning fiber	350– 650
No. 4—Shingle fiber	180– 245
No. 5—Paper fiber	120– 150
No. 6—Waste, stucco, or plaster	86
No. 7—Refuse or shorts	40– 80

British Columbia chrysotile asbestos prices, f.o.b. Vancouver, quoted by Bell Asbestos Mines, Ltd., sales representative of Cassiar Asbestos Corp., Ltd., were as follows:

Grade:	*Per short ton*
No. 1 crude	Can$1,522
AAA (C&G 1)	787
AA (C&G 2)	625
A (3K)	470
AC (C&G 3)	325
AK (4K)	220
AS (4T)	181
AX (5D)	142

Vermont asbestos prices, f.o.b. Hyde Park or Morrisville, changed in May as follows:

	Per short ton	
Grade:	*Jan. 1*	*May 10*
Group No. 3—Spinning and filtering	$353–440	$345–402
Group No. 4—Shingle fiber	181–218	181–320
Group No. 5—Paper fiber	120–142	120–142
Group No. 6—Waste, stucco, or plaster	86	86
Group No. 7—Refuse or shorts	41– 75	40– 75

Quotations in Asbestos magazine for Arizona asbestos, f.o.b. Globe, were changed from 1960 as follows:

Grade:	Per short ton 1960	Jan. 10, 1961
No. 1 soft	$1,475–$1,800	$1,650–$1,800
No. 2 soft	830– 1,050	800– 1,000
Group 3—Filtering and spinning	350– 450	375– 450
Group 4—Plastic and filtration	190– 250	225– 250
Group 5—Plastic and molding	125– 177	190– 225
Group 7—Refuse and shorts	60– 100	58– 90

Market quotations were not available for African, Australian, and South American asbestos, as sales were negotiated individually. U.S. Department of Commerce reports showed the following average values per short ton for imports:

Imports:	Per short ton 1960	1961
Amosite	$152	$163
Crocidolite:		
Bolivia	---	182
Australia	211	209
Union of South Africa	219	202

FOREIGN TRADE [5]

Imports of amosite, crocidolite, and chrysotile decreased 24, 9, and 7 percent, respectively, from 1960, resulting in a net decrease of 8 percent in total imports in 1961.

Low-iron chrysotile imports of spinning length from British Columbia decreased from 6,254 tons in 1960 to 5,374 tons. Ninety-seven percent of all chrysotile imported was short fiber of less than spinning length.

The Union of South Africa supplied crocidolite and chrysotile and was the only source of amosite. Imports from Australia consisted solely of crocidolite. The total crocidolite imported from the two countries and a small tonnage from Bolivia was 17,863 tons. Only chrysotile was imported from other countries.

Exports of unmanufactured asbestos decreased from 5,525 tons in 1960 to 3,799 tons.

WORLD REVIEW

NORTH AMERICA

Canada.—Technical and research facilities were established at the University of Sherbrooke in cooperation with the Quebec Asbestos Mining Association to meet expanding needs of the asbestos mining industry in the eastern townships of Quebec. Maintenance of product uniformity under increasingly complex grading requirements was a primary function of the new establishment.[6]

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

[6] Canadian Mining and Metallurgical Bulletin (Montreal). Asbestos Fibre Standards Laboratory Established at the University of Sherbrooke. V. 54, No. 589, May 1961, p. 380.

TABLE 2.—U.S. imports for consumption of asbestos (unmanufactured), by classes and countries

Year and country	Crude (including blue fiber)		Mill fibers		Short fibers		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1960:								
North America:								
Canada	357	$64,989	148,584	$29,055,547	467,860	$24,998,784	616,801	$54,119,320
Guatemala	2	400					2	400
South America: Venezuela	15	2,100			46	6,210	61	8,310
Europe:								
Finland					165	8,250	165	8,250
Italy	[1] 4	[1] 5,490	[1] 2	[1] 2,295	2	338	8	8,123
Portugal	22	2,800					22	2,800
Yugoslavia	4,578	157,122					4,578	157,122
Africa:								
Rhodesia and Nyasaland, Federation of [2]	1,865	494,055	110	24,209	464	99,476	2,439	617,740
Union of South Africa [3]	36,644	6,771,421	523	90,024	3,627	583,382	40,794	7,444,827
Oceania: Australia	4,626	977,959					4,626	977,959
Total	[1] 48,113	[1] 8,476,336	[1] 149,219	[1] 29,172,075	5,472,164	25,696,440	669,496	63,344,851
1961:								
North America: Canada	437	60,097	143,382	27,978,572	426,234	22,898,349	570,053	50,937,018
South America: Bolivia	50	9,090					50	9,090
Europe:								
Finland					164	14,500	164	14,500
Italy [3]	1	1,530	2	4,590	110	16,530	113	22,650
Portugal [3]	8	645					8	645
Yugoslavia	5,194	173,260					5,194	173,260
Africa:								
Rhodesia and Nyasaland, Federation of [2 3]	2,071	531,435	41	12,633	940	171,210	3,052	715,278
Union of South Africa [3]	33,393	6,181,852	116	20,872	2,155	384,144	35,604	6,586,868
Oceania: Australia	2,314	482,764					2,314	482,764
Total	43,408	7,440,673	143,541	28,016,667	429,603	23,484,733	616,552	58,942,073

[1] Revised figure.
[2] All believed to be from Southern Rhodesia.
[3] Data reported by the Bureau of the Census has been adjusted by the Bureau of Mines.

Source: Bureau of the Census

TABLE 3.—U.S. imports for consumption of asbestos, from specified countries, by grades

(Short tons)

Grade	1960			1961		
	Canada	Southern Rhodesia [1]	Union of South Africa	Canada	Southern Rhodesia [1]	Union of South Africa [2]
Chrysotile:						
Crude:						
No. 1		353		[3]	29	118
No. 2	28	18		56	284	
Other	329	1,494	2,164	381	1,758	2,738
Spinning or textile	19,172	110	[2] 220	16,903		18
Shingle	88,475		301	86,070	40	97
Paper	40,937		[2] 2	40,409	1	1
Short fiber	467,860	464	[2] 3,627	426,234	940	2,155
Crocidolite (blue)			[2] 14,899			15,499
Amosite			[2] 19,581			14,978
Total	616,801	2,439	40,794	570,053	3,052	35,604

[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] Less than 1 short ton.

Source: Bureau of the Census.

TABLE 4.—U.S. exports [1] and reexports [2] of asbestos and asbestos products

Product	1960		1961	
	Quantity	Value	Quantity	Value
Exports:				
Unmanufactured:				
Crude and spinning fibers, short tons	1,524	$339,996	1,064	$281,444
Nonspinning fibers, do	867	150,557	1,084	256,261
Waste and refuse, do	3,070	354,054	1,424	170,755
Total unmanufactured, do	5,461	844,607	3,572	708,460
Products:				
Brake lining and blocks—molded, semimolded and woven	[3]	4,488,132	[3]	4,192,908
Clutch facing and lining, number	1,461,015	1,149,765	1,452,435	1,149,299
Construction materials, n.e.c, short tons	9,961	2,237,444	11,300	2,980,726
Pipe covering and cement, do	3,488	1,906,238	2,627	1,485,640
Textiles, yarn, and packing, do	1,323	3,128,870	1,288	3,106,542
Manufactures, n.e.c	[4]	776,905	[4]	889,625
Total products		13,687,354		13,804,740
Reexports:				
Unmanufactured:				
Crude and spinning fibers, short tons	40	7,290	108	24,175
Nonspinning fibers, do	24	4,972	106	26,003
Waste and refuse, do			13	594
Total unmanufactured	64	12,262	227	50,772
Products:				
Brake lining and blocks—molded, semimolded and woven, short tons	[3]	1,251	[3]	1,580
Construction materials, n.e.c, do	[5]	1,154	63	18,353
Textiles, yarn, and packing, do	56	13,720	1	228
Total products		16,125		20,161

[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] Less than 1 ton.

Source: Bureau of the Census.

TABLE 5.—World production of asbestos, by countries [1] [2]

(Short tons)

Country [1]	1952–56 (average)	1957	1958	1959	1960	1961
North America:						
Canada (sales) [3]	968,546	1,046,086	925,331	1,050,429	1,118,456	1,173,695
United States (sold or used by producers)	48,364	43,653	43,979	45,459	45,223	52,814
Total	1,016,910	1,089,739	969,310	1,095,888	1,163,679	1,226,509
South America:						
Argentina	412	319	285	320	[4] 330	[4] 330
Bolivia—(exports)	283	121		168	66	57
Brazil	2,495	2,654	3,816	12,325	14,590	[4] 16,500
Venezuela	1,633	8,390	9,152	5,095	4,333	650
Total	4,823	11,484	13,253	17,908	19,319	[4] 17,500
Europe:						
Bulgaria	1,146	1,100	1,100	[4] 1,100	[4] 1,100	[4] 1,100
Finland [5]	11,664	10,979	7,932	9,579	10,534	10,339
France	12,107	16,008	20,742	23,360	28,111	30,865
Greece	8	9				
Italy	30,479	40,361	42,500	49,778	56,672	62,816
Portugal	83	64	98	40	144	[4] 110
Spain	42			19	4	
U.S.S.R [4]	375,000	500,000	550,000	600,000	660,000	880,000
Yugoslavia	3,792	6,128	5,960	4,748	5,970	6,709
Total [4]	435,000	575,000	630,000	690,000	765,000	990,000
Asia:						
China [4]	16,500	33,000	66,000	88,000	88,000	88,000
Cyprus	16,024	15,028	16,494	14,424	23,369	[4] 22,000
India	1,031	1,925	1,302	1,464	1,886	1,618
Japan	6,325	13,192	11,187	13,633	17,042	18,799
Korea, Republic of	71	96	22	88	740	341
Taiwan	142	268	47	150	485	44
Turkey	188	99	839	411	238	496
Total [4]	40,000	64,000	96,000	118,000	132,000	131,000
Africa:						
Bechuanaland	973	1,582	2,265	1,410	1,849	1,924
Kenya	220	109	120	43	117	151
Morocco: Southern zone	569	132				
Mozambique	140	152	198	37	22	162
Rhodesia and Nyasaland, Federation of:						
Southern Rhodesia	95,353	132,124	127,115	119,699	133,963	161,610
Swaziland	31,501	30,727	25,261	24,807	32,026	30,793
Union of South Africa	118,805	157,474	175,644	182,405	175,867	194,834
United Arab Republic (Egypt Region)	57	22	485	502	496	[4] 500
Total	247,618	322,322	331,088	328,903	344,340	389,974
Oceania:						
Australia	5,117	14,670	15,570	17,875	15,613	16,746
New Zealand	261	230	454	640	319	[4] 330
Total	5,378	14,900	16,024	18,515	15,932	17,076
World total (estimate) [1] [2]	1,750,000	2,080,000	2,055,000	2,270,000	2,440,000	2,770,000

[1] Asbestos also is produced in Czechoslovakia, Eritrea, Iran, North Korea, Rumania, and Uganda. 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 and gravel and stone (waste rock only), production of which is reported as follows: 1952–56 (average), 31,375 tons; 1957, 13,652 tons; 1958, 18,449 tons; 1959, 29,532 tons; 1960, 51,624 tons; 1961, 41,696 tons.

[4] Estimate.

[5] Includes asbestos flour.

Compiled by Helen L. Hunt Division of Foreign Activities.

TABLE 6.—Canada: Sales of asbestos by grades

Grades	1960			1961		
	Short tons	Value		Short tons	Value	
		Total (thousands)	Average per ton		Total (thousands)	Average per ton
Crude No. 1, 2, and other	330	$341	$1,034	163	$132	$810
Milled group:						
3	32,190	14,272	443	29,296	10,619	362
4	294,092	54,757	186	339,082	56,874	168
5	156,901	19,709	126	179,852	20,359	113
6	179,361	14,763	82	193,467	14,461	75
7	445,509	18,794	42	423,116	15,916	38
8	10,073	208	21	8,719	164	19
Total, all grades	1,118,456	122,844	110	1,173,695	118,525	101
Waste rock	51,625	46	1	41,696	35	1

Source: Dominion Bureau of Statistics.

A series of articles containing descriptions of asbestos mining operations at most of the Canadian deposits was published.[7]

An inclined skipway with a capacity of 30,000 tons per day and designed for an eventual depth of 1,200 feet was being installed at the Jeffrey mine, Asbestos, Quebec, as transition from underground to open-pit mining continued. A smaller skipway was installed at the Flintkote Mines, Ltd., pit near Thetford mines.

Fiber recovery from the Black Lake mine of United Asbestos Corp. increased to 5.46 percent in the first 9 months of 1961, compared with 5.04 percent in the same period of 1960, while production increased from 62,000 to 71,000 tons.

Downward continuation of the main ore zone at the Munro mine of Canadian Johns-Manville Co., Ltd., was explored at the 900-foot level. Deeper drilling was planned from this level. A third stope was opened during 1961, and another was in preparation above the main 637-foot haulage level. Grouting around the edges of the abandoned open pit was necessary to reduce inflow of surface water to underground workings. Mill output was 2,500 tons of asbestos per month, all classified as M–100, a new grade designation replacing the former 4Y. The harsh fiber was used exclusively in asbestos-cement products. A new milling stage increased capacity 20 to 25 percent by preconcentration.[8]

The proposed milling rate at Advocate Mines, Ltd., Baie Verte property, under development in northern Newfoundland, was increased from 3,000 to 5,000 tons of ore per day as production plans were expanded. Ore reserve estimates rose to 40 million tons. Con-

[7] Precambrian-Mining in Canada (Winnipeg). Bell Asbestos Mines, Ltd., British Canadian Mine, Carey-Canadian Mines, Cassiar Asbestos Corporation Limited, Jeffrey Mine, Johnson's Asbestos Company, Johnson's Company Ltd., King-Beaver Mine, Munro Mines Ltd., Lake Asbestos of Quebec, Ltd., National Asbestos Mines Ltd., Nicolet Asbestos Mines, Ltd., Normandie Mine, Advocate Mines Ltd., Murray Mining Corporation Limited. V. 34, No. 5, May 1961, pp. 10–31.

Precambrian-Mining in Canada (Winnipeg). Cassiar Asbestos Mine, Flintkote Mines Limited. V. 34, No. 6, June 1961, pp. 23–26, 42.

[8] Northern Miner (Toronto). Start Deep Block Development as J.-M's Munro at Capacity. V. 47, No. 24, Sept. 7, 1961, pp. 1, 5.

struction of docks and other facilities was underway as part of the $20 million asbestos project scheduled for production in 1963.[9]

Continued drilling at the Ungava deposit of Murray Mining Corp., Ltd., in northern Quebec, brought increased ore estimates to 20.1 million tons, grading 8 to 9 percent fiber, mainly in group 4. Lying within a partially explored asbestos-bearing zone at least 1½ miles long, the ore body outlined was 2,200 feet long, 200 feet wide, and 465 feet or more deep. The 12-inch cores from drilling were substituted for the usual bulk sampling by adit. Progress was sufficient to permit the planning of a mill to produce 100,000 tons of fiber annually.[10]

At the Cassiar Asbestos Corp., Ltd., mine in British Columbia 675,000 tons of ore was mined and 582,000 tons milled; 19 percent of the rock mined was rejected ahead of the tramline. Sales of short cement-grade fibers continued to rise, as in 1960, with stronger trade in European markets. Development on the 5,700-foot level showed persistent size and grade of ore body. Exploration holes on the northern extension of the deposit went as deep as 105 feet. Additional equipment was installed in the mill to improve recoveries of AK and AX grades.

Construction of a 40-ton-per-day pilot mill began at the Hedman Mines asbestos property east of Matheson, near Lake Albititi, eastern Ontario, while exploration and stripping of overburden continued. The main zone reportedly contained more than 8 million tons of ore, and bulk samples indicated an average fiber content of 15.6 percent, all group 5 and shorter grades.[11] Exploration by McAdam Mining Corp., at Roberge Lake, northeast of Chibougamau, northwestern Ontario, outlined an ore body 1,000 feet long, 600 feet wide, and 450 feet deep, averaging 8.4 percent asbestos. Magnetic anomalies found in earlier work were investigated.[12]

Geophysical surveys were conducted in the Matheson area, McCool Township, Ontario, by Desjardins Mines and Young-Davidson Mines. A brief report by the British Columbia Department of Mines and Petroleum Resources on the Letain Asbestos property near Cassiar, British Columbia, was made available for inspection.[13]

Mexico.—Manufacture of pipe insulation utilizing amosite was scheduled to start in the new plant of Aislantes Industriales, S.A. de C.V., north of Mexico City. Construction began on a US$1 million asbestos-cement pipe plant in Chihuahua by Mexalit del Norte, S.A. de C.V.

SOUTH AMERICA

Brazil.—Deliveries of chrysotile to Brazilian ports from the Minevacão de Amianto, S.A., mine at Djalma Dutra (Pocões), Bahia, decreased from 1,580 tons in 1960 to 1,292 tons in 1961.

Colombia.—Imports of asbestos in the first 11 months of 1961 totaled 11,299 tons, compared with 7,635 tons for all of 1960. The ad

[9] Canadian Mining Journal (Quebec). Asbestos Deposits Development Started. V. 82, No. 12, December 1961. p. 97.
[10] Northern Miner (Toronto). Bulk Samples from Murray Mining Confirm High Asbestos Content. V. 47, No. 12, June 15, 1961, pp. 1, 9.
[11] Northern Miner (Toronto). Install Pilot Plant to Determine Grade of Hedman Deposit. V. 47, No. 25, Sept. 14, 1961, pp. 17, 22.
[12] Northern Miner (Toronto). Cut Good Asbestos in Initial Boring at McAdam Mining. V. 47, No. 13, June 22, 1961, pp. 1, 12.
[13] Northern Miner (Toronto). Letain Asbestos Deposit. V. 47, No. 18, July 27, 1961, p. 6.

valorem tax of 10 percent on such imports was continued, but a specific duty of 0.1 peso per gross kilogram (about US$11 per ton) was dropped.

EUROPE

Belgium.—Construction was scheduled by Johns-Manville Corp. on the first of three asbestos manufacturing plants to be built near Ghent.

Germany, West.—Of the 146,125 tons of asbestos imported in 1960, Canada supplied 55 percent and the U.S.S.R. 21 percent. Sixty to 70 percent of the imports were utilized in asbestos-cement products. Overall consumption of asbestos products was reportedly increasing 10 percent yearly.[14]

Greece.—Asbestos was imported from Canada for use in a new asbestos cement pipe and sheet plant on the island of Euboea. Asbestos deposits said to be the largest in Europe were being developed in northern Greece.

Poland.—Imports totaled 16,800 tons of asbestos in 1960; 39 percent came from the U.S.S.R.

U.S.S.R.—Asbestos exports showed yearly increases of 9 to 16 percent from 1956 to 1960. Free world markets, mainly those of West Germany, France, and Belgium, received 68 percent of the 161,000 tons exported in 1960.[15] Tuvaasbestos Trust was established for large-scale development of newly discovered chrysotile and amphibole deposits in Tuva, where some unusually long spinning-grade fiber was reported. Nearly all the 1960 production came from Ural Mountain deposits. A new deposit was discovered at Bazhenov. A two-fold increase in asbestos production from the 1960 level was expected by 1965.

Yugoslavia.—Plans were reported to increase asbestos output at the Stragari mine, 60 miles south of Belgrade, from 6,000 to 15,000 tons per year by 1965. Grades 3, 4, and 5 were expected to comprise 40 percent of the fiber. Four-fifths of the production was being exported to the United States. Ore reserves were 5 million tons.

ASIA

Cyprus.—Exports in 1960 were 17,167 tons valued at US$2,469,600, compared with 16,131 tons in 1959 valued at US$1,839,600. Production was from Cyprus Asbestos Mines, Ltd., at Pano Amiandos, where reserves were reported sufficient for 200 years' operation at the 1960 rate of production.

India.—The Geological Survey of India estimated chrysotile reserves in the Brahmanapalle and Chinnakudala areas of Andhra Pradesh at 300,000 tons of fiber. Investigations in the Chamoli district, Uttar Pradesh, disclosed small amounts of asbestos.

Indonesia, Republic of.—Plans to open small asbestos mines were part of an 8-year economic development program to start in 1961.

Philippines.—Results of laboratory tests on samples from several Philippine asbestos deposits were published.[16] Reserves blocked out

[14] Turcotte, R. F. West Germany Buys Asbestos. Foreign Trade (Ottawa). V. 116, No. 3, July 29, 1961, pp. 7–9.
[15] Bureau of Mines. Mineral Trade Notes. V. 54, No. 4, April 1962, 108 pp.
[16] Quicho, R. B., L. O. Pedron, and A. S. Malicsi. Recovery of Asbestos from Zambales and Pangasinan Ores. Philippine Bureau of Mines Rept. of Inv. 26, November 1960, 18 pp.; Min. Newsletter (Philippines), v. 12, No. 5, May–June 1961, pp. 8–14, 38–39.

in Bocaclio, Pangasinan, totaled over 1½ million tons containing an estimated 3 percent of recoverable short-fiber chrysotile.

Taiwan.—All production, amounting to 485 tons valued at US$15,000 in 1960, was from the Feng-Tieu mine near Hualien. Imports in 1961 totaled 919 tons.

AFRICA

Bechuanaland.—The mine at Moshaneng produced 1,500 tons of chrysotile annually. Several asbestos occurrences were explored by core drill.

Nigeria.—Asbestos Cement Products Nigeria, Ltd., opened the country's first asbestos-cement plant at Ikeja, near Lagos. Another plant was planned for Emene, 7 miles from Enugu, eastern Nigeria; it was to be operated by Turners Asbestos Cement (Nigeria).

TABLE 7.—Southern Rhodesia: Asbestos production

Year	Short tons	Value (thousands)	Year	Short tons	Value (thousands)
1957	132,124	$25,185	1960	133,963	$20,888
1958	127,115	24,147	1961	161,610	24,453
1959	119,699	20,735			

Rhodesia and Nyasaland, Federation of.—Asbestos exports increased 24 percent in 1960 over those in 1959 to 128,000 tons valued at US$23,430,400. Plants to recover grade 7 fiber were under construction in 1961 at the Serpentine mine, Belingwe, and the Boss mine, Mashaba. Rand Mines, Ltd., of Johannesburg acquired the Thornwood mine in the Gwanda area, explored ore extensions, and rebuilt the mill to produce fiber grades 3 to 7. The expanded plant at the Ethel mine in the northern Umvukwes area produced 2,500 tons of grades 3 and 4 fibers in 1960, all exported to Sweden.[17] Descriptions of operations and flowsheets were published.[18] A reportedly rich asbestos ore body was being explored at the Pangani mine, near Filabusi, east of Bulawayo.

Swaziland.—The Havelock mine at Emlembe continued to be the only producer in 1960; its total output of 32,026 tons valued at US$7,802,141 was exported, mainly to the United Kingdom. Measured ore reserves were set at 10 million tons. A reopened adit in the mine's west extension disclosed a vein 30 feet wide; it contained 3.5 percent fiber. Chrysotile production was over 2,500 tons monthly from ores averaging 4.7 percent fiber; grades ranged from 2 to 5, with most fiber in grades 3 and 4.[19]

Union of South Africa.—Crocidolite in the Cape Province and Transvaal and amosite in the eastern Transvaal were subjects of a thorough report.[20] A report was issued describing production of amosite by

[17] Bureau of Mines. Mineral Trade Notes. V. 53, No. 5, November 1961, pp. 6–8.
[18] Airey, N. M. Operations at the Ethel Asbestos Mine, Southern Rhodesia—Further Notes. Inst. of Min. and Met. Bull. (London), v. 70, No. 653, April 1961, pp. 407–413.
[19] Bureau of Mines. Mineral Trade Notes. V. 53, No. 5, November 1961, pp. 8, 9.
[20] Keep, F. E. Amphibole Asbestos in the Union of South Africa. 7th Commonwealth Min. and Met. Cong., Johannesburg, South Africa, April 1961, 27 pp.

Amosa (Pty.), Ltd., and chrysotile by African Chrysotile Asbestos, Ltd.; detailed data on South African exports in 1959 and the first half of 1960 and a list of producers were included.[21] Sinking of a new vertical shaft at Penge progressed. The mine produced 5,000 tons of amosite monthly, with recoveries of 11 percent fiber from the ore. One-half the South African chrysotile output was from the Msauli mine, where production of grades 3, 4, and 5 totaled 1,300 tons monthly. Average fiber recoveries were 5 percent of the ore. Plans to produce grades 6 and 7 were reported.[22] Federale Mynbou Beperk acquired a one-half share in a venture to explore an extensive asbestos prospect in the Kuruman area of Northwestern Cape Province. Turner's Asbestos Products (Pty.), a subsidiary of Turner and Newall, Ltd., planned to build a $2 million asbestos-cement pipe and sheet plant at Durban.

TABLE 8.—Union of South Africa: Asbestos production by varieties and sources

(Short tons)

Variety and source	1957	1958	1959	1960	1961
Amosite (Transvaal)	56,798	69,773	71,720	68,630	69,234
Chrysotile (Transvaal)	25,646	27,403	29,326	29,471	31,726
Blue (Transvaal)	15,303	16,670	13,113	11,185	11,176
Blue (Cape)	59,549	61,520	68,024	66,567	82,624
Tremolite (Transvaal)	178	278	222	14	74
Total	157,474	175,644	182,405	175,867	194,834

TABLE 9.—Union of South Africa: Production and exports of asbestos

Year	Production (short tons)			Exports	
	Transvaal	Cape Province	Total	Short tons	Value (thousands)
1957	97,925	59,549	157,474	142,799	$25,278
1958	114,124	61,520	175,644	145,796	25,420
1959	114,381	68,024	182,405	151,515	25,971
1960	109,300	66,567	175,867	174,810	28,965
1961	112,210	82,624	194,834	180,684	29,830

OCEANIA

Australia.—Plans were announced by Australian Blue Asbestos Pty., Ltd., to nearly double production of crocidolite to 500 tons per week at Wittenoom Gorge in Western Australia.[23]

TECHNOLOGY

Several papers on asbestos, subsequently published, were given at the annual general meeting of the Canadian Institute of Mining and Metallurgy in Quebec in March 1961. One report emphasized the importance of asbestos export earnings to Canada's economy and

[21] Bureau of Mines. Mineral Trade Notes. V. 52, No. 4, April 1961, pp. 4–10.
[22] South African Mining and Engineering Journal (Johannesburg). Mining at Mamba Hill. V. 72, pt. 2, No. 3593, Dec. 15, 1961, p. 1407.
[23] Mining Journal (London). More Blue Asbestos from Australia. V. 257, No. 6580, Sept. 29, 1961, pp. 312–313.

cautioned against imposing an export duty on asbestos in order to stimulate Canadian manufacture of finished products.[24] Another described problems in separating magnetite from asbestos for a true and accurate determination of magnetic rating. An improved procedure was presented whereby the rating was established as a function of fiber agitation required to release the magnetite.[25] Operations and equipment were described for treating asbestos samples in the newly established pilot plant of the Quebec Department of Mines at Quebec City.[26]

Asbestos marketing and methods of classification and testing practiced in the Canadian industry were discussed in a series of articles. A strong market was predicted for fibers in groups 4, 5, and 6, and, despite excessive overall mill capacity in Canada, demand for asbestos was expected to equal supply within 2 years.[27] A technical meeting in October at Ottawa included a symposium on the asbestos industry of the eastern townships of Quebec; three papers, covering geology, mining and milling, and testing and quality control were given.[28]

Selective mining at the Regal mine and mill operations of Jaquays Mining Corp. in Arizona were described.[29]

Studies on hydrothermal synthesis of crysotile showed fiber growth to be promoted by certain mineralizers, trace elements, and the control of pH. A test product, classified as mainly clinochrysotile, formed bundles averaging 100 microns or more which were composed of shorter fibers 15 to 20 microns long.[30] Thermal reactions in serpentine, not fully understood, were disclosed by studies of the effect of particle size on differential and thermal gravimetric analysis. Peak endothermic temperatures for chrysotile were found to decrease from 710° C with no grinding to 670° C with fine grinding.[31]

Analyses of South African crocidolite fibers taken from the weathered zone showed only slight differences in composition from fresh material, even though the asbestos-bearing ironstones were leached extensively to depths of 250 feet.[32] The chemical composition of fiber in the unweathered zone was almost constant.

Articles were published on the manufacture and use of asbestos-cement pipe and on the process of fiberizing asbestos.[33] For special purposes pipe was being made to withstand pressures up to 800 psi. It was noted that overmilling of asbestos, while possibly increasing

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[24] Lindell, K. V. Asbestos and the Canadian Economy. Can. Min. and Met. Bull. (Montreal), v. 54, No. 595, November 1961, pp. 809–812.

[25] Badollet, M. S. and N. W. Edgerton. The Magnetite Content of Asbestos by Magnetic Separations. Can. Min. and Met. Bull. (Montreal), v. 54, No. 591, July 1961, pp. 547–550.

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[28] Pit and Quarry. Third Joint Meeting of Industrial Minerals Divisions of A.I.M.E. and C.I.M., Held in Ottawa, Ont. V. 54, No. 7, January 1962, pp. 146–149.

[29] Stewart, L. A. Mining Methods and Costs, Regal Asbestos Mine, Jaquays Mining Corp., Gila County, Ariz. BuMines Inf. Circ. 7986, 1961, 53 pp.

[30] Yang, J. C. S. The Growth of Synthetic Chrysotile Fiber. Am. Mineralogist, v. 46, Nos. 5, 6, May, June 1961, pp. 748–752.

[31] Martinez, E. The Effect of Particle Size on the Thermal Properties of Serpentine Minerals. Am. Mineralogist. v. 46, Nos. 7, 8, July, August 1961, pp. 901–912.

[32] Cilliers, J. J. LeR., A. G. Freeman, A. Hodgson, and H. F. W. Taylor. Crocidolite from the Koegas-Westerberg Area, South Africa. Econ. Geol., v. 56, No. 8, December 1961, pp. 1421–1437.

[33] Sinclair, W. E. Asbestos-Cement Piping in Industry and Mines. Asbestos, v. 43, No. 5, November 1961, pp. 4–16. Sinclair, W. E. Fiberization, A Critical Operation in Asbestos Processing. Asbestos, v. 43, No. 3, September 1961, pp. 2–10.

the grade according to the Quebec Box Test, could severely damage and weaken the fiber. More positive control of fiberization was needed.

Experimentation continued on asbestos-asphalt paving mixtures, with road tests planned or underway in Delaware,[34] Colorado,[35] California, and elsewhere. A special asphalt mixture, containing 5-percent short-fiber asbestos, was said to offer increased resistance to jet blast erosion of airfield pavement.

Several patents were issued on asbestos-cement pipe-making machinery [36] and one on a system to compress and package asbestos fiber.[37] Other patents were issued on the use of asbestos in plastics,[38] with polymer latex for patching defects in plywood,[39] in a smoking tobacco mixture,[40] in drilling fluids,[41] and as insulation for rocket motors.[42]

Colored asbestos-cement sheets with acrylic baked-on finishes were marketed. Silicones increased the moisture resistance of sheeting and improved electrical insulation qualities. Asbestos-phenolic compounds were available for use at temperatures up to 6,000° F under ablation conditions. It was found that asbestos increased the life of cutting tools used in machining operations when placed at the entry of the cut.[43]

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[34] Roads and Streets. Delaware Builds Asbestos Asphalt Test Strip. V. 104, No. 6, June 1961, pp. 132–134.

[35] Roads and Streets. Colorado Will Test Asbestos Paving Fibers. V. 104, No. 2, February 1961, p. 138.

[36] Colliva, D. (assigned to Johns-Manville Corp.). Machine for Continuously Forming Tubes of Asbestos Cement. U.S. Pat. 3,003,553, Oct. 10, 1961.

Swensen, J. H. (assigned to Johns-Manville Corp.). Apparatus for Forming Asbestos-Cement Pipe. U.S. Pat. 3,000,776, Sept. 19, 1961.

[37] Roberts, J. W., H. Daum, and W. T. Donahue (assigned to Johns-Manville Corp.). Apparatus for Packing Asbestos Fibers and the Like. U.S. Pat. 2,984,172, May 16, 1961.

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[39] Clock, G. E., W. E. F. Rupprecht, and I. J. Cummings (assigned to The Dow Chemical Co.). Process for Patching and Repairing Surface Defects in Plywood and the Like and the Article Resulting Therefrom. U.S. Pat. 3,011,903, Dec. 5, 1961.

[40] Shaw, R. J. Smoking Tobacco Mixture and Method of Making. U.S. Pat. 3,002,863, Sept. 3, 1961.

[41] Jordan, J. W., R. E. Offeman, and D. J. Weintritt (assigned to National Lead Co.). Oil Base Drilling Fluids. U.S. Pat. 2,995,514, Aug. 8, 1961.

[42] Kimmel, N. A. (assigned to Phillips Petroleum Corp.). Insulation for Rocket Motors. U.S. Pat. 2,987,880, June 13, 1961.

[43] Metalworking News. Asbestos Adds Tool Life, Cincinnati Milling Finds. V. 2, No. 54, Oct. 16, 1961, p. 10.

Barite

By Milford L. Skow [1] and Victoria R. Schreck [2]

DOMESTIC production and imports of barite receded from the quantities of 1960, but consumption increased slightly.

DOMESTIC PRODUCTION

Output of primary barite from domestic mines was 5 percent less than in 1960, but the number of active mines was greater. Production was reported from 15 States.

Arkansas continued to lead in output and sales, followed in order by Missouri, Georgia, and Nevada. Other producing States were California, Tennessee, Washington, Texas, South Carolina, Kentucky, Idaho, Utah, New Mexico, Montana, and North Carolina. Stocks of primary barite at the mines decreased 31 percent in 1961.

Production of crushed and ground barite increased 13 percent over 1960 to satisfy the larger demand. End-of-year stocks at processing plants were 15 percent less.

Blackhawk Prospecting, Mining & Exploration Co. opened a new barite mine 3½ miles east of Lincoln, Benton County, Mo. The barite occurs chiefly as veinlets and masses in Ordovician dolomite.

International Minerals & Chemical Corp. began operating a 120,000-ton-per-year barite plant in Houston, Tex., to supply drilling-mud companies in the South. Bar-Tex, Inc., completed a beneficiation mill in Madison County, N.C., and began reclaiming barite from previously mined dump piles.

Production of most barium compounds decreased in 1961.

Mallinckrodt Chemical Works began operating a new plant at St. Louis, Mo., to produce barium sulfate for X-ray diagnosis, and FMC Corp. began producing barium hydroxide monohydrate at its Modesto, Calif., plant.

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.

TABLE 1.—Salient barite and barium-chemical statistics

	1952–56 (average)	1957	1958	1959	1960	1961
United States:						
Primary:						
Mine or plant production short tons	1,064,980	1,304,542	486,287	867,201	[1] 771,318	731,381
Sold or used by producers short tons	1,035,462	1,145,791	605,402	901,815	[1] 714,276	798,785
Value thousands	$10,210	$12,897	$7,507	$10,301	[1] $8,574	$9,312
Imports for consumption short tons	341,698	832,626	526,561	639,598	[1] 641,682	608,160
Value thousands	$2,299	$5,864	$3,733	$4,825	[1] $5,006	$5,185
Consumption short tons [2]	1,378,806	1,670,720	1,195,669	1,396,239	[1] 1,190,371	1,391,399
Ground and crushed sold by producers short tons	1,106,458	1,467,117	1,026,865	1,209,907	[1] 976,830	1,035,782
Value thousands	$26,687	$42,353	$28,352	$30,431	[1] $24,219	$25,182
Barium chemicals sold by producers short tons	95,806	89,757	75,372	98,670	99,100	97,379
Value thousands	$13,092	$12,254	$10,685	$13,657	$14,152	$13,770
World: Production short tons	2,450,000	3,700,000	2,800,000	3,000,000	3,100,000	3,000,000

[1] Revised figure.
[2] Includes some witherite.

TABLE 2.—Domestic barite sold or used by producers in the United States, by States

State	1952–56 (average)		1957		1958	
	Short tons	Value	Short tons	Value	Short tons	Value
Arkansas	425,829	$3,881,794	477,327	$4,536,827	182,779	$1,668,039
California	[1]	[1]	13,144	182,378	24,812	271,766
Georgia, South Carolina, Tennessee	111,883	1,613,322	175,072	2,982,195	108,511	2,284,561
Missouri	338,593	3,554,285	317,350	3,938,486	199,268	2,666,496
Nevada	108,711	659,831	109,663	720,806	59,407	402,936
Other States [2]	50,446	500,560	53,235	536,727	30,625	213,299
Total	1,035,462	10,209,792	1,145,791	12,897,419	605,402	7,507,097

State	1959		1960		1961	
	Short tons	Value	Short tons	Value	Short tons	Value
Arkansas	338,539	$3,096,583	277,851	$2,578,164	277,855	$2,630,028
California	28,143	326,301	16,157	181,019	21,203	295,225
Georgia, South Carolina, Tennessee	89,484	1,809,367	119,304	2,347,220	119,591	2,299,482
Missouri	296,093	3,923,651	180,702	2,587,820	227,323	3,051,663
Nevada	91,298	622,973	[3] 86,061	[3] 590,910	129,524	863,183
Other States [2]	58,258	521,985	34,201	289,276	23,289	172,877
Total	901,815	10,300,860	[3] 714,276	[3] 8,574,409	798,785	9,312,458

[1] Included with Other States to avoid disclosing individual company confidential data.
[2] Includes Arizona (1952–55), Idaho, Kentucky (1959–61), Montana, New Mexico (1959–61), North Carolina, Texas (1961 only), Utah (1959–61), and Washington (1953–55, 1957–61).
[3] Revised figure.

CONSUMPTION AND USES

There was some improvement in the domestic barite industry, but continued curtailment in oil- and gas-well drilling kept activity below 1951–57. The tonnage of domestic barite sold or used by producers in 1961 increased about 12 percent over 1960.

The quantity of crude barite, both domestic and imported, used in manufacturing crushed and ground barite, barium chemicals, and lithopone increased 17 percent over 1960. Sales of crushed and ground barite rose 6 percent chiefly because consumption in the well-drilling and glass industries increased. Oil- and gas-well drillers used 91 percent of the crushed and ground barite and the glass industry, 3 percent.

Consumption of barite by manufacturers of barium chemicals and lithopone was down about 18,000 tons from 1960, a decrease of 10 percent. Sales of most barium chemicals declined, but demand for the carbonate and the chloride increased slightly.

TABLE 3.—Ground and crushed barite produced and sold by producers in the United States

Year	Plants	Production (short tons)	Sales		Year	Plants	Production (short tons)	Sales	
			Short tons	Value (thousands)				Short tons	Value (thousands)
1952–56 (average)	28	1,148,637	1,106,458	$26.687	1959	33	1,198,534	1,209,907	$30,431
1957	33	1,480,585	1,467,117	42,353	1960	36	[1] 973,089	976,830	[1] 24,219
1958	34	1,014,133	1,026,865	28,352	1961	35	1,101,432	1,035,782	25,182

[1] Revised figure.

PRICES

During 1961, 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:		
Crude, oil well drilling, minimum 4.25 specific gravity, bulk, c.i.f. Gulf Ports,		
Before May 11	short ton	16 to 18
Beginning May 11	do	12.50 to 14

Prices of all categories except imported crude oil-well-drilling barite had been unchanged since 1957.

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TABLE 4.—Crude barite (domestic and imported) used in the manufacture of ground barite and barium chemicals in the United States

(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]	
1952–56 (average)	1,184,629	194,177	1,378,806	1959	1,226,633	169,606	1,396,239
1957	1,501,415	169,305	1,670,720	1960	[3] 1,005,170	185,201	[3] 1,190,371
1958	1,053,297	142,372	1,195,669	1961	1,224,181	167,218	1,391,399

[1] Includes some crushed barite.
[2] Includes some witherite.
[3] Revised figure.

TABLE 5.—Ground and crushed barite sold by producers, by consuming industries

Industry	1952–56 (average)		1957		1958	
	Short tons	Percent of total	Short tons	Percent of total	Short tons	Percent of total
Well drilling	1,022,812	93	1,392,394	95	977,255	95
Glass	26,813	2	27,595	2	9,890	1
Paint	23,447	2	16,179	1	14,641	1
Rubber	21,241	2	21,782	1	18,387	2
Undistributed	12,145	1	9,167	1	6,692	1
Total	1,106,458	100	1,467,117	100	1,026,865	100

Industry	1959		1960		1961	
	Short tons	Percent of total	Short tons	Percent of total	Short tons	Percent of total
Well drilling	1,153,560	95	920,283	94	941,539	91
Glass	12,165	1	15,012	1	30,713	3
Paint	17,046	1	18,273	2	16,128	2
Rubber	19,806	2	17,082	2	24,007	2
Undistributed	7,330	1	[1] 1,180	1	23,395	2
Total	1,209,907	100	[1] 976,830	100	1,035,782	100

[1] Revised figure.

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]					
1952–56 (average)	11	128,550	127,079	2,219	$177,577
1957	9	112,048	110,900	1,087	79,474
1958	8	93,539	81,861	1,351	126,050
1959	7	104,740	102,040	2,947	289,580
1960	9	116,995	113,466	3,136	298,741
1961	8	105,117	102,591	2,363	228,358
Carbonate (synthetic):					
1952–56 (average)	4	71,673	26,262	46,237	4,237,747
1957	6	74,160	31,056	42,937	4,335,469
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
Chloride (100 percent $BaCl_2$):					
1952–56 (average)	3	12,493	1,292	11,186	1,596,426
1957	3	9,715	----------	9,373	1,538,809
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
Hydroxide:					
1952–56 (average)	5	13,865	282	13,460	2,579,264
1957	5	12,698	162	12,551	1,915,700
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
Oxide:					
1952–56 (average)	3	15,188	7,388	7,596	1,707,782
1957	3	20,452	5,446	14,159	2,585,193
1958	3	(5)	(5)	(5)	(5)
1959	3	(5)	(5)	(5)	(5)
1960	3	(5)	(5)	(5)	(5)
1961	3	(5)	(5)	(5)	(5)
Sulfate (synthetic):					
1952–56 (average)	6	11,725	112	11,293	1,422,600
1957	4	9,124	----------	8,719	1,281,657
1958	3	6,581	----------	6,628	844,940
1959	4	(5)	----------	(5)	(5)
1960	4	(5)	----------	(5)	(5)
1961	5	(5)	----------	(5)	(5)
Other barium chemicals: [6]					
1952–56 (average)	(7)	4,716	904	3,815	1,370,591
1957	(7)	1,252	137	931	517,224
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	(8)	23,452	4,557,193
Total: [9]					
1952–56 (average)	----------	----------	----------	95,806	13,091,987
1957	14	----------	----------	89,757	12,253,526
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

[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, nitrate, 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 company confidential data.
[9] A plant producing more than 1 product is counted only once in arriving at grand total.

TABLE 7.—Price quotations for barium chemicals in 1961

		January–December
Barium carbonate, precipitated, bags, carlots, works	short tons	$111.50
Smaller lots, works	do	126.50
Barium chlorate, drums, works	pound	.32–.41
Barium chloride, anhydrous, bags, carlots, works	short tons	176.00
Less carlots, works	do	196.00
Barium dioxide (peroxide), drums, freight equaled	pound	.20
Barium hydrate, crystals, bags, carlots, truckloads, freight equaled	short tons	208.00
Less carlots, less truckloads freight equaled	do	218.00
Barium nitrate, barrels, carlots, truckloads, delivered	pound	.16
Less carlots, less truckloads, delivered	do	.17
Barium oxide, ground, drums, carlots, truckloads, freight equaled	short tons	275.00
Less carlots, less truckloads, freight equaled	do	285.00
Blanc fixe, direct process, bags, carlots, works	do	160.00
Less carlots, works	do	170.00
New York warehouse	do	215.00
Lithopone, ordinary, bags, carlots, delivered	pound	[1] .08⅜ E
Less carlots, delivered	do	[1] .09⅛ E
Lithopone, titanated (high-strength), bags, carlots, delivered	do	.11
Less carlots, delivered	do	.12

[1] E=East.

Source: Oil, Paint and Drug Reporter.

FOREIGN TRADE [3]

Imports.—Imports of crude barite were 5 percent less than in 1960 and again came principally from Canada, Mexico, and Peru. These three countries furnished 64 percent of the total. All the imported crude barite entered the United States through four Gulf Coast ports: New Orleans, La., 45 percent; Laredo, Tex., 31 percent; Sabine, Tex., 14 percent; and Galveston, Tex., 10 percent.

The quantity of ground barite imported was the largest since 1944. Virtually all of this came from Canada; West Germany, the other supplier, provided less than 1 percent of the total.

Crude witherite was imported from the United Kingdom and Japan, and crushed or ground witherite was imported from Canada, West Germany, and Italy.

Total imports of barium chemicals declined 8 percent from 1960 although imports of barium nitrate increased to a record quantity. The net loss was attributed mostly to appreciable decreases in imports of blanc fixe and precipitated barium carbonate. West Germany supplied 82 percent of the tonnage of imported barium chemicals; France and the United Kingdom, 5 percent each; and Italy, 3 percent. The remaining 5 percent came from the Netherlands, U.S.S.R., Belgium-Luxembourg, Spain, Switzerland, and Japan.

Exports.—Lithopone exports, more than triple the 1960 volume, were the highest since 1958. Viet-Nam took 71 percent of the total and Aden and Canada, about 11 percent each. The remaining 7 percent was shipped to Venezuela, Guatemala, Panama, and the Philippines.

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

TABLE 8.—U.S. imports for consumption of barite, by countries

	1960		1961	
	Short tons	Value	Short tons	Value
Crude barite:				
North America:				
Canada	112,833	$977,759	145,043	$1,232,892
Cuba	336	2,850		
Mexico	165,864	1,121,877	133,733	1,076,905
Total	279,033	2,102,486	278,776	2,309,797
South America:				
Brazil	23,303	216,282	19,351	150,490
Peru	112,744	1,131,634	109,986	1,039,056
Total	136,047	1,347,916	129,337	1,189,546
Europe:				
Greece	[1] 105,875	[1] 589,854	63,926	415,219
Italy	6,468	60,060	7,276	90,940
Spain	13,741	108,125	10,204	112,542
Yugoslavia	45,426	348,337	60,401	537,714
Total	[1] 171,510	[1] 1,106,376	141,807	1,156,415
Africa: Morocco	55,092	449,238	58,240	528,989
Grand total	[1] 641,682	[1] 5,006,016	608,160	5,184,747
Ground barite:				
North America: Canada	13	406	6,935	503,262
Europe: Germany, West	33	1,624	33	1,653
Total	46	2,030	6,968	504,915

[1] Revised figure.

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
1952–56 (average)	56	$7,856	750	$64,771	663	[1] $51,370	61	$12,568
1957	57	8,124	1,447	115,627	1,407	[1] 120,080	113	18,905
1958	69	9,307	1,573	103,865	1,376	129,159	161	25,832
1959	73	8,752	1,757	122,067	1,510	134,663	232	35,104
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

Year	Barium nitrate		Barium carbonate precipitated		Other barium compounds	
	Short tons	Value	Short tons	Value	Short tons	Value
1952–56 (average)	305	[1] $49.537	1,696	$118,022	584	[1] $121,119
1957	798	120,075	1,543	105.046	61	22,209
1958	701	107,724	322	23,350	38	26,415
1959	596	89,822	1,895	127,734	55	41,823
1960	736	106.818	1,406	104,674	172	132,294
1961	807	128,120	1,190	86,123	160	111,427

[1] Data known to be not comparable with other years.

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]
1952-56 (average)	3,963	$140,779	[2]	[2]
1957	3,029	138,494	8	$533
1958	2,240	108,119	202	15,610
1959	2,552	113,229	[3]	478
1960	1,344	59,257	50	3,246
1961	[4] 1,716	67,280	87	22,659

[1] Value at port of shipment.
[2] Class established June 1, 1956; no transactions.
[3] Less than 1 ton.
[4] Adjusted by the Bureau of Mines.

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
1952-56 (average)	4,041	$642,340	$158.96	1959	538	$99,578	$185.09
1957	991	177,891	179.51	1960	190	35,160	185.05
1958	613	122,462	199.77	1961	608	87,905	144.58

Source: Bureau of the Census.

WORLD REVIEW

World production of barite was estimated at 3 million tons, about the same as for the previous 3 years. Output was known to have come from 36 countries in 1961.

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. During the fiscal year ended May 31, 1961, the company recovered 4,735 tons of barite valued at Can$35,512.[4]

A report on the Canadian barite industry included a history of production, a description of the principal deposits, and a discussion of pertinent technology and marketing.[5]

Mexico.—Exports of barite in 1960 totaled 172,600 tons valued at US$2,278,320, compared with 174,400 tons valued at US$2,302,080 in 1959.[6]

[4] Canadian Mining and Metallurgical Bulletin (Montreal). Monthly Correspondence. V. 54, July 1961, pp. 568–569.
[5] Ross, J. S. The Barium Minerals Industry in Canada. Canada Dept. Mines and Tech. Surveys Inf. Circ. 126, Ottawa, September 1960, 60 pp.
[6] Bureau of Mines. Mineral Trade Notes. V. 53, September 1961, p. 5.

TABLE 12.—World production of barite, by countries [1] [2]

(Short tons)

Country [1]	1952–56 (average)	1957	1958	1959	1960	1961
North America:						
Canada	235,854	228,048	195,719	238,967	154,292	177,954
Cuba (exports)	981	22,796	11,931			
Mexico	81,704	579,646	397,550	314,933	315,627	277,046
United States	1,064,980	1,304,542	486,287	867,201	771,318	731,381
Total	1,383,519	2,135,032	1,091,487	1,421,101	1,241,237	1,186,381
South America:						
Argentina	19,541	25,264	18,716	19,842	[3] 20,000	[3] 20,000
Brazil	11,403	55,349	68,630	56,009	43,826	[4] 46,729
Chile	2,045	860	[3] 880	[3] 880	[3] 880	[3] 880
Colombia	7,587	6,963	14,330	11,023	8,047	[3] 8,000
Peru	12,104	95,388	117,943	105,557	120,813	122,538
Total	52,680	183,824	220,499	193,311	193,566	198,147
Europe:						
Austria (marketable)	4,076	3,902	4,697	4,067	4,876	3,375
France	54,961	84,426	133,934	95,259	99,208	[3] 99,200
Germany, West (marketable)	395,422	472,518	409,105	428,304	517,657	[3] 535,000
Greece	25,619	143,549	169,629	143,014	[3] 165,000	[3] 130,000
Ireland	3,810	11,231	8,736	9,369	9,890	7,627
Italy	88,266	124,945	122,976	133,734	157,925	140,308
Poland	[5] 11,960	[3] 12,400	[3] 12,400	[3] 12,400	[3] 12,400	41,161
Portugal	424	853	1,351	3,760	4,310	[3] 4,300
Spain	13,459	20,287	31,408	28,186	28,596	[3] 28,000
Sweden	49					
U.S.S.R. [3]	110,000	110,000	130,000	130,000	140,000	140,000
United Kingdom [6]	83,056	87,280	66,139	68,408	67,431	82,021
Yugoslavia	90,895	133,137	103,801	118,267	120,691	126,766
Total [1] [3]	914,000	1,240,000	1,230,000	1,210,000	1,360,000	1,370,000
Asia:						
Burma			907	1,120	1,792	2,248
China	(7)	(7)	[3] 55,000	[3] 55,000	[3] 65,000	[3] 90,000
India	11,683	14,462	17,536	14,939	14,976	16,794
Japan	19,361	27,514	16,510	21,331	25,184	32,232
Korea, Republic of	816	8			220	772
Pakistan			342	569	709	489
Philippines	[5] 5,045	6,088	64	186	6,198	2,109
Turkey		2,111	6,035	2,513	1,653	
Total [1] [3]	53,400	83,000	96,000	96,000	116,000	145,000
Africa:						
Algeria	23,852	54,261	67,911	24,038	53,192	29,728
Morocco	14,705	16,276	47,060	40,574	92,945	90,610
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	114		34	239		
Swaziland	445	351	480	461	200	454
Union of South Africa	2,187	3,369	2,721	2,355	1,878	1,962
United Arab Republic (Egypt)	47	294	2,282	2,017	2,866	[3] 3,000
Total	41,350	74,551	120,488	69,684	151,081	125,754
Oceania: Australia	6,668	10,951	7,618	6,960	12,787	19,600
World total (estimate) [1] [3]	2,450,000	3,700,000	2,800,000	3,000,000	3,100,000	3,000,000

[1] Barite is produced in 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 1955–56.

[6] Includes witherite.

[7] Data not available; estimate by senior author of chapter included in total.

[8] One year only, as 1956 was first year of commercial production.

Compiled by Liela S. Price, Division of Foreign Activities.

SOUTH AMERICA

Brazil.—Crude barite was produced at Camamú, Bahia, by Pigmentos Minerais Industrial e Comercial Pigmina, S.A. Local consumption of barite increased to 7,119 tons in 1961 from 2,837 tons in 1960, but exports decreased to 45,294 tons from 52,522 tons.

Chile.—Barite had been mined for several years in the area from Santiago to Arica. Total production was small and was consumed by local paint and chemical industries. Chilean barite deposits are numerous and of high quality but are small and occur as pockets. Cía. Minera Indiana held leases in the Chañaral and Copiapó regions.[7]

TABLE 13.—Exports of crude barite from State of Bahia, Brazil

Country of destination	1960		1961	
	Short tons	Value	Short tons	Value
Bolivia	1,070	US$16,113	500	US$7,258
Trinidad	24,495	199,998	28,891	235,890
United States	20,652	168,624	15,903	129,843
Venezuela	6,305	51,480	----------	----------
Total	52,522	436,215	45,294	372,991

Source: Bureau of Mines. Mineral Trade Notes. V. 54, May 1962, p. 7.

Peru.—Total barite production in 1960 and 1961 came from mines in the Rimac Valley operated by two firms, Barmine Co. and Cía. Perforadora de Pozos para Irrigación, S.A. Barite continued to be the only nonmetallic mineral exported in appreciable quantities. These exports in 1961 were down 2 percent from 1960.

TABLE 14.—Exports of crude barite from Peru

Country of destination	1960 [1]		1961 [2]	
	Short tons	Value	Short tons	Value
United States	112,845	US$959,948	110,122	US$914,159
Ecuador	985	13,875	1,252	17,577
Chile	1,250	17,577	951	13,361
Total	115,080	991,400	112,325	945,097

[1] Bureau of Mines. Mineral Trade Notes. V. 53, August 1961, p. 9.
[2] U.S. Embassy, Lima, Peru. State Department Dispatch 627, Apr. 25, 1962, encl. 1, p. 4.

EUROPE

Ireland.—About 1,600 tons of barite was shipped to Liverpool, England, from old mines at Derryginnock, near Bantry, County Cork. The ore had been mined years before and stockpiled near the surface.[8]

U.S.S.R.—Barite to supplement domestic production was obtained from North Korea and Yugoslavia. Short tons imported in 1959 and 1960, were 14,330 and 44,092, respectively, from North Korea and 21,826 and 22,487 from Yugoslavia.[9]

[7] Bureau of Mines. Mineral Trade Notes. V. 53, August 1961, p. 8.
[8] Mining Journal (London). Mining Miscellany. V. 257, Aug. 25, 1961, p. 193.
[9] Bureau of Mines. Mineral Trade Notes. Supplement 61. V. 54, April 1962, pp. 39, 82.

Yugoslavia.—The Geological Institute at Belgrade reported the discovery of barite deposits at Brezak and Donje Livade near Cacak, about 75 miles southeast of Belgrade. Reserves were estimated at 1.2 million tons.[10]

Exports of crude barite in 1961 declined 21 percent from 1960 to 71,620 tons, much of the decrease resulted from decreased exports to the United States. However, purchases by Czechoslovakia, East Germany, Hungary, France, and West Germany also declined. Exports of ground barite decreased 11 percent to 11,426 tons.[11]

ASIA

India.—The Government of India granted a license for a plant to manufacture barium chemicals. The facilities were to be set up near Tirupati with British assistance.[12]

AFRICA

Morocco.—Exports of barite increased from 39,936 tons in 1959 to 66,630 tons in 1960 and were shipped as follows:

Destination:	*Short tons*
Belgium	3,077
France	3,858
Germany	44
Libya	386
Netherlands	12,123
United Kingdom	9,065
United States	38,077

Source: Bureau of Mines. Mineral Trade Notes. V. 53, October 1961, pp. 4–5.

Swaziland.—The only barite producer continued to be Swaziland Barytes, Ltd., operating the Londosi mine, northeast of Oshoek near the Transvaal border. A reserve of more than 1 million tons in four veins, whose widths range from 10 to 49 inches, was indicated through drilling by the Geological Survey. The main zone is 89 percent barium sulfate.[13]

United Arab Republic (Egypt).—Barite deposits were reported in igneous rocks southeast of Aswan and at Gebel Araf, Wadi Deeb, and Gebel Bakriya in the Eastern Desert.[14]

TECHNOLOGY

Barite was recovered by flotation during processing of the lead-zinc-copper ore of the Rammelsberg mine near Goslar, West Germany.[15]

Superior results in froth flotation of barite were claimed for use of a flotation agent composed of a mixture of an alkali metal salt of an alkyl half-sulfate ester containing 8 to 20 carbon atoms in the

[10] Bureau of Mines. Mineral Trade Notes. V. 53, December 1961, p. 6.
[11] E&MJ Metal and Mineral Markets. Yugoslav Barite Exports to U.S. Decline Sharply. V. 33, Apr. 12, 1962, pp. 3, 8.
[12] Chemical Age (London). U.K. Aid for Indian Barium Chemicals Project. V. 86, Dec. 30, 1961, p. 1019.
[13] Bureau of Mines. Mineral Trade Notes. V. 53, November 1961, p. 9.
[14] Engineering and Mining Journal. In the Middle East. V. 162, July 1961, pp. 136, 138.
[15] Mine and Quarry Engineering (London). Processing the Rammelsberg Ores. V. 27, October 1961, pp. 452–461.

alkyl portion and an alkali metal salt of a fatty acid containing 8 to 20 carbon atoms.[16] In another process developed to recover barite by flotation, saponified tall-oil pitch was used as a low-cost collector.[17] A proposed method of recovering barite from drilling fluids comprised removing soluble components by washing with water, eliminating insoluble components such as bentonite and rock cuttings by elutriation, thickening the remaining heavier fraction, and recovering the barite from thickened material by froth flotation.[18]

Barium values were recovered from compounds such as barium sulfate, barium sulfite, and barium carbonate by heating the particular compound with silica to form a barium silicate with a barium-to-silicon ratio greater than 1.1 to 1 and leaching the silicate with a solution containing initially about 20 percent barium hydroxide.[19]

A number of barium silicates were synthesized, with and without adding mineralizers. Mineralizers improved the mechanical properties of the silicates but did not affect their dielectric properties appreciably in most instances.[20] Reaction rates of barium with oxygen and nitrogen were measured as a function of temperature and pressure, and tentative reaction mechanisms were proposed.[21] In phase studies of the barium oxide-columbium pentoxide system, five binary compounds were observed, and one was postulated.[22] Heats of solution were determined for barium chloride solutions at various concentrations over a range of temperatures, and results were used to calculate heat capacity data.[23]

Methods reported for the chemical analysis of barium compounds included precipitation,[24] ion exchange,[25] flame spectrophotometry,[26] and scintillation counting.[27] Barium and other constituents in an optical glass were determined by a series of titrations.[28]

Barite was used as a major ingredient in concrete blocks for radiation shielding[29] and in a composition for casting into high-strength structural shapes.[30]

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[16] Henderson, R. A. Flotation of Barite. U.S. Pat. 2,970,692, Feb. 7, 1961.
[17] Bishop, W. T. Froth Flotation Process. U.S. Pat. 2,987,183, June 6, 1961.
[18] Talbot, C. F. Process for Reclaiming Barite From Waste Drilling Fluids. U.S. Pat. 2,982,401, May 2, 1961.
[19] Coma, J. G., and M. C. Marcellus. Leaching of Barium Silicates Containing Water-Soluble Barium Salts. U.S. Pat. 2,983,579, May 9, 1961.
[20] Sergeeva, V. I., V. B. Glushkova, and E. K. Keler. (Technical Physical Properties of Barium and Strontium Silicates.) J. Appl. Chem. (U.S.S.R.), v. 34, January 1961, pp. 212–214; English trans. by Consultants Bureau Enterprises, Inc.
[21] Chandrasekharaiah, M. S., and J. L. Margrave. The Kinetics of Oxidation and Nitridation of Lithium, Calcium, Strontium, and Barium. J. Electrochem. Soc., v. 108, November 1961, pp. 1008–1012.
[22] Roth, R. S., and J. L. Waring. Phase Equilibrium Relations in the Binary System Barium Oxide-Niobium Pentoxide. NBS J. Res., v. 65A, July 1961, pp. 337–344.
[23] Criss, C. M., and J. W. Cobble. Thermodynamic Properties of High-Temperature Aqueous Solutions; Standard Partial Molal Heat Capacities of Sodium Chloride and Barium Chloride From 0° to 100°. J. Am. Chem. Soc., v. 83, Aug. 5, 1961, pp. 3223–3228.
[24] Firsching, F. H. Precipitation of Barium Sulfate From Homogeneous Solution Using Complexation and Replacement. Anal. Chem., v. 33, December 1961, pp. 1946–1947. Norwitz, G. Assay of Barium Compounds by Precipitation of Barium Chromate From Homogeneous Solution. Anal. Chem., v. 33, February 1961, pp. 312–313.
[25] Wish, L. Quantitative Radiochemical Analysis by Ion Exchange; Calcium, Strontium, Barium. Anal. Chem., v. 33, January 1961, pp. 53–55.
[26] Dean, J. A., J. C. Burger, T. C. Rains, and H. E. Zittel. Flame Spectrophotometric Study of Barium. Anal. Chem., v. 33, November 1961, pp. 1722–1727.
[27] Lane, W. B. Method of Determining Barium 140 and Lanthanum 140 in a Mixture of the Two Radioisotopes. Anal. Chem., v. 33, March 1961, p. 478.
[28] Malat, M., and V. Mucka. Determination of Thorium, Lanthanum, Barium, and Boron in a Rare-Element Nonsilica Optical Glass. Chemist-Analyst, v. 50, October–December 1961, pp. 110–111.
[29] Technical Survey. Nucleonics. V. 17, Mar. 18, 1961, p. 195.
[30] Atkin, O. W. (assigned to American Nuclear Shielding Corp.). Building Materials. U.S. Pat. 3,006,777, Oct. 31, 1961.

A review of the literature on applications of barium chemicals was published.[31] Barium carbonate and barium soaps of long-chain fatty acids were used in manufacturing lubricating greases.[32]

Oxide systems containing barium oxide were studied for compositions useful in developing frits and glazes for ceramic bodies.[33] Highly refractory properties and good chemical stability were reported for barium zirconate ceramics.[34]

The history, characteristics, advantages, and production methods of barium ferrite ceramics as material for permanent magnets were described briefly.[35] Barium ferrite permanent magnets that were prepared from compositions containing small additions of lead oxide exhibited lower sintering temperatures, higher residual inductances, and higher coercive forces than ordinary barium ferrites.[36] Useful single crystals of barium ferrite were grown from a sodium carbonate flux of the constituent oxides.[37] Microwave properties of single-crystal barium ferrite were reported.[38]

Continued interest in barium titanates was shown by a number of reported methods of preparation[39] and other published results of research on these compounds. The properties of single-crystal barium titanate were studied,[40] the effect of composition on the properties of substituted barium titanates was investigated,[41] and the fabrication

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[31] Food Machinery and Chemical Corp. Barium Bibliography—A Comprehensive Survey of the Literature on Applications of Barium Compounds. 1961., 433 pp.

[32] Myers, Herbert, and F. P. Otto (assigned to Socony Mobil Oil Company, Inc.). Colloidal Barium Carbonate Dispersion and Barium Soap—Barium Carbonate Grease Composition. U.S. Pat. 3,010,897, Nov. 28, 1961.

Wilson, John W., Jr. (assigned to Socony Mobil Oil Company, Inc.). Barium C_{20}–C_{22} Soap—Barium Carbonate Grease Composition and Process for Forming Same. U.S. Pat. 3,010,898, Nov. 28, 1961.

[33] Watts, A. S. Control of the Properties of Glazes by the Aid of Eutectics: III. The Alkaline Earth—Boric Oxide-Silica Systems Separately and in Combinations. J. Am. Ceram. Soc., v. 44, June 1961, pp. 272–276.

[34] Keler, E. K., and A. K. Kuznetsov. (Synthesis and Physicotechnical Properties of Strontium and Barium Zirconates.) Zhur. prikladnoi Khim. (U.S.S.R.), v. 34, October 1961, pp. 2146–2153; U.S. Dept. of Commerce, Current Rev. of the Soviet Tech. Press, Off. of Tech. Serv., Dec. 22, 1961, p. 1 (603).

[35] Ireland, J. R. Ceramics—New Dimension in Magnetism. Research/Development, v. 12, May 1961, pp. 5–7, 10–13.

[36] Schieber, Michael. Preparation and Magnetic Heat Treatment of Barium Ferrite Permanent Magnet Containing Lead Oxide Additions. Bull. Am. Ceram. Soc., v. 40, Sept. 15, 1961, pp. 563–567.

[37] Gambino, R. J., and F. Leonhard. Growth of Barium Ferrite Single Crystals. J. Am. Ceram. Soc., v. 44, May 1961, pp. 221–224.

[38] Wang, F. F. Y., K. Ishii, and J. B. Y. Tsui. Ferrimagnetic Resonance of Single-Crystal Barium Ferrite in the Millimeter Wave Region. J. Appl. Phys., v. 32, August 1961, pp. 1621–1622.

[39] Di Vita, Sam, and R. J. Fischer (assigned to the U.S. Army). Method of Producing Barium Titanate. U.S. Pat. 2,985,506, May 23, 1961.

Malinofsky, W. W. (assigned to the U.S. Army). Method of Preparation of Barium Titanate Powder. U.S. Pat. 2,976,116, Mar. 21, 1961.

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[41] Ern, V., and R. E. Newnham. Effect of WO_3 on Dielectric Properties of $BaTiO_3$ Ceramics. J. Am. Ceram. Soc., v. 44, April 1961, p. 199.

Saburi, Osamu. Semiconducting Bodies in the Family of Barium Titanates. J. Am. Ceram. Soc., v. 44, February 1961, pp. 54–63.

Tennery, V. J., and R. L. Cook. Investigation of Rare-Earth Doped Barium Titanate. J. Am. Ceram. Soc., v. 44, April 1961, pp. 187–193.

and uses of barium titanate ceramics were reported.[42] An X-ray study was made of a barium-titanium-phosphate compound previously found to be luminescent.[43]

[42] Gravley, C. K. (assigned to Clevite Corp.). Prestressed Dielectric Ceramic Bodies. U.S. Pat. 2,972,176, Feb. 21, 1961.
Hanel, R. A. Dielectric Bolometer—A New Type of Thermal Radiation Detector. J. Opt. Soc. Am., v. 51, February 1961, pp. 220–224.
Marks, G. W., and D. A. Hanna. Quantitative Study of Low-Frequency Hysteresis Loops of Polarized Polycrystalline Barium Titanate. Communication and Electronics, January 1961, pp. 799–808.
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Quehl, H. E., Jr. (assigned to E. I. du Pont de Nemours and Co., Inc.). Dielectric Heating Sealing Blanket. U.S. Pat. 2,969,327, Jan. 24, 1961.
[43] Harrison, D. E., and G. Shirane. Crystal Growth and Structural Study of the Barium-Titanium-Phosphate Phosphor. J. Electrochem. Soc., v. 108, August 1961, pp. 788–790.

Bauxite

By Kenneth B. Higbie,[1] Arden C. Sullivan,[2] and Mary E. Trought [2]

WORLD production of bauxite increased 8 percent in 1961. U.S. imports reached a record high, increasing 5 percent over the preceding year. Total supply of bauxite for domestic consumption exceeded 10 million tons for the second successive year. Jamaica continued as the leading world producer and supplied 54 percent of the U.S. imports.

Domestic production declined 39 percent and composed 12 percent of the domestic supply of new bauxite. About 3.9 million short tons of alumina and aluminum oxide products was produced from bauxite. Production of aluminum consumed 88 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)

	1952–56 (average)	1957	1958	1959	1960	1961
United States:						
Production, crude ore (dry equivalent)	1,755	1,416	1,311	1,700	1,998	1,228
Value	$14,054	$12,868	$12,815	$17,725	$21,107	$13,937
Imports for consumption [1]	4,646	7,098	7,915	8,149	[2] 8,739	9,206
Exports (as shipped)	23	61	12	17	29	151
Consumption (dry equivalent)	6,205	7,633	7,034	8,619	8,883	8,621
World: Production	15,675	20,150	[2] 21,030	[2] 22,660	[2] 26,980	29,040

[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

Production of crude bauxite in the United States was 1.2 million long tons, dry equivalent, and was valued at $13.9 million. Production decreased 770,000 tons or 39 percent, and shipments to consumers from mines and processing plants decreased 531,000 tons, or 32 percent from 1960.

Arkansas production was 96 percent of the total U.S. output. The two leading producers in Arkansas were Aluminum Company of America (Alcoa) and Reynolds Metals Co., and each shipped crude ore to its own alumina plant. American Cyanamid Co. and Norton

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

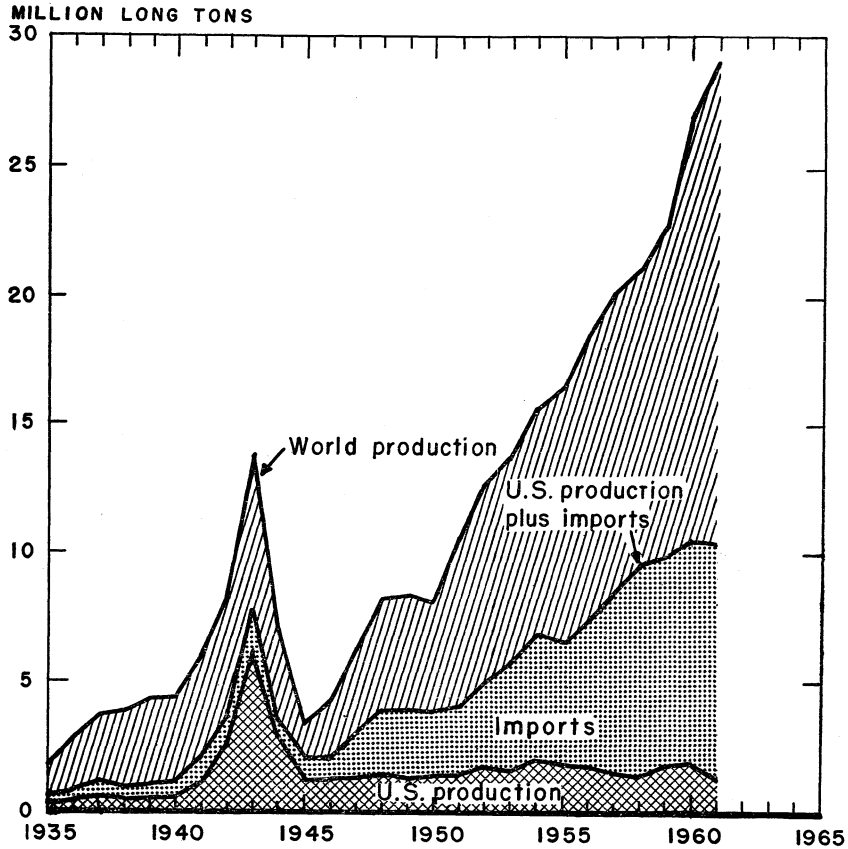


FIGURE 1.—U.S. supply and world production of bauxite, 1935–61.

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 also by Porocel Corp.

D. M. Wilson Bauxite Co., R. E. Wilson Mining Co., and Harbison-Walker Refractories Co. operated bauxite mines in Barbour and Henry Counties, Ala., and American Cyanamid Co. mined in Bartow, Floyd, and Sumter Counties, Ga. Together they produced 49,000 long dry tons of ore, a 26-percent decrease from 1960. Crude ore was shipped to consumers by D. M. Wilson Bauxite Co. The other three companies processed their crude ore to produce dried or calcined bauxite.

Alcoa put on stream its new hydrogen fluoride plant at Point Comfort, Tex.[3] This represented a replacement rather than new capacity as Alcoa had shut down its fluorine operations at East St. Louis, Ill., in 1960. Capacity of the new plant was 25,000 tons per year. Kaiser Aluminum & Chemical Corp. announced plans to build

[3] Chemical & Engineering News, v. 40, No. 5, Jan. 29, 1961, p. 30.

its own 15,000-ton-per-year plant. Inasmuch as Reynolds was already producing hydrogen fluoride, the three major aluminum producers will have their own plants to supply their needs of fluorides, furnished as synthetic cryolite, for the electrolytic reduction operations.

Kaiser's alumina plant facilities at Baton Rouge, La., were expanded in 1961 to permit a fivefold increase in productive capacity for tabular alumina products.

Harvey Aluminum Inc., announced it was planning to build in the Caribbean area an alumina plant, which would have production capacity of 150,000 tons of alumina per year.

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:						
1952–56 (average)	76	60	$519	63	59	$650
1957	77	59	554	67	62	672
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
Arkansas:						
1952–56 (average)	2,003	1,695	13,535	1,938	1,695	14,771
1957	1,625	1,357	12,314	2,004	1,696	16,476
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
Total United States:						
1952–56 (average)	2,079	1,755	14,054	2,001	1,754	15,421
1957	1,702	1,416	12,868	2,071	1,758	17,148
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

[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
1952–56 (average)	272,046	170,552	31,249	201,801	219,018
1957	187,921	128,509	13,093	141,602	147,508
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

CONSUMPTION AND USES

Domestic consumption of bauxite decreased 3 percent. Of the total consumed, 88 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 32 percent. Domestic sources provided the remainder.

Shipments of domestic ore (which serve as an index of the grade of ore consumed) containing less than 8 percent silica were 7 percent of the total, an increase from the 4 percent shipped in 1960. The proportion of ore containing 8 to 15 percent silica decreased from 65 percent in 1960 to 58, and the proportion of the ore containing more than 15 percent silica increased to 35 percent.

The eight domestic alumina plants operated by the aluminum companies produced 3,844,000 short tons of calcined alumina and aluminum oxide products calculated on the basis of the calcined equivalent. This represented a decrease of 5 percent from 1960. The gross weight of the calcined alumina and aluminum oxide products was 3,909,000 tons, of which calcined alumina was 3,688,000 tons and trihydrate alumina 180,000 tons. The remainder was activated or tabular alumina. Shipments of alumina and aluminum oxide products totaled 3,867,000 tons, of which 94 percent or 3,635,000 tons went to the aluminum industry. The remaining 232,000 tons, valued at $22 million, was shipped as commercial trihydrate or as

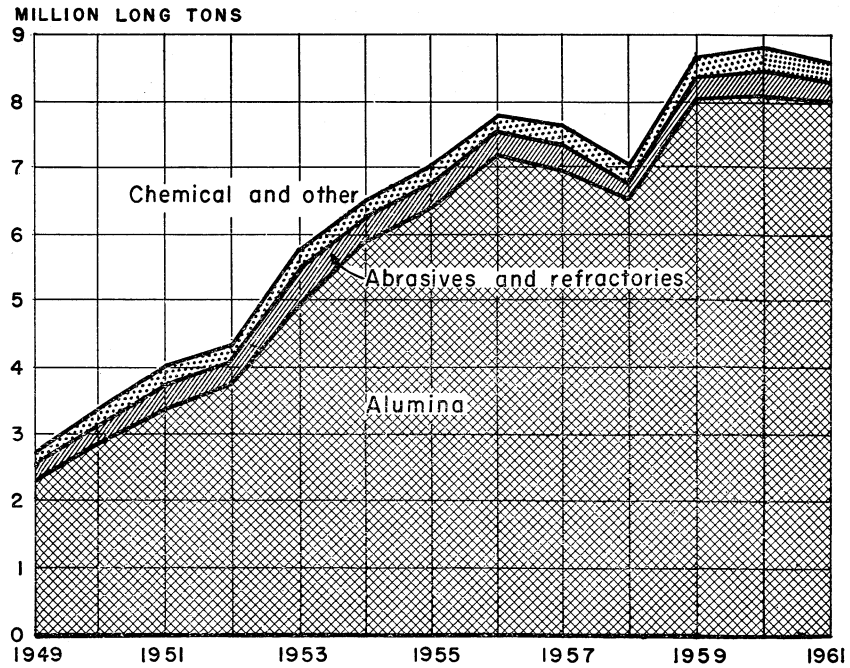


FIGURE 2.—Domestic consumption of bauxite, by uses, 1949–61.

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 3,618,000 short tons, 5 percent less than in 1960. An average of 2.090 long dry tons of bauxite was required to produce 1 short ton of alumina, and an average of 1.901 short tons of alumina was required to produce 1 short ton of aluminum metal. The overall ratio was 3.973 long dry tons of bauxite to 1 short ton of aluminum.

The increasing use of aluminum alkyls was shown by the quadrupling of production capacity for manufacturing aluminum alkyls by Texas Alkyls, Inc.,[4] in its plant at La Porte, Tex. Capacity of the plant was approximately 10 million pounds of aluminum alkyls per year.

TABLE 4.—Bauxite consumed in the United States, by industries

(Long tons, dry equivalent)

Year and industry	Domestic	Percent	Foreign	Percent	Total	Percent
1960:						
Alumina	1,478,324	91.6	6,663,094	91.7	8,141,418	91.6
Abrasive [1]			284,185	3.9	284,185	3.2
Chemical	89,829	5.6	213,687	2.9	303,516	3.4
Refractory	18,684	1.2	75,027	1.0	93,711	1.1
Other	26,377	1.6	34,201	.5	60,578	.7
Total [1]	1,613,214	100.0	7,270,194	100.0	8,883,408	100.0
Percent	18.2		81.8		100.0	
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	

[1] Includes consumption by Canadian abrasives industry.

TABLE 5.—Bauxite consumed in the United States in 1961, by grades

(Long tons, dry equivalent)

Grade	Domestic origin	Foreign origin	Total	Percent
Crude	925,330	558	925,888	10.7
Dried	27,637	7,325,297	7,352,934	85.3
Calcined	66,058	266,093	332,151	3.9
Activated	10,353		10,353	.1
Total	1,029,378	7,591,948	8,621,326	100.0
Percent	11.9	88.1	100.0	

[4] Chemical & Engineering News. Texas Alkyls Quadruples Capacity. V. 39, No. 46, Nov. 13, 1961, pp. 38-39.

TABLE 6.—Capacities of domestic alumina plants in operation and under construction

Company and plant	Capacity as of Dec. 31, 1961 (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.	876,000	
La Quinta, Tex.	730,000	
Total	1,606,000	
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	5,011,500	375,000

TABLE 7.—Production and shipments of selected aluminum salts in the United States in 1960

Type of salt	Number of plants producing	Production (short tons)	Shipments and interplant transfers	
			Short tons	Value f.o.b. plant (thousands)
Aluminum sulfate:				
General:				
Commercial (17 percent Al_2O_3)	53	879,105	861,711	$31,984
Municipal (17 percent Al_2O_3)	5	4,035		
Iron-free (17 percent Al_2O_3)	12	51,744	25,640	1,767
Sodium aluminate (62.2 percent Al_2O_3)	4	(1)	(1)	(1)
Aluminum chloride:				
Liquid (32° Be')	10	25,830	14,523	1,222
Crystal (32° Be')				
Anhydrous (100 percent $AlCl_3$)	5	24,013	24,108	6,902
Aluminum fluoride, technical	6	67,975	66,456	17,855
Aluminum trihydrate (100 percent $Al_2O_3 \cdot 3H_2O$)	10	211,026	180,481	10,666
Other aluminum salts				[2] 13,475
Total				83,871

[1] Included with "Other aluminum salts."
[2] Includes cryolite, sodium-aluminum sulfate, aluminum hydroxide (light or litho), alums, potassium-aluminum sulfate, ammonium-aluminum sulfate, and other aluminum compounds.

Source: Data are based upon report Form MA-28E.1, Annual Report on Shipments and Production of Inorganic Chemicals and Gases, Bureau of the Census.

STOCKS

Bauxite stocks in the United States on December 31, 1961, had increased 62,000 long dry tons from the stocks held a year earlier. On a dry basis, consumers' inventories of crude and processed bauxite increased less than 1 percent; those at mines and processing plants increased 6 percent. No withdrawals were made from the Govern-

ment-held 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, 1,255,604 long dry tons of Jamaican-type ore and 461,878 tons of Surinam-type ore were acquired by barter, bringing the total Government inventories to 6,494,000 tons of Jamaican-type ore and 6,985,000 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.

TABLE 8.—Stocks of bauxite in the United States [1]

(Long tons)

Year	Producers and processors		Consumers		Government, crude	Total	
	Crude	Processed [2]	Crude	Processed [2]		Crude and processed [2]	Dry equivalent
1957	739,836	6,313	488,564	2,364,206	2,204,674	5,803,593	5,329,014
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

[1] Excludes strategic stockpile.
[2] Dried, calcined, and activated.

TABLE 9.—Bauxite in Government inventories as of December 31, 1961

(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	4,965,000	299,000
DPA inventories	1,370,000		
CCC and supplemental stockpile	4,244,000	2,020,000	
Total	6,494,000	6,985,000	299,000
Surplus over maximum objective:			
Quantity	3,894,000	585,000	162,000
Percent	149.8	9.1	118.2

PRICES

No open-market price was in effect for bauxite mined in the United States, as the output was consumed mainly by the producing companies.

The average value of bauxite shipped and delivered to domestic alumina plants was estimated at $17.40 per long ton, dry equivalent, for imported ore.

Prices in E&MJ Metal and Mineral Markets for December 21, 1961, were listed for imported bauxite only and were noted 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 at $27.85 per long ton, increases of $1.00 and $1.25, respectively, over quotations of December 29, 1960.

The average value of calcined alumina, as determined from producer reports, was $0.0344 per pound. The value of imported calcined alumina at the port of shipment was $0.0288 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	
	1960	1961		1960	1961
Crude (undried)	$9.51	$9.78	Calcined	(2)	(2)
Dried	12.09	12.77	Activated	$64.18	$68.89

[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	
	1960	1961		1960	1961
Imports:			Imports—Continued		
Crude and dried:			Calcined: [2]		
Brazil		$12.51	British Guiana	$21.59	$23.30
British Guiana	$6.85	7.24	Canada	34.85	
Dominican Republic [1]	12.59	13.21	Greece	12.37	
Greece	4.95	13.95	Surinam	20.19	24.88
Haiti [1]	8.90	9.41	Average	19.13	23.84
Jamaica [1]	9.48	9.47	Exports:		
Surinam	7.72	9.32	Bauxite and bauxite concentrate	88.29	80.89
Trinidad and Tobago		9.26			
Average	8.93	9.65			

[1] Dry equivalent tons used for computation.
[2] 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. 26, 1960	Dec. 25, 1961
Alumina, calcined, bags, carlots, works—pound	$0.0535	$0.0530
Aluminum hydrate, heavy, bags, carlots, freight equalized—do	.0370	.0370
Aluminum sulfate, commercial, ground, bulk carlots, 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 9.2 million long tons on a dry weight basis, 5 percent above 1960. Imports from Jamaica, the principal source in recent years, were the second highest value in history, up 18 percent over the preceding year and almost 54 percent of the total. Imports from Surinam decreased 11 percent and amounted to 31 percent of the total. The remainder came mostly from the Dominican Republic, British Guiana, and Haiti.

On a dry basis, 44 percent of the imports entered through the New Orleans, La., customs district; 33 percent through the Galveston, Tex., district; 21 percent through the Mobile, Ala., district; and 2 percent through other districts.

Imports of calcined alumina for producing aluminum were 188,000 short tons; 54 percent came from Japan and 35 percent from Jamaica. Other aluminum compounds imported into the United States, totaling 10,240 short tons, were chiefly from Canada, West Germany, Italy, and the United Kingdom.

TABLE 13.—U.S. imports for consumption of bauxite (crude and dried) [1] by countries

(Thousand long tons and thousand dollars)

Country	1952–56 (average)	1957	1958	1959	1960	1961
North America:						
Dominican Republic (dry equivalent)	----------	----------	----------	384	632	722
Haiti (dry equivalent)	----------	318	317	307	341	289
Jamaica (dry equivalent)	1,543	3,622	4,950	4,220	[2] 4,175	4,936
Trinidad and Tobago	2	----------	----------	----------	----------	27
Total	1,545	3,940	5,267	4,911	[2] 5,148	5,974
South America:						
British Guiana	193	391	223	160	330	316
Surinam	2,896	2,767	2,425	3,078	3,256	2,885
Other South America	([3])	----------	----------	----------	----------	4
Total	3,089	3,158	2,648	3,238	3,586	3,205
Europe	2	----------	([3])	----------	5	27
Asia	4	----------	----------	----------	----------	----------
Africa	6	----------	----------	----------	----------	----------
Grand total	4,646	7,098	7,915	8,149	[2] 8,739	9,206
Value	$34,028	$60,933	$70,107	$73,549	[2] $78,024	$88,821

[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] Revised figure.

[3] Less than 1,000 tons.

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 14.—U.S. exports of bauxite (including bauxite concentrate),[1] by countries

(Long tons)

Destination	1952–56 (average)	1957	1958	1959	1960	1961
North America:						
Canada	21,624	58,654	9,548	13,377	24,879	108,104
Mexico	632	862	1,177	1,614	2,781	562
Other North America	149	153	164	92	406	109
Total	22,405	59,669	10,889	15,083	28,066	108,775
South America	55	121	37	346	92	559
Europe	312	403	601	1,082	577	39,859
Asia	102	764	309	835	542	1,327
Africa	16	36	32	57	33	10
Oceania					7	153
Grand total as exported	22,890	60,993	11,868	17,403	29,317	150,683
Dried bauxite equivalent[2]	35,263	94,539	18,395	26,975	45,441	233,559
Value—thousands	$752	$4,847	$968	$1,825	$2,588	$12,189

[1] Classified as "Aluminum ores and concentrates" by the Bureau of the Census.
[2] Calculated by Bureau of Mines.

Source: Bureau of the Census.

Exports.—Exports of bauxite and bauxite concentrate increased 414 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 72 per ent of the exports; France and Poland, approximately 25 percent.

Of the 14,213 short tons of aluminum sulfate exported, about 68 percent was shipped to Canada, Venezuela, and Guatemala. Of the 55,610 short tons of other aluminum compounds exported, 71 percent was shipped to Norway. Small quantities were shipped to 55 other countries.

Tariff.—The duties on crude bauxite, calcined bauxite, and alumina imported for making aluminum were suspended in 1960 until July 16, 1962. Duties on aluminum hydroxide and alumina not used for aluminum production were 0.25 cent per pound.

WORLD REVIEW

World bauxite production rose 8 percent. Jamaica, the principal producer, continued to produce 23 percent of the total. Countries other than Jamaica showing a considerable increase in output were Guinea, 49 percent; Greece, 40 percent; India, 24 percent; Yugoslavia, 20 percent; and Hungary, 14 percent.

Tables 17 and 18 show the international flow of bauxite in 1959 and 1960, respectively. Total exports of bauxite in the world increased approximately 5 percent in 1959 and 16 percent in 1960 over the figures for 1958 and 1959, respectively. Jamaica and Surinam continued to be the world's leading exporters.

TABLE 15.—World production of bauxite by countries [1]

(Thousand long tons)

Country	1952–56 (average)	1957	1958	1959	1960	1961
North America (dried equivalent of crude ore):						
Dominican Republic	----	----	----	759	678	[2] 722
Haiti	----	263	280	255	268	263
Jamaica	1,865	4,643	5,722	5,125	5,745	6,663
United States	1,755	1,416	1,311	1,700	1,998	1,228
Total	3,620	6,322	7,313	7,839	8,689	8,876
South America:						
Brazil	35	63	69	95	119	[3] 140
British Guiana	2,378	2,202	1,586	1,674	2,471	2,374
Surinam	3,243	3,324	2,941	3,376	3,400	3,351
Total	5,656	5,589	4,596	5,145	5,990	5,865
Europe:						
Austria	18	22	23	24	26	18
France	1,283	1,663	1,801	1,729	2,006	2,148
Germany, West	6	5	4	4	4	[3] 4
Greece	426	820	843	904	915	1,280
Hungary	1,180	893	1,032	942	1,170	1,337
Italy	282	257	294	290	310	318
Rumania	28	61	72	70	87	[3] 87
Spain	7	8	8	8	2	----
U.S.S.R. [3]	1,515	2,410	2,710	2,950	3,450	4,000
Yugoslavia	679	874	721	802	1,009	1,213
Total [3]	5,424	7,013	7,508	7,723	8,979	10,405
Asia:						
China (diasporic) [3]	----	----	150	300	350	400
India	76	97	166	215	378	468
Indonesia	243	238	338	381	389	413
Malaya, Federation of	165	326	262	382	452	403
Pakistan	[4] 2	3	2	2	1	1
Sarawak	----	----	136	207	285	253
Taiwan (Quemoy)	2	----	----	----	----	----
Total	488	664	1,054	1,487	1,855	1,938
Africa:						
Ghana (exports)	121	185	207	148	224	193
Guinea, Republic of	357	360	343	296	1,171	1,739
Mozambique	3	5	5	4	5	5
Total	481	550	555	448	1,400	1,937
Oceania: Australia	7	8	7	15	71	[3] 18
World total (estimate)	15,675	20,150	21,030	22,660	26,980	29,040

[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] U.S. imports.
[3] Estimate.
[4] Average annual production 1955–56.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

TABLE 16.—Relationship of world production of bauxite and aluminum

(Million long tons)

Commodity	1952–56 (average)	1957	1958	1959	1960	1961
Bauxite	15.7	20.2	21.0	[1] 22.7	[1] 27.0	29.0
Aluminum	2.7	3.3	3.5	4.0	4.5	4.6
Tons of bauxite per ton of aluminum produced	5.8	6.1	6.0	[1] 5.7	6.0	6.3

[1] Revised figure.

TABLE 17.—Production and trade of bauxite in 1959, by major countries

(Thousand long tons)

Country	Production	Exports by country of destination										
		Total	North America		Europe						Asia	All other countries
			Canada	United States	Germany, West	Italy	Norway	U.S.S.R.[1]	United Kingdom	Other Europe	Japan	
North America:												
Dominican Republic	759	481		481								
Haiti	255	[2] 307		[2] 307								
Jamaica	5,125	4,197		4,197								
United States	1,700	17	13		[3]	[3]			[3]	[3]	1	3
South America:												
Brazil	95	3										3
British Guiana	1,674	1,515	1,019	373	22	15	1		28	28	11	18
Surinam	3,376	3,339	156	3,109	[4] 29					24		21
Europe:												
Austria	24	6			6							
France	1,729	271			123	2			121	13		12
Germany, West	4	[3]										
Greece	904	841			266	9	35	444	50	37		
Hungary	942	459						459				
Italy	290											
Rumania	70	81						81				
Spain	8											
U.S.S.R.	[5] 2,950	[6]										
Yugoslavia	802	592			384	173		28	2	5		
Asia:												
China (diasporic)	[5] 300	[6]										
India	215	23			2	7			[3]		10	4
Indonesia	381	243									243	
Malaya, Federation of	382	364									345	19
Pakistan	2											
Sarawak	207	203									175	28
Africa:												
Ghana	[7] 148	148			[4] 20				128			
Guinea, Republic of	296	297	237		49							11
Mozambique	4	6										6
Oceania: Australia	15											
Other countries	3											
Total	[5] 22,660	13,393	1,425	8,467	901	206	36	1,012	329	107	785	125

[1] U.S.S.R. and other Communist nations of East Europe.
[2] United States imports.
[3] Less than 500 tons.
[4] Imports.
[5] Estimate.
[6] Data not available.
[7] Exports.

Compiled by Corra A. Barry, Division of Foreign Activities.

TABLE 18.—Production and trade of bauxite in 1960, by majorcoun tries

(Thousand long tons)

Country	Production	Exports by country of destination											
		Total	North America		Europe						Asia	Australia	All other countries
			Canada	United States	France	Germany, West	Italy	U.S.S.R.[1]	United Kingdom	Other Europe	Japan		
North America:													
Dominican Republic	678	775	----------	775	----------	----------	----------	----------	----------	----------	----------	----------	----------
Haiti	268	[2] 341	----------	[2] 341	----------	----------	----------	----------	----------	----------	----------	----------	----------
Jamaica	5,745	4,148	----------	4,148	----------	----------	----------	----------	----------	----------	----------	----------	----------
United States	1,998	29	25	----------	[3]	[3]	[3]	----------	[3]	[3]	[3]	----------	4
South America:													
Brazil	119	2	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	2
British Guiana	2,471	2,095	1,401	535	21	34	18	----------	43	15	8	----------	20
Surinam	3,400	3,577	296	3,142	----------	[4] 108	----------	----------	----------	25	----------	----------	6
Europe:													
Austria	26	6	----------	----------	----------	6	----------	----------	----------	----------	----------	----------	----------
France	2,006	312	----------	----------	----------	164	5	----------	130	8	----------	----------	5
Germany, West	4	[3]	----------	----------	----------	----------	[3]	----------	----------	[3]	----------	----------	[3]
Greece	915	891	----------	----------	24	303	5	425	52	42	----------	----------	40
Hungary	1,170	[5] 491	----------	----------	----------	----------	----------	[5] 491	----------	----------	----------	----------	----------
Italy	310	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------
Rumania	87	87	----------	----------	----------	----------	----------	87	----------	----------	----------	----------	----------
Spain	2	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------
U.S.S.R.	[5] 3,450	[6]	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------
Yugoslavia	1,009	790	----------	----------	8	517	221	34	----------	10	----------	----------	----------
Asia:													
China (diasporic)	[5] 350	[6]	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------
India	378	75	----------	----------	----------	9	3	----------	[3]	----------	46	15	2
Indonesia	389	343	----------	----------	----------	----------	----------	----------	----------	----------	343	----------	----------
Malaya, Federation of	452	448	----------	----------	----------	----------	----------	----------	----------	3	354	76	15
Pakistan	1	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------
Sarawak	285	260	----------	----------	----------	----------	----------	----------	----------	----------	238	----------	22
Africa:													
Ghana	[7] 224	224	----------	----------	----------	34	----------	----------	176	----------	14	----------	----------
Guinea, Republic of	1,171	694	593	----------	----------	85	----------	16	[3]	----------	----------	----------	----------
Mozambique	5	4	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	4
Oceania: Australia	71	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------
World total	[8] 26,980	15,592	2,315	8,941	53	1,260	252	1,053	401	103	1,003	91	120

[1] U.S.S.R. and other Communist nations of East Europe.
[2] United States 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.

Table 19 includes information on capacity, location, and ownership of plants producing alumina throughout the world. Most of the data were based on company reports, consular dispatches, newspaper and journal articles, and private communications.

TABLE 19.—World producers of alumina

(Short tons)

Country, company, and plant locations	Capacity, end of 1961	Participants
FREE WORLD		
North America:		
Canada:		
Aluminum Company of Canada, Ltd.: Arvida.	1,250,000	Subsidiary of Aluminum, Ltd. (Canadian).
Jamaica:		
Jamaica, Ltd.:		
Kirkvine	540,000	Do.
Ewarton	270,000	
Total	810,000	
Total [1] United States	5,011,500	
Total, North America	7,071,500	
South America:		
Brazil:		
Aluminio Minas Gerais: Ouro Preto	16,500	Do.
Cie. Brasileirado Aluminio: Sorocaba	33,900	Industrias Votorantim S.A. 80 percent and other Brazilian interests, 20 percent.
Total	49,500	
British Guiana:		
Demarara Bauxite Co.: MacKenzie	245,000	Aluminium, Ltd. (Canadian).
Total South America	294,500	
Europe:		
France:		
Pechiney, Compagnie de Produits Chimiques et Electrometallurgiques:	X	Privately owned (French).
Gardanne	354,000	
Salindres	110,700	
Soc. d'Electro - Chimie, d'Electro - Metallurgie et des Acieries Electriques d'Ugine: La Barasse.	110,000	Do.
Soc. Francaise pour l'Industrie de l'Aluminium: St. Louis les Aygelades.	66,000	Affiliate of Aluminium-Industrie, A.G. (AIAG) (Swiss).
Total	640,700	
Germany, West:		
Aluminium G.m.b.H.: Martinswerke	154,000	Subsidiary of Swiss AIAG.
Vereinigte Aluminium Werke A.G.:		
Lippewerk	143,000	Government owned.
Innwerk	121,000	
Gebrueder Giulini, G.m.b.H.: Ludwigshafen.	132,000	Privately owned (German).
Total	550,000	
Italy:		
Montecatini, Soc. Generale per l'Industrie Mineraria e Chimica.: Porto Marghera.	95,000	Montecatini group.
Soc. Alluminio Veneto per Azioni (SAVA): Porto Marghera.	110,000	Subsidiary of Swiss AIAG.
Total	205,000	
Norway: Norsk Aluminium A/S: Hoyanger.	18,700	Privately owned (Norwegian) 50 percent, and Aluminium, Ltd. (Canadian) 50 percent.
Sweden: A/B Svenska Aluminiumkompaniet: Kubikenborg.	[2] 8,800	Privately owned (Swedish) 50 percent and Aluminium, Ltd. (Canadian) 50 percent.

See footnotes at end of table.

TABLE 19.—World producers of alumina—Continued

Country, company, and plant locations	Capacity, end of 1961	Participants
FREE WORLD—Continued		
Europe—Continued		
United Kingdom:		
British Aluminium Co., Ltd		Tube Investments, Ltd. (British) 47 percent, Reynolds Metals Co. (American) 45 percent, Reynolds Tube Investments, Ltd.; 14 percent, and miscellaneous shareholders, 4 percent.
Burntisland	67,200	
Newport	50,400	
Total	117,600	
Yugoslavia: State concerns		Government owned.
Lozorac	8,800	
Moste	8,800	
Strnisce (Kidricevo)	55,000	
Total	72,600	
Total Europe	1,613,400	
Asia:		
India:		
Indian Aluminium Co., Ltd.: Muri	19,800	Indian owned 35 percent, Aluminium, Ltd. (Canadian), 65 percent.
Aluminium Corp. of India, Ltd.: Jaykaynagar.	5,500	Privately owned (Indian).
Total	25,300	
Japan:		
Showa Denko, K.K. (Showa Electro-Chemical Industry Co., Ltd.): Yokohama.	114,600	Privately owned (Japanese).
Nihon Keikinzoku K.K. (Japan Light Metals Co.): Shimizu.	204,100	Aluminium, Ltd. (Canadian) 50 percent, and privately owned (Japanese) 50 percent.
Sumitomo Kagaku K.K. (Sumitomo Chemical Co., Ltd.): Kikumoto.	132,500	Privately owned (Japanese).
Total	451,200	
Taiwan:		
Taiwan Aluminium Corp.: Takao	32,000	Government owned.
Total Asia	508,500	
Africa:		
Guinea: FRIA, Compagnie Internationale pour la Production d'Alumine: Fria.	530,000	Olin Mathieson Chemical Corp. (American), 48.5 percent; Pechenly-Ugine (French), 26.5 percent; British Aluminium Co., Ltd. (British) and Aluminium Industries, A.G. (Swiss) each 10 percent; and VAW (German) 5 percent.
Oceania: Australia:		
Comalco Industries Pty. Ltd.: Bell Bay	38,500	Consolidated Zinc Corp., Ltd. 3/4 Tasmanian Government 1/4.
Total free world	10,056,400	
SOVIET BLOC		
U.S.S.R.: Soviet Aluminium Trust:		Government owned.
Boksitogorsk	165,000	
Kamensk-Uralskiy	385,000	
Krasnotourinsk	385,000	
Pikaleva	881,800	
Volkhov	88,000	
Zaporzhye	220,000	
Total	2,124,800	
Germany, East:		
Vereinigte Aluminium Werke, A.G.: Lauta.	100,000	Do.
Hungary:		
Bonautaler Alaunnerde: Alamasfuzito	126,700	Do.
Ungarische Bauxit Gruben A.G.: Ajaka	66,000	Do.
Bauxit Industrie A.G.: Magyarovar	38,500	Do.
Total	231,200	

See footnotes at end of table.

TABLE 19.—World producers of alumina—Continued

Country, company, and plant locations	Capacity, end of 1961	Participants
SOVIET BLOC—Continued		
China:		Government owned.
Fushun	24,200	
Nanting	44,000	
Total	68,200	
North Korea	(3)	
Total Soviet Bloc	2,524,200	
Total world	12,580,600	

[1] For company and plant breakdown see table 6, this chapter.
[2] The plant is in standby condition. Some electrical parts have been removed.
[3] Data not available; capacity in 1943 was given as 75,500 tons.

NORTH AMERICA

Canada.—The Aluminium, Ltd., contract with Canadian British Aluminium Co., Ltd., for the exchange of alumina was canceled on December 31, 1961. Thereafter, Canadian British Aluminium Co., Ltd., was to receive its alumina requirements from FRIA, Compagnie Internationale pour la Production d'Alumine, in Guinea and from the Reynolds Metals Co. plant in Corpus Christi, Tex. Canadian British Aluminium is jointly controlled by Tube Investments, Ltd., and Reynolds Metals.

Jamaica.—Jamaica continued to be the world's leading producer of bauxite and furnished 23 percent of the total output. Exports of 5 million long tons went entirely to the United States. Alcan Jamaica, Ltd., formerly Alumina Jamaica, Ltd., produced and exported 787,879 short tons of alumina. Of the alumina exported 424,478 tons went to Canada, 220,734 tons to Norway, 62,988 tons to the United States, 33,358 tons to Sweden and the remainder to other countries.

As a result of a contract to supply the U.S. Government stockpile with 400,000 tons of bauxite from its Jamaica properties, Kaiser resumed production on a second property and planned to extend the railway line.

Reynolds Jamaica Mines, subsidiary of Reynolds Metals Co., also received a contract to supply 600,000 tons of bauxite to the U.S. Department of Commerce, Commodity Credit Corporation, in exchange for surplus agricultural products.

Panama.—Kaiser Aluminum & Chemical Corp. signed an agreement with the Government of Panama to explore Chiriqui Province for bauxite. A United Nations special fund of US$2,004,800 was granted to Panama for a survey of the country's hydraulic and mineral resources. Panama's share of the survey was US$1,139,740.

Puerto Rico.—An exclusive prospecting license was granted to Alumina Caribe, Inc., to explore for bauxite and other aluminous laterites.

SOUTH AMERICA

British Guiana.—Production of bauxite decreased 4 percent and exports of dried ore 31 percent. Reynolds Metals Co. increased its

output of bauxite 62 percent, from 224,000 tons in 1960 to 364,000 tons. Harvey Aluminum, Inc., met with little success in its exploration in the Essequibo area and was considering withdrawal from British Guiana.

TABLE 20.—British Guiana: Bauxite exports

(Long tons)

Country of destination	1960		1961	
	Dried ore	Calcined ore	Dried ore	Calcined ore
Canada	1,315,411	85,831	772,660	102,602
France		21,506		14,470
Germany, West		33,662		25,130
Italy		17,872		18,178
Japan		8,402		19,746
United Kingdom	11,490	31,709	11,510	32,338
United States	453,908	80,694	415,155	90,830
Other countries	7,154	27,280	36,231	67,467
Total	1,787,963	306,956	1,235,556	370,761
Value, BWI$ [1]	17,930,693	11,565,070	14,197,888	14,277,089

[1] BWI$ *H* US$0.58 in 1960 and US$0.59 in 1961.

Demarara Bauxite Co. assembled a new dragline, larger than any used before, for stripping the sand overburden, 150 to 175 feet deep, overlying its bauxite deposit.

The company's new 245,000-short-ton alumina plant at MacKenzie began operating in January 1961 and by yearend had produced 146,000 tons of alumina. Of the alumina exported, 14,600 short tons was shipped to Norway and 119,980 tons to Canada.

In a survey of the ferruginous bauxites of the Pakaraima Mountains, the large tonnage of ore was deemed not suitable for the Bayer process. The Kopinang River Basin, the Sukabi River Basin, and the Kamarang-Kukui area were investigated.[6]

French Guiana.—Société Guyanaise de Bauxite, subsidiary of Kaiser Aluminum & Chemical Corp., obtained an extension of its option to prospect for bauxite in the Kaw Mountains for another 18 months. The original option expired at the end of 1960. An estimated 42 million tons of exploitable bauxite averaging 41.5 percent alumina was delineated in the region. If Kaiser takes up the option, it will be committed to produce 492,000 long tons of bauxite a year, beginning in 1965.

Surinam.—Bauxite production decreased 1 percent, and exports declined 6 percent in 1961 from the record high reported in 1960. Of the total exports, 3.1 million was metal grade; 147,000 tons, abrasive grade; and 60,200 tons, chemical grade ore.

At Paranam, Surinam Aluminum Co., a subsidiary of Alcoa, began constructing a 49,000-long-ton calcining plant, which was scheduled for completion in the second quarter of 1962.

Bauxite deposits, containing an estimated 200 million tons, were found near the Corantijn River. Olin Mathieson Chemical Corp. established a subsidiary, Bakhuis Mining Co., and applied for exploration rights for bauxite in an area between the Nickerie and

[6] Bateson, J. H. Preliminary Report on the Ferruginous Bauxites of the Pakarima Mountains, Miner, Res. Pamphlet No. 10, Geol. Survey of British Guiana, Georgetown, 1961, 27, pp.

Corantijn Rivers. Harvey Aluminum, Inc., applied for bauxite concessions in a 475-square mile area of the Corantijn River district.

EUROPE

Greece.—An increase of 40 percent was reported in bauxite production. Approval of the Greek Government was sought for the creation of Aluminium de Grece S.A., the company which is assuming for a period of 60 years the exclusive rights to exploit the bauxite deposits in Greece, and to create an alumina and aluminum industry. Capital of the company will be US$25 million divided between Pechiney, Compagnie de Produits Chimiques et Électrométallurgiques S.A. (US$12.5 million); Greek Minerals S.A. (US$5.25 million); Reynolds Metals Co. (US$4.25 million); and the state-controlled Industrial Development Corp. of Greece (US$3 million). Pechiney assumed management of the company for a period of not more than 20 years.

A geological survey of the bauxite-bearing districts by the Institute for Geology and Subsurface Research continued during the year.

Hungary.—Bauxite production increased 14 percent to 1.3 million long tons. The first of three articles describing the aluminum industry in Hungary dealt with the history of the alumina industry.[7]

Italy.—Production was started on a limited scale at the bauxite deposits discovered by Monte–Amiata Co. near Alghero, Sardinia.

Poland.—Alumina, obtained by a new process from clay associated with newly discovered bituminous coal deposits in the Nowa Ruda, Turoszow, and Konin districts, was analyzed at the Skawina aluminum plant and found suitable for the production of aluminum. Construction of a 220,000-short-ton alumina plant was proposed. The first stage of the plant was to be completed by 1966. The process entails treating the raw material with sulfuric acid and hydrolyzing the resulting product to yield ammonium-aluminum sulfate, which is roasted to obtain aluminum oxide. The method was said to be 25 percent cheaper than the standard process.

Rumania.—Construction was started on a 132,000-short-ton alumina plant near Oredea. The plant will use bauxite from the northwestern part of the country.

Yugoslavia.—The bauxite reserve in Yugoslavia was reported to be large enough to permit an annual production of 292,000 short tons of alumina for a 60-year period. Most of the bauxite is near Istria in Montenegro. The government planned to spend about US$9 million to double bauxite output by 1970.

ASIA

India.—The Government of India licensed the Bharat Reynolds Aluminium Corp. (BRALCO) to build an alumina plant with an annual capacity of 66,000 short tons near Hubli-Dandeli, in Mysore State.

Bombay Mineral Supply Co. (Private), Ltd., contracted to ship 50,000 long tons of bauxite under a long-term contract to the Bell Bay,

[7] Metal Bulletin (London). Aluminium in Hungary, the Alumina Industry. No. 4603, June 13, 1961, pp. i, iv.

Tasmania, smelter. The Government of India authorized the export of 350,000 tons of bauxite annually in 1962 and 1963.

The Geological Survey of India reported the discovery of bauxite in Kutch, in the Kharagpur Hills, Bihar State, and in the Jamnagar region of Saurashtra State. The bauxite deposits in Katni, Madhya Pradesh, were found to contain at least 4.6 million long tons compared with an estimate of 520,000 tons a decade before.

Indonesia.—Mining Sales Co. contracted to ship 1.2 million long tons of bauxite from Bintan Island deposits to three Japanese aluminum companies during 1962–64.

Malaya, Federation of.—Aluminium, Ltd., announced the building of a washing plant at Sungei Ringitt to treat ore mined by South East Asia Bauxite Co. The plant, to be completed in 1962, was to have the capacity to treat 500,000 long tons a year and was to be operated by newly formed Johore Mining and Stevedoring Co., Ltd.

New Guinea.—The Dutch mining company, Oost-Borneo, announced that exploration for bauxite on Misool Island off New Guinea had been abandoned and the concession returned to the Dutch New Guinea administration.

Philippines.—The Philippine Bureau of Mines conducted investigations of the aluminous laterite deposits on Monoc Island, Surigao Mineral Reservation, from February 1960 to March 1961. The potential reserves of the three deposits, Conico, Northern Conico, and Lutawon Peak, were estimated to total 28 million long tons. The feasibility of using the Pederson process in modified and (or) improved form for the beneficiation of these laterites was being studied.[8]

Taiwan.—Imports of bauxite increased 131 percent in 1961 and totaled 56,300 long tons. Of the 55,200 tons imported from North Borneo for manufacturing aluminum, only 35,500 tons was consumed. A total of 1,160 long tons of bauxite was imported for consumption in manufacturing firebrick.

AFRICA

Cameroun.—More than 12,000 acres of the Minim-Martrap deposits were prospected by the end of 1960, and ore reserves in the area were estimated to total 900 million tons. Principal prospecting was in the Nagaoundal area, where the reserve was estimated to be 100 million tons. Prospecting at Bangam and Fongo-Tongo was discontinued because of terrorist activities in these areas. The extent and quality of the ore at Bangam were not known, but pending further exploration, the reserve at Fongo-Tongo was estimated to be 40 million tons, containing 45 percent alumina and 2 percent silica.

Guinea, Republic of.—Aluminium, Ltd., announced that work on the Boké alumina and bauxite projects, scheduled for completion in July 1964, was suspended owing to inability to solve financial problems under the present agreement. An expenditure of US$175 million was required. New proposals that the company submitted to the government were not accepted, and Bauxites du Midi, subsidiary of Aluminium, Ltd., was ordered to cease all operations in Guinea.

[8] Esguerra, Fernando B. Progress Report on the Aluminous Laterite Investigation Monoc Island, Surigao Mineral Reservation. Philippine Bureau of Mines. Rept. of Inv. 33, Manila, October 1961, 8 pp.

Aluminium, Ltd., through Bauxites du Midi, was granted bauxite rights in the Boké area in 1920 and acquired additional rights in the Los Islands in the mid-1930's. Operations in Los Islands, supended during World War II, were resumed in 1952.

Sierra Leone.—A survey made by the Sierra Leone Geological Survey showed that the bauxite in the Mokanji Hills occurred in a narrow band about 18 miles long. The thickness of the ore varied up to a maximum of about 70 feet and probably averaged 30 feet. Two portions of the deposit were selected for more detailed drilling to determine the exact quantity and grade of bauxite. The ore recovered during prospecting was shipped to West Germany for trial runs to find the most suitable washing plant design. A 15-year mining concession was granted to Aluminium Industries, A.G., and mining was expected to begin in 1962. Sierra Leone Ore & Metals Co., formed in 1960 as a subsidiary of Aluminium Industries, A.G., was in charge of preparatory work.

OCEANIA

Australia.—It was announced in June that Alcoa had joined with Western Aluminium N.L. (Western Mining Corp. Ltd., North Broken Hill Ltd., and Broken Hill South, Ltd.) in a project to establish and operate an integrated aluminum industry in Australia. Alcoa of Australia Pty., Ltd., was formed with Alcoa holding a 51-percent interest and the Australian company, 49 percent. Western Aluminium N.L. was to be granted a bauxite mineral lease covering 2,799 square miles and a temporary mineral reserve covering another 2,739 square miles, in the Darling Range, Western Australia. The proved reserve in the Jarrahdale-Dwellingup area was nearly 80 million tons. Bauxite will be mined by opencut methods and the first area to be worked will be at Jarrahdale. The bauxite will be trucked to a crushing plant and then to an alumina plant to be built at Kwinana, Western Australia. The alumina will be shipped to a company smelter to be built at Point Henry in eastern Geelong.

Duval Holdings Pty. was granted rights to prospect for bauxite for 18 months in the Gove Peninsula area of Northern Territory. British Aluminium Co., Ltd., also had bauxite rights in the Gove area.

An article listing the developments planned by the three major groups of companies-Alcoa, British Aluminium/Alcan, and Comalco—stated that bauxite reserves in the northern areas, particularly Weipa and Gove, may be as high as 3 billion long tons, 2 billion of which will be high grade ore. In addition 21 million tons was known to occur in other localities.[9]

TECHNOLOGY

Some features of open-pit bauxite mining in Arkansas as practiced by Reynolds Mining Corp. were explained.[10] Bauxite deposits in Pulaski and Saline Counties, Ark., lie a short distance from the flanks

[9] Wardrop, Robert. Survey of Aluminum Industry. Min. and Chem. Eng. Rev., Melbourne, v. 54, No. 1, Oct. 15, 1961, pp. 52–61.

[10] Fuller, J. A., and J. R. Krause. Open Pit Mining of Bauxite in Arkansas. Min. Cong. J., v. 47, No. 3, March 1961, p. 24.

of a nepheline syenite outcrop and are directly associated with the weathering of nepheline syenite.

One article described some chemical aspects of bauxite genesis in Jamaica;[11] another described the mining and treatment of bauxite in Jamaica since they began in 1952.[12]

A plant designed to be the first commercial application of an ultra-flotation technique for upgrading materials which resist conventional flotation methods was under construction by Minerals & Chemicals Philipp Corp. at McIntyre, Ga.[13] Among other items, the new facility was capable of processing low-grade bauxite slimes. The process used an auxiliary mineral that acted as a carrier for air bubbles, which in turn collected the aluminum minerals.

Olin Mathieson Chemical Corp. announced development of a new process for purifying aluminum sulfate.[14] This technique opened the possibility for a commercially practical way to extract alumina from common clays or coal shales. The process involved three steps: (1) Leaching the low alumina-content clays or shales with a sulfuric acid solution, (2) separating the iron and aluminum sulfate by crystallization, forming large easily filterable crystals, and (3) thermally decomposing the aluminum sulfate crystals to alumina and recovering the sulfur trioxide as sulfuric acid. The process allows a complete aluminum plant containing alumina extraction and aluminum reduction facilities to be placed on one site where coal for electric power is cheap and where the aluminum-bearing materials are readily available.

A second acid-extraction process for recovering alumina from waste coal shales, developed through research carried out jointly by North American Coal Corp. and Strategic Materials Corp., was to be used in production.[15] The first phase of the process, extraction of aluminum in the form of aluminum sulfate, was to be carried out in a 40,000-ton aluminum sulfate plant which was under construction during 1961. A second plant, which would convert the aluminum sulfate to alumina, was planned for construction during 1962.

Another new acid process for extracting alumina from bauxite, clays, or other aluminum-bearing ores was announced by Australian researchers.[16] This process involved a new combination of techniques, using high-temperature hydrolysis, which was reported to have solved most of the problems of previous methods and was capable of producing pure alumina from a much greater variety of source materials. In general, the process involves: (1) Digesting the aluminous material in sulfuric acid, (2) treating the digestion liquor to reduce the ratio of sulfur trioxide (SO_3): alumina (Al_2O_3) by weight to a value less than 2.35: 1, (3) hydrolysing the modified digestion liquor at a temperature between 180° C and 300° C to precipitate an aluminum compound, and (4) decomposing the precipitate to produce alumina.

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[11] Burns, Donald John. Some Chemical Aspects of Bauxite Genesis in Jamaica. Econ. Geol., v. 56, No. 7, November 1916, pp. 1297–1303.

[12] Moorhead, G. A. Bauxite Mining in Jamaica. Min. and Quarry Eng., v. 27, No. 6, June 1961, pp. 248–257.

[13] E&MJ Metal and Mineral Markets. Many Low-Grade Ores May Gain Value Through Ultraflotation. V. 32, No. 43, Oct. 26, 1961, p. 4.

[14] Light Metal Age. Alumina from Clay. V. 20, No. 344, April 1961, p. 8.

[15] American Metal Market. Coal Firm Building Aluminum Oxide Plant. V. 68, No. 206, Oct. 26, 1961, p. 10.

[16] Scott, Thomas R. (assigned to Commonwealth Scientific and Industrial Research Organization). Production of Alumina. Canadian Pat. 631,055, Nov. 14, 1961.

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A French concern patented yet another method of extracting alumina from siliceous bauxite,[17] wherein an electric blast furnace was utilized to produce a slag containing alumina and aluminum sulfide from a mixture of bauxite, carbon, and iron pyrites. Simultaneously, the iron in the original bauxite was tapped off as a siliceous cast iron which contained most of the other metallic impurities. The mixed slag was treated with water or dilute acid to hydrolyze the sulfide to yield amorphous alumina in addition to the crystalline alumina already present in the mixture.

Aluminum oxide powder consisting of fiber-like particles 1,500 angstroms long by 50 angstroms in diameter was prepared.[18] This oxide was made up almost entirely (83.1 percent) of the boehmite form of alumina monohydrate. In dry form, the oxide had no ionic charge and resembled a fine chalk, but in water it swelled and dispersed to form a stable colloid that would not settle as ordinary alumina powder does.

A new absorptive form of alumina with its major crystalline phase consisting of eta-alumina was developed.[19] The new material had an extremely large surface area, 360 square meters per gram, making it especially suited for drying industrial gases, air conditioning, packaging, and instrumentation applications.

A new desiccant for industrial gas drying applications was developed through a variation in alumina processing techniques.[20] A different alumina structure from that of standard-grade aluminas was achieved that made the material particularly suited for this purpose.

Studies were made to increase the strength of aluminum through addition of pure aluminum oxide sapphire whiskers and thus prepare a composite material having a potential strength-to-weight ratio three to four times greater at high temperatures than known high-strength alloys.[21] The sapphire whiskers were grown by oxidizing aluminum in a hydrogen and water vapor atmosphere and the alumina deposited as single-crystal growths.

Coating of steel dies with aluminum oxide by flame- or plasma-arc spraying permitted the dies to be useful at temperatures up to 3,400° F.[22]

A high-alumina castable-refractory mix coupling low gunning rebound with minimum dusting was developed, producing a strong monolithic body that resists severe abrasion and thermal shocks.[23] Recommended use temperatures range up to 2,500° F. By heating the refractory to 2,400° F a cold compressive strength of about 4,200 psi can be obtained.

A set of standards for high-alumina ceramics provided under one cover a compilation of properties, test procedures, design criteria, and recommendations for use of the materials.[24]

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[17] Tardieu, Pierre (assigned to Pechiney, Compagnie de Produits Chimiques et Életrométallurgiques). Alumina Manufacture in Low-Stack Blast Furnace. U.S. Pat. 3,009,778, Nov. 21, 1961.
[18] Chemical Engineering. Colloidal Alumina Triggers Application Search. V. 68, No. 13, June 26, 1961, p. 76.
[19] Chemical Engineering. Active Alumina. V. 68, No. 19, Sept. 18, 1961, p. 88.
[20] Industrial and Engineering Chemistry. KA-101 Active Alumina. V. 53, No. 12, Dec. 1961, p. 89a.
[21] Missiles and Rockets. Sapphire Whiskers for Safer Re-entry. V. 8, No. 15, Apr. 10, 1961, p. 36.
[22] Simonson, R., J. W. Long, R. W. Tombough, and R. C. Green. Development of Optimum Methods for the Primary Working of Refractory Metals. WADC-TR-60-418, January 1961, pp. 10.
[23] Iron Age. High Strength Refractory. V. 188, No. 10, Sept. 7, 1961, p. 15.
[24] Standards of the Alumina Ceramic Manufacturers Association. Al. Ceram. Manuf. Assoc. New York, N.Y., 1961, 11 pp.

Thermodynamic data pertaining to the heat of formation, heat capacity, and heat content of aluminum nitride at various temperatures were released.[25]

Aluminum nitride was found to possess the essential requirements of a containing material in the aluminum vacuum metallizing process.[26] The refractory possessed a long life expectancy, which was attractive for continuous metallizing processes requiring large quantities of metal. A method of preparing aluminum nitride was discussed involving the reaction of aluminum phosphide in dry ammonia.[27]

Reactions of alumina monohydrate and alumina with wet hydrogen fluoride gas were studied by the Federal Bureau of Mines from 200° to 350° C and from 350° to 700° C, respectively.[28] Both reactions were found to be reversible and proceeded in directions determined by the temperature and the relative $HF:H_2O$ concentration.

A new low-cost process for producing complex metal hydrides of aluminum was developed, involving the reaction of sodium and aluminum with a solvent under pressure of hydrogen gas.[29]

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[25] Mah, A. D., E. G. King, W. W. Weller, and A. V. Christensen. Thermodynamic Properties of Aluminum Nitride. BuMines Rept. of Inv. 5716, 1961, 8 pp.

[26] Long, George, and L. M. Foster. Aluminum Nitride Containers for Vacuum Evaporation of Aluminum. Bull. Am. Ceram. Soc., v. 40, No. 7, July 1961, pp. 423–425.

[27] Addamiano, Arrigo. On the Preparation of Nitrides of Aluminum and Gallium. J. Electrochem. Soc., v. 108, No. 11, November 1961, p. 1072.

[28] Koch, Robert K., and Henry E. Blake, Jr. Aluminum Fluoride From Wet Hydrogen Fluoride Offgas. BuMines Rept. of Inv. 5820, 1961, 11 pp.

[29] Chemical & Engineering News. Cost Could Drop for Complex Metal Hydrides. V. 39, No. 51, Dec. 18, 1961, p. 45–46.

Beryllium

By Donald E. Eilertsen [1]

BERYLLIUM continued to attract widespread attention in 1961, and production of beryllium metal, alloys, and compounds was high. Research continued on the technology of the metal for greater usage in high speed aircraft, missiles, and space vehicles, nuclear energy generation and industry.

LEGISLATION AND GOVERNMENT PROGRAMS

A total of 310 short tons of cobbed domestic beryl was bought in 1961 under the Domestic Beryl Purchase Program (authorized in 1953, Public Law 206, 83d Cong.) and the cumulative total under the program rose to 3,030 tons of beryl. This program was scheduled to terminate June 30, 1962, or when deliveries total 4,500 short tons, whichever occurs first.

No beryl or beryllium-copper master alloy was acquired in 1961 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 and beryllium-copper master alloy for the supplemental stockpile. A total of 1,432,717 pounds of beryllium-copper master alloy was acquired under this program during 1961. This alloy was processed in the United States from raw materials obtained through barter. Negotiations also were completed for acquiring a large quantity of beryllium metal through barter. This material was to be processed in the United States from beryl obtained through barter.

The Office of Minerals Exploration (OME) offered financial assistance to explore for all types of beryllium ore, and participation in approved projects was up to 50 percent. No new contracts for beryllium exploration were made in 1961. The contract of Lithium Corporation of America, Minneapolis, Minn., for exploration of beryl and columbium and tantalum minerals in Custer County, S. Dak., was completed and certified. The contract of Vitro Minerals Corp., Salt Lake City, Utah, for exploration of beryllium minerals in Juab County, Utah, continued in force at the close of 1961. The contract of Tri-State-Metals Corp., Chester, W. Va., for exploration of beryl and tantalum minerals in Taos County, N. Mex., terminated without certification in 1961.

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[1] Commodity specialist, Division of Minerals.

TABLE 1.—Salient beryl statistics

	1952-56 (average)	1957	1958	1959	1960	1961
United States:						
Beryl, approximately 11 percent BeO unless otherwise stated:						
Domestic beryl shipped from mines—short tons	576	521	463	328	244	317
Value, delivered	$278,087	$275,855	$238,017	$170,523	$121,105	(1)
Other domestic low-grade beryllium ore—short tons	----------	----------	42	97	265	805
Value, delivered	----------	----------	$5,000	$8,622	$41,250	(1)
Imports—short tons	7,640	7,290	4,599	8,038	8,943	8,516
Consumption—do	3,257	4,309	6,002	8,173	9,692	9,392
Price, approximate, per unit BeO domestic cobbed beryl, delivered	$44	$48	$47	$48	$46	(1)
Price, approximate, per unit BeO domestic low-grade beryllium ore, delivered	----------	----------	$42	$20	$31	(1)
Price, approximate, per unit BeO, imported, cobbed beryl at port of exportation [2]	$37	$32	$31	$27	$29	$30
World: Production—short tons	9,400	11,300	[3] 7,500	[2] [3] 6,300	[2] [3] 9,300	[3] 8,600

[1] Figure withheld to avoid disclosing individual company confidential data.
[2] Revised figures.
[3] Includes other domestic low-grade beryllium ore.

DOMESTIC PRODUCTION

Mine Production.—Cobbed beryl production continued to be low. Domestic production (mine shipments) of various beryllium concentrate totaled 1,122 short tons. This consisted of 317 tons of cobbed beryl averaging 10.95 percent BeO from more than 100 producers in 9 States and 805 tons of other beryllium concentrate averaging 3.37 percent BeO from the Boomer Lode and Redskin mines in Park County, Colo.

Many private companies and the Government continued the widespread and intensified search of mineral deposits for adequate and dependable long-range supply of domestic beryllium.

TABLE 2.—Beryllium concentrates shipped from mines in the United States, by States

State	1960				1961			
	Cobbed beryl (short tons)	Units BeO	Lower grade beryllium ore (short tons)	Units BeO	Cobbed beryl (short tons)	Units BeO	Lower grade beryllium ore (short tons)	Units BeO
Colorado	39	396	265	1,325	14	155	805	2,715
New Hampshire	14	160	----------	--------	23	272	----------	--------
New Mexico	----------	----------	----------	--------	24	249	----------	--------
South Dakota	167	1,807	----------	--------	238	2,613	----------	--------
Other States [1]	24	276	----------	--------	18	181	----------	--------
Total	244	2,639	265	1,325	317	3,470	805	2,715
Value	$121,105	--------	$41,250	--------	(2)	--------	(2)	--------

[1] Arizona, Connecticut, Maine, New York, and Wyoming.
[2] Figure withheld to avoid disclosing individual company confidential data.

Refinery Production.—The Beryllium Corp. of Reading and Hazelton, Pa., and The Brush Beryllium Co. of Elmore, Ohio, were the only 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. More beryllium metal was produced than in any previous year. Production data were not available for publication. The fourth year elapsed of the 5-year contracts awarded The Beryllium Corp. and The Brush Beryllium Co. for annual delivery of 37,500 pounds of nuclear-grade beryllium to the U.S. Atomic Energy Commission (AEC) by each of these firms.

CONSUMPTION AND USES

Cobbed beryl consumption of 9,392 tons almost equaled the record established in 1960. Nearly all of the beryl was imported and processed into beryllium metal and its alloys and compounds.

Sales of The Beryllium Corp. were $23.6 million, compared with $24.3 million in 1960. The Brush Beryllium Co. sales were $26 million, compared with $28.8 million in 1960.

Five other consumers of cobbed beryl were Beryl Ores Co., Arvada, Colo., which produced specialized beryl materials for the ceramic industry; Glass Coating Materials Division, A. O. Smith Corp., Milwaukee, Wis., which produced ground-coat frit (glass) for ceramics; Lapp Insulator Co., LeRoy, N.Y., which used ground beryl in making high-voltage electrical porcelain; the Ceramic Division, Champion Spark Plug Co., Detroit, Mich., which used beryl as a minor constituent in special ceramic compositions (primarily spark plugs); and Thomas Works, Delta Star Electric Division, H. K. Porter, Co., Lisbon, Ohio, which used beryl in glass for high-voltage suspension insulators.

Mineral Concentrates and Chemical Co., Inc., Loveland, Colo., consumed lower grade beryllium ore for production of various beryllium compounds.

Considerable beryllium was utilized for special applications in aircraft, missiles, vehicles for space exploration, nuclear energy, and for research and development of applications in these fields. Beryllium metal was available in machined shapes and to a limited degree in forgings, tubing, wire, structural shapes, and sheet. The Mercury capsule, Freedom 7, that carried Commander Allan B. Shepard, Jr., on the first flight of an American into suborbital space on May 5, 1961, contained a heat shield and other components of beryllium.

Beryllium-copper alloys were widely used in many industries. Beryllium-copper casings, each measuring about 13 inches in diameter by 30 inches in length and machined to close tolerances, were produced for covering repeater assemblies that are to be installed at intervals of 20 miles along a new international telephone cable on the ocean floor. Lightweight, high-temperature, and high-strength beryllides consisting of beryllium combined with tantalum and zirconium were available for special applications. Beryllium oxide was utilized in nuclear, thermal, and electronic applications and in research and development of new applications in these fields.

STOCKS

Consumer stocks of beryl at the end of the year totaled 4,886 tons, compared with 2,740 tons (revised figure) at the close of 1960. Stocks of beryllium metal and beryllium-copper were larger than in 1960.

As of December 31, 1961, the national (strategic) stockpile contained the equivalent of 23,233 short tons of beryl, of which 2,171,000 pounds was beryllium copper master alloy. This slightly exceeded the maximum stockpile objective for beryl, which was 23,100 tons.

Additional Government stocks of beryllium-bearing materials on hand at yearend were as follows: Supplemental stockpile, the equivalent of 11,151 tons of beryl of which 12,392,974 pounds was beryllium-copper master alloy; CCC stocks, the equivalent of 169 tons of beryl of which 230,999 pounds was beryllium-copper master alloy; and Defense Production Act (DPA) stocks, 1,835 tons of domestically produced beryl.

The AEC sold 4,800 tons of cobbed beryl from its stock to domestic producers of beryllium.

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 of BeO, f.o.b. mine. 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 $31.75 to $32.50 on spot contracts until January 5. Thereafter spot contracts were quoted at $32 to $33.[2] GSA bought domestically-produced cobbed beryl at depots in Custer, S. Dak., Franklin, N.H., and Spruce Pine, N.C. Purchases were made on the basis of a short-ton unit (20 pounds) 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, beads or pebbles, f.o.b. Reading, Pa., and Cleveland, Ohio, was $70 to $71.50 per pound in small quantities, and $62 per pound in 1,000 to 2,000 pound quantities. Beryllium powder was quoted at $64 to $76 per pound until April, and thereafter 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-aluminum was quoted f.o.b. Reading, Pa., Detroit, Mich., and Elmore, Ohio, at $65 per pound of contained beryllium with aluminum paid for at the market price. Beryllium-magnesium-aluminum was quoted at $57 per pound of contained beryllium until September and thereafter at $60 per pound, with magnesium and aluminum paid for at the market price. The prices of beryllium-copper strip, rod, bar, and wire ranged from $1.935 to $1.98 per pound.[3]

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[2] E&MJ Metal and Mineral Markets, v. 32 Nos. 1–52, January–December 1961.
[3] American Metal Market, v. 68, Nos. 1–249, January–December 1961.

FOREIGN TRADE[4]

Imports.—Imports of cobbed beryl in 1960–61 are shown in table 3. Other imports in 1961 were 3,281 pounds of beryllium oxide or carbonate, valued at $46,065; and probably some beryllium metal not separately reported from other commodities.

TABLE 3.—U.S. imports for consumption of beryl, by countries

(Short tons)

Country	1960	1961
South America:		
Argentina	1,212	1,117
Brazil	3,493	2,661
Total	4,705	3,778
Europe: Portugal	28	----------
Asia: India	1,000	885
Africa:		
British East Africa (principally Uganda)	260	1,029
British West Africa, n.e.c.	9	----------
Congo, Republic of the, and Ruanda-Urandi	534	220
Malagasy Republic	[1] 151	564
Mozambique	1,694	1,094
Rhodesia and Nyasaland, Federation of	236	188
Union of South Africa (includes South-West Africa)	326	445
Total	[2] 3,210	3,540
Oceania: Australia	----------	313
Grand total: Short tons	8,943	8,516
Value	$2,863,503	$2,785,894

[1] Revised figure.
[2] Minerals Yearbook, v. 1, 1960, p. 256, French Somaliland revised to none.

TABLE 4.—U.S. exports of beryllium products, in 1961, 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	200	$256	----------	----------	----------	----------
Australia	----------	----------	100	$376	----------	----------
Austria	----------	----------	7,040	22,503	----------	----------
Belgium-Luxembourg	8	396	428	2,828	29	$6,525
Canada	----------	----------	10,050	33,066	55	22,770
Denmark	----------	----------	44	200	202	41,560
France	400	141	73	2,685	55	20,916
Germany, West	50	2,790	54,029	175,785	36	11,774
India	----------	----------	660	2,177	1	384
Italy	----------	----------	6,476	22,804	----------	----------
Japan	8	400	507	1,611	----------	----------
Mexico	----------	----------	440	1,598	----------	----------
Netherlands	----------	----------	550	2,322	----------	----------
Norway	----------	----------	12,620	44,436	----------	----------
Spain	----------	----------	548	1,961	----------	----------
Switzerland	----------	----------	1,770	5,091	7	2,791
United Kingdom	1,149	81,373	25,501	90,595	307	42,285
Total	1,815	85,356	120,830	410,038	692	149,005

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 Census.

Exports.—Twelve pounds of beryllium ore and concrete valued at $200 was exported to Japan. Separate data on beryllium-copper alloy exports were not available. Exports of other beryllium products are shown in table 4.

WORLD REVIEW

World production of beryl, totaling 8,600 tons, consisted of 7,795 tons of cobbed beryl and 805 tons of low-grade beryllium ore.

Argentina.—Cia. Argentina Berilio y Aleaciones, which began producing beryllium alloys in 1958, was reported to have a monthly production of approximately 600 kilograms of beryllium-copper master alloy and 500 kilograms of cobalt-beryllium-copper alloy analyzing 2.6 percent cobalt, 0.5 percent beryllium, and 96.9 percent copper. The company's first export was 300 kilograms of beryllium-copper to a firm in Switzerland.[5]

Japan.—The production capacities of the three Japanese producers of beryllium products were reported as follows: For Nippon Gaishi Kaisha, Ltd.—270 tons of beryllium-copper master alloy containing 4 percent beryllium, 12 tons of beryllium-aluminum master alloy containing 3 to 5 percent beryllium, 2 tons of beryllium oxide powder, 0.1 ton of beryllium metal, and 0.8 ton of fabricated beryllium oxide shapes; for Yokozawa Kagaku Kogyo—120 tons of beryllium-copper master alloy and 1 ton beryllium oxide powder; and for Santoku Kinzoku Kogyo—30 tons of beryllium-copper master alloy, 12 tons of beryllium-aluminum master alloy, and 0.5 ton beryllium oxide powder. Yokozawa Kagaku Kogyo also produced a little beryllium-aluminum experimentally and had some research studies under way on the production of beryllium metal. Santoku Kinzoku Kogyo also had some research studies under way on beryllium production.[6]

Malagasy Republic.—A comprehensive report describing the location, size, geology, mineralogy, and potential for beryl and other valuable minerals of numerous pegmaties in the Malagasy Republic was prepared.[7]

TECHNOLOGY

The Bureau of Mines continued its comprehensive program on beryllium for the fourth consecutive year, and in 1961 the program was the largest the Bureau had ever undertaken on beryllium. It consisted of continuing a nationwide study to determine the nature and extent of potential domestic beryllium resources, continuing metallurgical studies on developing milling methods to recover disseminated beryllium minerals from low-grade ores that someday may substitute for cobbed beryl, continuing metallurgical studies on the

[5] Bureau of Mines. Mineral Trade Notes. V. 53, No. 4, October 1961, p. 6.
[6] Japan Association of Metals for Atomic Energy. Beryllium. Current Situation of Newer Metals in Japan, 1961, p. 1.
[7] Murdock, Thomas G. The Beryl Resources of the Malagasy Republic. U.S. Operations Mission of the Malagasy Republic, Miner. Rept. No. 11, August 1961, 33 pp.
Bureau of Mines. Mineral Trade Notes. V. 54, No. 1, January 1962, pp. 4–26.

TABLE 5.—World production of beryl, by countries [1]

(Short tons)

Country	(1952–56 (average)	1957	1958	1959	1960	1961
North America:						
United States (mine shipments):						
Cobbed beryl	576	521	463	328	244	317
Other lower grade beryllium ore			42	97	265	805
Total	576	521	505	425	509	1,122
South America:						
Argentina	1,058	1,571	1,004	645	739	[2] 770
Brazil	2,232	1,452	1,314	969	1,870	[2] 1,870
Total	3,290	3,023	2,318	1,614	2,609	[2] 2,640
Europe:						
Norway (U.S. imports)			3	4		
Portugal	293	191	52	41	32	14
Sweden			28	[3] 41		
U.S.S.R.[2]	100	110	160	220	220	220
Total [2]	400	300	240	310	250	230
Asia:						
Afghanistan	21	14			11	
India (U.S. imports)	999	1,256	600		1,000	885
Korea, Republic of	[3] 3	(4)				
Total	1,023	1,270	600		1,011	885
Africa:						
Congo, Republic of the (formerly Belgian)	[5] 690	1,666	1,063	280	[2] 340	[2] [6] 440
Kenya	1	6	4	2	1	1
Malagasy Republic (Madagascar)	418	299	181	468	701	[2] 660
Morocco: Southern zone	40					
Mozambique	682	1,870	1,161	1,559	1,649	[2] 1,025
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia	10	6	13	2	2	
Southern Rhodesia	1,121	572	333	440	539	396
Ruanda-Urundi	[7] 63	106	51	187	310	(6)
Somali Republic	[8] 18					
South-West Africa	535	386	247	170	413	252
Swaziland				2	6	7
Uganda	68	78	86	235	470	[2] 500
Union of South Africa	283	711	464	203	325	192
Total	3,929	5,700	3,603	3,548	4,756	[2] 3,470
Oceania: Australia	198	442	278	355	213	[2] 280
World total (estimate)[1]	9,400	11,300	7,500	6,300	9,300	8,600

[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] United States imports.
[4] Less than 0.5 ton.
[5] Average annual production 1954–56.
[6] Ruandi-Urundi included in Republic of the Congo in 1961.
[7] Average annual production 1953–56.
[8] Average annual production 1955–56.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

extraction and purification of beryllium, and starting some studies on casting beryllium. Sensitive nuclear electronic instruments were widely used in the search for beryllium deposits, and in the Northwestern States use of a mobile spectrographic laboratory for detecting beryllium in samples of rocks was continued. The exploration of certain mineral deposits in the Badger Flats area in Park County,

Colo. was completed. Numerous occurrences of beryl in north-central New Mexico were described.[8]

Operation of the Bureau's experimental flotation plant, having a capacity of 2 tons of feed per hour, at King's Mountain, N.C., was terminated after good progress was made in developing milling methods to recover 0.5 percent beryl from the flotation tailing of a commercial spodumene mill. Feed for the spodumene mill was rock mined from a small area within the extensive pegmatite belt, which has been estimated to contain 41,000 tons of beryllium. A report describing pioneering research on producing beryl flotation concentrate containing 6 to 7 percent beryllium oxide (BeO) from tailing of the same spodumene mill in North Carolina was published.[9] Another report described the production of beryl flotation concentrates analyzing 11.9 percent BeO and 7.8 percent BeO from Connecticut and New Hampshire pegmatite rock which analyzed 1.16 percent BeO and 0.43 percent BeO, respectively. Respective recoveries of BeO were 80.2 percent and 63.5 percent.[10] Other small-scale mineral dressing experiments were made on developing methods to recover beryllium concentrate from ore from the Mount Wheeler area in Nevada, the Badger Flats Area in Colorado, and from various other western deposits. Bench-scale batch flotation tests on a sample of Mount Wheeler bertrandite-phenacite ore containing 0.49 percent BeO yielded a concentrate containing 14 percent BeO with recovery at 82 percent. Phenacite ore containing 5 percent BeO was upgraded to a concentrate of 34 percent BeO with recovery at 85 percent.[11] Also, the chemical mineralogical, and physical nature of beryllium-bearing tuff from the Spor Mountain area in Utah were studied. Beryl concentrate from the Bureau's experimental flotation plant at King's Mountain, N.C., and the Black Hills of South Dakota, as well as beryllium-bearing tuff from Spor Mountain were studied hydrometallurgically for the extraction of beryllium salts. Other experiments were directed at producing high-purity beryllium by electrorefining and by Kroll-process reduction techniques. The Bureau also sought methods for producing ductile beryllium.

Numerous companies searched for beryllium deposits.

The geology and mineralogy of recently discovered beryllium-bearing tuff at Spor Mountain in Juab County, Utah, were described.[12] Occurrences of bertrandite, beryl, chrysoberyl, gadolinite, genthelvite, helvite, phenacite, and several hundred nonberyllium minerals in Colorado were reported.[13] A total of 1,385 coal ash samples from domestic coals were analyzed for beryllium, and the Appalachian

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[8] Redmon, D. E. Reconnaissance of Selected Pegmatite Districts in North-Central New Mexico. Bu. Mines Inf. Circ. 8013, 1961, 79 pp.

[9] Browning, J. S., B. H. Clemmons, and T. L. McVay. Beneficiating North Carolina Spodumene-Beryl Ores. BuMines Rept. of Inv. 5750, 1961, 20 pp.

[10] Shelton, John E. Flotation of Beryl From North-Eastern Pegmatites, A Progress Report. BuMines Rept. of Inv. 5767, 1961, 10 pp.

[11] Havens, Richard, W. I. Nissen, and J. B. Rosenbaum. Flotation of Bertrandite and Phenacite from Mount Wheeler, Nev., Beryllium Ore. BuMines Rept. of Inv. 5875, 1961, 14 pp.

[12] Staatz, Mortimer H., and Wallace G. Griffitts. Beryllium-Bearing Tuff in the Thomas Range, Juab County, Utah. Econ. Geol. v. 56, No. 5 August 1961, pp. 941–950.

[13] Eckel, Edwin B. Minerals of Colorado, a 100-Year Record. Geol. Survey Bull. 1114, 1961, 399 pp.

region was found to contain the highest average beryllium content of 62 ppm.[14]

U.S. Atomic Energy Commission research on beryllium metal included studies on basic purification and single-crystal deformation, irradiation damage mechanisms, and tube manufacturing techniques. Investigations also were made on beryllium oxide basic precipitation and sintering, thermal and mechanical properties, irradiation damage, and fabrication of large parts for reactor moderation. Studies on zirconium and columbium beryllides sought to solve the intermediate temperature-breakdown problem.

Considerable other research on beryllium sponsored by the U.S. Armed Forces, especially the Air Force, and industry was under way to advance the technology of beryllium metal. The emphasis in this work was on defense applications. Other experiments were directed toward producing ductile beryllium. Several single crystals of beryllium prepared by the floating-zone method of zone melting were tested in tension and exhibited substantial basal plane glide before fracture. These tests appeared to indicate that impurities in beryllium influence the ductility of the metal.[15] The manufacture of beryllium billet, sheet, and plate, the forming of beryllium sheet and plate, the forging, extruding, and drawing of tube and wire, and the joining of beryllium were described.[16] Exploratory studies on process variables that control the sinterability of unconsolidated beryllium powder were reported.[17] Various conditions that influence the arc welding of beryllium were studied.[18] Techniques were developed for joining beryllium to itself by gas-pressure bonding. Results indicated that bonding was improved by cold working, followed by bonding at 1,500° to 1,600° F for 4 hours at 10,000 psi.[19]

The proceedings of a conference on beryllium toxicity were reported.[20]

A comprehensive book on beryllium technology was published.[21]

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[14] Stadnichenko, Taisia, Peter Zubovic, and Nola B. Sheffley. Beryllium Content of American Coals. Geol. Survey Bull. 1084–K, 1961, pp. 253–295.

[15] Herman, Marvin, G. E. Spangler, and Edwin Hein. The Preparation of High Purity Beryllium and the Study of Its Flow and Fracture Properties. Franklin Inst., Philadelphia, Pa., Final Rept. F–A2323 prepared for Dept. of the Navy, Bureau of Aeronautics, 1960, 22 pp.

[16] Beaver, Wallace W. Wrought Fabrication of Beryllium Metal. The Brush Beryllium Co., Research and Development, Aug. 3, 1961, 48 pp.

[17] Lympany, B. B., J. G. Theodore, and W. W. Beaver. Factors Controlling the Sintering Characteristics of Beryllium Powder. The Brush Beryllium Co., Research and Development, Aug. 7 1961, 25 pp.

[18] MacPherson, B. M., and W. W. Beaver, (The Brush Beryllium Co.). Fusion Welding of Beryllium. U.S. Air Force, Wright-Patterson Air Force Base, Ohio, WADD Tech. Rept. 60–917, April 1961, 63 pp.

[19] Paprocki, S. J., E. S. Hodge, and J. P. Gripshover. Gas-Pressure Bonding. Battelle Memorial Inst., Defense Metals Inf. Center, DMIC Rept. 159, Sept. 25, 1961, pp. 6, 9.

[20] Kettering Laboratory (Univ. Cincinnati, Cincinnati, Ohio). Workshop on Beryllium, January 5–6, 1961: Sponsored by Mfg. Methods Div., LMBM, Headquarters, Air Materiel Command, Wright-Patterson Air Force Base, Ohio, 1961, 111 pp.

[21] Darwin, G. E. and J. H. Buddery. Beryllium. Academic Press, Inc., New York, N.Y., 1960, 392 pp.

Bismuth

By Richard N. Spencer [1] and Edith E. den Hartog [2]

Imports of bismuth, production of refined metal, industrial consumption, and stocks all declined in 1961. No bismuth was acquired for any of the Government stockpile programs; however, some barter contracts were executed for bismuth deliveries for supplemental stockpiling.

World production in 1961 was estimated at 5.5 million pounds, slightly higher than the 1960 total. The market price of bismuth metal, quoted in New York, remained steady throughout the year at $2.25 per pound, in ton lots. This price had not changed since September 5, 1950.

TABLE 1.—Salient bismuth statistics

(Pounds)

	1952–56 (average)	1957	1958	1959	1960	1961
United States:						
Consumption	1,568,600	1,615,200	1,242,700	1,598,000	1,527,300	1,478,400
Imports, general	701,532	847,868	637,309	457,163	1,167,019	798,518
Exports	200,084	158,393	316,318	179,744	156,636	167,166
Price: New York, ton lots	$2.25	$2.25	$2.25	$2.25	$2.25	$2.25
Stocks Dec. 31: Consumer and dealer	218,860	375,300	546,100	472,000	362,800	323,000
World: Production	4,400,000	5,000,000	4,600,000	5,100,000	[1] 5,300,000	5,500,000

[1] Revised figure.

DOMESTIC PRODUCTION

Refined bismuth, derived from foreign and domestic ores, again was almost entirely a metallurgical byproduct of lead refining. Output declined only slightly from 1960. 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 & Smelting Co. Bismuth recovered from alloy scrap in alloy products decreased substantially from 1960.

CONSUMPTION AND USES

Consumption of refined bismuth metal amounted to 1.5 million pounds, 3 percent less than in 1960. A considerable additional

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

quantity of bismuth contained in bismuth-lead bullion was used in alloys. Bismuth alloys used as low-melting or fusible alloys, those used to improve machinability of aluminum alloys, and those used in malleable irons and steels accounted for 61 percent of the total industrial consumption of the metal. Pharmaceuticals and other laboratory and industrial chemicals consumed 35 percent and miscellaneous and experimental uses accounted for the remaining 4 percent. Bismuth consumption in thermoelectric uses increased substantially, but the quantity remained small.

TABLE 2.—Bismuth metal consumed in the United States, by uses

(Pounds)

Use	1960	1961	Use	1960	1961
Fusible alloys	515,570	[1] 683,804	Experimental uses	24,667	9,742
Other alloys	239,757	222,241	Other uses	36,627	41,913
Pharmaceuticals [2]	710,631	520,723	Total	1,527,252	1,478,423

[1] Includes 140,300 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 remained relatively high and imports decreased 32 percent, so dealer and consumer stocks decreased to 323,000 pounds.

Government stocks of bismuth metal on December 31, 1961, amounted to a total of 2,825,000 pounds comprised of: 1,306,000 pounds in the national (strategic) stockpile, 23,000 pounds in the DPA stockpile, and 1,496,000 pounds in the CCC and supplemental stockpile. This amounts to 94 percent of the maximum stockpiling objectives of the Federal Government.

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 1961—a price that had remained unchanged since September 1950. The Metal Bulletin (London) quotation also remained unchanged at $2.24 per pound. No commercial-grade bismuth ore was produced in the United States, and ore was not quoted on the domestic market; Metal Bulletin (London) quoted ore at $1.19 per pound of contained bismuth in concentrate having a minimum of 65 percent bismuth, and $0.71 per pound of contained bismuth in concentrate containing a minimum of 30 percent bismuth. Other grades of concentrate commanded proportionate prices. Prices of most bismuth chemicals and compounds remained unchanged during the year; prices of some changed slightly.

FOREIGN TRADE [3]

General imports of refined metal were 798,500 pounds, a decrease of 32 percent from the quantity imported during 1960. This sharp

[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.

decline in general imports was misleading; the substantial change was due mostly to differences in acquisitions for Government stockpiling. Imports available to industry were almost constant with those available in 1960. Metal imports were augmented by receipts of bismuth-rich lead-base bullion, intermediate bismuth-rich smelter products, bismuth-containing base-metal concentrates, and bismuth chemicals. Nearly all the bismuth-lead bullion was consumed to produce alloys. Bismuth in intermediate smelter products and concentrates was processed and entered the market as domestically produced refined bismuth. Consumption statistics for 1961 in this chapter include an estimated 140,300 pounds of imported bismuth in bismuth-lead bullion.

Exports of bismuth metal and alloys totaled 167,200 pounds (gross weight), an increase of 7 percent over 1960 exports. Bismuth-metal exports reported to the Bureau of Mines were 73,900 pounds, compared with 17,300 pounds in 1960.

TABLE 3.—U.S. imports [1] of metallic bismuth, by countries

(Pounds)

Country	1960	1961	Country	1960	1961
North America:			Europe:		
Canada	90,536	106,291	Belgium-Luxembourg		2,000
Mexico	190,827	203,539	France		501
Total	281,363	309,830	Netherlands	5,437	11,805
South America:			United Kingdom	53,003	(2)
Argentina	12,334		Yugoslavia	69,390	39,681
Peru	745,492	434,701	Total	127,830	53,987
Total	757,826	434,701	Grand total	1,167,019	798,518

[1] Data are "general" imports; that is, they include bismuth imported for immediate consumption plus material entering the 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
1952–56 (average)	200,084	$408,770	1959	179,744	$261,367
1957	158,393	213,313	1960	156,636	275,540
1958	316,318	389,078	1961	167,166	267,775

Source: Bureau of the Census.

WORLD REVIEW

World production of bismuth, about 5.5 million pounds, was slightly greater than that of 1960. Canada, Bolivia, Japan, the Republic of Korea, Mexico, Peru, the United States, and Yugoslavia were the major producers.

Bolivia.—Production of bismuth increased 15 percent despite continued reduction in the output of tin, which is the major metal of Bolivian ores containing bismuth as a byproduct.

Canada.—Bismuth metal was recovered as a byproduct of silver, copper, and molybdenum refining. Canadian production increased 13 percent.

Korea, Republic of.—Bismuth was recovered as a byproduct in processing tungsten ores and concentrates. The Government-owned Tungsten Mining Company, operating the San-dong mine, was the principal producer.

Mexico.—Refined bismuth metal was produced by Metalurgica Penoles, S.A., a subsidiary of American Metal Climax, Inc. Most of the output was exported to the United States, England, Netherlands, and West Germany.

TABLE 5.—World production of bismuth, by countries [1] [2]

(Pounds)

Country [1]	1952–56 (average)	1957	1958	1959	1960	1961
North America:						
Canada (metal) [3]	218,034	319,941	412,792	334,736	423,827	479,700
Mexico [3]	874,437	780,200	417,700	527,700	599,300	[4] 600,000
South America:						
Argentina (in ore) [4]	8,800	47,800	[5] 59,000	[5] 114,600	[5] 350	----------
Bolivia [6]	92,617	90,600	244,700	487,400	403,600	465,300
Peru [3]	681,587	804,800	851,560	737,617	913,106	1,044,980
Europe:						
France (in ore)	110,900	99,200	112,400	122,000	120,400	[4] 150,000
Spain (metal)	47,183	190,500	116,229	53,168	29,875	[4] 26,500
Sweden [4]	121,700	120,000	110,000	60,000	80,000	80,000
Yugoslavia (metal)	230,209	219,805	169,670	200,026	231,582	216,348
Asia:						
China (in ore)	[4] 190,000	(7)	(7)	(7)	(7)	(7)
Japan (metal)	124,811	144,800	168,751	223,187	261,089	[4] 287,000
Korea, Republic of (in ore)	341,700	240,000	198,000	227,000	317,000	[4] 323,000
Africa:						
Mozambique	5,018	6,975	2,167	22,100	30,000	31,000
South-West Africa (in ore)	1,054	670	680	520	310	[4] 390
Uganda	2,293	2,700	15,030	18,984	6,726	[4] [5] 260
Union of South Africa (in ore)	1,332	145	2,023	526	512	[4] 220
Oceania: Australia (in ore)	2,665	1,340	2,352	----------	----------	[4] 1,000
World total (estimate) [1] [2]	4,400,000	5,000,000	4,600,000	5,100,000	5,300,000	5,500,000

[1] United States 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 for them are included in the world total.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Refined metal plus bismuth content of bullion exported.
[4] Estimate.
[5] Exports.
[6] Content in ore and bullion exported, excluding that in tin concentrates.
[7] Data not available; estimate included in world total.

Compiled by Augusta W. Jann, Division of Foreign Activities.

Peru.—Cerro de Pasco Corp. was again the sole producer of bismuth. The bismuth output of this firm was a byproduct of its La Oroya copper, lead, and zinc smelter-refinery operation in which refined bismuth metal and bismuth-rich lead-bismuth bullion were produced. Almost all of the output was exported to the United States. Peruvian production increased 14 percent.

Yugoslavia.—Bismuth metal was recovered as a byproduct of lead-zinc production. The source of much of the bismuth-containing ore was the lead-zinc mines of Zletovo and Rudnik in southern Serbia.

The bismuth was recovered as a byproduct in The Zvecan Lead Smelter & Refinery. Additional resources of bismuth for future consideration are the undeveloped low-grade bismuth ores of Aldimac and Jasikovo, both in eastern Serbia.

TECHNOLOGY

An abrupt 10-to-1 increase in electric current carrying capacity was discovered in ultrapure bismuth single crystals at minus 459° F.[4]

Commercial refrigerators, coolers, and icemakers using bismuth telluride thermoelectrics were placed on the market, and others were in the design stage of development. Franklin Institute Laboratories conducted extensive research on thermoelectric phenomena; the program was sponsored by 13 large industrial firms.

Studies of the conditions under which bismuth tellurides exhibit isotropic and anisotropic characteristics enabled the development of a theory predicting means by which thermoelectric power units can be made anisotropic.[5]

Constitutional diagrams were developed for bismuth-cadmium-tin alloys.[6]

The solubility of uranium in liquid bismuth and the effect of fission products on that solubility under conditions similar to those of a liquid metal fuel reactor were subjects of research.[7] Because of the increased demand for high-purity metals, a survey was presented of the known methods of removing bismuth from lead and the advantages of each method.[8]

Studies were made of the magnesium and uranium concentrations required in liquid bismuth to prevent oxidation of uranium fuel by an air leak in liquid metal fuel reactors using bismuth.[9]

Electrolytic polishing of honeycomb filled with low-melting bismuth alloy is common practice. Electrolytic polishing of bismuth metallographic specimens was described.[10]

Data were given concerning polarographic behavior of bismuth in bismuth trichloride as determined by an electrochemical study.[11]

The Bureau of Mines released a publication treating the heats of formation of a bismuth compound.[12]

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[4] Electronic News, Esaki Finds New Trait in Bismuth Crystal. V. 7, No. 296, Jan. 1, 1962, pp. 1, 9.

[5] Dennis, Jane Hodgson, Anisotropy of Thermoelectric Power in Bismuth Tellurides. Massachusetts Inst. Technol. Tech. Rept. 377, Jan. 15, 1961, 52 pp.; reproduced as Armed Services Tech. Inf. Agency Rept. AD252210.

[6] Bray, H. J., F. D. Bell, and S. J. Harris, The Constitution of Bismuth-Cadmium-Tin Alloys. J. Inst. Metals (London), v. 90, pt. 1, September 1961, pp. 24–27.

[7] Weinberg, A. F., R. J. Thyne, and R. E. Steiner. Uranium Solubility in Bismuth-Base Liquid Solutions. Trans. of Metal. Soc. of AIME, v. 221, No. 1, February 1961, pp. 83–90.

[8] Holmes, J. F. Survey of Methods for the Removal of Bismuth. Metal Ind. (London), v. 99, No. 6, Aug. 11, 1961, pp. 110–112; No. 7, Aug. 18, 1961, pp. 124–126; No. 8, Aug. 25, 1961, pp. 146–147.

[9] Schweitzer, D. G., and D. H. Gurnsky. Kinetic and Equilibrium Studies of Kedox Reactions in Liquid Bismuth. Trans. of Metal. Soc. of AIME, v. 221, No. 1, February 1961, pp. 192–198.

[10] Hare, G. A., and H. D. Mallon. Electrolytic Polishing of Bismuth. Metallurgia (Manchester, England), v. 63, No. 378, April 1961, pp. 208–209.

[11] Topol, L. E., and R. A. Osteryoung. Polarography of Bismuth in Molten Bismuth (III) Chloride. J. Electrochem. Soc., v. 108, No. 6, June 1961, pp. 573–576.

[12] Mah, Alla D. Heats of Formation of Cerium Sesquioxide and Bismuth Sesquioxide by Combustion Calorimetry. BuMines Rept. of Inv. 5676, 1961, 7 pp.

Boron

By Henry E. Stipp [1] and Victoria R. Schreck [2]

BORON compounds have broad industrial applications, and sales are sensitive to changes in industrial activity. Consumption of boron materials in the glass and ceramic industries and exports, principally to Europe, decreased from 1960.

TABLE 1.—Salient boron minerals and compounds statistics in the United States

	1952–56 (average)	1957	1958	1959	1960	1961
Sold or used by producers:						
Short tons:						
Gross weight [1]	631,214	541,124	528,209	619,946	640,591	602,613
Boron Oxide	225,398	269,251	265,613	314,286	323,955	313,104
Value—thousands	$24,405	$38,041	$38,310	$46,150	$47,550	$46,936
Imports for consumption:						
Short tons	23	[2] 5,077	[3] 133	[3] 91	[3] 74	15
Value—thousands	$60	$284	[3] $155	[3] $174	[3] $202	$52
Exports:						
Short tons	182,907	214,497	235,584	253,674	300,606	269,271
Value—thousands	$11,946	$15,975	$18,292	$21,047	$25,576	$23,212
Consumption, apparent:						
Short tons	448,330	331,704	[4] 292,758	[4] 366,363	[4] 340,059	333,357

[1] Gross weight reported for 1952–54 included a higher proportion of crude ore to finished products than in 1955–61.
[2] Imports for 1957 include a higher proportion of crude ore to refined products.
[3] Revised to include ferroboron and boric acid and anhydride.
[4] Revised figure.

DOMESTIC PRODUCTION

Production of boron minerals and compounds (as measured by sales) decreased 6 percent in quantity and 1 percent in value compared with 1960. A decrease in sales was recorded for each primary boron product except anhydrous sodium tetraborate, which increased slightly.

Boron minerals and compounds were produced from the brine of Searles Lake by American Potash & Chemical Corp. at Trona, Calif., and West End Chemical Division of Stauffer Chemical Co. at Westend, Calif. Pacific Coast Borax Division of United States Borax & Chemical Corp. mined borax and kernite from a deposit in the Kramer district near Boron, Calif., colemanite at Death Valley Junction, Calif., and ulexite from a deposit near Shoshone, Calif.

Production of alloy steel ingots (other than stainless steel ingots) containing boron totaled 297,434 short tons in 1960 compared with 282,063 short tons in 1959.[3]

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.
[3] American Iron and Steel Institute. Annual Statistical Report. New York, N.Y., 1960, p. 58.

American Potash & Chemical Corp. increased plant facilities at Trona, Calif., for producing boric acid and sodium tetraborate (anhydrous). United States Borax & Chemical Corp. expanded some production units at Boron, Calif., to increase product output. Olin Mathieson Chemical Corp. received a contract from the U.S. Navy, Office of Naval Research, to make research studies on boron polymers. Cyprus Mines Corp. and Kern County Land Co. reportedly were to reopen the Little Placer mine near Boron, Calif.

Metal Hydrides, Inc., obtained sole ownership of the sodium borohydride plant at Danvers, Mass., previously owned jointly by the U.S. Navy and Metal Hydrides.

CONSUMPTION AND USES

Boron minerals and compounds had numerous industrial and agricultural uses; however, the largest quantity of boron compounds was consumed by the glass and ceramic industries. Sales of boron compounds to these industries decreased from 1960 reportedly because of a slackness in demand for durable goods, such as refrigerators, stoves, and bath tubs, which consume boron materials in porcelain coatings. Also sales in the glass-fiber industry, another large consumer of boron compounds, did not increase as much as anticipated early in the year.

Sales of borax consumed as herbicides and plant foods in agriculture were about equal to sales in 1960.

Boron materials were used in various other products such as soaps and detergents, starch and adhesives, antifreeze, insulation, drugs and cosmetics, electrolytic condensers, and in metal smelting. Boron nitride was used in producing semiconductors, insulating tubes and shapes; chemical equipment parts, crucibles, brazing components, and gaskets and seals.

Several new uses were reported. A powdered nickel-chromium-boron alloy was flame-sprayed on worn machinery parts to give a smooth nonporous hard facing. Boron silicide was considered for use as a general refractory because of its excellent oxidation and thermal shock resistance, and as a control rod material for nuclear reactors. Borax mixed with cutting oils inhibited corrosion of metals. Among other new products for boron compounds were a brake fluid, a dry bleaching agent, a plastic composition, and a coating material for paper. A new waterproofing agent that could be used to protect sidewalks and highways against chemical action of salt contained boron and silicon esters. Boron trifluoride-methanol reagent was developed for esterification of fatty acids. A new low-carbon ferroboron was marketed for addition to stainless steels used in nuclear applications.

PRICES

Changes in the exwarehouse prices for a number of boron chemicals were made in January 1961 to compensate for higher freight rates. The following prices were quoted by Oil, Paint and Drug Reporter:

Compound:	January 1–January 15 (per ton)	January 16–December 31 (per ton)
Borax, technical:		
Anhydrous, 99.5 percent:		
Bags, carlots, works	$92.00	$92.00
Ton lots, bags, exwarehouse, New York or Chicago	148.40	153.40
Bulk, carlots, works	83.00	83.00
Granular, decahydrate, 99.5 percent:		
Bags, carlots, works	50.00	50.00
Ton lots, bags, exwarehouse, New York or Chicago	106.40	106.20
Bulk, carlots, works	43.50	43.50
Granular, pentahydrate, 99.5 percent:		
Bags, carlots, works	64.50	64.50
Ton lots, bags, exwarehouse, New York or Chicago	121.00	122.40
Bulk, carlots, works	58.00	58.00
Powder, 99.5 percent:		
Bags, carlots, works	54.00	54.00
Ton lots, bags, exwarehouse, New York or Chicago	129.00	131.40
Borax, U.S.P., $15 per ton higher than technical.		
Boric acid, technical:		
Anhydrous, 99.9 percent:		
Bags, carlots, works	335.00	335.00
Ton lots, bags, exwarehouse, New York or Chicago	392.40	425.40
Crystals, 99.9 percent:		
Bags, carlots, works	163.50	163.50
Ton lots, bags, exwarehouse, New York or Chicago	221.00	233.40
Granular, 99.9 percent:		
Bags, carlots, works	112.00	112.00
Ton lots, bags, exwarehouse, New York or Chicago	160.40	175.60
Powder, 99.9 percent:		
Ton lots, bags, exwarehouse, New York or Chicago	177.00	184.00
Boric acid, U.S.P., in bags, $25 per ton higher than technical.		

FOREIGN TRADE [4]

Boron carbide imports from West Germany, Canada, United Kingdom, and France totaled 11,992 pounds valued at $37,361, compared with 85,965 pounds valued at $171,805 in 1960. Imports of ferroboron totaled 17,239 pounds valued at $14,190, compared with 33,540 pounds valued at $28,033 in 1960. Boric acid imported from the United Kingdom totaled 7 pounds valued at $509, compared with no imports in 1960. In 1961, barium, boron, strontium, thorium, and vanadium metal imports not reported separately totaled 30,609 pounds valued at $313,921, compared with 1,507 pounds valued at $22,951 in 1960.

Exports of boric acid, borates, and compounds decreased 10 percent in quantity and 9 percent in value compared with exports in 1960. Exports to Europe and Oceania, which showed large percentage increased in 1960, decreased in 1961. European countries such as United Kingdom, West Germany, Italy, and France, which reported decreases in imports of U.S. boron compounds, were estimated to have increased imports of Turkish boron minerals.

[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. exports of boric acid, borates, and compounds,[1] by countries

Destination	1960		1961	
	Short tons	Value	Short tons	Value
North America:				
Canada	13,351	$1,588,352	15,296	$1,764,152
Costa Rica	289	26,064	373	33,136
Cuba	529	54,260		
Dominican Republic	8	1,006	26	3,094
Mexico	5,688	581,759	5,625	556,295
Nicaragua	18	5,566	22	6,040
Trinidad and Tobago	17	1,495	5	900
Other	25	4,515	78	10,588
Total	19,925	2,263,017	21,425	2,374,205
South America:				
Argentina	139	15,034	273	22,153
Brazil	4,734	432,269	5,507	499,150
Columbia	605	60,274	723	69,451
Peru	615	54,353	479	40,360
Uruguay	172	19,801	185	20,840
Venezuela	184	24,871	232	30,194
Other	15	1,519	93	7,842
Total	6,464	608,121	7,492	689,990
Europe:				
Austria	4,145	229,058	2,602	141,582
Belgium-Luxembourg	5,172	507,590	4,722	465,109
Denmark	1,236	96,774	1,095	84,707
Finland	1,311	99,228	2,064	175,394
France	34,757	2,627,604	29,470	2,407,901
Germany, West	65,523	4,864,963	52,092	3,731,511
Greece	520	42,442	133	8,389
Ireland	1,068	73,330	1,163	78,564
Italy	12,295	903,521	7,753	627,805
Netherlands	15,304	1,537,092	17,722	1,730,363
Norway	2,427	221,398	2,836	241,335
Poland and Danzig	551	32,775	64	5,711
Portugal	732	61,626	556	48,413
Spain	4,420	229,536	2,886	128,442
Sweden	2,860	240,772	3,776	343,756
Switzerland	3,044	290,660	2,770	262,130
Trieste	143	11,631		
United Kingdom	62,730	4,961,077	46,358	3,912,046
Yugoslavia	1,403	128,598	1,134	114,721
Total	219,641	17,159,675	179,196	14,507,879
Asia:				
Ceylon	137	$9,573	576	$40,572
Hong Kong	3,695	325,938	3,983	354,651
India	6,366	527,935	7,961	660,859
Indonesia	204	15,160	784	55,605
Iran	126	10,368	195	15,423
Israel	738	64,710	506	46,465
Japan	21,865	2,067,341	27,282	2,455,072
Korea, Republic of	421	32,623	345	29,584
Lebanon	56	4,672	19	1,221
Malaya, Federation of	242	17,715	96	7,354
Pakistan	1,416	107,483	612	65,896
Philippines	482	48,400	389	37,111
Singapore	26	2,399	143	12,446
Taiwan	1,187	74,169	682	47,182
Thailand	445	43,938	660	65,372
United Arab Republic (Syria Region)	28	2,796	45	3,635
Viet-Nam	100	5,750	855	57,643
Other	35	4,316	21	1,676
Total	37,569	3,365,286	45,154	3,957,767
Africa:				
Rhodesia and Nyasaland, Federation of	241	19,143	275	26,553
Spanish Africa, n.e.c.	112	13,928	356	43,507
Union of South Africa	1,914	209,439	2,227	238,456
United Arab Republic (Egypt Region)	368	38,048	673	86,016
Other	104	12,700	137	12,828
Total	2,739	293,258	3,668	407,360
Oceania:				
Australia	9,983	1,367,363	8,146	806,176
New Zealand	4,239	516,456	4,190	468,883
Other	46	2,990		
Total	14,268	1,886,809	12,336	1,275,059
Grand total	300,606	25,576,166	269,271	23,212,260

[1] Classified by the Bureau of the Census as boric acid and borates, crude, refined, and compounds (including borate esters and other boron compounds) n.e.c.

Source: Bureau of the Census.

WORLD REVIEW

SOUTH AMERICA

Argentina.—Production of borates decreased from 11,000 short tons (estimated) in 1959 to 10,340 tons (estimated) in 1960. Exports also declined from 2,530 to 1,067 tons.[5]

Chile.—Consumption of ulexite in 1960 totaled 3,240 short tons.[6] In 1961 the mines were closed because of large stocks, but they were expected to be reopened in the first half of 1962. Sales of ulexite in 1961 totaled less than 3,300 tons. Exports to Uraguay were 108 tons. Anglo-Lautaro Co. boric acid plant at Coya Sur produced 247 tons in 1961 and was expected to produce 4,400 tons in 1962.[7]

EUROPE

France.—American Potash & Chemical Corp., Los Angeles, Calif., and Société d'Électro-Chimie, d'Électro-Métallurgie et des Aciéries Électriques d'Ugine (Ugine) established a subsidiary in France, Société Européenne du Bore (SEUROBOR), to prepare boric acid. A new plant at Pierre-Bénite (Rhône), near Lyon, was scheduled for completion before the end of 1961.[8] Borax Francais, S.A., constructed additional plant capacity at its Dunkirk refinery.[9]

Germany, West.—Manufacture of boron compounds totaled 38,525 short tons in 1960 compared with 54,298 tons in 1959.[10] Metal Hydrides and Farbenfabriken Bayer A.G., agreed to exchange information on uses for borohydrides. The agreement included patents, licenses, and some manufacturing information.[11]

Italy.—Boric acid production totaled 1,289 short tons (96 percent boron in acid) in 1961 compared with 2,438 tons in 1960.[12]

Sweden.—Mo och Domsjo Aktiebolag, Örnskoldsvik, and Metal Hydrides, a U.S. firm, agreed to develop sodium borohydride as a bleach for pulp and paper. A borohydride process patented by the Swedish firm will be licensed by Metal Hydrides.[13]

United Kingdom.—Borax Consolidated Ltd. increased boric acid plant capacity at Belvedere, Kent.[14]

ASIA

China.—New deposits of boron were reportedly discovered by Chinese geological workers.[15]

Israel.—Several U.S. firms were considering erection of a plant to produce 6,000 to 7,000 tons of borax annually and a boric acid plant with capacity of 10,000 tons per year.[16]

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[5] U.S. Embassy, Buenos Aires, Argentina. State Department Dispatch 151. Aug. 2, 1961, p. 6.
[6] Bureau of Mines. Mineral Trade Notes. V. 53, No. 2, August 1961, p. 14.
[7] U.S. Embassy, Santiago, Chile. State Department Dispatch 645. Apr. 17, 1962, p. 26.
[8] Bureau of Mines, Mineral Trade Notes. V. 53, No. 1, July 1961, p. 10.
[9] Chemical Age (London). Project News. V. 85, No. 2173, Mar. 4, 1961, p. 361.
[10] U.S. Embassy, Duesseldorf, West Germany. State Department Dispatch 13, July 19, 1961, encl. 1, p. 1.
[11] Chemical Week. Technology Newsletter. V. 89, No. 12, Sept. 13, 1961, p. 60.
[12] U.S. Embassy, Rome, Italy. State Department Dispatch 851, May 4, 1962, encl. 1, p. 2; State Department Dispatch 941, Apr. 19, 1961, p. 2.
[13] Chemical Age (London). U.S./Swedish Sodium Borhydride Agreement. V. 86, No. 2205. Oct. 14, 1961, p. 594.
[14] Chemical Age. Project News. V. 85, No. 2173, Mar. 4, 1961, p. 361.
[15] Science Newsletter. Minerals Found in China. V. 79, No. 1, Jan. 7, 1961, pp. 3–4.
[16] U.S. Embassy, Tel Aviv, Israel. State Department Dispatch 707, June 6, 1961, p. 4.

Turkey.—Production of boron minerals in 1960 totaled 76,823 short tons, compared with 80,670 (revised) tons in 1959. Exports in 1960 totaled 64,417 tons valued at US$2,088,766, compared with 67,646 (revised) tons valued at US$2,293,557 in 1959.[17] Boron minerals production in 1961 totaled 71,529 tons valued at US$2,015,800.[18]

OCEANIA

Australia.—Mount Isa Mines Ltd. was granted a 12-month license to explore Western Australia's saline lakes which may contain borax.[19]

TECHNOLOGY

A new hydrous calcium borate ($CaO \cdot 3B_2O_3 \cdot 4H_2O$), nobleite, was discovered in the Furnace Creek area of Death Valley, Calif.[20] The platy euhedral mineral was crystallized from weathered colemanite and priceite veins in altered basaltic rocks. Monoclinic nobleite had a hardness of 3, specific gravity of 2.09 ± 0.01, and was biaxial positive.

Polymorphic forms of rare-earth borates in general were of the same structure as the three forms of calcite.[21]

A study of the boron content of the Pierre shale of South Dakota, Wyoming, and Montana, indicated that montmorillonite and mixed-layer clay apparently contain as much boron as illite.[22] Boron content in samples tested was related to total abundance of clay minerals, rather than abundance of specific clay minerals. Several other factors could be responsible for the widespread occurrence of boron.

The economics of transporting borate ore from the open pit mine to surface by truck and belt conveyor system was reviewed.[23] Studies showed that both systems could be used economically. Trucks were used initially but a belt system was used when the pit had been developed sufficiently to permit installation of a crusher.

The use of a sodium calcium borate slurry to control forest fires was increasing.[24] An analysis of the slurry showed 32 percent boron trioxide, calcium oxide 17 percent, sodium oxide 5 percent, and the remainder water of crystallization and additives. The slurry was mixed to give 3.3 pounds of solids per gallon. The material's ability to control forest and brush fires depended upon three properties; the coating excluded air, the white material reflected heat, and borate salts were effective fire retardants.

Probertite was added to an aqueous solution of sodium borate contaminated with calcium.[25] The probertite settled, carrying down cal-

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[17] U.S. Embassy, Ankara, Turkey. State Department Dispatch 99, Aug. 15, 1961, encl. 1, p. 18.

[18] U.S. Embassy, Ankara, Turkey. State Department Dispatch 521, Apr. 19, 1962, encl. 1, p. 1.

[19] Mining World. Mt. Isa Seeks Saline Minerals in Western Australian Playas. V. 23, No. 3, March 1961, p. 27.

[20] Erd, Richard C., James F. McAllister, and Angelina C. Vlisidis. Nobleite, Another New Hydrous Calcium Borate From the Death Valley Region, California. Am. Mineral., v. 46, Nos. 5, 6, May–June 1961, pp. 560–571.

[21] Levin, E.M., R. S. Roth, and J. B. Martin. Polymorphism of ABO_3 Type Rare Earth Borates. Am. Mineral., v. 46, Nos. 9, 10, September–October, 1961, pp. 1030–1055.

[22] Tourtelot, Harry A., L. G. Schultz, and C. H. Huffman, Jr. Boron in Bentonite and Shale From the Pierre Shale, South Dakota, Wyoming, and Montana. Geol. Survey Prof. Paper 424–C, 1961, pp. C-288–C-292.

[23] Mining Congress Journal. Economics of Truck vs. Belt Haulage. V. 47, No. 7, July 1961, pp. 48–51.

[24] Chemical Engineering News. Forest Fires Spur Demand for Retardants. V. 39, No. 29, July 17, 1961, pp. 35–36.

[25] Nies, Nelson P. (assigned to U.S. Borax & Chemical Corp., Los Angeles, Calif.). Production of Sodium Borates. U.S. Pat. 3,000,701, Sept. 19, 1961.

cium impurities. Sodium borate solution was separated from the probertite and crystallized.

A book was published in Russia that described the geochemistry and processing of boron, and the properties, manufacture, and use of elemental boron, boron hydrides, and halogens.[26] Information was included on the properties, production methods, technology, and crystal chemistry of boron compounds with metals and nonmetals. Applications for boron alloys in the manufacture of fireproof materials, electronics, machine building, metallurgy, and chemistry were reviewed.

New methods of synthesizing boron monoxide and diboron tetrachloride could speed research in diboron chemistry.[27] Acid hydrolysis of tetra (dimethylamino) diboron at 0° C gave tetrahydroxydiboron in 56 percent yield. Dehydration of tetrahydroxydiboron at 250° C and 0.5 mm pressure gave boron monoxide in 99-percent yield. Diboron tetrachloride was prepared by passing boron trichloride over boron monoxide at 200° C and 450 mm pressure followed by two passes at 236° C.

Information on the structure of vitreous and liquid boronoxide (B_2O_3) and binary borates was reported.[28] X-ray diffraction studies on crystals of B_2O_3 and infrared absorption studies of solid and liquid B_2O_3 were used to supply some data. The viscosity, electric conductance, and density of liquid B_2O_3 also was investigated. Nuclear magnetic resonance absorption in vitreous B_2O_3, viscosity measurements of binary borates, single crystal X-ray studies, and mechanism of flow in B_2O_3 were reviewed.

The density of boron oxide at 500° C to 1,300° C was measured.[29] The density of rubidium and cesium borates with 20 percent alkali oxide content decreased linearly with increase in temperature.

Polymeric boron monoxide was produced by reacting boron oxide, or a metal borate with boron at 800° to 1,800° C. The materials were reacted at pressures ranging from 10^{-1} to 10^{-6} mm of mercury and rapidly quenched to a temperature below 700° C.[30]

Boron trichloride was prepared by continuously charging carbon, boric acid, and a recycle mixture from a third fluidized bed, into the first fluidized bed.[31] Air was introduced into the bed to fluidize it, oxidizing the carbon and heating the contents to 800° or 900° C, and decomposing the boric acid to boric oxide and water vapor. A part of the product from the first bed was passed into a second bed with air and part of the product from the second bed was then passed into a third fluidized bed. Chlorine was charged into the third bed, and boron trichloride was recovered from the gaseous effluent that formed.

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[26] Samsonor, G. V., L. Ya. Markovskiy, A. F. Zhigach, and M. G. Valyashka. (Boron, Its Compounds and Alloys). Izdat. Akad. Nauk Ukrain. S.S.R. (Kiev), 1960, 589 pp.

[27] Chemical Engineering News. Two Syntheses May Spur Diboron Research. V. 39, No. 14, Apr. 3, 1961, pp. 47–48.

[28] MacKenzie, J. D. The Structure of Boron Oxide and Simple Borates. Gen. Elec. Res. Lab., Schenectady, N.Y., October 1960, 31 pp; ASTIA, ARL Tech., Note 60–130.

[29] Li, Pei-Ching, Anil C. Ghose, and Gang-Jen Su. Density of Molten Boron Oxide and Rubidium and Cesium Borates. Phys. and Chem. Glasses, v. 1, No. 6, 1960, pp. 198–200.

[30] Chemical Trade Journal and Chemical Engineer (London). Patent Abstracts. V. 148, No. 3855, Apr. 21, 1961, pp. 889–890.

[31] Juckniess, Paul R. (assigned to The Dow Chemical Co., Midland, Mich.). Preparation of Boron Trichloride. U.S. Pat. 3,000,705, Sept. 19, 1961.

Anhydrous borax was reacted with magnesium in an inert atmosphere to obtain a boron material which was then reacted with ammonia above 650° C to produce boron nitride.[32]

Extremely pure dielectric material with improved properties for use as electrical insulation at 500° C was prepared from boron nitride.[33] Hot pressing techniques were used. A method of preparing boron nitride capacitors using organic binders was developed. Boron nitride was also deposited on platinum metal with a plasma jet to prepare capacitors.

Diazonium fluoborates were converted to fluorinated aromatics by a continuous process.[34] The modified process was fast, gave better control, and less carryover loss than a former batch process.

Surface coatings that gave protection from temperatures as high as 6,000° F contained phosphate and boron compounds in a flexible polyurethane binder.[35]

A waterproofing compounds was developed that contained boron and silicon esters in an aqueous base.[36] The boron ester binds the silicon ester to calcium in the treated masonry.

Pyrolytic graphite alloyed with boron had high bend strength at temperatures above 3,500° F.[37] At room temperature the material had bend strength of 37,000 psi. The alloy was harder than pyrolytic graphite and had better oxidation and erosion resistance.

Two patents were obtained for preparing materials containing boron and graphite.[38] The materials had potential use in neutron shields.

Semiconducting diamonds were manufactured by adding boron, beryllium, or aluminum impurities to the mixture of graphite and catalyst from which diamonds were made.[39]

A method of preparing relatively pure alloys of boron carbide and a study of their physical properties and phase composition was reported.[40] Boron carbide was prepared by hot-pressing a mixture of amorphous boron and lampblack in an argon atmosphere. Alloys of boron carbide were studied with metallographic tests, X-ray analysis and microhardness, and electrical resistance and thermal electromotive force measurements.

Salts of several diglycol borates were prepared by reacting diglycol borate with metallic sodium in boiling toluene or with sodium hydroxide in cyclohexane.[41] Diglycol borates were prepared by reacting a glycol with boric acid in benzene solution.

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[32] May, Frank H., and Charles C. Cook (assigned to American Potash & Chemical Corp., Delaware). Process for Production of Boron Nitride. U.S. Pat. 2,959,469, Nov. 8, 1960.

[33] Divens, W. C., and others. Synthesis and Purification of Dielectric Materials. USAF, Wright-Patterson AFB, Ohio, September 1960, 68 pp.; ASTIA, AD 247176.

[34] Chemical Engineering News. Pierce Modifies Schiemann Process. V. 39, No. 17, Apr. 24, 1961, pp. 65–67.

[35] Chemical Engineering. Foaming Surface-coatings Furnish Protection From Scorching Heat. V. 68, No. 11, May 29, 1961, p. 38.

[36] Chemical Engineering. Masonry Waterproofing. V. 68, No. 17, Aug. 21, 1961, pp. 82–84.

[37] Materials in Design Engineering. New Alloyed Graphite is Strong at 3,500° F. V. 54, No. 2, August 1961, p. 168.

[38] Clark, Eugene V. (assigned to North American Aviation, Inc.). Graphite Boron Neutron Shielding. U.S. Pat. 2,987,488, June 6, 1961.

Smith, Charles R. F., and Edward L. Reed (assigned to North American Aviation, Inc.). Graphite Boron Neutron Shielding. U.S. Pat. 2,988,522, June 13, 1961.

[39] Electronics News. G. E. Diamond Semicons. V. 6, No. 280, Sept. 11, 1961, p. 52.

[40] Zhuravlev, N. N., G. N. Makarenko, G. V. Samsonov, V. S. Sinel'nikova, and G. G. Tsebulya. (The Question of the Properties and Phase Composition of Alloys of Boron and Carbon). Izvestiya Akademii nauk S.S.S.R. Otdeleniye tekhnicheskikh nauk, Metallurgiya i toplivo, No. 1, 1961, pp. 133–141.

[41] Chemistry and Industry (London). Recent Research Work on Organoboron Chemistry. No. 36, Sept. 9, 1961, p. 1427.

The structural analogy between boron and carbon bonding and its relationship to boron chemistry was reviewed.[42] This method of studying boron chemistry could be followed successfully by making allowances for chemical differences between boron and carbon compounds having similar structural patterns.

Filaments of boron had a tensile strength of 500,000 psi and a modulus of rupture of 55 million psi for 4-mil-diameter material.[43] Filaments 700 feet long were produced. Potential application of the material was for reinforcing epoxy resin structures.

High-purity boron for semiconductor research was prepared by a method that utilized a boron nitride crucible.[44] Chlorine was reacted with boron oxide and carbon at 700° C to obtain boron trichloride and carbon monoxide. The boron trichloride was fractionally distilled to decrease contaminating impurities. Yields of 40 to 50 percent elemental boron were obtained by reducing the boron trichloride with excess hydrogen in a quartz tube at 1,100° to 1,200° C. This boron was melted in a boron nitride crucible by induction or by electron-bombardment furnaces to obtain polycrystalline material.

New techniques have recently been perfected for preparing titanium diboride in large, high-strength, low-cost parts.[45] The material had a purity of 99.5 percent, density of 0.158 lb. per in^3, flexural strength of 35,000 psi, and an elastic modulus of 60 million psi over a temperature range of 77° to 3,600° F. It had a Knoop hardness of about 3,300. Oxidation resistance was excellent up to 1,800° F and relatively low at 2,500° F. Titanium diboride was inert to molten aluminum, zinc and slags, but not to molten ferrous metals.

A method was patented for the production of titanium boride.[46] A mixture of uncalcined titania hydrate pulp, carbon, and boron oxide were slurried and heated from 1,350° to 1,750° C in an inert atmosphere. Titanium boride with a particle size of 1 to 15 microns was produced.

Two refractory materials systems, titanium boronitride and tantalum borocarbide, were developed.[47] Titanium boronitride materials melted or sublimed at about 3,000° C. Several titanium boronitride samples were machinable with carbide tools. The materials were prepared by applying high temperatures and high pressures in a system which held pressure constant and permitted a change in volume. Experimental work covered the effect of composition on properties in the titanium boronitride system.

Titanium boride and 5 percent boron carbide withstood a Mach 2 jet for 2 minutes at a temperature of 380° F.[48]

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[42] Burg, Anton B. Bonding in Boron Compounds and in Inorganic Polymers. J. Chem. Ed., v. 37, No. 9, September 1960, pp. 482–490.

[43] Materials in Design Engineering. What's New in Materials at a Glance. V. 54, No. 7, December 1961, p. 7.

[44] Chemical Engineering News. Boric Acid Yields High Purity Boron. V. 39, No. 17, Apr. 24, 1961, p. 61.

[45] Materials in Design Engineering. Titanium Diboride Now Available as Large, High Strength Parts. V. 53, No. 1, January 1961, pp. 10–11.

[46] Espenschied, Helmut (assigned to National Lead Company, New York, N.Y.). Titanium Boride and Method for Making Same. U.S. Pat. 2,973,247, Feb. 28, 1961.

[47] Forney, G. J. and J. J. Marshall. Investigation of Titanium Boronitride and Tantalum Borocarbide Materials Systems. Electro-Thermal Ind. Inc., Pearl River, N.Y., Tech. Rept. No. WAL371.9/2, January 1961, 25 pp.; ASTIA, AD 253669.

[48] Materials in Design Engineering. Materials Engineering and Design. V. 54, No. 3, September 1961, p. 109.

Excessive corrosion of the boron control rods in the atomic reactor at Idaho Falls, Idaho, could have allowed reactivity in the core to rise to a point beyond the ability of the control rods to contain the reaction.[49]

A boron phosphate-silica ceramic that compared with fused silica was developed.[50] Silicon and boron phosphate powder were mixed, melted, and poured into water. The nodules that formed were crushed and fabricated with binders. Boron phosphate was recrystallized by a second firing.

A report describing a method of synthesizing zirconium diboride directly from zirconium silicate was published.[51] Zirconium diboride prepared by this method was comparable in quality to that produced commercially from zirconium dioxide.

The chemical stability of beryllium borides in oxygen, nitrogen, and carbon at temperatures up to 1,200° C was described.[52] The most stable compounds were those with a high boron content; whereas the least stable were borides with a high beryllium content.

Cadmium manganese ferrites were treated with boron before sintering to promote grain growth.[53] Boron additions accelerated reaction rates.

Lanthanum boride had a thermal coefficient of resistivity equal to 0.06 microhm per centimeter per degree centigrade.[54] Thermal electromotive force of test samples was independent of porosity.

Rocket nozzles were protected from oxidation and erosion by a coating of chromium and zirconium boride that was applied to metals and nonmetals by an electro-deposition process.[55] This coating protected small-scale rocket engines at flame temperatures of 6,000° to 6,500° F.

Research on the application of high-melting boride crucibles was reported.[56] Pieces of carbon steel, melted in titanium boride crucibles, showed an interaction which led to the formation of low-melting eutectics. Chromium or titanium boride crubicles alloyed with molybdenum were not affected by molten carbon steel. Molten alloy steel interacted with chromium boride crucibles. No visible interaction occurred despite wetting of chromium boride crucibles by basic and acid slags. Tungsten boride crucibles exposed to molten cast iron were unchanged, and their mechanical strength was not affected. Molybdenum boride crucibles were heat resistant and showed no cracks after repeated immersions into molten cast iron. Zirconium boride crucibles were not wetted by molten tin, bismuth, lead, and cadmium after an immersion of 10 hours.

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[49] Chemical Engineering. Chementator. V. 68, No. 2, Jan. 23, 1961, p. 74.
[50] Chemical Engineering. New Processes. V. 68, No. 2, Jan. 23, 1961, p. 123.
[51] Cotter, Perry G. Preparing Zirconium Diboride Directly From Zircon. BuMines, Rept. of Inv. 5770, 1961, 9 pp.
[52] Markevich, G. S., and L. Ya. Markovskii. (Chemical Stability of Beryllium Borides in Oxygen, Nitrogen and Carbon at High Temperatures). Trans. of Zhurnal Prikladnoi Khimii (U.S.S.R.), v. 33, No. 5, 1960, pp. 1008–1012; Tech. Trans., Office Tech. Services, U.S. Dept. of Commerce, v. 6, No. 10, Nov. 29, 1961, p. 771.
[53] Technical Survey. Electrical, Electronic Developments. V. 17, No. 14, Apr. 8, 1961, p. 241.
[54] Technical Survey. Electrical, Electronic Developments. V. 17, No. 9, Mar. 4, 1961, p. 151.
[55] Chemical Engineering News. Electrodeposition Forms Rocket Nozzle Coating. V. 39, No. 46, Nov. 13, 1961, pp. 53–57.
[56] Samsonov, G. V., G. A. Yasinskaya, and T'aishouwei. High-Melting Carbide, Boride and Nitride Crucibles. Refractories. Nos. 1–2, January–February 1960, pp. 26–29.

The vacuum-thermal process for production of high-melting metal borides was investigated.[57] Relatively simple and economic production of borides was developed with a high degree of impurity removal.

A Russian paper presenting information on the structure and properties of borides of rare-earth metals was translated.[58] Hexaborides (MeB_6) of sodium, lanthanum, cerium, praseodymium, neodymium, gadolinium, erbium and ytterbium had cubic lattice of the cesium chloride type, centered by the octaohdron of six boron atoms. Diborides (MeB_2) had structures which presented a successive alternation of hexagonal layers of metal atoms, located in the nodes of the densely packed hexagonal lattice with a small c to a ratio, and layers of boron atoms, which formed a two-dimensional hexagonal network. The structure of tetraborides was described as a combination of the MeB_2 and MeB_6 structures. MeB_{12} borides were considered to have the face-centered cubic coordination of metal atoms.

Hexaborides of lanthanum, cerium, calcium, barium, samarium and yttrium displayed metallic conductivity. All hexaborides of rare-earth metals were characterized by low values of electron work junction and some by high emission currents. Hexaborides of yttrium and lanthanum were diamagnetic. All hexaborides tested exhibited a positive sign for thermal electromotive force. Borides of scandium, yttrium, and lanthanum were characterized by high-melting points and hardness, moderate coefficients of thermal expansion, and good chemical stability. The chemical properties of borides, methods of obtaining the borides of rare-earth metals, and sintering techniques were reviewed.

Waste nuclear fission products were stored in a glass mixture prepared with a slurry of silica and borax.[59]

The addition of boron compounds to portland cement was studied to determine which compounds would impart radiation protection properties to the cement.[60] Deterioration of the mechanical properties of cement by addition of soluble boron compounds depended on the quantity of boron added. The addition of lime to cement slightly inhibited the deteriorating effects. The addition to cement of water insoluble materials, such as datolite ($2CaO \cdot B_2O_3 \cdot 2SiO_2 \cdot H_2O$), produced satisfactory setting time and mechanical properties. Cement made from clinker containing no more than 1.3 percent boron anhydride had satisfactory properties.

A study to determine if boron-oxygen-titanium-oxygen linkages could be developed was reported.[61] Although there was a replacement of alkoxy group by chlorine in reacting titanium alkoxyl with boron trichloride, the boron chloroester could not be isolated. Nontitanium compounds were chiefly alkyl choride, boric oxide, and boron trichloride.

The high temperature strength characteristics of fiberglass laminates was improved by dispersing elemental boron in an organic resin,

[57] Funke, V. F., S. I. Yudkovskii, and G. V. Samsonov. (Some Characteristics of the Vacuum-Thermal Process for Production of Titanium Boride). J. Appl. Chem., v. 33, No. 4, April 1960, pp. 833–836.

[58] Samsonov, G. V. (Borides of Rare-Earth Metals). Uspekhi Khimii, v. 28, No. 2, 1959, pp. 189–217; ASTIA AD 255366.

[59] Chemical Week. Processes. V. 88, No. 19, May 13, 1961, p. 81.

[60] P'yachev, V. A. (Physical-mechanical Properties of Boron-Containing Cements). Zhurnal prikladnoy khimii, v. 34, No. 1, 1961, pp. 107–112; ASTIA AD 254399.

[61] Cooper, R. M., and W. Gerrard. Interaction of Boron Trichloride and Titanium Esters. Chem. Ind. (London), No. 10, Mar. 11, 1961, p. 320.

impregnating a multi-ply fiberglass fabric with the resin, and forming, curing, and subjecting the product to a temperature of at least 1,300° F.[62]

Annealed borosilicate glass was employed in preparing master gratings for use in place of prisms in optical instruments.[63] Up to 50,000 straight, equally spaced, parallel lines were ruled on a piece (1 inch wide) of the aluminum-coated glass.

Two ceramic materials, hexaboron silicide (B_6Si) and tetraboron silicide (B_4Si) were developed for high-temperature applications.[64] These materials had good thermal shock and oxidation resistance up to 2,500° F, and could be fabricated by conventional powder metallurgy techniques. Tetraboron silicide partly dissociated to hexaboron silicide and silicon at high temperatures.

Studies of a polymorphic inversion in crystalline boron oxide, compound formation in the B_2O_3-SiO_2 system, and a two-liquid area in the B_2O_3-SiO_2 system were made.[65]

Volume, ultrasonic attenuation, and velocity changes in glass caused by slow neutrons reacting with boron 10 were studied.[66] Irradiated samples of boron glass exhibited birefringence caused by nonuniform shrinkage. Annealing of samples caused relatively large contraction compared to irradiation change. Annealing did not appear to alter contraction caused by irradiation. Photoelastic measurements of nonuniform shrinkage gave a nonlinearity between birefringence and irradiation time.

Deficiencies of boron in soils of the United States were present chiefly in humid regions.[67] Boron deficiencies were present frequently on highly leached acid soils and on most alkaline soils. Microbial action released boron from organic matter, but during a drought not enough boron was released.

Geobotanical indicators were used to prospect for deposits of boron minerals.[68]

It was reported that cotton plants reacted sharply to an increase of boron concentration in soil solution.[69] The greatest quantity of boron accumulated in the leaves. A study of penetration and movement of boron through cotton plants showed there was more boron in the bottom leaves than in the top ones. Boron absorbed by the roots moved rapidly into the leaves as inorganic compounds and combined with organic compounds to form complex organoboric molecules of low mobility. Boron introduced into the soil prior to sowing accelerated the appearance of the first bud, flower, and bursting of the first boll.

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[62] Leeg, Kenton J., David A. Yeomans, and William E. Ripley, Jr. (assignors of small interests to various assignees). High Temperature Resistant Materials Containing Boron and Method of Manufacture Thereof. U.S. Pat. 2,992,960, July 18, 1961.

[63] Chemical Engineering News. Bausch and Lomb Readies Grating Laboratory. V. 39, No. 8, Feb. 20, 1961, pp. 40–41.

[64] Colton, E. Two Boron Silicides. Materials in Design Engr., v. 53, No. 6, June 1961, pp. 9–10.

[65] 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, Columbus, Ohio, October 1960, 7 pp; ASTIA AD 246920.

[66] Truell, John, and Constantine Mylonas. Radiation Effects Involving the (n,α) Reaction in Glass Containing Boron. Metals Res. Lab., Brown Univ., AF OSR TR 60–160. Oct. 1, 1960, p. 19; ASTIA, AD 247031.

[67] Chemical Engineering News. Micronutrient Shortage Widespread. V. 39, No. 38, Sept. 18, 1961, p. 52.

[68] Buyalov, N. I., and A. M. Shvyryeva. Geobotanical Method in Prospecting for Salts of Boron. International Geol. Rev., v. 3, No. 7, July 1961, pp. 619–625.

[69] Kruglova, E. K. Application of Boron in Microdoses as Cotton Ferilizer. Usbekskii Bilogicheskii Zhurnal, v. 5, 1959, pp. 55–60.

Boron also increased the yield of raw cotton and percentage of seed in the bolls, and it appreciably increased the oil content of the seed. Spraying of the plants with 0.01 percent boric acid solution in the bud-forming and flowering periods had favorable results.

A liquid high-energy fuel was prepared by contacting a lower alkyl diborane with pentaborane -9.[70]

A patent was granted for a motor fuel consisting of leaded gasoline and a boron compound.[71] The boron compound was prepared by reacting a borated oxazoline compound with a nonoxidizing acid.

A new process for preparing sodium borohydride could reduce manufacturing costs considerably.[72] Borax, quartz, and sodium were reacted under hydrogen at three atmospheres of pressure and a temperature of 450° to 500° C. The sodium borohydride was extracted from the solid mixture of sodium borohydride and sodium silicate with aqueous ammonia.

A new boron hydride was discovered which contained a direct bond between two boron atoms that had no attached hydrogen.[73] The material was prepared by passing pentaborane (B_5H_9) through an electric glow-discharge tube between copper electrodes. Reaction conditions were varied and volatile compounds were collected and separated. Crystals slightly more volatile than decaborane ($B_{10}H_{14}$) were obtained.

Mixtures of tetraborane with oxygen, and oxygen and inert gas, exploded on heating.[74] Data indicated a branching chain reaction. Tetraethyl lead inhibited the reaction and in some areas prevented explosion. Argon had no effect on the reaction.

A process was patented for recovering amine borane from a compound formed by reacting a heavy metal borohydride with a sulfide in a base containing liquid nitrogen.[75]

Decaborane was introduced into single and double base materials.[76] The heat stability of the single-base decaborane was satisfactory, whereas double-base mixtures were unsatisfactory.

Pentaborane was prepared by pyrolysis of diborane passed through a hot tube.[77] An overall yield of about 18 percent per pass was obtained. New methods of making boron hydrides were investigated. Methylborate was prepared from an excess of boron oxide and methanol. The addition compound $NH_3:B(OCH_3)_3$ could be used for preparing borozole. Several new methods of preparing boron hydrides, which could reduce production costs, consisted of reactions between

[70] Lichtenwalter, Myrl and Kenneth E. Harwell (assigned to Callery Chemical Co., Pittsburgh, Pa.). Preparation of Alkyl Substituted Boron Hydrides. U.S. Pat. 2,979,530, Apr. 11, 1961.

[71] Belden, Sarah H. (assigned to The Standard Oil Company, Cleveland, Ohio). Gasolines Containing Acid-Treated Borated Oxazolines. U.S. Pat. 2,993,765, July 25, 1961.

[72] Chemical Engineering. Solids-Gas Reaction Slashes Production Cost, Brightens Sodium Borohydride Future. V. 68, No. 12, June 12, 1961, pp. 92–93.

[73] Chemical Engineering News. Harvard Group Finds New Borane. V. 39, No. 34, Aug. 21, 1961, pp. 36–37.

[74] Tudlum, Kenneth H., Stephen F. Wiberley, and Walter H. Bauer. The Oxidation of Tetraborane. Rensselaer Polytech. Inst., Troy, N.Y., June 1961, 81 pp.; U.S. Dept. of Commerce, Office Tech. Services, AD 259093. V. 36, No. 6, Sept. 20, 1961, pp. 13, 14.

[75] Schubert, Friedrich, and Konrad Lang (assigned to Farbenfabriken Bayer A. G., Leverkusen, Germany). Process for the Production of Boron-Nitrogen Compounds. U.S. Pat. 2,994,698, Aug. 1, 1961.

[76] Semel, Stanley, Yvan C. Carignan, and Frank J. Masuelli. Reactions of Decaborane with Cellulose and Cellulose Derivatives. Feltman Res. Labs., Dover, N.J., Tech. Note FRL–TN–16, December 1960, p. 1.

[77] Walters, S. L., R. M. Bovard, and R. H. Shapely. The Preparation of Pentaborane and the Evaluation of the Hazards of Handling Diborane and Pentaborane. Mine Safety Appliances Co., Callery, Pa., May 11, 1954, 23 pp.; Dept. of Commerce, Office Tech. Services, PB 157709. V. 36, No. 8, Oct. 20, 1961.

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an active metal and boron halides or esters. The mechanical shock stability of diborane and pentaborane was tested.

Studies on the toxicology of boron fuels were reviewed.[78] Information on the absorption and transport of boranes and evidence of chronic buildup of boranes in the human body were presented. Data from animals were correlated with studies and observations of accidental human exposures.

A modification of the sodium borohydride-sulfuric or methanesulfonic acid reaction was developed.[79] Yields of 94 to 97 percent diborane were obtained by reacting sodium borohydride with phosphoric acid and added phosphorous pentoxide. The thermal conversion of diborane to pentaborane-11 also was studied. The first stable boron hydride produced by decomposition of diborane the authors believe was (B_4H_{10}) tetraborane-10. B_4H_8CO was successfully prepared from tetraborane and carbon monoxide. The reaction between lithium amalgam and diborane produced a white solid with properties similar to those of lithium borohydride.

A series of experiments was conducted to determine the lower limit of oxygen pressure for combustion of boron.[80] Excellent self-propagating burning was obtained at 0.04 atm at both 500 and 1,000 cm/sec. oxygen linear flow velocity. Boron reacted with water vapor at atmospheric pressure and temperatures between 1,400° and 3,000° K. When boron was heated to 2,000° K beneath water, hydrogen gas was evolved. Boron also was heated in a nitrogen plasma jet to temperatures of 2,300° K, but very little boron was consumed, showing the low reactivity of boron and nitrogen.

Vacuum evaporation and colorimetric studies to determine boron hydrides in pentaborane (B_5H_9) and decaborane ($B_{10}H_{14}$) in the solid residue was reported.[81]

Flameproofing chemicals containing boron were tested in a Titan rocket thrust chamber.[82] The boron compounds applied with brush or spray protected metals by becoming intumescent.

Trimethylborane of 99.9 mole percent purity was prepared by a special technique.[83] Measurements of some thermodynamic properties of the trimethylborane were as follows: Equilibrium melting temperature, 113.21° K; molae heat of fusion, 3,250 abs j/mole; molae heat of transition, 810 abs j/mole; heat of formation, 34.8 kcal/mole; heat of combusion, 714.5 kcal/mole at 25° C.

The escape of hydrogen gas from a stored solution of soda and sodium borohydride caused an explosion in a chemical factory.[84]

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[78] Miller, D. F., A. A. Tamas, L. Robinson, and E. Merriweather. Cumulative Effects of Borane Toxicity as Revealed by a Clinical Test. Wright Air Development Div., Air Res. and Development Command, USAF, Wright-Patterson AFB, Ohio, WADD Tech. Rept. 60–604, August 1960, 11 pp.; ASTIA, AD 247355.

[79] Schaeffer, Riley. An Experimental Investigation on the Chemistry and Interconversion of Boron Hydrides. Dept. of Chem., Indiana Univ. (Aeronautical Res. Lab., Air Force Res. Div., Air Res. and Development Command, USAF, Wright-Patterson AFB, Ohio), ARL Tech. Rept. 60–334, December 1960, 29 pp.; ASTIA, AD 252810.

[80] Experiment Incorporated. Combustion of Elemental Boron. TM–1211, Richmond, Va., May 1, 1960, 10 pp.; ASTIA, AD 248955.

[81] Gashgarian, Berge B., and J. Gonzales. Determination of Dissolved Solids and Decarborane in Pentaborane. Air Force Flight Test Center, Edwards AFB, Calif., Air Res. and Development Command, USAF, AFFTC–TN–60–30, November 1960, 12 pp.; ASTIA, AD 247028.

[82] Chemical Week. Technology. V. 88, No. 13, Apr. 1, 1961, p. 44.

[83] National Bureau of Standards, Technical News Bulletin. High-Purity Trimethylborane. V. 45, No. 6, June 1961, pp. 99–100.

[84] Chemical Trade Journal and Chemical Engineer (London). Current Topics. V. 149, No. 3867, July 14, 1961, p. 78.

Evolution of hydrogen occurred even in alkaline borohydride solutions of pH 10.5.

Tablets containing sodium borohydride and cobalt chloride reacted in water to form cobalt boride which catalyzed the hydrolysis of sodium borohydride, liberating hydrogen.[85]

Trialkylboranes were reported to be pyrophoric, toxic, and insensitive to water.[86] Autoxidation occurred in all alkylboranes, but the reaction was not vigorous for compounds with high molecular weights. No toxicity data for trialkylboranes had been published, but they were treated as if they were toxic. Alkylborane fires produced fumes considered to be toxic. Water showers could be used on organo boron fires. Trialkylboranes did not react with water or alcohols under normal conditions. They were stored in glass containers, but little was known about their stability in metal containers. Copper was inert to alkylborons; however, tygon plastic tubing was used in conducting laboratory reactions involving boron compounds. As a safety precaution, laboratory distillations of organoborons should not exceed 500 ml and waste organoborons should be diluted with hydrocarbon and transferred to a hood. Then the material should be exposed to air from 24 hours to 1 week. Hydrogen peroxide was added to the organoborons before disposing of them.

[85] Chemical Engineering News. Hydripills Generate Hydrogen for Lab Use. V. 39, No. 31, July 31, 1961, p. 44.

[86] Mirviss, S. B., A. J. Rutkowski, C. W. Seelback, and H. T. Oakley. Pyrophoric Organometallics. Ind. Engr. Chem., v. 53, No. 1, January 1961, pp. 58A–60A, 62A.

Bromine

By Henry E. Stipp [1] and Victoria R. Schreck [2]

SALES of bromine and bromine compounds in 1961 rose 3 percent, reversing the preceding year's trend. Exports increased for the second consecutive year.

DOMESTIC PRODUCTION

The gain in total sales of bromine in 1961 was attributed chiefly to increased sales of ethylene dibromide. Inasmuch as a large portion of total bromine production goes into ethylene dibromide, even a small change in gasoline sales causes a substantial change in sales of bromine. Gasoline production totaled 1,532 million barrels in 1961, compared with 1,522 million barrels in 1960.

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
1952–56 (average)	177,786	$38,923	1959	195,483	$51,508
1957	191,971	48,038	1960	175,010	44,637
1958	176,397	46,689	1961	180,798	44,517

Ethyl Dow Chemical Co. recovered bromine from sea water at Freeport, Tex., and FMC Corp.,[3] Mineral Products Division, extracted bromine from sea water bittern at Newark, Calif. 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. FMC Corp. recovered bromide from well brines in Michigan. FMC Corp. recovered bromine from well brines at South Charleston, W. Va.; Michigan Chemical Corp. and Arkansas Chemicals, Inc., extracted bromine from oil-well brines near El Dorado, Ark. American Potash & Chemical Corp. extracted bromine from the brine of Searles Lake at Trona, Calif.

Arkansas Chemicals, Inc., completed its bromine plant south of El Dorado, Ark. The plant capacity was rated at 30 million pounds per year. Bromine output was sold to Great Lakes Chemical Corp. and Houston Chemical Corp. Houston Chemical used its bromine to prepare ethylene dibromide-tetraethyl lead antiknock mixture.

Michigan Chemical Corp. completed expansion of its bromine plant capacity at El Dorado, Ark., to 10 million pounds per year.

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.
[3] Name changed from Food Machinery and Chemical Corp., May 23, 1961.

Germanium tetrabromide in semicommercial quantities was marketed by Penn Rare Metals, Inc., Revere, Pa.

TABLE 2.—Bromine and bromine compounds sold by primary producers in the United States

(Thousand pounds and thousand dollars)

	Gross weight	Bromine content [1]	Value
1960:			
Elemental bromine	18,878	18,878	$3,892
Methyl bromide	10,247	8,625	4,141
Other bromine compounds [2]	177,823	147,507	36,604
Total	206,948	175,010	44,637
1961:			
Elemental bromine	17,706	17,706	3,510
Methyl bromide	10,260	8,636	4,277
Other bromine compounds [2]	184,531	154,456	36,730
Total	212,497	180,798	44,517

[1] Calculated as theoretical bromine content present in compound.
[2] Includes ethylene dibromide, sodium bromide, ammonium bromide, potassium bromide, ethyl bromide, and other bromine compounds.

CONSUMPTION AND USES

The largest portion of bromine compounds sales was as ethylene dibromide, a component of gasoline antiknock fluid. Ethylene dibromide also was used in fumigating mixtures for treating soil and seeds. Although consumption of ethylene dibromide increased in 1961, the general consumption trend has been down since the peak year of 1956. Elemental bromine, the second largest consumption item, was used for preparing ethylene dibromide, laboratory reagents, bleaching and disinfecting agents, brominating dyes, lachrymators, and swimming pools sanitizors, and in chemical synthesis and water purification. Methyl bromide, another large consumption item, was used principally in fumigating mixtures but also as a fire-extinguishing fluid.

Potassium and sodium bromide were the next principal bromine compounds consumed; however, several other compounds also accounted for substantial sales. The alkali bromides—those of potassium, sodium, and ammonium—were used principally in the preparation of sedatives and medicines, and photographic plates, films, and emulsions. Potassium bromate was added to flour to improve the quality, and in the laboratory it was used as an oxidizing agent.

Bromine compounds such as monobromotrifluoromethane and bromodichloromethane were used as fire-extinguishing agents. Bromochlorotrifluoroethane served as a nonflammable anesthetic. The use of bromine compounds as flameproofing agents, fumigants, and water purification compounds was reported to be growing at a significant rate. Bromobutyric acid was used as an intermediate for preparing amino acids and hormones, as a fungicide, as a germicide, and as a heat stabilizer for photographic film supports. Di-*n*-propyl bromacetal was offered for use as an intermediate for amino compounds, ethers, and heterocyclic chemicals.

Some of the numerous minor uses of bromine and its compounds were in dehumidifying agents, atomic shields and viewing solutions, hydraulic liquids, flotation media, and rubber additives.

PRICES

Prices for bromine and bromine compounds remained steady and were virtually the same as in 1960. 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
Cases, less than carlots, same basis	34–39
Drums, carlots, ton lots, delivered east of Rocky Mountains	31
Drums, less than carlots, same basis	31–34
Tanks, carlots, same basis	21½
Ammonium bromide, N.F. granular, drums, carlots, freight equalized	44
Drums, less than carlots, same basis	46
Bromochloromethane, drums, carlots, freight equalized	48
Drums, less than carlots, same basis	50
Tanks, same basis	47
Ethylene dibromide, drums, carlots, freight equalized	30½
Drums, less than carlots, freight equalized	31½
Tanks, freight equalized	28½
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[4]

Imports of bromine and bromine compounds totaled 269,582 pounds valued at $184,708, compared with 121,943 pounds valued at $102,015 in 1960. Sodium bromide imports totaled 24,000 pounds valued at $9,376, compared with 225,220 pounds valued at $89,299 in 1960.

Bromine, bromides, and bromates exports increased for the second consecutive year to a record 11.1 million pounds valued at $3 million, compared with 10.2 million pounds valued at $2.9 million in 1960.

TABLE 3.—U.S. exports of bromine, bromides, and bromates, by countries

Destination	1960		1961	
	Pounds	Value	Pounds	Value
North America:				
Bahamas	1,012	$606	6,588	$2,754
Bermuda	4,800	3,060	4,068	3,287
Canada	6,955,138	1,193,151	6,407,557	1,127,375
Canal Zone			7,767	2,579
Costa Rica	2,000	1,138	1,536	1,236
Cuba	16,800	8,941		
Dominican Republic	500	376		
El Salvador	41,770	13,151	17,415	5,851
Guatemala	16,560	7,862	29,564	8,889
Honduras	5,025	2,954	7,497	2,506
Jamaica	288	208	790	444
Mexico	659,180	308,323	459,273	240,645
Nicaragua	2,248	1,792	1,420	1,496
Panama	5,840	2,711	2,200	822
Trinidad and Tobago	112	290	2,085	1,048
Total	7,711,273	1,544,563	6,947,760	1,398,932

[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 3.—U.S. exports of bromine, bromides, and bromates, by countries.—Con.

Destination	1960		1961	
	Pounds	Value	Pounds	Value
South America:				
Argentina			19,849	9,265
Bolivia			300	240
Brazil	1,411,726	713,799	896,500	455,470
Chile	1,000	500	272	370
Colombia	17,100	9,834	27,189	6,473
Ecuador			1,000	839
Paraguay			5,000	2,034
Peru	3,600	2,181	3,980	2,410
Uruguay	26	204		
Venezuela	58,942	31,479	52,184	21,533
Total	1,492,394	757,997	1,006,274	498,634
Europe:				
Austria			4,800	2,730
Belgium-Luxembourg	15,960	18,422	15,616	8,459
Czechoslovakia			880	1,914
Denmark	9,088	5,473	33,655	9,769
France	90,080	46,537	116,262	68,238
Germany, West	41,766	30,435	66,041	36,191
Greece	3,000	1,538	3,468	1,343
Hungary	4,200	3,389		
Italy	50,190	27,066	1,122,531	234,242
Netherlands	81,988	51,343	355,173	95,976
Norway	800	264	400	260
Spain			662	990
Sweden	10,900	5,509	11,239	4,841
Switzerland	129,940	64,159	125,570	260,380
United Kingdom	48,219	67,621	41,282	28,811
Total	486,131	321,756	1,897,579	754,144
Asia:				
India	8,800	6,165	32,954	19,973
Indonesia	410	529		
Iran	22,914	16,501	27,878	16,132
Israel	260	224		
Japan	520	523	1,890	2,223
Korea, Republic of			150	250
Lebanon	4,880	2,451	1,600	888
Pakistan			2,800	1,554
Philippines	9,599	8,420	11,838	5,559
Saudi Arabia	480	350	250	444
Singapore	1,400	1,050	2,300	1,782
Thailand	6,888	3,402	1,680	1,361
Turkey	11,404	7,086		
Viet-Nam			1,150	1,380
Total	67,555	46,701	84,490	51,546
Africa:				
Canary Islands			34,995	8,679
Liberia	2,150	1,146		
Libya			1,600	888
Mozambique	51,200	23,492		
Rhodesia and Nyasaland, Federation of	195,856	94,080	953,701	191,217
Union of South Africa	178,544	79,894	96,632	36,720
United Arab Republic (Egypt)	7,500	3,777		
Total	435,250	202,389	—1,086,928	237,504
Oceania:				
Australia	30,780	14,662	97,054	39,437
New Zealand	17,795	10,357		
Total	48,575	25,019	97,054	39,437
Grand total	10,241,178	2,898,425	11,120,085	2,980,197

WORLD REVIEW

France.—Production of bromine in 1960 totaled 2,216 short tons valued at US$691,187.[5]

Germany, West.—Bromine and bromine compounds production in 1960 totaled 2,317 short tons valued at about US$1.1 million.[6] Bromine production capacity of plants at Cassel and Sarzdetfurth was increased.[7]

India.—Production of 540 tons per year of ethylene dibromide was scheduled for a new plant to be completed in March 1963 at Bombay.[8]

Israel.—The World Bank loaned $25 million to Dead Sea Works, Ltd., to help finance expansion of bromine and other facilities at Sodom.[9] Expansion of the Dead Sea Works, Ltd., plant was expected to increase bromine production to 10,000 short tons in fiscal year 1961–62.[10]

Elemental bromine production in the 1960 calendar year totaled 2,646 short tons; output of bromine compounds reached 1,519 short tons.[11]

Italy.—Elemental bromine production in 1960 totaled 66,288 pounds valued at US$644.[12]

Japan.—Production of elemental bromine in calendar year 1960 totaled 2,151 short tons. Potassium bromide manufacture was 390 short tons, compared with 349 short tons (revised figure) in 1959.[13] A $4 million plant at Kurobe City was scheduled to start producing 580 tons per year of bromine and other byproducts in March 1961.[14]

TECHNOLOGY

Arsenic tribromide immersion liquids that had been stored for 10 years were tested for indexes of refraction.[15] Changes ranged from −0.004 to 0.001. Some liquids contained a fine precipitate but had no large crystals. Liquids tested were otherwise transparent and suitable for use.

Liquefied bromotrifluoromethane was reported to be 6 to 12 times as effective on a weight basis as carbon tetrachloride for extinguishing fires.[16] Bromotrifluoromethane was 3½ to 7 times as effective as carbone dioxide and twice as effective as dry sodium bicarbonate. A chemical reaction between bromotrifluoromethane and combustion

[5] U.S. Embassy, Paris, France. State Department Dispatch 363. Sept. 29, 1961, encl. 1, p. 1.
[6] U.S. Embassy, Düsseldorf, West Germany. State Department Dispatch 13. July 19, 1961, encl. 1, p. 2.
[7] Chemical Trade Journal and Chemical Engineer (London). Notes From Abroad. V. 149, No. 3884, Nov. 10, 1961, p. 1040.
[8] Chemical Engineering. CPI News Briefs. V. 68, No. 25, Dec. 11, 1961, p. 196D.
[9] Oil, Paint and Drug Reporter. Potash, Bromine Project Gets $25 Million Loan. V. 180, No. 3, July 17, 1961, p. 62.
[10] Bureau of Mines. Mineral Trade Notes. V. 52, No. 5, May 1961, p. 6.
[11] U.S. Embassy, Tel Aviv, Israel. State Department Dispatch 758. June 23, 1961, encl. 1, p. 1.
[12] U.S. Embassy, Rome, Italy. State Department Dispatch 941. Apr. 19, 1961, encl. 1, p. 2.
[13] U.S. Embassy, Tokyo, Japan. State Department Dispatch 1,172. Apr. 18, 1961, encl. 1, p. 1.
[14] Chemical Week. Foreign Roundup. V. 88, No. 5, Feb. 4, 1961, p. 25.
[15] Meyrowitz, Robert, and Harold Westley. The Stability of the Arsenic Tribromide Immersion Liquids During Storage. Am. Mineral, v. 46, No. 5–6, May–June, 1961, pp. 761–762.
[16] Chemical Engineering. Fire Extinguisher Outstrips Itself—and Its Theory. V. 68, No. 16, Aug. 7, 1961, p. 78.

products was said to cause rapid and violent flame propagation, cutting off the combustion chain reaction.

A convenient and controllable method for the preparation of bromide alkoxides of zirconium was reported.[17] The exothermic reaction between zirconium isopropoxide and acetyl bromide was rapid and straightforward, quantitatively yielding the dibromide diisopropoxide of zirconium.

The heat of formation of the hypobromite ion was reported as -23.05 ± 0.2 kcal per mole.[18]

A process was patented for hologenating butyl rubber with bromine and chlorine to produce a copolymer that gave improved adhesion with natural rubber, diene-styrene rubber, and diene-acrylonitrile rubber.[19]

A patent was granted for brominating butyl rubber in the presence of heterocyclic tertiary amines.[20]

Studies designed to clarify details in peroxide-induced additions of hydrogen bromide to olefins were conducted at the Pennsylvania State University.[21] The experiments indicated that a complete rearrangement of a carbon skeleton could result from removing a hydrogen atom from the methyl groups of 2-propyl and tert-butyl bromides.

Bromine or chlorine was bubbled into crude trona solution to decrease the foam of sodium products derived from trona.[22]

The synthesis of *m*-bromo-phenyllithium under nitrogen, in darkness, and in a hydrocarbon solvent gave an explosive solution.[23] Chemists believed that a benzyne structure could be involved in the explosions, but infrared analysis had failed to prove its existence.

A parasiticidal compound, consisting of propargyl bromide and methyl bromide, was patented for use in impregnating soil.[24]

A sodium amalgam fuel cell was developed that used bromine or chlorine as the oxidizing agent.[25] The cell was expensive but could be used for military applications.

Bromine in solutions of lithium bromide affected wool fibers differently, varying with the pH of the lithium bromide solutions.[26] In 1 normal hydrochloric acid, supercontraction of wool was accelerated.

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[17] Kapoor, R. N., and R. C. Mehrotra. Bromide Alkoxides of Zirconium. J. Less-Common Metals, v. 3, No. 3, June 1961, pp. 188–193.

[18] McDonald, J. W., and J. W. Cobble. The Heat of Formation of the Hypobromite Ion. Purdue Univ., Lafayette, Ind., May 1, 1961, 7 pp.; Department of Commerce, Off. Tech. Services, Res. repts., v. 36, No. 2, July 20, 1961, p. 15.

[19] Serniuk, George E., Irving Kuntz, and Francis P. Baldwin (assigned to Esso Research and Engineering Co., Delaware). Process for the Halogenation of Butyl Rubber With Chlorine and Bromine, and Product Obtained Thereby. U.S. Patent 3,009,904, Nov. 21, 1961, p. 828.

[20] Cottle, Delmer L., Leon S. Minckler, Jr., and Lawrence T. Eby (assigned to Esso Research and Engineering Co., Delaware). Method of Brominating Butyl Rubber in the Presence of Heterocyclic Tertiary Amines, Product Obtained and Vulvanized Product Thereof. U.S. Patent 2,995,545, Aug. 8, 1961.

[21] Chemical & Engineering News. New Free Radical Reactions Give Rapid Rearrangements. V. 39, No. 6, Feb. 6, 1961, p. 52.

[22] Osborne, R. T. (assigned to Food Machinery & Chemical Corp., New York, N.Y.). Deactivation of Color Forming and Foam Stabilizing Bodies in Sodium Carbonate Produced From Trona. U.S. Patent 2,989,369, June 20, 1961.

[23] Chemical & Engineering News. N, Dark, and Solvent Sensitize Reaction. V. 39, No. 16, Apr. 17, 1961, pp. 43, 44.

[24] Youngson, Charles R., and Cleve A. I. Goring (assigned to The Dow Chemical Co., Midland, Mich.). Fumigant Composition Containing Propargyl Bromide and Methyl Bromide. U.S. Patent 3,009,853, Nov. 21, 1961.

[25] Chemical Engineering. Industry and Economic News. V. 68, No. 12, June 12, 1961, p. 104.

[26] Crewther, W. G., and L. M. Dowling. Supercontracting of Wool in Aqueous Li Br; Inhibition by Free Br_2 and Its Relation to Sulfhydryl-Disulfide Interchange. Textile Res. J., v. 31, No. 1, January 1961, pp. 31–37.

At pH 4 to 5 the first stage of supercontraction was accelerated, and the second stage was retarded, and at pH greater than 6 supercontraction was retarded. Bromine was reported to inhibit supercontraction in lithium bromide solutions by interfering with interchange reactions between sulfhydryl and disulfide groups in the wool.

A process was described for separating uranium from its oxides by dissolving the uranium in bromine in ethyl acetate solution.[27] Quantitative uranium recoveries were obtained with metallic uranium and with shot. Uranium oxides had no effect on results when dissolution time was short. Good results were obtained when dissolution time was increased and when the side reaction of bromine with ethyl acetate formed acids.

An investigation was conducted to determine the possibility of using methyl bromide for additional fumigations after first treating food commodities.[28] In 24-hour exposure tests only two fumigations were carried out owing to sorption of gas by commodities. In a varied exposure series three fumigations were carried out over a period of 27 hours at a 100-percent mortality to test insects.

A study was presented on the chemistry, bactericidal effects, and reactions of bromine used in the sterilization of swimming pools.[29] Bromine in water hydrolyzed to form chiefly hypobromous acid and hypobromite. These bromine compounds oxidized urea forming bromamine intermediate products, which were powerful bactericidal agents. Bromine did not appear to form an analog of chlorine nitrogen trichloride, which was considered the probable cause for eye irritation and chlorine smell around swimming pools. Bromine could be more economical than chlorine for use in pools, because it was more efficient as a bactericidal agent.

Trifluoromethyl bromide and methyl bromide were found to be more effective inhibitors of chemical fires when applied to the air around the flame instead of to the fuel or center of the flame.[30] When the inhibitor was added to the fuel the diffusion flame was extinguished when the mixture reached 50 percent fuel and 50 percent inhibitor. However, the flame was extinguished when the inhibitor around the flame amounted to 2 to 3 percent by volume of the resulting oxygen-nitrogen mixture.

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[27] Brunzie, G. F., T. R. Johnson, and R. K. Steunenberg. Selective Dissolution of Uranium From Uranium-Uranium Oxide Mixtures by Bromine-Ethyl Acetate. Anal. Chem., v. 33, No. 8, July 1961, pp. 1005–1006.

[28] Muthu, M., K. S. Srinivasan, and S. K. Majumder. Serial Fumigation of Processed and Packaged Foods With Air-Washed Residual Methyl Bromide From Fumigation Chambers. Food Technol., v. 15, No. 6, June 1961, pp. 295–298.

[29] Johannesson, J. K. The Bromination of Swimming Pools. Am. J. Public Health, v. 50, No. 11, November 1960, pp. 1731–1736.

[30] National Bureau of Standards. Inhibition of Combustion Reactions. Tech. News Bull., v. 45, No. 7. July 1961, pp. 122–124.

Cadmium

By H. J. Schroeder [1] and Esther B. Miller [2]

HIGHER imports with slightly lower production and consumption and greatly reduced exports in 1961 augmented stocks of cadmium metal in the United States by 10 percent, bringing them to 2.3 million pounds. Exports of metal declined more than 70 percent to 702,000 pounds.

TABLE 1.—Salient cadmium statistics

(Thousand pounds of contained cadmium)

	1952-56 (average)	1957	1958	1959	1960	1961
United States:						
Production [1]	9,639	10,549	9,673	8,602	10,180	9,943
Imports for consumption, metal	1,496	1,586	1,002	1,638	942	1,079
Exports	809	693	580	900	2,448	702
Consumption, estimated	(2)	[3] 10,966	[3] 8,209	[3] 11,409	[3] 10,127	10,116
Price: Average [4] per pound	$1.91	$1.70	$1.52	[3] $1.36	$1.52	$1.68
World: Production	16,700	[3] 20,700	[3] 19,700	19,800	[3] 22,100	20,800

[1] Primary and secondary cadmium metal.
[2] Estimated consumption of primary and secondary metal not available before 1956.
[3] Revised figure.
[4] Average quoted price for cadmium sticks and bars in lots of 1 to 5 tons.

LEGISLATION AND GOVERNMENT PROGRAMS

On January 19, 1961, the U.S. Department of Agriculture, Commodity Credit Corporation (CCC), reinstated cadmium to the list of foreign-produced commodities eligible for barter for surplus perishable agricultural products.

DOMESTIC PRODUCTION

Combined production of primary and secondary metal declined 2 percent when compared with 1960 output but was higher than output in 1958 or 1959.

Flue dust from Mexico again provided the source for 18 percent of the total cadmium metal. It was estimated that 50 percent of the cadmium production came from foreign zinc ores and concentrates and other base-metal concentrates. The remainder was from domestic

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

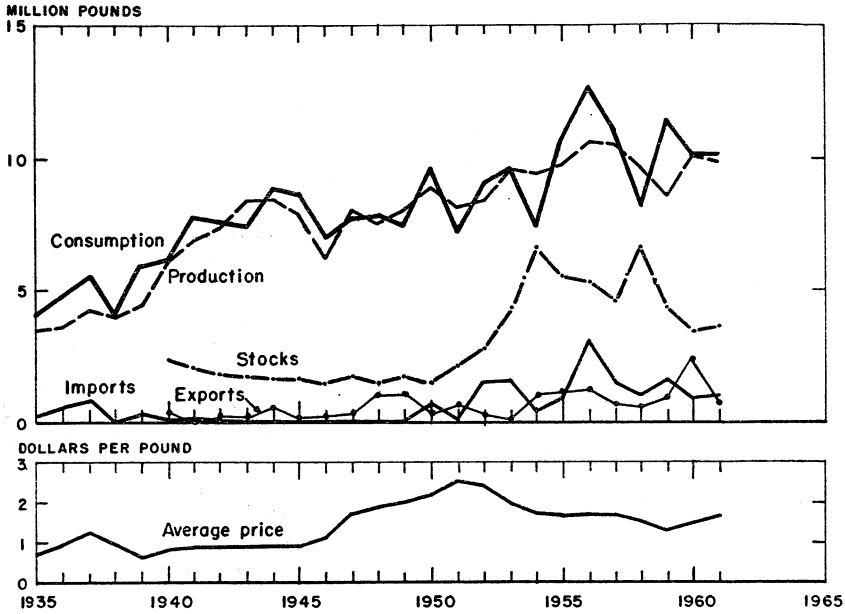


FIGURE 1.—Trends in production, consumption, yearend stocks, imports, exports, and average price of cadmium metal in United States, 1935–61.

zinc ores, except for a small quantity of secondary production. The main sources of zinc concentrates were Mexico, Canada, Peru, Guatemala, and the Union of South Africa.

Secondary cadmium was recovered from scrap alloys.

In February 1961, the General Services Administration (GSA) accepted a bid of approximately 16 cents per pound for 4,400 tons of 20 percent cadmium—76 percent magnesium casings of deactivated bombs. Delivery of the material will be spread over a 3-year period, at a rate of about 600,000 pounds of contained cadmium per year.

TABLE 2.—Primary and secondary cadmium metal produced and shipped in the United States

(Thousand pounds of contained cadmium)

	1952–56 (average)	1957	1958	1959	1960	1961
Production	9,639	10,549	9,673	8,602	10,180	9,943
Shipments by producers	9,294	10,091	7,921	11,273	12,151	10,165
Value----thousands	$15,443	$14,921	$10,067	$12,054	$14,924	$14,200

Figures on cadmium oxide output are withheld to avoid disclosing individual company data.

The list of producers of primary and secondary cadmium published in the Cadmium chapter of the 1960 Minerals Yearbook was unchanged.

Production of cadmium sulfide, including cadmium lithopone and cadmium sulfoselenide, increased 3 percent to 1.1 million pounds.

TABLE 3.—Cadmium sulfide [1] produced in the United States

(Thousand pounds)

Year	Gross weight	Cadmium content	Year	Gross weight	Cadmium content
1952-56 (average)	3,637	1,156	1959	3,701	1,243
1957	3,198	1,041	1960	3,484	1,084
1958	2,884	983	1961	3,355	1,115

[1] Includes cadmium lithopone and cadmium sulfoselenide.

CONSUMPTION AND USES

Estimated consumption of cadmium was 10.1 million pounds, 2 percent less than the 10.3 million pounds provided by metal production plus net imports.

Cadmium was consumed in electroplating automobile engine parts, radio and television parts, and nuts and bolts. It also was used in alloys, dentistry, photography, paint pigments, dyeing, in nuclear energy reactors, and as organo-cadmium compounds to provide heat and light stabilization in plastics.

Cadmium of 99.999 percent or higher purity was in greater demand for a number of electronic uses, and several companies marketed this grade in commercial instead of laboratory quantities.

In a survey of cadmium metal consumption for 1960, responses from 1,500 users accounted for 73 percent of the estimated consumption. Table 4 compares similar surveys in 1955 and 1956. Changes indicate that a larger share of the cadmium in 1960 was used in electroplating at the expense of low-melting alloys and pigments and chemicals. The distribution of cadmium used in electroplating, shown in table 5, represents 1,400 respondents for 1960. The pattern of end uses was evident, but exact changes were obscured by the quantities assigned to other uses where the ultimate use could not be identified.

TABLE 4.—Cadmium metal consumption in the United States, by uses

Use	1955		1956		1960	
	Thousand pounds	Percent of total	Thousand pounds	Percent of total	Thousand pounds	Percent of total
Electroplating	4,538	59.4	4,959	59.9	5,129	69.8
Pigments and chemicals	2,305	30.1	2,245	27.1	1,580	21.5
Alloys [1]	402	5.3	594	7.2	409	5.6
Low-melting alloys	352	4.6	413	5.0	149	2.0
Other uses	49	.6	69	.8	[2] 81	1.1
Total reported consumption	7,646	100.0	8,280	100.0	7,348	100.0
Estimated consumption	10,674		12,711		10,127	

[1] Includes brazing alloys, bearing alloys, copper-cadmium alloys, solder, and other metal alloys.
[2] Includes alkaline batteries, reactors, and solder.

TABLE 5.—Distribution of cadmium in electroplating

(Thousand pounds)

Use	1955	1956	1960
Transportation equipment [1]	1,324	1,346	1,268
Ordnance	193	101	81
Communications and other electrical equipment [2]	1,044	1,202	978
Building materials [3]	533	696	596
Fasteners [4]	880	960	910
Machinery [5]	226	205	99
Other [6]	505	612	1,197
Total	[7] 4,705	[7] 5,122	5,129

[1] Includes automobile, truck, tank, and tractor parts; aircraft parts, including bolts, rivets, and fasteners; ship parts and equipment.
[2] Includes household electrical appliances and equipment; radio, television, telephone, and signal apparatus.
[3] Includes conduit fittings and hardware (not classifiable elsewhere).
[4] Includes nuts, bolts, screws, nails, tacks, and rivets.
[5] Includes textile machinery parts, office machinery and supplies, industrial machinery parts, heating and refrigeration equipment, petroleum industry equipment, and amusement and vending machines.
[6] Includes metal merchandizing equipment, steel stampings, castings, wire products, bicycles, control instrument parts, medical, health, and safety equipment. Includes substantial quantities of unspecified consumption which could not be assigned to specific uses listed in table.
[7] Includes cadmium oxide used in electroplating; 167,000 pounds in 1955 and 163,000 pounds in 1956.

STOCKS

Reported stocks of cadmium metal were 2.3 million pounds at the end of 1961 compared with 2.1 million pounds on hand at yearend 1960. Cadmium contained in compounds at the end of 1961 was 3 percent below 1960. Total stocks increased 6 percent to 3.1 million pounds.

During the first quarter of the year, 277,000 pounds of cadmium from CCC stocks was transferred to the Government supplemental stockpile, bringing the supplemental stockpile inventory to 6,608,616 pounds at yearend. In the last quarter, 438,700 pounds of cadmium was delivered to CCC stocks. As of December 31, 9,719,000 pounds of cadmium was held in the national (strategic) stockpile bringing the total Government inventory to 16,766,000 pounds of cadmium.

TABLE 6.—Industry stocks, Dec. 31

(Thousand pounds of contained cadmium)

Stocks	1960 [1]		1961	
	Cadmium metal	Cadmium in compounds	Cadmium metal	Cadmium in compounds
Metal producers	1,579	[2]	1,819	[2]
Compound manufacturers	243	716	115	710
Distributors	291	59	382	44
Total	2,113	775	2,316	754
Consumers	[3] 1,303	[4]	[5] 1,300	[4]

[1] Figures partly revised.
[2] Included with stocks of cadmium contained in compound at compound manufacturers in order to avoid disclosing individual company confidential data.
[3] As reported by consumers canvassed in 1960.
[4] Data not available.
[5] Estimate.

PRICES

The quoted price of cadmium metal at the beginning of the year was $1.60 for sticks, bars, and shapes in lots under 1 ton and $1.50 for 1- to 5-ton lots. On April 3 the prices increased to $1.70 and $1.60, respectively, where they remained for the balance of the year.

Cadmium on the London market was quoted at the beginning of the year at 11s. ($1.54 on the basis of $2.80 per pound sterling). The price advanced in November to 11s. 6d. ($1.61) and remained at that level for the balance 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. The price rose in May to 2,300 lire per kilogram ($1.68) but declined again in October to 2,250 lire where it remained for the balance of the year. The French quotation for cadmium was 15.75 francs per kilogram at the beginning of the year or $1.43 per pound on the basis of $0.20 per franc. Several price increases during the year brought the quotation to 17.25 francs in November ($1.60 per pound), where it remained for the rest of 1961.

FOREIGN TRADE[3]

Imports.—General imports of cadmium metal increased to 1.1 million pounds as shipments from the Republic of the Congo (including Ruanda-Urundi) and Peru increased. Canada supplied 510,000 pounds of metal during 1961. The 1.8 million pounds of cadmium contained in imported flue dust was supplied by Mexico.

Exports.—Exports of cadmium dropped to 702,000 pounds. The United Kingdom and France received the largest quantities, with much of the remainder going to Brazil, Italy, India, Japan, and the Netherlands.

Tariff.—The import duty on cadmium metal remained at 3.75 cents per pound in 1961—the rate effective January 1, 1948, as established at the Geneva Trade Conference in 1947. Cadmium contained in flue dust remained duty free.

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

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TABLE 7.—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]			
	1960		1961		1960		1961	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
CADMIUM METAL								
North America:								
Canada	839	1,033	510	695	839	1,033	510	695
Mexico	11	13	----	----	11	13	----	----
Total	850	1,046	510	695	850	1,046	510	695
South America: Peru	30	33	104	140	30	33	104	140
Europe:								
Belgium-Luxembourg	33	42	48	67	39	49	48	67
Italy	----	----	44	64	----	----	44	64
United Kingdom	[3]	1	[3]	1	[3]	1	[3]	1
Total	33	43	92	132	39	50	92	132
Asia: Japan	----	----	22	31	----	----	22	31
Africa:								
Angola	----	----	66	89	----	----	66	89
Congo, Republic of the and Ruanda-Urundi [4]	6	6	318	430	23	28	285	386
Total	6	6	384	519	23	28	351	475
Total cadmium metal	919	1,128	1,112	1,517	942	1,157	1,079	1,473
FLUE DUST (Cd content)								
North America:								
Canada	18	25	----	----	9	11	----	----
Mexico	1,852	767	1,812	948	1,852	767	239	112
Total flue dust	1,870	792	1,812	948	1,861	778	239	112
Grand total	2,789	1,920	2,924	2,465	2,803	1,935	1,318	1,585

[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.
[4] Belgian Congo prior to July 1, 1960.

Source: Bureau of the Census.

TABLE 8.—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
1952-56 (average)	809	1,272	1959	900	1,024
1957	693	1,060	1960	2,448	3,014
1958	580	771	1961	702	983

Source: Bureau of the Census.

WORLD REVIEW

World production of cadmium metal declined to 20.8 million pounds, 6 percent below 1960 but approximately 5 percent above 1958 and 1959 figures. Output increased in Japan, U.S.S.R., Republic of the Congo, and Canada but dropped in the United States and Belgium.

TABLE 9.—World production of cadmium, by countries [1] [2]
(Thousand pounds)

Country	1952-56 (average)	1957	1958	1959	1960	1961
North America:						
Canada	1,482	2,368	1,756	2,160	2,357	2,399
Mexico (refined metal) [3]			42	114	204	[4] 143
United States (primary and secondary metal)	9,639	10,549	9,673	8,602	10,180	9,943
South America: Peru (refined metal) [3]	11	58	141	141	185	[4] 154
Europe:						
Austria	[5] 5	25	25	43	32	[4] 32
Belgium	[4] 1,254	[4] 1,323	[4] 1,488	[6] 1,512	[6] 1,583	[4 6] 295
France	285	388	386	539	560	551
Germany, West	468	611	703	926	902	946
Italy	405	492	410	552	638	765
Netherlands [4]	[7] 30	77	88	88	88	88
Norway	214	244	240	234	243	231
Poland [4]	501	560	573	595	620	640
Spain	19	20	14	14	26	[4] 56
U.S.S.R. [4]	499	900	975	1,005	1,035	1,100
United Kingdom [8]	326	228	278	310	236	217
Yugoslavia	[5] 18	57	55	72	84	[4] 88
Asia: Japan	616	873	964	1,082	1,251	[4] 1,350
Africa:						
Congo, Republic of the (formerly Belgian)	246	911	1,080	1,047	1,113	1,168
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia	23	125	38		58	
Oceania: Australia	649	880	791	763	674	[4] 668
World total (estimate) [1 2]	16,700	20,700	19,700	19,800	22,100	20,800
The following data are not included in the above table: [3]						
Guatemala (exports) [3 9]	[5] 107	84	52		123	94
Mexico (exports) [3]	1,920	1,673	1,655	1,151	[4] 2,270	[4] 2,500
Peru (exports) [3]	63	46	50	29	51	[4] 44
South-West Africa (exports) [3]	1,531	2,838	2,688	1,294	1,732	1,747

[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] To avoid duplicating figures, data on cadmium exported in zinc concentrates, flue dusts, and so on are not included in the world total but are shown separately at end of table.
[4] Estimate.
[5] One year only, because 1956 was first year of commercial production.
[6] Exports.
[7] Average for 1954-56.
[8] Including secondary.
[9] Recoverable.

Compiled by Augusta W. Jann, Division of Foreign Activities.

Mexico.—Exports of cadmium contained in flue dust were 1.8 million pounds. A contract was signed by Zincamex, a newly formed, government-owned company, to construct a zinc smelter at Saltillo, Coahuila, which will also provide for recovery of cadmium from the zinc ores treated.

United Kingdom.—Production of cadmium metal was 217,000 pounds, a decrease of 8 percent from 1960. Imports of metal declined 15

percent, making an overall decrease of 15 percent in new supply of metal. Consumption was 2.8 million pounds and was used for the following purposes (in thousand pounds): Plating anodes, 1,324; plating salts, 275; cadmium-copper alloys, 156; other alloys, 84; alkaline batteries, 136; dry batteries, 10; solder, 193; colors, 529; and miscellaneous uses, 49.

TECHNOLOGY

Cadmium plating by vacuum processes [4] and by impact action in a wet tumbler [5] were reported. A high-purity cadmium fluoborate solution for plating semiconductors was made available, and several new single-dip chemical coatings to enhance brightness and retard corrosion were marketed. Reaction of cadmium vapor with a wide variety of alkyl radicals was devised to produce semiconductor cadmium compounds.[6]

Improved hermetic seals were provided for widely marketed nickel-cadmium rechargeable batteries. An article [7] discussed the various types of electrodes used, including one employing microporous plastic structures for holding the active and conductive materials. A silver–cadmium battery yielding a high-energy output per unit volume was under development.[8]

Processes were patented for producing cadmium-mercury sulfide pigments by a wet chemical method [9] and by a pyrometallurgical method.[10] A process was patented for preparing a red cadmium sulfide telluride pigment.[11]

Addition of 1½ percent cadmium to lead was reported [12] to provide solid-solution hardening and improved tensile strength in wrought lead alloys. An alloy containing 47½ percent cadmium was developed that exhibits phase changes at 0° and −6° C.[13]

Thermodynamic properties were determined for the cadmium-copper system,[14] the cadmium-antimony system,[15] and the cadmium-zinc system.[16]

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[4] Steel. Vacuum Cadmium Plating Avoids Hydrogen. V. 149, Nov. 27, 1961, pp. 114–115. The Iron Age. Cadmium Coating Under Vacuum Curbs Hydrogen Embrittlement. V. 188, Nov. 9, 1961, pp. 120–121.

[5] The Iron Age. Mechanical Plating. V. 187, Mar. 23, 1961, p. 15.

[6] Miller, Herbert (assigned to Monsanto Chemical Co.). Method for the Preparation of Semi-Conductor Cadmium Compounds. U.S. Patent 2,980,500, Apr. 18, 1961.

[7] Duddy, J. C., and A. J. Salkind. High Energy. Weight Ratio, Nickel-Cadmium Cells. J. Electrochem. Soc., v. 108, August 1961, pp. 717–719.

[8] Electronic News. Burgess Labs Experiments in Silver-Cadmium Cells. V. 6, Mar. 23, 1961, p. 20.
American Metal Market. Silver-Cadmium Batteries Coming in Larger Size. V. 65, Mar. 30, 1961, p. 14.

[9] Allan, Benjamin W., Frank O. Rummery, Roy W. Chrest, and Reuben Roseman (assigned to The Glidden Co.). Process for Preparing Cadmium Red Pigments and Resulting Pigments. U.S. Patent 3,008,845, Nov. 14, 1961.

[10] Chemical Trade Journal and Chemical Engineer (London). Cadmium-Mercury Sulfide Pigments. Brit. Patent 856,428, v. 149, July 28, 1961, p. 238.

[11] Giordano, Anthony (assigned to The Harshaw Chemical Co.). Method of Preparing Cadmium Sulfide Telluride Pigment. U.S. Patent 3,012,899, Dec. 12, 1961.

[12] Metal Progress. Wrought Lead-Cadmium-Nickel Alloys. V. 80, October 1961, pp. 190–191.

[13] Muldawer, Leonard Bala-Cynwyd, and Ralph Feder (assigned to the U.S. Dept. of Defense). Temperature Responsive Cadmium-Silver-Gold Alloys. U.S. Patent 3,012,882, Dec. 12, 1961.

[14] Borg, Richard J. Some Thermodynamic Properties of the Cadmium-Copper System. Metal. Soc., AIME, v. 221, June 1961, pp. 527–531.

[15] Borg, Richard J. The Free Energy of Formation of CdSb. Metal. Soc., AIME, v. 221, April 1961, pp. 242–243.

[16] Wynnemer, D. J., and G. W. Preckshot. Thermodynamic Properties for the Zinc-Cadmium System From Electromotive Force Measurement. Metal. Soc., AIME, v. 221, February 1961, pp. 186–191.

Rates of prismatic plastic glide in pure cadmium crystals were measured for the temperature range of 158° to 276° C.[17]

A cadmium-indium-silver alloy, containing 5 percent cadmium, extruded in a cruciform shape and nickel plated, was being tested in operating units for use as a nuclear reactor control rod.[18]

A cadmium-uranium phase diagram was established for possible use in the pyrometallurgical reprocessing of nuclear fuels.[19] The constitution of bismuth-cadmium-tin alloys was studied by microscopical, thermal, and X-ray methods.[20]

Research continued to determine fundamental properties and the techniques of use of cadmium compounds for transistor, photoconductive, and other uses in the electronics industry. The U.S. Naval Research Laboratory made progress in developing a method to obtain a transparent cadmium silicate phosphorcoating on glass or silica and in developing use of cadmium sulfide in a meter to monitor nuclear fallout.

The Federal Bureau of Mines reported research on the extraction of cadmium from zinc concentrates.[21]

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[17] Gilman, J. J. Prismatic Glide in Cadmium Crystals. Metal. Soc., AIME, v. 221, No. 3, June 1961, pp. 456–457.

[18] Giacobbe, J. B. Trends in Materials for Reactor Control Rods. Metal Progress, v. 79, March 1961, pp. 105–106.

[19] Martin, Allen E., Irving Johnson, and Harold M. Feder. The Cadmium-Uranium Phase Diagram. Metal. Soc., AIME, v. 221, No. 4, August 1961, pp. 789–791.

[20] Bray, H. J., F. D. Bell, and S. J. Harris. The Constitution of Bismuth-Cadmium-Tin Alloys. J. Inst. of Metals (London), v. 29, October 1961, p. 121.

[21] Starliper, A. G., H. Kenworthy, and P. T. Goin. Recovery of Germanium, Cadmium, and Lead as Sulfides From Zinc Concentrates by Batch and Fluid-Solids Roasting. BuMines Rept. of Inv. 5891, 1961, 21 pp.

Calcium and Calcium Compounds

By C. Meade Patterson [1]

THE importance of calcium remained that of a minor metal in the economy. Its radioactive isotopes were valuable in metallurgical and medical research. The use of calcium chloride in highway maintenance continued to increase because of its dustlaying and ice-melting capabilities.

DOMESTIC PRODUCTION

The standard method of producing calcium until World War II was electrolytic deposition on cathodes in a molten calcium chloride bath. The high reactivity of calcium with other elements at elevated temperatures required that molten calcium be solidified and removed from the bath at the same rate it was deposited. Conical calcium deposits that formed on the cathode were descriptively called "carrots." Aluminum reduction was introduced during World War II, and more calcium was produced by this new method than ever before at lower unit cost. It was the only method of producing commercial calcium in the United States in 1961. Quicklime (calcium oxide) was thermally reduced, and the resulting calcium thermally distilled in vacuum retorts at elevated temperatures.[2]

Although undisclosed, domestic calcium production was known to be minor. The only producer of commercial calcium was Nelco Metals, Inc., Canaan, Conn., a subsidiary of New England Lime Co., Adams, Mass. It was acquired by Chas. Pfizer & Co., Inc., New York, N.Y., a manufacturer of pharmaceuticals, on October 18 with the purchase of New England Lime Co. for $13 million.[3]

American Smelting and Refining Company produced some calcium for captive use in debismuthizing lead in lead refineries. Calcium was obtained by mixing calcium carbide into a molten lead bath having a calcium chloride slag cover to limit the oxidation of the carbide.[4]

Oak Ridge National Laboratory, Oak Ridge, Tenn., produced the radioactive isotope calcium-47 for general distribution by bombarding enriched calcium-46 in the Oak Ridge Research Reactor. Research

[1] Commodity specialist, Division of Minerals.
[2] Union Carbide Metals Review. The Elements That Surround Us—Calcium. V. 4, No. 1, Winter-Spring 1961, pp. 30–31.
[3] Pfizer News. Pfizer Acquires New England Lime, Announces Capital Expansion Program. Oct. 18, 1961, 4 pp.
[4] The Chemical Market Research Association. Chemicals and Metals—Their Industrial Relationship. Pittsburgh, Pa., Nov. 9–10, 1960, p. 35.

was in progress to produce calcium–47 by proton bombardment of calcium–48.[5]

Shipments of natural and synthetic solid and flake calcium chloride (77–80 percent $CaCl_2$) in 1960 were 557,000 short tons valued at $15.7 million ($28.19 a ton). Brine (40 percent $CaCl_2$) shipments amounted to 212,000 tons valued at $2.1 million ($9.91 a ton). Total production of natural and synthetic solid and flake calcium chloride was 556,000 tons in 1960, and production of calcium chloride brine amounted to 210,000 tons, excluding all brine that went into the production of solid and flake calcium chloride.[6] Reported output of natural calcium chloride and calcium-magnesium chloride averaged annually 452,000 tons valued at $7.4 million ($16.37 a ton) during 1957–61. The annual average tonnage for this 5-year period was 407,000 tons valued at $18.18 a ton after the reported production had been converted to the basis of 75 percent calcium chloride and 25 percent water. This base almost corresponds to the lower limit of regular flake calcium chloride (77–80 percent $CaCl_2$). Anhydrous or concentrated flake calcium chloride contains 94 to 97 percent $CaCl_2$. The annual national average production for the latest 5–year period was used in order to conceal confidential company reports.

Natural calcium chloride, including natural calcium-magnesium chloride, was produced by eight plants: two in California, five in Michigan, and one in West Virginia. Michigan was by far the leading State with 93 percent of the reported domestic production, California next with 6 percent, and West Virginia last with only 1 percent. Calcium chloride was obtained from Bristol Dry Lake in California and from wells tapping underground saline formations in Michigan and West Virginia. All natural calcium chloride and calcium-magnesium chloride was collected first as brine, but most of it was crystallized by the producers. Total production was 69 percent flake, 31 percent liquid, and less than 1 percent solid calcium chloride. Also synthetic calcium chloride was manufactured by Pittsburgh Plate Glass Co., Chemical Division, and by Allied Chemical Corp., Solvay Process Division. Natural calcium chloride constituted 57 percent of the total solid and flake and 65 percent of the total brine produced in 1960.

Leslie Salt Co., San Francisco, Calif., acquired California Salt Co., a producer of calcium chloride from the brines of Bristol Dry Lake, in December 1960.[7] The Dow Chemical Co., Ludington and Midland, Mich., was the largest producer of natural calcium chloride and calcium-magnesium chloride. Columbia-Southern Chemical Corp., Pittsburgh, Pa., a producer of synthetic calcium chloride, became Pittsburgh Plate Glass Co., Chemical Division.

CONSUMPTION AND USES

Calcium was employed as a deoxidizer, a sulfide former, and a scavenger to clean melts. It was a deoxidizer for nonferrous metals,

[5] Chemical and Engineering News, v. 39, No. 27, July 3, 1961, p. 41.
[6] U.S. Department of Commerce, Bureau of the Census, Industry Division. Inorganic Chemicals and Gases, 1960. Current Ind. Rept. Ser. M28A–60, Oct. 27, 1961, p. 9.
[7] Chemical and Engineering News, v. 40, No. 1, Jan. 1, 1962, p. 30.

a reductant for refractory metallic oxides, and an absorbent for gases, including oxygen, hydrogen, and nitrogen. Calcium in calcium-silicon alloy and in calcium-manganese-silicon alloy controlled sulfur distribution in steel, increased ductility, reduced the hot-tearing tendency of carbon and alloy steel castings, and improved the fluidity of steel. These alloys counteracted the deleterious effects of nonmetallic inclusions in steel. Calcium helped control the size and distribution of microscopic graphite flakes in cast iron, thereby improving tensile and transverse strength.

Some cable sheaths were made of lead-calcium alloy. Resistance to fatigue, tensile strength, and hardness were improved by as little as 0.04 percent calcium. Also, lead-calcium alloy was used in storage battery grids where increased strength and more resistance to sulfating were necessary. A few of the refractory metallic oxides that yielded their metal in the presence of calcium were the oxides of chromium, thorium, uranium, and vanadium. Sulfur was removed from crude oil fractions in petroleum refining by calcium.[8] Calcium–47 was used in medical research because its beta- and gamma-ray activity disappears in 3 weeks, compared with 2½ years for calcium–45, which formerly was used as a tracer in medical studies.[9]

Calcium chloride and salt deicing mixtures were used by many highway departments as an inexpensive and very effective means of clearing and drying highways after winter storms. Annual consumption of crystalline calcium chloride was estimated at 600,000 short tons: 150,000 tons for dust control, 150,000 tons for deicing highways, 75,000 tons for treating concrete, 70,000 tons for industrial uses, 30,000 tons for brine refrigeration, and 125,000 tons for other uses. Dust control of roads was the largest single use of calcium chloride. It accounted for 150,000 tons of solid calcium chloride and nearly 200,000 tons of calcium chloride brine annually. Flake calcium chloride used in snow and ice removal from highways had increased from 90,000 to 150,000 tons a year in the last 5 years. It was estimated that eventually 1.5 million tons of calcium chloride would be produced and consumed annually. Consumption of calcium chloride consistently lagged behind production, and some calcium chloride from soda ash production was discarded.[10]

Each year California consumed between 25,000 and 50,000 short tons of calcium chloride, which was used primarily in treating concrete and in extracting chemicals from seaweed.[11] The steel industry used about 1,000 short tons of calcium chloride for maintenance in 1959.[12] A new calcium chloride drying tube was designed.[13]

PRICES AND SPECIFICATIONS

The New York price of calcium, 97–98 percent pure, cast in slabs and small pieces, in over 1-ton lots, was quoted at $2.05 a pound

[8] Work cited in footnote 2.
[9] Work cited in footnote 5.
[10] Oil, Paint and Drug Reporter. Calcium Chloride Use Pointing Up. Slow Rise Toward 1.5 Million Tons. V. 181, No. 5, Jan. 29, 1962, p. 35.
[11] Wright, Lauren A., and John L. Burnett. The Search for Industrial Minerals. Calif. Div. Mines and Geol., v. 15, No. 1, January 1962, p. 5.
[12] Page 24 of work cited in footnote 4.
[13] Journal of Chemical Education, v. 38, No. 7, July 1961, p. A483.

during 1961.[14] Smaller quantities were quoted at the following prices per pound throughout the year: 100 pounds to 1 ton—$2.40, and small lots 99.9 percent pure—$4.55.[15] Calcium-47 sold for $200 a millicurie at Oak Ridge National Laboratory, Oak Ridge, Tenn.[16]

Most calcium chloride prices did not change in 1961: USP granular—$0.32 per pound (drums); purified granular—$0.27 per pound (drums); concentrated flake or pellet, 94–97 percent $CaCl_2$—$39.30 per ton (paper bags, carlots, at works, freight equalized); flake, 77–80 percent $CaCl_2$—$32 per ton (paper bags, carlots, at works, freight equalized); solid, 73–75 percent $CaCl_2$—$36–$73 (drums, less than carlots, at works, freight equalized); and liquor, 40 percent $CaCl_2$—$12.50 per ton (tankcars, at works, freight equalized). Solid, 73–75 percent $CaCl_2$, was $29.50 per ton (drums, carlots, at works, freight equalized) on January 1, but rose to $30.50 a ton January 16, remaining at that price the rest of the year. Powdered, 77 percent minimum $CaCl_2$, was $37 per ton (paper bags, carlots, at works, freight equalized) at the beginning of the year but increased to $38 per ton May 15, and remained at that price.[17]

Wyandotte Chemicals Corp., Wyandotte, Mich., introduced lightweight fiber drums (15½ inches in diameter by 17¼ inches) as containers for all grades of calcium chloride in place of steel drums. The price structure remained unchanged.[18]

FOREIGN TRADE[19]

Imports.—Most of the imported calcium came from Canada, but not all of it as in previous years. West Germany supplied 4 percent (770 pounds valued at $1,266 or $1.64 a pound). The 96 percent from Canada, or 16,496 pounds, was valued at $21,626 or $1.31 a pound. All calcium-silicon alloy came from France at an average value of 14.8 cents a pound. Calcium chloride was imported from Canada, 35 percent; Belgium-Luxembourg, 25 percent; West Germany, 19 percent; United Kingdom, 13 percent; and Italy, 8 percent. The average value of imported calcium chloride was $33.98 a short ton.

Exports.—Calcium chloride was exported mainly to Canada, 82 percent; Mexico, 8 percent; Colombia and Philippines, 2 percent each; and Uruguay, 1 percent. The remaining 5 percent of the exported calcium chloride was distributed among 35 other countries in South America, North America, Europe, Asia, Oceania, and Africa, in descending amounts.

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[14] E&MJ Metal and Mineral Markets, v. 32, Nos. 1–52, Jan. 5–Dec. 28, 1961.
[15] American Metal Market, v. 68, Nos. 1–249, Jan. 2–Dec. 29, 1961.
[16] Work cited in footnote 5.
[17] Oil, Paint and Drug Reporter, v. 179, Nos. 1–26; v. 180, Nos. 1–26; Jan. 2–Dec. 25, 1961.
[18] Chemical and Engineering News, v. 39, No. 12, Mar. 20, 1961, p. 26.
[19] 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
1952-56 (average)	626,967	$678,230	212,424	$29,322	1,850	$59,849	19,004	$600,914
1957	24,204	39,411	498,735	97,077	1,989	77,058	47,965	1,627,545
1958	15,694	24,084	130,866	25,111	1,234	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

Source: Bureau of the Census.

WORLD REVIEW

NORTH AMERICA

Canada.—Calcium production was 134,801 pounds valued at Can$159,241 (Can$1.18 a pound) in 1960. The output of calcium in 1959 (revised figures) was 67,429 pounds, valued at Can$76,409 (Can$1.13 a pound). Dominion Magnesium, Ltd., Haley Station, Ontario, was the only producer. By thermally reducing minus 200-mesh quicklime (calcium oxide) with commercial-grade minus 20-mesh aluminum in horizontal vacuum retorts at 1,170° C., calcium was deposited in the water-cooled retort head sections that projected outside the furnace wall. Exports of calcium amounted to 87,157 pounds in 1960. West Germany received 25 percent; United Kingdom, 22 percent; India, 18 percent; United States, 17 percent (14,918 pounds); Belgium and Luxembourg, 10 percent; Union of South Africa, 7 percent; and other countries, 1 percent. A small quantity of calcium was consumed in Canada in lead alloys for battery plates, in reducing titanium, and as an alloy with magnesium.[20] Calcium chloride in chemicals and allied products in 1959 amounted to 686 short tons costing Can$36,031 (Can$52.52 a ton) at the works.[21]

SOUTH AMERICA

Brazil.—Calcium chloride production was 4,500 short tons in 1960. Some calcium chloride was imported from East Germany.[22]

EUROPE

Austria.—An International Atomic Energy Agency meeting in Vienna reviewed research on human bones using calcium-47, which

[20] Jackson, W. H. Calcium 1960. Canada Dept. Mines and Tech. Surveys, Ind. Min. Div., Ottawa, Rev. 6, June 1961, 3 pp.
[21] Dominion Bureau of Statistics (Ottawa). Chemicals and Allied Products, 1959, General Review. January 1962, p. 11.
[22] U.S. Consulate, Sao Paulo, Brazil. State Department Dispatch 454. June 5, 1961, p. 3. U.S. Embassy, Rio de Janeiro, Brazil. State Department Dispatch 985. May 5, 1961, encl. 1, p. 17.

was available at acceptable prices in the United States and the United Kingdom.[23]

Finland.—A plant was designed to produce 62,000 tons of calcium chloride annually, most of which would be used on unpaved roads.[24]

Norway.—Norsk Hydro-Elektrisk Kvaelstof A/S produced 25,000 tons of calcium chloride in 1958–59.[25]

ASIA

Israel.—The Dead Sea constituted an important reserve of calcium chloride that was not being exploited. Each gallon of Dead Sea water contained 4.7 ounces of calcium chloride.[26]

TECHNOLOGY

The oxidation rates of calcium were obtained from 334° to 431° C., at 110 and 160 mm of mercury, and for exposures to oxygen of 45 to 125 minutes duration. Rates of oxidation were small and linear below 340° C., but became exponential above 340° C. after an initial induction period.[27] The nitridation of calcium and calcium-magnesium alloy was investigated.[28]

Calcium inoculations by means of calcium-manganese-silicon alloy helped decrease the sulfur content of basic-induction-furnace steel. Sulfur content was reduced from 0.25 to 0.002 percent in about 10 minutes by only 0.36 percent calcium. The ductility and toughness of low-sulfur steel was better than that of normal-sulfur steels at the same strength level. The low-sulfur contents were attributed to the increased deoxidation by aluminum which was added before the calcium-manganese-silicon alloy (so that the tendency of calcium to act as a deoxidizer was reduced), the reaction of calcium and sulfur to form a sulfide, and the basic-slag cover that was high in calcium.[29]

Harrison Steel Foundry, Attica, Ind., used calcium-manganese-silicon alloy (calcium, 16 to 20 percent; manganese, 14 to 18 percent; and silicon, 53 to 59 percent) in casting steel parts for railroad and earth-moving equipment. This alloy was used in ladle deoxidation to maintain consistent fine-grained structure and good reduction-in-area and low-temperature impact values. Calcium-manganese-silicon formed round, well-distributed sulfides in place of intergranular, chainlike sulfides that lower ductility. Four pounds of calcium-manganese-silicon and 4 pounds of ferrotitanium were added to each ton of open-hearth steel, and 4 pounds of calcium-

[23] Chemistry and Industry (London). IAEA Panel on Research Applications of Calcium-47. No. 51, Dec. 23, 1961, p. 2101.
[24] Chemical Age (London). Finland's Sodium Sulphate and Calcium Chloride Project. V. 85, No. 2168, Jan. 28, 1961, p. 182.
[25] Chemical Trade Journal and Chemical Engineer (London). Norwegian Chemicals. V. 146, No. 3806, May 13, 1960, p. 1084.
[26] U.S. Embassy, Tel Aviv, Israel. State Department Dispatch 816. June 16, 1960, p. 8.
[27] Chandrasekharaiah, M. S., and John L. Margrove. The Kinetics of Oxidation and Nitridation of Lithium, Calcium, Strontium, and Barium. J. Electrochem. Soc., v. 108, No. 11, November 1961, pp. 1008–1012.
[28] Roberts, M. W., and F. C. Tompkins. Nitriding of Calcium and Other Tarnishing Reactions of Metals. Abs., J. Inst. Metals (London), v. 28, pt. 6, February 1961, p. 491. Work cited in footnote 27.
[29] Colling, David A., and Paul J. Ahearn. Desulfurization by Calcium Inoculation Improves Properties of Cast Steel. Watertown Arsenal Lab. Tech. Rept. No. WAL TR 311/45, Watertown, Mass., January 1961, 23 pp.

manganese-silicon and 3 pounds of aluminum were added to each ton of electric-furnace steel. Calcium-manganese-silicon alloy improved fluidity and random distribution of sulfides in electric-furnace steel.[30]

The alloys, Mg_2Ca and Al_2Ca, were produced in a steel crucible in an electric-resistance furnace employing a $MgCl_2$–KCl–$CaCl_2$–CaF_2–MgO flux.[31]

Calcium–45 had been used in Czechoslovakia to trace endogenous and exogenous nonmetallic inclusions in steel since 1954. This radioactive calcium isotope had been selected because its half-life of 152 days is suitable for this use, its oxide is not reduced by molten iron, and it can be used to label both refractory material and slag. More sensitive methods indicated that exogenous nonmetallic inclusions in steel occurred in higher percentages than had been realized previously.[32]

Calcium and magnesium were used to debismuthize approximately 80 percent of the lead refined by American Smelting and Refining Company. Calcium bismuthide, formed when calcium was added to molten lead containing bismuth, was removed from the surface of the bath as dross, and bismuth was recovered by chlorination of the dross. The resulting lead chloride was used to remove any residual calcium from the debismuthized lead. In 1959–60, 1¼ pounds of calcium was used for each ton of lead.[33]

Removal of oxygen from thorium by calcium vapor or liquid calcium proceeded inward from the thorium surface, according to a parabolic time law, at temperatures from 1,000° to 1,200° C. Oxygen that had diffused out of the thorium combined with calcium to form quicklime. Invariably the chief impurity in thorium, oxygen occurred as tiny thorium-oxide particles. Thorium, containing 1,300 ppm of oxygen, was obtained by reducing thorium fluoride with calcium. The lowest concentration of oxygen ever measured in thorium (16 ppm) was a result of experiments at 1,000° C.[34]

Uranium tetrafluoride was reduced by calcium to uranium.[35] Vanadium pentoxide was reduced to vanadium in a bomb by calcium with iodine. It required 4¼ pounds of calcium to yield a pound of high-purity vanadium.[36] Scandium was prepared by treating thortveitite ore with ammonium bifluoride and then reducing the fluorides with calcium.[37]

When used as a cover slag in debismuthizing lead, calcium chloride limited the oxidation of the calcium carbide and the magnesium that were added to the lead bath to collect bismuth. Calcium chloride was used at the rate of 2⅛ pounds per ton of lead refined by American

[30] Union Carbide Metals Review. At Harrison Steel Foundry Ca–Mn–Si Boosts Casting Quality. V. 4, No. 1, Winter-Spring 1961, p. 23.
[31] Drits, M. E., M. V. Mal'tsev, L. L. Rokhlin, and O. N. Udalova (Study of the Alloys of the Quaternary System Magnesium-Manganese-Aluminium-Calcium). Abs., J. Inst. Metals (London), v. 28, pt. 6, February 1961, p. 495.
[32] Cadek, J., T. Myslivec, M. Mandl, J. Vrsek, and J. Fiala. Tracing Non-metallic Inclusions in Steel With Radioactive Calcium. Iron and Coal Trades Rev. (London), v. 182, No. 4826, Jan. 13, 1961, pp. 73–80.
[33] Work cited in footnote 4.
[34] Peterson, David T. Thermodynamics and Kinetics of the Deoxidation of Thorium by Calcium. Trans. Met. Soc., AIME, v. 221, No. 5, October 1961, pp. 924–926.
[35] Page 51 of work cited in footnote 4.
[36] Page 57 of work cited in footnote 4.
[37] Spedding, F. H., J. E. Powell, A. H. Daane, M. A. Hiller, and W. H. Adams. Methods for Preparing Pure Scandium Oxide. J. Electrochem. Soc., v. 105, No. 11, 1958, pp. 683–686.

Smelting and Refining Company in 1959–60. To produce a pound of tungsten by reduction required two-thirds pound of calcium chloride.[38]

The Asphalt Institute undertook laboratory research at the University of Maryland, College Park, Md., to determine whether calcium chloride adversely affected asphalt pavements.[39]

[38] Pages 36, 56–57 of work cited in footnote 4.
Chemical Week, v. 89, No. 11, Sept. 16, 1961, p. 95.
[39] Roads and Streets. Institute Studying Salts on Asphalt Paving. V. 104, No. 9, September 1961, p. 88.

Cement

By J. M. West [1] and Ardell H. Lindquist [2]

PRODUCTION and shipments of portland cement in 1961 were second only to the record year of 1959, and shipments of 37.1 million barrels in August were slightly above the previous monthly high established in July 1959, in spite of the fact that early in the year construction was slowed by a business recession.

TABLE 1.—Salient cement statistics [1]

	1952-56 (average)	1957	1958	1959	1960	1961
United States:						
Production....thousand barrels..	[2] 293,230	308,255	321,490	350,419	328,715	332,558
Capacity used at portland cement mills.....percent..	90.9	78.2	77.3	80.5	73.5	73.1
Shipments from mills thousand barrels..	[2] 291,001	299,189	317,263	346,675	321,646	329,443
Value [3].....thousands..	[2] $824,739	$961,499	$1,038,672	$1,144,867	$1,089,134	$1,105,537
Average value....per barrel..	$2.83	$3.21	$3.27	$3.30	$3.39	$3.36
Stocks Dec. 31: At mills thousand barrels..	18,338	28,748	30,664	31,437	[4] 35,660	36,198
Imports for consumption..do....	2,198	4,427	3,390	5,265	[4] 4,108	3,621
Exports.....do....	2,272	1,331	641	277	187	286
Consumption, apparent [5]..do....	290,927	302,285	320,012	351,663	325,567	332,778
World: Production.....do....	1,157,032	[4] 1,448,003	[4] 1,539,662	[4] 1,724,585	[4] 1,866,277	1,997,319

[1] Barrel as used in this chapter, unless otherwise stated, refers to a 376-pound barrel.
[2] Portland cement, 1952-56; and masonry and natural cement, 1955-56.
[3] Value received f.o.b. mill, excluding cost of containers.
[4] Revised figure.
[5] Quantity shipped plus imports minus exports.

Plans for adding approximately 20 million barrels to the annual cement capacity were announced, with construction of four new plants and expansion of six existing plants. Some industry spokesmen were apprehensive of rising cement capacity and the declining percentage of capacity used.[3] As a reflection of increasing competition for sales, numerous distribution centers for cement were springing up throughout the country. Approximately two dozen such centers were under construction by a dozen companies.

Three classes of hydraulic cement were produced in the United States—portland, natural, and slag cements. In addition, many plants produced prepared masonry cements.

LEGISLATION AND GOVERNMENT PROGRAMS

Hearings were held by the U.S. Tariff Commission in Washington, D.C., to determine if sales of imported cement from several countries should be considered injurious to domestic cement producers under

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.
[3] Chemical & Engineering News. Battle for Cement Markets Grows Sharper. V. 39, No. 26, June 26, 1961.

the Anti-Dumping Act. Rulings required the Secretary of the Treasury to impose higher import duties on cement from Belgium, Sweden, and Portugal to conform to the fair market values in those countries. It was ruled that Danish cement was not sold at less than fair value. A statement handed down by the Tariff Commission was taken to show that it recognized existence of more than one cement industry in the United States for purposes of the Anti-Dumping Act. This industry comprised domestic plants supplying Rhode Island, eastern Massachusetts and eastern Connecticut.[4] At a special hearing by House of Representatives Subcommittee on Impact of Imports and Exports on American Employment, held on August 29, the Treasury was urged to speed up determinations under the Anti-Dumping Act.[5]

A complaint concerning antitrust laws was made by the Federal Trade Commission against one cement company.[6]

Shipments from two new Hawaiian cement plants to Federal project contractors on the Islands were held up by complex government test regulations. Meanwhile, the projects were supplied with shipments from the U.S. mainland until the U.S. Bureau of Standards testing was completed.

PORTLAND CEMENT

PRODUCTION AND SHIPMENTS

Production of portland cement increased 2 percent above the 319 million barrels in 1960, but was 15 million barrels below the record high set in 1959. Ninety-two of the 176 plants producing in 1960 had greater outputs in 1961. Only one new gray portland plant reported production in 1961—Dewey Portland Cement Co., Tulsa, Okla. Operations at two plants were discontinued; one at Sandts Eddy, Pa., and the other at Bay Bridge, Ohio. A new white portland cement plant went into production in California. New plants were under construction in New York, Georgia, Indiana, and California.

Descriptions were published of equipment installed as part of expansion plans or in new cement plants at Tulsa, Okla.;[7] Waianae, Oahu, Hawaii;[8] Barber's Point, Oahu, Hawaii;[9] Crestmore, Calif.,[10] Alpena, Mich.;[11] Glens Falls, N.Y.;[12] Mason City, Iowa;[13] Rapid

[4] Rock Products. Import Battles Pay Off. V. 64, No. 5, May 1961, pp. 126, 128, 186, 189.

[5] Pit and Quarry. Amend Anti-Dumping Act, Management, Union Urge at Cement Import Hearing. V. 54, No. 4, October 1961, p. 38.

[6] Business Week. FTC Challenges Cement Maker. No. 1642, Feb. 18, 1961, p. 34.

[7] Trauffer, Walter E. Automation Concept, Chief Design Factor in Dewey's New Tulsa Plant. Pit and Quarry, v. 54, No. 1, July 1961, pp. 110–123, 131, 135, 147

[8] Watson, Ian M. Permanente's Hawaiian Plant. Pit and Quarry, v. 53, No. 10, April 1961, pp. 82–93. Bergstrom, John H. Hawaii Leaps into Cement Production Race. Rock Products, v. 64, No. 5, May 1961, pp. 100–107.

[9] Utley, Harry F. Hawaiian Cement Corporation Paces Progress in 50th State. Pit and Quarry, v. 53, No. 12, June 1961, pp. 87–91, 97.

[10] Bell, Joseph N. White Cement Debuts on West Coast. Rock Products, v. 64, No. 5, May 1961, pp. 153–158. Utley, Harry F. Riverside's New White Cement Plant. Pit and Quarry, v. 54, No. 1, July 1961, pp. 127–130.

[11] Pit and Quarry. Huron's New Mill With 18-ft. Separator Produces 350 Bbl. of Cement per Hour. V. 54, No. 3, September 1961, pp. 134, 135.

[12] Pit and Quarry. Cement Packing and Shipping Facilities Modernized at Glens Falls. V. 54, No. 6, December 1961, pp. 108–111.

[13] Meschter, Elwood. Conveyors Speed Raw Materials Through New Cement Plant. Rock Products, v. 64, No. 12, December 1961, pp. 84–89.

City, S. Dak.;[14] Barberton, Ohio;[15] Salt Lake City, Utah;[16] and Nashville, Tenn.[17]

Acquisition of North American Cement Co. (3 plants), Green Bag Cement Co. (1 plant formerly owned by Pittsburgh Coke and Chemical Co.), and Hawkeye Portland Cement Co. of Iowa (1 plant) was completed by Marquette Cement Manufacturing Co. American-Marietta Co. merged with The Martin Co. to form Martin Marietta Corp. The Bessemer Limestone & Cement Co. became a division of Diamond Alkali Co., and National Cement Co. became a division of Woodward Iron Co. Universal Atlas Cement Co. acquired the cement carrier, S.S. Florida State and dock facilities in Florida through purchase of Ponce Products, Inc., from Maule Industries, Inc., Florida. Ownership of Ponce Cement Corp. remained unchanged.

Medusa Portland Cement Co. planned to raze its Bay Bridge mill at Sandusky, Ohio.

TYPES OF PORTLAND CEMENT

General-use and moderate-heat cements (types I and II) were produced at 174 of the 175 operating plants and comprised 93 percent of all portland cement made. High-early-strength cement (type III) was produced at 135 plants, the same number as in 1960. Eight plants reported production of portland-slag cement, with three plants accounting for 74 percent of the 3.6 million barrel output. Seven of these eight plants also produced other types of portland cement.

CAPACITY OF PLANTS

The estimated annual capacity of all portland cement plants on December 31, as reported to the Bureau of Mines by producers, was 2 percent greater than on December 31, 1960. The capacity increase was 9.8 million barrels and resulted mainly from expansions at 9 of the 175 plants in operation in 1960 and the addition of 1 new plant.

Number of portland cement plants in the United States (including Puerto Rico) in 1961, by size groups

Estimated annual capacity, Dec. 31, million barrels:	*Number of plants*	*Percent of total capacity*
Less than 1	8	1.3
1 to 2	58	19.5
2 to 3	61	33.0
3 to 4	28	20.7
4 to 5	12	11.3
5 to 11	9	14.2
Total	[1] 176	100.0

[1] Includes one nonproducing plant in standby condition.

[14] Herod, Buren C. South Dakota Cement Expanded 500 Percent. Pit and Quarry, v. 54, No. 3, September 1961, pp. 90–96.
[15] Pit and Quarry. Pittsburgh Plate Glass Cement Plant Served by Deepest Limestone Mine. V. 54, No. 4, October 1961, pp. 112–116.
[16] Intermountain Industry. Portland Cement of Utah Doubles Production Capacity. V. 63, No. 4, April 1961, pp. 6–7.
[17] Rock Products. Open House Shows Off Modernized Marquette Plant. V. 64, No. 7, July 1961, p. 50.

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			1960			1961				Thousand barrels		
							Value			Value		Change from 1960 (percent) in—			
	1960	1961	1960	1961	Change from 1960 (percent)	Thousand barrels	Total	Average per barrel	Thousand barrels	Total	Average per barrel	Barrels	Average value	1960 [2]	1961	Change from 1960 (percent)
Eastern Pennsylvania, Maryland	21	20	35,290	34,658	−2	34,679	$118,131	$3.41	34,783	$117,739	$3.38	--------	−1	5,097	4,606	−10
New York, Maine	12	12	20,134	18,061	−10	19,301	64,394	3.34	18,189	61,982	3.41	−6	+2	2,788	2,515	−10
Ohio	11	10	16,850	15,059	−11	16,752	58,470	3.49	15,303	53,251	3.48	−9	--------	1,962	1,695	−14
Western Pennsylvania, West Virginia	6	6	10,960	10,636	−3	10,505	35,857	3.41	10,440	35,494	3.40	−1	--------	1,586	1,664	+5
Michigan	9	9	20,971	21,661	+3	21,187	73,082	3.45	21,948	75,172	3.43	+4	−1	3,024	2,737	−9
Illinois	4	4	9,270	8,757	−6	8,770	29,321	3.34	8,595	28,301	3.29	−2	−2	1,201	1,236	+3
Indiana, Kentucky, Wisconsin	7	7	19,723	20,052	+2	18,832	64,070	3.40	18,692	63,410	3.39	−1	--------	2,070	2,578	+25
Alabama	8	8	11,935	12,837	+8	11,355	36,142	3.18	12,445	39,027	3.13	+10	−2	1,145	1,162	+1
Tennessee	6	6	7,926	8,729	+10	7,517	24,688	3.28	8,357	26,964	3.23	+11	−2	712	803	+13
Virginia, South Carolina	4	4	7,311	8,063	+10	7,130	24,409	3.42	8,064	27,261	3.38	+13	−1	718	717	--------
Georgia, Florida	6	6	11,204	10,928	−2	11,110	37,417	3.37	10,841	36,497	3.37	−2	--------	865	912	+5
Louisiana, Mississippi	5	5	7,267	6,615	−9	7,201	23,925	3.32	6,536	20,693	3.17	−9	−5	715	737	+3
Iowa	5	5	12,527	12,786	+2	12,105	42,330	3.50	12,108	41,718	3.45	--------	−1	1,357	1,910	+41
Minnesota, South Dakota, Nebraska	4	4	8,366	8,740	+4	8,330	28,046	3.37	8,650	28,382	3.28	+4	−3	1,014	1,077	+6
Missouri	5	5	12,606	11,940	−5	11,856	40,915	3.45	11,839	41,142	3.48	--------	+1	1,851	1,900	+3
Kansas	6	6	7,996	8,329	+4	7,877	25,194	3.20	8,028	25,605	3.19	+2	--------	1,094	1,359	+24
Oklahoma, Arkansas	5	6	7,155	9,094	+27	7,127	22,044	3.09	8,940	27,825	3.11	+25	+1	844	986	+17
Texas	16	16	23,190	24,889	+7	22,721	73,964	3.26	25,101	80,808	3.22	+10	−1	2,449	2,237	−9
Colorado, Arizona, Utah, New Mexico	7	7	11,908	13,730	+15	11,745	40,076	3.41	13,605	46,128	3.39	+16	−1	1,001	1,126	+12
Wyoming, Montana, Idaho	3	3	2,608	2,787	+7	2,607	9,503	3.64	2,803	10,191	3.64	+8	--------	310	294	−5
Northern California	5	5	16,534	16,911	+2	16,170	52,979	3.28	16,944	54,698	3.23	+5	−2	1,258	1,224	−3
Southern California	8	8	23,358	24,254	+4	23,542	75,847	3.22	24,146	75,138	3.11	+3	−3	1,408	1,516	+8
Oregon, Washington	9	9	8,244	7,413	−10	8,319	29,325	3.52	7,386	25,832	3.50	−11	−1	952	975	+2
Hawaii	2	2	261	1,115	+327	113	571	5.03	1,077	5,574	5.18	+853	+3	154	191	+24
Puerto Rico	2	2	5,415	6,070	+12	5,441	14,546	2.67	5,931	16,946	2.86	+9	+7	65	204	+214
Total	176	175	319,009	324,114	+2	[3] 312,292	1,045,246	3.35	[3] 320,751	1,065,778	3.32	+3	−1	35,640	36,361	+2
Pennsylvania	23	22	37,170	36,591	−2	36,374	124,122	3.42	36,635	124,506	3.40	+1	+1	5,728	5,373	−6

[1] Includes Puerto Rico. [2] Incorporates some revisions.
[3] Does not include finished cement used in manufacturing prepared masonry cement, as follows: 1960, 2,720,000 barrels; 1961, 2,642,000 barrels.

TABLE 3.—Production, shipments from mills, and stocks at mills of finished portland cement in the United States [1] in 1961, by months [2] and districts

(Thousand barrels)

District	January	February	March	April	May	June	July	August	September	October	November	December
Production:												
Eastern Pennsylvania, Maryland	1,199	1,291	2,292	3,098	3,311	3,529	3,527	3,400	3,358	3,545	3,260	2,780
New York, Maine	1,216	701	722	1,305	1,553	1,867	1,854	1,783	1,670	1,625	1,577	1,509
Ohio	590	407	836	1,095	1,443	1,464	1,693	1,774	1,820	1,867	1,270	801
Western Pennsylvania, West Virginia	439	430	473	656	1,040	1,108	1,232	1,339	1,168	1,175	746	897
Michigan	567	603	1,175	1,842	2,363	2,510	2,650	2,528	2,243	2,354	1,823	1,027
Illinois	548	190	380	615	914	816	926	1,044	938	866	866	649
Indiana, Kentucky, Wisconsin	769	902	1,202	1,498	1,844	2,028	2,469	2,299	2,243	2,055	1,593	1,209
Alabama	807	692	917	984	1,175	1,162	1,124	1,227	1,163	1,289	1,176	1,074
Tennessee	562	372	509	713	834	825	842	841	818	900	756	758
Virginia, South Carolina	438	362	541	623	762	701	783	785	777	804	741	748
Georgia, Florida	838	750	972	827	887	938	980	904	878	938	940	1,075
Louisiana, Mississippi	436	300	341	590	633	617	627	615	551	649	671	584
Iowa	840	598	540	798	1,226	1,361	1,363	1,478	1,367	1,343	1,025	846
Minnesota, South Dakota, Nebraska	189	298	480	780	889	988	1,060	1,127	981	917	631	399
Missouri	337	389	881	1,010	1,192	1,224	1,154	1,352	1,229	1,296	1,016	859
Kansas	373	462	702	773	912	831	664	811	707	791	730	574
Oklahoma, Arkansas	465	488	692	860	875	848	930	872	946	858	631	629
Texas	1,496	1,511	2,266	2,315	2,473	2,149	2,123	2,342	2,049	2,183	2,067	1,916
Colorado, Arizona, Utah, New Mexico	801	771	1,121	1,173	1,393	1,373	1,273	1,309	1,295	1,190	1,028	1,002
Wyoming, Montana, Idaho	86	98	175	210	240	286	303	326	311	346	242	161
Northern California	1,174	814	1,414	1,401	1,553	1,418	1,525	1,667	1,504	1,736	1,518	1,187
Southern California	1,782	1,691	2,076	2,077	2,167	2,085	2,066	2,118	2,082	2,223	1,962	1,867
Oregon, Washington	354	469	537	639	772	783	672	750	706	736	655	340
Hawaii	21	45	107	83	134	144	106	31	136	92	173	44
Puerto Rico	417	404	500	498	517	539	565	540	534	570	528	458
Total:												
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
1960	18,669	16,080	18,422	27,015	31,999	31,930	31,982	33,270	31,181	31,533	26,469	20,505

See footnotes at end of table.

TABLE 3.—Production, shipments from mills, and stocks at mills of finished portland cement in the United States[1] in 1961, by months[2] and districts—Continued

(Thousand barrels)

District	January	February	March	April	May	June	July	August	September	October	November	December
Shipments:												
Eastern Pennsylvania, Maryland	1,080	982	2,501	2,903	3,432	3,809	3,107	3,580	3,787	4,188	3,220	2,196
New York, Maine	572	509	900	1,224	1,710	2,048	1,829	2,020	1,900	2,093	1,549	1,051
Ohio	376	465	790	843	1,482	1,761	1,675	2,060	1,961	1,971	1,305	613
Western Pennsylvania, West Virginia	302	279	595	642	949	1,112	1,136	1,412	1,306	1,272	926	508
Michigan	573	630	989	1,313	2,199	2,880	2,676	2,947	2,509	2,644	1,758	829
Illinois	223	273	437	546	921	1,038	1,068	1,253	892	966	688	292
Indiana, Kentucky, Wisconsin	597	658	1,016	1,257	1,880	2,282	2,074	2,599	2,112	2,072	1,422	723
Alabama	756	678	950	1,001	1,111	1,048	1,167	1,282	1,176	1,400	1,060	815
Tennessee	400	391	591	637	862	823	824	903	903	883	681	458
Virginia, South Carolina	397	369	636	616	766	702	796	828	774	884	763	533
Georgia, Florida	757	761	961	824	901	894	905	994	994	1,063	963	825
Louisiana, Mississippi	341	343	479	590	708	576	535	655	636	742	551	380
Iowa	251	271	407	753	1,282	1,554	1,448	1,869	1,607	1,621	745	299
Minnesota, South Dakota, Nebraska	205	229	421	730	926	1,021	1,104	1,328	973	1,064	447	201
Missouri	414	380	694	917	1,072	1,293	1,226	1,500	1,411	1,591	900	443
Kansas	402	366	554	732	820	907	733	898	844	930	538	304
Oklahoma, Arkansas	519	495	731	719	812	846	898	1,042	840	896	676	467
Texas	1,557	1,636	2,507	2,327	2,450	2,174	2,133	2,595	2,014	2,290	1,752	1,648
Colorado, Arizona, Utah, New Mexico	740	833	1,024	1,169	1,444	1,554	1,385	1,457	1,175	1,218	908	699
Wyoming, Montana, Idaho	93	105	163	213	281	335	253	354	334	378	185	109
Northern California	1,003	889	1,278	1,386	1,485	1,581	1,518	1,870	1,619	1,761	1,400	1,155
Southern California	1,677	1,874	2,031	1,997	2,228	2,108	1,991	2,263	2,083	2,205	1,884	1,807
Oregon, Washington	440	442	688	619	712	802	645	706	700	667	532	434
Hawaii	75	78	74	70	85	97	100	116	93	102	88	92
Puerto Rico	424	415	467	503	512	494	527	575	561	509	505	442
Total:												
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
1960	12,766	14,576	17,681	27,341	30,185	34,045	32,674	36,387	33,599	32,991	24,961	14,977

Stocks (end of month):												
Eastern Pennsylvania, Maryland	5,283	5,586	5,333	5,508	5,337	5,011	5,399	5,162	4,704	4,027	4,021	4,583
New York, Maine	3,407	3,592	3,409	3,481	3,295	3,071	3,044	2,760	2,511	2,012	2,029	2,476
Ohio	2,171	2,114	2,160	2,410	2,370	2,067	2,085	1,797	1,655	1,546	1,510	1,695
Western Pennsylvania, West Virginia	1,722	1,871	1,738	1,735	1,804	1,781	1,857	1,762	1,603	1,484	1,291	1,664
Michigan	2,668	2,641	2,827	3,357	3,567	3,258	3,329	3,019	2,766	2,476	2,539	2,737
Illinois	1,526	1,437	1,375	1,428	1,408	1,172	1,020	796	831	716	882	1,234
Indiana, Kentucky, Wisconsin	2,129	2,349	2,454	2,648	2,524	2,173	2,491	2,108	2,141	2,046	2,144	2,578
Alabama	1,174	1,161	1,099	1,053	1,077	1,155	1,081	986	942	793	868	1,109
Tennessee	860	833	726	776	721	693	688	593	482	470	520	803
Virginia, South Carolina	758	751	655	662	658	656	643	600	603	523	502	717
Georgia, Florida	946	935	939	941	923	963	1,037	942	823	696	666	913
Louisiana, Mississippi	803	756	615	614	535	570	658	613	522	422	537	737
Iowa	2,136	2,456	2,576	2,599	2,496	2,253	2,113	1,649	1,389	1,099	1,367	1,910
Minnesota, South Dakota, Nebraska	997	1,066	1,104	1,154	1,116	1,083	1,039	838	846	699	904	1,102
Missouri	1,775	1,780	1,963	2,050	2,166	2,092	2,016	1,864	1,678	1,379	1,489	1,900
Kansas	1,065	1,160	1,300	1,323	1,415	1,340	1,270	1,184	1,047	896	1,088	1,359
Oklahoma, Arkansas	787	779	738	879	943	943	975	804	910	872	826	985
Texas	2,387	2,262	2,019	2,007	2,031	2,006	1,995	1,743	1,778	1,675	1,991	2,259
Colorado, Arizona, Utah, New Mexico	1,064	1,002	1,099	1,102	1,052	871	760	611	730	703	823	1,126
Wyoming, Montana, Idaho	303	297	310	308	266	218	268	240	219	186	243	294
Northern California	1,430	1,355	1,491	1,505	1,572	1,409	1,415	1,213	1,098	1,073	1,191	1,224
Southern California	1,529	1,346	1,391	1,515	1,455	1,431	1,506	1,360	1,360	1,378	1,455	1,516
Oregon, Washington	867	894	743	763	823	803	829	873	879	947	1,069	954
Hawaii	92	59	91	104	153	200	206	121	165	154	239	191
Puerto Rico	60	49	82	77	82	127	165	130	103	165	188	204
Total:												
1961	37,939	38,531	38,237	39,999	39,789	37,346	37,889	33,768	31,785	28,437	30,382	36,270
1960	37,284	38,553	39,165	38,554	40,101	37,667	36,611	33,244	30,505	28,841	30,095	[3] 35,525

[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)	Average per barrel
General-use and moderate-heat (types I and II):					
1952–56 (average)	157	250,559	248,784	$687,344	$2.76
1957	163	[2] 275,968	268,855	844,962	3.14
1958	167	[2] 291,688	287,377	922,921	3.21
1959	171	[2] 316,600	312,970	1,012,836	3.24
1960	175	[2] 297,279	290,968	962,453	3.31
1961	174	[2] 302,107	298,616	980,371	3.28
High-early-strength (type III):					
1952–56 (average)	101	10,003	9,843	31,809	3.23
1957	111	[3] 12,853	11,867	43,325	3.65
1958	120	[3] 12,161	12,274	45,107	3.67
1959	129	[3] 14,439	14,363	53,484	3.72
1960	135	[3] 13,961	13,772	51,731	3.76
1961	135	[3] 13,530	14,305	53,000	3.71
Low-heat (type IV):					
1952–56 (average)	1	109	99	296	2.99
1957	2	21	5	16	3.23
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
Sulfate-resisting (type V):					
1952–56 (average)	5	96	89	321	3.61
1957	9	191	191	712	3.72
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
Oil-well:					
1952–56 (average)	17	1,779	1,766	5,548	3.14
1957	16	1,511	1,482	5,161	3.48
1958	15	983	1,058	3,739	3.54
1959	16	1,288	1,182	4,121	3.49
1960	14	1,055	1,059	3,669	3.46
1961	14	1,015	1,235	4,181	3.39
White:					
1952–56 (average)	4	1,133	1,135	6,401	5.64
1957	4	[4] 1,087	1,024	6,595	6.44
1958	4	[4] 1,377	1,237	8,001	6.47
1959	4	[4] 1,525	1,515	9,819	6.48
1960	4	[4] 1,504	1,384	9,274	6.70
1961	5	[4] 1,647	1,532	10,387	6.78
Portland-slag and portland pozzolan:					
1952–56 (average)	8	3,705	3,616	10,262	2.84
1957	11	[5] 5,219	5,237	17,246	3.29
1958	11	[5] 4,096	3,977	13,632	3.43
1959	8	[5] 3,653	3,806	12,864	3.38
1960	7	[5] 3,630	3,525	12,057	3.42
1961	8	[5] 3,586	3,316	11,179	3.37
Miscellaneous: [6]					
1952–56 (average)	23	1,229	1,125	3,851	3.42
1957	26	[4] 1,574	1,037	3,942	3.80
1958	21	[4] 915	931	3,499	3.76
1959	22	[4] 1,387	1,414	5,331	3.77
1960	20	[4] 1,128	1,141	4,366	3.83
1961	19	[4] 1,280	1,317	4,992	3.79
Grand total:					
1952–56 (average)	157	279,936	277,712	774,637	2.79
1957	[7] 164	298,424	289,698	921,959	3.18
1958	[7] 168	311,471	307,068	997,701	3.25
1959	[7] 172	339,091	335,452	1,099,244	3.28
1960	[7] 176	319,009	312,292	1,045,246	3.35
1961	[7] 175	324,114	320,751	1,065,778	3.32

[1] Includes Puerto Rico.
[2] Includes air-entrained portland cement as follows (in thousand barrels): 1957, 32,791; 1958, 31,470; 1959, 38,961; 1960, 35,473; 1961, 36,373.
[3] Includes air-entrained portland cement as follows (in thousand barrels): 1957, 3,497; 1958, 4,382; 1959, 5,126; 1960, 4,645; 1961, 4,140.
[4] Includes a small amount of air-entrained portland cement.
[5] Includes air-entrained portland cement as follows (in thousand barrels): 1957, 2,311; 1958, 2,164; 1959, 1,969; 1960, 1,400; 1961, 1,996.
[6] Includes hydroplastic, plastic, and waterproofed cements.
[7] Includes number of plants making air-entrained portland cement as follows: 1957, 112; 1958, 113; 1959, 119; 1960, 120; 1961, 120.

TABLE 5.—Portland-cement-manufacturing capacity of the United States[1] by districts

District	Capacity Dec. 31, (thousand barrels)		Percent utilized	
	1960	1961	1960	1961
Eastern Pennsylvania, Maryland	52,233	52,228	67.6	66.4
New York, Maine	26,431	27,006	76.2	66.9
Ohio	23,520	22,370	71.6	67.3
Western Pennsylvania, West Virginia	15,468	14,968	70.9	71.1
Michigan	31,242	31,154	67.1	69.5
Illinois	9,880	10,725	93.8	81.7
Indiana, Kentucky, Wisconsin	23,350	25,249	84.5	79.4
Alabama	16,340	16,340	73.0	78.6
Tennessee	9,554	9,843	83.0	88.7
Virginia, South Carolina	9,390	10,390	77.9	77.6
Georgia, Florida	14,822	16,061	75.6	68.0
Louisiana, Mississippi	9,245	9,366	78.6	70.6
Iowa	14,330	15,424	87.4	82.9
Minnesota, South Dakota, Nebraska	9,632	9,232	86.9	94.7
Missouri	15,800	16,277	79.8	73.4
Kansas	12,490	12,490	64.0	66.7
Oklahoma, Arkansas	11,485	12,785	62.3	71.1
Texas	38,949	38,809	59.5	64.1
Colorado, Arizona, Utah, New Mexico	14,150	15,850	84.2	86.6
Wyoming, Montana, Idaho	3,150	3,350	82.8	83.2
Northern California	19,235	19,360	86.0	87.4
Southern California	32,520	32,520	71.8	74.6
Oregon, Washington	11,025	11,025	74.8	67.2
Hawaii	2,700	2,400	9.7	46.5
Puerto Rico	6,000	7,500	90.3	80.9
Total	432,941	442,722	73.7	73.2

[1] Includes Puerto Rico.

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								
	1959	1960	1961	1959	1960	1961	1959	1960	1961	1959	1960	1961
Wet	244,306	252,288	258,867	58.1	58.3	58.5	81.2	74.0	72.8	58.5	58.5	58.1
Dry	176,089	180,653	183,855	41.9	41.7	41.5	79.9	73.3	73.8	41.5	41.5	41.9
Total	420,395	432,941	442,722	100.0	100.0	100.0	80.7	73.7	73.2	100.0	100.0	100.0

[1] Includes Puerto Rico.

CLINKER PRODUCTION

Output of clinker was slightly less than that in 1960; it reached a high in July of 30 million barrels. Yearend stocks of clinker were 7 percent less than those of 1960.

TABLE 7.—Portland-cement clinker produced and in stock at mills in the United States,[1] by process[2]

Process	Plants		Production		Stocks on Dec. 31—	
	1960	1961	1960 (thousand barrels)	1961 (thousand barrels)	1960[3] (thousand barrels)	1961[4] (thousand barrels)
Wet	107	104	186,814	188,751	8,352	8,553
Dry	68	69	137,715	134,659	12,606	10,978
Total	175	173	324,529	323,410	20,958	19,531

[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 1961, by months and districts

(Thousand barrels)

District	January	February	March	April	May	June	July	August	September	October	November	December
Eastern Pennsylvania, Maryland	1,545	1,383	2,350	2,976	3,361	3,476	3,727	3,231	3,216	3,463	3,207	2,805
New York, Maine	1,402	887	894	1,295	1,608	1,840	1,696	1,763	1,538	1,592	1,612	1,633
Ohio	1,039	749	1,356	1,410	1,429	1,537	1,573	1,374	1,204	1,459	1,283	1,041
Western Pennsylvania, West Virginia	670	639	738	523	1,121	1,043	849	1,154	1,073	1,026	745	849
Michigan	1,538	1,513	1,809	1,805	2,097	2,171	2,145	1,834	1,710	2,020	1,937	1,816
Illinois	735	377	498	677	854	766	753	935	867	758	874	647
Indiana, Kentucky, Wisconsin	1,388	1,270	1,551	1,705	1,764	1,758	2,087	1,737	1,826	1,878	1,814	1,580
Alabama	924	724	919	978	1,155	1,140	1,135	1,022	1,130	1,231	1,213	1,116
Tennessee	510	454	629	753	793	768	829	782	812	861	774	786
Virginia, South Carolina	544	423	588	655	741	760	753	731	714	825	791	662
Georgia, Florida	830	720	993	890	930	882	954	908	857	1,059	1,007	1,040
Louisiana, Mississippi	546	357	395	574	617	659	638	617	584	584	677	710
Iowa	987	624	710	907	1,239	1,236	1,276	1,262	1,269	1,242	1,176	1,021
Minnesota, South Dakota, Nebraska	633	573	670	723	793	743	787	646	760	845	754	733
Missouri	667	681	1,036	1,100	1,226	1,059	1,038	1,193	1,135	1,130	1,010	812
Kansas	395	590	654	820	827	811	709	774	676	700	708	600
Oklahoma, Arkansas	554	593	700	884	828	869	798	800	872	770	653	625
Texas	1,793	1,492	2,286	2,290	2,151	2,105	2,099	2,110	2,075	2,163	2,096	2,053
Colorado, Arizona, Utah, New Mexico	1,037	945	1,064	1,046	1,214	1,098	1,188	1,237	1,283	1,230	1,156	1,174
Wyoming, Montana, Idaho	207	180	161	185	302	298	248	159	188	231	251	218
Northern California	1,281	1,142	1,369	1,365	1,478	1,437	1,488	1,440	1,315	1,424	1,410	1,316
Southern California	1,613	1,619	1,884	1,999	2,032	1,966	2,002	1,972	1,948	2,066	2,070	2,050
Oregon, Washington	482	441	515	661	729	720	719	577	611	718	606	371
Hawaii	16	43	129	106	126	139	128	32	105	143	184	30
Puerto Rico	431	404	488	485	501	509	502	511	528	574	531	479
Total:												
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
1960	24,079	21,458	24,520	27,165	31,577	29,537	29,125	29,314	28,068	28,785	26,168	24,733

[1] Includes Puerto Rico.

RAW MATERIALS

Approximately 71 percent of the domestic output of portland cement was made from limestone and clay or shale. Argillaceous limestone (cement rock) or a mixture of cement rock and limestone was used for 22 percent of the portland cement produced. Three plants used marl instead of limestone, and nine plants used shells.

Blast-furnace slag was used as a raw material in producing portland cement at 23 plants, 7 of which used approximately 304,000 tons of slag to produce portland-slag cement.

TABLE 9.—Production and percentage of total output of portland cement in the United States,[1] by raw materials used

Year	Cement rock and pure limestone		Limestone and clay or shale [2 3]		Blast-furnace slag and limestone	
	Thousand barrels	Percent	Thousand barrels	Percent	Thousand barrels	Percent
1952–56 (average)	60,850	21.8	199,124	71.1	19,962	7.1
1957	64,776	21.7	211,743	71.0	21,905	7.3
1958	71,681	23.0	225,495	72.4	14,295	4.6
1959	79,895	23.5	239,336	70.6	19,860	5.9
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

[1] Includes Puerto Rico.
[2] Includes output of 4 plants using marl and clay in 1952–56 (average); 4 plants in 1957–60; and 3 plants in 1961.
[3] Includes output of 8 plants using oystershell and clay in 1952–56 (average); and 9 plants in 1957–61.

TABLE 10.—Raw materials used in producing portland cement in the United States [1]

Raw material		1959	1960	1961
Cement rock	thousand short tons	25,663	19,917	18,482
Limestone (including oystershell)	do	65,250	66,823	68,139
Marl	do	2,006	1,224	549
Clay and shale [2]	do	10,363	9,657	10,105
Blast-furnace slag	do	1,139	1,269	1,295
Gypsum	do	2,770	1,146	2,754
Sand and sandstone (including silica and quartz)	do	1,311	2,690	1,386
Iron materials [3]	do	671	774	623
Miscellaneous [4]	do	26	66	137
Total	do	109,199	103,566	103,470
Average total weight required per barrel (376 pound) of finished cement	pounds	644	649	638

[1] Includes Puerto Rico.
[2] Includes fuller's earth, diaspore, and kaolin for making white cement.
[3] Includes iron ore, pyrite cinders and ore, and mill scale.
[4] Includes fluorspar, pumicite ,pitch, red mud and rock, hydrated lime, tufa, calcium chloride, sludge, air-entraining compounds, and grinding aids.

FUEL AND POWER

Less coal and oil and more natural gas were used in producing cement in 1961 than in 1960. Coal and oil supplied 54 percent of the heat used, compared with 57 percent in 1960. Consumption of natural gas increased 5 percent compared with that in 1960. The 175 active plants used an average of 1.2 million B.t.u. per barrel of cement produced.

TABLE 11.—Finished portland cement produced and fuel consumed by the portland-cement industry in the United States,[1] by processes

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)
1960:						
Wet	107	186,370	58.4	4,138	3,216	110,208,571
Dry	69	132,639	41.6	4,230	816	61,393,837
Total	176	319,009	100.0	[2] 8,368	4,032	[3] 171,602,408
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	[4] 7,768	3,910	180,353,595

[1] Includes Puerto Rico.
[2] Comprises 151,704 tons of anthracite and 8,216,358 tons of bituminous coal.
[3] Includes 486,957 thousand cubic feet of coke-oven gas.
[4] Comprises 152,644 tons of anthracite and 7,615,153 tons of bituminous coal.

TABLE 12.—Portland cement produced in the United States,[1] by kinds of fuel

Year and fuel	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)
1960:						
Coal	61	[2] 107,084	33.6	5,693		
Oil	9	[2] 13,405	4.2		2,491	
Natural gas	37	[2] 57,677	18.1			[3] 69,978,032
Coal and oil	23	47,775	15.0	1,969	851	
Coal and natural gas	21	37,075	11.6	498		36,615,218
Oil and natural gas	18	42,441	13.3		667	51.732,873
Coal, oil, and natural gas	7	13,552	4.2	208	23	13,276,285
Total	176	319,009	100.0	[4] 8,368	4,032	171,602,408
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	[5] 7,768	3,910	180,353,595

[1] Includes Puerto Rico.
[2] Average consumption of fuel per barrel of cement produced as follows; 1960—coal, 106.3 pounds; oil, 0.1858 barrel; natural gas, 1,213 cubic feet. 1961—coal, 104.0 pounds; oil, 0.1880 barrel; natural gas, 1,205 cubic feet.
[3] Includes 486,957 thousand cubic feet of coke-oven gas.
[4] Comprises 151,704 tons of anthracite and 8,216,358 tons of bituminous coal.
[5] Comprises 152,644 tons of anthracite and 7,615,153 tons of bituminous coal.

TABLE 13.—Electric energy used at portland cement plants in the United States,[1] by processes

Year and process	Electric energy used						Finished cement produced (thousand barrels)	Average electric energy used per barrel of cement produced (kilowatt-hours)
	Generated at portland cement plants		Purchased		Total			
	Active plants	Million kilowatt-hours	Active plants	Million kilowatt-hours	Million kilowatt-hours	Percent		
60:								
Wet	25	615	100	3,537	4,152	55.9	186,370	22.3
Dry	29	1,222	67	2,052	3,274	44.1	132,639	24.7
Total	54	1,837	167	5,589	7,426	100.0	319,009	23.3
Percent of total electric energy used		24.7		75.3	100.0			
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			

[1] Includes Puerto Rico.

TRANSPORTATION

Bulk shipments of cement continued to increase and reached a new high of 84 percent of total shipments. Most of the remainder was shipped in paper bags but a small quantity was shipped in cloth bags. Shipments by truck increased 10 percent compared with those in 1960. The largest gains were registered in the Northeast and Central States. Rail freight rates on cement shipped into the upper Midwest States were reduced an average of 15 percent on June 6, Shipments by boat were highest from plants in Puerto Rico, New York, Kentucky, and Louisiana. Other States reporting boat shipments included Pennsylvania, Alabama, Virginia, Missouri, Texas, California, Oregon, and Washington. 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.

CONSUMPTION

Shipments of cement into the various States are considered to be a reliable index of consumption. Total shipments into 32 States and the District of Columbia were higher than in 1960.

Shipments to ready-mixed concrete producers increased 6.3 million barrels over shipments in 1960; shipments to building-material dealers decreased 3.4 million barrels. As in 1960, replies to the canvas of shipments of cement by type of customers were essentially complete.

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
1960:						
Truck	119,689	46.5	27,515	50.3	147,204	47.1
Railroad	130,416	50.6	27,112	49.5	157,528	50.4
Boat	7,030	2.7	74	.1	7,104	2.3
Used at the plant	417	.2	39	.1	456	.2
Total	257,552	100.0	54,740	100.0	312,292	100.0
Percent of total	82.5		17.5		100.0	
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	

[1] Includes Puerto Rico.
[2] Cloth bags and other containers included with paper bags to avoid disclosing individual company confidential data.

STOCKS

Stocks of finished portland cement and clinker at portland cement plants on December 31 were 2 percent higher and 7 percent lower, respectively, than those on hand on December 31, 1960. Changes in stocks from 1951 to 1961 are shown in figure 1.

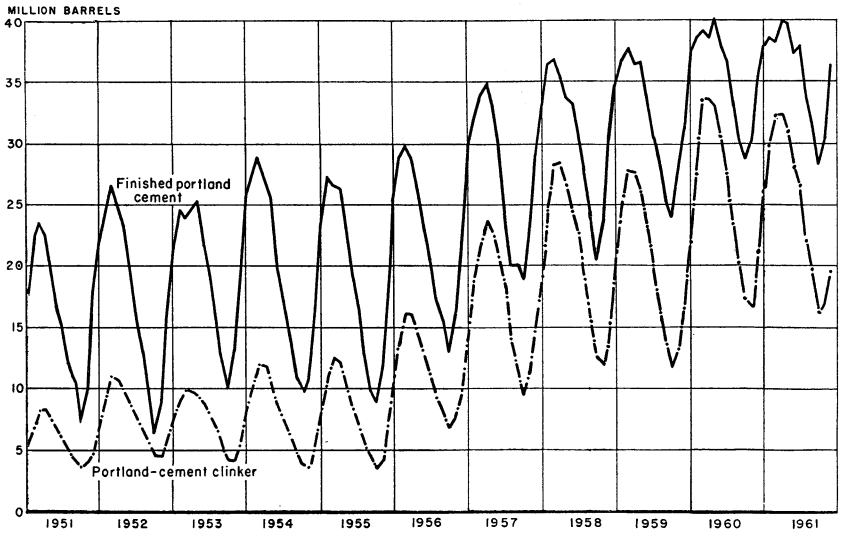


FIGURE 1.—End-of-month stocks of finished portland cement and portland-cement clinker, 1951–61.

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	
	1960	1961	1960	1961
Alabama	4,622	4,992	289	154
Alaska [1]	(2)	(2)	(2)	(2)
Arizona	4,835	5,409	38	24
Arkansas	2,590	2,968	30	30
Northern California	13,307	14,401	33	27
Southern California	22,023	23,409	185	166
Colorado	4,061	4,725	13	16
Connecticut [1]	3,170	3,617	344	355
Delaware [1]	856	665	88	66
District of Columbia [1]	1,275	1,632	83	81
Florida	[3] 12,132	[3] 11,743	1,022	907
Georgia	5,882	6,261	245	165
Hawaii	1,241	1,242	----------	----------
Idaho	1,351	1,125	2	----------
Illinois	18,543	17,791	589	595
Indiana	8,759	8,476	451	443
Iowa	6,940	6,746	229	247
Kansas	5,070	5,770	101	73
Kentucky	3,802	4,179	105	153
Louisiana	8,007	7,865	74	94
Maine	793	866	78	91
Maryland	5,478	5,538	244	296
Massachusetts [1]	4,261	4,605	457	481
Michigan	13,887	13,828	816	821
Minnesota	6,350	6,838	345	395
Mississippi	3,324	3,603	34	44
Missouri	7,684	8,066	220	250
Montana	1,078	1,085	14	48
Nebraska	4,250	4,168	166	192
Nevada [1]	839	981	4	10
New Hampshire [1]	722	771	71	80
New Jersey [1]	8,016	8,769	1,373	1,440
New Mexico	2,399	2,607	111	123
New York	20,351	17,646	1,466	1,316
North Carolina [1]	5,011	5,630	239	199
North Dakota [1]	1,377	1,271	2	17
Ohio	17,061	15,828	411	433
Oklahoma	4,669	5,573	25	15
Oregon	3,097	2,987	8	8
Pennsylvania	13,721	13,238	1,264	1,261
Rhode Island [1]	622	688	65	71
South Carolina	2,230	2,312	55	54
South Dakota	1,864	2,250	47	60
Tennessee	5,041	5,929	225	286
Texas	20,195	21,566	1,018	1,362
Utah	2,093	2,527	36	71
Vermont [1]	438	358	26	33
Virginia	6,220	6,459	451	504
Washington	5,643	5,462	405	508
West Virginia	2,306	2,473	25	33
Wisconsin	6,967	7,754	105	149
Wyoming	1,051	1,023	14	38
Unspecified	60	----------	1	----------
Total United States	307,564	315,715	13,742	14,285
Other countries	[4] 4,728	[4] 5,036	[5] 30	[5] 20
Total shipped from cement plants	312,292	320,751	13,772	14,305

[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, Alaska, and to Puerto Rico, including distribution from Puerto Rican mills.
[5] Direct shipments by producers to other countries and Alaska.

TABLE 16.—Cement shipments by types of customers in 1961

District	Number of plants in district	Plants reporting, percent	Building material dealers		Concrete product manufacturers		Ready-mixed concrete		Highway contractors		Other contractors		Federal, State and other Government agencies		Miscellaneous, including own use		Total
			Percent	Thousand barrels	Percent	Thousand barrels	Percent	Thousand barrels	Percent	Thousand barrels	Percent	Thousand barrels	Percent	Thousand barrels	Percent	Thousand barrels	Thousand barrels
Eastern Pennsylvania, Maryland	21	100	14.6	5,095	19.4	6,739	56.7	19,742	6.6	2,282	1.4	494	.1	25	1.2	406	34,783
New York, Maine	12	100	12.4	2,256	11.0	1,997	63.2	11,485	9.3	1,694	3.9	712	.1	24	.1	21	18,189
Ohio	11	100	9.6	1,465	14.7	2,253	59.7	9,139	14.0	2,142	1.6	241	.1	21	.3	42	15,303
Western Pennsylvania, West Virginia	6	100	13.0	1,361	16.6	1,729	56.5	5,895	12.4	1,290	.8	86	.1	13	.6	66	10,440
Michigan	9	100	9.3	2,046	15.5	3,407	54.3	11,903	14.9	3,265	5.1	1,124	.1	23	.8	180	21,948
Illinois	4	100	6.5	556	12.0	1,029	65.3	5,613	15.4	1,328	.8	68	------	----------	------	1	8,595
Indiana, Kentucky, Wisconsin	7	100	11.0	2,059	12.8	2,394	59.5	11,120	14.2	2,653	1.1	212	.2	32	1.2	222	18,692
Alabama	8	100	8.9	1,105	20.8	2,593	46.0	5,731	15.5	1,932	5.9	735	2.6	318	.3	31	12,445
Tennessee	6	100	9.9	827	17.4	1,454	51.4	4,296	11.8	983	5.0	415	4.2	354	.3	28	8,357
Virginia, South Carolina	4	100	9.1	735	18.7	1,512	57.2	4,604	6.8	548	6.6	532	.5	43	1.1	90	8,064
Georgia, Florida	6	100	12.2	1,325	18.7	2,028	53.4	5,792	8.8	952	2.0	214	1.9	204	3.0	326	10,841
Louisiana, Mississippi	5	100	6.9	451	12.8	836	44.2	2,892	24.8	1,620	1.3	87	.2	13	9.8	637	6,536
Iowa	5	100	15.2	1,854	16.1	1,947	48.7	5,897	15.1	1,832	4.5	538	.3	37	.1	3	12,108
Minnesota, South Dakota, Nebraska	4	100	14.9	1,291	8.2	712	52.2	4,515	15.4	1,333	6.6	566	2.4	208	.3	25	8,650
Missouri	5	100	9.3	1,104	11.3	1,338	59.9	7,085	13.8	1,634	4.8	573	.1	10	.8	95	11,839
Kansas	6	100	15.0	1,205	6.3	506	51.6	4,140	18.4	1,475	4.5	360	.5	44	3.7	298	8,028
Oklahoma, Arkansas	6	100	12.3	1,097	6.6	592	48.1	4,297	11.4	1,018	15.9	1,424	2.8	252	2.9	260	8,940
Texas	16	100	11.2	2,811	9.4	2,361	56.2	14,096	10.2	2,569	2.8	706	1.6	394	8.6	2,164	25,101
Colorado, Arizona, Utah, New Mexico	7	100	12.1	1,646	8.7	1,188	50.3	6,848	10.2	1,391	7.4	1,006	8.2	1,112	3.1	414	13,605
Wyoming, Montana, Idaho	3	100	11.2	314	14.9	418	54.5	1,528	7.2	201	7.8	219	------	----------	4.4	123	2,803
Northern California	5	100	8.1	1,369	9.4	1,593	64.6	10,949	3.3	564	13.8	2,331	------	1	.8	137	16,944
Southern California	8	100	12.9	3,106	9.7	2,338	66.8	16,135	2.7	646	7.1	1,724	.1	27	.7	170	24,146
Oregon, Washington	7	100	7.4	549	11.2	829	63.0	4,654	2.8	208	14.2	1,047	1.3	94	.1	5	7,386
Hawaii	2	100	14.6	158	11.9	128	67.1	722	------	----------	5.4	58	.6	7	.4	4	1,077
Puerto Rico	2	100	------	----------	2.2	128	29.8	1,767	------	----------	------	----------	1.8	110	66.2	3,926	5,931
Total	175	100	11.1	35,785	13.1	42,049	56.4	180,845	10.4	33,560	4.8	15,472	1.0	3,366	3.2	9,674	320,751

TABLE 17.—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
1957	Cement	28,716	October	19,213	April	34,893
	Clinker	14,853	do	9,444	do	23,620
1958	Cement	30,718	do	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	[2] 35,640	do	28,841	May	40,101
	Clinker	[2] 20,958	November	16,838	April	33,616
1961	Cement	36,361	October	28,437	do	39,999
	Clinker	19,531	do	16,215	do	32,432

[1] Includes Puerto Rico.
[2] Revised figure.

PREPARED MASONRY CEMENTS

Prepared masonry cements were produced at 138 portland cement plants, 2 natural cement plants, 2 slag-cement plants, and 1 hydraulic-lime cement plant. Production was 2 percent less than in 1960. The largest shipments were to Ohio and North Carolina.

Since masonry cements vary considerably in composition and bulk density, producers were requested to report them in equivalent 280-pound barrels, as shown in the following tables.

NATURAL, SLAG, AND HYDRAULIC-LIME CEMENTS

Natural cement was produced at two plants and slag cement at two others. Output was small, although the four plants made large quantities of prepared masonry cements. One hydraulic-lime cement plant produced only masonry cement. Annual capacity of about 1 million barrels was reported for the five plants. Producers reported using 30,000 tons of cement rock, 10,000 tons of lime, 10,000 tons of slag, 5,300 tons of coal, and 31 million cubic feet of natural gas in processing these cements.

TABLE 18.—Shipments of prepared masonry cement from mills in the United States, by States

(Thousand barrels) [1]

Destination	1960	1961
Alabama	481	509
Alaska [2]	(3)	(3)
Arizona	(3)	(3)
Arkansas	218	239
California	1	1
Colorado	251	279
Connecticut [2]	100	110
Delaware [2]	31	38
District of Columbia [2]	231	257
Florida	1,312	1,146
Georgia	854	888
Idaho	17	14
Illinois	777	774
Indiana	626	659
Iowa	206	201
Kansas	182	218
Kentucky	493	455
Louisiana	299	287
Maine	69	76
Maryland	448	480
Massachusetts [2]	262	258
Michigan	1,131	1,063
Minnesota	376	382
Mississippi	305	304
Missouri	207	196
Montana	31	23
Nebraska	87	93
New Hampshire [2]	60	66
New Jersey [2]	522	550
New Mexico	122	117
New York	1,103	1,068
North Carolina [2]	1,229	1,326
North Dakota [2]	75	61
Ohio	1,385	1,334
Oklahoma	231	249
Oregon	2	2
Pennsylvania	1,186	1,162
Rhode Island [2]	30	28
South Carolina	588	612
South Dakota	53	57
Tennessee	869	884
Texas	811	816
Utah	17	14
Vermont [2]	34	37
Virginia	991	1,057
Washington	47	45
West Virginia	215	206
Wisconsin	523	501
Wyoming	20	30
Unspecified	5	----------
Total United States	19,113	19,172
Other countries [4]	21	103
Total shipped from cement plants	19,134	19,275

[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 19.—Prepared masonry cement produced and shipped in the United States, by districts

District	Active plants		Production (thousand barrels) [1]		Shipments from mills					
					1960			1961		
	1960	1961	1960	1961	Thousand barrels [1]	Value (thousands)	Average per barrel	Thousand barrels [1]	Value (thousands)	Average per barrel
Eastern Pennsylvania, Maryland	19	19	2,330	2,186	2,265	$6,512	$2.88	2,319	$6,108	$2.63
New York, Maine	12	12	1,079	1,036	1,055	2,863	2.71	1,056	2,769	2.62
Ohio	9	8	951	871	978	3,008	3.08	846	2,604	3.08
Western Pennsylvania, West Virginia	6	6	1,233	1,211	1,157	3,362	2.91	1,206	3,366	2.79
Michigan	5	6	1,599	1,584	1,577	4,612	2.92	1,515	4,467	2.95
Illinois	4	4	546	423	496	1,411	2.85	461	1,420	3.08
Indiana, Kentucky, Wisconsin	6	6	2,643	2,720	2,581	7,208	2.83	2,674	7,463	2.79
Alabama	8	8	2,159	1,976	2,117	6,564	3.10	2,006	6,156	3.07
Tennessee	5	5	1,000	997	979	2,696	2.75	1,018	2,753	2.70
Virginia, South Carolina	4	4	1,115	1,288	1,109	3,127	2.82	1,288	3,512	2.73
Georgia, Florida	5	5	1,213	1,111	1,217	3,630	2.98	1,094	3,312	3.03
Louisiana, Mississippi	5	5	213	341	224	665	2.96	272	714	2.63
Iowa	4	4	600	522	554	1,874	3.38	557	1,843	3.31
Minnesota, South Dakota, Nebraska	4	4	259	279	296	946	3.20	300	959	3.20
Missouri	5	5	504	368	439	1,415	3.22	437	1,398	3.20
Kansas	7	7	391	412	382	1,179	3.08	379	1,156	3.05
Oklahoma, Arkansas	5	6	367	427	379	1,186	3.13	417	1,268	3.04
Texas	13	13	860	852	865	2,613	3.02	851	2,529	2.97
Colorado, Arizona, Utah, New Mexico	4	5	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]
Wyoming, Montana, Idaho	2	3	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]
Northern California	1	1	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]
Southern California	1		[2]		[2]	[2]	[2]			
Oregon, Washington	6	6	65	56	62	186	2.99	61	186	3.04
Hawaii		1		[2]				[2]	[2]	[2]
Undistributed			421	528	402	1,338	3.34	518	1,754	3.37
Total	140	143	19,548	19,188	19,134	56,485	2.95	19,275	55,737	2.89
Pennsylvania	21	21	2,739	2,557	2,613	7,641	2.92	2,678	7,232	2.70

[1] Barrels of 280 pounds.
[2] Included with "Undistributed" to avoid disclosing individual company confidential data.

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Since 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 18 and 19). Production figures of natural and slag cements from 1957 to 1961 are not strictly comparable with those for earlier years because of changes in method of reporting by several producers.

TABLE 20.—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)	
1955–56 (average)	6	1,035	1,014	$3,304	91
1957	5	631	662	2,027	79
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	41

PRICES

The average net value of shipments from all cement plants was $3.35 a barrel, compared with $3.37 in 1960.

Portland cement prices at the plant decreased from $3.33 a barrel in the last quarter of 1960 to $3.31 in the first quarter of 1961, then increased to $3.35 and $3.36 in the second and third quarters, respectively. Prices dropped to $3.27 in the fourth quarter. Average prices of types I and II portland cement (93 percent of all portland cement produced) increased from $3.26 a barrel in the first quarter to $3.31 and $3.33 in the second and third quarters, respectively, then fell to $3.23 in the fourth quarter.

The average price of high-early-strength cement increased from $3.72 in the first quarter to $3.75 and $3.78 in the second and third quarters, respectively, followed by a drop to $3.68 in the fourth quarter.

The price of prepared masonry cement decreased from $2.93 (barrels of 280 pounds) in the last quarter of 1960 to $2.91 and $2.90 in the first and second quarters, respectively, rose to $2.96 in the third quarter, and fell back to $2.89 in the fourth quarter.

The composite wholesale price index of portland cement, f.o.b. destinations, according to the Bureau of Labor Statistics index (1947–49 =100) was 154.8, compared with 155.2 in 1960.

FOREIGN TRADE [18]

Imports.—Imports of hydraulic cement decreased from 4.1 million barrels in 1960 to 3.6 million barrels in 1961. Imports into New England and New York totaled 2.4 million barrels, about the same as in 1960, but they represented 67 percent of all cement imports, compared with 59 percent in 1960. Canada, Norway, and Colombia supplied

[18] 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.

69 percent of the cement imported in 1961. Imports from Norway totaled 721,000 barrels. There were no imports from Norway in 1960.

TABLE 21.—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]
1952–56 (average)	$2.79	$3.07	$2.53	$2.84
1957	3.18	3.06	2.83	3.21
1958	3.25	3.32	2.81	3.27
1959	3.28	3.28	2.82	3.70
1960	3.35	3.56	2.95	3.37
1961	3.32	3.60	2.89	3.35

[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.

Most of the white cement imported (62 percent) came through the Florida customs district. Belgium-Luxembourg and France supplied 52 percent of the white cement imports; 23 percent was from Japan.

Exports.—Exports of hydraulic cement were 53 percent greater than the 1960 exports.

TABLE 22.—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
1952–56 (average)	1,882	[1] $5,551	191	$337	125	[1] $706	2,198	[1] $6,594
1957	3,856	[1] 11,887	122	221	449	[1] 2,711	4,427	[1] 14,819
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	[2] 3,826	[2] 8,736	(3)	(3)	282	1,570	[2] 4,108	10,306
1961	3,363	7,882	----------	----------	258	1,343	3,621	9,225

[1] Data from 1954–57 not comparable with earlier years.
[2] Revised figure.
[3] Revised to none.

Source: Bureau of the Census.

WORLD REVIEW

A Swedish publication of considerable international interest was issued during the year. It contained a worldwide listing of cement manufacturing plants and pertinent data, accompanied by maps showing plant locations and geographic distribution of capacities.[19]

[19] CEMBUREAU (The Cement Statistical and Technical Association). World Cement Directory (in English). Malmö, Sweden, 1961. 140 pp.

TABLE 23.—U.S.[1] imports for consumption of hydraulic cement in 1961,[2] by countries and customs districts

(Barrels)

Customs district	Belgium-Luxembourg	Canada	Colombia	Denmark	France	Germany, West	Japan	Norway	Poland-Danzig	Sweden	United Kingdom	Yugoslavia	Other [3]	Total
Alaska		57,325					1,325							58,650
Buffalo		107,180			11	1,075								108,266
Chicago						175								175
Connecticut					8,703			700,887					24,204	733,794
Dakota		36,782												36,782
El Paso													632	632
Florida	181,875		130,239		6,265	10,171	34,552		72,807	3,954	9,727			449,590
Galveston											62			62
Georgia											3,748			3,748
Hawaii							1,826							1,826
Laredo													19,041	19,041
Los Angeles				2,120			17,637				2,636			22,393
Maine and New Hampshire		14,892												14,892
Massachusetts		99							119,400			12,034		131,533
Michigan						8,498								8,498
Montana and Idaho		19,702												19,702
New Orleans	2,390				125						2,761			5,276
New York	1,300		26,747		150						2,530		423,095	453,822
Oregon		16,434												16,434
Philadelphia						6,781		20,455			1,916	37,055		66,207
Puerto Rico	1,380		388,272	498	18,973		7,330				54		39,036	455,543
Rhode Island									14,578	25,020				39,598
Rochester		754,900												754,900
St. Lawrence		22,312				1,094								23,406
San Diego				1,004			578							1,582
San Francisco				501		300	378				300			1,479
Vermont		192,397												192,397
Washington							457							457
Total: Barrels	186,945	1,222,023	545,258	4,123	34,227	28,094	64,083	721,342	206,785	28,974	23,734	49,089	506,008	3,620,685
Value	$808,804	$3,287,692	$1,146,361	$19,997	$148,531	$213,731	$320,119	$1,484,219	$407,113	$61,013	$141,967	$160,740	$1,024,675	$9,224,962

[1] Includes Puerto Rico.

[2] Changes in Minerals Yearbook 1960, p. 327, should read as follows; Sweden (Florida customs district) 50,945 barrels; United Kingdom $167,485. Total barrels 4,108,273, value $10,305,676. Revisions in the footnote should read, Tunisia (Philadelphia customs district) 37,740 barrels; Canary Islands, delete.

[3] Includes Dominican Republic (New York customs district) 423,095 barrels, (Puerto Rico) 39,036 barrels; Italy (Connecticut) 24,204 barrels; Mexico (Laredo) 19,041 barrels (El Paso) 632 barrels.

Source: Bureau of the Census.

TABLE 24.—U.S. exports of hydraulic cement, by countries

Destination	1959		1960		1961	
	Barrels	Value	Barrels	Value	Barrels	Value
North America:						
Bermuda	1,040	$8,939	1,363	$7,913	745	$4,128
Canada	99,093	542,196	55,440	364,976	54,802	376,575
Central America:						
British Honduras	200	814	382	1,717	590	2,377
Canal Zone	132	957	140	1,227	32,675	126,962
Costa Rica	17,912	58,398	4,557	16,432	24,083	74,624
El Salvador			26	560	323	1,520
Guatemala	1,057	7,404	1,026	5,775	48	522
Honduras	9,980	42,666	9	198	12	260
Nicaragua	3,804	18,995	7,776	33,915	4,813	21,515
Panama	1,300	5,660			124	1,382
Mexico	18,810	107,446	7,344	60,324	13,696	61,410
West Indies:						
British:						
Bahamas	16,910	73,129	14,403	65,265	34,236	108,490
Barbados			2,024	6,240		
Jamaica	727	4,615	537	1,803	202	870
Leeward and Windward Islands	11,250	37,572	12,241	43,162	16,773	52,965
Trinidad and Tobago	412	2,563	398	2,042	5,048	26,579
Cuba	3,394	23,079	1,157	7,239		
Dominican Republic			94	1,364	74	374
French West Indies	5,625	15,385	6,455	18,244	615	2,164
Netherlands Antilles	600	1,560	640	6,048	419	1,310
Total	192,246	951,378	116,012	644,444	189,278	864,027
South America:						
Argentina	9,285	51,398	10,928	57,747	8,310	40,501
Bolivia	4,477	32,695	2,891	21,093	4,650	29,251
Brazil	1,216	13,083	2,004	22,074	22	484
Chile	5,834	59,556	10,353	64,153	1,381	17,360
Colombia	4,628	31,292	219	3,840	1,203	8,855
Peru	379	8,824	815	8,967	2,505	15,115
Venezuela	10,201	50,064	287	4,694	66	1,144
Other South America	350	3,015			306	2,529
Total	36,370	249,927	27,497	182,568	18,443	115,239
Europe:						
Belgium-Luxembourg	533	4,957	264	2,582	1,321	2,135
France	3,900	21,369	21	3,100		
Germany, West	639	7,521	191	2,960	120	600
Netherlands	65	1,800	88	1,654		
Other Europe	589	11,110	258	8,498	2,511	16,952
Total	5,726	46,757	822	18,794	3,952	19,687
Asia:						
Arabia Peninsular States, n.e.c.	4,098	31,023	1,250	10,598		
India	697	3,588	55	1,238	562	4,355
Indonesia			750	3,735	19,159	86,278
Iraq	10,750	82,135	8,250	70,010	1,250	7,791
Japan	2,918	91,403	1,112	28,567	8,762	72,041
Korea, Republic of	740	4,618			36	970
Kuwait	2,010	10,261	1,500	6,533	804	3,660
Pakistan	1,892	11,230	1,366	9,501	206	1,140
Philippines	1,807	18,399	751	5,991	1,506	7,721
Saudi Arabia	125	2,300	54	936	1,067	3,316
Other Asia	352	2,970	2,473	15,236	1,163	7,932
Total	25,389	257,927	17,561	152,345	34,515	195,204
Africa:						
British West Africa	4,250	16,585	1,150	5,393		
Liberia	11,250	46,900	5,500	29,688	3,250	2,326
Libya	1,782	22,003	1,025	8,900	400	4,968
Other Africa	254	3,100	1,179	6,572	6,249	29,055
Total	17,536	88,588	8,854	50,553	9,899	36,349
Oceania			16,558	85,971	29,729	156,340
Grand total	277,267	1,594,577	187,304	1,134,675	285,816	1,386,846

Source: Bureau of the Census.

NORTH AMERICA

Canada.—Several plants were expanded, but no new ones were completed. Cement productive capacity of 19 plants with 45 kilns rose to nearly 50 million barrels. Almost one-half this capacity was in plants of Canada Cement Co., Ltd. The value of Canadian production increased to Can$100.7 million in 1961 from Can$93.7 million in 1960. Ready-mixed concrete provided a market for 27 percent of all cement consumed in Canada in 1960.

TABLE 25.—World production of hydraulic cement by countries [1]

(Thousand barrels)

Country	1952–56 (average)	1957	1958	1959	1960	1961
North America:						
Canada (sold or used by producers)	21,794	32,178	32,729	33,427	30,782	32,688
Cuba	2,674	3,805	4,192	3,670	[2] 2,345	[3] 1,759
Dominican Republic	1,067	1,642	1,583	1,114	997	[2] 997
Guatemala	410	575	692	680	657	733
Haiti	[3] 211	164	211	223	281	258
Honduras				64	199	246
Jamaica	604	844	1,044	1,155	1,243	1,266
Mexico	10,994	15,010	14,887	15,884	18,112	17,801
Nicaragua	164	252	235	205	188	229
Panama	463	463	393	569	639	668
Salvador	[4] 246	498	510	487	504	440
Trinidad	[5] 557	780	879	1,055	1,038	575
United States (including Puerto Rico)	288,914	313,756	326,352	355,734	334,130	338,628
Total	328,098	369,967	383,707	414,267	391,115	396,288
South America:						
Argentina	10,372	13,861	14,488	13,884	15,485	16,675
Bolivia	205	141	170	170	223	[2] 205
Brazil	14,301	19,900	22,222	22,521	26,232	27,610
Chile	4,609	4,263	4,257	4,902	4,855	5,101
Colombia	5,629	7,194	7,200	7,904	8,590	8,895
Ecuador	674	909	938	921	1,179	1,284
Paraguay	47	70	41	76	82	94
Peru	2,814	3,195	3,547	3,412	3,524	3,835
Uruguay	1,759	2,445	2,539	2,474	2,433	2,281
Venezuela	6,766	10,243	9,475	10,976	8,719	8,795
Total	47,176	62,221	64,877	67,240	71,322	74,775
Europe:						
Albania	182	410	457	434	428	434
Austria	9,616	12,483	12,630	14,172	16,593	18,082
Belgium	26,344	27,587	23,787	26,027	25,728	27,862
Bulgaria	4,485	5,160	5,476	8,402	9,293	10,273
Czechoslovakia	15,397	21,530	24,098	27,815	29,621	31,328
Denmark	7,200	6,825	6,262	8,150	8,408	9,217
Finland	5,576	5,541	5,424	6,860	7,347	7,863
France	58,357	73,930	78,650	82,080	83,101	91,057
Germany:						
East	15,649	20,287	20,862	24,655	29,504	30,929
West	95,273	112,335	115,407	135,817	146,025	159,576
Greece	5,353	7,183	7,857	8,467	9,598	10,765
Hungary	6,139	5,799	7,634	8,402	9,211	9,393
Iceland			193	457	428	440
Ireland	3,412	3,078	3,055	3,102	3,342	4,538
Italy	53,045	70,072	75,185	83,417	92,927	105,487
Luxembourg	862	1,114	1,149	1,126	1,231	1,354
Netherlands	5,863	7,740	8,009	9,381	10,542	11,158
Norway	4,603	5,963	6,045	6,631	6,860	7,200
Poland	20,187	26,361	29,657	31,175	38,651	43,177
Portugal	4,784	5,740	6,004	6,045	7,024	7,300
Rumania	10,589	13,808	15,080	16,716	17,907	19,396
Spain	22,386	29,117	31,193	33,591	32,600	35,485
Sweden	14,048	14,365	14,717	16,535	16,452	17,660
Switzerland	10,882	14,723	12,811	15,731	17,824	21,108

See footnotes at end of table.

TABLE 25.—World production of hydraulic cement by countries[1]—Continued

(Thousand barrels)

Country	1952–56 (average)	1957	1958	1959	1960	1961
Europe—Continued						
U.S.S.R.	112,816	169,426	195,283	227,402	266,897	299,028
United Kingdom	71,016	71,274	69,486	74,992	79,137	84,291
Yugoslavia	8,332	11,627	11,533	13,017	14,060	13,691
Total	592,396	743,478	787,944	890,599	980,739	1,078,092
Asia:						
Afghanistan				199	205	[2] 205
Burma	281	217	211	211	264	235
Ceylon	434	287	469	557	498	481
China	26,068	40,222	54,529	71,943	[2] 93,813	[2] 82,086
Cyprus	[6] 217	399	487	487	516	545
Hong Kong	551	610	891	833	879	1,079
India	25,177	33,368	36,270	40,662	45,939	61,002
Indonesia	856	1,472	1,753	2,017	2,269	2,609
Iran	633	1,835	2,404	3,395	4,585	[2] 4,691
Iraq	1,507	3,541	3,923	3,876	3,624	5,125
Israel	3,225	4,210	4,181	4,579	4,726	[2] 4,984
Japan	58,803	88,981	87,862	101,247	132,147	144,448
Jordan	[5] 446	627	668	645	967	1,290
Korea:						
North	1,460	5,248	7,177	11,293	13,398	13,263
Republic of	287	539	1,736	2,099	2,527	3,096
Lebanon	2,187	3,283	2,973	4,356	5,007	5,125
Malaya, Federation of	[4] 487	668	645	1,132	1,677	1,941
Pakistan	3,882	6,409	6,391	5,875	6,796	7,288
Philippines	2,052	2,996	3,764	4,263	4,661	5,975
Taiwan	3,149	3,541	5,951	6,256	6,936	8,824
Thailand	1,999	2,357	2,674	2,990	3,084	4,673
Turkey	4,087	7,394	8,895	10,167	11,949	11,891
United Arab Republic (Syria Region)	1,372	1,847	2,269	2,621	2,949	3,166
Viet-Nam, North	1,249	967	1,771	2,228	2,380	2,656
Total	140,409	211,018	237,894	283,931	351,796	376,678
Africa:						
Algeria	3,483	4,169	4,937	5,611	6,227	6,274
Angola	[4] 334	756	973	909	944	921
Cameroun, Republic of	[3] 53	64	64	[2] 64		
Canary Islands		12	35	293	405	[2] 410
Congo, Republic of the (formerly Belgian) (including Ruanda-Urundi)	1,994	2,721	2,427	2,035	[2] 1,173	[2] 1,026
Ethiopia	123	147	188	147	164	176
Kenya	534	1,208	1,272	1,841	2,070	1,935
Morocco	3,676	2,955	2,392	2,943	3,401	3,735
Mozambique	657	979	1,055	1,249	1,302	1,243
Nigeria			663	721	909	2,680
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia	457	3,987	4,667	3,489	[2] 3,518	715
Southern Rhodesia	1,935					1,853
Senegal	586	926	874	1,020	985	1,067
Sudan, Republic of the	[3] 387	352	522	586	709	487
Tunisia	1,712	2,351	2,023	2,592	2,375	2,105
Uganda	[4] 258	504	610	481	422	369
Union of South Africa	13,040	14,811	15,960	15,520	15,854	15,233
United Arab Republic (Egypt)	7,153	8,596	8,871	10,419	10,859	10,683
Total	36,382	44,538	47,533	49,920	51,317	50,912
Oceania:						
Australia	10,548	13,615	14,418	15,333	16,370	16,757
New Zealand	2,023	3,166	3,289	3,295	3,618	3,817
Total	12,571	16,781	17,707	18,628	19,988	20,574
World total (estimate) [1]	1,157,032	1,448,003	1,539,662	1,724,585	1,866,277	1,997,319

[1] This table incorporates some revisions.
[2] Estimate.
[3] Average annual production 1955–56.
[4] Average annual production 1953–56.
[5] Average annual production 1954–56.
[6] Average for 1 year only, as 1956 was first year of commercial production.

Compiled by Helen L. Hunt, Division of Foreign Activities.

Descriptions were published of the new 4-million-barrel Miron Co., Ltd., plant at St. Michael on the island of Montreal.[20] The company, formerly known as Miron & Freres, Ltd., was purchased in late 1960 by a Belgian firm, Cimenteries et Briqueteries Reunies (Brussels).

Expansions were completed; 500,000 barrels was added to the capacity of the Saskatchewan Cement Co., Ltd., plant at Regina, Saskatchewan, and 1.1 million barrels each was added to plants of Cement Quebec, Inc., at St. Basile, Quebec, and Inland Cement Co., Ltd., at Edmonton, Alberta. Lafarge Cement of North America, Ltd., with operations in British Columbia, extended its holdings in ready-mixed concrete and concrete products manufacturing concerns. Associated Portland Cement Manufacturers, Ltd., a British corporation, purchased one-tenth of the outstanding shares in Canada Cement Co., Ltd.

An article was published describing cement manufacture at the Bamberton, British Columbia, plant of British Columbia Cement Co., Ltd., near Victoria on Vancouver Island. Limestone, once obtained from Texada Island and shipped 90 miles by barge, was mined from a nearby quarry and hauled by truck to the plant.[21] The company announced plans to market premixed pozzolan cements that use shale processed on Saturna Island.

The self-unloading vessel, Cementkarrier, operated by Canada Cement Co., Ltd., on the St. Lawrence Seaway, was lengthened 48 feet to obtain greater capacity and, at the same time, shallower draft.[22]

Guatemala.—Cementos Novella, S.A., was the only cement producer.

Jamaica.—Caribbean Cement Co., Ltd., planned to spend $7 million for a third kiln and other equipment at its Kingston plant, raising capacity by 50 percent. Exports in 1961 totaled 72,575 barrels, all produced by the one company.

Mexico.—A 1-million-barrel plant to cost US$5.6 million was scheduled for construction by Cementos del Sur, S.A., Cosoleacaque, near Minatitlan, in southern Veracruz. On completion of the new 600,000-barrel Cementos Atoyac, S.A., plant at Puebla, Puebla State, the existing plant was to be razed. San Vincento Cementos Portland, S.A., was building a $16 million plant about 55 miles south of Ensenada, Baja California. Part of the production was expected to be marketed in the San Diego. Calif., area, with possible exports to the Far East. Mexico reported no exports and imported only from the United States in 1960. Consumption of cement increased in 1960 to 18.1 million barrels from 15.4 million barrels in 1959.

Panama.—Sales of cement in 1959 included 508,524 barrels in Panama and 56,840 barrels in the Canal Zone.

Puerto Rico.—A fourth wet-process kiln, with 1.7 million barrels rated capacity, was installed in the Puerto Rico Cement Corp. plant at San Juan as part of a $4.5 million expansion program.

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[20] Herod, Buren C. Miron Company Limited. Pit and Quarry, v. 54, No. 1, July 1960, pp. 137–139, 142–147.
Swenson, E. G. The Miron Cement Plant at Montreal. Canadian Min. and Met. Bull. (Montreal), v. 54, No. 591, July 1961, pp. 542–546.

[21] Utley, Harry F. British Columbia Cement's Automated Crushing-Blending System. Pit and Quarry, v. 54, No. 5, November 1961, pp. 112–116.

[22] Jarman, Hugh G. Canada Cement's Cementkarrier Has More Length, More Cargo, Greater Speed, Save Power. Pit and Quarry, v. 53, No. 11, May 1961, pp. 167, 168.

SOUTH AMERICA

Argentina.—Minera Alumine, S.A., Industrial Comercial y Financiera, Buenos Aires, an Argentine combine, contracted with a German firm to build a 300,000-barrel plant at Neuquen, Patagonia. The plant was designed for eventual tripling of this capacity.

Brazil.—Cimento Arutú, S.A., the only cement producer in the State of Bahia, added a third kiln, which increased capacity to 1 million barrels. Brazil's overall productive capacity of 35 million barrels was scheduled to increase to 38 and 41 million barrels by 1963 and 1964, respectively; 26 plants were operating, and 3 new ones were in advanced stages of construction.

Chile.—Cement manufacture in 1960 was divided between two plants: Sociedad Fabrica de Cemento de "El Melón," S.A., at La Calera, near Valparaiso, with a capacity of 4.5 million barrels produced 70 percent of the output, and Cemento Cerro Blanco de Polpaico, S.A., north of Santiago, with a capacity of 1.5 million barrels, produced 30 percent of the output. Total cost of the new 750,000-barrel Cementos Bio-Bio, S.A., plant under construction at Huachipato, 350 miles north of Santiago, was estimated at US$5.7 million. A supplemental loan of US$200,000 was made by International Finance Corp. to insure adequate foundations for earthquake protection. Lack of an export market for Chilean cement was blamed on high shipping costs.

Colombia.—White portland cement production amounted to 105,480 barrels in 1960, compared with 103,722 barrels in 1959. Cementos del Caribe, S.A., and Cementos Nare announced plans to build a 200,000- to 300,000-barrel cement plant at Cartegena to begin operating in 1963. Most of the cement would be for bulk export, but a small packing plant would supply the local market. At Cucuta, near the Venezuelan border, a new 600,000-barrel plant, a joint venture of Fabrica de Cemento Samper, of Bogatá, and Cia. de Cementos Hercules, S.A., of San Gil, was scheduled for initial operation at half capacity.

Equador.—A construction contract was signed with a French firm for a 400,000-barrel plant.

Paraguay.—Imports in 1960 supplied 21,401 barrels of the estimated 70,000 barrels consumed. To protect the Government's cement industry at Vallemi, a temporary ban was placed on portland cement imports.

Peru.—The specific duty on portland cement imports was removed, provided a certified statement was submitted that the price was not less than the domestic price in the country of origin. Ad valorem duty at 15.917 percent of c.i.f. value was continued.

EUROPE

Bulgaria.—Bulgaria's first Lepol process plant went into operation at Beli Iswor, near Wraza. Output of 2.3 million barrels was planned when fully operating. This output would equal about one-fourth of the country's total capacity.

Czechoslovakia.—Goals were set in per-capita figures for 1965 cement production of 3.6 barrels, representing a 69 percent increase over the

2.1 barrels in 1960. A third rotary kiln was added to the Banska Bystrica cement plant, part of the State's largest production complex.

France.—Cement consumption in 1960 was 77.2 million barrels, including 1 million barrels delivered customs free to the Saar. Imports were 59,000 barrels.

Iceland.—Operations of the Iceland Government Cement Works at Akranes were described. The 600,000-barrel plant was supplied with shell sand, 80 percent calcium carbonate, dredged from 140 feet deep in nearby Faxa Bay and upgraded by flotation. Production was confined to Types I and III cements, but manufacture of pozzolan cement utilizing a tuffaceous component of the shell sand was planned. Production was said to be exceeding consumption by 100,000 to 160,000 barrels.[23]

Ireland.—Cement, Ltd., the only cement producer in Ireland, reported exports totaling 1,179,705 barrels, of which 901,605 barrels was shipped to Great Britain and the remainder to Northern Ireland.

Italy.—Plans were announced in November 1961 by the large Italian industrial combine, CEMENTIR, to build a 3-million-barrel plant at Taranto, which would use waste slag from the parent company's new steel mill being constructed nearby. Another such plant was in operation at Bagnoli near Naples. Seventy companies operated a total of 111 cement plants throughout Italy, and production was about 85 percent of rated capacity.

Netherlands.—First Netherland Cement Industry, Inc., completed a new 1.8-million-barrel plant at Maastricht, with a cost of US$4.5 million. Because limestone supply was limited, slag from nearby Liege was used to manufacture a blast-furnace-slag cement. Plants of first Netherland and Cementfabriek IJmuiden, N.V., the only Netherlands producers, supplied about 60 percent of the country's cement requirements. The remainder was imported, mainly from West Germany and Belgium.[24]

Poland.—Exports of 1,075,984 barrels in the first 4 months of 1961 were 9 percent of production during the same period. The Chelin cement plant, with planned capacity of 5.3 million barrels, went into production in 1960. Poland's 5-year plan included construction of three new cement plants with a combined capacity of 15.8 million barrels. This new capacity would bring Poland's total capacity to 64.5 million barrels by 1965—67 percent above 1960 production. One of these plants, which was to be the third largest in Europe, was under construction at Rudniki, near Czestochowa, and was scheduled to go into production at 4.7 million barrels in 1965. This production was to be increased to 7.0 million barrels capacity in 1966. The plant, a dry-process operation, was to use blast-furnace slag from the Bierut metallurgical plant 9 miles away and limestone from nearby Lasosowiec.

Portugal.—Cement production in 1961 was valued at US$21,863,000.

Spain.—A US$3.3 million cement plant, with capacity of 2 million barrels of clinker from two kilns, was scheduled to begin producing in the Galicia region, Province of Lugo, in late 1961. The new

[23] Vestdal, Jon. Iceland Relies on Sea for New Cement Industry. Pit and Quarry v. 53, No. 8, February 1961, pp. 82–89, 91.
[24] Bureau of Mines. Mineral Trade Notes. V. 52, No. 5, March 1961, pp. 8, 9.

600,000-barrel Cementos de La Robla plant (planned for eventual expansion to 2.4 million barrels) was opened in November 1961 at La Robla, Province of Leon.[25] Construction was being considered by Hijos de Carlos Irazusta, S.A., of a 600,000-barrel plant at Andoain, Guipuzcoa Province, on the Oria River, near San Sebastian.

Sweden.—Capacity and number of kilns were unchanged in 1961. Exports nearly equaled the 1960 figure of slightly over 1 million barrels.

U.S.S.R.—A production goal of 1.38 billion barrels of cement was set for 1980.[26] Expansion plans included rebuilding 45 plants and constructing 26 new ones, with emphasis on placement of facilities in the Kazakh and Uzbek Republics and in Eastern and Western Siberia. The national quota for 1962 was set at 334 million barrels; pledges from the 85 operating plants exceeded this by 4.4 million barrels. Capacities added in 1958, 1959, 1960, and 1961 were 36.9, 30.5, 36.9, and 38.1 million barrels, respectively. The U.S.S.R. continued to be a net importer of cement in 1960, with imports of 10.0 million barrels and exports of 2.1 million barrels.

United Kingdom.—A new kiln at the Southam, Warwicks, plant of Rugby Portland Cement Co., Ltd., added 1.1 million barrels to the plant's capacity. Solvay Chemicals, Ltd., installed a third kiln at its Whitehaven plant, where anhydrite was used to produce sulfuric acid and cement as coproducts. Capacity of each kiln was to be increased 70 percent by early 1962 to 170,000 tons (1 million barrels of cement). Manufacture of cement at the Barrington plant of Eastwoods, Ltd., near Cambridge was described.[27]

ASIA

Cambodia.—Plans were readied for construction of the 300,000-barrel Chicom cement plant near Chakrei Ting, Kampot Province. Operation of the plant was expected to require 331 employees, including 17 technicians.

Ceylon.—Subject to Cabinet approval, the Government planned to import cement until its own plants could meet demands. Distribution and prices were under governmental control. Work was started on the railway to Puttalam, where a new cement plant was being built. Cement production in 1960 was valued at US$1,778,588.

India.—The Government issued licenses for expanding 17 existing cement plants and for constructing 8 new plants at the following locations: Vizianagram, Andhra Pradesh; Cherrapunji, Assam; Veraval, Gujarat; Kunmoh, Jammu and Kashmir; Drug, Madhya Pradesh: Thiruvattiyur, Madras; Rajur, Maharashtra; and Ammasandra, Mysore. Increased cement capacity expected by these additions in fiscal years 1961 to 1963 was 20 million barrels. Financing was provided for the Ammasandra plant (600,000-barrel capacity) of Mysore Cements, Ltd., from private U.S. industry sources and by a loan under the U.S. Agricultural Trade Development and Assistance Act (1954). In West Bengal local shortages were created, as cement was shunted to Government construction projects. Cement prices

[25] Bureau of Mines. Mineral Trade Notes. V. 54, No. 5, May 1962, p. 8.
[26] Bureau of Mines. Mineral Trades Notes. V. 54, No. 2, February 1962, p. 9.
[27] Cement, Lime and Gravel (London). Cement Manufacture by the Wet Process at the Barrington Works of Eastwoods, Ltd. V. 36, No. 12, December 1962, pp. 347–352.

(effective February 20, 1961) were established by the Indian government equivalent to US$3.75 per barrel in bulk and US$4.36 in jute bags, f.o.b. destination; State retail prices were set accordingly. Sales of cement by metric weights began October 1, 1960. The new bag contained 50 kilograms net (110 pounds).

Israel.—Nesher Cement Co. agreed with the Minister of Commerce and Industry to add 1.7-million-barrels annual capacity to each of its plants, one in Ramleh and the other in Haifa.

Japan.—Mitsubishi Cement Co. installed a 2-million-barrel kiln—the country's largest—at its Kurosaki plant. Industry cement capacity was over 165 million barrels at the beginning of 1961, with 20 companies operating 46 plants.[28] Three companies—Nihon Cement Co., Onodo Cement Co., and Iwaki Cement Co.—accounted for 48 percent of all shipments. Only 30 percent of the cement sold was transported in bulk. Exports in 1960 totaled 9,570,000 barrels, 12 percent higher than in 1959; they went mainly to Indochina (2,174,000), the Ryukyus (1,289,000), Republic of Korea (1,055,000), Hong Kong (920,000), and Singapore (820,000). Shipments to Korea in 1961 totaled 624,400 barrels valued at US$2,885,000. White cement production in 1961 was 786,000 barrels.

Korea, Republic of.—Two existing cement plants were undergoing expansion. Plans for 1962 to 1964, submitted to the Supreme Council for National Reconstruction by the Korean Businessman's Association, included construction of new cement plants by Daehan Cement Industrial Co. at Yongwal (2 million barrels) and by Central Mill Supply Co. at Shihung (1.7 million barrels); 1.2 million barrels of capacity was to be added to the Oriental cement plant. Gypsum and bituminous coal for the Yongwal plant were expected to be supplied from the United States or Japan.[29]

Kuwait.—Cement imports declined to 1,616,000 barrels in 1961, comparedwith 2,631,000 in 1960 and 3,850,000 in 1959. The main supplier was Japan (54 percent), followed by U.S.S.R. (17 percent), Poland (14 percent), and Egypt (11 percent).

Lebanon.—Societe Libanaise du Ciment Blanc began constructing a 400,000-barrel white cement plant at Chekka that would be equipped with machinery from France.

Malaya, Federation of.—Increased construction was expected to spur demand for cement. Malaya Cement, Ltd., operated at capacity; its two kilns were converted to fuel oil in 1960 after the local colliery closed. Another plant, with 150,000-barrel capacity, operated near Batu Caves, north of Kuala Lumpur. Imports in 1960 were 332,000 barrels, and exports were 65,000 barrels.

Pakistan.—Demand for cement continued to exceed supply in East Pakistan, and it was estimated in 1961 at nearly 1.5 million barrels. The 900,000-barrel plant of Assam-Bengal Cement Co., Ltd., at Chhatak produced at only 64 percent of capacity mainly because of problems in obtaining limestone, which had to be hauled 10 miles by ropeway from the quarry in Assam, India. Other deposits, even more difficult to mine, were resorted to at Lal Ghat and Takerghat

[28] Bureau of Mines. Mineral Trade Notes. V. 54, No. 1, January 1962, pp. 27, 28.
[29] Bureau of Mines. Mineral Trade Notes. V. 54, No. 2, February 1962, pp. 8, 9.

near Sunamganj. Expected demand in East Pakistan by 1965 was 2.3 million barrels and by 1970, 3.2 million barrels. West Pakistan, with six plants having total capacity of 7.5 million barrels, produced an excess of 17 percent over the estimated demand. Requirements were expected to rise to about 15 million barrels by 1970. Construction began on the 2.5-million-barrel plant of Ismail Cement Industries, Ltd., at Gharibwal, financed by the International Monetary Fund. German funds were to go into new 1-million-barrel plants at Manghopir, near Karachi, and at Hattar, near Rawalpindi. A 400,000-barrel plant was planned for Chittagong.

Philippines.—Excess cement capacity was discussed and increased use of cement over other materials for road construction was suggested as an economic solution.[30] More concrete highways were urged by the Philippine President, Carlos Garcia, in a major address and by the Cement Institute of the Philippines. Initial operation of the 1-million-barrel Iligan City plant of Mindanao Portland Cement Co., built by a Florida-based U.S. company on the Island of Mindanao, was scheduled for December 1961. Equipment for the 800,000-barrel Mindoro plant of San Jose Cement Corp. was obtained from Japan as part of the war reparations agreement.

Saudi Arabia.—The 900,000-barrel capacity Jidda plant of Arabian Cement Co., Ltd., produced only 615,000 barrels in 1961, as deterioration of magnesia brick kiln linings (thought due to flexing of the steel shell) interrupted production. Excavation was found to be cheaper using rippers on coral limestone rather than blasting. The country's second plant, with a capacity of 600,000 barrels, was completed in October at Hofuf. A German-equipped plant was planned by Saudi Yamamah Cement Co. at Riyadh.

Singapore.—A 1-million-barrel plant was under construction in Singapore Harbor by a combine of Onodo Cement Co., Mitsui and Co., Ltd. (Japan), and Hong Leong Co., Ltd. (Singapore).

Taiwan.—Capacity of the Taiwan cement industry was expected to reach 9.4 million barrels by 1962, and demand was expected to reach 13.5 million barrels by 1968, as large new hydroelectric projects such as the Shimen and Tachia Dams, irrigation, and other construction encouraged further expansion. Exports were 676,000 barrels in 1959, but it was necessary to import nearly 120,000 barrels of cement from Japan in 1960, owing to temporary short supply. Wholesale prices of cement at Taipei averaged $2.85 per barrel in 1960. Of 32,000 tons of gypsum used by the industry in 1959, 17,000 tons was imported.[31] Plants and current production capacities were listed, with a breakdown by types as follows, in thousand barrels: Portland cement, 5,696; masonry, 1,231; fly-ash (pozzolan), 1,113; and white, 1,172.[32]

United Arab Republic (Syria Region).—The $2.2-million Homs cement plant, constructed with East German assistance, began operating in 1960. A contract was signed in March 1961 with a Copenhagen firm to construct a similar-size 500,000-barrel plant at Hama. The coun-

[30] Mining Newsletter (Philippines). Warn on Cement Overproduction. V. 12, No. 1, September–October, 1960, p. 46.
[31] Bureau of Mines. Mineral Trade Notes. V. 53, No. 3, September 1961, pp. 6, 7.
[32] Keshen, Albert S. Taiwan Cement Producers Forge Ahead. Rock Products, v. 64, No. 5, May 1961, pp. 172, 174, 176.

try's Five Year Economic and Social Development Plan aimed at 4.1 million barrels yearly production by 1965. Production in 1960 was valued at US$11,242,000.

Viet-Nam.—Construction was started on a plant to supply 1.4 million barrels of cement clinker to a grinding plant, which would be situated near Ha Tien, southwest Viet-Nam. Imports in 1960 totaled 1,789,000 barrels; 92.4 percent came from Japan, and the remainder came from Taiwan, France, India, and Belgium-Luxembourg.

AFRICA

Ethiopia.—All cement production came from the Government's Imperial Ethiopian Cement Co. plant at Dire Dawa. Ingra, a Yugoslavian State enterprise, was to provide funds for a new cement plant near Addis Ababa, and it signed an agreement with the Ethiopian government to make preliminary studies for a plant at Massawa.

Ghana.—The Government announced a joint project with Associated Portland Cement Manufacturers, Ltd., United Kingdom, to build a 600,000-barrel, clinker-producing plant at the Banyere limestone deposit west of Takoradi and a grinding plant of twice that capacity at Takoradi. Clinker was to be transported to the grinding plant via the Tano River; excess capacity of the grinding plant was to be used to grind imported clinker.

Guinea.—Imports in 1960, mainly from Soviet bloc countries, totaled 373,000 barrels of cement valued at US$1,117,400.[33]

Kenya.—The Bumburi plant of British Standard Portland Cement Co., Ltd., several miles north of Mombasa, supplied nearly all of Tanganyika's cement requirements and exported to Mauritius, Reunion, Malagasy Republic, Mogadishu, Berbera, Aden Protectorate, and Persian Gulf ports. The company's newly converted bulk cement ship, Southern Baobob, was scheduled to deliver 650,000 barrels annually, 60 percent to Dar es Salaam and the rest to Mauritius.[34]

Malagasy Republic.—Raw material supply and other factors, except electric power, were found favorable for establishment of a 600,000-barrel cement plant in the Antisirabe area.

Mozambique.—Application was filed with the Provincial Government by a local group to establish a new plant at Lourenco Marques. Two operating plants, one at Lourenco Marques and the other at Beira, were owned by Companhia de Cimentos de Mocambique. Of the 1959 production, 40 percent was from the Beira plant.

Nigeria.—Sales of cement were 4,207,000 barrels in 1960. Of this quantity, 3,159,000 barrels was imported; the remainder was produced at the Nkalagu plant in Eastern Nigeria. A review before starting feasibility studies to be carried out in the Northern Region indicated sufficient market potential for establishing a 1 million-barrel cement plant. Lokoja, at the confluence of the Niger and Benue Rivers, where limestone deposits were proven, was suggested as a plant site.[35]

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[33] Bureau of Mines. Mineral Trade Notes. V. 54, No. 2, February 1962, p. 8.
[34] Pit and Quarry. Cement from Mombasa Shipped by Self-Loader-Unloader. V. 54, No. 3, September 1961, pp. 106–107.
[35] Foreign Commerce Weekly. Cement Production Studied in Nigeria. V. 64, No. 13, Mar. 27, 1961, p. 32.

Sudan.—Imported clinker amounting to 132,000 barrels supplemented production of the Atbara Cement Factory.

United Arab Republic (Egypt).—The cement industry's capacity was 14 million barrels in 1961. Exports in 1961 were 3,223,000 barrels (preliminary figure), down from 3,809,000 barrels in 1960, mainly because of less construction in Kuwait.

OCEANIA

Australia.—A report was issued describing operations of the Adelaide Cement Co., Ltd., plant at Birkenhead, South Australia. Limestone for the 1.2-million-barrel plant was supplied by ship from Klein's Point quarry, 40 miles distant, and unloaded by a unique twin-screw-fed bucket elevator, lowered into the hold.[36] Coral was dredged from deposits in the Mud Island area, Moreton Bay, near Brisbane, to supply requirements of the Queensland Cement and Lime Co., plant at Darra, Queensland. Expansion was scheduled to increase the company's capacity from 1.8 to 3.0 million barrels in 1961.[37] In Tasmania, Goliath Portland Cement Co., Ltd., planned a 25-percent expansion from 900,000 barrels. The plant's limestone came from Northwestern Tasmania deposits.

TECHNOLOGY

Automation of cement plants drew increasing attention during the year. A number of technical reports discussed instrumentation and other features of automatic control. Subjects of papers given at the third annual Cement Industry Conference of the American Institute of Electrical Engineers, held in April 1961 at Detroit, included basic concepts of automation, recommended practices, X-ray chemical control, use of a computer by one company, and centralized control.[38]

Centralized control of production was said to produce a better and more uniform quality cement. Future possibilities were seen for control from a single location of a number of plants operating throughout the United States.

Raw mix requirements were determined by computer at the Oro Grande, Calif., plant of Riverside Cement Co., and information was logged in preparation for trial use of the computer to control kiln operations. The Mohave, Calif., plant of California Portland Cement Co., utilized analog-loop control systems to regulate kiln draft and fuel flow for optimum ratios of air-to-fuel.[39]

Data processing equipment installed at the Dundee, Mich., plant of Dundee Cement Co. supplied a variety of information on production, sales, maintenance costs, inventories, accounting and payroll. Use of punchcards for inventories and a system of self-servicing by

[36] Schroeder, E. W. Cement Manufacture in Adelaide. Min. and Chem. Eng. Review (Melbourne), v. 53, No. 3, Dec. 15, 1960, pp. 50–54.

[37] South African Mining and Engineering Journal (Johannesburg). Cement from Coral. V. 72, Part 2, No. 3577, Aug. 25, 1961, p. 465.

[38] Trauffer, Walter E. Automation Featured at A.I.E.E. Cement Industry Technical Conference. Pit and Quarry, v. 53, No. 12, June 1961, pp. 98–101, 104.
Rock Products. Electrical Engineers Probe Cement Industry Problems. V. 64, No. 6, June 1961, pp. 132,134.

[39] Patterson, R. G. Instrumentation and Automation of Plant Operation. Min. Cong. J., v. 47, No. 5, May 1961, pp. 42–45.

suppliers resulted in reduced spare-parts stocks with subsequent savings.[40]

An article discussed nuclear gages and their application in cement plants for controlling slurry density, clinker cooler levels, and kiln feed.[41] Use of X-rays for chemical control and process investigations was discussed.[42]

Investigative work on hydration of cements embraced the following subjects: A study of reaction products;[43] measurement of free water by nuclear resonance;[44] differential thermal analysis;[45] examination of colloidal products by electron miscroscope;[46] and measurement of heat of hydration.[47] Effects of mixing and other factors on development of bubbles in air-entrained cement pastes were investigated.[48]

A report summarized results of past investigations on variations in strength-producing qualities of portland cement. Cements from different sources were found to produce greatly differing strengths.[49] In discussion of this report it was theorized that better blending while manufacturing and storing cement would do much to improve uniformity.[50]

The National Bureau of Standards published a report pointing to a number of possible sources of error in chemical analyses and physical tests of portland cement.[51] A paper reviewing the status of available information on quick and false set of portland cement was published.[52] Specifications for cement in 42 countries were compiled in a Swedish publication.[53]

Phase transformations of dicalcium silicate were studied. Small additions of various oxides were made, and samples were heated above and below the inversion temperature. After cooling, a modified form of silicate was present with some oxides but not with others.[54]

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[40] Dersnah, W. R. How Do Big Plants Work Out? Pit and Quarry, v. 54, No. 1, July 1961, pp. 162–180.

[41] Othmar, Philip E. How to Employ Nuclear Gauges. Nonmet. Min. Proc., v. 2, No. 3, March 1961, pp. 28–29.

[42] Kester, Bruce E. Here's How to Use the X-ray Spectrograph. Rock Products, v. 64, No. 3, March 1961, pp. 90–94, 138, 140.
Loranger, W. F. On-Line X-ray Analysis. Nonmet. Min. Proc., v. 2, No. 7, July 1961, pp. 15–16.

[43] Powers, T. C. Some Physical Aspects of the Hydration of Portland Cement. J. PCA Res. and Dev. Lab., v. 3, No. 1, 1961, pp. 47–56.

[44] Watanabe, K., and T. Sasaki. [Investigation of the Hydration of Cement by Measuring the Nuclear Magnetic Resonance]. Zement-Kalk-Gyps. v. 50, No. 3, 1961, pp. 101–105; Building Science Abs. (London), v. 34, No. 9, September 1961, p. 261.

[45] Proks, J., and V. Siske. [A Study of the Course of Hydration of Cement by Means of DTA.] Silikaty, v. 5, No. 3, 1961, pp. 229–233; Building Science Abs., v. 34, No. 12, December 1961, p. 367.

[46] Czernin, W. [Electron Microscopy of Hardening Cement.] Schweiz. Arch. Angew. Wiss., v. 26, No. 5, 1960, pp. 185–191; Building Science Abs., v. 34, No. 4, April 1961, p. 103.

[47] Ginsburg, Ts. G., V. V. Kind, and R. E. Litvinova. [Some Questions in Connection with the Evolution of Heat During the Hardening of Cement.] Tsement, v. 26, No. 4, 1961, pp. 11–15; Building Science Abs., v. 34, No. 10, October 1961, p. 293.

[48] Bruere, G. M. Relative Importance of Various Physical and Chemical Factors on Bubble Characteristics in Cement Pastes. Australian J. Appl. Sci., v. 12, No. 1, 1961.

[49] Gaynor, Richard D. Studies of Variations in Portland Cement. Paper pres. 31st Ann. Conv. of the Nat. Ready Mixed Concrete Assoc., Miami Beach, Fla., January 1961, 7 pp.

[50] Rockwood, Nathan C. More About Nonuniformity in Cements. Rock Products, v. 64, No. 7, July 1961, pp. 22, 119–121.

[51] Bean, B. Leonard, and John R. Dise. Causes of Variation in Chemical Analyses and Physical Tests of Portland Cement. Monograph 28, 1961, 24 pp.

[52] Hansen, W. C. Quick and False Set in Portland Cements. Mat. Res. & Standards, v. 1, No. 10, October 1961, pp. 791–798.

[53] CEMBUREAU (Cement Statistical and Technical Association). Revue of Portland Cement Standards of the World. Malmö, Sweden, 1961, 96 pp.

[54] Smith, Deane D., A. J. Majumdar, and Fred Ordway. Reexamination of the Polymorphism of Dicalcium Silicate. J. of Am. Ceram. Soc., v. 44, No. 8, August 1961, pp. 405–411.

A number of previously published Japanese papers on cement and concrete were reviewed, and the results were summarized.[55]

Depth of water penetration into clinker grains of different cements was investigated. Penetration was found to be greater for type I than type V cement and for cements having higher tricalcium aluminate content, larger proportion of fine particles, or smaller percentages of potassium sulfate.[56]

American and European cement-making processes were compared. It was estimated that the American industry required 45 percent more fuel, 57 percent less labor, and 48 percent more power than the European industry.[57]

Complex geologic conditions at the Hudson Cement Co. quarry in New York were evaluated, and results were applied to control of raw material grade.[58] Mineralogy of a sequence of limestones important to the cement industry in the Lehigh Valley, Pa., was studied.[59]

Kiln Feed.—Control of pelletizing rates to provide an even supply of feed to the kiln is a difficult problem. In a newly patented design, the flows of water and raw mix into the pelletizer were regulated according to the kiln speed.[60]

Slurries.—Characteristics of raw cement slurries were discussed, and calculations were shown for determination of optimum pipeline diameters and pump horsepower required for various pulp densities.[61]

A Japanese wet-process cement plant utilized waste sulfite liquor from a pulpmill to lower the viscosity and water content of the slurry. Use of the waste from the pulpmill helped solve a difficult disposal problem. Tests showed that the water content of the slurry could be lowered 2 percent by adding 1.5 percent of waste liquor. In practice, moisture was reduced about 3.7 percent. Advantages were less heat and power consumed, increased raw mill output, less dust, and formation of harder nodules during calcination.[62]

With the use of complex phosphate dispersants to thin cement plant slurries, the problem arose of checking the amount present in the mixture. A rapid colorimetric method was devised whereby the percentage of phosphorus pentoxide was determined and converted to the equivalent percentage of compound added.[63]

Increased fuel economy was claimed for a process in which water was removed from slurry feed until the feed reached a puttylike con-

[55] Rockwood, Nathan C. Japanese Research in Cement and Concrete is Practical. Rock Products, v. 64, No. 2, February 1961, pp. 122–130.
———. Japanese Cement and Concrete Research. Rock Products, v. 64, No. 3, March 1961, pp. 16, 136, 138.
[56] Steinherz, A. R. (Penetration of Water Inside Clinker Grains.) Rev. Mat. Constr., C., No. 536, 1960, pp. 119–125; Building Sci. Abs., v. 34, No. 6, June 1961, p. 164.
[57] Voldbaek, Erik. Cement Manufacturing Processes—European Versus American. Paper pres. 1961 Metal Min. and Ind. Miner. Conv. Am. Min. Cong., Seattle, Wash., Sept. 10–13, 1961.
[58] Dunn, James R. Geologic Studies Play Major Role at Hudson Cement Co.'s Quarry. Min. Eng., v. 13, No. 11, November 1961, pp. 1243–1245.
[59] Ray, S., and H. R. Fault. Mineralogy of Jacksonburgh (Middle Ordovician) Formation in Eastern Pennsylvania and Western New Jersey. Bull. Am. Assoc. Petrol. Geologists, v. 45, No. 1 January 1961, pp. 39–50.
[60] Ludwig, N. C. (assigned to U.S. Steel Corp.). Apparatus for Making Pellets. U.S. Pat. 2,969,227, Jan. 24, 1961.
[61] Fritts, Stewart S. Practical Considerations in Pumping Slurry. Pit and Quarry, v. 54, No. 1, July 1961, pp. 155, 166.
[62] Ushiro, Eitaro, and Tsuyoshi Yano. Cement Mill Profits from Paper Mill Waste. Rock Products, v. 64, No. 9, September 1961, pp. 136–142.
[63] Chess, W. B., D. N. Bernhart, and R. Gates. Do You Add Phosphates to Your Slurries? Rock Products, v. 64, No. 10, October 1961, pp. 120, 122.

sistency; the feed then was extruded in strands onto a traveling grate and sintered.[64]

A novel use of filter presses in a British plant was described.[65] Slurry was successfully dewatered in an intermittent filtering procedure that removed 18 to 19 percent of the moisture. This percentage was said to compare reasonably well with amounts normally removed by vacuum filters.

Grinding.—Actual power consumption was compared to that theoretically required for raw mix and clinker grinding circuits in nine plants. Theoretical requirements were calculated from basic mill data and grindability tests. Results compared favorably for small- and medium-size ball-mills. However, less than the calculated power was needed to drive the new large-diameter mills and for race and roller mills, thus indicating exceptional grinding efficiency for these types.[66]

Investigation of high steel losses in wet grinding raw cement mills indicated that corrosion was an important factor. Losses were reduced by adding precipitated kiln dust to the circuit to raise the pH of the slurry.[67]

A design providing for closer control of feed imput to raw mix and clinker grinding mills was patented.[68]

Preheaters.—A new British cement plant, at Plymstock, Davon, adopted the Humboldt suspension type preheater process developed in Germany. In this process the ground raw material feeds downward into the kiln through a series of cyclones against the flow of hot off-gases. Plant operations were described.[69]

Various types of preheaters and their characteristics were discussed along with methods of heat exchange and improvements in fuel utilization.[70] Comparison of the different systems was said to be difficult because of the variations in raw materials, fuels, and general arrangements of equipment.

A design was patented for an improved preheater with a compartmented chamber containing an assembly of fixed and movable grates.[71]

Calcination.—Several patents were issued dealing with the manufacture of cement by the fluidized-bed process. These covered the method of processing,[72] a design for avoiding formation of large clinker balls,[73] and control of particle size.[74]

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[64] Gieskieng, D. H. (assigned to Allis-Chalmers Manufacturing Co.). Wet Process for Making Cement and Apparatus for Use Therewith. U.S. Pat. 2,993,687, July 25, 1961.
[65] Pit and Quarry. Design of British Filtration Unit Proves Its Worth in Operation. V. 54, No. 2, August 1961, pp. 40, 42.
[66] Smith, Ross W. Determination of Power Consumption of Grinding Mills in Cement Plants. Min. Eng., v. 13, No. 4, April 1961, pp. 390–392.
[67] Anderlini, Vincenza, and H. E. Vivian. Suppression of Steel Corrosion in Wet Grinding Mills. Australian J. Appl. Sci., v. 12, No. 1, 1961, pp. 87–95; Building Sci. Abs., v. 34, No. 9, September 1961, p. 260.
[68] Herz, J. H. (assigned to California Portland Cement Co.). Cement Raw Mix and Clinker Grinding Mill Control System. U.S. Pat. 3,011,726, Dec. 5, 1961.
[69] Cement, Lime and Gravel (London). The First All-Dry Cement Plant in Great Britain. V. 36, No. 11, November 1961, pp. 313–317.
[70] Tonry, J. Richard. Heat Transfer Systems for Dry-Process Kilns in Cement Manufacturing. Pit and Quarry, pt. I, v. 54, No. 1, July 1961, pp. 151–154; pt. II, v. 54, No. 2, August 1961, pp. 113–116, 120–122.
[71] Kayatz, K. H. (assigned to Fuller Co.). Gas-Solids Heat Exchanger. U.S. Pat. 3,010,215, Nov. 28, 1961.
[72] Pyzel, R. (assigned to Union Commerce Bank, Ohio). Hydraulic Cement Process. U.S. Pat. 3,013,786, Dec. 19, 1961.
[73] Pyzel, R. (assigned to Pyzel-Fitzpatrick, Inc., New York). Apparatus for Cement Manufacture. U.S. Pat. 2,977,105, Mar. 28, 1961.
[74] Pyzel, R. Particle Size Control. U.S. Pat. 2,981,531, Apr. 25, 1961.

Constant-speed kiln rotation was considered the first essential to acquiring stability in the manufacture of portland cement.[75] A theory was advanced that yet-undetected silicide compounds of silica and alkali metals might form under certain conditions as calcination progresses in cement kilns.[76]

For maximum thermal efficiency in wet rotary-kiln operation, importance was placed on the proper division of preheating and deoxidizing zones.[77]

Selection of guns and shells for greatest economy in shooting down clinker rings in rotary kilns was discussed.[78] An improved ring-shaped sealing connection allowing a wide gap for expansion between a rotary cement kiln and the stationary flue structure was patented.[79]

Coolers.—Patents were issued on a clinker-cooling conveyor mechanism that imparts a lifting and tossing motion,[80] a tower-type cooler with heat-conductive walls sprayed by water jets,[81] and a method by which clinker was cooled by adding cool solid balls before grinding.[82]

Vertical Kilns.—Improvements, especially in fuel consumption and cement quality, in German cement manufacture and in high-duty shaft kilns were discussed. One thousand barrels per day was said to be adequate production for the vertical kiln.[83] Formation of calcium carbide was reported at higher-than-normal operating temperatures in a vertical kiln, but this formation was said to be impossible in the rotary type.[84]

Clinker Grinding.—Patents were issued for a sifting apparatus to separate both coarse and fine particles before finish-grinding,[85] a method for grinding that was said to increase ballmill capacity,[86] and modification of ballmill ring elements to direct larger balls toward the mill entrance and small ones toward the outlet.[87]

Dust Control.—Comparison of electrostatic and glass baghouse dust collectors was made, and considerable operational savings were shown for the electrical method.[88] Potential for ultrasonic dust precipita-

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[75] Derrom, Donald L. Safaris in Cement; III, How "Equilibrium" Solves Kiln Problems. Rock Products, v. 64, No. 1, January 1961, p. 114.

[76] Rockwood, Nathan C. Something About the Chemistry of Cement. Rock Products, v. 64, No. 9, September 1961, pp. 24, 142, 145.

[77] Eigen, H. [Explanation of the Thermal Operation of the Wet Rotary Cement Kiln]. Radex Rdschau, No. 2, 1961, pp. 529–535; Building Sci. Abs., v. 34, No. 9, September 1961, p. 261.

[78] Davis, William G. Shooting Down Rotary Kiln Buildups. Nonmet. Min. Proc., v. 2, No. 8, August 1961, pp. 21–22.

[79] Deussner, H. (assigned to Klockner-Humboldt-Deutz, A.G.). Rotary Kiln, Particularly for the Burning of Cement Raw Material. U.S. Pat. 3,012,765, Dec. 12, 1961.

[80] Trunbo, L. C. Material Handling and Cooling Conveyor. U.S. Pat. 2,981,269, Apr. 25, 1961.

[81] Nielsen, P. B. (assigned to F. L. Smidth & Co.). Apparatus for Cooling Finely Divided Material. U.S. Pat. 3,002.289, Oct. 3, 1961.

[82] Mitchell, D. W. (assigned to The Oil Shale Corp., California). Cooling of Cement Clinker. U.S. Pat. 3,003,757 Oct. 10, 1961.

[83] Bellwinkel, A. [Development Trends in the Construction of Cement-Making Plants]. Zement-Kalk-Gyps, v. 14, No. 2, 1961, pp. 41–56; Building Sci. Abs., v. 34, No. 10, October 1961, p. 291.

[84] Mall, G. [Calcium Carbide in Cement]. Zement-Kalk-Gyps, v. 50, No. 6, 1961, pp. 254–257; Building Sci. Abs., v. 34, No. 12, December 1961, pp. 355–356.

[85] Claes, G. (assigned to Firma Gebr. Hischmann, Maschinenfabrik). Apparatus for Hard Disintegrating and Sifting. U.S. Pat. 2,980,347, Apr. 18, 1961.

[86] Weston, D. (assigned to Fred H. Jowsey, Toronto, Canada). Grinding. U.S. Pat. 3,008,656, Nov. 14, 1961.

[87] Falla, F. Classifying Liner for Ballmills. U.S. Pat. 2.967.671. Jan. 10. 1961.

[88] Plass, Robert J. Comparison of Electrostatic Precipitator and Glass Baghouse Collectors. Nonmet. Min. Proc., v. 2, No. 2, February 1961, pp. 21–24.

tion in the cement industry was suggested; particles as small as .001 micron, escaping from other collectors, could be trapped.[89] Potassium in flue dust was recovered as a sulfate from a water solution by heating, filtering, and precipitating with sulfuric acid.[90]

Additives.—An automatic control system for additives in cement grinding mills was described. Cooling water, grinding aids, and air-entraining agents were introduced through spray nozzles, and liquid flow rates were varied in accordance with millfeed [91] by means of an electrical proportioning method. False set of cement was inhibited by admixture of a small percentage of N-methyl tauride of either tall oil or sulfonated oleic acid.[92] Moisture-resistant portland cement was made by grinding clinker with a small percentage of oleic acid and tri-n-butyl phosphate or similar compound.[93]

Portland Blast-Furnace Slag Cements.—Results were summarized of several years' studies by the U.S. Bureau of Public Roads comparing properties of air-entrained concretes made with portland blast-furnace slag cement with similar concretes using ordinary portland cement. Slag cement concrete had lower early strength but higher ultimate strength and showed greater durability in freeze-thaw tests. Content of slag was considered beneficial for controlling the alkali-aggregate reaction.[94] Manufacture of slag cement was an important industry in Belgium. A review of problems of quality control and construction uses in that country was published.[95]

Structural units said to be highly resistant to fire, and radiation were made from a mixture of 4 parts of blast-furnace slag and 1 part of portland cement, with a minor quantity of calcium chloride.[96] Setting of a blast-furnace slag cement was accelerated by adding basic magnesium carbonate.[97]

High-Alumina Cements.—Performance of concretes made from several types of portland and calcium aluminate cements was compared after cyclical heating to temperatures of 800° F and above. Portland cement specimens fractured badly. Expansion was said to be caused by re-hydration of calcium oxide formed when heated. Satisfactory strengths were retained by specimens made from calcium aluminate cements.[98] A barium aluminate cement was said to have better refractory properties than calcium aluminate types.[99] A patented

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[89] Rock Products. What's Happening; Ultrasonic Housekeeping. V. 64, No. 9, September 1961, p. 14.

[90] Patzias, T. Method of Recovering Potassium Sulphate from Cement Kiln Flue Dust. U.S. Pat. 2,991,154, July 4, 1961.

[91] Ludwig, Norman C., and L. M. O'Hara. How to Get Better Additives Control for Finish Mills. Rock Products, v. 64, No. 7, July 1961, pp. 102–104, 106, 108.

[92] Copes, J. P., and R. L. Mayhew (assigned to General Aniline & Film Corp.). Inhibition of False Set in Portland Cement. U.S. Pat. 3,000,746, Sept. 19, 1961.

[93] Stoll, U. W. (assigned to U.S. Government, Secretary of the Navy). Hydrophobic Portland Cement. U.S. Pat. 2,996,394, Aug. 15, 1961.

[94] Grieb, William E., and George Werner. Final Report of Tests of Concrete Containing Portland Blast-Furnace Slag Cement. Public Roads, U.S. Dept. of Commerce, v. 31, No. 9, August 1961, pp. 183–193.

[95] Blondiau, L. [Quality and Application of Belgian Blastfurnace Cement]. Silicates ind., v. 25, No. 12, pp. 545–550; V. 26, No. 1, pp. 32–39; No. 2, pp. 93–98; No. 3, pp. 141–145; No. 4, pp. 201–206; Building Sci. Abs., v. 34, No. 12, December 1961, p. 356.

[96] Stocker, R. Concrete Structure. U.S. Pat. 3,022,843, Oct. 3, 1961.

[97] Ulfstedt, Leo T., Endel Wijard, Anders G. Wastesson, and Karl A. Jörgensen (assigned to Casius Corp., Ltd.). Method of Accelerating the Setting of Hydraulic Binders. U.S. Pat. 2,987,407, June 6, 1961.

[98] Livovich, A. F. Portland Vs. Calcium Aluminate Cements in Cyclic Heating Tests. Am. Ceram. Soc. Bull., v. 40, No. 9, Sept. 15, 1961, pp. 559–562.

[99] Braniski, A. Highly Refractory Concrete Containing Barium Aluminate Cement. Tonind.-Ztg. u. Keram. Rundschau, v. 85, No. 6, 1961, pp. 129–135; J. Am. Ceram. Soc. Ceram. Abs., v. 44, No. 10, Oct. 1, 1961, p. 233.

device for tapping molten alumina cement from a rotating kiln closed the taphole between turns.[1]

Special Concretes.—Tests were made of 97 samples of material from 74 sources for possible use in pozzolan concrete on the Glen Canyon Dam project before deciding upon pumice from deposits near Flagstaff, Ariz.[2] Compositions for pozzolans derived from several fly ash fractions were patented.[3] Concrete containing vermiculite with a cement-to-aggregate ratio of 1:8 by volume showed favorable energy-absorption characteristics for use in protection of underground structure from impact damage. The large amount of entrapped air was held chiefly responsible for the cushioning effect of the mix.[4]

Latex-modified cement mortar was applied to the deteriorated surface of a concrete bridge deck. Satisfactory repair was accomplished by a ½-inch layer of mortar. The ratio was 3½ gallons of latex to 282 pounds of sand and 1 bag of portland cement.[5]

Factors that caused thermal and other stresses in a concrete nuclear reactor shield were investigated, and distribution of moisture content in the concrete was found to be highly important. Based on information obtained, it was possible to establish the type and characteristics of concrete most suitable for reactor shielding.[6] A concrete mixture for neutron-shielding consisted of 30 to 60 percent barite, 15 to 45 percent cement, and the remainder water and unspecified aggregate.[7]

Soil-Cement.—Experimental work on strengthening effects of various chemical additives for possible use in soil-cement mixtures was reviewed. Responses to treatment varied considerably depending on type of soil. Some compounds added in concentrations of 1 percent produced strengths equivalent to a 10-percent cement mixture with only one-half that amount present.[8] Problems of maintaining proper moisture content while laying a soil-cement road in Lagos, Nigeria, were told.[9]

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[1] Boehler, R E. (assigned to U.S. Steel Corp.). Apparatus and Method for Tapping Molten Material from a Rotary Kiln. U.S. Pat. 2,983,501, May 9, 1961.

[2] Grindrod, J. Aggregates, Sand, and Cement for the World's Largest Dam Contract. Cement, Lime and Gravel, v. 36, No. 12, December 1961, pp. 355, 356.

[3] Minnick, Leonard J. (assigned to G. W. H. Corson, Inc.). High Density Fly Ash Fraction. U.S. Pat. 2,987,406, June 6, 1961; Pozzolanic Material. U.S. Pat. 2,987,406, June 6, 1961.

[4] Corington, C. Dynamic Energy-Absorbing Characteristics of Lightweight Vermiculite Concrete. Defense Atomic Support Agency No. 1238, Structural Mechanics Res. Lab., Univ. of Texas, Balcones Res. Center, Austin, Tex., June 1961, 44 pp.

[5] Engineering News-Record. Latex Modified Portland Cement. V. 167, No. 10, Sept. 7, 1961, pp. 26–28.

[6] Thorne, C. P. Concrete Properties Relevant to Reactor Shielding. J. Am. Conc. Inst., v. 32, No. 11, May 1961, pp. 1491–1508.

[7] Borst, Lyle B. (assigned to U.S. Atomic Energy Commission). Neutronic Reactor Shielding. U.S. Pat. 2,992,175, July 11, 1961.

[8] Cement, Lime and Gravel. Recent American Developments in the Stabilization of Soils with Cement and Lime. V. 36, No. 9, September 1961, pp. 263–265.

[9] Johnston, C. M. The Design and Construction of a Soil-Cement Pavement. Cement, Lime and Gravel, v. 36, No. 11, November 1961, pp. 327–330.

Chromium

By Andrew S. Prokopovitsh [1] and Hilda V. Heidrich [2]

THE ESTIMATED value of chromite concentrate produced in the United States in 1961 exceeded $2.9 million. The chromite was delivered to the Federal Government, thereby completing the contract entered into in 1952 for delivery of 900,000 short tons of chromite concentrate.

World chromite production declined 6 percent, principally because of decreased output by five of the seven producing countries in Asia.

TABLE 1.—Salient chromite statistics

(Thousand short tons and thousand dollars)

	1952–56 (average)	1957	1958	1959	1960	1961
United States:						
Production (shipments)	121	166	144	[1] 105	[1] 107	[1] 82
Value	$5,546	$7,815	$6,187	[2] $3,765	[2] $3,813	[2] $2,939
Imports for consumption	1,883	2,283	1,263	1,554	1,387	1,323
Exports	1	1	1	11	5	10
Consumption	1,373	1,760	1,221	1,337	1,220	1,200
Stocks Dec. 31: Consumer	1,075	1,619	1,537	1,800	1,707	1,633
World: Production	[4] 4,170	[3] 5,120	[3] 4,245	[3] 4,355	[3] [illegible],930	4,655

[1] Produced for Federal Government only.
[2] Estimate by Bureau of Mines.
[3] Revised figure.

LEGISLATION AND GOVERNMENT PROGRAMS

A plan to dispose of 1,890 tons of subspecification grade chromite in the strategic stockpile was submitted to Congress by the General Services Administration (GSA) pursuant to the provisions of section 3(e) of the Strategic and Critical Materials Stock Piling Act, 50 U.S.C. 98 b(e). GSA proposed to transfer the chromite ore to other Government agencies, or to offer the material for sale on a competitive basis or otherwise to dispose of it in the best interest of the Government upon the express approval by the Congress. The plan and the dates of disposition were fixed with necessary protection for producers, processors, and consumers against avoidable disruption of their usual markets.[3]

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.
[3] Federal Register. Chromite Ore Held in National Stockpile. Oct. 18, 1961, p. 9793.

In 1961 GSA accepted a bid for the sale of 35,200 tons of chromite-bearing materials. The materials included domestic low-grade metallurgical chromite ore, concentrates, nodules, and briquets stored in Alaska, Montana, Nevada, and Oregon. Ferrochromium alloys consisted of ferrochromium, ferrochromium-silicon, ferrosilicon chromium, and manganese ferrochromium located in Indiana.[4]

Chromite was eligible for acquisition under the agricultural barter program administered by the U.S. Department of Agriculture, Commodity Credit Corporation. Government financial assistance for exploring domestic chromite deposits was available upon approval by the Office of Minerals Exploration.

DOMESTIC PRODUCTION

All domestic production of chromite during 1961 was from the Mouat mine of American Chrome Co. in Montana. This firm shipped 82,260 short tons of chromite concentrate, valued at about $2,939,000, under a contract with the U.S. Government, and produced an additional quantity of concentrate that was used in its ferrochromium smelter. The quantity of concentrate shipped to a Government stockpile completed the firm's contract (entered into in 1952) for delivery of 900,000 short tons of chromite concentrate containing a minimum of 38.5 percent chromic oxide (Cr_2O_3).

At yearend the company was closing all of its Montana operations, including the ferrochromium smelter. However, American Chrome Co. was planning to build a new $7 million, 100-ton-a-day ferrochrome smelter in Butte, Mont., to employ about 400 people.

Stockholders of Goldfield Consolidated Mines Co. approved a merger with American Chrome Co. and changing the firm's name to Goldfield Corp. The company adopted plans to diversify and to improve mining and refining facilities.

H. K. Porter Co., Inc., put into operation its new refractory plant at Pascagoula, Miss., for making bricks and refractory specialties from Philippine chrome ores.

TABLE 2.—Chromite production (mine shipments) in the United States, by States

State	1957 (short tons, gross weight)	1958 (short tons, gross weight)	1959 (short tons, gross weight)	1960		1961	
				Shipments (short tons, gross weight)	Value (thousands)	Shipments (short tons, gross weight)	Value (thousands)
Alaska	4,207						
California	34,901	20,588	(1)				
Montana	119,149	119,057	[2] 105,000	[2] 107,000	[3] $3,813	[2] 82,000	[3] $2,939
Oregon	7,900	4,133					
Washington		17					
Total	166,157	143,795	[2] 105,000	[2] 107,000	[3] 3,813	[2] 82,000	[3] 2,939

[1] Small quantity produced; Bureau of Mines not at liberty to publish.
[2] Dry weight; excludes quantity consumed by American Chrome Co.
[3] Estimate.

[4] General Services Administration News Release No. 1526, Oct. 12, 1961, 1 p.

CONSUMPTION AND USES

Domestic consumption of chromite ores and concentrates was 2 percent below 1960, although in the fourth quarter of 1961 consumption was 82 percent above the level of the first quarter. The metallurgical industry used 649,000 short tons of chromite containing 205,000 tons of chromium in producing 287,000 tons of chromium ferroalloys and chromium metal that contained 169,000 tons of chromium. In addition, 13,000 tons of chromite having 4,000 tons of chromium was added directly to steel. Of the 649,000 tons consumed in making chromium ferroalloys and metal, 79 percent (47.7 percent Cr_2O_3) was metallurgical-grade ore, 15 percent (44.4 percent Cr_2O_3) chemical-grade ore, and 6 percent (32.3 percent Cr_2O_3) refractory-grade ore. Sixty-eight percent of the metallurgical-grade ore had a Cr:Fe ratio of 3:1 and above, 28 percent had a ratio between 2:1 and 3:1, and 4 percent a ratio less than 2:1. The metallurgical industry used 55 percent of total consumption, the refractory industry used 31 percent, and the chemical industry used the remaining 14 percent.

Producers of chromite-bearing refractories consumed 366,000 short tons of ore containing 87,000 tons of chromium; and 9,000 tons of ore containing 2,500 tons of chromium was used directly in furnace repairs.

The chemical industry consumed 163,000 short tons of chromite having 50,000 tons chromium in producing 120,000 tons of chemicals, sodium bichromate equivalent.

Production of chromium ferroalloys gained 3 percent over 1960—low-carbon ferrochromium increased 10 percent, high-carbon was about the same, and ferrochromium-silicon output was 3 percent below 1960. The average chromium content of all alloys produced was 58.9 percent. The chromium content of low-carbon ferrochromium averaged 68 percent, that of high-carbon (which includes charge chrome) averaged 63 percent chromium, and that of ferrochromium-silicon was about 40 percent.

Consumption of chromium ferroalloys increased 6 percent over 1960; consumption during the last half of 1961 gained 25 percent over that of the first 6 months.

TABLE 3.—Consumption of chromite and tenor of ore used by primary consumer groups in the United States

Year	Metallurgical industry		Refractory industry		Chemical industry		Total	
	Thousand short tons, gross weight	Average Cr_2O_3 (percent)	Thousand short tons, gross weight	Average Cr_2O_3 (percent)	Thousand short tons, gross weight	Average Cr_2O_3 (percent)	Thousand short tons, gross weight	Average Cr_2O_3 (percent)
1952–56 (average)	825	46.5	403	34.1	145	44.7	1,373	42.9
1957	1,177	47.1	435	34.8	148	45.0	1,760	43.9
1958	778	46.9	312	35.2	131	45.6	1,221	43.8
1959	796	46.7	379	35.0	162	45.4	1,337	43.2
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

Pacific Northwest Alloys, Inc., planned to close its large metal plant at Mead, Wash., and transfer chromium production facilities to a subsidiary plant at Woodstock, Tenn.

TABLE 4.—Production, shipments, and stocks of chromium ferroalloys and chromium metal in 1961

(Short tons, gross weight)

Alloy	Net production	Chromium contained	Shipments	Producer stocks Dec. 31
Low-carbon ferrochromium	109,364	74,486	118,767	15,871
High-carbon ferrochromium	95,729	60,082	102,714	25,591
Ferrochromium silicon	58,507	22,810	59,478	13,252
Other [1]	23,819	11,856	24,784	2,926
Total	287,419	169,234	305,743	57,640

[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 1961, by major end uses, and consumer stocks Dec. 31

(Short tons)

	Low-carbon ferro-chro-mium	High-carbon ferro-chro-mium	Ferro-chro-mium silicon	Exother-mic ferro-chro-mium silicon	Chro-mium briquets	Other [1]	Total
Stainless steels	53,686	30,647	20,479		[2] 7,044	70	111,926
High-speed steels	304	537					841
Other tool steels	390	919				5	1,314
Other alloy steels [3]	7,086	20,995	2,518	1,508	351	5,495	37,953
Gray and malleable iron	301	1,926	99	34	167	136	2,663
High-temperature alloys	3,989	246	61		2	1,240	5,538
Nickel-base alloys	218	17	2			67	304
Other nonferrous alloys	158	775	2	1	5	480	1,421
Total (contained chromium)	66,132	56,062	23,161	1,543	7,569	7,493	161,960
Total (gross weight)	96,656	87,452	53,240	3,903	12,761	14,145	268,157
Stocks on hand (gross weight)	10,006	10,086	5,022	822	513	1,754	28,203

[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.

TABLE 6.—End use of individual chromium ferroalloys and chromium metal in the United States in 1961

(Percent in contained weight)

Alloy	Stain-less steels	High-speed steels	Other tool steels	Other alloy steels	Gray and malleable castings	High-temper-ature alloys	Nickel-base alloys	Other non-ferrous alloys
Low-carbon ferrochromium	81.2	0.5	0.6	10.7	0.5	6.0	0.3	0.2
High-carbon ferrochromium	54.7	1.0	1.6	37.5	3.4	.4		1.4
Ferrochromium-silicon	88.4			10.9	.4	.3		
Chromium briquets	[1] 93.1			4.7	2.2			
Exothermic ferrochrome-silicon				97.8	2.2			
Low-carbon exothermic ferro-chromium				92.2	.6	7.2		
High-carbon exothermic ferro-chromium				96.7	1.9			1.4
Chromium metal	3.2		.3	12.5	.3	60.2	3.3	20.2
Other chromium alloys	11.8				85.3			2.9

[1] Believed to be low-carbon ferrochromium.

STOCKS

Industry stocks at all locations are given in table 7. Chromium materials in Government inventories on December 31, 1961, are presented in table 8.

Compared with 1960, stocks of chromium ferroalloys and chromium metal at producer plants decreased 24 percent, but stocks at consumer plants increased 71 percent.

Chromium chemicals at producer plants decreased 49 percent and totaled 9,892 short tons, sodium bichromate equivalent, at the end of the year.

TABLE 7.—Stocks of chromite at consumer plants, Dec. 31

(Thousand short tons)

Industry	1957	1958	1959	1960	1961
Metallurgical	849	749	[1] 955	[1] 863	[1] 773
Refractory	610	612	730	719	728
Chemical	160	176	115	125	132
Total	1,619	1,537	[1] 1,800	[1] 1,707	[1] 1,633

[1] Includes stocks at locations other than consumer plants.

TABLE 8.—Chromium materials in Government inventories on Dec. 31, 1961

	National (strategic stockpile) [1]	DPA Inventory [2]	CCC and supplemental stockpile [3]	Total
Chromite, chemical grade—thousand short dry tons	559	----------	401	960
Chromite, metallurgical grade-----do----	3,800	1	1,428	5,229
Chromite, refractory grade-----do----	1,047	----------	180	1,227

[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 quoted by E&MJ Metal and Mineral Markets for chromite ores and concentrates were unchanged during 1961 (see table 9).

The yearend prices for chromium ferroalloys quoted by E&MJ Metal and Mineral Markets for lump material in bulk carload lots, delivered, per pound of contained chromium were: High-carbon ferrochromium (67 to 71 percent chromium (Cr), 4 to 9 percent carbon (C)), 24 cents; low-carbon ferrochromium (67 to 73 percent Cr, 0.75 percent C), 33 cents; special low-carbon ferrochromium (68 to 73 percent Cr, 0.025 C), 33.50 cents; charge chrome (58 to 65 percent Cr, 5.25 percent C), 22 cents; and refined ferrochromium (58 to 65 percent Cr, 4.25 percent C), 24 cents.

Electrolytic chromium metal (99.8 percent pure) and aluminothermic chromium metal (98.5 percent chromium, 0.05 percent carbon), were quoted at $1.15 to $1.19 per pound, delivered, depending on size of lot; vacuum melting 4 cents more.

TABLE 9.—Price quotations for various grades of foreign chromite in 1961

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
Union of South Africa	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 [5]

Imports.—Imports of chromite ores and concentrates declined less than 5 percent (see table 10). Metallurgical-grade ore (46.0 percent Cr_2O_3) comprised 34 percent of total imports, refractory-grade (32.9 percent Cr_2O_3), 24 percent, and chemical-grade (45.4 percent Cr_2O_3), 42 percent. Of the 1.3 million tons imported, 49 percent came from the Union of South Africa; 16 percent from the Federation of Rhodesia and Nyasaland; 21 percent from the Philippines; 11 percent from Turkey; 2 percent from U.S.S.R.; and the remaining 1 percent from Cuba.

Of the ferrochromium imports given in table 11, 62 percent of the quantity containing 3 percent or more carbon, and 56 percent of the quantity containing less than 3 percent carbon entered duty free for the U.S. Government, and duty free under certain public laws. Imports for consumption of sodium chromate and sodium bichromate totaled 1,561 short tons valued at $287,803.

[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 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	
1960:									
North America: Cuba	----------	----------	----------	32,774	10,968	$722,704	32,774	10,968	$722,704
Europe:									
Greece	2,352	1,279	$80,102	----------	----------	----------	2,352	1,279	80,102
Latvia	71	29	2,450	----------	----------	----------	71	29	2,450
U.S.S.R.	7,148	[1] 3,716	[1] 160,310	----------	----------	----------	7,148	[1] 3,716	[1] 160,310
Total	9,571	[1] 5,024	[1] 242,862	----------	----------	----------	9,571	[1] 5,024	[1] 242,862
Asia:									
India	4,520	2,486	176,188	----------	----------	----------	4,520	2,486	176,188
Philippines	16,878	7,332	305,260	376,282	120,371	[1] 7,067,568	393,160	127,703	[1] 7,372,828
Turkey	122,665	56,660	2,891,536	----------	----------	-------	122,665	56,660	2,891,536
Total	144,063	66,478	3,372,984	376,282	120,371	[1] 7,067,568	520,345	186,849	[1] 10,440,552
Africa:									
Rhodesia and Nyasaland, Federation of	307,142	141,705	[1] 7,135,873	15,693	6,391	338,584	[2] 323,218	[2] 148,250	[1 2] 7,481,389
Union of South Africa	80,556	36,102	982,835	52,049	21,478	481,417	[1 2] 500,714	[1 2] 219,976	[1 2] 5,425,685
Total	387,698	177,807	8,118,708	[1 3] 67,742	[1 3] 27,869	[1 3] 820,001	[2] 823,932	[2] 368,226	[1 2] 12,907,074
Grand total	541,332	[1] 249,309	[1] 11,734,554	[1] 476,798	[1] 159,208	[1] 8,610,273	[2] 1,386,622	[1 2] 571,067	[1 2] 24,313,192
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	150,744	71,280	3,847,072	----------	----------	----------	150,744	71,280	3,847,072
Total	160,824	75,738	4,036,072	272,429	85,911	5,052,500	433,253	161,649	9,088,572
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	452,187	207,321	10,225,504	318,220	104,705	5,587,660	[2] 1,323,464	[2] 563,140	[2] 21,443,950

[1] Revised figure.

[2] Includes chemical grade 1960: Federation of Rhodesia and Nyasaland 383 short tons, gross weight, 154 short tons Cr_2O_3, valued at $6,932; Union of South Africa [1] 368,109 short tons gross weight, [1] 162,396 short tons Cr_2O_3, valued at [1] $3,961,433; 1961: Union of South Africa 553,057 short tons, gross weight, 251,114 short tons, Cr_2O_3, valued at $5,630,786.

[3] Mozambique revised to none.

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	
1960:						
North America: Canada				1,115	752	$289,235
Europe:						
France	2,493	1,782	$916,264	4,508	3,111	1,164,177
Germany, West	2,355	1,693	794,416	5,732	4,117	1,546,541
Italy				7,041	4,731	1,694,147
Norway	4,764	3,270	1,783,423	4,422	3,036	1,129,856
Sweden	1,805	1,289	650,848	1,385	940	348,018
United Kingdom				7,180	4,974	1,929,920
Yugoslavia	614	435	218,953			
Total	12,031	8,469	4,363,904	30,268	20,909	7,812,659
Asia: Japan	2,725	1,828	938,957	2,077	1,394	551,573
Africa:						
Rhodesia and Nyasaland, Federation of	1,106	790	334,776			
Union of South Africa				65	44	21,539
Total	1,106	790	334,776	65	44	21,539
Grand total	15,862	11,087	5,637,637	33,525	23,099	8,675,006
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

Source: Bureau of the Census.

Imports for consumption of chrome or chromium metal totaled 692 tons valued at $1,149,916; 187 tons was from the United Kingdom, 255 tons from France, 69 tons from West Germany, and 181 tons from Japan.

Imports for consumption totaled 12 tons of chromium-nickel and chromium-vanadium valued at $5,703 from Canada and the United Kingdom; 30 tons of chromium carbide valued at $56,465 from West Germany; 508 tons of chrome yellow, chrome green (chromic oxide), and other chromium colors, valued at $245,255, from seven other countries; and 5 tons of potassium chromate and dichromate valued at $1,802 from the United Kingdom and West Germany.

Exports.—Exports of chromium products included 7,845 tons of ferrochromium valued at $2,837,518; 1,068 tons of chromic acid and anhydride valued at $604,113; 7,124 tons of sodium bichromate and chromate valued at $1,678,829; 10 tons of chromium or chromite

metal and alloys in crude form and scrap valued at $24,484; and 4 tons of chromium or chromite semifabricated forms valued at $21,532. Reexports of ferrochromium totaled 429 tons valued at $137,498.

TABLE 12.—U.S. exports of chromite ore and concentrates

Year	Exports [1]		Reexports [2]	
	Short tons	Value	Short tons	Value
1952-56 (average)	1,326	$70,945	8,741	$400,200
1957	837	52,579	4,872	193,546
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	10,465	516,209	40,483	1,559,765

[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 Bureau of Mines.

Source: Bureau of the Census.

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 the U.S.S.R. and other designated Communist countries and areas were unchanged from 1960.

WORLD REVIEW

World chromite production was 6 percent below the high level of 1960 although it equaled the average output of the preceding 4 years.

Four countries in three continents accounted for more than 70 percent of the world chromite production; U.S.S.R. produced 22 percent; Union of South Africa 21 percent; the Philippines 15 percent; and the Federation of Rhodesia and Nyasaland 13 percent. The remaining 29 percent came from 16 other countries.

Some countries in Asia and Europe had difficulty in selling chromite on the world market despite strong demand, as large quantities of high-grade Russian and Albanian chromite became available for export.

NORTH AMERICA

Canada.—The Strategic-Udy process for producing ferrochrome on a commercial basis was brought into operation in December at the Niagara Falls, Ont., plant of Strategic Materials Corp. The operation was a joint venture of Strategic Materials Corp. and Universal-Cyclops Steel Corp. of Bridgeville, Pa. Constructed at a cost of $1.5 million, the unit was supposed to have the highest capacity of any test plant available in North America for testing custom chrome ores. The unit reportedly had been used to process complex ores which could not be handled economically by other plants.[6]

Cuba.—Cuba published no mineral production or foreign trade figures for 1960 or 1961. A report attributed to the Instituto Cubano

[6] Mining Journal (London). New Development in Metallurgy. V. 257, No. 6591, Dec. 15, 1961, p. 629.

TABLE 13.—World production of chromite by countries [1] [2]

(Short tons)

Country [1]	1952–56 (average)	1957	1958	1959	1960	1961
North America:						
Cuba	72,619	127,126	[3] 82,800	[4] 43,732	[4] 32,774	([5])
Guatemala	384	[3] 1,100	1,168	452	200	110
United States	[6] 120,880	166,157	143,795	[7] 105,000	[7] 107,000	[7] 82,000
Total	193,883	294,383	227,763	149,184	139,974	([5])
South America: Brazil	3,610	8,748	5,832	6,861	6,245	6,990
Europe:						
Albania	105,160	184,400	221,800	272,300	315,300	[3] 330,000
Greece	44,060	96,172	92,935	88,185	[3] 110,200	[3] 44,000
U.S.S.R [3] [8]	715,000	850,000	880,000	940,000	1,010,000	1,015,000
Yugoslavia	133,077	132,570	125,188	117,965	110,873	119,188
Total [1] [3]	1,020,000	1,280,000	1,340,000	1,440,000	1,580,000	([5])
Asia:						
Cyprus (exports)	9,903	5,678	13,260	13,637	15,702	[3] 11,000
India	64,624	87,968	70,500	93,936	110,354	50,625
Iran [9]	28,754	42,549	[3] 38,600	60,600	75,000	[3] 55,000
Japan	40,550	51,216	46,155	63,578	74,394	77,579
Pakistan	25,504	18,114	26,619	17,946	20,265	28,116
Philippines	618,583	799,733	458,903	720,345	809,579	705,811
Turkey	824,781	1,052,665	631,403	427,324	530,676	443,932
Total [3]	1,612,699	2,057,923	1,285,440	1,397,366	1,635,970	1,372,063
Africa:						
Malagasy (Madagascar)						[10] 9,900
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	533,107	654,072	618,841	543,104	668,401	590,888
Sierra Leone	23,952	17,602	15,944	19,974	6,023	[3] [10] 13,200
Union of South Africa	686,617	733,612	696,057	749,873	850,916	989,718
United Arab Republic (Egypt Region)	405	114		275	330	
Total	1,244,081	1,405,400	1,330,842	1,313,226	1,525,670	1,603,706
Oceania:						
Australia	3,400	3,415	869	134	592	
New Caledonia	90,225	70,768	52,249	48,463	43,166	40,413
Total	93,625	74,183	53,118	48,597	43,758	40,413
World total (estimate) [1]	4,170,000	5,120,000	4,245,000	4,355,000	4,930,000	4,655,000

[1] In addition to countries listed, Bulgaria and Rumania produce chromite, but data on output are not available; estimates by senior author of chapter included in total.
[2] This table incorporates 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] Data not available; estimate included in world total.
[6] Includes 45,710 tons of concentrates from low-grade ores and concentrates stockpiled near Coquille, Oreg., during World War II.
[7] Produced for Federal Government only; excludes quantity consumed by American Chrome Company.
[8] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.
[9] Year ended March 20 of year following that stated.
[10] Exports.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

de Mineria, Cuba's government mining monopoly, however, indicated that in 1961 chromite would be produced at the rate of 60,000 tons per year at the Yamaniguey and Cayoguan mines.[7]

EUROPE

Finland.—Mining on a trial basis began at the chromite deposit discovered in 1960 in the lower part of the Kemi River valley. The

[7] Engineering and Mining Journal. V. 162, No. 4, April 1961, p. 162.

ore was delivered to a Finnish metal firm, A/B Outokumpu OY, for concentration.[8]

Greece.—The Domokos chromite mines were closed after 45 years of operation because of their inability to meet severe price competition in the world market. The mine operator, Union Minière du Haut-Katanga had stocks of about 12,000 tons of chrome concentrates which it reportedly was unable to sell.

U.S.S.R.—The U.S.S.R. was the leading world producer of chromite. Soviet ore exports totaled one-half million tons in both 1960 and 1961, 50 percent more than in 1959. Exports were made to many countries, with the free world receiving about two-thirds of the total. West Germany, Japan, Sweden, France, the United Kingdom, and Italy accounted for most of the exports; the Sino-Soviet bloc countries—Poland, Czechoslovakia, China, and East Germany—received the remainder. Soviet exports of ferrochrome totaled 22,000 tons in 1960. West Germany, Austria, and Finland accounted for about one-third of the total. A large portion of the exports unaccounted for went to the Sino-Soviet bloc. No data were available on imports, but they were probably small, if any.[9]

ASIA

Pakistan.—The Government of Pakistan approved measures for protecting the chromium chemicals manufacturing industry for a period of 3 years. One of the approved measures was the imposition of a protective duty of 50 percent ad valorem on imported sodium dichromate.[10]

Philippines.—A cooperative effort between the International Cooperation Administration (ICA) and the Philippine Bureau of Mines in geological mapping, trenching, and diamond drilling established an indicated 600,000 tons of good grade refractory chromite ore adjacent to the Consolidated Mines area in Zambales province. A new agreement between Consolidated Mines, Inc., and the Philippine Government will permit Consolidated to operate this government reservation and in effect to extend operations in this principal producing area for 2½ years beyond the present estimated 12 years. About 85 percent of United States refractory chromite ore requirements are met from Philippine production, almost entirely from Consolidated Mines.[11]

Production of metallurgical-grade chromite concentrates was 152,166 short tons with a 50 percent Cr_2O_3 content, metallurgical-grade lump ore was 7,099 tons (53 percent Cr_2O_3), and refractory-grade ore was 546,546 tons (32 percent Cr_2O_3).[12]

Turkey.—A comprehensive report on chromite mining in Turkey described measures required to stimulate production and increase exports of chromium bearing ores. The report also presented mining development prospects and views on the economic benefits to be derived from long-term exploration and prospecting.[13] One leading

[8] American Metal Market. Finnish Chrome Ore Mining Trial. V. 68, No. 80, Apr. 27, 1961, p. 19.
[9] Bureau of Mines. Mineral Trade Notes. Special Supplement No. 61, April 1962, 108 pp.
[10] Chemical Age (London). V. 86, No. 2209, Nov. 11, 1961, p. 768.
[11] U.S. Embassy, Manila, Philippines. State Department Dispatch 409, Dec. 8, 1961, pp. 10–11.
[12] U.S. Embassy, Manila, Philippines. State Department Dispatch 750, Apr. 23, 1962, pp. 1-3.
[13] Bekisoglu, K. Chromite Mining in Turkey. Turkish Econ. Rev., v. 2, No. 10, December 1961, pp. 16-26.

producer of Turkish chromite concentrate was having difficulty in marketing its output in 1961.

AFRICA

Rhodesia and Nyasaland, Federation of.—Windsor Ferroalloys, (pvt.) Ltd., announced plans to construct a new smelter in Que Que, Southern Rhodesia, to produce initially 12,000 tons a year of high-carbon ferrochrome from local chromite ore. The smelter will be rated at over 7,500 kva using Kariba power for smelting about 25,000 tons per year of chromite concentrates.[14]

TECHNOLOGY

The Federal Bureau of Mines published the results of its studies on the feasibility of electric smelting of Montana chromite concentrate for producing ferrochromium of varying silicon and carbon contents.[15] Bureau of Mines chromium research was directed mainly toward beneficiating low-grade chromite-bearing materials by flotation and gravity methods, extracting chromium directly from chromite concentrates, and improving the efficiency of pyrometallurgical techniques for recovering chromium.

Industry continued using oxygen top-blowing techniques for refining ferrochromium. In the refractories area, the use of South African chromite for refractory brickmaking was a significant technological development.

After a continuous period of over 30 years using one type of chromite (Cuban-Philippines) the basic refractories industry found it necessary to change to another type because of approaching depletion of reserves. Conversion to Transvaal chromite proved successful in large-scale industry service trials, thus assuring a continuing supply of chromite refractories for many years.[16] E. J. Lavino & Co. announced that transition to Transvaal chromite was virtually complete.

Chrome composites formed by combining electrolytic chromium with magnesium oxide yielded a structural engineering material having potential use for high-temperature applications.

Publications on the technology of chromium presented information on metallurgy, chemistry, and physical and chemical properties. The phenomenon of evaporation of chromium oxide from chromium alloys oxidized at high temperatures was investigated by observing the loss in weight when chromium oxide pellets were heated at 1,000° C. in various atmospheres.[17] Chromium chelates of malonaldehyde and formylacetone were synthesized.[18] Magnetic properties of chromium between 0° and 350° C., and the electron spin resonance of pure chromium were measured.[19] Chromium manganese antomide, a

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[14] Iron and Coal Trades Review (London). V. 183, No. 4862, Sept. 22, 1961, p. 645.
[15] Hunter, W. L., and G. A. Kingston. Ferrochromium From Western Metallurgical-Grade Chromite. BuMines Rept. of Inv. 5397, 1961, 9 pp.
Hunter, W. L., and L. H. Banning. Electric Smelting of Montana Chromite Concentrates. BuMines Rept. of Inv. 5775, 1961, 30 pp.
[16] Mikami, H. M., H. A. Heiligman, D. G. Samuel. Transvaal Chromite in Basic Refractories. Paper pres. at Pacific Coast Regional Meeting of the Am. Ceram. Soc., San Francisco, Calif., Oct. 26, 1961.
[17] Journal of the Electrochemical Society. V. 108, No. 5, May 1961, pp. 438–442.
[18] Chemical & Engineering News. Chromium Chelates. V. 39, No. 37, Sept. 11, 1961, p. 58.
[19] Collings, E. W., F. T. Hedgcock, A. Siddiqui. Magnetic Properties of Chromium Between 0° and 350° C. J. Inst. Metals, v. 29, October 1961, p. 98.

new metallic compound, was reported to exhibit unique on-off magnetic characteristics. The magnetic characteristics of the alloy were determined by the chemical composition.[20]

The tensile properties of high-purity extruded chromium in the annealed condition were established between minus 196° and plus 900° C.[21] The recovery and early recrystallization of heavily deformed 99.98 percent chromium were investigated by studying structure, X-ray line sharpening, electrical resistivity, plastic properties, internal friction, and shear modulus. Observations on the ductility and fracture of recrystallized chromium were also reported.[22] The thermodynamic properties of chromium carbide at high temperatures were published.[23]

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[20] Journal of Metals. On-Off Magnetic Properties, V. 13, No. 1, January 1961, p. 15.
[21] Weaver, C. W. Tensile Properties of Annealed Chromium Between −196° and +900° C. J. Inst. Metals, v. 89, No. 10, June 1961, pp. 385–390.
[22] Morton, M. E. Recovery and Recrystallization in 99.98 Pct. Cr. Trans. of the Metallurgical Soc. of AIME, v. 221, No. 2, April 1961, pp. 395–400.
[23] Fujishiro, S. E., and N. A. Gokcen. Thermodynamic Properties of Chromium Chloride. Trans. of Metallurgical Soc. of J. Metals, v. 221, No. 2, April 1961, pp. 275–279.

Clays

By Taber de Polo [1] and Betty Ann Brett [2]

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TONNAGE and value of clays sold or used by producers in 1961 both decreased 3 percent compared with 1960. Exports increased 5 percent. Bentonite and fuller's earth production increased, kaolin and ball clay production remained at about the same level as in 1960, and fire clay and miscellaneous clay production decreased.

TABLE 1.—Salient clay and clay products statistics in the United States

(Thousand short tons and thousand dollars)

	1952–56 (average)	1957	1958	1959	1960	1961
Domestic clays sold or used by producers	[1] 45,096	45,622	43,750	49,383	[2] 49,069	47,389
Value	[1] $136,280	$155,805	$143,487	$159,659	[2] $162,411	$156,829
Imports for consumption	165	162	162	176	160	156
Value	$2,502	$2,940	$2,900	$3,288	$3,103	$3,060
Exports	370	485	450	489	[2] 530	559
Value	$9,176	$13,528	$12,129	$13,490	[2] 13,714	$14,285
Clay refractories, shipments (value)	[3] $167,905	$207,640	$162,887	$178,632	[2] $178,836	$168,098
Clay construction products [4], shipments (value)	[5] $464,733	$437,000	[2] $459,700	$521,500	$487,300	$479,100

[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 1954–56 only.

The 100 leading firms supplied 15 percent of clay production; the other 1,300 firms supplied 85 percent.

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.

Trends in the clay industry were toward increased automation, company mergers, greater emphasis on research to improve existing products and develop new ones to meet competition from domestic and import sources, and increased use of lightweight aggregate, especially in larger formed and prestressed structural units.

A proposal for a clays nonmenclature system using letters and numerical subscripts appeared in the literature.[3]

TABLE 2.—Value of clays produced in the United States, by States

(Thousand dollars)

State	1960	1961	Kinds of clay produced in 1961
Alabama	[1] $2,170	[1] $2,068	Kaolin, fire clay, miscellaneous clay.
Arizona	[2] 260	[2 3] 240	Fire clay, bentonite, miscellaneous clay.
Arkansas	2,456	1,758	Fire clay, miscellaneous clay.
California	5,663	6,405	Kaolin, ball clay, fire clay, bentonite, fuller's earth, miscellaneous clay.
Colorado	1,424	1,241	Fire clay, bentonite, miscellaneous clay.
Connecticut	308	[1] 260	Kaolin, miscellaneous clay.
Florida	[1 4] 6,357	7,202	Kaolin, fuller's earth, miscellaneous clay.
Georgia	40,160	42,024	Do.
Idaho	[2 3] 29	[1 2 3] 20	Kaolin, fire clay, bentonite, miscellaneous clay.
Illinois	5,479	4,166	Fire clay, miscellaneous clay.
Indiana	3,396	2,446	Do.
Iowa	1,345	1,426	Do.
Kansas	1,224	1,225	Do.
Kentucky	[5] 2,646	[5] 2,406	Ball clay, fire clay, miscellaneous clay.
Louisiana	749	645	Miscellaneous clay.
Maine	50	51	Fire clay, miscellaneous clay.
Maryland	[5] 853	997	Ball clay, fire clay, miscellaneous clay.
Massachusetts	71	85	Miscellaneous clay.
Michigan	1,904	1,975	Do.
Minnesota	[3] 163	[3] 241	Fire clay, miscellaneous clay.
Mississippi	4,786	5,034	Ball clay, fire clay, bentonite, fuller's earth, miscellaneous clay.
Missouri	7,207	5,040	Fire clay, miscellaneous clay.
Montana	[3] 77	[3] 76	Do.
Nebraska	109	148	Miscellaneous clay.
New Hampshire	27	30	Do.
New Jersey	1,597	1,681	Fire clay, miscellaneous clay.
New Mexico	[3] 132	[3] 165	Do.
New York	1,717	1,373	Miscellaneous clay.
North Carolina	[1] 1,548	[1] 1,669	Kaolin, miscellaneous clay.
North Dakota	[2 3] 129	([6])	Fire clay, bentonite, miscellaneous clay.
Ohio	14,325	13,790	Fire clay, miscellaneous clay.
Oklahoma	[2] 739	[2] 801	Fire clay, bentonite, miscellaneous clay.
Oregon	370	357	Bentonite, miscellaneous clay.
Pennsylvania	[1] 16,536	[1] 14,402	Kaolin, fire clay, miscellaneous clay.
South Carolina	6,201	6,169	Kaolin, miscellaneous clay.
South Dakota	[2] 202	[2] 249	Bentonite, miscellaneous clay.
Tennessee	4,537	[7] 4,190	Ball clay, fuller's earth, miscellaneous clay.
Texas	[7] 5,058	[7] 5,737	Fire clay, bentonite, fuller's earth, miscellaneous clay.
Utah	[1] 416	1,080	Kaolin, fire clay, bentonite, fuller's earth, miscellaneous clay.
Virginia	1,395	1,332	Miscellaneous clay.
Washington	[3] 162	[3] 138	Fire clay, bentonite, miscellaneous clay.
West Virginia	2,639	2,193	Fire clay, miscellaneous clay.
Wisconsin	156	130	Miscellaneous clay.
Wyoming	[4] 9,571	[3 4] 10,301	Fire clay, bentonite, miscellaneous clay.
Other [8]	[9] 6,068	3,863	
Total	[9] 162,411	156,829	
Puerto Rico	102	112	Miscellaneous clay.

[1] Value of kaolin included with "Other."
[2] Value of bentonite included with "Other."
[3] Value of fire clay included with "Other."
[4] Value of miscellaneous clay included with "Other."
[5] Value of ball clay included with "Other."
[6] Included with "Other."
[7] Value of fuller's earth included with "Other."
[8] Includes Alaska, Delaware, District of Columbia, Hawaii, Nevada, and Vermont, and values indicated by footnotes 1 through 7, to avoid disclosing individual company confidential data.
[9] Revised figure.

[3] Ernst, Th., W. Forkel, and K. v. Gehlen. A System of Nomenclature for Clays and Similar Ceramic Raw Materials. Am. Ceram. Soc. Bull., v. 40, No. 8, August 1961, pp. 479–483.

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 slightly, while the value increased 3 percent. These increases established new highs for the industry. The paper, rubber, refractories, and pottery industries consumed 82 percent of the kaolin used in 1961. The remainder was used for a variety of purposes, including cement, floor and wall tile, fertilizers, chemicals, insecticides, paint filler or extender, and linoleum. Use in paper coating continued to increase substantially, 9 percent in 1961.

Georgia continued to be the major producer, with 78 percent of the tonnage, the same as in 1960, and 84 percent of the value.

In December, Oil, Paint and Drug Reporter quoted prices for Georgia kaolin as follows: Dry ground, air floated, 99 percent through 325-mesh, in bags, carlots, f.o.b. plant, $11 to $17 a short ton; same, less than carlots, $13.50 to $22.50 a ton.

Prices for imported china clay in December were quoted by Oil, Paint and Drug Reporter as follows: White, lump, carlots, ex dock

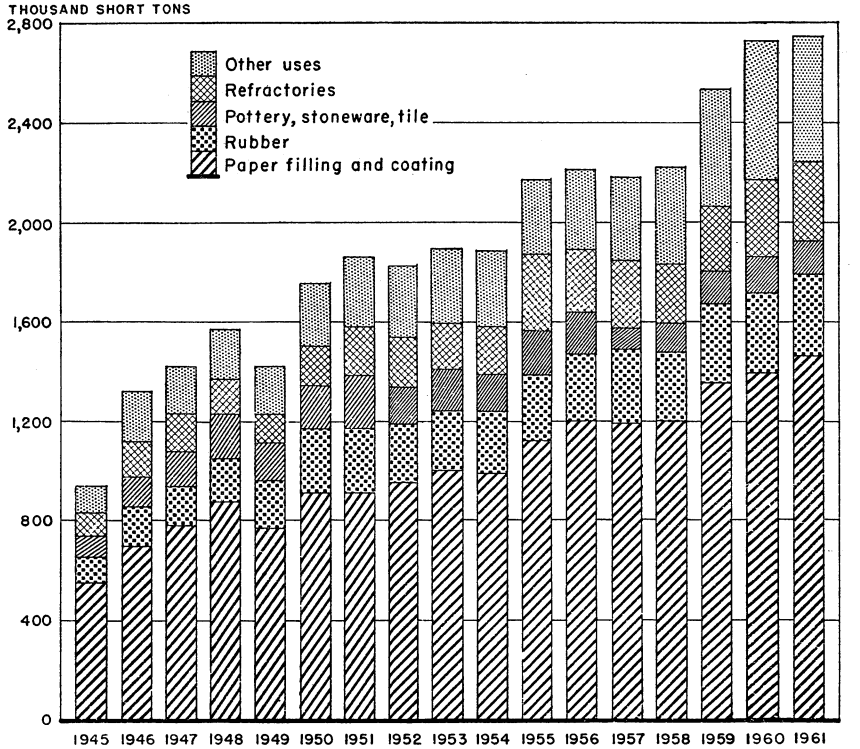


FIGURE 1.—Kaolin sold or used by domestic producers for specified uses, 1945–61.

(Philadelphia, Pa., and Portland, Maine), $23 to $35 a long ton; powdered, ex dock, in bags, $50 a ton; less than carlots, ex warehouse, $60 to $70 a ton.

In 1961 the average value per short ton for kaolin used, as reported by producers, was $7.66 per short ton and for kaolin sold, $18.16 a ton.

Imports of kaolin were 132,441 short tons, up 4 percent from 1960. Virtually all imports came from the United Kingdom; small quantities came from Australia, Canada, Japan, and Mexico.

Exports of kaolin or china clay increased 24 percent over 1960; 62 percent went to Canada, 12 percent to Mexico, 8 percent to Japan, 5 percent to Italy, 3 percent to Venezuela, and 2 percent to Colombia. Small tonnages also went to other countries in Central and South America, Europe, Africa, and Asia.

The scraper and dragline mining operations at the J. M. Huber Corp. kaolin pits were described in an article.[4]

Minerals & Chemicals Philipp Corp. was building a $2 million plant at McIntyre, Ga., to product beneficiated kaolin. The plant, which will be the first to use ultraflotation, is scheduled to commence operations in 1962.[5]

Southern Clays, Inc. opened its new $350,000 research laboratory at Gordon, Ga., for basic research in ceramics, paint, paper, rubber, and plastics.

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
1952-56 (average)	1,823,181	$27,830,227	177,298	$1,510,562	2,000,479	$29,340,789
1957	1,941,801	33,072,638	241,884	2,525,143	2,183,685	35,597,781
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:						
California	14,247	212,120			14,247	212,120
Florida and North Carolina	29,760	663,604			29,760	663,604
Georgia	1,942,745	36,915,750	178,492	906,505	2,121,237	37,822,255
South Carolina	(1)	(1)	(1)	(1)	446,620	5,502,342
Other States [2]	446,166	5,626,115	119,041	1,353,001	118,587	1,476,774
Total	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

[1] Included with "Other States."
[2] Includes States indicated by footnote 1, and Alabama, Connecticut (1961), Idaho (1961), Pennsylvania, Utah, and Vermont (1961).

[4] Brick and Clay Record. How Do You Mine Clay. V. 139, No. 4, October 1961, pp. 56–57, 77–78.
[5] Chemical & Engineering News. Ultraflotation Gets First Commercial Try. V. 39, No. 42, Oct. 16, 1961, pp. 52–54.

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	Average per ton
1952-56 (average)	1,258	168	1,426	$21,794	$15.28
1957	1,414	245	1,659	28,210	17.01
1958	1,510	187	1,697	29,348	17.30
1959	1,751	189	1,940	33,965	17.51
1960	1,861	260	2,121	37,822	17.83
1961	1,925	222	2,147	39,557	18.42

BALL CLAY

The tonnage of ball clay sold or used by producers remained virtually the same, and the value increased 2 percent over 1960. Tennessee continued to be the major producer, accounting for 65 percent of the U.S. total tonnage and 64 percent of the value; Kentucky ranked second.

Demand in the pottery and floor and wall tile industries decreased, and in 1961 they consumed 53 percent and 21 percent, respectively, of the total.

Quotations on domestic ball clay in Oil, Paint and Drug Reporter for December 1961 were crushed, shed moisture, bulk, carlots, f.o.b. plant (Tennessee), $8 to $11.25 a short ton; air floated, in bags, carlots, f.o.b. plant (Tennessee), $17.50 to $21.50 a ton. In 1961 the average value per short ton for ball clay, as reported by producers, was $13.70, compared with $13.45 in 1960.

Prices for imported ball clay in December 1961 were quoted by Oil, Paint and Drug Reporter as follows: Air floated, in bags, carlots, Atlantic ports, $43 to $47 a short ton; lump, bulk, Atlantic ports, $31.50 to $37.50 a ton.

Imports of common blue and ball clay decreased 13 percent in tonnage and 12 percent in value compared with 1960. Unmanufactured blue and ball clays represented the major share of the imports; the United Kingdom supplied 99 percent of this classification and most of the imports of manufactured blue and ball clay. The remainder of the unmanufactured blue and ball clays came from Canada. Imports of Gross Almerode clays, including fuller's earth, totaled 459 short tons. West Germany accounted for 61 percent, and Brazil, Canada, Japan, Netherlands, Norway, and the United Kingdom for the remainder.

Descriptions and chemical analyses of ball-clay deposits in western foothills of the Sierra Nevada Range in California were given.[6]

[6] Ceramic News. California Ball Clays Being Shipped to Major Sanitary-Ware Plants. V. 10, No. 1, January 1961, pp. 10–11.

Material handling in the underground and open-pit mines of England's largest producer of ball clay, Pike Brothers Fayle & Co., Ltd., was described.[7]

TABLE 5.—Ball clay sold or used by producers in the United States

Year	Short tons	Value	Year	Short tons	Value
1952-56 (average)	360,838	$4,596,258	1959	475,235	$6,459,902
1957	408,286	5,521,195	1960	444,369	5,977,963
1958	396,949	5,502,986	1961	444,593	6,090,091

FIRE CLAY

The tonnage and value of fire clay sold or used by producers in the United States decreased 12 percent and 14 percent, respectively, from the 1960 figures. Most of this loss was due to a lower demand for firebrick and block. The decrease in refractory uses accounted for 90 percent of the decline. Some minor categories gained in use.

The three States producing the largest quantities—Ohio, Pennsylvania, and Missouri—all reported substantial decreases representing almost 70 percent of the loss in 1961. Together these three States accounted for 56 percent of the total U.S. fire-clay production, and 63 percent of the value. Only California, Iowa, and Mississippi reported increases.

The principal uses of fire clay were for the manufacture of refractories, which consumed 49 percent of the total output (54 percent in 1960), and heavy clay products, including terra cotta, which consumed 48 percent (43 percent in 1960). Floor and wall tile and chemicals accounted for about 1 percent each, and 1 percent went for a variety of applications.

The average value per short ton of fire clay sold by producers (as reported to the Bureau of Mines) was $3.43, compared with $3.55 in 1960, and $3.47 in 1959. The average value of all fire clay, including both sales and captive tonnage, was $4.47, compared with $4.56 in 1960. Captive tonnage amounted to 76 percent of the fire clay produced.

Prices quoted on firebrick in December 1961 in E&MJ Metal and Mineral Markets were 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 $161 in 1961. For superduty fire-clay brick and shapes the value was $284.

Exports of fire clay decreased 13 percent in quantity to 155,166 short tons, and increased 3 percent in value compared with 1960. The average value was $21.85 a short ton, compared with $18.60 in 1960. Canada received 30 percent, Mexico 26 percent, Japan 22 percent, Italy and Belgium-Luxembourg 4 percent each, France 3 percent, United Kingdom, Sweden, Venezuela, and Argentina 2 percent each, and Chile 1 percent of the exports. The remaining 2 percent comprised small tonnages to many destinations in Central and South

[7] Mine & Quarry Engineering (London). Handling Ball Clay. V. 27, No. 11, November 1961, p. 512.

America, Europe, Asia, and Africa. Of the larger consumers, Japan accounted for the highest revenue per ton.

The Bureau of Mines released a comprehensive report covering the occurrence, mining, and use of Wyoming refractory clays.[8]

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
1952–56 (average)	3,048,016	$9,488,517	7,550,479	$33,717,612	10,598,495	$43,206,129
1957	2,947,798	9,431,240	7,857,301	41,879,524	10,805,099	51,310,764
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:						
Alabama	197,468	504,903	93,776	248,468	291,244	753,371
Arkansas			427,042	2,068,717	427,042	2,068,717
California	95,568	314,629	319,091	1,060,944	414,659	1,375,573
Colorado	210,048	651,940	80,876	389,429	290,924	1,041,369
Illinois	(2)	(2)	(2)	(2)	359,357	2,378,344
Indiana	(2)	(2)	(2)	(2)	347,706	635,268
Iowa	(2)	(2)	(2)	(2)	13,599	37,172
Kansas			285,635	616,177	285,635	616,177
Kentucky	83,480	390,488	223,288	1,455,161	306,768	1,845,649
Maryland	(2)	(2)	(2)	(2)	26,468	144,633
Mississippi			129,161	258,322	129,161	258,322
Missouri	218,385	526,650	1,322,763	5,681,657	1,541,148	6,208,307
Nebraska			900	900	900	900
New Jersey	(2)	(2)	(2)	(2)	127,099	938,215
Ohio	562,932	2,153,245	1,739,544	8,765,109	2,302,476	10,918,354
Oklahoma			510	5,100	510	5,100
Pennsylvania	(2)	(2)	(2)	(2)	1,857,981	11,640,393
Texas	(2)	(2)	(2)	(2)	715,491	1,668,337
Utah	(2)	(2)	(2)	(2)	27,567	78,778
West Virginia	(2)	(2)	(2)	(2)	346,053	2,328,865
Wyoming			6,308	12,616	6,308	12,616
Other States [3]	1,122,064	4,298,749	2,796,533	15,827,657	97,276	276,401
Total	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

[1] Includes stoneware clay as follows: 1952–56 (average), 63,915; 1957, 30,089; 1958, 26,429; 1959, 27,418; 1960, 27,470; 1961, 24,554 tons.
[2] Included with "Other States."
[3] Includes States indicated by footnote 2 and Alaska (1960), Arizona (1961), Idaho, Maryland (1961), Minnesota, Montana, Nevada, New Mexico, North Dakota, Utah (1961), Washington, and Wyoming (1961).

[8] Van Sant, Joel N. Refractory-Clay Deposits of Wyoming. U.S. BuMines Rept. of Inv. 5652, 1961, 105 pp.

BENTONITE

Increased demand for bentonite in pelletizing and absorbent uses in 1961 more than offset the decreases in consumption by foundry and steelworks and in filtering requirements. The quantity sold or used by producers increased 3 percent, with an attendant 1-percent increase in value. The foundry, petroleum, and filtering industries continued to consume the greater part of the tonnage.

Wyoming, the largest producer of bentonite, accounted for 66 percent of the total production and 68 percent of the total value; Mississippi and Texas had substantial production with 17 percent and 9 percent, respectively. Wyoming, with a 10-percent increase in production, accounted for the total U.S. increase.

The price of bentonite was given in Oil, Paint and Drug Reporter for December 1961, as follows: 200-mesh, in bags, carlots, f.o.b. mines (Wyoming), $14 a short ton; imported, Italian, white, high gel, in bags, 5-ton lots, ex warehouse, $95.20 a ton, and 1-ton lots, $99 a ton; Italian, low gel, in bags, 5-ton lots, ex warehouse, $93.40 a ton, and 1-ton lots, $97.16 a ton.

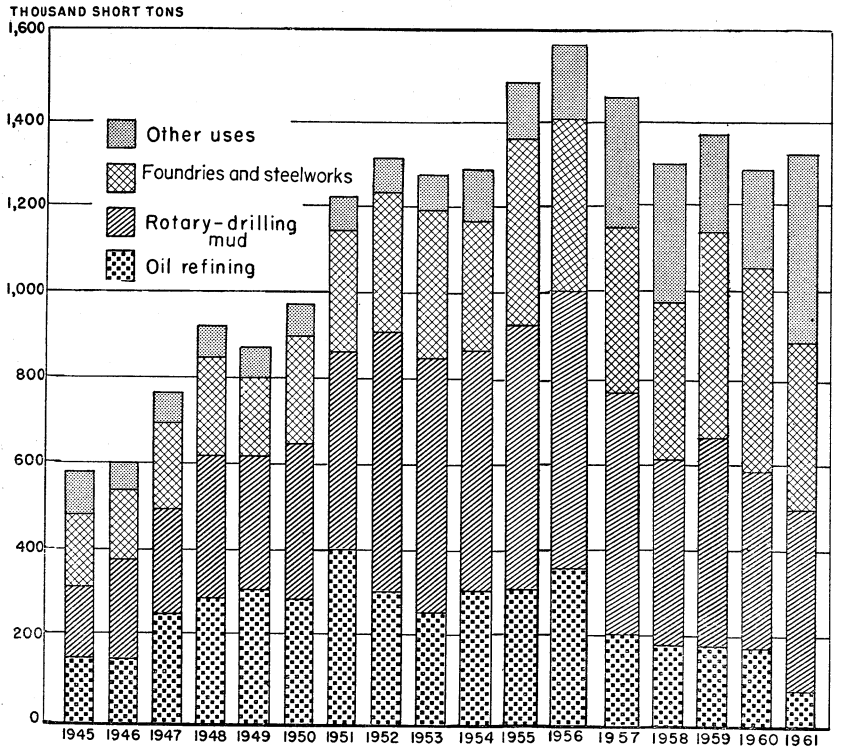


FIGURE 2.—Bentonite sold or used by domestic producers for specified uses, 1945–61.

The average value per short ton, as reported to the Bureau of Mines, was $11.65 in 1961, compared with $11.83 in 1960.

Exports of bentonite decreased 25 percent, from 58,091 short tons in 1960 to 43,813 tons in 1961, according to reports received by the Bureau of Mines.

The Benton Clay Co., Casper, Wyo., completed a $500,000 expansion program at its processing plant.

A new source of bentonite was exploited on the Mediterranean island of Ponza, with a resultant large increased use in animal-food.[9]

TABLE 7.—Bentonite sold or used by producers in the United States, by States

Year and State	Short tons	Value	Year and State	Short tons	Value
1952–56 (average)	1,383,432	$16,265,575	1961:		
1957	1,450,867	17,806,546	California	12,873	$347,127
1958	1,291,414	15,317,250	Colorado	700	4,500
1959	1,372,286	15,841,455	Mississippi	228,020	2,836,181
1960:			Oregon	1,309	15,711
California	10,664	231,717	Texas	122,456	900,426
Colorado	1,000	9,930	Utah	2,790	38,868
Mississippi	237,564	2,899,847	Washington	27	258
Oregon	600	7,320	Wyoming	859,476	10,300,990
Texas	115,587	872,940	Other States [1]	79,540	780,286
Utah	6,255	85,247	Total	1,307,191	15,224,347
Washington	78	440			
Wyoming	782,168	9,558,969			
Other States [1]	114,884	1,338,347			
Total	1,268,800	15,004,757			

[1] Includes Arizona, Idaho, Nevada, North Dakota, Oklahoma, and South Dakota.

FULLER'S EARTH

Fuller's earth sold or used by producers increased 3 percent in tonnage and 4 percent in value over 1960. Florida continued to be the leading producer and, with Georgia, supplied 86 percent of the total U.S. tonnage and accounted for 89 percent of the value. The largest single use was as an absorbent, which took 45 percent of the national consumption. Other uses were insecticides and fungicides, 25 percent; rotary-drilling mud, 14 percent; and mineral and vegetable oil refining, 8 percent.

The average value per short ton of fuller's earth reported sold or used in the United States was $22.55, compared with $22.44 in 1960.

The latest quotations on fuller's earth, published in Oil, Paint and Drug Reporter for February 1960, were as follows: Insecticide grade, dried, powdered, in bags, carlots, Georgia or Florida mines, $17.50 a short ton; oil-bleaching grade, 100-mesh, in bags, carlots, f.o.b. Georgia and Florida mines, $16.30 to $17 a short 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 are not given separately in official foreign-trade statistics. According to reports made by producers to the Bureau of Mines, exports in 1961 were a negligible 280 short tons, compared with 12,035 tons in 1960.

[9] Chemical Trade Journal and Chemical Engineer (London). Bentonite on the Farm. V. 148, No. 3857, May 5, 1961, p. 974.

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
1952–56 (average)	404,489	$7,570,298	1961:		
1957	366,101	8,056,841	Florida and Georgia	363,233	$8,477,603
1958	357,883	7,609,049	Utah	3,068	41,770
1959	409,622	9,027,059	Other States [1]	55,880	998,865
1960:			Total	422,181	9,518,238
Florida	252,106	6,357,173			
Georgia	93,689	1,777,051			
Tennessee	21,319	316,466			
Utah	3,238	43,645			
Other States [1]	37,973	667,323			
Total	408,325	9,161,658			

[1] Includes California, Mississippi, Nevada, Tennessee (1961) and Texas.

Articles described the operation of Minerals & Chemicals Philipp Corp. facility in Attapulgus, Ga., where attapulgite was processed into over 90 commercial grades. A flow sheet was included.[10]

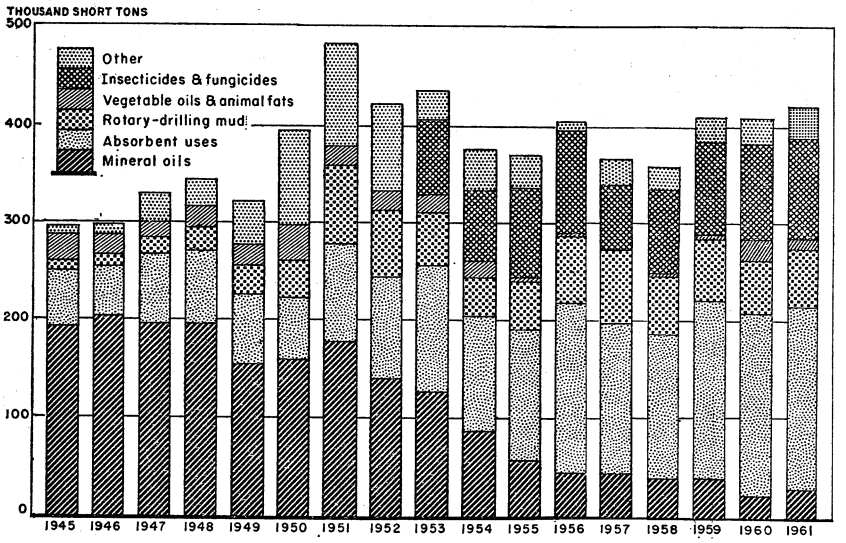


FIGURE 3.—Fuller's earth sold or used by producers for specified uses, 1945–61.

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.

[10] Chopey, N. P. Attapulgite: 1 Process, 90+ Grades. Chem. Eng., v. 68, No. 26, Dec. 25, 1961, pp. 60–62. Pit and Quarry. Unique Handling Techniques Used to Automate New Georgia Clay Processing Plant. V. 54, No. 3, September 1961, pp. 122–125.

Miscellaneous clay sold or used by producers decreased 2 percent in tonnage and 3 percent in value compared with 1960. A decline of 8 percent in requirements for heavy clay products, the largest use, accounted for most of the loss. A substantial increase of 10 percent was recorded for use in lightweight aggregate, and miscellaneous clay used for cement increased 5 percent. Almost all other categories registered decreases. 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 1961. Texas, Ohio, North Carolina, and California reported tonnages exceeding 2 million short tons. About half the States showed increases and half decreases in production. Production in the North Central States of Ohio, Indiana, and Illinois together decreased by almost 1 million tons. Of the States producing over 1 million tons, Texas made the largest gain, with a 21-percent increase.

The average reported value of miscellaneous clay sold as crude or prepared clay was $1.13 a short ton, compared with $1.44 in 1960. There was a 37-percent quantity decrease 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 $1.19 a short ton.

According to figures compiled by the Bureau of the Census, exports of clay not elsewhere classified were 304,858 short tons valued at $8,498,868, an increase of 12 percent in tonnage and less than 2 percent in value from 1960. Some countries of destination with percentages received were Canada, 36 percent; Mexico and United Kingdom, 8 percent each; Australia and West Germany, 5 percent each; Brazil and Venezuela, 4 percent each; Netherlands, 3 percent; and Colombia, Italy, Japan, and Switzerland, 2 percent each. Smaller quantities were shipped to other countries in Central and South America, Europe, Asia, and Africa.

Details of recommended procedure to follow in searching for and testing commercial deposits of clay for use in structural clay products were presented.[11]

A comprehensive report on Ohio shale, was published by the Ohio Division of Geological Survey.[12]

Mississippi Clay Products Co. acquired 51 acres of clay-bearing land south of Yazoo City, Miss.

[11] Moffitt, Roy B. Let's Go Prospecting for Clay. Brick and Clay Record, v. 138, No. 6, June 1961, pp. 82–84, 86–88, 91–92, 94–95.
[12] Hoover, K. V. Devonian-Mississippian Sequence in Ohio. Ohio Div. of Geol. Survey Circ. 27. 1961, 154 pp.

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
1952-56 (average)[1]	1,639,913	$2,887,372	28,708,277	$32,413,097	30,348,190	$35,300,469
1957	1,097,620	1,588,484	29,310,775	35,923,688	30,408,395	37,512,172
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:						
Alabama			1,548,673	1,416,739	1,548,673	1,416,739
Arizona			173,272	259,908	173,272	259,908
Arkansas			387,633	387,633	387,633	387,633
California	211,864	613,048	2,216,159	3,057,733	2,428,023	3,670,781
Colorado	38,000	76,000	159,838	296,940	197,838	372,940
Connecticut	45,188	35,891	162,270	271,867	207,458	307,758
Georgia			1,304,044	560,527	1,304,044	560,527
Idaho			36,250	29,450	36,250	29,450
Illinois	(2)	(2)	(2)	(2)	1,997.499	3,100,860
Indiana	85,061	114,298	1,388,720	2,646,874	1,473,781	2,761,172
Iowa	3,823	14,012	1,004,256	1,294,459	1,008,079	1,308,471
Kansas			607,541	607,541	607,541	607,541
Kentucky			644,388	799,513	644,388	799,513
Louisiana			749,432	749,432	749,432	749,432
Maine			41,114	49,917	41,114	49,917
Maryland	(2)	(2)	(2)	(2)	585,694	707,975
Massachusetts			83,221	70,724	83,221	70,724
Michigan	(2)	(2)	(2)	(2)	1,737,588	1,904,389
Minnesota			125,387	162,997	125,387	162,997
Mississippi			597,694	599,156	597,694	599,156
Missouri			998,533	998,709	998,533	998,709
Montana			63,248	77,167	63,248	77,167
Nebraska			106,870	108,243	106,870	108,243
New Hampshire			27,260	27,260	27,260	27,260
New Jersey	(2)	(2)	(2)	(2)	536,619	659,059
New Mexico	1,647	12,926	54,840	118,616	56,487	131,542
New York	(2)	(2)	(2)	(2)	1,172,492	1,716,704
North Carolina			2,476,170	1,547,680	2,476,170	1,547,680
North Dakota			102,044	128,444	102,044	128,444
Ohio	156,424	206,100	2,705,800	3,200.576	2,862,224	3,406,676
Oklahoma			733,900	734,400	733,900	734,400
Oregon	(2)	(2)	(2)	(2)	316,900	362,720
Pennsylvania	(2)	(2)	(2)	(2)	1,699,447	4,895,957
South Carolina			850,254	698,727	850,254	698,727
South Dakota			201,970	201,970	201,970	201,970
Tennessee	(2)	(2)	(2)	(2)	965,908	373,449
Texas	14,266	27,253	2,456,691	2,489,866	2,470,957	2,517,119
Utah	6,623	8,824	99,681	199,467	106,304	208,291
Virginia			1,347,766	1,394,665	1,347,766	1,394,665
Washington	(2)	(2)	(2)	(2)	169,370	162,115
West Virginia			279,570	310,341	279,570	310,341
Wisconsin			144,358	156,018	144,358	156,018
Undistributed [3]	894,491	993,498	[4] 8,963,560	[4] 13,609,553	[4] 676,534	[4] 719,823
Total	1,457,387	2,101,850	[4] 32,842,407	[4] 39,263,112	[4] 34,299,794	[4] 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

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
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

[1] Includes Puerto Rico 1953–54.
[2] Included with "Undistributed."
[3] Includes States indicated by footnote 2 and Alaska (1960), Delaware, District of Columbia, Florida, Hawaii (1960), Maryland (1961), Nevada, North Dakota (1961), Utah (1961), Vermont, and Wyoming.
[4] Revised figure.

CONSUMPTION AND USES—ALL CLAYS

Of the total clay consumed in 1961, heavy clay products (building brick, structural tile, and sewer tile) accounted for 46 percent. The total tonnage and value of clays consumed decreased 3 percent.

Some decreases for individual classifications were total refractories, 20 percent; floor and wall tile, 19 percent; insecticides and fungicides, 16 percent; pottery and stoneware, 10 percent; and exports, 8 percent. Some increases in consumption were: Absorbents, 61 percent; lightweight aggregate, 10 percent; paper coating, 9 percent; total filler, 3 percent; rotary drilling mud, 3 percent; and whiteware, 2 percent.

Refractories.—In 1961 manufacturers' shipments of clay refractories amounted to $168 million, a 6-percent decline from the 1960 value. Almost all classifications of clay refractories registered decreases.

Trends in the refractories industry were toward increased use of insulating firebrick in kiln and furnace construction; attention of manufacturers to supplying customer requirements for more and better technical know-how, as evidenced by expansion of research facilities; improvement in purity of existing materials to satisfy higher temperature requirements of the steel and ceramic industries, rather than a search for new materials; improvements in abrasion and spalling resistance, of concern primarily to the cement and lime industries; and improvement in plastics and castables lines. Other features in increasing demand by various consumers are; more uniform surface textures, higher mechanical strength, lighter weight, more accurate dimensions.

A detailed account of the new H. K. Porter Co. basic refractory plant at Pascagoula, Miss., was published.[13]

TABLE 10.—Clay sold or used by producers in the United States in 1961, 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.	121,360	235,782					357,142
Stoneware, including chemical stoneware			17,726			10,642	28,368
Art pottery, flower pots, and glaze slip	6,485		6,828			61,813	75,126
Total	127,845	235,782	24,554			72,455	460,636
Floor and wall tile	12,225	92,299	109,052			104,769	318,345
Refractories:							
Firebrick and block	241,855		3,350,336				3,592,191
Bauxite, high-alumina brick			24,373				24,373
Fire-clay mortar			77,920			6,880	84,800
Clay crucibles			31,760				31,760
Glass refractories			3,367				3,367
Zinc retorts and condensers			46,119				46,119
Foundries and steelworks			461,340	384,182		7,657	853,179
Saggers, pins, stilts, and wads			116,042				116,042
Other refractories	78,465	44,522	178,331			27,724	329,042
Total	320,320	44,522	4,289,588	384,182		42,261	5,080,873
Heavy clay products: Building brick, paving brick, drain tile, sewer pipe, and kindred products		49,340	4,150,802			17,704,263	21,904,405
Architectural terra cotta			4,033				4,033
Lightweight aggregates						6,047,092	6,047,092
Filler:							
Paper filling	577,782						577,782
Paper coating	880,000						880,000
Rubber	327,094						327,094
Linoleum and oilcloth			6,400				6,400
Paint	54,650						54,650
Fertilizers	18,366		1,800			4,298	24,464
Insecticides and fungicides	26,505			34,090	103,536		164,131
Other fillers	104,688	4,600	8,926	617	4,397	4,907	128,135
Total	1,989,085	4,600	17,126	34,707	107,933	9,205	2,162,656
Portland and other hydraulic cements	59,069		14,445			9,688,258	9,761,772
Miscellaneous:							
Filtering and declorizing (raw and activated earths):							
Mineral oils and greases				60,845	31,807		92,652
Vegetable or animal oils and fats				15,330	1,303		16,633
Other filtering and clarifying				4,540	712		5,252
Rotary-drilling mud			1,382	413,611	61,109	8,900	485,002
Chemicals	27,203		68,050				95,253
Absorbent uses				109,836	191,376		301,212
Exports	95,347			43,813	280		139,440
Other uses	108,722	18,050	10,685	240,327	27,661	110,726	516,171
Total	231,272	18,050	80,117	888,302	314,248	119,626	1,651,615
Grand total:							
1961	2,739,816	444,593	8,689,717	1,307,191	422,181	33,787,929	47,391,427
1960	2,730,451	444,369	9,915,372	1,268,800	408,325	[1]34,299,794	[1]49,067,111

[1] Revised figure.

[13] Trauffer, W. E. South's First Sea Water Magnesite Basic Refractory Plant. Pit and Quarry, v. 54, No. 2, August 1961, pp. 78–84, 89.

Details, complete with flowsheet, of the new plant of North American Refractories Co. at Cleveland, Ohio, were presented.[14] Officials of this company announced the acquisition of Ironton Fire Brick Co. of Ironton, Ohio.

Kaiser Refractories and Chemicals Division, Kaiser Aluminum & Chemical Corp. completed its new technical center at Mexico, Mo., to be used to develop new or improved fire clay, silica, and alumina refractory brick and specialties.

Rutland Fire Clay Co. of Vermont set up a new plant at Gastonia, N.C.

A $2.5 million expansion and modernization program at the H. K. Porter Co. refractories division's Buckeye Works, Wellsville, Ohio, was completed. Improvements included a modern mechanized mine and modern tunnel kilns.

New additions were announced by McDanel Refractory Porcelain Co., of Beaver Falls, Pa., and American Clay Forming Co., Tyler, Tex.

TABLE 11.—Shipments of refractories in the United States, by kinds

Product	Unit of quantity	Shipments			
		1960		1961	
		Quantity	Value (thousands)	Quantity	Value (thousands)
Clay refractories:					
Fire-clay brick, standard and special shapes, except superduty.	1,000 9-inch equivalent.	341,177	$55,167	279,315	$44,966
Superduty fire-clay brick and shapes	do	70,310	18,679	61,885	17,553
High-alumina brick and shapes (50 percent Al_2O_3 and over) made substantially of calcined diaspore or bauxite.[1]	do	21,962	9,978	23,346	10,851
Insulating firebrick and shapes	do	47,250	11,681	39,412	9,834
Ladle brick	do	193,290	20,438	187,404	20,925
Sleeves, nozzles, runner brick and tuyeres	do	[2] 34,653	[2] 7,640	32,563	6,814
Glasshouse pots, tank blocks, feeder parts and upper structure shapes used only for glass tanks.[1]	Short ton	18,792	5,254	15,681	4,943
Hot-top refractories	do	[2] 69,913	[2] 4,472	75,994	5,167
Clay-kiln furniture, radiant-heater elements, potters' supplies, and other miscellaneous shaped refractory items.			5,345		5,993
Refractory bonding mortars, air-setting (wet and dry types).[3]	Short ton	52,553	6,168	49,010	5,779
Refractory bonding mortars, except air-setting types.[3]	do	11,239	1,038	9,658	987
Ground crude fire clay, high-alumina clay, and silica fire clay.[4]	do	513,006	5,809	432,757	5,573
Plastic refractories and ramming mixes [1]	do	128,122	10,392	138,373	11,407
Castable refractories (hydraulic-setting)	do	92,523	9,217	99,090	10,259
Insulating castable refractories (hydraulic-setting).	do	23,492	2,546	27,312	2,951
Other clay refractory materials sold in lump or ground form.[4 5]	do	241,396	5,012	176,339	4,096
Total clay refractories			[2] 178,836		168,098

See footnotes at end of table.

[14] Brick and Clay Record. North America's New Basic Plant. V. 139, No. 6, December 1961, pp. 50–52, 56.

TABLE 11.—Shipments of refractories in the United States, by kinds—Continued

Product	Unit of quantity	Shipments			
		1960		1961	
		Quantity	Value (thousands)	Quantity	Value (thousands)
Nonclay refractories:					
Silica brick and shapes	1,000 9-inch equivalent.	183,297	$39,069	145,027	$29,643
Magnesite and magnesite-chrome (magnesite predominating) brick and shapes (excluding molten-cast).	do	52,815	45,493	61,659	52,090
Chrome and chrome-magnesite (chrome ore predominating) brick and shapes (excluding molten-cast).	do	44,330	35,742	41,248	32,367
Graphite crucibles, retorts, stopper heads, and other shaped refractories, excluding those containing natural graphite.	Short ton	11,360	8,785	11,939	8,865
Mullite brick and shapes made predominantly of kyanite, sillimanite, andalusite or synthetic mullite (excluding molten-cast).	1,000 9-inch equivalent.	5,559	6,748	4,634	5,768
Extra-high alumina brick and shapes made predominantly of fused bauxite, fused or dense-sintered alumina (excluding molten-cast).	do	3,134	4,937	3,230	5,580
Silicon carbide brick and shapes made substantially of silicon carbide.	do	3,991	9,389	3,780	8,781
Zircon and zirconia brick and shapes made predominantly of either of these materials.	do	1,150	4,510	844	3,386
Forsterite, pyrophyllite, molten-cast, and other nonclay brick and shapes.			23,237		21,685
Nonclay refractory bonding mortars, air-setting (wet and dry types).	Short ton	99,680	10,816	146,744	14,634
Nonclay refractory bonding mortars, except air-setting types.	do	14,039	1,262	13,311	1,157
Nonclay refractory castables (hydraulic-setting).	do	7,789	1,105	12,362	1,752
Nonclay plastic refractories and ramming mixes (wet and dry types).	do	156,986	18,967	194,270	21,066
Dead-burned magnesia or magnesite.[4]	do	138,143	8,367	155,307	9,615
Carbon refractories; brick, blocks, and shapes excluding those containing natural graphite.	do	208,302	16,223	158,264	12,816
Other nonclay gunning mixes	do				
Other nonclay refractory materials sold in lump or ground form.[4]	do				
Total nonclay refractories			234,650		229,205
Grand total refractories			413,486		397,303

[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.—For the second successive year, the clay-industry market was slow during the first half and picked up towards the end of the year. In 1961, the overall decline was 6 percent in total quantity of all clays consumed. In contrast, the value of construction in 1961 increased over that of 1960, indicating competition among heavy clay products and alternate materials. However, the 6 percent decrease of clays reported used in the heavy clay industry did not represent that much loss in the construction industries. The com-

bined use of clays in heavy clay products, lightweight aggregate, and cement was only 1 percent less than in 1960. The fact that over 50 percent of the heavy clay product plants in the United States made improvements or expansions or announced their intention of doing so, attested to the health of, and confidence within, the industry.

Trends were to larger sizes of brick, tile, and panels; increased use of glazed tile; and increased automation of plant operations. Considerable research was conducted on clay-bonded block manufacturing techniques. Use of lightweight aggregate made from expanded clay and shale continued to increase. A number of mergers took place during 1961.

A study was conducted on shipping problems, covering common carriers, contract haulers, and company-owned fleets, and reasons for choice in various regions were presented.[15]

An account, including plant layout, was given of the vitrified clay sewer pipe operation of Pacific Clay Products at Corona, Calif., producer of pipe sizes up to 42 inches in diameter.[16] The new, modern clay-pipe plant of W. S. Dickey Clay Manufacturing Co. at Bessemer, Fla. went into operation and its facilities were described.[17] Another new, highly automated, clay-pipe plant was put into production at Ocala, Fla., by United States Concrete Pipe Co. Operations at this $3 million plant were described.[18] American Vitrified Products Co. attained increased production and cost reduction with new automated equipment in its clay-pipe plant at Somerville, N.J.[19]

The new brick plant of Gleason Clay Products Co. at Gleason, Tenn., was described in detail. This plant produced more than 20 different types and blends of brick and was capable of producing 50,000 bricks a day with a total employment of 33 men.[20] Other new heavy clay products plants completed and in operation were a brick plant by Delta Brick & Tile Co., Inc., at Macon, Miss.; a pottery plant in Kensington, Conn., primarily for flower pots, by Keller-Whilldin Pottery Co.; and a brick plant in Malvern, Ark., with a capacity of 20 million brick annually, by Acme Brick Co.

Stark Ceramics, Inc., Canton, Ohio, completed an expansion program designed to increase production of lightweight glazed structural units to 14,000 tons monthly. The new facilities were described.[21]

Other expansion programs completed were a new plant at Newell, W. Va., by Globe Brick Co. of East Liverpool, Ohio; installation of new brick-making machinery capable of extruding a column of clay at the rate of 16,000 brick an hour, in the Denver, Colo., plant of Robinson Brick & Tile Co., and installation of facilities for increasing production by 36 million brick a year by The Georgia-Carolina Brick and Tile Co., of Augusta, Ga.

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[15] Brick and Clay Record. How Does Clay Industry Ship. V. 139, No. 5, November 1961, pp. 68–69.
[16] Brick and Clay Record. Pacific Clay Pioneers Pipe Progress. V. 138, No. 3, March 1961, pp. 62–64, 82, 84.
[17] Childers, E. S. Engineer Your Plant—W. S. Dickey Did. Ceram. Age, v. 77, No. 4, April 1961, pp. 34–37.
[18] Brick and Clay Record. Clay Pipe Joins Florida Boom. V. 139, No. 1, July 1961, pp. 40–43, 66–68.
[19] Ceramic Age. Amoit Builds for Increased Efficiency. V. 77, No. 8, August 1961, pp. 25, 27.
[20] Brick and Clay Record. Gleason, Tennessee. V. 138, No. 5, May 1961, pp. 40–42, 56.
[21] Brick and Clay Record, New Facilities for the Future. V. 139, No. 6, December 1961, pp. 40–42.

Rockford Brick and Tile Co., Rockford, Iowa, Dixie Brick, Inc., Natchitocher, La., and Elgin Standard Brick Manufacturing Co., Austin, Tex., were expanding their plants to increase production.

A number of other plants throughout the country, manufacturing brick, pipe, and tile, announced plans for expansion; and others modernized existing plants for more economical operation.

Some clay products plants, shut for various periods of time, resumed production or were being renovated for reopening.

Some of the many mergers that took place in the clay products industry were: Stylon Corp., Milford, Mass., producer of ceramic tile, acquired the Cal-Mar Tile Manufacturing Co. plant at Salt Lake City, Utah; Thermal Ceramics Industries, Inc., Denver, Colo., purchased Brazil Hollow Brick & Tile Co., Brazil, Ind., and renamed the firm Denver Fire Clay Co. of Indiana, Inc.; Sylvan Ceramic, Inc., Pasadena, Calif., purchased the Stockton plant of Laurel Potteries of Calif.; Gladding, McBean & Co., Los Angeles, Calif., acquired Harrisville Brick Co., Ogden, Utah; Texstar Corp., San Antonio, Tex., acquired Desert Ceramic Corp., Albuquerque, N.M.; Acme Brick Co., Fort Worth, Tex., purchased all assets of Fraser Brick & Tile Co., Sequin, Tex.; Mississippi Industries acquired Atlas Tile and Brick Co., Shuqualak, Miss.; and Jackson Sand Mining Co., Jackson, Ohio, assumed control of McArthur Brick Co., McArthur, Ohio.

A number of articles described the operations of expanded clay or shale lightweight aggregate operations.[22]

Another article described the conversion of a burned-down brick plant into a lightweight aggregate producing operation.[23]

A number of companies were constructing plants to produce lightweight aggregate from expanded clay and shale with production expected to commence in 1962. They were Susquehanna-Western, Inc. a subsidiary of The Susquehanna Corp. of Chicago, to produce aggregate from expanded shale by rotary kiln, near Clemente, Calif.; New York Trap Rock Corp., through a subsidiary company, to produce lightweight aggregate at the rate of 500,000 cubic yards a year, at Ulster, N.Y.; Buildex. Inc., Ottawa, Kans., to produce expanded shale aggregate by the rotary-kiln method at the company's second plant, near Marquette, Kans.; The Idealite Co., to produce a coated type of expanded shale aggregate, near Golden, Colo.; and the Hudson Valley Lightweight Aggregate Corporation, to produce aggregate by the rotary-kiln method, at Saugerties, N.Y.

Other plants were planned by Waco Aggregate Co. at Waco, Tex.; Baukol-Noona, Inc., at Mandon, N.D.; and Masslite, Inc., at Plaineville, Mass.

The country's first clay-block plant was completed and put into operation 10 miles west of Statesville, N.C.

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[22] Bergstrom, J. H. Rocklite Celebrates 20th Birthday. Rock Products, v. 64, No. 7, July 1961, pp. 64–65, 117. Herod, B. C. North Central Lightweight Aggregate Co. Pit and Quarry, v. 53, No. 10, April 1961, pp. 144–147, 150–151.
Herod, B. C. Veteran Haydite Operation Meets Market Challenge. Pit and Quarry, v. 54, No. 5, November 1961, pp. 90–93, 95.

[23] Brick and Clay Record. Convert It to Lightweight Aggregate Operation. V. 138, No. 6, June 1961, pp. 66–67, 73.

TABLE 12.—Shipments of principal structural clay products in the United States

Product	Unit of quantity	Shipments			
		1960		1961	
		Quantity	Value (thousands)	Quantity	Value (thousands)
Unglazed brick (building)	1,000 standard brick	6,502,200	$223,500	6,427,600	$225,300
Unglazed structural tile	Short tons	488,200	7,800	476,000	7,400
Vitrified clay sewer pipe and fittings.	do	1,854,500	94,800	1,749,000	89,600
Facing tile, ceramic glazed, including glazed brick.	1,000-brick equivalent	369,500	29,100	388,000	30,400
Facing tile, unglazed and salt glazed.	1,000-tile, 8- by 5- by 12-inch, equivalent.	12,300	2,600	11,900	2,100
Clay floor and wall tile and accessories, including quarry tile.	1,000 square feet	233,000	129,500	228,400	124,300
Total			487,300		479,100

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

WORLD REVIEW

NORTH AMERICA

Canada.—Reviews of bentonite,[24] clays and clay products,[25] and lightweight aggregates[26] in Canada in 1960 were published. The occurrence, use, and export-import information on bentonite, miscellaneous clay and shale, stoneware clay, fire clay, ball clay, and kaolin were reported.

A third producer of bentonite, Baroid of Canada, Ltd., began operations at Onoway, Alberta, in 1960. This rapidly expanding local industry lowered the need for imported U.S. activated clays to 5,878 tons in 1960, in spite of Canada's growing needs. The value of clay products made in Canada from domestic and imported clays during 1960 was Can$63.1 million, a decline of 5 percent from the 1959 revised figure of Can$66.5 million. Production from domestic clays showed a corresponding 6-percent decrease from the 1959 revised figure of Can$42.5 million. The value of domestic clays including bentonite, not used in clay products, increased significantly to Can$1 million in 1960.

The value of imports of clay and clay products was Can$42.4 million, a slight decrease, and of exports Can$5 million, about the same as in 1959.

A number of new clay-mining operations were started during 1960.

Although the total value of construction in Canada in 1960 was 3 percent less than in 1959 and production of all lightweight aggregate was about the same, there was a 25-percent increase in expanded clay and shale aggregate, to 363,600 cubic yards valued at Can$2 million.

[24] Ross, J. S. Bentonite, 1960. Dept. of Mines and Tech. Surveys, Ottawa, Canada, Rev. 33, May 1961, 5 pp.
[25] Brady, J. G. Clays and Clay Products, 1960. Dept. of Mines and Tech. Surveys, Ottawa, Canada, Rev. 35, July 1961, 10 pp.
[26] Wilson, H. S. Lightweight Aggregates, 1960, Preliminary. Dept. of Mines and Tech. Surveys, Ottawa, Canada, Rev. 29, May 1961, 5 pp.

Hoganar of Canada, a new company, was established to manufacture tile, brick, glazed pipe, and other materials. National Sewer Pipe, Ltd., Oakville, Ontario, announced that it would manufacture ceramic glazed structural tile and glazed brick not previously produced in Canada.

A revised list of ceramic plants in Canada appeared. Included was information on location, management, kind and source of raw materials used, processes, number and types of kilns, fuel used, products, and plant capacity. Information included data received up to July 1, 1961.[27]

SOUTH AMERICA

Chile.—Production of clay for ceramic and refractory use amounted to 33,060 short tons, and of kaolin, 9,367 tons.[28]

Peru.—Production of clay for building brick in 1960 totaled 244,402 short tons valued at US$490,112. Production of clay for refractories was 3,850 tons valued at US$13,016.[29]

Uruguay.—In 1961, production of common clay amounted to 17,684 short tons, and of refractory clay, 73,119 tons.[30]

EUROPE

Austria.—Output of kaolin in 1961 was 378,969 short tons. Bentonite totaled 3,950 tons; common clay, 54,266 tons; and clay sand, 62,478 tons.[31]

Italy.—Kaolin output in 1961 amounted to 48,486 short tons and that of bentonite was 144,509 tons.[32]

Portugal.—During the first 4 months of 1961, production of kaolin was 8,300 short tons, of which 77 percent was exported.[33]

U.S.S.R.—It was reported that 2 million tons of kaolin was produced in 1960, mostly from the Ukraine, and that double this quantity was required to satisfy growing needs, especially in the paper industry.[34]

United Kingdom.—Production of fire clay in Northern Ireland in 1961 amounted to 19,975 short tons with a value of US$57,338; common clay output was 223,836 tons valued at US$137,038.[35]

Yugoslavia.—Production of fire clay in 1961 was 132,877 short tons valued at US$2,014,000; bentonite production was 19,836 tons valued at US$540,000. Some poor grade kaolin was produced, but data on it were not available.[36]

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[27] Department of Mines and Technical Surveys, Ottawa. Ceramic Plants in Canada. Ind. Min. Div. Operators List 6. July 1961, 39 pp.
[28] U.S. Embassy, Santiago, Chile. State Department Dispatch 645. Apr. 17, 1962, p. 2.
[29] Bureau of Mines. Mineral Trade Notes. V. 53, No. 3, September 1961, p. 10.
[30] U.S. Embassy, Montevideo, Uruguay. State Department Dispatch 555, Apr. 2, 1962, p. 1.
[31] U.S. Embassy, Vienna, Austria. State Department Dispatch 910. Apr. 11, 1962, pp. 1–2.
[32] U.S. Embassy, Rome, Italy. State Department Dispatch 851. May 4, 1962, p. 4.
[33] Mining Journal (London). Portugal's Mining Statistics. V. 257, No. 6571, July 28, 1961, p. 99.
[34] Mining Journal (London). Mineral Resources Development in U.S.S.R.—II. V. 257, No. 6571, July 28, 1961, pp. 93–94.
[35] U.S. Consulate, Belfast, Ireland. State Department Dispatch 78. Apr. 26, 1962, p. 1.
[36] U.S. Embassy, Belgrade, Yugoslavia. State Department Dispatch 647. Apr. 16, 1962, pp. 1–2.

ASIA

Hong Kong.—Production of kaolin amounted to 7,463 short tons in 1960 compared with 8,137 tons in 1959.[37]

India.—It was announced that the U.S.S.R. would grant credit for construction of a refractories plant near Bhilai, Central India, for production of fire clay and other refractory products.[38]

Japan.—In 1961 Japan produced 33,659 short tons of kaolin and 1,105,929 tons of fire clay. These figures represented increases of 44 percent and 21 percent, respectively, over 1960 production.[39]

Korea, Republic of.—Kaolin production was 56,397 short tons valued at US$708,605 in 1961.[40]

Malaya, Federation of.—Kaolin production in 1961 was 1,760 short tons valued at US$35,540.[41]

Pakistan.—Production of fire clay was 18,000 short tons valued at US$67,525 in 1960. Seventy tons of china clay was produced for experimental purposes, in the vicinity of Bijaipeur in East Pakistan. Extensive tests were made on this clay by the Ceramics Institute at Decca.[42]

Philippines.—A detailed account of the geology, exploration, mining, and processing of a recently investigated deposit of ball clay was presented.[43]

Taiwan.—Production of clay and values by uses for 1961 were reported as follows:[44]

Use:	*Short tons*	*Value*
Cement	228,059	$51,740
Paper industry	3,306	30,000
Brick	551,000	125,000
Ceramics and pottery	44,080	265,000

AFRICA

Algeria.—In 1961 fuller's earth production increased 17 percent over that of 1960 to 128,301 short tons.[45]

Libya.—Eleven million building brick, valued at US$554,400 was produced in 1961.[46]

Morocco.—Production of fuller's earth (smectite and ghassoul) totaled 45,647 short tons, valued at US$208,498 in 1960. Over 50 percent of the output was exported to Algeria, France, and Spain.[47]

Rhodesia and Nyasaland, Federation of.—Output of kaolin in Southern Rhodesia more than tripled in 1961 to 20,386 short tons valued at

[37] Mining Journal (London). The Mineral Deposits of Hong Kong. V. 257, No. 6579, Sept. 22, 1961, p. 285.
[38] Chemical Age (London). Rouble Credit for Indian Project. V. 85, No. 2172, Feb. 25, 1961, p. 330.
[39] U.S. Embassy, Tokyo, Japan. State Department Dispatch 820. Apr. 4, 1962, p. 2.
[40] U.S. Embassy, Seoul, Korea. State Department Dispatch 413. May 14, 1962, p. 1.
[41] U.S. Embassy, Kuala Lumpur, Malaya. State Department Dispatch 321. May 16, 1962, p. 1.
[42] Bureau of Mines. Mineral Trade Notes. V. 53, No. 1, July 1961, pp. 12–14.
[43] Viloria, R. L. The Ball Clay of del Fallego, Camarines Sur. Min. Newsletter (Philippines), v. 12, No. 5, May–June, 1961, pp. 3–7.
[44] U.S. Embassy, Taipei, Taiwan. State Department Dispatch 427. May 2, 1962, pp. 5–6.
[45] U.S. Consulate, Algiers, Algeria. State Department Dispatch 282. May 17, 1962, p. 1.
[46] U.S. Embassy, Tripoli, Libya. State Department Dispatch 301. Apr. 2, 1962, p. 1.
[47] Bureau of Mines. Mineral Trade Notes. V. 53, No. 4, October 1961, pp. 10–11.

US$14,109. Fire clay production was 16,138 tons valued at US$21,473.[48]

Uganda.—Koki Kaolin Mines and Manufacturers were hoping to interest foreign capital to exploit what is reportedly the only kaolin mine in the country.[49]

Union of South Africa.—Reported sales of clay in 1961 were as follows: Fuller's earth, 740 short tons valued at US$3,080, and kaolin, 27,001 tons valued at US$147,794.[50]

OCEANIA

Australia.—It was announced that Swindell-Dressler Corp. would construct a US$2.5 million brick plant near Sydney, with a capacity of 82 million brick a year.[51]

Two U.S. refractories manufacturers, Harbison-Walker Refractories Co., and The Carborundum Co. were reported to have formed associations with local companies to manufacture fire brick and associated products.[52]

Universal Milling Co. registered a claim of over 45 acres near Coolgardie, said to contain the only known deposit of halloysite in Australia.[53]

TECHNOLOGY

A bulletin on Colorado clays was published, including some basic information on clays, geology, occurrence, clay testing, physical and chemical properties, firing properties, uses, statistical data, and potential.[54]

The American Petroleum Institute published a supplement to the reference clay minerals studies, presenting revised X-ray diffraction information based on the original specimens.[55]

The evolution of methods of analysis of clay and possible future rapid-technique developments were discussed.[56]

A method for rapid identification of clay minerals in natural clays or in artificial aggregates, based on certain physical properties of clay minerals and clay aggregates in the presence of polar liquids, was described.[57] Other work was conducted on the density separation of clay minerals in thallous formate solutions in an effort to develop a method of quantitative analysis.[58]

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[48] U.S. Consulate, Johannesburg, Union of South Africa. State Department Dispatch 431. Apr. 26, 1962, p. 1.
[49] Foreign Commerce Weekly. Uganda Seeks Kaolin Mine Capital. V. 66, No. 21, Nov. 20, 1961, p. 20.
[50] U.S. Consulate, Johannesburg, Union of South Africa. State Department Dispatch 390. Mar. 14, 1962, p. 2.
[51] Brick and Clay Record. To Build Australian Brick Plant. V. 131, No. 1, January 1961, pp. 36, 38.
[52] U.S. Consulate, Sydney, Australia. State Department Dispatch 241. Feb. 7, 1962, p. 1.
[53] Financial Standard (Melbourne). Unique Mineral Clay Found. V. 117, No. 2926, Apr. 20, 1961, p. 26.
[54] Yingst, Parke O. Colorado Clay. Colorado Sch. Mines Miner. Ind. Bull., v. 4, July 1961, 8 pp.
[55] Molloy, M. W., and P. F. Kerr. Diffractometer of A.P.I. Reference Clay Minerals. Am. Mineral., v. 46, Nos. 5–6, May–June 1961, pp. 583–605.
[56] Bennett, H. The Chemical Analysis of Clay—Today and Tomorrow. Trans. Brit. Ceram. Soc., v. 60, No. 3, March 1961, pp. 165–176.
[57] Konta, J. Imbibometry—A New Method for the Investigation of Clays. Am. Mineral., v. 46, Nos. 3–4, March–April 1961, pp. 289–303.
[58] Kittrick, J. A. The Density Separation of Clay Minerals in Thallous Formate Solutions. Am. Mineral., v. 46, Nos. 5–6, May–June 1961, pp. 744–747.

The results of experimental studies to determine the effect of natural water in clay, prior to mixing and forming, and water content versus forming pressure were published.[59]

Clarification of the advantages, processing methods, and results of using calcined clay was presented.[60]

A comprehensive paper describing the electric charges of clays appeared.[61]

Work was conducted on developing standards for the quantitative determination of kaolinites by X-ray diffraction.[62] The scope of the quantitative determination of the constituents of kaolins and other clays was discussed. The internal standard method was reported to be the most reliable.[63]

Experiments were conducted on low-temperature synthesis of kaolin minerals.[64] A study was made on the flow and failure of refractories using kaolin and controlled variables of composition, temperature, and stress.[65]

Other kaolin research was conducted on fluidification,[66] differential thermal curves,[67] and exothermic reactions.[68]

Results of a study to show the effect of soluble salts on the casting properties of ball clays were presented.[69]

An extensive report, with many diagrams, presenting chemical, cation exchange, differential thermal, infrared, and optical data on 40 samples of the montmorillonite group of clay minerals was published.[70]

The properties of molding sands (sand-bentonite-water-air), green, dry, and at high temperatures are governed by intergranular bond, properties and surface area of the aggregate, particle size and packing, and number and size of voids, according to a well-illustrated article.[71]

Information on the use of bentonite as a fire retardant[72] and in foundation engineering appeared.[73]

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[59] Ekedahl, Charles Influence of Water and Pressure on the Forming of Clay Bodies. Ceram. Age, v. 77, No. 5, May 1961, pp. 28–30, 32–33.

[60] Brick and Clay Record. Calcining Cuts Density, Maintains Brick Strength. V. 138, No. 2, February 1961, pp. 46–47.

[61] Cashen, G. H. Electric Charges of Clays. Chem. and Ind. (London), No. 43, Oct. 28, 1961, pp. 1732–1737.

[62] Brindley, G. W., and Sari S. Kurtossy. Quantitative Determination of Kaolinite by X-Ray Diffraction. Am. Mineral., v. 46, Nos. 11–12, November–December 1961, pp. 1205–1215.

[63] Weigmann, J., and Z. Kranz. A Contribution to the Quantitative Analysis of Clays, Kaolins and Similar Minerals by X-Ray Methods. Ber. dtsch. keram., v. 38, No. 7, July 1961, pp. 294–302.

[64] Brindley, G. W., and C. De Kimpe. Attempted Low-Temperature Syntheses of Kaolin Minerals. Nature, v. 190, No. 4772, January 1961, p. 254.

[65] Chi, Vng Vp, and R. B. Sosman. Deformation of a Kaolinite Body Under Stress at High Temperatures. Am. Ceram. Soc. Bull. v. 40, No. 7, July 1961, pp. 426–431.

[66] Czerch, W. K. Fruhauf, and V. Hofmann. Causes of the Fluidification of Kaolin. Ber. dtsch. keram., v. 37, No. 6, June 1960, pp. 255–265; Building Sci. Abs., v. 33, No. 12, December 1960, pp. 367–368.

[67] McLaughlin, R. J. W. Effect of Dilution on the Shape of Differential Thermal Curves of Kaolinite. Trans. Brit. Ceram. Soc., v. 60, No. 3, March 1961, pp. 177–189; Building Sci. Abs., v. 34, No. 9, September 1961, p. 257.

[68] Freund, F. Explanation of the Exothermic Reaction of Kaolinite as a Reaction of the Active State. Ber. deut. keram., v. 37, No. 5, May 1960, pp. 209–218; J. Am. Ceram. Abs., v. 44, No. 8, August 1961, p. 188.

[69] Phelps, G. W. Soluble Salts. Ceram. Ind., v. 76, No. 3, March 1961, pp. 68–69.

[70] Grim, R. E., and Kulbicki. Montmorillonite–High Temperature Reactions and Classification. Am. Mineral., v. 46, Nos. 11–12, November–December 1961, pp. 1329–1369.

[71] Lawrence, Dr. W. G. Factors Influencing Molding Sand Properties. Foundry, v. 89, No. 10, October 1961, pp. 61–67.

[72] Chemical Trade Journal and Chemical Engineer (London). Bentonite as a Fire Retardant. V. 149, No. 3877, Sept. 22, 1961, p. 628.

[73] Schweiz Bauztg. Bentonite in Foundation Engineering. V. 78, No. 19, 1960, pp. 313–315; Bldg. Sci. Abs., v. 34, No. 4, April 1961, p. 117.

The optimum conditions for the best results in pelletizing iron ore, and the functions of bentonite in the process, were explained.[74] Another article described the operation of pelletizing iron concentrate by mixing reground material with bentonite with the use of a grate-kiln process.[75]

Research on improving blast furnace coke quality with special reference to the effect of bentonite was conducted.[76]

The Bureau of Mines published a report on the first phase of research work aimed at developing economical methods of upgrading refractory clays by removing excessive quartz, pyrite, and other impurities.[77]

Data were presented on the use of ion-exchange analysis as a rapid and accurate method for the determination of alumina and alkali oxide impurities in fire-clay materials.[78]

A new process for making insulating firebrick, consisting of mixing fire clay, kaolin, sawdust, and grog and firing in slabs 26 by 10 by 3 inches was developed. Brick were cut from the fired slabs.[79]

Laboratory tests showed that the physical and mechanical properties of basic brick varied widely with differences in processing, and the best results were obtained for a narrow range of bond water content at maximum pressure.[80]

Articles discussed the technical aspects of insulating firebrick.[81]

An abrassive test for refractory brick was developed. The apparatus and procedure were described, and data were given for fireclay, and high-alumina, silica, and basic refractory brick.[82]

Articles described how automatic blending of raw materials improved structural clay products.[83]

A glossary of terms relating to structural clay products and technical notes on manufacturing structural clay products [84] were among the releases of the Structural Clay Products Institute.

Data were presented on a study of the bloating mechanism in producing pellets with central cavities and a strong porous wall by a con-

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[74] Mining World. Sephon Sizers Reduce Silica—Improve Green Pellets for Harder Firing. V. 12, No. 2, February 1961, pp. 22–23.

[75] Urich, D. M. Pelletizing Humboldt's Iron Concentrate by Grate-Kiln Process. Mining World, v. 23, No. 11, October 1961, pp. 16–21.

[76] Gregory, J. A. Research into Methods of Improving Blast Furnace Coke Quality. Blast Furnace & Steel Plant, v. 45, No. 5, May 1961, pp. 426–431.

[77] Calhoun, W. A., and H. E. Powell. Removing Quartz and Other Impurities from Refractory Clays by Mineral Dressing Methods. BuMines, Rept. of Inv. 5754, 1961, 22 pp.

[78] Osborn, W. O. Separate Determination of Aluminum and of Lithium, Sodium, and Potassium in Fire-Clay and Silica Raw Materials and Refractories by Cation-Exchange Chromatography. J. Am. Ceram. Soc., v. 44, No. 11, Nov. 1, 1961, pp. 527–532.

[79] Brick and Clay Record. Johns-Manville Firebrick Are Different. V. 138, No. 5, May 1961, pp. 48–50, 58, 60, 62–63.

[80] Eusner, G. R., and D. H. Hubble. Effect of Some Processing Variables in Basic-Brick Manufacture. Am. Ceram. Soc. Bull., v. 40, No. 11, Nov. 15, 1961, pp. 698–701.

[81] McCullough, J. D., and E. B. Suddarth. How Insulating Firebrick Affect your Shuttle Kiln. Brick and Clay Record, v. 139, No. 2, August 1961, pp. 48–50, 53, 55. Ceramic Industry. A Design That Delivers Profit. V. 76, No. 2, February 1961, pp. 30–31.

[82] Reid, D. R., and Edwin Ruh. Abrasion Resistance of Refractories. Am. Ceram. Soc. Bull., v. 40, No. 7, July 1961, pp. 452–455.

[83] Russell, Dan R. Automatic Batching, Modernization Program Means Progress at General-Hocking Brick. Ceram. Age, v. 77, No. 7, July 1961, pp. 20–22.

Oesch, R. B. Blending of Materials for Structural Clay Products by Continuous Weighing. Am. Ceram. Soc. Bull., v. 40, No. 12, December 1961, pp. 735–737.

[84] Structural Clay Products Institute. Technical Notes, Glossary of Terms Relating to Structural Clay Products. No. 2, February 1961, 4 pp.

Structural Clay Products Institute. Technical Notes, Manufacturing Structural Clay Products. No. 9, September 1961, 4 pp.

trolled preheating to 550° to 600° C and a second flash-firing at about 1,250° C.[85]

Studies showed that the most common gas-producing reaction in the production of lightweight aggregate from clays and shales was the reduction of iron oxide to the ferrous state.[86]

The introduction of tube coolers in a clay lightweight-aggregate plant was expected to increase efficiency and conserve space.[87]

Freezing and thawing tests were conducted on concrete made from a number of lightweight aggregates, and the collected data were presented.[88]

Clay-bonded block received much attention in 1961. Technical aspects, including types of aggregates, forming process, firing, and glazing, were discussed at a meeting of clay and concrete block industry representatives from the United States, Canada, and Mexico.[89]

The Structural Clay Products Research Foundation released information on the production of 8- by 8- by 16-inch clay.[90]

A number of other articles on clay-bonded block covering aggregates,[91] formation on concrete block machines,[92] firing schedule,[93] and other background information appeared.[94]

Studies showed that when dried brick is stored too long under fluctuating atmospheric conditions before firing an inferior product results.[95]

Equilibrium conditions in matured brick were studied in an attempt to determine proper firing cycles for producing better finished products.[96]

An investigation of hot-pressing techniques to attain dense bodies, with low water absorption and zero thermal expansion was reported.[97]

The operation of a newly installed shuttle-kiln showed how a brick plant could modernize and lower operating expenses at low cost.[98]

It was shown that it is possible to eliminate large losses in fired ware by a systematic method of testing wet ware at the off-bearing belt, as well as dry unfired ware.[99]

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[85] Slamboliev, Hristo. Production of Hollow Lightweight Aggregate by Controlled Preheating. J. Am. Ceram. Soc., v. 44, No. 12, Dec. 1, 1961, pp. 577–583.

[86] Hill, R. D., and D. N. Crook. Some Causes of Bloating in Expanded Clay and Shale Aggregates. Australian J. Appl. Sci., v. 2, No. 3, September 1960, pp. 374–384.

[87] Mining Engineering. Tube Coolers for Lightweight Aggregates. V. 13, No. 5, May 1961, p. 438.

[88] Klieger, Paul, and J. A. Hannon. Freezing and Thawing Tests of Lightweight Aggregate Concrete. J. Am. Concrete Inst., v. 32, No. 7, July 1961, pp. 779–796.

[89] Brick and Clay Record. Clay Block Comes of Age. V. 138, No. 4, April 1961, pp. 75–79, 122, 124, 126, 131

[90] Brick and Clay Record. Research Shifts into High. V. 139, No. 2, August 1961, pp. 42–45.

[91] Robinson, C. G. Use These Aggregates in Making Clay Block. Brick and Clay Record, v. 138, No. 5, May 1961, pp. 51–52.

[92] Robinson, C. G. Clay Block on Concrete Block Machines. Brick and Clay Record, v. 139, No. 6, December 1961, pp. 43–47.

[93] Moffitt, Roy B. Determine Firing Schedule of Ceramic Block. Brick and Clay Record, v. 139, No. 5, November 1961, pp. 60–62, 83.

[94] Moffitt, Roy B. Why Not Call it Ceramic Block. Brick and Clay Record, v. 139, No. 2, August 1961, pp. 38–40, 62.

[95] Anwyl, Robert H. Deterioration of Dried Brick. Am. Ceram. Soc. Bull., v. 40, No. 6, June 1961, pp. 359–361.

[96] Hedges, P. E. Crystalline and Glassy Phases in Commercially Fired Brick. Am. Ceram. Soc. Bull., v. 40, No. 6, June 1961, pp. 371–377.

[97] Weiss, David, and W. J. Knapp. Hot-Pressing a Simple Petalite-Clay Body. Am. Ceram. Soc. Bull., v. 40, No. 2, February 1961, pp. 66–67.

[98] Brick and Clay Record. Modernize at Low Cost with New Envelope Kiln. V. 138, No. 6, June 1961, pp. 64–65, 96.

[99] Hough, Carlton H. Put a Number on Quality—at the Machine. Am. Ceram. Soc. Bull., v. 40, No. 3, March 1961, pp. 117–121.

Some problems in maintaining heat balance in firing of tunnel kilns,[1] and down draft kilns [2] were discussed and diagnosed.

A roller conveyor tunnel kiln was designed and a scale model built in the laboratories of the State University of New York College of Ceramics at Alfred University. It was intended for the continuous, automatic production of structural clay products, and operated at 1,800° to 2,400° F.[3]

An article presented some of the principles, problems, and possible remedies in attaining rapid tunnel-kiln firing without losing the effects of uniform heating.[4]

Ceramic research was conducted on cutting the firing time for floor and wall tile to 1 hour.[5]

A new clay quarry tile only 5/16-inch thick was produced in both rectangular and contoured shapes.[6]

A new packaging machine effected a 20-percent saving in labor and lowered the amount of brick chippage.[7]

A patent was issued on a process for separating clays into particle-size fractions by subjecting an aqueous solution of clay and deflocculant to a sedimentation force several hundred times the force of gravity.[8] Another method of fractionation of kaolin, to produce paper coating clay, was patented.[9]

Patents were issued on new methods of producing activated kaolin by dry processes.[10]

Other patents were obtained on methods and equipment for bleaching,[11] flocculating,[12] filtering,[13] and extracting [14] kaolin suitable for paper coating and other special uses.

Patents were issued on methods of using acid-activated kaolin for removing deleterious hydrocarbons from cigarette tobaccos,[15] as crack-

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[1] Whitaker, L. R. Solve Your Problems in Heating and Cooling. Brick and Clay Record, v. 139, No. 2, August 1961, pp. 35–37.

[2] Seanor, J. G. Static Pressure in Down-Draft Kilns. Brick and Clay Record, v. 138, No. 1, January 1961, pp. 86–89, 111.

[3] Coffin, L. B., and D. O. Anderson. A Continuous Roller Conveyor Kiln. Am. Ceram. Soc. Bull., v. 40, No. 3, March 1961, pp. 126–130.

[4] Brickhouse, Robert. Circulation: A Necessity For Heat Uniformity. Ceram. Age, v. 77, No. 2, December 1961, pp. 31–32, 34, 36.

[5] Ceramic Industry. Cuts Tile Firing Time. V. 76, No. 3, March 1961, p. 38.

[6] Ceramic Industry. Royal Announces Streamlined Natural Clay Tile. V. 76, No. 5, May 1961, p. 28.

[7] Brick and Clay Record. Package 100 Brick Every 19 Seconds. V. 138, No. 6, June 1961, pp. 76–78.

[8] Millman, Nathan, and James Brooks Whitley (assigned to J. M. Huber Corp.). Fractionation of Clays. U.S. Pat. 2,987,473, June 6, 1961.

[9] Rouland, B. W. (assigned to Georgia Kaolin Co.). Clay Products and Fractionation Treatment of Heterogeneous Aggregates Such as Clay. U.S. Pat. 2,981,630, Apr. 25, 1961.

[10] Robinson, A. J., and J. V. Weir (assigned to Minerals & Chemicals Philipp Corp.). Activation of Clay by Acid Treatment and Calcination. U.S. Pat. 2,967,157, Jan. 3, 1961.
Robinson, A. J., and J. V. Weir (assigned to Minerals & Chemicals Philipp Corp.) Activation of Clay by Acid Treatment and Calcination in the Presence of Carbonaceous Material. U.S. Pat. 2,988,519, June 13, 1961.

[11] Conley, R. F. (assigned to Georgia Kaolin Co.). Clay Bleaching. U.S. Pat. 3,001,852, Sept. 26, 1961.

[12] Paschall, E. F., and W. H. Minkema (assigned to Corn Products Corp.). Flocculation by Starch Ethers. U.S. Pat. 2,995,513, Aug. 8, 1961.

[13] Demeter, L. (assigned to Licencia Talalmanyokat Ertesito Vallalat, Budapest, Hungary). Filter Press. U.S. Pat. 2,989,187, June 20, 1961.

[14] Roberts, J. T., and J. A. Hjulian (assigned to Crane Co.). Material Extracting Device. U.S. Pat. 3,005,553, Oct. 24, 1961.

[15] Gary, W. W., and A. J. Miller (assigned to Minerals & Chemicals Philipp Corp.). Tobacco Composition and Smokable Unit Containing Material for Removing Deleterious Matter. U.S. Pat. 2,967,118, Jan. 3, 1961.

ing catalysts,[16] and for removing exhaust gases containing unburned hydrocarbons.[17]

A method of treating coating-grade kaolin to obtain phosphate or phosphate-sulfate pigments was patented.[18]

A patent was obtained on an improved process for production of Type A zeolites using kaolin as the starting material.[19]

Patents were issued on the use of bentonite, kaolin, and other clays for treating mine waters,[20] clarifying sugar liquors,[21] briquetting granular materials,[22] and manufacturing pencil leads.[23]

Canadian patents were issued on methods of producing metallurgical grade alumina from clays.[24]

A method for producing high bulk volume, highly absorptive filler clays was patented. The clays are finely ground, injected into a current of gas heated to 500° to 1,200° C, separated from the hot gases, and cooled. The method eliminates sintering of the particles to one another.[25]

A German patent was obtained on a method of bleaching clays and other nonmetallic minerals by acid treatment and ball milling, after which the mixture is allowed to stand for about 2 days and then washed.[26]

A process for stabilizing cation-exchange pellets made of bentonite, hectorite, and other montmorillonitic clays against disintegration in water and other liquids was patented. The stabilization is accomplished by treating with polyvinyl alcohol or incompletely etherified ethyl cellulose polymer, which does not impair the cation-exchange properties.[27]

A number of patents were issued on new clay-thickened greases and lubricating oils, and on new methods for making such products.[28]

New synthetic materials made from attapulgite and sepiolite were patented. The new materials, which were formed by hydrothermal treatment at pressures of several tons, have increased base-exchange

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[16] Talvenheimo, G. (assigned to Houdry Process Corp.). Phosphated Kaolin Cracking Agent. U.S. Pat. 2,967,156, Jan. 3, 1961.

[17] Gary, W. W. (assigned to Minerals & Chemicals Philipp. Corp.). Method of Treating Exhaust Vapors Containing Unburned Fuel Hydrocarbons. U.S. Pat. 3,006,718, Oct. 31, 1961.

[18] Beamesderfer, J. W., and H. H. Morris (assigned to Southern Clays, Inc.). Treatment of Clay. U.S. Pat. 2,974,054, Mar. 7, 1961.

[19] Sensel, E. E. (assigned to Texaco, Inc.). Process for Production of Type A Zeolite. U.S. Pat. 3,009,776, Nov. 21, 1961.

[20] Polibento, S.r.L. Italian Pat. 577,302, May 30, 1958.

[21] Polibento, S.r.L. Italian Pat. 574,771, Mar. 26, 1958.

[22] Ekdahl, W. G. (assigned to Johns-Manville Corp.). Briquetting Granular Material. U.S. Pat. 2,976,162, Mar. 21, 1961.

[23] Murray, H. H., and H. M. Johnson (assigned to Georgia Kaolin Co.). Pencil Clays. U.S. Pat. 2,986,472, May 30, 1961.

[24] Laist, F. (assigned to The Anaconda Co.). Canadian Pats. 617,232 and 617,442, Mar. 28, 1961.

[25] Farbenfabriken Bayer A. G. British Pat. 869,966, June 7, 1961.

[26] Centanin, O. German Pat. 1,090,568, Oct. 6, 1960.

[27] Jones, G. K., and B. S. Neumann (assigned to The Fuller's Earth Union, Ltd.). British Pat. 874,432, Aug. 10, 1961.

[28] Odel, N. R., and J. F. Lyons (assigned to Texaco, Inc.). Solids Thickened Lubricating Greases Containing Formamide. U.S. Pat. 2,986,517, May 30, 1961.

Freeman, P. K., and W. H. Peterson (assigned to Shell Oil Co.). Hydrophobic Oleophilic Organo Clay Thickened Lubricating Oil. U.S. Pat. 2,986,520, May 30, 1961.

Loeffler, D. E. (assigned to Shell Oil Co.). Lubricating Oil Thickened to a Grease with Asphaltem Absorbed Clay. U.S. Pat. 2,981,685, Apr. 25, 1961.

Caruso, G. P. (assigned to Shell Oil Co.). Clay Grease Manufacturing Process. U.S. Pat. 3,006,848, Oct. 10, 1961.

Moore, H. D., and P. Willcock (assigned to Shell Research, Ltd.). British Pat. 875,732, Aug. 23, 1961.

capacity, and were used in drilling muds, paints, plastics, rubber, and other products.[29]

A method was patented for producing brick with machined faces which could be laid with a thin adhesive film of water glass and brick dust.[30]

Foreign patents were issued on methods of making pressure-resistant refractories [31] and chemically inert refractories of fire clays.[32]

A patent was obtained on the production of spark-plug bodies and other ceramics from ball clay and kaolin.[33]

A process for producing expanded clay aggregate pellets with porous interiors was patented. Air-dried peat is added to the clay, which is then pelletized and fired by conventional methods.[34]

High-strength lightweight building units were produced by a newly patented process using swelling bentonite as the binder, together with finely-ground prefired vesicular material and lightweight aggregate. The firing temperature was less than the fusion temperature of the lightweight aggregate.[35]

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[29] Weir, J. V. (assigned o Minerals & Chemicals Philipp Corp.). Adsorptive Porous Minerals Mass and Method of Making Same. U.S. Pat. 2,968,633, Jan. 17, 1961.
Hemstock, G. A. (assigned to Minerals & Chemicals Philipp Corp.). Synthetic Magnesium Aluminum Silicate Product. U.S. Pat. 3,001,853, Sept. 26, 1961.
[30] Intiainen, I. Canadian Pat. 612,958, Jan. 24, 1961.
[31] Terasky, B. German Pat. 1,055,431, Apr. 16, 1959.
[32] Blondel, R. C. M. F. French Pat. 1,207,047, Feb. 12, 1960.
[33] Smith-Gorman, R. J. (assigned to Rolls-Royce Ltd.). British Pat. 880,531, Oct. 25, 1961.
[34] Kiniburgh, W. British Pat. 862,723, Mar. 15, 1961.
[35] Burnett, William H. Building Units and Method of Producing. U.S. Pat. 2,970,060, Jan. 31, 1961.

Cobalt

By Joseph H. Bilbrey, Jr.[1]



DURING 1961, domestic cobalt consumption increased 7 percent to 9.6 million pounds. Imports of cobalt decreased to 10.5 million pounds. The mining and refining facilities of the National Lead Co. at Fredericktown, Mo., were closed, leaving the Bethlehem Cornwall Corp. as the only domestic producer mining cobalt. The refinery of Freeport Nickel Co. at Port Nickel, La., did not operate during the year because suitable concentrate was not available. Free world production of cobalt decreased somewhat because production in Canada and the Federation of Rhodesia and Nyasaland was less. The difficult political situation in the Republic of the Congo did not materially affect cobalt production in 1961.

TABLE 1.—Salient cobalt statistics

(Thousand pounds of contained cobalt)

	1952–56 (average)	1957	1958	1959	1960	1961
United States:						
Domestic mine production of ore or concentrate	2,164	4,144	4,844	2,994	(1)	(1)
Recoverable cobalt	1,537	3,303	4,023	2,331	(1)	(1)
Imports for consumption	16,688	17,379	15,149	21,245	12,170	10,495
Stocks, Dec. 31: Consumer	1,203	977	874	1,403	1,856	1,807
Consumption	9,644	9,157	7,542	9,899	8,930	9,596
Price: Metal—per pound	$2.40–$2.35	$2.35–$2.00	$2.00	$2.00–$1.75	$1.75–$1.50	$1.50
Free world: Production	27,400	31,800	29,200	34,600	[2] 33,600	32,200

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

DOMESTIC PRODUCTION

In 1961 cobalt concentrates were produced only by Bethleham Cornwall Corp. and National Lead Co. The latter company closed its mining and refining facilities at Fredericktown, Mo., in the early part of the year because of depressed metal prices and depletion of the lead and cobalt ore bodies. The plant and equipment were to be liquidated.[2] Bethlehem Cornwall Corp. produced 26 percent more cobalt in concentrate from its magnetic iron ores at Cornwall and Morgantown, Pa. Pyrites Co., Wilmington, Del., processed the concentrate into metal, oxide, and hydrate.

[1] Commodity specialist, assisted technically by Isaac E. Weber, Division of Minerals.
[2] National Lead Co., 70th Annual Report. 1961, pp. 10–12.

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The Bunker Hill Co. recovered 81 tons of residues, containing 7,862 pounds of cobalt at its Kellogg, Idaho, zinc plant. No shipments were made.

The refinery of Freeport Nickel Co. at Port Nickel, La., did not operate during the year because suitable concentrate was not available.

Based on cobalt content, domestic production of cobalt oxide declined 15 percent from 1960, hydrate 4 percent, and salts 14 percent.

TABLE 2.—Cobalt ore or concentrate produced and shipped in the United States

	1952–56 (average)	1957	1958	1959	1960	1961
Produced:						
Gross weight, short tons	25,420	38,417	47,345	45,834	(1)	(1)
Cobalt content, thousand pounds	2,164	4,144	4,844	2,994	(1)	(1)
Recoverable cobalt, do	1,537	3,303	4,023	2,331	(1)	(1)
Shipped from mines:						
Gross weight, short tons	26,074	39,744	46,294	40,896	(1)	(1)
Cobalt content, thousand pounds	2,185	4,123	4,832	2,944	(1)	(1)
Recoverable cobalt, do	1,568	3,231	4,017	2,316	(1)	(1)

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

TABLE 3.—Cobalt materials consumed by refiners or processors in the United States

(Thousand pounds of contained cobalt)

Form [1]	1952–56 (average)	1957	1958	1959	1960	1961
Alloy and concentrate	4,458	5,793	4,645	3,342	2,062	1,121
Metal	761	877	999	1,098	961	1,101
Hydrate	76	82	57	24	18	16
Carbonate				3	2	
Purchased scrap	147	93	250			
Other		93	56	55	28	33

[1] Total consumption is not shown because the metal, hydrate, and carbonate originated from alloy and concentrate.

TABLE 4.—Cobalt products produced and shipped by refiners and processors in the United States

(Thousand pounds)

Product	1960				1961			
	Production		Shipments		Production		Shipments	
	Gross weight	Cobalt content	Gross weight	Cobalt content	Gross weight	Cobalt content	Gross weight	Cobalt content
Metal	1,549	1,540	1,604	1,595	(1)	(1)	(1)	(1)
Oxide	517	362	506	354	437	306	459	322
Hydrate	189	107	165	93	225	103	244	113
Salts:								
Acetate	241	57	234	55	284	59	309	65
Carbonate	372	173	330	154	282	129	311	142
Sulfate	401	95	450	104	383	88	399	91
Other	242	60	247	61	260	54	238	49
Driers	12,333	711	12,507	727	10,362	608	10,231	593
Total	15,844	3,105	16,043	3,143	12,233	1,347	12,191	1,375

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

CONSUMPTION AND USES

U.S. industry consumed 9.6 million pounds of cobalt, 7 percent more than in 1960. Cobalt consumed for metallic uses increased 10 percent and for nonmetallic uses (exclusive of salts and driers) 11 percent. Consumption for salts, driers, and other nonmetallic uses decreased 11 percent.

Again the largest single use of cobalt was for permanent magnet alloys—26 percent of the total, 3 percent more than in 1960. Cobalt for high-temperature, high-strength alloys was the second largest use at 25 percent, 16 percent greater than in 1960.

TABLE 5.—Cobalt consumed in the United States, by uses

(Thousand pounds of contained cobalt)

Use	1952–56 (average)	1957	1958	1959	1960	1961
Metallic:						
High-speed steel	216	237	88	214	155	220
Other tool steel	133	109	100	619	53	44
Other alloy steel					574	540
Permanent magnet alloys	2,346	2,927	2,340	2,979	2,387	2,457
Cutting and wear-resisting materials	4,238	264	161	139	263	257
High-temperature, high-strength alloys		2,755	2,193	2,423	2,024	2,354
Alloy hard-facing rods and materials	538	501	361	404	447	550
Cemented carbides	339	249	148	339	320	298
Nonferrous alloys	233	237	252	654	107	145
Other					495	659
Total	8,043	7,279	5,643	7,771	6,825	7,524
Nonmetallic (exclusive of salts and driers):						
Ground-coat frit	436	474	457	543	465	526
Pigments	160	205	251	200	190	192
Other	87	188	161	254	278	314
Total	683	867	869	997	933	1,032
Salts and driers: Lacquers, varnishes, paints, inks, pigments, enamels, glazes, feed, electroplating, etc. (estimate)	918	1,011	1,030	1,131	1,172	1,040
Grand total	9,644	9,157	7,542	9,899	8,930	9,596

TABLE 6.—Cobalt consumed in the United States, by forms

(Thousand pounds of contained cobalt)

Form	1952–56 (average)	1957	1958	1959	1960	1961
Metal	7,145	7,028	5,403	7,630	6,761	7,478
Oxide	659	755	754	877	757	900
Purchased scrap	921	363	355	261	240	178
Salts and driers	918	1,011	1,030	1,131	1,172	1,040
Total	[1] 9,644	9,157	7,542	9,899	8,930	9,596

[1] Includes a small quantity of ore and alloy.

STOCKS

In addition to the consumer stocks reported in table I, the total quantity of specification-grade cobalt held in Government inventories

of strategic materials as of December 31, 1961, was 97,048,000 pounds. This included 76,974,000 pounds in the national (strategic) stockpile, 18,997,000 pounds in Defense Production Act (DPA) inventory, and 1,077,000 pounds in the supplemental stockpile. Of this total quantity 78,048,000 pounds was declared surplus, 410.8 percent over the maximum stockpile objective. An additional 6,211,000 pounds of cobalt in the DPA inventory did not meet stockpile specification.

PRICES

The price of cobalt metal granules remained unchanged throughout the year at $1.50 per pound, f.o.b. carrier, Port of New York, packed in 500-pound drums. The prices of ceramic-grade oxide (70–71 percent cobalt) at $1.12 a pound and ceramic-grade oxide (72½–73½ percent cobalt) at $1.15 a pound, east of the Mississippi River, f.o.b. shipping point, packed in 250-pound kegs, freight allowed, also remained unchanged. The prices of both grades of oxide were subject to a 1-percent discount.

FOREIGN TRADE [3]

Imports.—The United States continued to depend almost entirely on imports for its cobalt. In 1961 imports of metal, oxide, and salts were 10.5 million pounds; cobalt content was 14 percent less than for 1960 but more than sufficient to meet consumption requirements. The Republic of the Congo supplied 46 percent of the total imports and Belgium supplied 22 percent. The Belgian metal and oxide originated in the Republic of the Congo, so that 68 percent of the U.S. imports came from the Congo. The next leading supplier was West Germany with 13 percent, 26 percent more than in 1960. Canada supplied 9 percent; Norway, 5 percent; France, 3 percent; and the Federation of Rhodesia and Nyasaland, 2 percent of the total.

Exports.—Exports of cobalt-bearing materials totaled 2,234,692 pounds, an increase of 22 percent over 1960. Scrap (5 percent or more cobalt) was the main item, and 159,449 pounds was in fabricated forms. The remainder was ore, concentrate, metal, and alloys in crude form. Shipments to Japan were 48 percent of the total; to West Germany, 13 percent; to Canada and the United Kingdom, 8 percent each; to Italy, 5 percent; and to France and the Netherlands, 4 percent each. All forms of cobalt metal remained on the list of commodities requiring validated export license for shipment to any destination other than Canada.

Tariff.—The duties on cobalt materials remained unchanged in 1961. Cobalt metal and ore entered the United States duty free. The duty on cobalt oxide continued to be 4 cents a pound, on sulfate 2½ cents a pound, on linoleate 5 cents, and on other salts and compounds 15 percent ad valorem.

[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, by classes

(Thousand pounds and thousand dollars)

Year	White alloy [1]		Ore and concentrates [2]		Metal	
	Gross weight	Cobalt content	Gross weight	Cobalt content	Gross weight	Value
1952–56 (average)	5,436	2,418	153	15	[3] 13,837	[3] $33,476
1957	1,883	817	140	15	[4] 16,173	[4] 32,431
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

Year	Oxide		Salts and compounds		Total	
	Gross weight	Value	Gross weight	Value	Gross weight	Cobalt content (estimated)
1952–56 (average)	666	$1,106	280	$178	20,372	16,688
1957	647	853	364	179	19,207	17,379
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

[1] Reported by importer to Bureau of Mines, which adjusted the figures for "Ore and concentrates" for 1952–57, 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 Bureau of Mines.
[4] Includes 4,903 pounds of scrap, valued at $1,698.

Source: Bureau of the Census.

TABLE 8.—U.S. imports for consumption of cobalt metal and oxide, by countries

(Thousand pounds)

Country	Metal		Oxide (gross weight)	
	1960	1961	1960	1961
North America: Canada	525	897	40	
Europe:				
Belgium-Luxembourg	3,276	1,802	1,419	681
France	[1] 104	295		
Germany, West	[1] 1,103	1,394		
Netherlands		5		
Norway	718	547		
United Kingdom	(2)	27		(2)
Total	5,201	4,070	1,419	681
Africa:				
Congo, Republic of the, and Ruanda-Urundi	4,735	4,869		
Rhodesia and Nyasaland, Federation of	340	200		
Total	5,075	5,069		
Grand total	10,801	10,036	1,459	681

[1] Revised figure.
[2] Less than 1,000 pounds.

Source: Bureau of the Census.

In response to Senate Resolution 206, 87th Congress, the U.S. Tariff Commission under authority of section 332 of the Tariff Act of 1930, as amended (19 U.S.C. 1332), instituted an investigation and ordered a public hearing in connection with the cobalt industry. The public hearing was scheduled for May 15, 1962, in the hearing room of the Tariff Commission. The report of the investigation was to include a description of the domestic industry, domestic production, foreign production, imports, consumption, channels and methods of distribution, U.S. exports, and other factors affecting the competition between domestic and imported products.

WORLD REVIEW

Estimated free world production of cobalt decreased 4 percent. Output from the Republic of the Congo, which supplied 58 percent of the 1961 total, increased 2 percent. The next largest production, 11 percent, again came from the Federation of Rhodesia and Nyasaland, and Canada produced 10 percent.

TABLE 9.—Free world production of cobalt, by countries [1] [2]

(Short tons of contained cobalt)

Country [1]	1952–56 (average)	1957	1958	1959	1960	1961
North America:						
Canada [3]	1,211	1,961	1,355	1,575	1,784	1,618
United States (recoverable cobalt)	768	1,652	2,012	1,165	(4)	(4)
Total	1,979	3,613	3,367	2,740	(4)	(4)
Africa:						
Congo, Republic of the (formerly Belgian) (recoverable cobalt)	9,121	8,945	7,166	9,294	9,063	9,259
Morocco: Southern zone (content of concentrate)	823	500	1,021	1,330	1,401	1,422
Rhodesia and Nyasaland, Federation of: Northern Rhodesia (content of white alloy, cathode metal, and other products)	928	1,583	1,792	2,270	2,036	1,701
Total	10,872	11,028	9,979	12,894	12,500	12,382
Oceania:						
Australia (recoverable cobalt in zinc concentrate)	13	14	17	16	15	[5] 21
New Caledonia (content of concentrate)			44	93		
Total	13	14	61	109	15	[5] 21
Free world total (estimate) [1] [2]	13,700	15,900	14,600	17,300	16,800	16,100

[1] Cobalt is also recovered, principally in West Germany, from pyrites produced in Finland and other European countries, and estimates are included in the world total. Production data for East Germany and U.S.S.R. are not available, and no estimates for these two countries 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 (estimate for which is included in the world total), but includes the cobalt content of Falconbridge 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 Augusta W. Jann, Division of Foreign Activities.

NORTH AMERICA

Canada.—Canada produced 1,618 tons of cobalt, 9 percent less than in 1960, mainly as a byproduct from the smelting and refining of nickel-copper ores from the Sudbury district, Ontario, and Thompson and Lynn Lake, Manitoba. The cobalt in the silver-cobalt ores of the Cobalt-Gowganda area of northern Ontario was not recovered in 1961. Deloro Smelting & Refining Co., Ltd., closed its Deloro, East Ontario, smelter in March because of inadequate supplies of ore and a decrease in the price of cobalt. Cobalt Refinery, Ltd., purchased the plant of Quebec Metallurgical Industries and its stock of low-grade residues at Cobalt, Ontario. The refinery was to produce silver, arsenic, and cobalt and nickel oxides, and expects to handle the silver-cobalt ores of the Cobalt-Gowganda area.[4]

The International Nickel Company of Canada, Ltd. (Inco), produced electrolytic cobalt at its refinery at Port Colborne, Ontario, and shipped impure cobalt oxide to its plant at Clydach, Wales, for conversion to high-grade oxide, metal, and salts. Inco delivered 2.5 million pounds of cobalt, 6 percent more than in 1960.[5]

Falconbridge Nickel Mines, Ltd., provided additional facilities for cobalt recovery in 1961 and delivered 1,462,000 pounds of cobalt, 77 percent more than in 1960. The cobalt was recovered from matte produced in Canada from Sudbury nickel-copper ore and exported to the Falconbridge refinery at Kristiansand S., Norway.[6]

Sherritt Gordon Mines, Ltd., produced 191,043 pounds of cobalt, 38 percent less than in 1960, from Lynn Lake, Manitoba, nickel-copper ore. The decrease was due to the plant being used as a custom pilot plant project part of the year. The capacity of the cobalt production circuit at the Fort Saskatchewan, Alberta, refinery was to be doubled.[7]

EUROPE

Finland.—Copper-bearing pyrite from the Outokumpu Oy mine in eastern Finland, containing 0.2 percent cobalt, was concentrated and roasted. The sinter was shipped to Duisburg, West Germany, for recovery of cobalt, copper, iron, and zinc.

Germany, West.—The major West German cobalt producer, the Duisburger Kupferhütte refinery at Duisburg recovered cobalt mainly from pyrite sinter imported from Finland and other European countries. It planned to raise its cobalt production to about 1,900 tons a year.[8] Cobalt-bearing scrap, residues, and speiss were treated at the refinery of Gebrüder Borchers A. G. at Goslar.

AFRICA

Congo, Republic of the (formerly Belgian).—The cobalt produced by Union Minière du Haut-Katanga was 9,259 tons, 58 percent of the estimated free world production and 2 percent more than in 1960.

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[4] Northern Miner (Toronto). New Refinery for Cobalt Area Turns Out First Silver Bullion. V. 47, No. 23, Aug. 31, 1961, pp. 13, 18.
[5] The International Nicket Company of Canada, Ltd. 1961 Annual Report. P. 9.
[6] Falconbridge Nicket Mines, Ltd. Thirty-third Annual Report. 1961, p. 7.
[7] Sherritt Gordon Mines, Ltd. Annual Report. 1961, pp. 3, 6.
[8] Mining Journal (London). Cobalt in West Germany. V. 257, No. 6575, Aug. 25, 1961, p. 197.

In spite of the very difficult political conditions existing in Katanga, the company managed to operate its facilities most of the time. The cobalt section of the new Luilu refinery near Kolwezi reached a yearly capacity of 3,800 tons of cobalt.

Morocco.—Production of cobalt concentrate at the Société Minière de Bou-Azzer et du Graara cobalt mine was 14,220 tons containing 1,422 tons of cobalt, about the same as in 1960.

Rhodesia and Nyasaland, Federation of.—The Rhokana Corporation, Ltd., milled 5,701,000 short tons of ore, averaging 0.11 percent cobalt in the fiscal year ending June 30, 1961. Cobalt concentrate produced from ores of the Mindola and Nkana mines was 50,227 short tons containing 2.92 percent cobalt, much less than the 99,122 tons of concentrate containing 2.60 percent cobalt of the preceeding year. Cobalt recovered was 837 short tons, compared with 1,307 tons in fiscal 1960. The reduced output was due to the treatment of a larger proportion of Mindola ore, which was of a lower grade and had a lower recovery factor than the ore from the Nkana mine. Nkana ore at depth, because of an unpredicted change in cobalt mineralization, also caused recovery problems.[9]

Chibuluma Mines, Ltd., during the fiscal year ending June 30, 1961, milled 558,996 short tons of ore averaging 0.21 percent cobalt and produced 26,394 short tons of cobalt-copper concentrate, containing 3.08 percent copper and 3.52 percent cobalt. During the year the Ndola refinery produced 11,065 tons of cobalt matte, containing 9.01 percent cobalt and 11.40 percent copper. Part of the cobalt matte production at Ndola was used to build up stocks, and part was shipped for refining to Belgium, which returned 464 tons of cobalt compared with 800 tons in fiscal 1960. Combined ore reserves as of June 30, 1961, for the Chibuluma and Chibuluma West ore bodies were estimated at 9.7 million tons averaging 4.59 percent copper and 0.15 percent cobalt. Chibuluma Mines, Ltd., expected to repay during the fiscal year ending June 30, 1962, the balance of the loan made to it by the U.S. Government.[10]

OCEANIA

Australia.—Electrolytic Zinc Co. of Australasia, Ltd., produced 27 tons of cobalt oxide in the fiscal year ended June 30, 1961, at its Risdon, Tasmania, electrolytic refinery. The cobalt oxide was obtained as a byproduct in treating zinc concentrates from the Broken Hill district and from the company mines in the Roseberry district.[11]

TECHNOLOGY

Federal Bureau of Mines research included the separation of nickel and cobalt by fused-salt electrolysis and by a combination of aqueous electrolysis and solvent extraction, and recovery of nickel and cobalt from high-temperature alloy scrap by chlorination and by anodic corrosion. A program was started to produce cobalt-tungsten binary alloys by simultaneous decomposition of gaseous compounds of the metals. Published reports included a study of methods for recovering

[9] Rhokana Corporation, Ltd. Annual Report. June 30, 1961, pp. 13, 14.
[10] Rhodesian Selection Trust, Ltd. Annual Report. 1961, pp. 6, 40, 51.
[11] U.S. Embassy, Canberra, Australia. State Department Dispatch 451. Mar. 13, 1962.

metal components from alloy scraps; [12] mining and milling costs at the Madison mine of National Lead Co., Fredericktown, Mo., where sulfides of copper and cobalt occur in commercial quantities with lead sulfide; [13] and salt roasting and leaching of sulfide ore concentrates containing cobalt, nickel, copper, lead, and iron.[14]

The production of nickel and cobalt at the new Thompson, Manitoba, plant of The International Nickel Company of Canada, Ltd., was described.[15]

Sherritt Gordon Mines, Ltd., made available cobalt coiled strip, 99.9 percent pure, 0.005 to 0.25 inch thick, and from 0.25 to 6 inches wide.[16]

New 18-percent nickel-cobalt-molybdenum maraging alloy steels with unmatched toughness at high strengths and good machining properties were reported by The International Nickel Company, Inc. The 250 steel has a composition range of 17 to 19 percent nickel, 7 to 8 percent cobalt, 4.6 to 5.1 percent molybdenum, and 0.3 to 0.5 percent titanium. It has a yield strength of 250,000 psi, a high resistance to stress corrosion, and good formability and weldability.[17]

A new superhard high-speed cutting tool steel was developed by Braeburn Alloy Steel Corp., Braeburn, Pa., with a nominal composition of carbon, 1.15 percent; chromium, 4.25 percent; vanadium, 2.25 percent; tungsten, 5.25 percent; molybdenum, 6.25 percent; cobalt, 12 percent; and iron, the remainder.[18]

An electron-microscope study of a cobalt-base alloy (UM–Co–50), containing 50 percent cobalt, 30 percent chromium, and 20 percent iron was published.[19]

A paper dealt with the fundamental properties of tungsten carbide-cobalt alloys used for mineral cutting tools. The cobalt content of the alloys ranged between 4 and 20 percent.[20]

The Centre d'Information du Cobalt (Cobalt Information Center), Brussels, Belgium, published a paper on cobalt and magnetism, which included magnetically soft alloys, magnetostrictive alloys, permanent magnet alloys, and ferrites; [21] and on the improvement of magnetic properties in alnico-type magnets by producing columnar structures.[22]

The Crucible Steel Co. of America announced the development of Alnico VIII with improved resistance to demagnetization, coercive force, and maximum energy product.[23] At the annual conference on

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Magnetism and Magnetic Materials (Phoenix, Ariz., Nov. 13–16, 1961), the use of iron-cobalt phosphides as possible new permanent magnet materials was discussed.[24]

The Federal Bureau of Mines, Pittsburgh Coal Research Center, Pittsburgh, Pa., tried a large number of catalysts in a microcatalytic reactor and found Co_3O_4 to be the most active single-component catalyst in oxidation of hydrocarbons.[25]

The papers presented, with discussions, at the International Symposium on the Extractive Metallurgy of Copper, Nickel, and Cobalt in New York in February 1960 under the auspices of AIME, were published in book form.[26]

A first comprehensive account of the geology of the Northern Rhodesian copperbelt was published. It included data on the areas where cobalt is associated with copper.[27]

Patents were issued on recovering cobalt from ores,[28] separating nickel from cobalt,[29] various alloys,[30] and cobalt catalysts.[31]

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Columbium and Tantalum

By F. W. Wessel[1]

THE PRICE of tantalite continued to rise throughout 1961, driven by a sharply increased demand and some uncertainty as to ore supplies. Ferrocolumbium consumption by the steel industry increased, and demand for columbium metal was off only slightly in spite of suspension of the construction of a nuclear-powered aircraft.

Outstanding features of research and development were the test production and appraisal of columbium capacitors, the cryogenic use of columbium intermetallic compounds, and the development and evaluation of many new alloys.

LEGISLATION AND GOVERNMENT PROGRAMS

In October, the General Services Administration advertised for bids on 18,900 tons of Malayan tin slag declared surplus to the national stockpile. This material was located at Niagara Falls, N.Y., and Welland, Ontario, Canada, and contained 4.0 to 4.5 percent columbium oxide and 2.5 to 3.5 percent tantalum oxide.

DOMESTIC PRODUCTION

There was no domestic mine production of tantalum or columbium ores in 1961.

In spite of the suspension (early in the year) of the program for constructing a nuclear-powered aircraft, columbium production declined only slightly from the 1960 total; 1961 production was 126 tons. Wah Chang Corp., Albany, Oreg., was the principal producer; others included E. I. du Pont de Nemours & Co., Inc., Newport, Del., Stauffer Chemical Co. and Union Carbide Metals Co., Division of Union Carbide Corp., both of Niagara Falls, N.Y., Fansteel Metallurgical Corp., North Chicago, Ill., and Kennametal, Inc., Latrobe, Pa.

Production of tantalum in 1961 reached 242 tons. All of the 1960 producers showed increased production in 1961—Fansteel Metallurgical Corp., Muskogee, Okla., Kawecki Chemical Co., Boyertown, Pa., National Research Corp., Newton, Mass., Wah Chang Corp., and Union Carbide Metals Co.—and two new producers, Stauffer Chemical Co. and Kennametal, Inc., entered the market.

Stearns-Roger Manufacturing Co. was engaged to explore the Powderhorn, Colo., pyrochlore deposit owned by Du Pont, and may also design and construct a mill. Meanwhile, columbium was being

[1] Commodity specialist, Division of Minerals.

TABLE 1.—Salient columbium-tantalum statistics

	1952–56 (Average)	1957	1958	1959	1960	1961
United States:						
Columbium - tantalum concentrate shipped from mines [1] pounds	56,528	370,483	428,347	189,263	----------	----------
Imports for consumption:						
Columbium-mineral concentrate ---------- do	5,636,084	3,348,706	2,555,942	3,395,816	[2] 5,066,514	2,973,769
Tantalum - mineral concentrate ---------- do	1,058,140	828,265	1,035,588	652,839	[2] 695,222	808,082
Industrial consumption: [3]						
Contained metal, short tons	[4] 523	924	593	828	1,058	1,283
World: Production of columbium-tantalum concentrates ---- pounds	7,570,000	6,840,000	4,880,000	6,050,000	6,850,000	7,370,000

[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 1954–56.

fabricated at the Du Pont Metals Center, Baltimore, Md., using a wide selection of modern equipment.[2]

Kawecki Chemical Corp. announced plans to build a separate plant to produce columbium.

National Research Corp. moved its tantalum production facilities from Cambridge to Newton, Mass., and doubled plant capacity to 80,000–100,000 pounds annually. The company's Metals Division produces capacitor-grade tantalum powder and wire, tantalum ingot and mill shapes, and tantalum alloy products for high-temperature uses.

General Electric Co. constructed a plant for rolling refractory metal sheet at Euclid, Ohio.

Production of ferrocolumbium totaled 932 short tons, an increase of 68 percent over 1960. Demand was light during the first half of the year, but became stronger in midsummer. Production of ferrotantalum-columbium declined, continuing a trend begun in 1956. Vanadium Corporation of America, Cambridge, Ohio; Molybdenum Corporation of America, Pittsburgh, Pa; Union Carbide Metals Corp., Niagara Falls, N.Y.; and Shieldalloy Corp., Newfield, N.J., were the principal producers of ferrocolumbium. The two latter companies also produced ferrotantalum-columbium.

Linde Co., Division of Union Carbide Corp., East Chicago, Ind., offered columbium carbide powders of 325-mesh size.

CONSUMPTION AND USES

Domestic consumption of columbium and tantalum raw materials in terms of metal content was 869 and 414 short tons, respectively.

The greatest single use for columbium (Cb) during 1961 was as an additive to semikilled steels, to which it was added in the form of ferrocolumbium. The resultant steel contained up to 0.05 percent Cb. Among the companies producing and marketing these steels were United States Steel Corp., National Steel Corp., Armco Steel Corp., and Jones & Laughlin Steel Corp.

[2] American Metal Market, v. 68, No. 86, May 5, 1961, pp. 1, 14.

Use of this steel in a 47-mile, 20-inch natural-gas pipeline was estimated to reduce cost by $1,000 per mile.[3] The steel was also successfully used in constructing an automobile-carrying vehicle capable of carrying 12 standard cars; present equipment carries 8.

Columbium, and to a lesser extent tantalum, continued to interest research and development organizations in the field of superconductivity and cryogenics. General Electric Co. developed a gryroscope with a columbium rotor to operate at the temperature of liquid helium. Bell Telephone Laboratories and Radio Corporation of America devised an electromagnet, the winding of which was coated with a columbium-tin compound, Cb_3Sn; the magnet generated 88,000 gauss at 18° K. Bell Telephone Laboratories, Atomic Internation Division of North American Aviation, Inc., and Westinghouse Electric Corp., developed a columbium-zirconium compound (Cb_3Zr), for the same purpose; a magnet using this material generated 43,000 gauss at about 5° K.

Capacitor-grade powder continued as the largest component of tantalum demand. Fansteel Metallurgical Corp., General Electric Co., Texas Instruments, Inc., and Kemet Co., Division of Union Carbide Corp. were among the leaders in this field. Other uses for tantalum were based on its heat- and corrosion-resistant properties; structural alloys for outer-space flight, tantalum pumps, absorption columns, autoclaves, and thermocouple protection tubes for the chemical industry, and tantalum alloys for missile coatings were developed or marketed during the year.

Union Carbide Metals Co. and Polaroid Corp. jointly developed a tantalum-carbide filament for an incandescent light bulb, made for use in slide and film projectors. A 50-percent increase in light output and a doubled life were reported.

Standard Pressed Steel Co. began production of bolts, nuts, and other parts made of columbium, tantalum, or other high-temperature metals and alloys. Manufacture of a cloth woven of tantalum wire also was announced.

STOCKS

The national (strategic) stockpile at the yearend contained 14,285,000 pounds of columbium contained in ore and an additional 339,000 pounds contained in ferroalloys. Also on hand was 3,036,000 pounds of tantalum contained in ore.

Consumers and dealers at yearend held inventories of columbite, tantalite, and tin slag amounting to 1,566, 1,047, and 4,152 short tons, respectively.

Inventories also included 66,000 pounds of primary tantalum metal and 132,000 pounds of ingot; 31,000 pounds of primary columbium metal and 36,000 pounds of ingot; 116,000 and 56,000 pounds, respectively, of tantalum and columbium scrap; 213,000 pounds of columbium oxide; and 62,000 pounds of potassium tantalum fluoride.

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[3] Steel. Columbium Treated Steel Promises Pipeline Savings. V. 149, No. 13, Sept. 25, 1961, pp. 160–161.

PRICES AND SPECIFICATIONS

Columbite prices opened 1961 at $1.18 to $1.25 per pound of contained pentoxides for the 10 : 1 ratio concentrate and $1.05 to $1.10 for the 8½ : 1 material. Demand for the latter grade disappeared during the year; prices for the 10 : 1 grade, however, closed at $1.00. Pyrochlore sold late in the year at prices somewhat in excess of $1.00.

The price of tantalite continued to climb throughout the year. Beginning at $7.20 per pound of contained Ta_2O_5 for a 60-percent concentrate, some quotations near yearend reached $11.50, plus or minus 10¢ for each percent above or below 60. London quotations in December 1961 ranged from 1,700s. to 1,800s. per long ton unit.

In November, prices of some tantalum end products were increased, reflecting the rise in ore costs. Oxide increased to the range of $18–$23 per pound; carbide to $22–$27, and commercial-grade powder to $31–$32.

No change in the prices of columbium products was announced, although over the long term a downward trend was forecast.

Canadian pyrochlore began to appear in domestic markets. Norwegian pyrochlore was imported for several years, and enough was learned about pyrochlore from Brazil and from a second mine in Canada's Oka district to permit the following comparative tabulation of concentrate analyses:

	Analysis, percent			
	Norway	Canada [1]	Canada [2]	Brazil
Cb_2O_5	50–60	52 (min.)	48	58
Ta_2O_5	1.5 (max.)	0. 5	0. 3	0. 12
P_2O_5	0. 14	0. 35	0. 02	[3]
TiO_2	7–10	4. 5	4. 6	2. 8
ZrO_2	2. 75	1	1. 1	3. 2
ThO_2	[3]	0. 23	[3]	2
$REO+Y_2O_3$	0. 65	4	10. 6	9. 4
CaO	4	15. 1	17. 5	[3]
SrO	[3]	0. 6	2. 25	[3]
BaO	[3]	[3]	[3]	15
Na_2O	1. 7	3. 5	2. 2	[3]
U_3O_8	[3]	0. 10	0. 07	1. 3

[1] St. Lawrence Columbium & Metals Corp.
[2] Columbium Mining Products, Ltd.
[3] Data not available.

TABLE 2.—Average grade of concentrate received by U.S. consumers and dealers in 1961, 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	42	15	2.8:1	42	28
Canada [1]	52	[2]			
Congo, Republic of the	48	27	1.8:1	37	36
Malaya, Federation of	60	15	4.0:1		
Mozambique				53	17
Nigeria	67	6	10.6:1		
Norway [1]	57	1			
Portugal and Spain	31	28	1.1:1		
Rhodesia and Nyasaland, Federation of				59	9

[1] Pyrochlore concentrate.
[2] Data not available.

FOREIGN TRADE[4]

Imports.—In addition to raw material imports shown in tables 3 and 4, 2,139 pounds of metallic columbium, valued at $44,486, were received almost entirely from West Germany.

Exports.—Exports are shown in table 5. The columbium ore was shipped principally to France and Austria. Canada and Japan were the major destinations of tantalum metal powder. Most of the crude and semifabricated metal was shipped to the United Kingdom, West Germany, and Canada.

WORLD REVIEW

NORTH AMERICA

Canada.—In October 1961 St. Lawrence Columbium and Metals Corp. became the first of the several columbium mines in Canada to produce and ship concentrate. A sales contract concluded in 1960 with Samincorp called for delivery of 250 tons of contained columbium pentoxide (Cb_2O_5) from October 1, 1961, to December 31, 1962, and 500 tons annually thereafter. The Anaconda Co., and Kuhn, Loeb and Co. were reported to be providing financial support. The St. Lawrence company reported a reserve of 62.6 million tons of pyrochlore ore at 0.4 percent Cb_2O_5, from which a concentrate can be made by gravity and flotation methods.[5]

Columbium Mining Products, Ltd. (a subsidiary of Coulee Lead & Zinc Mines, Ltd., and Headway Red Lake Gold Mines, Ltd.) continued to drill and develop its property in the Oka district, Quebec, and to design a 250-ton mill based on a gravity-flotation flowsheet.

Early in 1961, Quebec Columbium, Ltd., completed its exploration work and placed its property on a standby basis, pending improvement in the columbium market.

SOUTH AMERICA

Brazil.—The pyrochlore mill of Distribuidora e Exportadora de Mineiros e Adubos (DEMA) at Araxá, Minas Gerais, came into production during the first quarter of 1961 and operated throughout the remainder of the year. Product was stockpiled pending satisfactory arrangements between DEMA and the Brazilian government as to conditions of export.

EUROPE

Columbium was reported to be of much greater interest in Europe than in the United States as a material of construction for nuclear reactors,[6] although there was generally less activity in the refractory metals field.

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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.

[5] Engineering and Mining Journal. St. Lawrence Columbium Project Starts Production in Quebec. V. 162, No. 10, October 1961, pp. 99–104.

[6] Jaffee, R. I. Refractory Metals in Europe. J. Metals, v. 13, No. 10, October 1961, pp. 714–716.

TABLE 3.—U.S. imports for consumption of columbium-mineral concentrates, by countries

(Pounds)

Country	1952–56 (average)	1957	1958	1959	1960	1961
North America: Canada				14,000		35,575
South America:						
Argentina	4,365		2,262	3,591		
Bolivia	6,912					
Brazil	111,468	54,500	101,992	137,648	126,374	73,363
British Guiana	2,031					
Total	124,776	54,500	104,254	141,239	126,374	73,363
Europe:						
Germany, West [1]	223,453	1,653	46,628	11,578	6,283	
Netherlands [1]				13,000	35,554	
Norway	293,403	236,147	310,858	454,535	164,486	
Portugal	83,248	72,953	65,461	38,083	35,383	22,457
Spain	1,387				976	
Sweden	3,342					
United Kingdom [1]	2,240	29,621			22,400	
Total	607,073	340,374	422,947	517,196	265,082	22,457
Asia:						
Aden	270					
Korea, Republic of	400					
Malaya, Federation of	267,977	127,524	709,077	151,881	[2] 264,660	[2] 303,968
Singapore, Colony of						[1] 7,298
Thailand				13,546		
Total	268,647	127,524	709,077	165,427	264,660	311,266
Africa:						
British West Africa	2,904					
Congo, Republic of the, and Ruanda-Urundi [3]	783,723	905,989	507,725	519,712	227,724	113,085
French Equatorial Africa	940					
Malagasy Republic [4]	11,619	3,075	9,920	11,939	17,412	6,524
Mozambique	43,676	81,422	171,164	85,249	75,851	60,613
Nigeria	3,705,284	1,804,631	543,925	1,936,296	4,071,115	[2] 2,294,580
Rhodesia and Nyasaland, Federation of	10,486				1,983	20,700
Uganda [5]	14,428		5,771	2,205	11,670	29,971
Union of South Africa	38,105	31,191	81,159		4,643	2,240
Total	4,611,165	2,826,308	1,319,664	2,555,401	4,410,398	2,527,713
Oceania: Australia	24,423			2,553		3,395
Grand total: Pounds	5,636,084	3,348,706	2,555,942	3,395,816	[2] 5,066,514	[2] 2,973,769
Value	$10,349,973	$3,037,706	$2,345,890	$2,651,783	[2] $3,696,180	[2] $2,527,495

[1] Presumably country of transshipment rather than original source.
[2] The Federation of Malaya has been adjusted by the Bureau of Mines to include 1960: 14,714 pounds ($9,631); 1961: 82,807 pounds ($120,022); Nigeria 1961, to include 113,262 pounds ($101,532) reported by the Bureau of the Census as tantalum-mineral concentrates but believed to be columbium-mineral concentrates.
[3] Effective July 1, 1960; formerly Belgian Congo.
[4] Effective July 1, 1960; formerly Madagascar and Dependencies.
[5] Classified by the Bureau of the Census as British East Africa.

Source: Bureau of the Census.

TABLE 4.—U.S. imports for consumption of tantalum-mineral concentrates, by countries

(Pounds)

Country	1952–56 (average)	1957	1958	1959	1960	1961
South America:						
Argentina	2,205	----------	11,635	1,611	----------	4,444
Brazil	142,673	199,205	159,015	205,898	182,118	159,925
French Guiana	14,683	3,075	----------	----------	----------	----------
Total	159,561	202,280	170,650	207,509	182,118	164,369
Europe:						
Belgium-Luxembourg [1]	----------	6,391	10,681	21,871	2,426	47,993
Germany, West [1]	131,379	----------	135,431	----------	----------	----------
Netherlands [1]	----------	----------	----------	----------	8,012	26,495
Norway	2,346	----------	----------	----------	----------	----------
Portugal	57,940	5,966	32,513	27,227	34,062	29,793
Spain	2,403	----------	----------	----------	3,157	11,148
Sweden	4,699	----------	992	----------	----------	----------
United Kingdom [1]	5,707	----------	----------	----------	----------	----------
Total	204,474	12,357	179,617	49,098	47,657	115,429
Asia:						
Malaya, Federation of, Singapore, Colony of	2,612	----------	[1] 6,000	----------	[2]	[2]
Thailand	----------	----------	----------	4,515	----------	----------
Total	2,612	----------	6,000	4,515	----------	----------
Africa:						
Congo, Republic of the, and Ruanda-Urundi [3]	531,370	491,124	370,120	166,317	332,424	164,277
Malagasy Republic [4]	7,406	6,835	7,716	9,375	30,738	11,953
Mozambique	14,497	24,046	149,777	68,343	87,801	219,847
Nigeria	77,431	16,815	34,537	50,902	7,698	[2] 7,848
Rhodesia and Nyasaland, Federation of	10,766	38,975	77,667	44,720	----------	53,098
Uganda [5]	2,543	----------	2,034	2,690	----------	36,182
Union of South Africa	5,491	6,910	27,368	24,805	2,239	31,677
Total	649,504	584,705	669,219	367,152	460,900	524,882
Oceania: Australia	41,989	28,923	10,102	24,565	4,547	3,402
Grand total: Pounds	1,058,140	828,265	1,035,588	652,839	[2] 695,222	[2] 808,082
Value	$1,920,255	$948,638	$1,838,338	$1,165,536	[2] $1,127,237	[2] $1,780,390

[1] Presumably country of transshipment rather than original source.
[2] The Federation of Malaya has been adjusted by the Bureau of Mines to exclude 1960: 14,714 pounds ($9,631); 1961: 82,807 pounds ($120,022); Nigeria 1961, to exclude 113,262 pounds ($101,532) reported by the Bureau of the Census as tantalum-mineral concentrates but believed to be columbium-mineral concentrates.
[3] Effective July 1, 1960; formerly Belgian Congo.
[4] Effective July 1, 1960; formerly Madagascar and Dependencies.
[5] Classified by the Bureau of the Census as British East Africa.

Source: Bureau of the Census.

TABLE 5.—U.S. exports of columbium and tantalum, by classes, in 1961

Class	Pounds	Value
Columbium ores and concentrates	56,487	$51,897
Metals and alloys in crude form, and scrap	18,882	140,238
Metals and alloys in semifabricated forms	10,048	713,314
Tantalum metal powder [1]	[1] 5,585	[1] 189,078

[1] Adjusted by Bureau of Mines.

Source: Bureau of the Census.

TABLE 6.—Free world production of columbium and tantalum concentrates[1] by countries[2]

(Pounds)

Country	1952–56 (average)		1957		1958		1959		1960		1961	
	Columbium	Tantalum	Columbium	Tantalum	Columbium	Tantalum	Columbium	Tantalum	Columbium	Tantalum	Columbium	Tantalum
North America:												
Canada	[3] 21	[3] 195					[4] 14,000				61,050	
United States (mine shipments)	56,528		370,483		428,347		189,263					
South America:												
Argentina	1,193		688		[4] 2,262	[4] 11,635	[4] 3,591	[4] 1,611				[4] 4,444
Brazil (exports)	150,486	107,393	68,206	204,675	158,513	213,114	33,459	207,232	26,460	257,951	[4] 73,363	[4] 159,925
French Guiana	[5] 13,895			2,976								
Europe:												
Norway	[5] 420,578		425,488		630,516		639,114		489,951		707,677	
Portugal (U.S. imports)	83,248	57,940	72,953	5,966	65,461	32,513	38,083	27,227	35,383	34,062	22,457	29,793
Spain (U.S. imports)	[5] 1,387	2,403							976	3,157		11,148
Sweden (U.S. imports)	[5] 3,343	[5] 4,699				992						
Asia: Malaya, Federation of	323,635		318,080		356,160		268,800		208,320		206,080	
Africa:												
Congo, Republic of the (formerly Belgian) and Ruanda-Urundi [6]	744,626		524,695		553,355		535,718		[4] 227,724	[4] 332,424	[4] 113,085	[4] 164,277
Malagasy Republic (Madagascar)	21,781		19,180		28,880		26,455		22,266		[7] 27,558	
Mozambique	64,856		288,503		378,916		320,004		335,099		297,621	
Nigeria	5,338,368	18,816	4,307,520	40,320	1,803,200	49,930	3,559,875	31,114	4,587,520	24,640	5,257,280	26,230
Rhodesia and Nyasaland, Federation of	8,320	17,390	760	76,960		96,260		116,820		108,080		138,380
Sierra Leone	[3] 5,973											
South-West Africa	14,582		9,325	14,676	4,152	6,574	2,610	1,539	2,899	7,491	670	5,790
Swaziland (Yttrotantalite)				32,920								
Uganda [8]	18,650		4,054		6,384		5,264		5,040		16,240	
Union of South Africa		23,780		1,981		37,920		11,500		14,000		20,000
Oceania: Australia	67,759		50,038		13,507		18,950		23,679		31,806	
Free world total (estimate) [2]	7,570,000		6,840,000		4,880,000		6,050,000		6,850,000		7,370,000	

[1] Frequently the composition (Cb_2O_5-Ta_2O_5) of this concentrate lies in an intermediate position, neither Cb_2O_5 nor Ta_2O_5 being strongly predominant. In such cases the production figure has been centered.

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail. The world total does not include U.S.S.R., for which country no production data are available.

[3] Average annual production, 1955–56.

[4] U.S. imports.

[5] Average annual production, 1953–56.

[6] In addition, tin-columbium-tantalum concentrate was produced as follows: 1952–56 (average) 4,863,348 pounds; 1957, 4,360,699 pounds; 1958, 3,196,670 pounds; 1959, 2,773,387 pounds; 1960, estimated 1,500,000 pounds; 1961, not available; columbium-tantalum content averaging about 10 percent.

[7] Exports.

[8] Average annual production, 1954–56.

[9] In addition, tin-columbium-tantalum concentrate was produced as follows: 1952–56 (average), 3,741 pounds; no further production recorded.

Compiled by Augusta W. Jann, Division of Foreign Activities.

Netherlands.—N. V. Billiton Maatschappij and Kawecki Chemical Co. late in 1961 formed a joint company to make tantalum and columbium sheet and foil and tantalum anodes for the European market. The plant was to be located at Arnhem.

Norway.—Norsk Bergverk A/S continued producing pyrochlore concentrate throughout 1961. Shipments to the United States, suspended in June 1960, were resumed late in November 1961.

Switzerland.—Ciba A. G. was actively engaged in research in all phases of columbium and tantalum production and use. Development of catalysts for organic synthesis was prominent.

ASIA

Japan.—Data released during 1961 showed demand for about 40,000 pounds of tantalum annually. About two-thirds of this quantity was in the form of carbide.

AFRICA

British East Africa.—A general discussion [7] referred to three pyrochlore deposits as having substantial reserves; these were at Sukulu in Uganda, Mrima Hill in Kenya, and Mbeya in Tanganyika. Research on processes for Mbeya ore continued and official sources recommended similar work on Mrima Hill ores.

Congo, Republic of the.—Exports of tantalite and columbite to the United States through the usual port of Matadi were limited to a single 10-ton shipment. Larger quantities were routed to Dar-es-Salaam, Tanganyika, for export, and an appreciable quantity was shipped as a semi-finished concentrate to Belgium, thence to its final destination. However, internal unrest continued to cause difficulties as to both production and transportation. Early in 1961, Manono again became the scene of military activity, and operations at the Geomines plant remained suspended until later in the year.

Nevertheless, a pyrochlore deposit at Lueshe, in Kivu, was being explored and a columbite-tantalite-tin property, also in Kivu, was considered for development.

Nigeria.—Two tin smelters began operating in the Bauchi (Jos) plateau region: Nigerian Embel Tin Smelting Co., Ltd., and Makeri Smelting Co., Ltd. The mines in this area produced 2,600 tons of columbite in 1961, and the smelters will probably provide a source of columbian-bearing tin slag.

Rhodesia and Nyasaland, Federation of.—Higher tantalite prices brought about a substantial increase of production. The Beryl Rose mine, near Darwin, began tantalite-beryl mining in January 1961. The Matsuo-Rhodesia Mining Co. (Pvt.), Ltd., purchased the Sutskwe mine, in Southern Rhodesia, and planned to produce tantalite and beryl. Most of the ore exported was shipped at Beira, Mozambique.

WORLD RESERVES

A moderately detailed study conducted on a continuing basis permits the tabulation of world columbium-mineral reserves in table 7.

[7] Sandor, J. Columbite and Pyrochlore. Min. J. (London), v. 257, No. 6579, Sept. 22, 1961, pp. 282–283.

Of the reserves in the United States, 45 percent are minerals other than columbite or pyrochlore, and thus may entail a somewhat complex metallurgical treatment.

Data on tantalum-mineral reserves were insufficient to permit publication.

TABLE 7.—Free world reserves of columbium ores in 1961

(Thousand short tons)

Country	Cb_2O_5 content	Country	Cb_2O_5 content
Brazil	7,068	Norway	320
British East Africa	1,077	United States	178
Canada	1,171	Other countries	12
Congo, Republic of the	451		
Nigeria	436	Total	10,723

TECHNOLOGY

The geology and mineralogy of the columbium-bearing deposits of Ravalli County, Mont., were described;[8] content of the ores ranged from 0.02 to 0.19 percent. Columbium-bearing deposits in Gunnison County, Colo., were similarly described.[9]

In 1961, studies of tantalum and columbium capacitors were published; in some applications columbium may prove to be competitive with tantalum.[10]

Investigators at Union Carbide Metals Co. determined that tantalum could be protected against hydrogen embrittlement by affixing a very minor quantity of platinum.[11]

Various aspects of the oxidation of columbium received the attention of a number of research teams.[12] Closely associated with this work was the development of coatings to protect columbium from oxidation. Chromium and some of its alloys, variously applied, showed some promise;[13] silicide coatings worked well on columbium, but not as

[8] Heinrich, E. W., and A. A. Levinson. Carbonatic Niobium-Rare Earth Deposits, Ravalli County, Mont. Am. Miner., v. 46, Nos. 11–12, November–December 1961, pp. 1424–1447.

[9] Hedlund, D. C., and J. C. Olson. Four Environments of Thorium-, Niobium-, and Rare-Earth-Bearing Minerals in the Powderhorn District of Southwestern Colorado. Geol. Survey Prof. Paper 424B, 1961, pp. 283–286.

[10] Belz, L. H. Capacitor Grade Tantalum. J. Electrochem. Soc., v. 108, No. 3, March 1961, pp. 229–235. Hand, R. B., H. W. Long, and T. L. Kolski. Electrical Characteristics of Anodized Niobium Foil and Sintered Pellets. J. Electrochem. Soc., v. 108, No. 11, November 1961, pp. 1023-1028. McLean, D. A. The A–C Properties of Tantalum Solid Capacitors. J. Electrochem. Soc., v. 108, No. 3, March 1961, pp. 48–56. Schwartz, N., M. Gresh, and S. Karlik. Niobium Solid Electrolytic Capacitors. J. Electrochem. Soc., v. 108, No. 8, August 1961, pp. 750–758. Shtasel, H., and H. T. Knight. An Investigation of Columbium as an Electrolytic Capacitor Metal. J. Electrochem. Soc., v. 108, No. 4, April 1961, pp. 343–347.

[11] Bishop, C. R., and M. Stern. Preventing Hydrogen Embrittlement of Tantalum. J. Metals, v. 13, No. 2, February 1961, pp. 144–145.

[12] Barrett, C. H., and J. L. Corey. Oxidation of Binary Niobium Alloys. NASA Tech. Note D283, Lewis Research Center, November 1960, p. 27. Hicks, W. T. Oxidation of Columbium Monoxide. Trans. Met. Soc. AIME, v. 221, No. 2, April 1961, pp. 352–356. ———. Motion Picture Studies of Columbium Oxidation. Trans. Met. Soc. AIME, v. 221, No. 2, April 1961, pp. 218–220. Hurlen, Tor. Oxidation of Niobium. J. Inst. Metals (London), v. 89, No. 8, April 1961, pp. 273–280. Kofstad, P., and H. Kjöllesdal. Oxidation of Niobium (Columbium) in the Temperature Range 500° to 1,200° C. Trans. Met. Soc. AIME, v. 221, No. 2, April 1961, pp. 285–294. Kubaschewski, O. Reduction of Niobium-Oxygen Solid Solutions by Alkaline Earth Metals. J. Inst. Metals (London), v. 89, No. 9, April 1961, pp. 295–296.

[13] Wlodek, S. T. Coatings for Columbium. J. Electrochem. Soc., v. 108, No. 2, February 1961, pp. 177–185.

well for tantalum.[14] Tantalum was protected for several hours at 3,000° F. by a hot-dip tin-aluminum coating developed by Sylvania Electric Products Division, General Telephone and Electronics Co.

Much research was published during the year on binary and ternary alloy systems. Binary alloys of tantalum with chromium, boron, and thorium, and of columbium with rhenium were studied;[15] tenary systems described included columbium-chromium-silicon, columbium-chromium-molybdenum, and tantalum-tungsten-rhenium.[16]

Some of the alloys developed during the year are listed in table 8. Most are for high-temperature service, but a few were devised as superconductors.

A physical-chemistry study bearing on the expanding use of columbium in steel showed that columbium was similar to vanadium in deoxidizing power.[17]

The addition of 0.25 to 0.60 percent columbium to 430 stainless steel solved the problem of maintaining the desired finish during severe forming operations.[18]

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[14] Lorenz, R. H., and A. B. Michael. Oxidation-Resistant Silicide Coatings for Columbium and Tantalum Alloys by Vapor Phase Reduction. J. Electrochem. Soc., v. 108, No. 9, September 1961, pp. 885–893.

[15] Auld, J. H., and N. E. Ryan. The Solid Solubility of Tantalum in Chromium. J. Less-Common Metals, v. 3, No. 3, June 1961, pp. 221–225. Giessen, B. C., Rolf Nordheim, and N. J. Grant. The Constitution Diagram Niobium (Columbium)-Rhenium. Trans. Met. Soc. AIME, v. 221, No. 5, October 1961, pp. 1009–1013. Leitnaker, J. M., M. G. Bowman, and P. W. Gilles. High Temperature Phase Studies in the Tantalum-Boron System Between Ta and TaB. J. Less-Common Metals, v. 3, No. 4, August 1961, pp. 312–320. McMasters, O. D., and W. L. Larsen. Phase Equilibria in the Thorium-Tantalum System. J. Less-Common Metals, v. 3, No. 4, August 1961, pp. 312–320.

[16] Brophy, J. H., M. H. Kamdar, and J. Wulff. The Ta-W-Re System. Trans. of the Met. Soc. AIME, v. 221, No. 6, December 1961, pp. 1137–1140. Goldschmidt, H. J. The Constitution of the Chromium-Niobium-Molybdenum System. J. Less-Common Metals, v. 3, No. 1, February 1961, pp. 44–61. ——— and J. A. Brand. The Constitution of the Chromium-Niobium-Silicon System. J. Less-Common Metals, v. 3, No. 1, February 1961, pp. 34–43.

[17] Elle, M., and J. Chipman. The Columbium-Oxygen Equilibrium in Liquid Iron. Trans. Met. Soc. AIME, v. 221, No. 4, August 1961, pp. 701–703.

[18] Evans, Charles T. (assigned to Universal Cyclops Steel Corp.). Non-Ridging Stainless Steels. U.S. Pat 2,965,479, Dec. 20, 1960.

TABLE 8.—Columbium and tantalum alloys developed in 1961

Developed by	Designation	Composition, percent							
		Cb	Ta	Zr	V	Mo	W	Ti	Other
High-temperature alloys									
Armour Research Foundation		60			40				
(1)		20			75			5	
Battelle Memorial Institute		86					14		
E.I. du Pont de Nemours & Co. Inc.	D14	95		5					
Do	D36	85		5				10	
Fansteel Metallurgical Corp	FS80	99		0.75					
Do	FS82	65	34	0.75					
Do	FS85	60	27	1		12			
General Electric Co	F50	74		1		5	15	5	
Haynes Stellite Division of Union Carbide Corp	Cb751	99		1					
Do	Cb752	85		5			10		
Stauffer Chemical Co	SCb291	80	10				10		
Union Carbide Metals Co	Cb7	65					28	7	
Do	Cb16	66			3		21	10	
Do	Cb22	94			3				3 Al
Do	Cb24	87			3			7	3 Al
Do	Cb74	86		4			10		
Do	Cb84	70				3	20	7	
U.S.S.R		95				5			
Do		90		5		5			
Do		89		5		5			1 Si
Do		88		5		5			1 Si, 1 Al
Do		88		5		5			1 Si, 1 Al, 0.2C
Wah Chang Corp	C103	89						1	10 Hf
Do		24		76					
Do		33		67					
Westinghouse Electric Corp	B33	96			4				
Do	B66	89		1	5	5			
Do	B77	84		1	5		10		
(1)	15/20	65	20				15		
(1)	20/20	60	20				20		
Battelle Memorial Institute			85				5		10 Hf
Do		30	62½		7½				
Westinghouse Electric Corp			90				8		2 Hf
Cryogenic alloys									
Atomics International Division of North American Aviation, Inc		75		25					
U.S. Bureau of Standards		70							30 Sn
Brush Beryllium Co		62							38 Be
Do		70							30 Be

[1] Data not available.

Copper

By Don H. Baker, Jr.,[1] Gertrude N. Greenspoon,[2] and Wilma F. Washington[2]

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THE COPPER industry in the United States in 1961 was marked by record mine production, a fairly stable price, decreased imports, and a high rate of consumption. Domestic mine output exceeded 1960 by 8 percent mainly because of virtually uninterrupted operations at producing properties and the startup of a new mine. The price of domestic copper rose to 31 cents a pound, delivered, by the middle of May and remained unchanged for the rest of the year.

The return of the United States to a net-exporting nation, which began in 1960, became more pronounced in 1961. Imports decreased to the lowest point since 1947, but exports closely paralleled the high shipments in 1960. Demand for refined copper continued high, and consumption rose 8 percent over 1960.

Production gains in many countries, notably Canada, Chile, and Peru, raised 1961 world mine output to a new high record.

LEGISLATION AND GOVERNMENT PROGRAMS

Through the Office of Minerals Exploration (OME), the Government participated with private industry to the extent of 50 percent of the financial risk in exploratory ventures judged capable of increasing the Nation's resources for selected mineral commodities. In

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

TABLE 1.—Salient copper statistics

	1952–56 (average)	1957	1958	1959	1960	1961
United States:						
Ore produced [1]						
thousand short tons	107,798	129,716	114,824	103,716	134,994	142,722
Average yield of copper percent	0.82	0.77	0.79	0.74	0.73	0.75
Primary (new) copper produced—						
From domestic ores, as reported by—						
Mines short tons	958,001	1,086,859	979,329	824,846	1,080,169	1,165,155
Value thousands	$631,210	$654,289	$515,127	$506,455	$693,468	$699,093
Smelters short tons	966,006	1,081,055	992,918	799,329	1,142,848	1,162,480
Percent of world total	28	27	25	19	23	23
Refineries short tons	954,969	1,050,496	1,001,645	796,452	1,121,286	1,181,015
From foreign ores, matte, etc., refinery reports short tons	338,596	403,680	350,875	301,795	397,641	369,124
Total new refined, domestic and foreign short tons	1,293,565	1,454,176	1,352,520	1,098,247	1,518,927	1,550,139
Secondary copper recovered from old scrap only short tons	446,833	444,492	411,367	471,007	429,365	411,110
Imports, general:						
Unmanufactured [2] do	615,933	594,032	496,301	570,891	[3] 524,344	457,669
Refined do	246,043	162,309	128,464	214,058	142,709	66,855
Exports:						
Metallic copper [4] do	247,347	[5] 428,787	[5] 6428,015	[5] 6196,012	[3] [5] 6510,494	[5] 6 486,359
Refined do	184,518	346,025	384,868	158,938	433,762	432,253
Stocks Dec. 31: Producers:						
Refined short tons	42,000	109,000	48,000	18,000	98,000	49,000
Blister and materials in solution short tons	212,000	274,000	257,000	253,000	261,000	236,000
Total do	254,000	383,000	305,000	271,000	359,000	285,000
Withdrawals (apparent) from total supply on domestic account:						
Primary copper short tons	1,347,000	1,239,000	1,157,000	1,183,000	1,148,000	1,234,000
Primary and old copper (old scrap only) short tons	1,794,000	1,683,000	1,568,000	1,654,000	1,577,000	1,645,000
Price: Average cents per pound	[7] 32.4	[7] 30.1	[7] 26.3	[7] 30.7	[7] 32.1	[7] 30.0
World:						
Production:						
Mine short tons	3,280,000	3,890,000	[3] 3,780,000	[3] 4,030,000	[3] 4,640,000	4,850,000
Smelter do	3,460,000	4,040,000	3,950,000	4,190,000	4,950,000	5,060,000
Price: London, average cents per pound	[8] 38.69	27.36	24.79	29.80	30.81	28.73

[1] Includes old tailings smelted or re-treated. Not comparable with mine production figure shown in that latter includes recoverable copper content of ores not classified as "copper."
[2] Data are "general" imports; that is, they include copper imported for immediate consumption plus material entering country under bond. Comprises copper in ingots, plates, and bars, ores and concentrates, regulus, blister, and scrap.
[3] Revised figure.
[4] Total exports of copper, exclusive of ore, concentrates, composition metal, and unrefined copper. Exclusive also of "Other manufactures of copper," for which quantity figures are not recorded before 1953. (See table 35.)
[5] Due to changes in classification 1957–61 data are not strictly comparable with earlier years.
[6] Beginning Jan. 1, 1958, copper rods not separately classified; included in "Other copper manufactures."
[7] Exclusive of copper produced abroad and delivered in the United States.]
[8] Average for 1954–56.

1961 one new contract was made to explore for copper ore, in conjunction with cobalt, at the Idaho Copper mine, Lemhi County, Idaho. Estimated total cost of the project was $88,030.

The 1.7-cent-a-pound excise tax on copper imports, effective July 1, 1958, was unchanged.

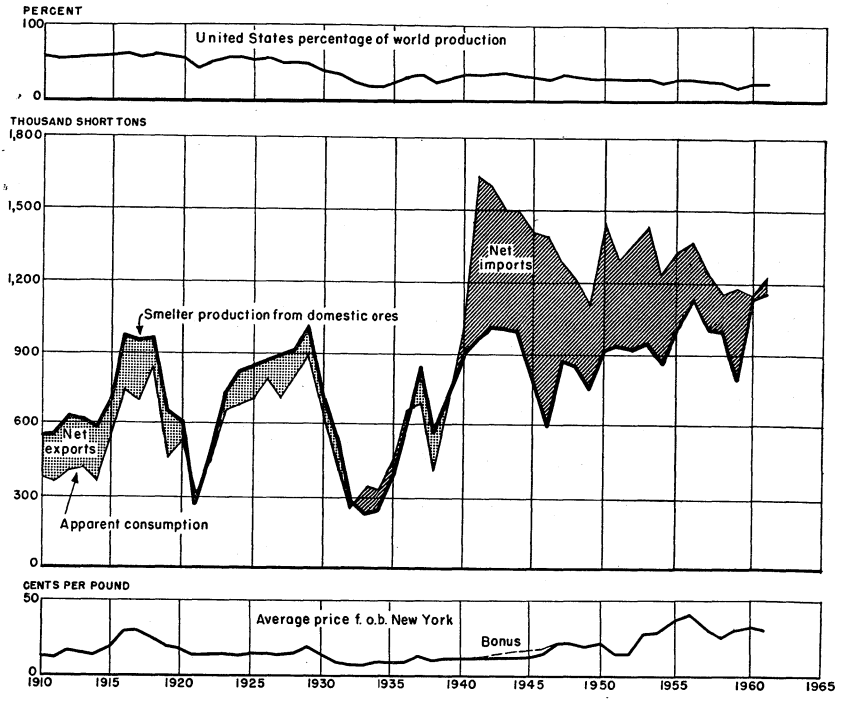


FIGURE 1.—Production, consumption, and price of copper in the United States, 1910–61.

DOMESTIC PRODUCTION

PRIMARY COPPER

Mine Production.—Domestic production rose 8 percent to a new record; 1961 output was 6 percent above the former peak of 1,104,000 tons in 1956. The new record in mine production was attributed largely to relatively strike-free operations and to the startup of production ahead of schedule at the Mission project in Arizona.

Arizona supplied 50 percent of the total U.S. output and continued to lead all States in mine production by a wide margin. Production rose 9 percent over 1960 to a new record. The Mission project, 15 miles southwest of Tucson, an open-pit operation of American Smelting and Refining Company, was completed about 6 months ahead of schedule, and production began in August. Development and operating data on the Mission project were published.[3]

Utah continued to rank second among major copper-producing States, although output declined 2 percent below 1960, and its share

[3] Engineering and Mining Journal. V. 163, No. 1, January 1962, pp. 70–79

of the total output decreased from 20 to 18 percent. A 21-day strike at the Utah Division of Kennecott Copper Corp.—the leading copper producer in the United States—mainly caused the reduced output.

Third-ranked Montana's 1961 production was the largest since 1944. It increased 13 percent over 1960 and represented 9 percent of the total U.S. output. New Mexico and Nevada, ranked fourth and fifth, respectively, in production, and each supplied 7 percent of the U.S. total copper output. New Mexico's output, increasing 18 percent over 1960 production, was the highest since 1942. Output in Nevada increased only slightly. Michigan, ranking sixth, produced 6 percent of the total output, 25 percent more copper than in 1960.

Classification of production by mining method showed that approximately 74 percent of the recoverable copper and 80 percent of the copper ore came from open pits. Most domestic copper 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.

The first 5 mines in table 6 produced 50 percent of the U.S. total, and the entire 25 furnished 97 percent.

TABLE 2.—Copper produced from domestic ores, by sources

(Short tons)

Year	Mine	Smelter	Refinery	Year	Mine	Smelter	Refinery
1957	1,086,859	1,081,055	1,050,496	1960	1,080,169	1,142,848	1,121,286
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				

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
1944	68	57	32	43	1953	83	75	17	25
1945	68	61	32	39	1954	83	79	17	21
1946	66	58	34	42	1955	83	77	17	23
1947	73	68	27	32	1956	78	73	22	27
1948	76	68	24	32	1957	77	72	23	28
1949	78	70	22	30	1958	76	71	24	29
1950	81	74	19	26	1959	79	74	21	26
1951	84	74	16	26	1960	80	75	20	25
1952	85	77	15	23	1961	80	74	20	26

TABLE 4.—Mine production of recoverable copper in the United States in 1961, by months [1]

Month	Short tons	Month	Short tons
January	97,674	August	84,028
February	88,712	September	98,265
March	100,796	October	104,620
April	91,314	November	104,398
May	102,826	December	103,250
June	99,331		
July	89,941	Total	1,165,155

[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 1961, by States

(Short tons)

State	Maximum production [1]		Production by years						Total production from earliest record through 1961
	Year	Quantity	1952–56 (average)	1957	1958	1959	1960	1961	
Alabama	1907	42							64
Alaska	1916	59,927	1	[2]	5	36	41	92	686,084
Arizona	1961	587,053	425,437	515,854	485,839	430,297	538,605	587,053	17,782,444
California	1909	28,644	603	945	749	663	1,087	1,382	638,770
Colorado	1938	14,171	3,924	5,115	4,193	2,940	3,247	4,141	303,172
Georgia	1917	465							1,117
Idaho	1958	9,846	4,690	7,912	9,846	8,713	4,208	4,328	175,214
Maine	1918	383							[3]
Maryland	1917	146							[3]
Massachusetts	1906	5							[3]
Michigan	1916	136,846	36,196	58,400	58,005	55,300	56,385	70,245	5,420,860
Missouri	1949	3,670	2,098	1,604	1,429	1,065	1,087	1,479	[4] 50,033
Montana	1916	176,464	75,376	91,512	90,683	65,911	91,972	104,000	7,683,960
Nevada	1942	83,663	69,871	77,750	66,137	57,375	77,485	78,022	2,730,736
New Hampshire	1908	[5] 94							[3]
New Mexico	1942	80,100	69,982	67,472	55,540	39,688	67,288	79,606	2,339,840
North Carolina	1930	6,695		[6]	[6]	[6]	[6]	[6]	57,895
Oregon	1916	1,791	5	23	10		6	[6]	[7]
Pennsylvania [8]	1942	6,410	3,599	7,516	8,073	6,604	7,907	8,934	[3]
South Carolina	1938	4							10
South Dakota	1918	32					1		107
Tennessee	1960	12,723	8,979	9,790	9,109	11,490	12,723	12,272	519,080
Texas	1928	224	4						1,384
Utah	1943	323,989	249,556	237,857	189,184	144,715	218,049	213,534	8,392,059
Vermont	1954	4,352	3,956	3,405	475				[3]
Virginia	1944	291							[3]
Washington	1940	9,612	3,723	1,700	52	49	78	66	121,814
Wisconsin	1914	5							[3]
Wyoming	1900	2,102	1	4	[2]			1	16,336
Total	1961	1,165,155	958,001	1,086,859	979,329	824,846	1,080,169	1,165,155	[9] 47,176,425

[1] For Missouri and States east of the Mississippi River, maximum since 1905.
[2] Less than 1 ton.
[3] Data not available.
[4] Small quantity for Wisconsin included with Missouri.
[5] The 1908 volume of Mineral Resources credits this figure to Massachusetts and New Hampshire; the 1909 volume credits it to New Hampshire alone.
[6] Included with Pennsylvania to avoid disclosing operations of individual companies.
[7] Figure withheld to avoid disclosing individual company confidential data.
[8] Includes North Carolina for 1956–61 and Oregon for 1961 to avoid disclosing operations of individual companies.
[9] Largely smelter production for States east of the Mississippi River except Michigan. Includes 255,446 tons for States indicated by footnote 3.

TABLE 6.—Twenty-five leading copper-producing mines in the United States in 1961, 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	San Manuel Copper Corp	Copper ore.
5	Chino	Central	New Mexico	Kennecott Copper Corp	Do.
6	New Cornelia	Ajo	Arizona	Phelps Dodge Corp	Copper, gold-silver ores.
7	Copper Queen-Lavender Pit	Warren (Bisbee)	do	do	Copper ore.
8	Ray Pit	Mineral Creek (Ray)	do	Kennecott Copper Corp	Do.
9	White Pine	Lake Superior	Michigan	White Pine Copper Co	Do.
10	Liberty Pit	Robinson (Ely)	Nevada	Kennecott Copper Corp	Do.
11	Inspiration	Globe-Miami	Arizona	Inspiration Consolidated Copper Co	Do.
12	Yerington	Yerington	Nevada	The Anaconda Company	Do.
13	Esperanza	Pima	Arizona	Duval Sulphur & Potash Co	Do.
14	Silver Bell	Silver Bell	do	American Smelting and Refining Co	Do.
15	Magma	Pioneer (Superior)	do	Magma Copper Co	Copper, gold-silver ores.
16	Copper Cities	Globe-Miami	do	Tennessee Corp	Copper ore.
17	Pima	Pima	do	Pima Mining Co	Do.
18	Calumet & Hecla, Inc	Lake Superior	Michigan	Calumet & Hecla, Inc	Copper ore and tailings.
19	Mission	Pima	Arizona	American Smelting and Refining Co	Copper ore.
20	Burra-Boyd	Polk County	Tennessee	Tennessee Copper Co	Copper-zinc ore.
21	Bagdad	Eureka (Bagdad)	Arizona	Bagdad Copper Corp	Copper ore.
22	Miami	Globe-Miami	do	Tennessee Corp	Copper precipitates.
23	Ore Knob	Ashe County	North Carolina	Appalachian Sulfides, Inc	Copper ore.
24	Palo Verde	Pima	Arizona	Banner Mining Co	Do.
25	Old Dick	Eureka (Bagdad)	do	Cyprus Mines Corp	Copper-zinc ore.

TABLE 7.—Copper ore sold or treated in the United States in 1961, 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			
Alaska	152	184,233	60.60	----------	1,913	$11.64
Arizona	71,918,991	1,092,360,900	.76	129,184	4,380,458	.12
California	19,449	1,501,100	3.86	4,504	43,721	10.18
Colorado	15,764	956,700	3.03	5,232	397,342	34.92
Idaho	20,866	1,268,200	3.04	564	22,317	1.93
Michigan [2]	9,232,210	140,490,000	.76	----------	----------	----------
Montana	12,533,042	199,548,400	.80	18,133	2,679,279	.25
Nevada	12,008,578	156,007,800	.65	44,011	241,222	.15
New Mexico	7,379,114	113,747,300	.77	4,612	81,260	.03
North Carolina	295,135	11,856,000	2.01	1,902	25,311	.30
Tennessee [3]	1,452,330	24,544,000	.84	152	83,417	.06
Utah	27,844,693	402,707,800	.72	323,850	2,428,969	.49
Washington	1,474	52,000	1.76	71	452	1.97
Total [4]	142,721,798	2,145,224,433	.75	532,215	10,385,661	.20

[1] Excludes copper recovered from precipitates as follows: Arizona, 68,698,300 pounds; Montana, 7,972,200 pounds; New Mexico, 43,148,600 pounds; Utah, 18,660,800 pounds.
[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 1961, with content in terms of recoverable copper

State	Ore concentrated (short tons)	Recoverable copper content	
		Pounds	Percent
Arizona	[1] 71,332,364	1,046,359,300	0.73
California	19,303	1,481,700	3.84
Colorado	230	7,600	1.65
Idaho	18,623	824,000	2.21
Michigan [2]	9,232,210	140,490,000	.76
Montana	12,532,512	199,489,500	.80
Nevada	[3] 11,940,292	[3] 154,304,300	.65
New Mexico	[4] 7,306,312	[5] 113,229,500	.77
North Carolina	295,135	11,856,000	2.01
Tennessee [6]	1,452,330	24,544,000	.84
Utah	27,844,650	402,704,300	.72
Washington	1,425	50,000	1.75
Total	141,975,386	2,095,340,200	.74

[1] Includes ore that was treated by leaching followed by concentration.
[2] Includes tailings.
[3] Includes ore treated by straight leaching, and copper precipitates recovered therefrom; Bureau of Mines not at liberty to publish.
[4] In addition 12,300 tons were treated by vat leaching.
[5] In addition 133,700 pounds of copper were recovered by vat leaching.
[6] Copper-zinc ore.

Smelter Production.—The recovery of copper from domestic ores by smelters in the United States rose 2 percent in 1961 to establish a new record. Copper produced from foreign materials was less than half that of 1960 and the smallest since 1959, but output from secondary sources rose 5 percent. Total output of the smelters decreased 2 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-

TABLE 9.—Copper ore shipped to smelters in the United States in 1961, with content in terms of recoverable copper

State	Ore shipped to smelters		
	Short tons	Recoverable copper content	
		Pounds	Percent
Alaska	152	184,233	60.60
Arizona	586,627	46,001,600	3.92
California	146	19,400	6.64
Colorado	15,534	949,100	3.05
Idaho	2,243	444,200	9.90
Michigan			
Missouri			
Montana	530	58,900	5.56
Nevada	68,286	1,703,500	1.25
New Mexico	60,502	384,100	.32
North Carolina			
Pennsylvania			
Tennessee			
Utah	43	3,500	4.07
Washington	49	2,000	2.04
Wyoming			
Total [1]	734,112	49,750,533	3.39

[1] Excludes small quantities for Oregon. Bureau of Mines not at liberty to publish.

TABLE 10.—Copper ores [1] produced in the United States, and average yield in copper, gold, and silver

Year	Smelting ores		Concentrating ores		Total				
	Short tons	Yield in copper, percent	Short tons [2]	Yield in copper, percent	Short tons [2 3]	Yield in copper, percent	Yield per ton in gold, ounce	Yield per ton in silver, ounce	Value per ton in gold and silver
1952–56 (average)	895,541	3.74	103,366,869	0.80	107,798,464	0.82	0.0053	0.090	$0.27
1957	827,226	4.32	124,640,436	.76	129,715,586	.77	.0043	.086	.23
1958	631,714	4.78	114,027,754	.77	114,824,468	.79	.0040	.080	.21
1959	467,598	3.98	103,239,445	.72	103,715,843	.74	.0035	.066	.18
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

[1] Includes old tailings, smelted or re-treated, etc., for 1952.
[2] Includes some ore classed as copper-zinc ore.
[3] Includes copper ore leached.

refined copper in Michigan is included in smelter production and in refinery output. 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.

Refinery Production.—Output of primary copper by the 15 primary refineries in the United States in 1961 was slightly larger than in 1960. 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 but shipped the remainder to electrolytic refineries. The Inspiration Consolidated Copper Co. at Inspiration, Ariz., produced electrolytic copper directly from leaching solutions; a substantial part of this copper was shipped as cathodes

TABLE 11.—Copper produced by primary smelters in the United States

(Short tons)

Year	Domestic	Foreign	Secondary	Total
1952–56 (average)	966,006	105,197	66,937	1,138,140
1957	1,081,055	97,090	75,931	1,254,076
1958	992,918	76,134	61,848	1,130,900
1959	799,329	42,466	54,895	896,690
1960	1,142,848	90,781	74,472	1,308,101
1961	1,162,480	44,874	78,377	1,285,731

to other refineries for melting and casting into commercial shapes.

The electrolytic plants, excluding the plant at Inspiration, had a rated capacity of 1,929,000 tons of refined copper a year and produced at 93 percent of capacity.

There were six large electrolytic refineries on the Atlantic seaboard (two each at Baltimore, Md., and Perth Amboy, N.J., and one each at Carteret, N.J., and Laurel Hill, N.Y.), three lake refineries on the Great Lakes, and four electrolytic refineries west of the Great Lakes (one each at Great Falls, Mont.; Tacoma, Wash.; El Paso, Tex.; and Garfield, Utah). The El Paso plant of the Phelps Dodge Refining Corp. and the Carteret plant of the American Metal Climax, Inc., produced fire-refined in addition to electrolytic-grade copper.

TABLE 12.—Primary and secondary copper produced by primary refineries in the United States

(Short tons)

	1952–56 (average)	1957	1958	1959	1960	1961
Primary:						
From domestic ores, etc.:[1]						
Electrolytic	851,108	945,394	892,758	699,890	1,009,983	1,037,489
Lake	32,060	58,814	59,111	54,543	56,232	70,061
Casting	71,801	46,288	49,776	42,019	55,071	73,465
Total	954,969	1,050,496	1,001,645	796,452	1,121,286	1,181,015
From foreign ores, etc.:[1]						
Electrolytic	326,898	372,791	340,470	256,002	389,178	355,009
Casting and best select	11,698	30,889	10,405	45,793	8,463	14,115
Total refinery production of primary copper	1,293,565	1,454,176	1,352,520	1,098,247	1,518,927	1,550,139
Secondary:						
Electrolytic[2]	170,824	203,073	199,508	200,183	241,169	231,836
Casting	15,631	8,521	7,828	11,405	10,585	11,294
Total secondary	186,455	211,594	207,336	211,588	251,754	243,130
Grand total	1,480,020	1,665,770	1,559,856	1,309,835	1,770,681	1,793,269

[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.

Copper Sulfate.—Production and shipments of copper sulfate declined 16 and 14 percent, respectively, in 1961. Of the total shipments of 46,500 tons (54,300 in 1960), producers' reports indicated that 17,800 tons (16,700) was for agricultural uses, 20,000 (20,000) for industrial uses, and 8,700 (17,600) for other purposes, chiefly for export. Stocks on December 31 were the largest since the end of 1953.

TABLE 13.—Copper cast in forms at primary refineries in the United States

Form	1960		1961	
	Thousand short tons	Percent	Thousand short tons	Percent
Billets	159	9	176	10
Cakes	134	8	145	8
Cathodes	158	9	194	11
Ingots and ingot bars	124	7	164	9
Wirebars	1,180	66	1,096	61
Other forms	16	1	18	1
Total	1,771	100	1,793	100

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		
1952–56 (average)	75,537	18,884	75,454	5,683
1957	70,680	17,670	70,256	3,828
1958	48,596	12,149	46,580	5,168
1959	40,292	10,073	42,100	2,500
1960	58,000	14,500	54,272	5,480
1961	48,584	12,146	46,544	6,740

[1] Some small quantities are purchased and used by producing companies, so that the figures given do not balance exactly.

SECONDARY COPPER AND BRASS

Recovery of copper in unalloyed and alloyed form from all classes of nonferrous scrap metal in the United States totaled 848,900 tons, 3 percent less than in 1960. Of the 24,200-ton decrease in recovery from copper-base scrap, primary copper producers contributed 9,400

TABLE 15.—Secondary copper produced in the United States

(Short tons)

	1952–56 (average)	1957	1958	1959	1960	1961
Copper recovered as unalloyed copper	229,798	248,015	255,121	261,588	300,259	279,511
Copper recovered in alloys [1]	694,449	593,872	542,267	668,982	571,129	569,428
Total secondary copper	924,247	841,887	797,388	930,570	871,388	848,939
Source:						
New scrap	477,415	397,395	386,021	459,563	442,023	437,829
Old scrap	446,833	444,492	411,367	471,007	429,365	411,110
Percentage equivalent of domestic mine output	79	77	81	113	81	73

[1] Includes copper in chemicals, as follows: 1952–56 (average), 17,126; 1957, 14,240; 1958, 9,491; 1959, 10,061; 1960, 12,714; and 1961, 10,708.

tons; foundries, 7,800 tons; secondary smelters, 4,600 tons; and brass mills and chemical plants supplied the remainder. New and old scrap furnished nearly equal portions of the copper recovered.

Consumption of purchased copper-base scrap declined 3 percent in 1961. Secondary smelters consumed 328,300 tons of copper scrap, of which 255,600 tons was old scrap. Primary copper producers used 220,700 tons of old scrap and 169,300 tons of new scrap. Of the 347,800 tons consumed by brass mills, 325,000 tons was new scrap and 22,800 tons was old scrap. Foundries and other plants consumed 104,000 tons of scrap.

Production of secondary copper and copper alloy products decreased 4 percent. Unalloyed copper products, most of which were recovered as refined copper by primary copper refineries, decreased 7 percent, and brass-mill products declined 2 percent. Brass and bronze ingot production was unchanged.

TABLE 16.—Copper recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

Kind of scrap	1960	1961	Form of recovery	1960	1961
New scrap:			As unalloyed copper:		
Copper-base	436,326	431,947	At primary plants	251,754	231,836
Aluminum-base	5,550	5,690	At other plants	48,505	47,675
Nickel-base	114	171			
Zinc-base	33	21	Total	300,259	279,511
Total	442,023	437,829	In brass and bronze	539,765	537,581
			In alloy iron and steel	2,779	2,662
Old scrap:			In aluminum alloys	15,605	18,291
Copper-base	426,222	406,354	In other alloys	266	186
Aluminum-base	2,505	4,181	In chemical compounds	12,714	10,708
Nickel-base	546	528			
Tin-base	25	24	Total	571,129	569,428
Zinc-base	67	23			
Total	429,365	411,110	Grand total	871,388	848,939
Grand total	871,388	848,939			

TABLE 17.—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	
	1960	1961	1960	1961	1960	1961
Recovered by—						
Secondary smelters	50,250	48,337	200,854	198,161	251,104	246,498
Primary copper producers	123,392	118,655	132,102	127,419	255,494	246,074
Brass mills	243,253	245,277	24,234	20,780	267,487	266,057
Foundries and manufacturers	18,192	18,510	62,489	54,399	80,681	72,909
Chemical plants	1,239	1,168	6,543	5,595	7,782	6,763
Total	436,326	431,947	426,222	406,354	862,548	838,301

TABLE 18.—Production of secondary copper and copper-alloy products in the United States

(Short tons)

Item produced from scrap	Nominal composition (percent) Cu	Sn	Pb	Zn	Ni	Gross weight 1960	1961
Unalloyed copper products:							
Refined copper by primary producers						251,754	231,836
Refined copper by secondary smelters						39,960	38,582
Copper powder						6,866	7,993
Copper castings						1,679	1,100
Total						300,259	279,511
Brass and bronze ingots:							
Tin bronze	88	10	------	2	------	15,513	15,740
Leaded tin bronze	88	6	1.5	4.5	------	16,605	15,980
Leaded red bronze	85	5	5	5	------	83,938	81,594
Leaded semired brass	81	3	7	9	------	64,198	71,310
High-leaded tin bronze	80	10	10	------	------	14,897	13,488
Do	84	6	8	2	------	14,040	12,583
Do	75	5	20	------	------	3,591	3,842
Leaded yellow brass	66	1	3	30	------	11,760	9,952
Nickel silver	58	2	7	18	14	2,926	3,370
Do	65	4	3	5	22		
Low brass	80	------	------	20	------	2,622	3,361
Conductor bronze	94	2	2	2	------	461	638
Manganese bronze	60 Cu 40 Zn, ±Mn, Al, etc.					12,590	11,377
Aluminum bronze	90 Cu 10 Al, ±Mn, Zn, Fe, etc.					6,452	6,628
Silicon bronze	92 Cu +Si, ±Zn, Fe, Al, Mn.					4,008	3,602
Copper-base hardeners and special alloys						12,411	11,551
Total						266,012	265,016
Brass-mill products						348,074	342,383
Brass and bronze castings						77,941	66,216
Brass powder						1,597	1,633
Copper in chemical products						12,714	10,708
Grand total						1,006,597	965,467

TABLE 19.—Composition of secondary copper-alloy production

(Short tons, gross weight)

Year	Copper	Tin	Lead	Zinc	Nickel	Aluminum	Total
Brass and bronze production: [1]							
1960	210,659	12,347	16,445	26,035	463	63	266,012
1961	209,194	13,159	17,228	24,901	468	66	265,016
Secondary metal content of brass-mill products:							
1960	265,774	118	2,976	77,811	1,387	8	348,074
1961	266,088	112	2,857	71,705	1,582	39	342,383
Secondary metal content of brass and bronze castings:							
1960	60,322	3,466	8,895	5,144	24	90	77,941
1961	51,801	2,995	7,511	3,828	24	57	66,216

[1] About 95 percent from scrap and 5 percent from other than scrap.

TABLE 20.—Stocks and consumption of copper scrap in the United States in 1961

(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		
Secondary smelters:								
No. 1 wire and heavy copper	2,663	33,666	--------	3,365	30,287	33,652	--------	2,677
No. 2 wire, mixed heavy, and light copper	3,380	56,822	--------	5,913	51,175	57,088	--------	3,114
Composition or red brass	4,148	83,294	--------	27,529	55,965	83,494	--------	3,948
Railroad-car boxes	153	1,251	--------	--------	1,040	1,040	--------	364
Yellow brass	4,361	53,360	--------	7,169	42,871	50,040	--------	7,681
Cartridge cases and brass	304	251	--------	--------	508	508	--------	47
Auto radiators (unsweated)	2,624	38,524	--------	--------	38,567	38,567	--------	2,581
Bronze	2,460	30,088	--------	7,918	23,059	30,977	--------	1,571
Nickel silver	905	3,103	--------	293	2,955	3,248	--------	760
Low brass	376	1,727	--------	1,131	711	1,842	--------	261
Aluminum bronze	211	493	--------	36	424	460	--------	244
Low-grade scrap and residues	3,833	27,180	--------	19,353	7,993	27,346	--------	3,667
Total	25,418	329,759	--------	72,707	255,555	328,262	--------	26,915
Primary producers:								
No. 1 wire and heavy copper	2,479	42,616	--------	17,965	25,447	43,412	--------	1,683
No. 2 wire, mixed heavy, and light copper	5,442	124,216	--------	69,450	54,789	124,239	--------	5,419
Refinery brass	4,931	22,507	--------	11,622	15,068	26,690	--------	748
Low-grade scrap and residues	53,647	170,955	--------	70,319	125,383	195,702	--------	28,900
Total	66,499	360,294	--------	169,356	220,687	390,043	--------	36,750
Brass mills: [1]								
No. 1 wire and heavy copper	5,828	81,476	--------	65,059	16,417	81,476	--------	5,930
No. 2 wire, mixed heavy, and light copper	3,555	29,144	--------	28,723	421	29,144	--------	4,333
Yellow brass	15,771	154,044	--------	154,044	--------	154,044	--------	15,867
Cartridge cases and brass	2,834	41,079	--------	35,142	5,937	41,079	--------	2,328
Bronze	427	2,019	--------	2,019	--------	2,019	--------	348
Nickel silver	2,584	7,241	--------	7,241	--------	7,241	--------	2,763
Low brass	2,613	21,035	--------	21,035	--------	21,035	--------	2,484
Aluminum bronze	149	402	--------	402	--------	402	--------	154
Mixed-alloy scrap	8,543	11,400	--------	11,400	--------	11,400	--------	8,830
Total [1]	42,304	347,840	--------	325,065	22,775	347,840	--------	43,037
Foundries, chemical plants, and other manufacturers:								
No. 1 wire and heavy copper	2,638	19,713	945	7,544	12,962	20,506	431	2,359
No. 2 wire, mixed heavy, and light copper	1,625	11,643	652	4,418	7,530	11,948	537	1,435
Composition or red brass	2,006	5,891	12,390	3,930	2,854	6,784	11,897	1,606
Railroad-car boxes	1,967	40,404	1,843	--------	40,264	40,264	1,796	2,154
Yellow brass	1,466	8,411	6,099	4,071	3,640	7,711	6,903	1,362
Auto radiators (unsweated)	224	5,948	2	--------	5,777	5,777	2	395
Bronze	1,072	2,771	1,777	1,307	1,487	2,794	1,662	1,164
Nickel silver	37	93	304	68	22	90	283	61
Low brass	203	441	2,049	29	392	421	1,995	277
Aluminum bronze	233	318	625	69	232	301	616	259
Low-grade scrap and residues	653	7,443	1,457	1,981	5,375	7,356	1,402	795
Total	12,124	103,076	28,143	[2]23,417	[2]80,535	[2]103,952	27,524	11,867
Grand total: [3]								
No. 1 wire and heavy copper	13,608	177,471	945	93,933	85,113	179,046	431	12,649
No. 2 wire, mixed heavy, and light copper	14,002	221,825	652	108,504	113,915	222,419	537	14,301
Composition or red brass	6,154	89,185	12,390	31,459	58,819	90,278	11,897	5,554
Railroad-car boxes	2,120	41,655	1,843	--------	41,304	41,304	1,796	2,518
Yellow brass	21,598	215,815	6,099	165,284	46,511	211,795	6,903	24,910
Cartridge cases and brass	3,138	41,330	--------	35,142	6,445	41,587	--------	2,375
Auto radiators (unsweated)	2,848	44,472	2	--------	44,344	44,344	2	2,976
Bronze	3,959	34,878	1,777	11,244	24,546	35,790	1,662	3,083
Nickel silver	3,526	10,437	304	7,602	2,977	10,579	283	3,584
Low brass	3,192	23,203	2,049	22,195	1,103	23,298	1,995	3,022
Aluminum bronze	593	1,213	625	507	656	1,163	616	657
Low-grade scrap and residues [4]	63,064	228,085	1,457	103,275	153,819	257,094	1,402	34,110
Mixed-alloy scrap	8,543	11,400	--------	11,400	--------	11,400	--------	8,830
Total [3]	146,345	1,140,969	28,143	590,545	579,552	1,170,097	27,524	118,569

[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] Of the totals shown, chemical plants reported the following: Unalloyed copper scrap, 977 tons of new and 4,290 old; copper-base alloy scrap, 903 tons of new and 5,342 old.

[3] Includes machine-shop scrap receipts and consumption for foundries, chemical plants, and other manufacturers.

[4] Includes refinery brass.

TABLE 21.—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
1960:						
Copper scrap	400,781	355,487		116,687	335,479	1,208,434
Refined copper [1]		486,460	828,823	26,407	8,206	1,349,896
Brass ingot		6,054	126	[2] 259,857		266,037
Slab zinc		86,639		3,227	9,157	99,023
Miscellaneous		60		465	4,106	4,631
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

[1] Detailed information on consumption of refined copper will be found in table 25.
[2] Shipments to foundries by smelters minus increase in stocks at foundries.

TABLE 22.—Dealers' monthly average buying price for copper scrap and consumers' alloy-ingot prices at New York in 1961

(Cents per pound)

Grade	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
No. 1 Heavy copper scrap	21.46	21.69	22.75	23.54	25.14	25.01	24.42	24.79	24.70	23.80	23.44	23.57	23.69
No. 1 Composition scrap	16.49	16.47	17.87	18.77	20.97	21.17	20.75	21.26	21.37	20.75	20.42	20.25	19.71
No. 1 Composition ingot	27.73	27.31	28.08	29.55	31.53	32.00	32.00	32.00	32.00	32.00	32.00	32.00	30.68

Source: Metal Statistics, 1962.

TABLE 23.—Foundry consumption of brass ingot, by types, in the United States

(Short tons)

Type of ingot	1952–56 (average)	1957	1958	1959	1960	1961
Tin bronze	15,536	15,408	10,272	11,257	9,689	11,152
Leaded tin bronze	28,404	23,118	20,591	24,868	23,818	22,876
Leaded red brass	150,379	138,289	138,183	162,798	142,817	149,405
High-leaded tin bronze	24,299	24,691	17,478	19,413	18,076	16,739
Leaded yellow brass	18,974	15,906	15,790	17,344	15,887	12,672
Manganese bronze	14,216	11,436	8,155	9,609	9,540	8,429
Hardeners	2,185	2,348	1,565	2,185	2,268	2,439
Nickel silver	3,450	2,967	2,428	2,921	2,732	2,792
Low brass	7,421	8,631	6,690	7,699	7,365	7,505
Total	264,864	242,794	221,152	258,094	232,192	234,009

CONSUMPTION

Apparent withdrawals of primary copper rose 7 percent in 1961. Actual consumption of refined copper increased 8 percent. These data are based on reports from consumers of quantities entering processing, with no adjustment for stock changes of material in process.

Unlike table 24, in which only new copper is included as far as possible, table 25 does not distinguish between new and old copper but includes all copper in refined form.

Although uses for refined copper remained the same as in previous years, wire-mill consumption decreased from 61 percent in 1960 to 56 percent of the total in 1961, and brass-mill consumption rose from 36 to 41 percent.

TABLE 24.—Primary refined-copper supply and withdrawals on domestic account
(Short tons)

Supply and withdrawals	1952–56 (average)	1957	1958	1959	1960	1961
Production from domestic and foreign ores, etc.	1,293,565	1,454,176	1,352,520	1,098,247	1,518,927	1,550,139
Imports [1]	246,043	162,309	128,464	214,058	142,709	66,855
Stock Jan. 1 [1]	34,000	78,000	109,000	48,000	18,000	98,000
Total available supply	1,573,608	1,694,485	1,589,984	1,360,305	1,679,636	1,714,994
Copper exports [1]	184,518	346,025	384,868	158,938	433,762	432,253
Stock Dec. 31 [1]	42,000	109,000	48,000	18,000	98,000	49,000
Total	226,518	455,025	432,868	176,938	531,762	481,253
Apparent withdrawals on domestic account [2]	1,347,000	1,239,000	1,157,000	1,183,000	1,148,000	1,234,000

[1] May include some copper refined from scrap.
[2] Includes copper delivered by industry to the national strategic stockpile.

TABLE 25.—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
1960:							
Wire mills	3,928	810,570	13,450			875	828,823
Brass mills	74,993	48,776	80,247	137,667	144,725	52	486,460
Chemical plants			465			571	1,036
Secondary smelters	5,939		1,913	177		177	8,206
Foundries	4,644	92	10,224	26	275	900	16,161
Miscellaneous [1]	1,220	5	2,328	6	558	5,093	9,210
Total	90,724	859,443	108,627	137,876	145,558	7,668	1,349,896
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

[1] Includes iron and steel plants, primary smelters producing alloys other than copper, consumers of copper powder and copper shot, and miscellaneous manufacturers.

STOCKS

Stocks of refined copper in the United States declined 50 percent and unrefined stocks decreased 10 percent to the lowest point since 1955.

According to the United States Copper Association, fabricators' stocks of refined metal (including in-process copper and primary

fabricated shapes) were 461,300 tons at the end of 1961, slightly larger than those on January 1. Working stocks (see table 27) were 361,300 tons, a 2-percent decrease from 1960. After unfilled sales orders for metal were discounted, copper classed as "available for sale" totaled 45,400 tons, 10,000 greater than at the end of 1960.

Data on Government inventories of strategic materials as of December 31, 1961, revealed that 1,142,000 short tons of copper was stockpiled. Of this quantity, 1,009,000 tons was in the national (strategic) stockpile, 122,000 tons in the Defense Production Authority inventory, and 11,000 tons in the supplemental stockpile.

Included in these data were 21,066 tons of oxygen-free high conductivity copper in the national stockpile and 5,199 tons in the supplemental stockpile. The maximum objective for copper was 1 million tons.

TABLE 26.—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]
1952-56 (average)	42,000	212,000	1959	18,000	253,000
1957	109,000	274,000	1960	98,000	261,000
1958	48,000	257,000	1961	49,000	236,000

[1] May include some copper refined from scrap.
[2] Includes copper in transit from smelters in the United States to refineries therein.

TABLE 27.—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)
1957	430,171	75,627	347,465	138,631	19,702
1958	446,358	90,401	326,438	177,869	32,452
1959	414,757	130,324	340,349	202,775	1,957
1960	456,094	75,222	370,055	126,260	35,001
1961	461,252	89,745	361,286	144,344	45,367

[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

Reports from copper-selling agencies indicated that 1,314,457 tons of domestic refined copper was delivered to purchasers at an average price of 30 cents a pound. The average price of foreign copper delivered in the United States was 30.4 cents a pound.

The price for electrolytic copper quoted by primary producers was 30 cents a pound, delivered, at the beginning of the year. On January

17 producers reduced the price to 29 cents which held until May 1, when a principal producer raised the price to 30 cents; by May 3 all producers were quoting 30 cents. Shortly after the middle of May producers again increased the price to 31 cents, which became effective for all principal producers on May 19 and was unchanged at yearend.

The custom smelter price closely paralleled the quotation of the primary producers; the price declined to 29 cents on January 11, was raised to 30 cents on May 1, but was withdrawn on May 16. On May 17 custom smelters quoted 31 cents, and this price held through the end of the year.

London Price.—The price of copper on the London Metal Exchange (LME) during January averaged £220 0s. 7d. per long ton (27.57 cents a pound). Prices trended upward until May when the high for the year was reached—£242 8s. 2d. (30.24 cents). Thereafter, quotations were at or near the equivalent of 29 cents. The price for the year averaged 7 percent less than in 1960.

TABLE 28.—Average weighted prices of copper deliveries,[1] consumer plants

(Cents per pound)

Year	Domestic copper	Foreign copper	Year	Domestic copper	Foreign copper
1957	30.1	29.6	1960	32.1	32.5
1958	26.3	25.0	1961	30.0	30.4
1959	30.7	31.6			

[1] Covers copper produced in the United States and delivered here and abroad and copper produced abroad and delivered in the United States; excludes copper both produced and delivered abroad, whether or not handled by U.S. selling agenices.

TABLE 29.—Average monthly quoted prices of electrolytic copper for domestic and export shipments, f.o.b. refineries, in the United States and for spot copper at London

(Cents per pound)

Month	1960				1961			
	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	32.82	33.654	31.555	32.41	28.82	29.057	26.746	27.57
February	32.82	32.976	31.994	33.02	28.82	28.600	27.040	27.95
March	32.82	32.613	30.745	31.72	28.82	28.600	27.303	28.13
April	32.82	32.600	31.684	32.88	28.82	28.600	27.781	28.63
May	32.82	32.600	30.302	31.10	30.19	29.985	29.505	30.24
June	32.82	32.600	30.290	31.37	30.82	30.605	28.701	29.45
July	32.82	32.600	31.010	31.92	30.82	30.600	27.873	28.58
August	32.82	32.600	29.925	30.76	30.82	30.600	28.087	28.89
September	32.82	32.600	28.611	29.47	30.82	30.604	28.036	28.81
October	30.87	30.598	27.111	27.89	30.82	30.600	27.875	28.74
November	29.82	29.600	27.470	28.43	30.82	30.600	28.005	28.82
December	29.82	29.600	28.036	28.95	30.82	30.600	28.072	28.84
Average	32.16	32.053	29.894	30.81	30.14	29.921	27.919	28.73

[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.—Imports of unmanufactured copper decreased 13 percent and were the lowest since 1947. Receipts of refined copper had decreased each year since 1953 except for 1959, and in 1961 were less than half the 1960 entries. Import of blister, however, increased for the third successive year and were 14 percent greater than in 1960. The other unrefined classes—ore, concentrate, and matte—were down 41 percent.

Chile, supplying 50 percent of the 1961 total and 9 percent more than in 1960, remained the chief source of imported copper. Although Peru furnished slightly less copper than in 1960, it supplied 20 percent of the total receipts, and rose to second place as a supplier. The Peruvian copper was mostly blister copper for refining in the United States. Canada, ranking second since 1951 as a supplier of copper, declined to third place in 1961, furnishing only 17 percent of the United States total. This was 33 percent less than in 1960. Imports from Mexico, the Union of South Africa, and the Philippines declined.

Exports.—Refined copper continued as the principal class of exports, and shipments were little changed from 1960. West Germany, United Kingdom, Italy, Japan, and France were the major recipients, but substantial shipments went to Brazil, India, and Argentina.

Exports of scrap copper declined sharply; Japan received the largest quantity, followed by Spain and West Germany. Shipments of brass and bronze scrap decreased 5 percent from the 1960 record; 90 percent of the total went to Japan.

Tariff.—The price of copper remained above 24 cents a pound throughout 1961 and the 1.7-cent-a-pound excise tax, effective July 1, 1958, was applicable to imported copper. If the price were to drop below 24 cents, the tariff would be 2 cents a pound.

TABLE 30.—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
1952-56 (average) [2]	8,226	103,811	6,385	244,413	246,043	7,055	615,933
1957	18,838	99,755	6,196	301,136	162,309	5,798	594,032
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:							
North America:							
Canada	273	14,108	569	333	100,641	[3] 1,717	[3]117,641
Cuba	-------	6,554	-------	-------	-------	14	6,568
Mexico	71	36	1,787	18,647	2,038	77	22,656
Other North America	(4)	-------	5	-------	-------	185	190
Total	344	20,698	2,361	18,980	102,679	[3] 1,993	[3]147,055
South America:							
Bolivia	76	1,270	-------	-------	-------	-------	1,346
Chile	-------	14,192	-------	190,489	3,486	-------	208,167
Peru	1,534	6,474	1,444	73,938	8,234	-------	91,624
Other South America	-------	7	-------	4	-------	-------	11
Total	1,610	21,943	1,444	264,431	11,720	-------	301,148

See footnotes at end of table.

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

TABLE 30.—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
1960:—Continued							
Europe:							
Belgium-Luxembourg					2,673		2,673
Germany, West					8,727	12	8,739
Spain					4,203		4,203
Sweden					2,789		2,789
United Kingdom					729	52	781
Other Europe					1,591	636	2,227
Total					20,712	700	21,412
Asia:							
Philippines	43	17,510	9				17,562
Other Asia				547		2	549
Total	43	17,510	9	547		2	18,111
Africa:							
Rhodesia and Nyasaland, Federation of			10		5,785		5,795
Union of South Africa	7,203	5,385	1,225	14,415			28,228
Other Africa	9				812		821
Total	7,212	5,385	1,235	14,415	6,597		34,844
Oceania: Australia	773				1,001		1,774
Grand total	9,982	65,536	5,049	298,373	142,709	[3] 2,695	[3] 524,344
1961:							
North America:							
Canada	184	13,775	571	[4]	61,659	2,165	78,354
Mexico	152	6	142	20,519	34	110	20,963
Other North America		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 South America		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 Europe					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 Africa	21		10				31
Total	6,262	1,034	10	14,402	1,797		23,505
Oceania:							
Australia	753	40	33				826
Other Oceania						163	163
Total	753	40	33			163	989
Grand total	8,937	36,851	1,606	339,189	66,855	4,231	457,669

[1] Data are "general" imports, that is, they include copper imported for immediate consumption plus material entering the country under bond.
[2] Some copper in "Ore" and "Other" from the Philippines is not separately classified and is included with "Concentrates".
[3] Revised figure.
[4] Less than 1 ton.

Source: Bureau of the Census.

TABLE 31.—U.S. imports [1] of copper (unmanufactured), by countries

(Short tons, copper content)

Country	1952–56 (average)	1957	1958	1959	1960	1961
North America:						
Canada	101,359	120,224	74,813	112,318	[2] 117,641	78,354
Cuba	18,778	17,435	14,464	10,807	6,568	----
Mexico	54,104	47,746	50,023	29,493	22,656	20,963
Other North America	561	543	453	412	190	308
Total	174,802	185,948	139,753	153,030	[2] 147,055	99,625
South America:						
Bolivia	3,757	4,463	3,395	1,790	1,346	905
Chile	274,741	236,016	200,145	241,392	208,167	226,971
Peru	26,850	41,636	30,426	28,725	91,624	90,435
Other South America	268	986	963	464	11	(3)
Total	305,616	283,101	234,929	272,371	301,148	318,311
Europe:						
Belgium-Luxembourg	1,632	447	56	8,504	2,673	----
France	1,734	660	1,188	1,125	526	----
Germany, West	3,782	2,552	4,173	24,342	8,739	14
Malta, Gozo, and Cyprus	4,091	8,937	6,911	3,524	----	----
Netherlands	504	22	392	727	506	----
Norway	3,242	----	20	50	248	----
Sweden	699	2,689	1,063	3,428	2,789	----
United Kingdom	3,452	2,415	7,185	13,436	781	1,316
Yugoslavia	5,756	----	----	----	----	----
Other Europe	19	----	----	1	5,150	11
Total	24,911	17,722	20,988	55,137	21,412	1,341
Asia:						
Philippines	14,397	13,067	14,583	13,759	17,562	13,898
Turkey	4,894	3,496	1,094	1,094	547	----
Other Asia	286	22	40	41	2	----
Total	19,577	16,585	15,717	14,894	18,111	13,898
Africa:						
Congo, Republic of the, and Ruanda-Urundi [4]	9,652	10,221	15,515	4,335	196	----
Rhodesia and Nyasaland, Federation of [5]	55,916	45,430	35,169	32,622	5,795	10
Union of South Africa	12,826	19,945	29,169	30,981	28,228	23,474
Other Africa	217	----	----	49	625	21
Total	78,611	75,596	79,853	67,987	34,844	23,505
Oceania:						
Australia	12,335	15,075	5,061	7,472	1,774	826
Other Oceania	81	5	----	----	----	163
Total	12,416	15,080	5,061	7,472	1,774	989
Grand total	615,933	594,032	496,301	570,891	[2] 524,344	457,669

[1] Data are "general" imports; that is, they include copper imported for immediate consumption plus material entering the country under bond.
[2] Revised figure.
[3] Less than 1 ton.
[4] Before July 1, 1960, classified as Belgian Congo.
[5] Before July 1, 1954, classified as Southern and Northern Rhodesia.

Source: Bureau of the Census.

TABLE 32.—U.S. imports for consumption of old brass and clippings from brass or Dutch metal [1]

Year	Short tons		Value (thousands)	Year	Short tons		Value (thousands)
	Gross weight	Copper content			Gross weight	Copper content	
1952–56 (average)	8,710	6,278	$3,449	1959	2,054	1,257	$698
1957	7,911	4,643	[2] 2,393	1960	566	309	184
1958	6,763	4,201	1,852	1961	608	390	173

[1] For remanufacture.
[2] Data known to be not comparable with those for years before 1956.

Source: Bureau of the Census.

TABLE 33.—U.S. imports for consumption of copper (copper content), by classes

Year	Ore		Concentrates		Matte		Blister		Refined		Scrap		Total value (thousands)
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	
1952–56 (average) [1]	5,795	$3,486	97,412	$58,244	5,513	$3,719	247,968	[2] $163,869	246,138	$169,723	7,138	[2] $4,230	[2] $408,271
1957	20,951	12,217	62,361	34,258	5,361	3,213	301,136	179,440	162,309	97,024	5,843	[2] 3,049	[2] 329,201
1958	5,926	2,357	84,871	37,968	4,925	2,173	138,633	66,321	124,629	61,139	5,849	2,676	172,634
1959	60	20	9,299	5,505	7,113	4,260	203	126	237,304	146,478	2,984	1,635	158,024
1960	3,503	2,016	20,935	12,391	185	80	486	311	171,021	[3] 109,490	1,836	1,106	[3] 125,394
1961	2,587	1,526	21,914	12,516	95	57	5,929	3,508	87,206	51,852	1,643	870	70,329

[1] Some copper in "Ore" and "Other" from the Philippines is not separately classified and is included with "Concentrates".
[2] Data known to be not comparable with years prior to 1956.
[3] Revised figure.

Source: Bureau of the Census.

TABLE 34.—U.S. exports of copper by classes and countries

(Short tons)

Year and destination	Ore, concentrates, matte (copper content)	Refined	Scrap	Pipes and tubes	Plates and sheets	Wire and cable, bare	Wire and cable, insulated	Other copper manufactures [1]
1952-56 (average)	6,025	184,518	35,215	1,651	420	7,821	17,088	[2]
1957	15,656	346,025	48,989	1,354	265	11,119	21,035	1,897
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 [3]	11,111	433,762	58,860	726	500	3,278	13,368	5,181
1961:								
North America:								
Canada	26	2,441	410	147	62	148	2,359	459
Mexico	-------	154	-------	45	17	34	190	2
Other North America	-------	24	1	152	16	104	1,266	3
Total	26	2,619	411	344	95	286	3,815	464
South America:								
Argentina	-------	12,885	-------	2	-------	44	535	9
Brazil	-------	20,288	-------	4	2	19	320	-------
Colombia	-------	18	1	92	2	79	272	1,999
Venezuela	-------	111	-------	90	12	70	447	3,983
Other South America	-------	160	-------	51	3	76	1,049	6
Total	-------	33,462	1	239	19	288	2,623	5,997
Europe:								
Belgium-Luxembourg	-------	2,164	314	3	[4]	1	50	-------
France	-------	60,306	596	[4]	31	8	62	27
Germany, West	2,112	77,352	6,768	12	28	2	156	43
Italy	1,541	63,047	3,636	7	13	6	107	36
Netherlands	-------	9,102	1,988	3	-------	9	186	-------
Norway	-------	2,938	-------	10	-------	6	42	-------
Spain	-------	-------	7,952	14	2	-------	36	-------
Sweden	-------	4,486	-------	2	16	15	124	-------
Switzerland	-------	6,568	-------	[4]	7	[4]	26	-------
United Kingdom	471	76,371	-------	7	71	4	103	5
Yugoslavia	-------	9,432	2,649	-------	-------	1	27	-------
Other Europe	-------	2,726	582	91	1	3	225	784
Total	4,124	314,492	24,485	149	169	55	1,144	895
Asia:								
India	-------	15,557	1,348	52	2	348	241	-------
Japan	328	60,839	8,606	1	15	78	118	2
Taiwan	-------	631	143	1	12	48	126	-------
Other Asia	-------	101	191	128	40	778	6,915	1
Total	328	77,128	10,288	182	69	1,252	7,400	3
Africa	-------	1,511	-------	32	-------	114	520	2
Oceania	-------	3,041	72	3	3	[4]	48	1
Grand total	4,478	432,253	35,257	949	355	1,995	15,550	7,362

[1] Beginning Jan. 1, 1958, rods not separately classified, included in "Other copper manufactures," 1952-56 (average) 634 tons; 1957, 1,659 tons.

[2] Weight not recorded before 1953 for other copper manufactures; 1953, 294 tons; 1954, 250 tons; 1955, 234 tons; 1956, 185 tons; 1957, 238 tons.

[3] Changes in Minerals Yearbook, 1960, p. 428, table 36, exports of scrap should read as follows: Canada, 2,040 short tons, total, 58,860 short tons.

[4] Less than 1 ton.

Source: Bureau of the Census.

TABLE 35.—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
1952–56 (average)	6,025	$4,644,356	247,347	$185,948,258	(1)	$294,103	253,372	$190,886,717
1957	15,656	9,963,640	428,787	287,820,254	1,897	1,437,266	446,340	299,221,160
1958	11,475	5,864,534	[2] 428,015	[2] 229,534,839	[2] 2,302	[2] 1,567,100	441,792	236,966,473
1959	2,982	1,808,289	[2] 196,012	[2] 128,577,107	4,352	[2] 3,280,116	203,346	133,665,512
1960	11,111	6,832,050	[2] [3]510,494	[2] [3]327,935,628	5,181	[2] 4,006,049	[3]526,786	[3]338,773,727
1961	4,478	2,474,679	[2] 486,359	[2] 295,397,080	7,362	[2] 5,260,315	498,199	303,132,074

[1] Weight not recorded before 1953; 1953, 294 tons ($352,124); 1954, 250 tons ($307,848); 1955, 234 tons ($308,792); 1956, 185 tons ($290,552).
[2] Beginning Jan. 1, 1958, copper rods not separately classified; included in "Other copper manufactures," have been included in 1957 with "Other copper manufactures."
[3] Revised figure.
Source: Bureau of the Census.

TABLE 36.—U.S. exports of copper-base alloys (including brass and bronze), by classes

Class	1960		1961	
	Short tons	Value	Short tons	Value
Ingots	699	$1,645,920	469	$904,983
Scrap and other forms	[1] 122,175	[1] 51,876,393	116,654	52,226,189
Bars, rods, and shapes	571	926,963	658	1,131,813
Plates, sheets, and strips	650	1,662,638	578	1,621,707
Pipes and tubes	1,035	1,487,445	1,343	1,743,463
Pipe fittings	1,400	3,391,334	1,398	3,415,918
Plumbers' brass goods	2,202	5,871,981	2,151	5,889,323
Welding rods and wire	794	1,587,843	689	1,738,423
Castings and forgings	276	688,288	502	1,013,570
Powder	325	385,145	483	518,494
Semifabricated forms, not elsewhere classified	13	40,079	13	35,863
Total	[1] 130,140	[1] 69,564,029	124,938	70,239,746

[1] Revised figure.
Source: Bureau of the Census.

TABLE 37.—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
1952–56 [2] (average)	3,573	$3,792,504	1959 [2]	1,471	$2,874,206
1957 [2]	1,747	2,943,557	1960 [2]	1,920	4,235,521
1958 [2]	1,396	2,228,688	1961 [2]	1,705	3,638,503

[1] Includes brass and bronze.
[2] Owing to changes in classifications, data for 1953–61 not strictly comparable with other years.
Source: Bureau of the Census.

TABLE 38.—U.S. exports of copper sulfate (blue vitriol)

Year	Short tons	Value	Year	Short tons	Value
1952–56 (average)	34,680	$7,386,368	1959	2,672	$674,522
1957	33,644	6,534,037	1960	14,841	3,376,649
1958	7,248	1,175,944	1961	7,575	1,542,212

Source: Bureau of the Census.

TABLE 39.—U.S. imports and exports of brass and copper scrap

(Short tons)

	1952–56 (average)	1957	1958	1959	1960	1961
Imports for consumption:						
Brass scrap (gross weight)	8,710	7,911	6,763	2,054	566	608
Copper scrap (copper content)	7,138	5,843	5,849	2,984	1,836	1,643
Exports:						
Copper-base-alloy scrap (new and old)	45,932	69,996	28,502	29,406	[1] 122,175	116,654
Copper scrap	35,215	48,989	21,861	10,721	[1] 58,860	35,257

[1] Revised figure.

Source: Bureau of the Census.

TABLE 40.—U.S. imports for consumption and exports of copper scrap, in 1961, by countries

(Short tons)

Country	Imports		Exports [1]	
	Unalloyed copper scrap (copper content)	Copper-alloy scrap (gross weight)	Unalloyed copper scrap	Copper-alloy scrap
North America:				
Canada	1,198	245	410	347
Mexico	100	153		41
Other North America	169	208	1	2
Total	1,467	606	411	390
South America			1	59
Europe:				
Belgium-Luxembourg			314	131
France			596	796
Germany, West	9		6,768	1,958
Italy			3,636	4,784
Netherlands			1,988	383
Spain			7,952	344
United Kingdom	4	2		328
Yugoslavia			2,649	498
Other Europe			582	136
Total	13	2	24,485	9,358
Asia:				
India			1,348	1,250
Japan			8,606	105,200
Philippines			9	223
Other Asia			325	173
Total			10,288	106,846
Oceania:				
Australia			72	1
Territory Pacific Islands	163			
Total	163		72	1
Grand total	1,643	608	35,257	116,654

[1] Revisions in Minerals Yearbook 1960; p. 430 should read as follows: Unalloyed copper scrap: Canada, 2,040 tons; grand total, 58,860 tons; Copper-alloy scrap: Netherlands, 2,415 tons; grand total, 122,175 tons.

Source: Bureau of the Census.

WORLD REVIEW

World production of copper continued upward for the third consecutive year. The high rate of output was achieved despite production curtailments instituted in late 1960 and continued into 1961. New records were set in the United States and Canada, and output rose 3 percent in Chile. In Northern Rhodesia production declined slightly. In the Republic of the Congo, production was reduced by the closure of the Union Minière du Haut-Katanga operations in December.

TABLE 41.—World mine production of copper (content of ore) by countries [1] [2]

(Short tons)

Country	1952–56 (average)	1957	1958	1959	1960	1961
North America:						
Canada	298,975	359,109	345,114	395,269	439,262	449,791
Cuba	18,807	18,000	14,343	9,942	[3] 13,058	
Haiti					1,000	3,800
Mexico	62,381	66,800	71,609	63,134	66,502	54,359
Nicaragua				1,001	5,398	6,919
United States	958,001	1,086,859	979,329	824,846	1,080,169	1,165,155
Total	1,338,164	1,530,768	1,410,395	1,294,192	1,605,389	1,680,024
South America:						
Bolivia (exports)	4,578	4,320	3,168	2,461	2,503	2,294
Brazil [4]	[3] 805	1,400	1,300	1,500	1,500	1,600
Chile	453,861	535,306	514,925	602,108	586,648	603,635
Ecuador	8	17	53	148	111	111
Peru	42,751	63,023	59,105	54,914	200,313	218,251
Total	502,003	604,066	578,551	661,131	791,075	825,891
Europe:						
Albania [4]	530	1,200	1,900	2,200	2,400	2,600
Austria	2,998	2,574	2,695	2,726	2,188	2,105
Bulgaria [4]	4,900	7,700	8,600	11,000	12,000	14,000
Finland	23,038	28,700	31,800	32,400	31,000	37,500
France [6]	452	410	757	592	733	481
Germany:						
East [4]	18,700	18,400	19,300	20,800	27,500	27,500
West	1,973	1,202	1,484	1,963	1,959	1,817
Ireland			[4] 5,300	4,736	6,685	6,534
Italy [7]	1,554	3,900	4,073	3,941	3,301	[4] 3,300
Norway	15,255	16,787	17,501	15,828	16,966	15,200
Poland	5,578	8,300	[4] 8,800	[4] 9,900	[4] 11,600	[4] 12,900
Portugal	734	619	819	791	579	[4] 500
Spain [8]	8,300	11,077	7,466	12,137	8,786	10,922
Sweden	16,540	19,924	20,453	19,079	18,396	18,629
U.S.S.R. [4 9 10]	365,000	450,000	470,000	480,000	550,000	600,000
Yugoslavia	34,228	36,883	38,840	38,141	36,681	55,255
Total [4 9]	500,000	608,000	640,000	656,000	731,000	809,000
Asia:						
Burma [4]	108	143	143	165	160	123
China [4]	9,700	17,000	35,000	55,000	80,000	110,000
Cyprus (exports) [8]	29,847	43,676	36,614	39,978	39,096	31,585
India	7,653	9,000	9,150	8,900	9,750	9,750
Israel			287	3,700	4,800	5,300
Japan	72,791	90,066	89,837	93,970	98,307	106,319
Korea, Republic of	1,076	710	590	370	454	410
Philippines	18,680	44,513	51,842	54,587	48,513	57,182
Taiwan	1,058	2,095	1,702	1,793	2,315	2,460
Turkey	27,087	28,871	27,744	30,551	30,110	31,793
Total [4 9]	168,000	236,100	252,900	289,000	313,500	354,900

See footnotes at end of table.

TABLE 41 —World mine production of copper (content of ore) by countries [1] [2]—Continued

(Short tons)

Country	1952–56 (average)	1957	1958	1959	1960	1961
Africa:						
Algeria	146	476	435	57	127	671
Angola	1,537	1,879	1,688	1,932	2,108	1,022
Congo, Republic of the (formerly Belgian) [10]	248,196	267,028	261,867	310,955	333,175	325,400
Morocco: Southern zone	942	694	1,216	1,601	1,680	1,885
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia	410,696	480,313	441,073	598,835	635,326	633,139
Southern Rhodesia	745	3,226	8,430	12,016	15,128	15,243
South-West Africa	19,405	29,910	30,975	34,436	22,555	27,770
Tanganyika [11]	646	1,178	1,770	1,220	1,383	111
Uganda	[12] 3,230	11,723	11,201	11,761	[10] 16,257	[10] 14,743
Union of South Africa	45,135	50,959	54,615	54,066	[10] 50,847	57,952
Total	730,678	847,386	813,270	1,026,879	1,078,586	1,077,936
Oceania: Australia	44,732	66,366	84,801	106,344	122,385	102,760
World total (estimate)	3,280,000	3,890,000	3,780,000	4,030,000	4,640,000	4,850,000

[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] Exports.
[4] Estimate.
[5] Average annual production, 1955–56.
[6] Includes copper content of auriferous ores.
[7] Includes copper content of cupriferous pyrites.
[8] According to Yearbook of American Bureau of Metal Statistics except 1961. These data do not include content of iron pyrites, the copper content of which may or may not be recovered.
[9] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.
[10] Smelter production.
[11] Copper content of exports and local sales.
[12] One year only, as 1956 was first year of commercial production.

Source: Compiled by Augusta W. Jann, Division of Foreign Activities.

NORTH AMERICA

Canada.—Production of copper rose 2 percent over 1960 to a new record. Decreased output in Quebec and Manitoba was more than offset by increases in the other principal producing Provinces. Production curtailments of 10 percent were instituted in June 1960 and continued throughout 1961 at Gaspé Copper Mines, Ltd.; Waite Amulet Mines, Ltd.; and Noranda Mines, Ltd.

Canada's leading producer, The International Nickel Company of Canada, Ltd., mined 17.5 million tons of ore in 1961, compared with 16.8 million in 1960. The 1961 tonnage included output from mines in the Sudbury district, Ontario, and from the Thompson mine, Manitoba. In the Sudbury district two new open-pit mines were brought into production; in late 1961 the Clarabelle open pit, north of Copper Cliff, and an open pit at the Ellen mine, Denison Township, began operating. Output from these mines did not increase capacity but replaced tonnage previously obtained from other mines. Open-pit operations ceased, but underground mining continued at the Frood-Stobie mine. Development of the Creighton, Garson, and Murray mines was continued. The cut-and-fill method of mining was extended from the Frood mine to the Creighton and Levack mines. The company delivered 134,400 tons of copper in 1961

TABLE 42.—World smelter production of copper, by countries[1]

(Short tons)

Country	1952-56 (average)	1957	1958	1959	1960	1961
North America:						
Canada	260,821	323,540	329,239	365,366	417,029	406,437
Mexico	52,876	62,061	67,109	61,105	64,861	52,498
United States[2]	1,071,203	1,178,145	1,069,052	841,795	1,233,629	1,207,354
Total	1,384,900	1,563,746	1,465,400	1,268,266	1,715,519	1,666,289
South America:						
Chile	424,121	496,736	484,678	570,593	556,636	577,544
Peru	29,498	46,137	42,403	38,024	181,650	200,587
Total	453,619	542,873	527,081	608,617	738,286	778,131
Europe:						
Albania	[3] 700	1,020	[4] 1,100	[4] 1,100	[4] 1,200	[4] 1,300
Austria	10,720	8,806	10,525	11,601	12,964	13,044
Bulgaria[4]	3,300	5,600	6,748	7,212	8,645	11,000
Finland	22,981	28,469	33,873	35,941	34,140	37,800
Germany:						
East[4]	27,000	27,500	27,500	33,000	35,000	35,000
West[5]	252,823	279,313	295,609	310,729	340,695	335,476
Italy	389	147	117	405	[4] 440	[4] 440
Norway	14,148	17,447	19,365	21,218	23,825	23,880
Poland	15,882	21,966	19,146	19,127	23,961	24,504
Spain	6,290	6,600	5,556	7,686	9,041	13,405
Sweden	18,062	21,472	22,268	27,921	23,927	22,822
U.S.S.R.[4 6]	365,306	450,000	470,000	480,000	510,000	600,000
Yugoslavia	33,499	37,186	37,117	38,858	39,384	34,027
Total[4 6 7]	771,000	906,000	949,000	995,000	1,063,000	1,153,000
Asia:						
China[4 8]	9,700	17,000	35,000	55,000	80,000	110,000
India	7,408	8,790	8,782	8,459	9,822	9,189
Japan	78,329	120,013	113,979	170,682	206,522	223,171
Korea, Republic of	381	874	886	824	1,113	1,456
Taiwan	1,084	1,883	1,833	1,986	1,962	2,500
Turkey	26,438	26,897	24,835	27,599	28,903	22,040
Total[4 6]	123,300	175,500	185,300	264,600	328,300	368,400
Africa:						
Angola	1,427	1,855	1,608	1,782	1,744	937
Congo, Republic of the (formerly Belgian)	248,196	267,028	261,867	310,955	333,175	325,400
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia	398,611	466,562	420,164	595,093	625,922	627,137
Uganda	168	8,361	12,130	13,376	16,257	14,743
Union of South Africa	43,518	48,229	53,406	53,843	50,847	57,562
Total	691,920	792,035	749,175	975,049	1,027,945	1,025,779
Oceania: Australia	40,025	56,440	72,360	76,713	79,130	71,692
World total (estimate)	3,460,000	4,040,000	3,950,000	4,190,000	4,950,000	5,060,000

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

[2] Smelter output from domestic and foreign ores, exclusive of scrap. Production from domestic ores only, exclusive of scrap, was as follows: 1952-56 (average), 966,006 short tons; 1957, 1,081,055; 1958, 992,918; 1959, 799,329; 1960, 1,142,848; and 1961, 1,162,480.

[3] Average annual production 1954-56.

[4] Estimate.

[5] Includes scrap.

[6] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.

[7] 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 from the Congo.

[8] Data represent estimated mine production.

Source: Compiled by Augusta W. Jann, Division of Foreign Activities.

(146,000 in 1960), about half of which was sold in Canada. The remainder went mostly to the United Kingdom.

Falconbridge Nickel Mines, Ltd., ranking second in producing copper in Ontario, set a new record for output for the 12th successive year. Ore deliveries from company mines totaled 2.5 million tons compared with 2.4 million in 1960. The northern area mines (Hardy, Boundary, Onaping, Longvack, and Fecunis) supplied most of the output; the Fecunis mine was the leading producer. The southern area mines (Falconbridge, East, and McKim) furnished the remainder. The company delivered 19,400 tons of copper to customers, 8 percent more than in 1960.

Geco Mines, Ltd., Manitouwadge area, milled 1.3 million tons of ore, averaging 1.54 percent copper. The mill produced 67,600 tons of concentrate containing 27.43 percent copper, which was shipped to the Noranda smelter. Copper production totaled 18,600 tons.

Noranda Mines, Ltd., Quebec, mined 1.3 million tons of ore at the Horne mine. The smelter treated 1.6 million tons (a record tonnage) of ore and concentrate, of which 0.8 million tons was smelted for other companies. Total output was 159,400 tons of copper in anodes. Production of copper from the Horne mine totaled 25,200 tons.

The electrolytic refinery of Noranda's subsidiary, Canadian Copper Refiners, Ltd., Montreal East, produced a total of 254,000 tons of refined copper, compared with 267,400 tons in 1960. Production was lower because of a 5-percent decrease in ore receipts.

TABLE 43.—Canada: Copper production (mine output), by Provinces

(Short tons)

Province	1952–56 (average)	1957	1958	1959	1960	1961 (preliminary)
British Columbia	22,766	15,411	6,010	8,121	16,559	19,421
Manitoba	13,682	18,551	12,601	12,945	12,793	10,998
New Brunswick	8	5,738	328			
Newfoundland	3,083	4,535	14,751	14,989	13,863	16,853
Northwest Territories	1	165	434	494	520	486
Nova Scotia	719					6
Ontario	139,876	171,703	142,035	188,272	206,272	211,534
Quebec	86,203	112,409	131,445	134,912	157,470	151,015
Saskatchewan	32,637	30,597	37,510	35,536	31,785	33,882
Yukon Territory						440
Total	298,975	359,109	345,114	395,269	439,262	444,635

Source: Dominion Bureau of Statistics, Department of Trade and Commerce, Government of Canada, Preliminary Report on Mineral Production, 1961.

Gaspé Copper Mines, Ltd., subsidiary of Noranda, mined 2.7 million tons, of which 29 percent came from the open pit. A total of 2.6 million tons of ore averaging 1.31 percent copper was milled, and 119,000 tons of concentrate was produced. The smelter treated 256,000 tons of concentrate and fluxing ore, of which 55,900 tons was custom concentrate. Copper produced totaled 43,000 tons.

The Quemont Mining Corp., Ltd., treated 822,300 tons of ore averaging 1.33 percent copper. Copper concentrate, smelted at Noranda, totaled 55,100 tons and contained 9,900 tons of copper.

Waite Amulet Mines, Ltd., subsidiary of Noranda, treated 248,800 tons of ore in its mill and produced 61,400 tons of concentrate contain-

ing 13,530 tons of copper. Most of the 248,000 tons of ore was mined from pillars and ore remnants in the Amulet Dufault Lower "A" and East Waite ore bodies. Mining at the East Waite ceased in April. During 9 years of operations the mine produced more than 1.6 million tons of ore averaging 4.12 percent copper. The remaining source of ore, Lower "A" ore body, will be exhausted by October 1962.

The Normetal Mining Corp., Ltd., concentrator treated 355,000 tons of ore averaging 3.10 percent copper. Copper concentrate produced totaled 44,400 tons and contained 10,400 tons of copper.

East Sullivan Mines, Ltd., mined and milled 674,800 tons of ore averaging 0.725 percent copper in the first 8 months of 1961. Copper production totaled 4,300 tons. Most of the assets of East Sullivan were purchased by Sullico Mines, Ltd., in 1961. Sullico Mines provided financial assistance to Hastings Mining & Development Co., Ltd., for developing its subsidiary, Solbec Copper Mines, Ltd. Construction of a 1,000 ton-per-day concentrator was nearly completed by yearend, and operations were expected to begin in early January 1962. A new company, Cupra Mines, Ltd., was formed in 1961 to develop a property 2½ miles south of the Solbec plant.

In the 1960–61 fiscal year, Campbell Chibougamau Mines, Ltd., mined and milled 796,600 tons of ore averaging 2.49 percent copper from its Main Mine, Koko Creek, Cedar Bay, and Henderson Divisions. Copper concentrate shipped to the Noranda smelter totaled 74,100 tons. The smelter shipped 18,700 tons of copper from Campbell Chibougamau concentrate. Milling capacity was enlarged from 2,400 tons to more than 3,000 tons a day to handle increased tonnage from the Henderson mine, which supplied 21.1 percent of the mine output compared with 1.6 percent in the preceding fiscal year.

Copper Rand Chibougamau Mines, Ltd., mined and milled 604,500 tons of ore averaging 2.44 percent copper in 1961. Concentrate totaling 56,100 tons was shipped to Noranda for treatment and yielded 14,400 tons of copper.

Willroy Mines, Ltd., produced 421,800 tons of ore from its mine in the Manitouwadge district. The ore averaged 1.34 percent copper, and the copper concentrate produced was shipped to the Noranda smelter. Copper production totaled 4,900 tons.

A 1,000-ton-per-day plant at the Little Bay property of Atlantic Coast Copper Co., Newfoundland, began operating in May. Shipment of concentrate to the Gaspé smelter at Murdochville began in September. A total of 196,100 tons of ore was milled, and 2,100 tons of copper was produced.

Maritimes Mining Corp., Ltd., mined 842,800 tons of ore at the Tilt Cove mine, Newfoundland, during 1961. Ore treated totaled 814,700 tons averaging 1.68 percent copper, and 61,300 tons of concentrate was produced. Copper production of 12,000 tons was the same as in 1960.

Hudson Bay Mining & Smelting Co., Ltd., and Sherritt Gordon Mines, Ltd., furnished all the copper produced in Saskatchewan and Manitoba. These Provinces furnished 10 percent of Canadian copper output in 1961.

The Hudson Bay Mining & Smelting Co., Ltd., mined and milled 1.7 million tons of ore from the Flin Flon Coronation, Chisel Lake, and Schist Lake mines. In addition, 17,200 tons of Coronation ore

was smelted without milling. Copper concentrate produced totaled 296,400 tons averaging 13.35 percent copper. The smelter treated 399,500 tons of Hudson Bay concentrate, residue, and direct smelting ore and shipped 40,100 tons of blister copper to the refinery. Refined copper production totaled 39,500 tons compared with 39,800 tons in 1960.

Sherritt Gordon Mines, Ltd., mined and milled 1.2 million tons of nickel-copper ore. Copper content of the concentrate totaled 5,600 tons (5,500 in 1960) and was shipped to the Flin Flon smelter. Sales of copper were 5,400 tons (5,700 in 1960). Exploration was continued on the Farley shaft, and a copper-zinc deposit was found at Fox Lake, southwest of Lynn Lake.

Phoenix Copper Co., Ltd., subsidiary of Granby Mining Co., Ltd., British Columbia, treated 392,800 tons of ore averaging 0.8 percent copper. Production of copper totaled 2,400 tons. The 1,000-ton-per-day mill was being enlarged to treat 1,500 tons of ore per day.

Production of refined copper in Canada was 406,000 tons in 1961 compared with 417,000 tons in 1960. Consumption of refined copper totaled 141,800 tons in 1961 compared with 117,600 tons in 1960.

Exports of copper in ore, concentrate, and matte totaled 42,900 tons (47,600 in 1960); Norway was the destination of 19,400 tons (18,700); the United States, 14,700 (17,200); Spain, 2,900 (none); Japan, 2,200 (9,100); and the United Kingdom, 2,200 (1,700). The remainder (in smaller quantities) went to Belgium-Luxembourg, West Germany, Italy, Sweden, and Australia. Exports of ingots, bars, and billets in short tons were as follows:

Destination:	*1960*	*1961*
United Kingdom	110, 540	115, 859
United States	104, 602	64, 189
France	12, 880	15, 885
Germany, West	12, 940	13, 355
Japan	4, 861	11, 207
Netherlands	5, 318	8, 992
Belgium	4, 481	5, 745
Sweden	2, 522	4, 894
Italy	2, 516	3, 497
Australia	1, 847	2, 239
Finland	2, 127	1, 064
India	10, 908	673
Other countries	2, 524	18, 648
Total	278, 066	266, 247

In addition, 27,700 tons of rods, strips, sheet, and tubing was shipped, of which 6,300 tons each went to Switzerland and Norway; 4,200, to the United States; and 3,500, to the United Kingdom.

Mexico.—Operations at Cananea Consolidated Copper Co., S.A., Sonora, were halted by a strike from September 6 to December 1, 1961. As a result, copper production decreased from 31,000 tons in 1960 to 21,600 tons. The entire output was shipped to Cobre de Mexico, S.A., Mexico City, for refining. Ore mined totaled 3.8 million tons, of which 65 percent came from open-pit operations.

Electrolytic copper was reportedly produced for the first time in Mexico in 1961.[5]

[5] Bureau of Mines. Mineral Trade Notes. V. 54, No. 4, April 1962, pp. 7–8.

SOUTH AMERICA

Chile.—Despite work stoppages in May and late summer, copper production rose 3 percent in 1961, and Chile ranked third among producing countries.

The Chuquicamata mine of Chile Exploration Co., subsidiary of The Anaconda Company, produced 275,200 tons of copper, compared with 254,800 tons in 1960. The 8-percent increase was achieved despite a month-long strike starting in August. The concentrator expansion program was continued.

Copper production from El Salvador mine of Andes Copper Mining Co., another Anaconda subsidiary, totaled 80,000 tons compared with 86,800 tons in 1960. Operations were adversely affected by a 31-day strike which began in August.

La Africana mine of Santiago Mining Co., also an Anaconda subsidiary, produced 25,300 tons of concentrate averaging 27.87 percent copper.

At El Teniente mine of The Braden Copper Co., subsidiary of Kennecott Copper Corp., 10.7 million tons of ore was mined and milled, and 175,900 tons of copper was produced compared with 11.5 million tons and 187,200 tons, respectively, in 1960. The decrease was due to strikes which halted production for 50 days in May and August. Ore mined in 1961 contained 1.9 percent copper compared with 2 percent in 1960. Virtually all Braden copper continued to be sold to European customers. Approximately $6 million in capital expenditure was made by the company during 1961 to increase productive capacity by about 11,200 tons of copper per year. Two projects completed in 1961 were the tie-in with the local electric utility, which would supplement power from the company hydroelectric plants and permit year-round near-capacity operations, and a chemical-treatment plant to recover copper from mill-tailing water.

The Paipote smelter operated by the Government's Empresa Nacional de Fundiciones produced 36,700 tons of blister copper. Output of Chile's small- and medium-sized mines totaled 26,100 tons of copper in ores, concentrates, and cement copper. In 1961, the first fire-refined copper was produced from these operations; output totaled 10,500 tons.

Cerro Corp. suspended work on the Rio Blanco copper deposit in November until financing negotiations could be completed.

The purchase of raw materials by National Mining Enterprise was begun for a new copper smelter at Ventanas, north of Valparaiso. The price paid for ores was to be the same as that at the Paipote smelter, but because of the shorter distance to Ventanas and resulting lower freight rates, payments to producers were to be larger. The smelter was scheduled to begin operating at yearend 1962.

In addition to the exports shown in table 44, 26,100 tons of ore and concentrate was shipped, of which 16,700 tons went to Japan; 6,500, to West Germany; 1,600, to Poland; 900, to the United States; and 400, to Sweden.

Peru.—Production of copper from Cerro de Pasco Corp. (Cerro-Peru) mines and purchased ores totaled 40,500 tons compared with 36,800 during 1960. Expansion of the Paragsha concentrator at the Cerro de Pasco mine was completed in December. The additional

TABLE 44.—Chile: Exports of copper by principal types

(Short tons)

Destination	1960				1961			
	Refined		Blister	Total	Refined		Blister	Total
	Electrolytic	Fire refined			Electrolytic	Fire refined		
Belgium	1,260	1,456		2,716	925	3,256		4,181
Brazil						1,076		1,076
France	16,590	276		16,866	10,444	668		11,112
Germany, West	25,163	16,833	49,577	91,573	22,766	18,121	46,773	87,660
Italy	12,807	11,620	2,690	27,117	11,871	12,273	1,496	25,640
Netherlands	49,677	2,632		52,309	67,382	2,613		69,995
Sweden	20,987	56	642	21,685	22,254	604	2,182	25,040
United Kingdom	24,704	48,262	45,882	118,848	26,153	34,732	53,160	114,045
United States	600	1,251	201,999	203,850	399	1,750	229,347	231,496
Yugoslavia						728		728
Other countries						974		974
Total	151,788	82,386	300,790	534,964	162,194	76,795	332,958	571,947

milling capacity was to permit greater ore production at the McCune pit, but the ore was of lower grade than that produced from underground operations, and copper production was to remain at about the same rate as in previous years.

Development of the Cobriza mine, 115 miles southeast of La Oroya, continued during 1961. The tonnage of 3.5 percent copper ore developed by yearend was enough for about 10 years of operation at an average annual rate of 9,000 tons of copper in concentrate. The concentrate would be shipped to La Oroya for smelting and refining.

Ore mined at the Toquepala mine of Southern Peru Copper Corp. totaled 10.7 million tons averaging 1.67 percent copper. Blister copper output was 160,000 tons compared with 145,000 tons in 1960—the first full year of operation. More than 50 percent of the output was sold in Europe through Southern Peru Copper Sales Corp. The remainder went to the four U.S. stockholding companies.

Exports of copper from Peru in short tons were as follows:

Destination:	*1961*
United States	88,242
Germany, West	49,588
Belgium	33,097
United Kingdom	23,146
Japan	16,048
Sweden	4,043
Brazil	1,271
Argentina	1,056
Pakistan	672
Netherlands	595
Other countries	302
Total	218,060

EUROPE

United Kingdom.—Consumption of primary and secondary copper in the United Kingdom (the free world's second largest copper-consuming country) decreased 6 percent; 582,900 tons was consumed in

1961, compared with 617,600 tons in 1960. In addition, 180,400 tons (191,700 in 1960) of copper in scrap was consumed. Of the total consumption of 763,300 tons, 561,000 tons of refined copper and 110,000 tons in scrap were consumed for semimanufactured products, and 21,900 tons of refined copper and 70,400 tons in scrap were used for castings, copper sulfate, and miscellaneous products.

Production of copper sulfate increased from 32,400 tons in 1960 to 33,400 tons in 1961.

Industrial inventories in the United Kingdom at the end of 1961 were 146,700 tons, an increase of 14 percent over 1960.

Imports of copper into the United Kingdom are shown in table 45.

TABLE 45.—United Kingdom: Imports of copper, by countries

(Short tons)

Country	1960			1961		
	Blister	Electrolytic	Fire refined	Blister	Electrolytic	Fire refined
Rhodesia and Nyasaland, Federation of: Northern Rhodesia	76,371	200,865		80,560	202,470	829
Canada		115,246			112,890	
Chile	47,759	29,884	50,371	50,402	21,506	33,861
United States		66,009	6,213	1,025	49,276	4,481
Peru	693	2,552		22,408		
Australia		4,490			4,797	
Congo, Republic of the		3,134			4,043	
Norway		2,464			1,463	
Belgium		1,688			815	
Union of South Africa			3,349		101	593
Germany, West		2,658		34	547	
Other countries	1,137	403	139	3	28	19
Total	125,960	429,393	60,072	154,432	397,936	39,783

Source: British Bureau of Nonferrous Metal Statistics.

Exports and re-exports of refined copper totaled 87,600 tons (62,300 in 1960), of which 13,400 (11,700) went to Czechoslovakia; 13,200 (9,900), to East Germany; 10,600 (3), to Belgium; 7,700 (5,400), to the Netherlands; 6,800 (2,000), to Poland; 5,500 (1,900), to Argentina; 5,100 (6,500), to West Germany; 3,700 (3,300), to Hungary; 3,600 (4,100), to China; 3,300 (6,500), to the U.S.S.R.; 1,800 (none), to Brazil; 1,500 (400), to Egypt; 1,500 (140), to France; and the remainder in lots of less than 1,500 tons to other countries. No blister copper had been re-exported since 1957.

Yugoslavia.—Production of copper ore in Yugoslavia totaled 3.6 million tons in 1961 compared with 2.6 million tons in 1960. The increase was because new operations began at the Majdanpek mine, 25 miles north of the Bor smelter (Yugoslavia's largest copper smelter). A new open-hearth furnace was installed at Bor in June, and the first concentrates from Majdanpek were received in July. Because of the development and expansion operations in process during 1961 at Majdanpek and Bor, production of blister copper decreased from 39,400 tons in 1960 to 34,000 tons in 1961 and electrolytic copper from 38,600 to 33,200 tons.

The Majdanpek-Bor operations included plans for further expansion of the Majdanpek mine, and an additional open-hearth furnace

in 1965 to raise capacity to 88,000 tons annually, and to an ultimate capacity by 1970 of 110,000 tons a year.

ASIA

Cyprus.—Production from the Mavrovouni mine of Cyprus Mines Corp., the company's principal producer, totaled 225,400 tons in 1961 compared with 302,300 tons in 1960. Output consisted of 79,900 tons of copper concentrate, 143,700 tons of cupreous pyrite, and 1,800 tons of precipitate. In addition, 445,600 tons of pyrite was produced by flotation. After the Cyprus Government had approved more favorable tax legislation for developing and operating new mines, the company announced that its Skouriotissa-Apliki project would be developed as open-pit mines. The existing mill, after moderization, was expected to begin treating ore from Skouriotissa in 1963.

India.—The entire copper output in India has come from Indian Copper Corp., and production has been constant at 8,000 to 9,000 tons per year. Imports of copper to meet requirements had increased each year. To help obtain self-sufficiency in copper, priority was given to developing deposits in the Khetri-Daribo region.

The Khetri project would include development of the mine, and construction of a concentrator and smelter. Annual capacity would be 11,000 tons of copper. The Daribo project was to comprise a mine and concentrator; output was to be about 1,600 tons of copper per year.

Mining at the Sikkim Mining Corp. joint Indo-Sikkimese project to bring the copper deposits in the Singtam area, Sikkim State, into production was expected to begin early in 1962. Operations were delayed because power was lacking, but partial power from the Singtam hydroelectric plant would be available in January 1962. The mill was expected to begin operating several months later. Installation of a flotation plant at the Rangpo copper mine was planned for June 1962. Concentrates produced would be smelted at the Indian Copper plant at Ghatsila.

Japan.—Mine production of copper rose to 106,300 tons in 1961 exceeding 100,000 tons for the first time since 1943. In addition, 123,200 tons of ore was imported. Production of refined copper totaled 305,300 tons, of which 103,000 tons came from domestic ore, 116,300 tons from imported ore, and 86,000 tons from slag and scrap, Supply was short of estimated consumption of 413,400 tons and 115,000 tons of refined copper was imported. Receipts from the United States were 68,800 tons, more than double the 32,600 tons received in 1960. Fabricators received 150,300 tons of imported copper-base alloy scrap and 11,600 tons of unalloyed copper scrap.

Nippon Mining Co., Ltd., adopted the oxygen-smelting process at its Hitachi smelter.[6] It reported that the changeover resulted in more economical smelting operations and increased recovery of copper.

Philippines.—Atlas Consolidated Mining & Development Corp. milled 4.2 million tons of ore averaging 0.62 percent copper from the Toledo mine, and produced 83,100 tons of 28.05-percent copper con-

[6] Insurumoto, Tamon. Copper Smelting in the Converter. J. Metals, v. 13, No. 11, November 1961, pp. 820-824.

centrate. Copper production of 23,300 tons was the largest since operations started at the Toledo mine in April 1955.

The Lepanto Consolidated Mining Co., Ltd., treated 472,300 tons of ore containing 3.16 percent copper and produced 52,500 tons of 27.15 percent copper concentrate. The tonnage treated in 1961 exceeded that in any previous year, but the lower metal content of the ore resulted in a 7-percent decrease in copper production. Output totaled 14,300 tons compared with 15,300 tons in 1960.

Elsewhere in the Philippines, Marinduque Iron Mines Agents, Inc., produced 4,400 tons of copper at the Bagacay mine and 9,600 tons at the Sipalay; Philex Mining Corp. produced 3,800 tons at its Santo Tomas group of mines; and Samar Mining Co., Inc., produced 1,200 tons from the Masara property. In the second half of 1961 Surigao Consolidated Mining Co., Inc., produced 350 tons of copper.

Turkey.—The Murgul and Ergani mines, subsidiaries of Etibank, supplied the entire copper production in Turkey. The Murgul smelter was closed from April to October to rebuild the 10-year-old reverberatory furnace, and output of blister copper declined from 28,900 tons in 1960 to 24,300 tons.

Etibank's plans for constructing new facilities to treat low-grade ore from the Weiss ore body continued in 1961, but whether to use the flotation-pyrometallurgical process or the leaching-electrolytic method, whereby cobalt would be recovered in addition to copper, had not been decided. The company requested an extension on its Export-Import Bank credit to enable it to test the leaching-electrolytic process in a small pilot plant to be built at Ergani.

AFRICA

Congo, Republic of the.—The only producer, Union Minière du Haut-Katanga, produced 2 percent less copper in 1961. The closing of the company properties in December prevented the achievement of 1961 production goals. Output decreased from 331,400 tons in 1960 to 323,500 tons in 1961. The Luilu electrolytic plant reached capacity output of 110,000 tons, and the Kambove concentrator started operations during the year.

Most of the output came from mines in the Western Group and the Prince Leopold mine in the Southern Group. A total of 9.8 million tons of ore was produced, consisting of 4.1 million tons from the Kamoto mine, 2.9 million tons from Ruwe, 352,000 tons from Musonoi, and 267,000 tons from Kolwezi. The Prince Leopold mine produced 1.1 million tons, and the Kambove mine in the Central Group produced 932,000 tons. The remainder came from miscellaneous properties.

The Kolwezi concentrator treated 4.5 million tons of copper and mixed ores from the Kamoto and Musonoi mines, and produced 823,000 tons of concentrate containing 25.39 percent copper. The Kipushi mill treated 1 million tons of coppr and zinc ores from the Prince Leopold mine and produced 185,900 tons of 24.73 percent copper concentrate and 201,800 tons of 54.43 percent zinc concentrate. The Kambove concentrator, with capacity of 66,000 tons a month, began operations on April 24; 607,500 tons of ore from the Kambove-

West mine was treated, and yielded 95,600 tons of 28.04 percent copper concentrate. The Ruwe concentrator produced 95,300 tons of concentrate averaging 22.86 percent copper, and 109,000 tons of 3.99 percent copper products that required further treatment. The Ruashi washing plant treated 114,300 tons of ore that yielded 17,200 tons of concentrate averaging 18.44 percent copper, and 16,900 tons of products to be re-treated.

Copper production was as follows:

	Short tons
Lubumbashi (blast furnaces and converters)	166, 325
Jadotville-Shituru (leaching, electrolysis, and refining)	96, 679
Luilu (leaching and electrolysis)	59, 303
Jadotville-Panda electric smelter (recoverable copper in white cobalt alloy)	783
Recoverable copper contained in zinc concentrate, lead concentrate, and miscellaneous products	448
Total	323, 538

Rhodesia and Nyasaland, Federation of.—In Northern Rhodesia, Roan Antelope Copper Mines, Ltd., mined and milled 6.1 million tons of ore averaging 1.79 percent copper during the fiscal year ended June 30, 1961. Concentrate produced contained 93,100 tons of recoverable copper. A total of 91,600 tons of blister copper was produced and was sent to the Ndola plant for electrolytic refining. In addition, 18,700 tons of blister was produced from scrap and furnace slag. Refined-copper production totaled 87,100 tons, of which 76,600 tons was in wirebar form and 10,500 tons in cathode form. The Roan smelter also produced 700 tons of copper for Nchanga.

Production at the electrolytic refinery of Ndola Copper Refineries, Ltd., was 99,200 tons of cathode copper of which 91 percent was for Roan Antelope. The casting plant converted 88,700 tons of cathode copper into 85,500 tons of wirebars, and the remainder, 10,500 tons, was shipped as cathodes.

Output at the electrolytic refinery of Rhodesia Copper Refineries, Ltd., decreased from 247,800 to 235,400 tons in the fiscal year ended June 30, 1961. Of the total, 207,500 tons was refined-copper shapes and 27,900 tons was cathode copper.

Nchanga Consolidated Copper Mines, Ltd., mined 5 million tons of ore averaging 5.09 percent copper during the fiscal year ended March 31, 1961. Nchanga West orebody supplied 3.7 million tons; Nchanga open pit, 0.9 million; and Chingola open pit, 0.4 million. The milled ore yielded 221,100 tons of copper in concentrate. Production of copper totaled 206,100 tons—35,800 tons of blister and 170,300 tons of electrolytic.

Rhokana Corporation, Ltd., mined and milled 5.7 million tons of ore averaging 2.47 percent copper in the fiscal year ended June 30, 1961. Production of concentrate totaled 335,400 tons averaging 36.05 percent copper and 0.67 percent cobalt. Copper production totaled 119,700 tons, of which 27,300 tons was blister and 92,400 tons was electrolytic. The smelter produced 314,400 tons of anode and blister copper compared with 301,500 tons in the preceding fiscal year. Of the total smelter output, 27,300 tons was blister and 93,400 tons of anode for Rhokana, 30,900 blister and 104,800 anode for Nchanga, 58,000 blister for Bancroft, and 13 tons of blister for others.

The Mufulira smelter treated 67,200 tons of concentrate for Chibuluma Mines, Ltd. Anode copper output was 21,500 tons, all of which was produced as fire-refined copper.

A total of 5.4 million tons of ore averaging 2.40 percent copper was mined by Mufulira Copper Mines, Ltd., in the fiscal year ended June 30, 1961. Anode copper produced, including 22,600 tons from scrap, was 135,800 tons. Fire-refined copper totaled 33,800 tons, and 102,000 tons of anode copper was sent to the refinery. The electrolytic plant produced 85,900 tons of cathode copper, of which 85,500 tons went to the casting plant and 400 tons to customers. Refined-copper output was 79,000 tons of wirebars and 3,000 tons of ingot bars.

There was very little change in production in Southern Rhodesia in 1961. Virtually the entire output came from three mines of Messina Transvaal Development Co., Ltd. At the Mangula mine about 13,000 tons of copper in concentrates was produced; at the Umkondo mine 1,800 tons of copper; and at the Alaska mine, which began operations in May, about 400 tons. Sixty percent of Mangula output was treated at the new smelter at Alaska near Sinoia, and 40 percent was exported. Production of fire-refined copper totaled 8,645 tons in the fiscal year ended September 30. Difficulties with the initial operation of the smelter caused it to be shut down in September for rebuilding. It was expected that the entire Mangula output would be treated in the Alaska smelter in 1962.

Exports of copper in the Federation of Rhodesia and Nyasaland were 164,400 tons of blister copper, 38,500 tons of cathodes, 375,100 tons of electrolytic wirebars, 23,200 tons of electrolytic bar and ingot, and 13,200 tons of ore and concentrate. In addition, small quantities of anodes and copper slimes were shipped.

Uganda.—Kilembe Mines, Ltd., milled 920,100 tons of ore in 1961. Blister copper production totaled 14,700 tons (16,300 in 1960). The output decreased because the smelter was closed to overhaul the furnace and power facilities were damaged by heavy rains.

Union of South Africa.—Output in the Union totaled 58,000 tons, 14 percent more than in 1960. O'okiep Copper Co., Ltd., produced 38,900 tons of copper in the fiscal year ended June 30, 1961, compared with 39,500 tons in fiscal 1960. Ore treated totaled 1.8 million tons averaging 2.31 percent copper. The estimated ore reserve was 31.6 million tons averaging 2.07 percent copper, a gain of 3.7 million tons. The increase was due mainly to the new Rietberg ore body, most of which can be mined by open-pit methods. Construction of the new mill to treat 110,000 tons of ore per month at Carolusberg proceeded on schedule, and the mill was expected to be in operation in 1963.

South-West Africa.—Output of the Tsumeb mine had increased almost without interruption since the reopening of the mine in 1947. The property, closed in 1939, was operated before World War II by Germans. Tsumeb Corp., Ltd., milled 652,000 tons of ore averaging 4.46 percent copper in the fiscal year ended June 30, 1961, compared with 614,000 tons averaging 5.02 percent copper in the 1960 fiscal period. Sales of copper totaled 23,900 tons in 1961 and 27,400 tons in 1960. The new copper smelter was expected to be in operation in September 1962. The Kombat copper-lead mine (formerly Asis), 65 miles from Tsumeb, was being prepared for 1,000-ton-per-day

output, and the mill, under construction, was to begin operations before mid-1962.

OCEANIA

Australia.—Mount Isa Mines, Ltd., Queensland, subsidiary of American Smelting and Refining Company, treated 3.2 million tons of ore, of which 2.3 million tons was copper ore and 0.9 million tons was silver-lead ore. The tonnage of ore treated was a record for the company despite a strike which began September 25 and continued to November 22. Refined-copper production totaled 51,400 tons, and 26,700 tons of copper concentrate was exported for treatment.

Expansion of tank capacity at Copper Refineries Pty., Ltd., subsidiary of Mount Isa, was on schedule, and refining capacity of 85,000 tons per year would be available in early January 1962. Mount Isa also announced plans for a new 6,000-ton-per-day flotation mill with two equal sections, either or both of which could be operated on silver-lead-zinc ores or on copper ore. Milling capacity would be increased to 14,000 tons a day.

At the Mount Morgan mine of Mount Morgan, Ltd., Queensland, 4.9 million tons of ore was mined, and 1.1 million tons was milled. Copper production totaled 6,900 tons.

The Mount Lyell Mining and Railway Co., Ltd., Tasmania, mill treated 2.2 million tons of ore and produced 54,100 tons of concentrates. Blister and electrolytic copper production were virtually the same—10,800 tons.

TECHNOLOGY

Many copper companies of the free world joined in a major basic and applied research program through the newly formed Copper Products Development Association.[7] The new research program was oriented chiefly toward customer requirements.

The geology and origin of the sulfide minerals in the Maybrun mines of the Kenora District, Ontario, Canada, and the usefulness of magnetometer and electromagnetic prospecting in that area were described.[8] Two published reports described theoretical and practical considerations in the selectivity in copper activation of minerals in flotation[9] and in the use of naphthenic acid as an extraction reagent for separation and recovery of copper and nickel from leach liquor.[10] The operation of a 175-ton-per-day plant for the copper-segregation process for mixed oxide-sulfide ore at the Lake Shore mine was described.[11]

Descriptions of larger scale and more efficient operations at Kennecott's Ray Division mill and the beginning of cement copper production at the new Badgad Copper Corp. plant were given.[12]

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[7] Milliken, Frank R. Copper Research Stepped Up. Steel, v. 149, No. 15, Oct. 9, 1961, pp. 73–75.

[8] Montgomery, Hugh B. Scientific Communications. Econ. Geol. v. 56, No. 7, November 1961, pp. 1305–1310.

[9] Bushell, C. H. G., C. J. Krauss, and G. Brown. Some Reasons for Selectivity in Copper Activation of Minerals. Canadian Min. and Met. Bull., v. 54, No. 587, March 1961, pp. 244–251.

[10] Fletcher, A. W., J. C. Wilson. Napthenic Acid as a Liquid-Liquid Extraction Reagent for Metals. Inst. of Min. and Met. (London), v. 70, No. 652, March 1961, pp. 355–366.

[11] Freeman, G. A., Carl Rampacek, and L. G. Evans. Copper Segregation Process Shows Promise at Lake Shore Mine. Min. Eng., v. 13, No. 10, October 1961, pp. 1152–1155.

[12] Huttl, John B. Ray Div.'s 50% Milling-Capacity Boost. Eng. Min. J., v. 162, No. 3, March 1961, pp. 84–91.

Huttl, John B. Cement Copper Begins at Bagdad. Eng. Min. J., v. 162, No. 6, June 1961, pp. 86–88.

Use of rotary film contactors, originally developed for recovering solutions of uranium compounds directly from ore slurries, showed promise of success in the processing of complex copper-nickel-cobalt ores. The use of these contactors could lead to improved recovery efficiencies, more rapid processing, and lower capital investment.[13]

Japanese technologists reported on 2 years of commercial-scale testing of converter smelting of copper concentrates with oxygen-enriched air.[14] One company adopted the process, and it resulted in improved smelting economy, increased copper recovery, and added recovery of sulfuric acid from converter gas. The industry was watching this development with intense interest.

Three articles described improved methods of refining copper or of controlling the refining operation.[15] Other articles described plating-shop layouts,[16] and an improved plating technique for both metal finishing and electronic applications.[17]

A new powder-metallurgy process which presses and sinters copper powders and may reduce the cost of electrical-grade copper parts, was reported.[18]

Techniques for producing high-conductivity copper castings were developed.[19] The use of high-conductivity copper in electrical and electronic equipment for space applications had not progressed as rapidly as could have been anticipated because of difficulties in casting desired shapes that meet conductivity and strength requirements. However, the techniques reported should overcome many of the problems.

Progress in copper and copper alloys technology was comprehensively reported.[20]

Several theoretical and practical papers described copper alloys of various types, their structure and properties, and the effect of alloy ingredients.[21]

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[13] South African Mining and Engineering Journal (Johannesburg) Treatment of Refractory Ores. V. 72, pt. 2, No. 3581, Sept. 22, 1961, p. 681.

[14] Tsurumoto, Tamon. Copper Smelting in the Converter. J. Metals, v. 13, No. 11, November 1961 pp. 820–824.

[15] Ward, R. G., and T. P. Hoar. The Electrolytic Removal of Oxygen, Sulphur, Selenium, and Tellurium from Molten Copper. J. Inst. Metals (London), v. 90, pt. 1 (Journal), pp. 6–12.

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[16] Darby, C. R. Plating Shop Layout and Installation. Metal Industry (London), v. 98, No. 15, Apr. 14, 1961 pp. 297–300.

[17] Chemical & Engineering News. V. 40, No. 1, Jan. 1, 1962, p. 50.

Dawson, J. Metal Finishing for the Electronics Industry. Metal Industry (London), v. 98, No. 17, Apr. 28, 1961, pp. 331–334.

[18] Iron Age, v. 188, No. 19, Nov. 9, 1961, p. 141.

[19] Fulthorpe, V. R., and F. M. Bunbury. Producing High-Conductivity Copper Castings. Foundry, v. 89, No. 3, March 1961, pp. 84–87.

[20] Metallurgia (Manchester, England). Copper and Copper Alloys, A Survey of Technical Progress During 1960 (compiled by Staff of the Copper Development Assn.). V. 63, No. 378, April 1961, pp. 175–184.

[21] Hume-Rothery, W. The Theory of the Alloys of Copper. J. Inst. Metals (London), v. 90, pt. 2 (Journal), October 1961, pp. 42–52.

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Davies, R. G. Steady State Creep in a $CuAu_3$-Alloy. Trans. Met. Soc. AIME, v. 221, No. 6, December 1961, p. 1280.

Moredock, A. E., and D. K. Fox. Zirconium-Copper Alloy, High Strength and Conductivity. Metal Progress, v. 79, No. 4, April 1961, pp. 75–77.

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Preston, Oliver, and Nicholas J. Grant. Dispersion Strengthening of Copper by Internal Oxidation. Trans. Met. Soc. AIME (Formerly Sec. II, Trans., J. Metals), v. 221, No. 1, February 1961, pp. 164–173.

The Federal Bureau of Mines published several reports covering investigations on the use of rock bolts in copper mines,[22] extractive processing of copper ores,[23] effects of ultrasonics in electroplating,[24] development of analytical techniques,[25] and damping alloys.[26]

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[22] Merrill, Robert H., Thomas A. Morgan, and C. J. Stehlik. Determining the In-Place Support of Mine Roof With Rock Bolts, White Pine Copper Mine, Michigan. BuMines Rept. of Inv. 5746, 1961, 28 pp.

[23] Shelton, John E. Flotation Studies on Copper-Nickel Sulfide Ores From Deposits near Rockport, Maine. BuMines Rept. of Inv. 5793, 1961, 17 pp.

Freeman, G. C., Carl Rampacek, and L. G. Evans. Copper Segregation at the Lake Shore Mine. J. Metals, May 1961, pp. 370–372; Min. Eng., October 1961, pp. 1152–1155.

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Brantley, F. E., R. G. Peterson, and J. B. Clemmer. Electric Smelting and Gaseous Refining of Cement-Copper Precipitate. BuMines Rept. of Inv. 5899, 1962, 14 pp.

Corrick, John D., and Joseph A. Sutton. Three Chemosynthetic Autotrophic Bacteria Important to Leaching Operations at Arizona Copper Mines. BuMines Rept. of Inv. 5718, 1961, 8 pp.

Kershner, K. K., and J. G. Donaldson. Chloridizing the Sulfides of Lead, Zinc, and Copper. BuMines Rept. of Inv. 5894, 1961, 19 pp.

[24] Kenahan, Charles B., and David Schlain. Effects of Ultrasonics on Electrolytic Deposition of Copper and Zinc From Sulfate and Cyanide Electrolytes. BuMines Rept. of Inv. 5890, 1961, 53 pp.

[25] Gajan, R. J., and D. M. Geehan. Rapid Determination of Aluminum, Iron, Copper, Cadmium, and Lead in Zinc Base Alloys. BuMines Rept. of Inv. 5727, 1961, 10 pp.

Prokopovitch, A. S., and T. E. Green. Spectrophotometric Determination of Trace Amounts of Copper in Tungsten Metal Powder. BuMines Rept. of Inv. 5720, 1961, 7 pp.

[26] Jensen, J. W., A. E. Schwaneke, and D. F. Walsh. Fatigue Properties of Manganese-Copper Damping Alloys. BuMines Rept. of Inv. 5853 1961 14 pp.

Diatomite

By John W. Hartwell[1] and Victoria R. Schreck[2]

OUTPUT of diatomite in the United States in 1961 exceeded that of 1960 by about 4 percent in quantity and 7 percent in value. Production data are company confidential and cannot be published for 1961, but the 3-year total for 1960–62 will be published in the 1962 chapter.

DOMESTIC PRODUCTION

California retained the position it had maintained since 1910 as the leading diatomite-producing State. The second leading State was Nevada, followed by Washington, Oregon, and Arizona. This was the first year since 1955 that Arizona had any production. Fourteen plants owned and operated by 13 companies reported production during the year, compared with 13 plants owned by 10 companies in 1960. Four firms with seven operations supplied a very large part of the output.

Great Lakes Carbon Corp. announced the closing of its mine and processing plant at Terrebonne, Oreg., about mid-1961, when the supply of filter-grade material was depleted. The mine had been in operation since 1936.

Two diatomite deposits near Trinity Mountain, Nev., owned by The Eagle-Pitcher Co., were uncovered for large-scale sampling. The company plant at Colado, Nev., operated at full capacity during the year because of heavy demand for filtration material by the swimming-pool-filter industry.

Kenite, Inc., near Vantage, Wash., undertook an exploratory drilling program for deposits of diatomite.

TABLE 1.—Diatomite sold or used by producers in the United States, 3-year totals

	1942–44	1945–47	1948–50	1951–53	1954–56	1957–59
Domestic production (sales)--short tons--	524,872	640,764	722,670	908,448	1,105,279	1,349,340
Average value per ton	$18.85	$20.17	$25.55	$29.97	$39.21	$45.73

CONSUMPTION AND USES

There was little change in the uses for diatomite in 1961, but total consumption increased. Diatomite remained the most widely

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.

used filter medium, although competition from expanded perlite increased. The quantity of filter-grade material used was slightly higher, but percentagewise its use remained the same as in 1960. Filler-grade diatomite consumption also increased in quantity, but its percentage of the total dropped 1 percent. The quantity used for insulation dropped about 3 percent, but percentage of the total used was the same as the previous year. Miscellaneous uses increased 7 percent in quantity but represented only 1 percent more of the total used. Miscellaneous uses were for abrasives, absorbents, carrier for catalysts, herbicides, pesticides, fungicides, fireproofing, glazes, enamels, flatting agents for paints, sodium and calcium silicate manufacture, and pozzolanic material.

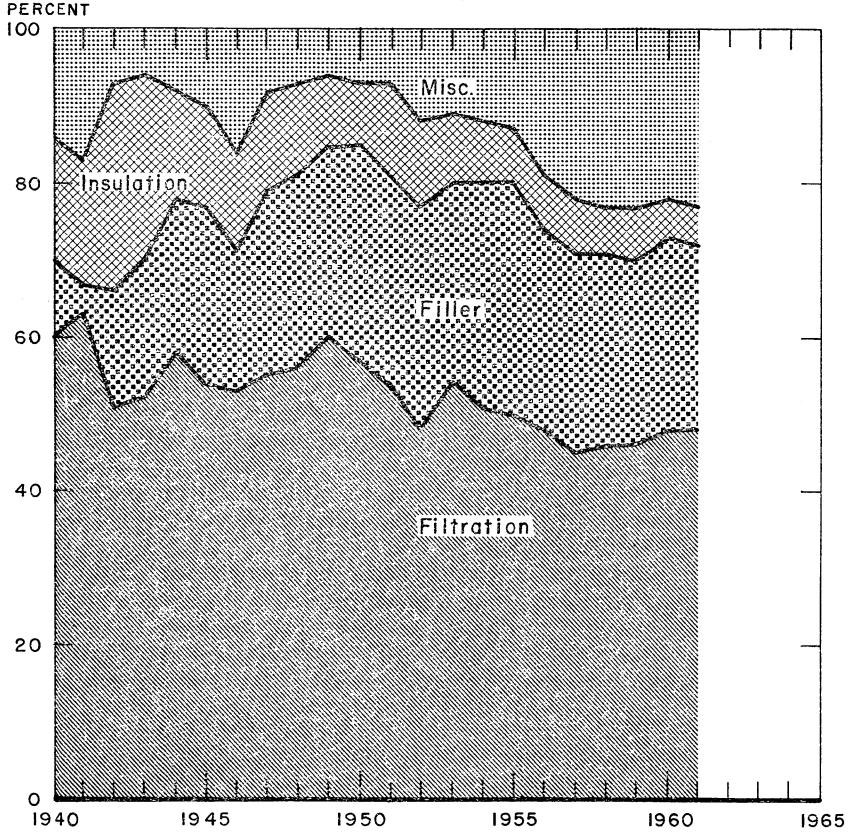


FIGURE 1.—Relative quantity of diatomite consumed in the United States for each principal class of use, 1940–61.

PRICES

Prices were higher for both filter and filler grades of diatomite and lower for most others. Because of the higher prices for filter and filler grades, the average price for all diatomite increased about 2 percent over that of 1960.

TABLE 2.—Average annual value per ton of diatomite, by uses

Use	1960	1961	Use	1960	1961
Filtration	$58.50	$59.77	Fillers	$46.39	$50.53
Insulation	49.29	47.61	Miscellaneous	32.92	31.71
Abrasives	138.14	137.00	Weighted average	49.50	50.65

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 led the world in diatomite production. Other major producers were West Germany, France, and Italy. These four countries accounted for almost three-quarters of the world output.

Canada.—Important deposits of diatomite and other minerals in British Columbia were shown on a map with some accompanying descriptive notes published by the Canadian Geological Survey.[3]

Iceland.—Representatives of a Dutch firm investigated diatomite deposits in Northern Iceland to determine the feasibility of commercial production.[4]

Kenya.—The East African Diatomite Syndicate, controlled two large deposits of diatomaceous earth on the main Nairobi-Nakuru road, about 80 miles from Nairobi. Investigations of the deposits proved reserves of 6 million tons and additional indicated reserves of 4 million tons. In one of the deposits the bed is 75 to 100 feet thick; in the other it is 10 to 16 feet thick. Both deposits are near the surface. The diatomite mined has few impurities, and 86-percent silica content, particle-size range of 5 to 250 microns, and a density of from 6 to 14 pounds per cubic foot.[5]

[3] Tipper, H. W., Geology, Prince George, Cariboo District, British Columbia. Canada Geol. Survey, Map 49–1960, 1961; Geo. Sci. Abs., v. 3, No. 10, October 1961, p. 1.
[4] U.S. Embassy, Reykjavik, Iceland. State Department Dispatch 141, Feb. 6, 1962, p. 16.
[5] Mining Journal (London). Diatomite in East Africa. V. 257, No. 6572, Aug. 4, 1961, p. 112.

TABLE 3.—World production of diatomite by countries [1 2]

(Short tons)

Country [1]	1952–56 (average)	1957	1958	1959	1960	1961
North America:						
Canada	31	120	27	5	44	25
Costa Rica	2,303	[3] 1,800	2,205	2,425	2,425	[3] 2,400
Guatemala	14,110	20,613	21,190			
Nicaragua				1,887	2,249	[3] 2,200
United States	342,182	[4] 449,780	[4] 449,780	[4] 449,780	[4] 449,780	[4] 449,780
South America:						
Argentina	4,236	4,084	4,540	4,829	[3] 4,800	[3] 4,800
Chile	121					
Colombia		275	220	330	275	[3] 275
Peru	[5] 8	39	117	254	1,284	[3] 1,300
Europe:						
Austria	4,241	3,823	4,086	4,492	4,431	5,993
Denmark:						
Diatomite	[3] 27,500	33,859	28,660	36,376	[3] 33,000	[3] 33,000
Moler [6]	[3] 40,000	41,074	46,486	40,542	[3] 38,500	[3] 38,500
Finland	1,836	1,874	2,315	1,520	1,457	[3] 1,400
France [7]	70,625	86,240	111,948	112,821	104,940	[3] 110,000
Germany, West [7]	57,500	71,918	115,319	111,826	107,831	[3] 119,000
Italy	10,421	29,707	49,828	57,100	[3] 55,000	[3] 55,000
Portugal [7]	1,745	1,613	1,159	2,075	1,172	[3] 1,100
Spain [7]	11,080	13,856	12,858	11,561	13,840	[3] 14,330
Sweden	1,423	1,317	1,260	[3] 1,100	2,205	[3] 2,200
United Kingdom	24,870	25,548	28,154	[3] 19,000	16,553	[3] 16,500
Yugoslavia	3,898	[3] 4,400	[3] 4,400	[3] 5,000	[3] 5,000	[3] 5,000
Asia: Korea, Republic of	1,786	1,472	518	1,865	2,646	1,989
Africa:						
Algeria	29,679	19,605	28,629	31,722	24,266	38,581
Kenya	4,783	4,737	3,892	4,041	3,791	3,537
Mozambique	21		61		103	[3] 110
Rhodesia and Nyasaland, Federation of: Southern Rhodesia				148	164	409
Union of South Africa	768	606	359	397	346	137
United Arab Republic (Egypt)	373	708	397	441	805	[3] 770
Oceania:						
Australia	6,065	6,968	4,749	5,700	5,218	[3] 5,500
New Zealand	261	3,537	6,336	8,152	6,992	[3] 7,000
World total [1 2 3]	710,000	940,000	1,040,000	1,030,000	1,000,000	1,030,000

[1] Diatomaceous earth is believed to be also produced in Brazil, Hungary, Japan, Rumania, and U.S.S.R., but complete data are not available; estimates by senior author of chapter 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 1953–56.
[6] A clay-contaminated diatomite used principally for lightweight building brick.
[7] Includes tripoli.

Compiled by Helen L. Hunt, Division of Foreign Activities.

United Kingdom.—The diatomite deposit in Skye, Inverness County, Scotland, was abandoned by Scottish Diatomite Ltd., after it had been worked at a loss for 10 years. Efforts by the Inverness County Council to find another company to mine the deposit were not successful.[6]

The only commercial diatomite deposit is in the Kentmere Valley, near Staveley, in northern Lancashire County, England. A subsidiary of Cape Asbestos Co. produces about 12,000 tons a year from this deposit.[7] In 1960 the United Kingdom produced less than 17,000 tons and imported about 63,000 tons of diatomite.

[6] Chemical Trade Journal and Chemical Engineer (London). The Skye Diatomite Deposits. V. 148, No. 3850, Mar. 17, 1961, p. 594.
[7] Chemical Trade Journal and Chemical Engineer (London). Diatomite or Scenery? V. 149, No. 3882, Oct. 27, 1961, p. 912

TECHNOLOGY

The Montana Bureau of Mines and Geology issued a publication containing information on diatomaceous earth deposits in the Drummond area of Montana.[8]

Diatomite deposits in the Pleistocene Lake basins of southeastern California were described. Only one commercial deposit had been exploited.[9]

Fifteen brands of high-temperature block insulation, including those made of diatomite, were evaluated for petrographic composition, bulk density, permeability, modulus of rupture, resistance to water disintegration, hot compressive strength, refractoriness, and thermal conductivity. Four brands, including one of diatomite, met tentative requirements for blast-furnace-stove insulation. Six brands, including three of diatomite, met tentative requirements for other steel-plant insulation.[10]

The production of organosilanes and silicones directly from silica or silicates was developed. The various modifications of the process involve reacting silica or a silicate with an alkyl aluminum halide either in an open system or in a sealed vessel. Silicates with open structures, such as diatomite, were more reactive than the clays, feldspars, and similar compact silicates.[11]

Estimates were made on the yearly production of diatomite, the quantity used as a filter aid, and its cost. A short history of the larger diatomite producers also was given.[12]

A study on the electrostatic behavior of both dust and filter fabric and their effect on filter operations was described. This study gave a guide to selecting a filter medium with electrostatic polarity and discharge rate that would give optimum capacity and efficiency. Some of the filtering products tested included flux-calcined and processed natural diatomite.[13]

Diatomite was described as being the most important filter aid for hard-to-filter liquids because it more nearly met the criteria for the ideal filtering agent.[14]

A porous material for use in handling and storing acetylene, made of a mixture of 3 to 15 percent diatomite and the remainder granular meerschaum, was patented.[15]

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[8] Gwinn, Vinton E. Geology of the Drummond Area, Central-Western Montana. Montana Bureau of Mines and Geol. Spec. Pub. 21 (Geol. Map 4), 1961; Geo. Sci. Abs., v. 3, No. 10, October 1961, p. 3.

[9] Blanc, Robert P., and George B. Cleveland. Pleistocene Lakes of Southeastern California—II. General Inf. Service, California Bureau of Mines, v. 14, No. 5, May 1961, p. 4.

[10] Eusner, G. R., and J. T. Shapland. Block Insulation for Stoves and Bustle Pipes. Am. Ceram. Soc. Bull., v. 40, No. 7, July 1961, pp. 439–444.

[11] Chemical & Engineering News. Silica and Silicates Give Silicones. V. 39, No. 15, Apr. 10, 1961, p. 45.

[12] Chemical Week. In the Bag: Filter-Aid Growth. V. 89, No. 6, Aug. 12, 1961, pp. 33–35.

[13] Frederick, Edward R. How Dust Filter Selection Depends on Electrostatics. Chem. Eng., v. 68, No. 13, June 26, 1961, pp. 107–114.

[14] Jackson, Thomas M., Jr. Filter Aids Speed Up "Difficult" Filtrations. Chem. Eng., v. 68, No. 6, Mar. 20, 1961, pp. 141–146.

[15] Tebboth, J. A. (assigned to The British Oxygen Co., Ltd.). Granular Porous Mass for an Acetylene Pressure Vessel and the Preparation Thereof. U.S. Patent 3,005,782, Oct. 24, 1961.

A method of making a water-repellent composition containing a filler such as diatomite for coating masonry was patented.[16]

The manufacture of a high-filtration-flow-rate filter aid, using diatomite, was patented. The pulverized diatomite was simultaneously mixed and sprayed with water to form agglomerates which were calcined in a rotary kiln. The discharged material was a satisfactory finished product without the need for air classification.[17]

A smoke-filtering cartridge for cigarettes, cigarette holders, and pipes, made from diatomite, clay, and glazing material, was patented.[18]

A patent was granted for a method of making molded thermal insulating shapes using perlite, asbestos, bentonite, chrysotile, and diatomite.[19]

A thermal insulating material and the method of making it were patented. The insulating material produced was a crystalline hydrous calcium silicate formed from reaction of a mixture of asbestos, lime, and diatomite, and incorporated into a chemically inert, finely divided additive of wollastonite, limestone, coal, and zircon. The inert material was reported to improve the thermal insulating efficiency of the product.[20]

A composition of either asbestos, rock wool, or glass fiber and an absorbant filler of diatomite or expanded perlite bound together with resin and forming evaporation plates for air-conditioning units was patented.[21]

Recent West German patents were granted for a method of bleaching diatomite,[22] a method of reducing the rate of corrosion of blast-furnace linings with 2 to 5 inches of diatomite,[23] a pozzolanic additive in portland cement using diatomite,[24] and production of a fertilizer containing diatomite.[25]

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[16] Liberthson, L., and H. Lipkind (assigned to Sonneborn Chemical & Refining Corp.). Water-Repellent Masonry Coating Composition Containing Filler Coated With an Organopolysiloxane and Masonry Coated Therewith. U.S. Patent 3,006,875, Oct. 31, 1961.

[17] Riede, R. G. (assigned to Johns-Manville Corp., New York, N.Y.). Calcination of Diatomaceous Earth. U.S. Patent 3,013,981, Dec. 19, 1961.

[18] Heine, H. W. Tobacco Smoke Filter and/or Absorbent. U.S. Patent 2,996,067, Aug. 15, 1961.

[19] Heilman, R. H., R. W. Ortmiller, and A. P. Mueller (assigned to The Philip Carey Mfg. Co., Cincinnati, Ohio). Insulation Material and Method of Making Same. U.S. Patent 2,971,878, Feb. 14, 1961.

[20] Taylor, W. C. (assigned to Owens-Corning Fiberglas Corp.). Thermal Insulating Material and Method of Making Same. U.S. Patent 3,001,882, Sept. 26, 1961.

[21] Breiner, R. C., and R. G. Quinn (assigned to Johns-Manville Corp., New York, N.Y.). Humidifier Plates. U.S. Patent 3,007,841, Nov. 7, 1961.

[22] Pesce, L. (assigned to S.p.A. del Monte Amiata Farine Fossile d'Italia). West German Patent 1,052,964, Mar. 19, 1959; Chem. Abs., v. 55, No. 3, Feb. 6, 1961, col. 2954d.

[23] Winters, C. (assigned to August Thyssen-Hutte A.G.). West German Patent 1,065,440, Sept. 17, 1959; Chem. Abs., v. 55, No. 10, May 15, 1961, col. 98251.

[24] Firma Paul Lechler. West German Patent 1,053,999, Mar. 26, 1959; Chem. Abs., v. 55, No. 4, Feb. 20, 1961, col. 3952a.

[25] Volker, H. (assigned to Firma Ferdinand Ludolff). West German Patent 1,071,064, Dec. 17, 1959; Chem. Abs., v. 55, No. 14, July 10, 1961, col. 13793g.

Feldspar, Nepheline Syenite, and Aplite

By Taber de Polo [1] and Gertrude E. Tucker [2]

FELDSPAR

OVERALL DEMAND for feldspar remained about the same in 1961 as in 1960. Substantial declines in flat and plate glass requirements (12 percent) caused by lower automobile-industry consumption and increased imports were offset by the requirements of the glass-container industry and increased use in structural building units.

Further excess production capacity and increased competition from substitutes resulted in the continuation of the price drop in glass-grade feldspar, which reached a low of $7.32 per short ton f.o.b. plants in North Carolina. Pottery-grade feldspar prices also declined in some areas. The price of some feldspar-silica mixtures was down to $6.75 per short ton.

TABLE 1.—Salient feldspar statistics

	1952-56 (average)	1957	1958	1959	1960	1961
United States:						
Crude:						
Sold or used by producers [1]						
long tons	551,624	498,057	469,738	548,390	502,380	496,808
Value thousands	$4,910	$4,935	$4,278	$5,372	$4,779	$5,120
Average per long ton	$8.90	$9.91	$9.11	$9.79	$9.51	$10.31
Imports for consumption						
long tons	2,384	72	73	45	44	24
Value thousands	$27	$7	$5	$5	$5	$2
Average per long ton	$11.37	$92.03	$63.82	$100.49	$106.95	$84.38
Consumption, apparent [2]						
long tons	554,008	498,129	469,811	548,435	502,424	496,832
Ground:						
Sold by merchant mills [3]						
short tons	597,860	503,170	469,602	560,105	528,348	541,626
Value thousands	$8,121	$7,062	$6,540	$7,659	$7,079	$6,694
Average per short ton	$13.58	$14.04	$13.93	$13.67	$13.40	$12.36
Imports for consumption						
long tons	725	3,969	6,584	5,160	6,980	2,529
Value thousands	$18	$67	$101	$82	$110	$63
Average per long ton	$24.83	$16.77	$15.27	$15.86	$15.69	$24.86
World: Production long tons	1,130,000	1,240,000	1,220,000	1,370,000	1,470,000	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.

DOMESTIC PRODUCTION

Crude Feldspar.—Production of crude feldspar was approximately the same as in 1960. Over 50 percent of the output came from North Carolina. California was second in production. Flotation was used to concentrate 91 percent of the feldspar produced in North Carolina and Georgia, a substantial increase in percentage over 1960. Countrywide, flotation accounted for approximately 62 percent of the total feldspar output.

Crude feldspar figures include hand-cobbed feldspar, flotation concentrate, and the feldspar content of feldspar-silica mixtures.

Byproduct feldspar production appeared to be gaining. The amount of hand-cobbed feldspar produced from mines operated to recover only feldspar continued to decrease. There also was an increase in the number of consumers using silica-feldspar mixtures.

The Feldspar Corp. operated its new mill at Middletown, Conn., for the first full year.

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)
1952–56 (average)	(3)	(3)	447,026	$4,151	104,598	$759	551,624	$4,910
1957	227,826	$1,958	208,984	2,449	61,247	528	498,057	4,935
1958	198,460	1,346	218,178	2,450	53,100	482	469,738	4,278
1959	169,473	1,508	293,356	3,114	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

[1] Partly estimated.
[2] Feldspar content.
[3] Included with flotation concentrate.

Ground Feldspar.—Ground feldspar sold by merchant mills in the United States increased 2 percent in quantity, but decreased 5 percent in value. Ground feldspar was produced at 21 mills in 13 States, a decrease of 3 mills and 1 State (New Jersey) from 1960. North Carolina, California, Connecticut, Georgia, and South Dakota were the leading producers in that order. Five Southeastern States (Georgia, North Carolina, South Carolina, Tennessee, and Virginia) produced almost 62 percent of the ground feldspar. Ground feldspar figures include flotation concentrate and the feldspar content of feldspar-silica mixtures. Tabular data show the origin of the feldspar (hand-cobbed, flotation 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)
1952–56 (average)	24	[2] 597,860	[2] $8,121
1957	23	503,170	7,062
1958	24	[3] 469,602	[3] 6,540
1959	26	[3] 560,105	[3] 7,659
1960	24	[3] 523,348	[3] 7,079
1961	21	541,626	6,694

[1] Exclude potters and others who grind for consumption in their own plants.
[2] Includes Canadian feldspar 1952–54.
[3] Includes Canadian feldspar.

CONSUMPTION AND USES

Crude Feldspar.—Virtually all crude feldspar was either ground by the producing companies or sold to merchant grinders. Some pottery, enamel, and soap manufacturers purchased crude feldspar for all or part of their requirements and ground it to company specifications in their own mills.

TABLE 4.—Ground feldspar sold by merchant mills in the United States, by derivation[1] and uses

(Short tons)

Year	Hand-cobbed					Flotation concentrate				
	Glass	Pottery	Enamel	Other	Total	Glass	Pottery	Enamel	Other	Total
1952–56 (average)	(2)	(2)	(2)	(2)	(2)	242,121	189,984	20,986	27,619	480,710
1957	54,283	109,910	26,052	16,742	206,987	166,933	58,131	--------	6,170	231,234
1958	48,376	93,805	21,734	13,519	177,434	171,002	53,205	--------	8,489	232,696
1959	40,365	88,233	36,929	24,662	190,189	219,139	72,496	--------	10,558	302,193
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

Year	Feldspar-silica mixtures[3]					Grand total				
	Glass	Pottery	Enamel	Other	Total	Glass	Pottery	Enamel	Other[4]	Total
1952–56 (average)	112,968	1,182	--------	3,000	117,150	355,089	191,166	20,986	30,619	597,860
1957	58,643	--------	--------	6,306	64,949	279,859	168,041	26,052	29,218	503,170
1958	49,003	4,767	--------	5,702	59,472	268,381	151,777	21,734	27,710	469,602
1959	55,809	5,323	--------	6,591	67,723	315,313	166,052	36,929	41,811	560,105
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

[1] Partly estimated.
[2] Included with flotation concentrate.
[3] Feldspar content.
[4] Includes soaps, abrasives, and other miscellaneous uses.

Ground Feldspar.—Most consumers bought material already ground, sized, and ready for use in their manufactured products. In 1961, the glass, pottery, and enamel industries consumed 91 percent of ground feldspar sold by merchant mills. Gains were made in glass, while pottery and enamel registered small declines. Other uses,

including soaps and abrasives, other ceramic uses, and poultry grit, decreased substantially. Almost 60 percent of the ground feldspar consumed in the United States was used in the major consuming States, California, Ohio, Pennsylvania, Illinois, and Indiana.

TABLE 5.—Ground feldspar shipped from merchant mills in the United States

(Short tons)

Destination	1957	1958	1959	1960	1961
California	75,012	77,407	87,332	91,452	99,149
Illinois	56,853	48,385	57,952	54,089	55,815
Indiana	(1)	16,353	34,212	28,426	39,700
Maryland	15,930	14,000	17,572	16,017	14,092
Massachusetts	4,746	3,738	4,229	5,101	6,235
New Jersey	29,358	24,306	28,577	25,989	38,245
New York	21,849	20,883	16,463	19,701	16,850
Ohio	61,834	56,367	71,293	67,324	67,304
Pennsylvania	64,302	60,322	56,332	60,907	55,947
Texas	20,934	(1)	22,057	21,440	22,994
West Virginia	44,893	(1)	51,965	36,216	27,384
Wisconsin	9,822	8,664	10,823	9,677	8,727
Other destinations [2]	97,637	139,177	101,298	92,009	89,184
Total	503,170	469,602	560,105	528,348	541,626

[1] Included with "Other destinations."

[2] Includes Alabama (1960–61), Arkansas, Colorado, Connecticut (1958–61), Florida (1960–61), Georgia (1960), Hawaii (1961), Kansas (1958), Kentucky, Louisiana, Maine (1957–60), Michigan, Minnesota, Mississippi, Missouri, Oklahoma, Rhode Island, Tennessee, Utah (1960), Vermont (1960), Washington (1957 and 1959–61), shipments that cannot be separated by States, and shipments to States indicated by footnote 1. Also includes exports to Canada, Colombia (1961), Cuba (1959–60), England (1957–59), Mexico, Panama, Puerto Rico (1957–59), Venezuela (1957 and 1959–61), and West Germany (1957–58), and small quantities to other countries.

PRICES

Prices of crude feldspar do not appear in trade publications. The average value of crude feldspar was $10.31 per long ton, compared with $9.51 in 1960.

The average selling price of ground feldspar was $12.36 per short ton, a decrease of almost 8 percent from the $13.40 figure for 1960.

The following producing States had the highest selling price per short ton: Illinois, $22.36; New Hampshire, $21.34; Arizona, $20.75; Virginia, $19.98; Georgia, $19.85; and Tennessee, $18.38.

The highest average value by uses was reported for enamel at $19.58 per short ton.

Quotations on ground feldspar in E&MJ Metal and Mineral Markets for December 1961 were as follows: North Carolina, bulk carlots, 325-mesh, $17 per short ton; 200-mesh, $17; 40-mesh, glass grade, $13.50; and 20-mesh semigranular, $7.50.

FOREIGN TRADE [3]

According to reports from grinders, ground-feldspar exports decreased to less than half the 1960 figure. Major countries of destination were Canada, Mexico, and Venezuela; small quantities were shipped to unspecified countries.

Cornwall Stone.—Imports for consumption of ground cornwall stone (all from England) increased to 30 tons valued at $882 in 1961.

[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 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
1952–56 (average)	2,384	$27,106	725	$18,103	1959	45	$4,522	5,160	$81,849
1957	72	6,626	3,969	66,548	1960	44	4,706	6,980	109,547
1958	73	4,659	6,584	100,564	1961	24	2,025	2,529	62,859

Source: Bureau of the Census.

WORLD REVIEW

World production of feldspar increased 2 percent, and the United States furnished 33 percent of the output. Production by countries remained virtually the same as in 1960.

A report on the feldspar economy of the U.S.S.R. was prepared by the Federal Bureau of Mines, based on an article ("Feldspar Raw Materials") in a Soviet publication. It was estimated that production was 220,500 long tons annually, with 60 percent used in glass, 30 percent in ceramics, 4 percent in abrasives, and 6 percent in other applications. Feldspar specifications in the U.S.S.R. were also given.[4]

TABLE 7.—World production of feldspar, by countries [1 2]

(Long tons)

Country [1]	1952–56 (average)	1957	1958	1959	1960	1961
North America:						
Canada (shipments)	16,770	18,259	18,203	16,030	12,376	8,797
United States (sold or used)	551,624	498,057	469,738	548,390	502,380	496,808
Total	568,394	516,316	487,941	564,420	514,756	505,605
South America:						
Argentina	6,886	4,271	4,221	4,922	[3] 3,900	[3] 3,900
Brazil	[4]	[4]	[4]	[4]	[3] 44,000	[3] 44,000
Chile	1,121	984	984	1,476	1,095	2,953
Colombia		5,905	3,937	14,763	14,763	[3] 14,800
Peru					236	992
Uruguay	548	168	267	352	713	877
Total [3]	22,700	36,000	39,000	56,000	65,000	68,000
Europe:						
Austria	2,238	2,612	2,613	3,445	4,573	3,907
Finland	10,441	8,932	11,969	9,114	9,158	14,554
France	66,372	65,223	81,103	78,737	73,816	[3] 74,000
Germany, West	129,568	167,278	187,504	186,011	237,648	[3] 235,000
Italy	35,323	63,969	55,160	59,990	85,076	88,230
Norway	33,376	55,423	41,618	60,037	64,958	68,895
Portugal	451	1,161	544	837	1,699	[3] 1,700
Spain	7,483	4,472	5,199	10,722	11,924	[3] 11,800
Sweden	47,216	52,968	42,785	46,159	54,328	[3] 54,000
U.S.S.R.	[4]	175,000	[3] 175,000	[3] 185,000	[3] 195,000	[3] 195,000
Yugoslavia	[5] 5,476	9,608	12,466	19,309	13,780	[3] 19,700
Total [1 3]	480,000	610,000	620,000	660,000	760,000	770,000

See footnotes at end of table.

[4] Bureau of Mines. Mineral Trade Notes. V. 54, No. 2, February 1962, pp. 15–17.

TABLE 7.—World production of feldspar, by countries[1 2]—Continued

(Long tons)

Country[1]	1952–56 (average)	1957	1958	1959	1960	1961
Asia:						
Hong Kong	[6] 91	1,156	1,653	1,716	2,511	1,206
India	4,303	7,872	8,432	9,740	10,287	[3] 8,930
Japan[7]	32,274	43,417	44,507	60,196	91,454	[3] 93,500
Philippines		49	74	1,684	3,896	14,526
Viet-Nam, South	[8] 1,181					
Total	37,849	52,494	54,666	73,336	108,148	[3] 118,160
Africa:						
Eritrea	7	394	413	1,476	984	2,953
Kenya		120	26			1
Malagasy Republic (Madagascar)	45					
Rhodesia and Nyasaland, Federation of: Southern Rhodesia			449			
Union of South Africa	6,053	11,381	7,708	10,447	15,600	23,290
United Arab Republic (Egypt)				492	354	
Total	6,105	11,895	8,596	12,415	16,938	26,244
Oceania: Australia[9]	15,263	8,820	7,016	6,750	8,414	6,900
World total (estimate)[1 2]	1,130,000	1,240,000	1,220,000	1,370,000	1,470,000	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] 1 year only as 1956 was first year of commercial production.
[6] Average annual production 1955–56.
[7] In addition, the following quantities of aplite and other feldspathic rock were produced: 1952–56 (average), 69,277 tons; 1957, 82,670 tons; 1958, 76,856 tons; 1959, 88,451 tons; 1960, 91,339 tons; 1961, 132,017 tons.
[8] Average annual production 1954–56.
[9] Includes some china stone.

Compiled by Liela S. Price, Division of Foreign Activities.

TECHNOLOGY

Deposits of high-potash feldspar in Arizona [5] and California [6] were described.

Descriptions of newly discovered deposits of feldspathic materials in the U.S.S.R.,[7] India,[8] Brazil,[9] and West Germany [10] were published. Geology, physical and chemical properties, and other laboratory data were given.

The geology and physical properties of English cornwall stone were discussed in detail.[11]

[5] Ceramic News. Outstanding Feldspar and Silica Produced in Arizona. V. 10, No. 1, January 1961, pp. 12–13.
[6] Ceramic News. Southern California Source for Silica and Feldspar. V. 9, No. 12, December 1960, p. 12.
[7] Kupfer, S. M. (New Sources of Feldspathic Material for the Ceramic and Glass Industries.) Steklo i Keram., v. 18, No. 3, March 1961, pp. 25–27; Ceram. Abs., v. 45, No. 3, March 1962, p. 71e.
[8] Datar, D. S., and S. H. Zaheer. Note on the Physical Properties of Golconda Feldspar—Eshwar Raj Saxena. Trans. Indian Ceram. Soc., v. 19, No. 3, March 1960, pp. 115–116.
[9] Zeemann, F. A. O. G., Y. S. Visconti, and B. N. F. Nicot. Study of a New Raw Material, Montmorillionized Feldspar From Barra do Piraí, and Its Ceramic Use. Cerâmica (São Paulo), v. 6, No. 24, 1960, pp. 23–24; Ceram. Abs., v. 44, No. 9, September 1961, p. 222.
[10] Schott, R. (Quartz Porphyry—Indigenous Feldspar Raw Material). Silikattech., v. 11, No. 2, 1960, pp. 87–88; Ceram. Abs., v. 44, No. 7, 1961, p. 174h.
[11] Keeling, P. S. Cornish Stone. Trans. Brit. Ceram. Soc., v. 60, No. 6, June 1961, pp. 390–426.

A patent was issued for a method of processing pegmatite and recovering feldspar.[12]

Background data on feldspar were included in a comprehensive reference book on ceramics.[13]

Detailed reports were published on the results of optical studies on feldspar minerals, including twinning and optical disturbances around stress centers.[14]

Experimental work was conducted on the decomposition of feldspar materials by water at 295° C and 2,500 psi.[15]

Experimental results were published showing that the particle size of commercial ground feldspar and flint particles is a major factor in variable slip behavior.[16]

The flotation process used at the Middletown, Conn., plant of The Feldspar Corp. was described.[17]

NEPHELINE SYENITE

Domestic Consumption.—Domestic consumption of nepheline syenite, imported from Canada, in the glass and ceramic industries decreased 5 percent in quantity and 15 percent in value in 1961. 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 "Stone" chapter.

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
1952–56 (average)	37	$157	101,109	[1] $1,544,117	1959	868	$18,652	184,464	$2,403,079
1957			166,989	[1] 2,505,248	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

[1] Data known to be not comparable with other years.

Source: Bureau of the Census.

Prices.[18]—Latest available published prices of processed nepheline syenite per short ton were quoted as follows, f.o.b. works, bags, carlots: Glass grade (30-mesh), $15; pottery grade (200- to 325-mesh), $21.50 to $28; and byproduct grade (100 mesh), $10 (add $3 per short ton to bulk quotations for bagging).

[12] Thomson, Alfred M. Method of Processing Pegmatite (Potash Feldspar). U.S. Pat. 2,994,581, Aug. 1, 1961.

[13] Kingery, W. D. Introduction to Ceramics. John Wiley & Sons, Inc., New York, N.Y., 1960, 781 pp.

[14] Ramberg, Hans. Artificial and Natural Photoelastic Effects in Quartz and Feldspars. Am. Mineralogist, v. 46, Nos. 7–8, July–August 1961, pp. 934–951.

Tobi, Alexander C. The Recognition of Plagioclase Twins in Sections Normal to the Composition Plane. Am. Mineralogist, v. 46, Nos. 11–12, November–December 1961, pp. 1470–1480.

[15] Morey, George W., and Robert O. Fournier. The Decomposition of Microcline, Albite and Nepheline in Hot Water. Am. Mineralogist, v. 46, Nos. 5–6, May–June 1961, pp. 688–699.

[16] Phelps, G. W., and John S. Dennis. Particle Size of Feldspar and Flint as a Factor in Slip Behavior. J. Am. Ceram. Soc., v. 44, No. 4, April 1961, pp. 149–156.

[17] Glass Industry. Feldspar by Flotation. V. 42, No. 12, December 1961, pp. 694–695.

[18] Reeves, J. E. Nepheline Syenite. Canada Dept. Mines and Tech. Surveys, Rev. 44, April 1959, p. 5.

Foreign Trade.—Imports of ground nepheline syenite from Canada, mostly for use in the glass industry, decreased 5 percent in quantity and 15 percent in value. About 1,167 short tons of crude nepheline syenite was imported from Canada.

World Review: *Canada.*—Canada continued to be the major known producer of nepheline syenite for the ceramic industry. In 1960, shipments totaled nearly 250,000 short tons, 9 percent more than in 1959, and were valued at over $3 million. Table 9 shows production, export, and consumption data.

Norway.—Exploration began on a nepheline syenite deposit in Finmark, northern Norway. Plant capacity was planned for 50,000 tons per year.[19]

U.S.S.R.—Russia was reported to have increased production of nepheline syenite for use as a source of alumina and for the glass and ceramic industries.

Other Countries.—Nepheline syenite also was mined in Belgium-Luxembourg, and deposits occur in Finland, India, Korea, and Peru.

TABLE 9.—Canada: Production, exports, and consumption of nepheline syenite

	1958	1959		1960 [1]	
	Short tons	Short tons	Value	Short tons	Value
Production (shipments)	----------	228,722	$2,930,932	249,200	$3,030,300
Exports:					
Belgium-Luxembourg	----------	240	4,635	353	6,326
Germany, West	----------	388	6,941	368	6,820
Puerto Rico	----------	900	13,500	900	12,225
United Kingdom	----------	4,788	74,844	6,808	98,132
United States	----------	170,094	2,213,938	183,864	2,231,761
Other	----------	1,710	31,483	1,005	18,090
Total	----------	178,120	2,345,341	193,298	2,373,354
Consumption (Canada):					
Glass, glass fibre, and mineral wool	24,165	27,470	----------	----------	----------
Clay products	2,579	2,453	----------	----------	----------
Miscellaneous	----------	103	----------	----------	----------
Total	26,744	30,026	----------	----------	----------

[1] Preliminary figures.

Source: Reeves, J. E. Nepheline Syenite 1960 (Preliminary). Canada Dept. Mines and Tech. Surveys, Rev. 45, May 1961, p. 4.

Technology.—An extensive publication on southern Ontario nepheline deposits, including information on existing uses and possibilities for expanded use, was published.[20]

A paper was presented on the production and quality control of pottery-grade nepheline syenite.[21]

[19] Mining Journal (London). Mining Miscellany. V. 256, No. 6566, June 23, 1961, p. 733.

[20] Hewitt, D. F. Nepheline Syenite Deposits of Southern Ontario. Sixty-ninth Annual Report of the Ontario Department of Mines. V. 69, pt. 8, Ontario Dept. Mines, 1960, 194 pp.

[21] Taylor, G. H., and R. C. Wilson. Particle Size Control of Nepheline Syenite for Whitewares. Am. Ceram. Soc. Bull., v. 41, No. 1, January 1962, pp. 12–13.

A general review discussed the use of nepheline syenite in ceramic bodies. Automatic dry pressing, dry mixing, automatic decoration, and glazing were included.[22]

APLITE

The quantity of ground aplite sold, primarily for use in making amber glass, increased substantially in 1961, to 109,000 short tons. There was a small decrease in average price per ton.

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 Metal & Thermit Corp., Hanover County.

[22] Jeuthe, H. K. New Methods in the Manufacture of Hotel and Domestic Ware. Keram. Z., v. 13, No. 4, April 1961, pp. 162–164; Ceram. Abs., v. 44, No. 10, October 1961, p. 244e.



Ferroalloys

By H. Austin Tucker,[1] Gertrude C. Schwab,[2] and Hilda V. Heidrich[2]

DOMESTIC production of ferroalloys in 1961 decreased 12 percent, and the quantity and value of shipments remained essentially the same as in 1960. Producer stocks declined 13 percent, and consumer stocks increased 13 percent. The ferroalloy industry produced 1.86 million short tons of products and shipped 1.94 million tons.

LEGISLATION AND GOVERNMENT PROGRAMS

The following paragraph is quoted from a release by the U.S. Department of Commerce:[3]

According to a barter contract that CCC negotiated with the India Government in 1960, India was to supply 186,000 short tons gross weight of ferromanganese to the United States. In 1961, the commitment was met. India shipped 112,000 short tons of ferromanganese and 65,000 short tons of ore to the United States, and 85,000 short tons of ore to other countries, all of the ore being converted to meet the remaining commitment of 74,000 short tons of ferromanganese. Chile was given a contract to supply 35,800 short tons of ferromanganese.

DOMESTIC PRODUCTION

In 1961, 52 producers in 19 States made 1.86 million tons of ferroalloy in 56 plants; 40 of the plants were electric furnace, 10 were blast furnace, and 6 were aluminothermic. Ohio was the leading State with 471,666 short tons, and Pennsylvania was next with 448,678 tons. Producers also reported from Alabama, Florida, Idaho, Illinois, Indiana, Iowa, Kentucky, Montana, New Jersey, New York, Oregon, South Carolina, Tennessee, Texas, Virginia, Washington, and West Virginia.

Interlake Iron Corp. closed its plant at Jackson, Ohio, early in the year. The plant consisted of a blast furnace and an electric furnace for making silvery pig iron and ferrosilicon.

Manganese Alloys.—The 11 producers of ferromanganese made 13 percent less alloy than in 1960 and shipped 3 percent less. This commodity was produced in 11 States in 5 blast-furnace and 14 electric-

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.
[3] Iron and Steel Division, Business and Defense Services Administration. Ferroalloy Industry: Outlook for 1962 and Review of 1961. Dec. 18, 1961, p. 4.

furnace plants. The average unit value of the electric-furnace product increased from 11.3 to 13.7 cents per pound of contained manganese. A new producer in 1961 was Montana Ferro-Alloys Co., Inc. Pittsburgh Coke & Chemical Co., Neville Island (Pittsburgh), Pa., a 1959 producer of ferromanganese and spiegeleisen and a 1960 producer of spiegeleisen, produced neither in 1961.

Silicomanganese was made by 8 companies in 14 electric-furnace plants in 8 States. Production and shipments increased 19 and 16 percent, respectively, with the average value down from 17.55 to 15.84 cents per pound of contained manganese. A new producer in 1961 was Montana Ferro-Alloys Co., Inc.

Silicon Alloys.—Eleven companies produced silicon alloys in 23 electric-furnace plants in 10 States. Output decreased 4 percent, but shipments increased 14 percent.

Silvery Iron.—Five companies continued to manufacture silvery iron in three blast-furnace plants and three electric-furnace plants in five States. Production decreased 49 percent and shipments decreased 22 percent from the 1960 figures. The unit value of the blast-furnace product decreased from 43 to 41 cents per pound of contained silicon; that of the electric-furnace product decreased from 29 to 26 cents.

TABLE 1.—Ferroalloys produced and shipped from furnaces in the United States

Alloy	1960				1961			
	Production		Shipments		Production		Shipments	
	Gross weight (short tons)	Alloy element contained (average percent)	Gross weight (short tons)	Value (thousands)	Gross weight (short tons)	Alloy element contained (average percent)	Gross weight (short tons)	Value (thousands)
Ferromanganese:								
Blast furnace	570,817	77.47	534,135	$122,162	504,744	76.90	508,441	$105,729
Electric furnace	272,001	78.17	247,874	43,700	228,069	78.18	248,904	53,321
Total	842,818	77.69	782,009	165,862	732,813	77.30	757,345	159,050
Silicomanganese	101,330	65.49	104,380	23,983	120,238	65.77	121,229	25,238
Ferrosilicon	367,371	55.33	342,210	63,610	352,017	56.23	389,268	72,833
Silvery iron:								
Blast furnace	221,236	8.65	166,711	12,365	73,873	8.58	112,904	8,170
Electric furnace	120,855	15.75	113,011	10,261	100,029	15.76	105,224	8,712
Total	342,091	11.16	279,722	22,626	173,902	12.71	218,128	16,882
Chromium alloys:								
Ferrochromium	[1] 193,747	65.26	193,807	78,851	[1] 213,091	65.10	231,701	84,547
Other chromium alloys	[2] 86,477	41.96	79,036	26,736	[2] 80,365	40.13	82,104	19,653
Total	280,224	58.07	272,843	105,587	293,456	58.26	313,805	104,200
Ferrotitanium	3,268	28.95	3,366	2,755	2,607	27.46	2,831	1,919
Ferrophosphorus	91,388	24.00	68.868	3,048	94,841	24.04	51,020	2,708
Ferrocolumbium and ferrotantalum-columbium	730	58.08	691	2,700	993	58.21	1,015	4,014
Ferronickel	24,364	44.50	24,359	44,056	20,241	51.01	19,800	12,992
Other	[3] 64,886	28.29	60,175		73,347	27.20	66,084	34,421
Grand total	2,118,470	55.60	1,938,623	434,227	1,864,455	58.51	1,940,525	434,257

[1] Includes low- and high-carbon ferrochromium and chromium briquets.
[2] Includes ferrochrome-silicon, exothermic chromium additives, and other chromium alloys.
[3] Includes Alsifer, ferroboron, ferromolybdenum, ferrotungsten, ferrovanadium, simanal, spiegeleisen, zirconium-ferrosilicon, ferrosilicon-zirconium, aluminum-silicon alloy, and other miscellaneous ferroalloys.

Chromium Alloys.—Eleven companies continued to make ferrochromium in 18 electric-furnace plants in 10 States. Production and shipments increased 5 and 15 percent, respectively. The average unit value of contained chromium decreased from 33 to 28.4 cents per pound.

Molybdenum Alloys.—Two companies produced ferromolybdenum, mostly by the aluminothermic method, although in one plant the electric-furnace method was also used. The average unit value increased again, from $1.82 to $2.17 per pound of contained molybdenum. Reading Chemicals continued to make molybdenum-aluminum with 55 percent contained molybdenum. Shieldalloy Corp., a 1960 producer of ferromolybdenum, did not produce this substance in 1961.

Titanium Alloys.—Four companies produced ferrotitanium in four electric-furnace plants and one aluminothermic plant in four States.

Ferrophosphorus.—Eight companies produced ferrophosphorus as a byproduct of the electric-furnace process for smelting phosphate rock to make elemental phosphorus. Production increased 4 percent and shipments declined 26 percent. The average value increased from $44.26 to $53.07 per ton.

Ferrocolumbium and Ferrotantalum-Columbium.—Six companies continued to produce ferrocolumbium in four States in three electric-furnace plants and three alminothermic plants. They made 44 percent more alloy than in 1960 and shipped 67 percent more. The average unit value decreased slightly, from $3.42 to $3.40 per pound of contained columbium.

Two companies continued to manufacture ferrotantalum-columbium in plants that also made ferrocolumbium. Production decreased 45 percent, and shipments decreased 61 percent. The average unit value declined slightly, from $3.07 to $2.99 per pound of contained columbium and tantalum.

Ferronickel.—Hanna Nickel Smelting Co., Riddle, Oreg., continued as the only ferronickel producer.

Vanadium Alloys.—Four producers made ferrovanadium containing 56 percent vanadium in one electric-furnace plant and three aluminothermic plants.

Zirconium Alloys.—One company, in two electric-furnace plants in two States, continued to make zirconium-ferrosilicon containing 13 percent zirconium. The unit value increased slightly, from 76 to 78 cents per pound of contained zirconium.

Ferroboron.—Ferroboron was produced by three companies in three electric-furnace plants in three States. The average boron content increased from 16.7 percent in 1960 to 17.3 percent. The average unit value increased from $6.60 to $6.80 per pound of contained boron. Metal & Thermit Corp., a producer in 1959, did not make ferroboron in 1960 or 1961.

Tungsten Alloys.—Ferrotungsten was produced by two companies in two electric-furnace plants in New York and Pennsylvania. Reading Chemicals, a third company, produced chromium-manganese-tungsten alloy by the aluminothermic process in Pennsylvania. Production of tungsten alloys increased 24 percent, and shipments declined 1 percent. The average unit value of contained tungsten was $2.47 per pound, compared with $2.10 per pound in 1960.

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CONSUMPTION AND USES

As reported to the Bureau of Mines, 1,660,000 short tons of the major ferroalloys was used in the United States, 5 percent less than in 1960. The American Iron and Steel Institute (AISI) showed that 1,398,000 short tons of the major ferroalloys was consumed by the steel industry.[4]

Most of the ferroalloys were consumed in alloy-steel ingot production. The AISI reported that 8.7 million tons of alloy steel was produced in 1961, compared with 8.4 million in 1960. Included in the 8.7 million tons was 5.3 million tons of heat-treatable engineering steel; 932,000 tons of low-alloy, high-strength, and non-heat-treated engineering and construction steels; 945,000 tons of silicon electric sheet; 649,000 tons of nominal 18–8 nickel-chromium stainless steels (AISI 300 series); 372,000 tons of essentially nickel-free chromium stainless steels (AISI 400 and 500 series); and 394 tons of miscellaneous alloy-steel ingot. The last category includes 280,000 tons of heat-treatable steel ingot containing boron, 17,700 tons less than in 1960. 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.

Manganese Alloys.—The consumption of ferromanganese declined 24,000 short tons from that in 1960. Almost half the decline was in gray and malleable castings.

The use of silicomanganese increased 13,000 tons over that of 1960 and was spread proportionately among the six categories listed in table 3.

Silicon Alloys.—The consumption of silicon alloys was down 78,000 short tons from that in 1960; of this decrease 69,000 tons was silvery pig iron. The greatest decline in the use of silvery pig iron was in gray and malleable castings, 58,000 tons, which was comparable to the 61,000 ton drop in the same category in 1960. The downward trend in the use of silvery pig iron was attributed to a preference by foundrymen for the 50-percent grade of ferrosilicon, principally because it was less expensive.

Titanium Alloys.—Consumption of ferrotitanium decreased for the second successive year.

Ferrophosphorus.—Seven hundred tons less ferrophosphorus was consumed than in 1960; 1,000 less tons was used in "other alloy steels," but this was offset in part by small gains in several other use categories.

Ferroboron.—Consumption of ferroboron declined 25 percent from that of 1960. The distribution of use changed markedly in 1961; alloy steel and carbon steel absorbed essentially the same quantities, whereas in previous years alloy steels had absorbed a much larger proportion.

Chromium Alloys.—Consumption of chromium alloys increased 11,000 tons over that of 1960 but was 7,000 tons less than in 1959. The use categories that increased markedly in 1961 were stainless steel and high-temperature alloys.

[4] American Iron and Steel Institute. Annual Statistical Report. 1961, pp. 20, 21.

TABLE 2.—Consumption by major end uses, and stocks, of silicon alloys, in the United States in 1961

(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 Dec. 31
Silvery pig iron	5–13	----------	1,163	1,022	----------	784	86,569	1	----------	----------	1	89,540	8,728
Do.	14–20	----------	4,890	12,755	----------	64	73,245	----------	----------	24	[3] 6,688	97,666	13,492
Ferrosilicon	[4] 21–55	5,763	45,741	73,246	491	663	41,151	35	178	1,736	[5] 9,304	178,308	23,836
Do.	56–70	237	11,979	16,965	----------	----------	573	----------	----------	----------	[5] 4,661	34,415	2,712
Do.	71–80	8,521	15,959	4,853	563	86	7,886	----------	39	19	[6] 3,609	41,540	5,688
Do.	81–89	66	643	1,707	1	52	2,987	----------	----------	37	10	5,503	813
Do.	90–95	14	3,681	143	----------	28	261	2,429	402	38	53	7,049	743
Silicon metal	96–99	26	44	24	1	----------	235	22,712	171	492	[7] 5,854	29,559	2,900
Ferrosilicon briquets	40–50	6	323	298	----------	15	22,658	----------	----------	----------	17	23,317	3,585
Misc. silicon alloys [8]	----------	245	4,972	7,390	55	105	3,336	172	44	24	2,114	18,457	2,285
Total	----------	14,878	89,395	118,403	1,116	1,797	238,901	25,349	834	2,370	32,311	525,354	64,782

[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.

Molybdenum Alloys.—No significant change occurred in the consumption of molybdenum alloys.

Tungsten Alloys.—Consumption increased 9 percent, or 41 tons, with "other tool steels" and "other alloy steels" the chief gainers.

Vanadium Alloys.—The same quantity of vanadium alloys was consumed as in 1960, with slightly more used for "other alloy steels" and less used for "tool steels."

Ferrocolumbium and Ferrotantalum-Columbium.—Consumption of ferrocolumbium alone increased 65 percent. Together with the 32-percent gain in 1960, this increase indicates the growing popularity of ferrocolumbium as a deoxidizer and grain refiner in stainless, common alloy, and carbon steels, and in high-temperature alloys. The consumption rate of ferrocolumbium averaged 30 tons per month until July and rose to 47 tons in August, 68 tons in September, and 65 tons in October. For a description of the influence of columbium upon the properties of steel, see the "Iron and Steel" chapter.

Zirconium Alloys.—The steel producers reported to the AISI that they consumed 1,786 short tons of ferrozirconium and 145 tons of the minor zirconium alloys, silicon-zirconium, aluminum-zirconium, and Grainal. As in 1960, the minor alloys increased in use significantly, but ferrozirconium declined.

TABLE 3.—Consumption by end uses of ferroalloys as additives in the United States in 1961 [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]	10,693	147,364	642,407	3,628	23,007	11,525	838,624
Silicomanganese	4,148	31,762	69,815	1,501	3,561	1,050	111,837
Silicon alloys [6]	14,878	91,192	118,403	1,116	238,901	60,864	525,354
Ferrotitanium	580	889	949	2	2	286	2,708
Ferrophosphorus	8	1,809	10,983		635	64	13,499
Ferroboron	2	44	43		12	5	106
Total	30,309	273,060	842,600	6,247	266,118	73,794	1,492,128

[1] Except for gray and malleable castings, other items may include steel castings as well as steel ingots.
[2] Includes steel mill rolls.
[3] Includes high-speed, hot-work, and other tool steels.
[4] Includes cutting and wear-resistant materials, high-temperature alloys, welding rods, alloy hard-facing rods and materials, permanent-magnet alloys, soft-magnetic alloys, nickel-base alloys, titanium-base alloys, wire, rod, sheet, aluminum-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 2 for more detail on silicon alloys.

TABLE 4.—Consumption by end uses of ferroalloys as alloying elements in the United States in 1961

(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	Total
Ferrochromium [2]	111,926	[3] 37,953	--	841	1,314	2,663	5,538	1,725	161,960
Ferromolybdenum [4]	1,010	[3] 822	--	276	86	1,116	102	396	3,808
Ferrotungsten	--	[5] 83	--	251	142	--	[6] 25	[7] 10	511
Ferrovanadium	23	[8] 961	70	241	131	17	14	31	1,488
Ferrocolumbium [9]	277	77	39	--	--	1	76	[10] 19	489
Ferrotantalum-columbium [9]	18	--	--	--	--	1	15	[10] 3	37
Total	113,254	39,896	109	1,609	1,673	3,798	5,770	2,184	168,293

[1] Includes hot-work and die steels.
[2] Includes ferrochromium alloys and chromium metals.
[3] Includes quantities believed used in producing high-speed and other tool stells and stainless steels, because some firms failed to specify individual uses.
[4] Includes calcium molybdate and molybdenum silicide.
[5] Includes steel mill rolls, stainless steel, and other alloy steels.
[6] Includes cutting and wear-resistant alloys.
[7] Includes diamond-drill bit matrices, electrical contact points, and welding rods.
[8] Includes steel mill rolls.
[9] See table 5 for more detail on end uses.
[10] Includes refractory alloys and research.

TABLE 5.—Consumption by end uses of ferrocolumbium and ferrotantalum-columbium in the United States

(Pounds of contained columbium and tantalum)

Product	1960	1961	Product	1960	1961
Stainless steels	482,360	591,389	High-temperature alloys	104,449	180,869
Other alloy steels	73,533	155,138	Permanent-magnet alloys	3,154	2,122
Carbon steels	21,482	77,967	Refractory alloys	2,000	3,500
Tool steels	260	234	Miscellaneous uses	7,933	7,999
Welding rods	25,933	30,687			
Gray and malleable castings	383	2,276	Total	721,487	1,052,181

STOCKS

Producer stocks declined 13 percent and consumer stocks increased 13 percent. In contrast to the general decrease in producer stocks, ferrophosphorus inventories increased 39 percent. Since ferrophosphorus is the unwanted byproduct of the smelting of phosphate rock in electric furnaces to make elemental phosphorus, no direct control of production is possible. This situation and decreased exports were the chief causes of the rapid accumulation of ferrophosphorus at the producers' plants. The Tennessee Valley Authority reduced its stock of ferrophosphorus from 79,500 to 31,667 short tons.

In addition to the stocks reported in table 6, the quantities of ferroalloys stored in the various U.S. Government stockpiles are shown in table 7. No ferroalloys were stored in the Defense Product Act stockpile as of December 31, 1961.

TABLE 6.—Stocks of ferroalloys held by producers and consumers in the United States, Dec. 31

(Short tons)

Alloy	Producers		Consumers	
	1960, gross weight	1961, gross weight	1960, gross weight	1961, gross weight
Manganese ferroalloys [1]	[2] 199,897	179,796	144,536	171,616
Silicon alloys [3]	[2] 212,607	130,139	[4] 73,621	[4] 64,782
Ferrochromium [5]	[2] 76,689	57,640	16,530	28,203
Ferrotitanium	[2] 989	765	690	695
Ferrophosphorus	[2] 111,059	154,184	3,666	3,610
Ferroboron	81	78	29	57
Total	[2] 601,322	522,602	239,072	268,963
	1960, contained alloy	1961, contained alloy	1960, contained alloy	1961, contained alloy
Ferromolybdenum [6]	(7)	(7)	574	545
Ferrotungsten	(7)	(7)	89	89
Ferrovanadium	(7)	(7)	259	262
Ferrocolumbium	163	156	87	76
Ferrotantalum-columbium	(7)	(7)	11	12
Total	[2] 1,513	933	1,020	984

[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 2.
[5] Includes other chromium ferroallys and chromium metal.
[6] Includes calcium molybdate and molybdenum silicide.
[7] Figures withheld to avoid disclosing individual company confidential data.

TABLE 7.—Government inventory of ferroalloys, Dec. 31, 1961

(Short tons)

Alloy	National (strategic) stockpile	CCC and supplemental stockpile	Total
Ferrochromium:			
High-carbon	126,000	257,000	383,000
Low-carbon	128,000	187,000	315,000
Ferrochromium-silicon, low-carbon	25,000	33,000	58,000
Ferrocolumbium	106	----------	106
Ferrotantalum-columbium	63	----------	63
Ferromanganese, standard high-carbon	144,000	646,000	790,000
Ferrotungsten (contained tungsten)	808	----------	808
Ferrovanadium (contained vanadium)	989	----------	989
Total	424,966	1,123,000	1,547,966

PRICES

Prices of the major ferroalloys fluctuated during the year. One major producer cut the prices of certain grades of chrome alloy 2 to 2½ cents per pound on January 25, and on February 2 lowered prices on all grades of low-carbon ferrochromium.[5] On October 15, the same producer raised prices of most grades of ferrochrome an average of slightly less than 2 cents per pound, but reduced the price of high-carbon ferrochrome 4.75 cents a pound to 24 cents. Other ferrochrome

[5] American Metal Market. Metal Market Staff Report. Carbide Again Cuts Some Tags for Ferrochromes. V. 68, No. 23, Feb. 2, 1961, pp. 1, 2.

producers quickly followed these price changes. Price cuts were attributed to improved technology of production and cheaper ores from Africa, and price increases were attributed to a need to adjust the price-cost relationship in making ferrochrome. Apparently, the lower steel production index during the first half of the year strongly influenced these price changes.

On February 2, the price of 50-percent ferrosilicon decreased 1.1 cents per pound to 13.5 cents; it increased to 14.5 cents about November 1.[6] These price changes apparently were caused by the same supply-demand forces as for ferrochromium.

One producer cut the price of standard ferromanganese from $220 to $190 per short ton and lowered the price of other manganese alloys on December 14 to meet competition from imported material.[7] Other producers soon followed. The price of silicomanganese was reduced 1 cent to 10.6 cents per pound of alloy, and that of silicomanganese briquets was reduced 0.9 cent to 13.1 cents.

FOREIGN TRADE[8]

Foreign trade in ferroalloys increased for the fourth consecutive year. Ferromanganese imports from India increased nearly threefold over 1960 as a result of barter for surplus agricultural products with the U.S. Department of Agriculture, Commodity Credit Corporation (CCC). Other items of note were the large increases in ferromanganese imports from West Germany and the Union of South Africa. Exports of ferrophosphorus, for years the leading ferroalloy exported, were 18,000 short tons less than in 1960. Ferrophosphorus dropped to second place among ferroalloy exports, with ferrosilicon taking the lead.

[6] Ruth, John P. Vanadium Lifts Price of 50% Ferrosilicon. Am. Metal Market, v. 68, No. 210, Nov. 1, 1961, pp. 1, 14.
[7] American Metal Market. Ferromanganese Price Cut. V. 68, No. 239, Dec. 14, 1961, pp. 1, 18.
[8] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 8.—U.S. imports for consumption of ferroalloys and ferroalloy metals

Alloy	1960			1961		
	Gross weight (short tons)	Content (short tons)	Value	Gross weight (short tons)	Content (short tons)	Value
Calcium silicide	176	(1)	$50,899	279	(1)	$82,561
Chromium metal	908	(1)	1,645,432	692	(1)	1,149,916
Chromium-nickel and chromium vanadium				12	(1)	5,703
Ferroboron	17	(1)	28,033	9	(1)	14,190
Ferrocerium and other cerium alloys	11	(1)	78,370	11	(1)	63,210
Ferrochrome and ferrochromium:						
Containing 3 percent or more carbon	33,525	23,099	8,675,006	14,406	9,433	3,125,214
Containing less than 3 percent carbon	15,862	11,087	5,637,637	13,408	9,265	4,486,413
Ferrochromium-tungsten, chromium-tungsten, chromium-cobalt-tungsten, tungsten-nickel, and other alloys of tungsten, n.s.p.f. (tungsten content)	(1)	18	61,758	(1)	5	14,998
Ferromanganese:						
Containing not over 1 percent carbon	277	218	122,004	[2] 551	[2] 487	[2] 233,131
Containing over 1 and less than 4 percent carbon	10,635	8,601	2,278,644	7,813	6,396	1,755,700
Containing not less than 4 percent carbon	109,310	83,775	16,607,675	213,572	163,316	32,407,357
Ferromolybdenum, molybdenum metal and powder, calcium molybdate, and other compounds and alloys of molybdenum (molybdenum content)	(1)	12	21,612	(1)	5	36,514
Ferrosilicon	17,869	4,972	1,532,740	13,730	2,307	803,283
Ferrosilicon-aluminum and ferroaluminum silicon and Alsimin	(3)	(1)	663			
Ferrotitanium	83	(1)	41,456	182	(1)	93,460
Ferrotungsten	112	84	207,257	214	170	421,746
Ferrovanadium	15	(1)	44,182			
Manganese metal (manganese content)	(1)	243	113,276	(1)	565	262,460
Manganese silicon (manganese content)	(1)	10,046	1,885,619	(1)	13,471	2,525,407
Silicon metal (silicon content)	301	297	80,706	31	30	8,206
Tungsten in combinations, in lump, grains, or powder (tungsten content)	(1)	80	369,711	(1)	28	139,370
Tungstic acid and other alloys of tungsten, n.s.p.f. (tungsten content)	(1)	(4)	264	(1)	194	373,503

[1] Not recorded.
[2] Adjusted by the Bureau of Mines.
[3] 780 pounds.
[4] 6 pounds.

Source: Bureau of the Census.

TABLE 9.—U.S. imports for consumption of ferromanganese and ferrosicilon, by countries

Country	Ferromanganese (manganese content), excluding silicomanganese				Ferrosilicon (silicon content)			
	1960		1961		1960		1961	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
North America:								
Canada	615	$296,670	166	$36,255	2,318	$799,162	2,203	$690,250
Mexico			1,513	235,955				
Total	615	296,670	1,679	272,210	2,318	799,162	2,203	690,250
South America: Chile	448	72,967	2,877	646,884				
Europe:								
Belgium-Luxembourg	2,757	492,265						
France	18,041	2,771,736	31,391	5,745,190				
Germany, West	634	196,247	[1] 16,816	[1] 2,572,525	201	247,071	87	109,403
Italy	1,611	412,745	363	97,119				
Norway	2,232	432,949	1,710	245,000	2,176	424,955		
Spain	1,422	231,262	1,058	163,858				
Sweden			844	126,000				
United Kingdom	852	168,080						
Yugoslavia	3,950	627,785	6,432	1,005,466	52	9,541		
Total	31,499	5,333,069	58,614	9,955,158	2,429	681,567	87	109,403
Asia:								
India	27,850	6,374,379	73,058	17,290,849				
Japan	23,328	5,523,179	12,463	3,104,794	183	43,074		
Total	51,178	11,897,558	85,521	20,395,643	183	43,074		
Africa: Union of South Africa	8,854	1,408,059	21,508	3,126,293	42	8,937	17	3,630
Grand total	92,594	19,008,323	[1] 170,199	[1] 34,396,188	4,972	1,532,740	2,307	803,283

[1] Adjusted by Bureau of Mines.

Source: Bureau of the Census.

TABLE 10.—U.S. exports of ferroalloys and ferroalloy metals

Alloy	1958		1959		1960		1961	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Ferrochrome	1,920	$1,012,260	6,127	$2,095,978	15,588	$5,248,750	7,844	$2,837,518
Ferromanganese	1,406	463,896	947	388,134	751	202,457	469	146,178
Ferromolybdenum	113	244,755	124	280,495	212	489,140	179	501,476
Ferrophosphorus	44,503	1,468,445	49,903	1,798,592	47,897	2,094,527	30,060	1,307,168
Ferrosilicon	2,177	391,621	10,558	980,658	5,501	867,140	34,764	6,104,913
Ferrotitanium and ferrocarbon-titanium	323	138,431	321	145,621	245	157,419	212	93,389
Ferrotungsten	1	3,508	38	57,147			[1]	1,569
Ferrovanadium	76	294,933	152	529,697	162	506,624	120	436,208
Other ferroalloys	189	109,146	323	194,187	3,845	846,888	4,839	1,234,682
Spiegeleisen	834	79,243	380	37,862	148	15,056	525	46,617
Total	51,542	4,206,238	68,873	6,508,371	74,349	10,428,001	79,012	12,709,718

[1] Less than 1 ton.

Source: Bureau of the Census.

WORLD REVIEW

SOUTH AMERICA

Chile.—In 1961, 5,047 short tons of ferroalloys was exported from Chile as itemized in table 11.

TABLE 11.—Chile: Ferroalloys exported in 1961, by countries

	Short tons	Value
Ferromanganese:		
United States	3,850	$646,884
Peru	272	39,178
Total	4,122	686,062
Silicomanganese:		
United States	220	26,910
Venezuela	485	65,828
Total	705	92,738
Ferrosilicon:		
Peru	181	34,336
Venezuela	39	4,301
Total	220	38,637

Source: U.S. Embassy, Santiago, Chile. State Department Dispatch 651. Apr. 18, 1962.

EUROPE

Italy.—The production of ferroalloys during the first half of 1961 was 77,000 short tons, compared with 66,600 tons for the same period in 1960.

Norway.—A new ferrosilicon plant under construction in Troms County and expansions in the existing ferrosilicon industry were expected to increase annual production to 250,000 tons by 1965.[9] For other ferrosilicon data on Norway see the "Silicon" chapter in this volume.

Norwegian exports of silicomanganese were nearly 43,400 tons in the first 6 months of 1961, compared with 42,100 for the same period in 1960. The largest importer of Norwegian silicomanganese was West Germany, followed by the United Kingdom.[10]

United Kingdom.—Union Carbide Ltd. built a new production plant for making 2-pound ferroalloy briquets of ferrosilicon, zirconium-silicon, ferrochromium, ferromanganese, and silicomanganese. The plant, believed to be the first of its kind in Europe, was fully automatic.[11]

ASIA

India.—The output of ferromanganese in 1961 was 115,000 short tons, and that of ferrosilicon was 8,800 tons. The total export value of both alloys was $22,000.[12]

[9] Bureau of Mines. Mineral Trade Notes. V. 53, No. 4, October 1961, p. 21.
[10] American Metal Market. More Manganese From Russia Goes to Norway. V. 68, No. 158, Aug. 17, 1961, p. 19.
[11] Metallurgia. Ferroalloy Briquettes for Iron Foundries. V. 63, No. 379, May 1961, p. 250.
[12] U.S. Embassy, New Delhi, India. State Department Dispatch 923. May 3, 1962, p. 1.

The National Metallurgical Laboratory at Jamshedpur developed a new process for producing low-carbon ferrochromium, employing existing equipment used to make high-carbon ferrochromium and ferrosilicon.[13] A new plant was under construction at Bhadrak in Orissa to produce 9,000 short tons of low-carbon ferrochrome and 2,200 tons of high-carbon ferrochrome.[14]

Since only ferrosilicon and standard high-carbon ferromanganese had been produced commercially in India, the National Metallurgical Laboratory organized a symposium to be held in February 1962 to encourage further growth of the ferroalloy industry.[15] Meanwhile, Ferro Alloys Corp., Ltd., of Andhra Pradesh was embarking on a program to increase its production of standard ferromanganese from 39,000 short tons in 1960 to 50,000 tons, using its three furnaces. It planned also to make silicomanganese and to erect an arc furnace for making low-carbon ferromanganese by the silicothermic reduction process. The plant was to have a capacity of 28 tons per day. Ferro Alloys Corp., Ltd., also planned to make ferrosilicon and ferrochromium.[16] Sirajuddin and Co. of Calcutta received permission from the Indian Government to produce 5,600 tons of ferrosilicon annually.[17]

Japan.—The Ministry of International Trade and Industry planned to liberalize the import restrictions on ferronickel early in 1962.[18] Japanese ferroalloy producers decided to import 2,300 tons of chrome ore from Iran to help rectify the imbalance in trade between the two countries.[19] Showa Denko K.K. concluded a long-term export contract with Rudolph Wolf Company of London to sell 6,700 short tons or more of low-carbon ferrochrome a year for the 5 years beginning with 1962. The first consignment was shipped in December 1961. Nippon Steel Tube Corp. concluded a contract to ship 6,700 tons of low-carbon ferrochrome to the United States. These two producers made most of Japan's low-carbon ferrochrome, which totaled between 78,000 and 90,000 tons in 1961.[20]

Philippines.—Acoje Mining Co. of Manila contracted with Koppers International C.A. to prepare specifications, design, and help build a small ferrochrome smelter near Iligan City on the island of Mindanao. The plant was to employ the Strategic-Udy direct-reduction process under license from Strategic Materials Corp. of New York.[21] The plant will produce 25,000 short tons of ferrochrome per year. The Philippines produced 318 tons of silicomanganese valued at US$76,700.[22]

[13] Mining Journal (London). Technical Briefs. V. 258, No. 6604, Mar. 16, 1962, p. 265.
[14] Journal of Mines, Metals and Fuels. Production of Low Carbon Ferrochrome for Alloy Steel Industries. V. 9, No. 12, December 1961, p. 18.
[15] Iron and Coal Trades Review. Symposium on Ferroalloy Industry in India. V. 183, No. 4863, Sept. 29, 1961, p. 674.
[16] Journal of Mines, Metals and Fuels. Ferro Alloys Expansion Plans. V. 9, No. 8, August 1961, p. 28.
[17] Mining Journal (London). Metals and Minerals. V. 256, No. 6563, June 2, 1961, p. 638.
[18] American Metal Market. Japan May Import More Ferronickel. V. 68, No. 158, Aug. 17, 1961, p. 19.
[19] American Metal Market. Persian Chrome Ore for Japan. V. 68, No. 158, Aug. 17, 1961, p. 20.
[20] Mining Journal (London). Metals and Minerals. V. 258, No. 6595, Jan. 12, 1962, p. 47.
[21] American Metal Market. Koppers Gets Contract To Build Philippines Ferrochrome Plant. V. 68, No. 141, July 15, 1961, p. 16.
[22] U.S. Embassy, Manila, Philippines. State Department Dispatch 750. Apr. 23, 1962, encl. 1, p. 2.

AFRICA

Rhodesia and Nyasaland, Federation of.—Windsor Ferroalloys (Pvt.) Ltd., with John Miles & Partners as consulting engineers, announced plans to erect a new smelter in Que Que, Southern Rhodesia, to produce 13,500 short tons per year of high-carbon ferrochromium. The plant was rated at over 7,500 kva, sufficient to smelt about 28,000 tons per year of local chromite ores.[23]

Union of South Africa.—African Metals Corp., Ltd. (AMCOR), made manganese, chromium, silicon, and phosphorus ferroalloys in three electric-furnace plants. It began installing an additional 6,000-kva electric furnace at its Kookfontein works, near Vereeniging, where an existing furnace was expanded from 7,500 to 9,000 kva. An additional 10,000-kva furnace was installed at Ferrometals Ltd., AMCOR's associated works at Witbank. With these additions, AMCOR's total installed electric furnace capacity become 90,000 kva.[24]

United Arab Republic (Egypt).—The Economic Development Organization of the United Arab Republic planned to spend about US$13 million at Aswan on calcium carbide and ferrosilicon ($3 million) and ferromanganese ($10 million) smelting facilities, beginning in 1962.[25]

OCEANIA

Australia.—The entire ferroalloy output in Australia was produced by Broken Hill Pty. Co., Ltd. (BHP), at Newcastle. Production was 18,600 short tons for the year ended November 30, 1960. Of this total, 670 short tons was high-carbon ferrochromium; 7,200 tons, standard ferromanganese; 720 tons, ferronickel; 8,100 tons, ferrosilicon (50-percent); and 1,900 tons, silicomanganese.[26] The ferromanganese plant being built for BHP at Bell Bay, Tasmania, as reported in the "Ferroalloys" chapter of the 1960 Minerals Yearbook, neared completion by yearend.[27]

TECHNOLOGY

A translation from Russian of "Production of Ferroalloys: Electrometallurgy," cosponsored by the Department of the Interior and the National Science Foundation, was published.[28]

Union Carbide Metals introduced a refined charge-chrome, produced by blowing oxygen into a ladle of molten charge-chrome.[29] The oxygen injection oxidizes some of the carbon and silicon, agitates and homogenizes the bath, and raises the temperature, allowing more time for impurities to rise to the surface. Also, deleterious gas is removed from the bath. The refined product contains 58 to 65 percent chro-

[23] Iron and Coal Trades Review. Ferrochrome Smelter for Southern Rhodesia. V. 182, No. 4862, Sept. 22, 1961, p. 645.
[24] Mining Magazine (London). New Letters. V. 105, No. 4, October 1961, p. 235.
[25] Engineering and Mining Journal, v. 162, No. 7, July 1961, pp. 136, 138.
[26] Bureau of Mines. Mineral Trade Notes. V. 54, No. 2, February 1962, pp. 17–19.
[27] Mining Journal (London). Mining Miscellany. V. 258, No. 6600, Feb. 16, 1962, p. 171.
[28] Elyutin, V. P., Yu. A. Pavlov, B. E. Levin, and E. M. Alekseev. Production of Ferroalloys: Electrometallurgy. Office of Technical Services, U.S. Department of Commerce. Order No. 61–11429, 2d ed., 1961, 446 pp.
[29] South African Mining Journal. Better Ferro-Chrome Being Made. V. 73, Pt. 1, No. 3602, Feb. 16, 1962, p. 369.

mium and maximums of 4.25 percent carbon, 1.00 percent silicon, and 0.03 percent sulfur.

The New Jersey Zinc Co. was building the first commercial electric-furnace plant at Palmerton, Pa. (to be completed in 1962), for the continuous production of spiegeleisen by an elaboration of the electric-coproduct ore-reduction process.[30] The company developed this process, which is a continuous reduction and distillation operation using a submerged-arc electric furnace with a rectification column that yields zinc. Part of the ore to be smelted consists of franklinite, an iron-manganese-zinc oxide mineral, from a deposit at Ogdensburg, N.J. The electric-furnace installation is reported to be more efficient and of wider scope than the three blast furnaces it replaces.

Nonmetallurgical-grade chrome ore containing 31 percent chromium and 19 percent iron from the Transvaal, Union of South Africa, was successfully smelted by the Strategic-Udy process in Niagara Falls, Ontario, Canada. The ore was crushed, concentrated, and partially reduced in a rotary kiln. Final reduction to ferrochromium was accomplished in a 10,000-kva electric furnace.[31]

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[30] Blast Furnace and Steel Plant. Spiegeleisen Made By New Process. V. 49, No. 7, July 1961, pp. 680, 681.

[31] Mining Journal (London). Ferro-Chrome Production at Niagara Falls. V. 258, No. 6596, Jan. 19, 1962, p. 61.

Fluorspar and Cryolite

By William V. Kuster[1] and Victoria R. Schreck[2]

FLUORSPAR

SHIPMENTS of fluorspar from domestic mines were down 11 percent from 1960, and imports for consumption were down 5 percent; however, fluorspar consumption reached a new high, exceeding by 6 percent the previous peak recorded in 1957. Excess fluorspar to supply this peak came from inventories of fluorspar held in consumers plants. Quoted prices remained stable throughout the year; however, the average unit sales price of acid-grade fluorspar at yearend was $2 less than in the first half of the year. The unit sales price of Mexican acid-grade fluorspar was down $5 at midyear from the figure received when the year opened, but it rose thereafter and closed the year only $2 below the opening figure.

TABLE 1.—Salient fluorspar statistics

	1952–56 (average)	1957	1958	1959	1960	1961
United States:						
Production:						
Crude:						
Mine production...short tons	796,840	861,500	818,100	404,900	575,700	615,075
Material milled or washed...do	725,800	790,600	814,800	442,000	558,600	491,000
Beneficiated material recovered...short tons	298,140	322,600	310,600	195,100	225,900	193,000
Finished (shipments)...do	300,832	328,872	319,513	185,091	229,782	205,083
Value...thousands	$14,054	$15,777	$15,071	$8,680	$10,391	$9,275
Imports for consumption...short tons	370,873	631,367	392,164	555,750	534,020	505,759
Value...thousands	$10,100	$16,031	$9,777	$13,368	$14,393	$13,644
Exports...short tons	631	754	3,374	1,144	458	338
Value...thousands	$49	$81	$191	$69	$38	$30
Consumption...short tons	555,797	644,688	494,227	589,979	643,759	681,883
Stocks Dec. 31:						
Domestic mines:						
Crude[1]...short tons	162,127	214,934	207,210	155,534	137,723	209,915
Finished...do	25,666	17,317	18,677	21,417	16,013	21,001
Consumer plants...do	190,755	227,990	185,291	179,771	216,330	183,198
Importers...do	36,183	51,410	39,035	46,422	61,578	75,811
World: Production...do	1,495,000	2,020,000	1,990,000	1,880,000	2,190,000	2,300,000

[1] This crude (run-of-mine) fluorspar in most cases is subjected to some type of processing before it can be marketed.

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.

LEGISLATION AND GOVERNMENT PROGRAMS

Senate Resolution 206, adopted September 23, 1961, authorized the U.S. Tariff Commission to conduct an investigation of the domestic fluorspar market under Section 332 of the Tariff Act of 1930. A public hearing was scheduled for Washington, D.C., on January 30, 1962.

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, 1961.

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. Shipments of finished fluorspar from mines totaled 205,083 short tons, by grade as follows: Acid, 128,978 tons valued at $6,693,090; ceramic, 33,593 tons, at $1,466,230; and metallurgical, 42,512 tons, at $1,115,299. Producers in Illinois, leading producing State, supplied 57 percent of the domestic output.

Output of crude ore from domestic mines was 615,075 short tons, 7 percent more than 1960. Of the total, 88 percent was obtained from mines that produced over 20,000 tons each. In 1961, six independent and consumer-operated mills processed 491,035 short tons of crude ore from which 209,545 tons of flotation concentrate was recovered. Also, 56,193 short tons of crude ore was treated in heavy-medium plants, but only 7,672 tons of heavy-medium concentrate was marketed; additional material recovered was further processed in flotation mills. Crude fluorspar marketed as mined totaled 37,583 tons, compared with 18,505 tons in 1960.

Captive mines produced 252,285 tons of ore, and their mills recovered 79,354 tons of concentrate from 196,392 tons of ore.

In April Stauffer Chemical Co. announced purchase of special fluoride-producing facilities of Aluminum Co. of America (Alcoa) at East St. Louis, Ill. Fluoride products produced at the East St. Louis plant included sodium fluoride, sodium bifluoride, fluoboric acid, and sodium fluoborate.

Late in 1961 Alcoa announced transfer of its hydrofluoric acid facilities from East St. Louis, Ill., to Point Comfort, Tex. The Point Comfort plant was to begin operating January 1962, and as it proceeded toward optimum production, the old plant in East St. Louis was to be phased out gradually so no production time would be lost.

At the request of the fluorspar industry, new geological maps of the Illinois fluorspar district were being made by the State geological survey to aid exploration for deposits. The mapping program covered all of Hardin County and adjacent parts of Pope, Gallatin, and Saline Counties. New maps, scaled 2½ inches to a mile, were to be

TABLE 2.—Number and production of domestic crude fluorspar mines by size of operation

Annual production (short tons)	1960			1961		
	Mines	Short tons	Percent	Mines	Short tons	Percent
Less than 1,000 [1]	18	4,700	0.8	13	2,004	0.3
1,000–10,000	12	51,300	8.9	6	38,845	6.3
10,000–20,000	1	14,500	2.5	2	30,793	5.0
Over 20,000	7	505,200	87.8	7	543,433	88.4
Total	38	575,700	100.0	28	615,075	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	1960			1961		
	Short tons	Value		Short tons	Value	
		Total	Average per ton		Total	Average per ton
Illinois	134,529	$6,935,511	$51.55	116,908	$5,956,350	$50.95
Kentucky	25,855	1,172,815	45.36	38,898	1,754,555	45.11
Montana	31,273	(1)	(1)	14,905	(1)	(1)
Nevada	18,505	387,842	20.96	18,129	356,610	19.67
Utah	1,912	51,152	26.75	610	17,608	28.87
Other [2]	17,708	1,842,845	37.62	15,633	1,189,496	50.00
Total [3]	229,782	10,391,000	45.22	205,083	9,275,000	45.22

[1] Figure withheld to avoid disclosing individual company confidential data; included with "Other."
[2] Includes Colorado and States indicated by footnote 1.
[3] Total value rounded.

accompanied by a brief description of rock formations, structural features, and economic geology of the area.

It was announced in November that N.F.Z. Corp., Cincinnati, Ohio, was to reopen Mackey-Humm fluorspar mine and mill, 6 miles west of Elizabethtown, Ill., on Illinois Route 146.

Stauffer Chemical Co. opened a new research center in Richmond, Calif. The research building contains 53,000 square feet of floor space divided into 25 individual laboratories with offices and service facilities. Research on polymers; agricultural, inorganic, and fluorine chemicals; catalysts; and analytical procedures was to be conducted.

CONSUMPTION AND USES

Domestic fluorspar consumption reached a record high of 682,000 short tons. Most of the fluorspar was reportedly consumed in 37 States; however, reports from producers, brokers, and importers indicated shipments were made to consumers in several other States. Delaware, New Jersey, Pennsylvania, Ohio, and Illinois accounted for 47 percent of fluorspar consumed.

Hydrofluoric acid producers used 11 percent more fluorspar than in 1960 to meet increased demands from aluminum and chemical industries.

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Kaiser Aluminum & Chemical Corp. announced plans to erect a $6 million hydrogen fluoride and fluorocarbon plant at Gramercy, La. For its fluorocarbon line, Kaiser planned to market a full range of fluorinated refrigerants, propellants, and blowing agents.

TABLE 4.—Fluorspar shipped from mines in the United States, by grades and industries

Grade and industry	1960				1961			
	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] 138,230	81.4	$7,298,151	$52.80	125,844	77.3	$6,552,757	$52.07
Glass	18,999	11.2	827,605	43.56	23,516	14.5	1,016,449	43.22
Ceramic and enamel	4,031	2.4	185,707	46.07	4,357	2.7	199,298	45.74
Nonferrous	2,429	1.4	108,545	44.69	2,179	1.3	97,445	44.72
Ferrous	2,936	1.7	119,219	40.61	4,083	2.5	166,878	40.87
Miscellaneous [2]	3,131	1.9	147,079	46.98	2,788	1.7	131,952	47.33
Total	169,756	100.0	[3] 8,686,000	51.17	162,767	100.0	[3] 8,164,800	50.16
Fluxing gravel and foundry lump:								
Nonferrous	64	[1].1	2,880	45.00	13		520	40.00
Ferrous	49,406	82.3	1,452,070	29.39	31,574	74.6	874,799	27.71
Miscellaneous	10,556	17.6	248,909	23.58	10,729	25.4	234,521	21.86
Total	60,026	100.0	[3] 1,704,000	28.39	42,316	100.0	[3] 1,109,800	26.23
All grades:								
Hydrofluoric acid	138,230	60.1	7,298,151	52.80	125,844	61.3	6,552,757	52.07
Glass	18,999	8.3	827,605	43.56	23,516	11.5	1,016,449	43.22
Ceramic and enamel	4,031	1.7	185,707	46.07	4,357	2.1	199,298	45.74
Nonferrous	2,493	1.1	111,425	44.70	2,192	1.1	97,965	44.69
Ferrous	52,342	22.8	1,571,289	30.02	35,657	17.4	1,041,677	29.21
Miscellaneous [2]	13,687	6.0	395,988	28.93	13,517	6.6	366,473	27.11
Total	229,782	100.0	[3]10,390,000	45.22	205,083	100.0	[3] 9,274,600	45.22

[1] Revised figure.
[2] Includes exports.
[3] Total rounded.

In December, E. I. du Pont de Nemours & Co., Inc., put on stream a 100,000-pound-per-year monofilament unit at Richmond, Va., to produce Teflon FEP (fluorinated ethylene propylene), second fluorocarbon fiber to reach commercial production. Like its predecessor, Teflon TFE (tetrafluoroethylene) multifilament, the new FEP fiber was expected to compete with metals in filter media and tower packing. FEP fiber already was being used by York Co. in demisters.[3]

Uses of the two fluorocarbon fibers were based on differences in their structure: The TFE multifilament lends itself to fine-pored media such as fabrics and needle-punched felts; the FEP monofilament is more suited for large-pored screening, e.g., filter fabrics where backwashing is needed, or where stiffness is required to support a precoat.

W. L. Gore & Associates Inc., Newark, Del., more than doubled its fluorocarbon processing facilities, to be used to produce fluorocarbon polymers, especially polytetrafluoroethylene.[4]

[3] Chemical Engineering. First Fluorocarbon Monofilaments Slated for Commercial Production. V. 68, No. 22, Oct. 30, 1961, pp. 47, 50.
[4] Missiles and Rockets. V. 9, No. 9, Aug. 14, 1962, p. 39.

American Fluoride Corp., New York, manufacturer and distributor of insecticides, rodenticides, and fluoride compounds, was acquired by Alexander M. Phillips and Harvey W. Rambach. The company was to be affiliated with Rambach Chemical Co. and American Firstoline Corp.[5]

TABLE 5.—Fluorspar (domestic and foreign) consumed and in stock in the United States, by grades and industries

(Short tons)

Grade and industry	1960 [1]		1961	
	Consumption	Stocks at consumer plants, Dec. 31	Consumption	Stocks at consumer plants, Dec. 31
Acid grade:				
Hydrofluoric acid	372,654	38,938	412,555	31,011
Glass	3,874	221	2,643	465
Enamel	135	17	262	46
Welding rod coatings	861	77	960	65
Nonferrous			54	35
Special flux, Ferroalloys, Primary aluminum	2,052	1,018	1,639	1,020
Total	379,576	40,271	418,113	32,642
Ceramic grade:				
Glass	22,396	2,952	24,340	3,505
Enamel	4,676	525	4,495	713
Weldin grod coatings	1,192	100	1,279	157
Nonferrous			53	120
Special flux, Ferroalloys	5,990	1,720	5,422	1,142
Total	34,254	5,297	35,589	5,637
Metallurgical grade:				
Glass	687	112	713	148
Enamel	4	2	4	2
Welding rod coatings	395	22	506	28
Nonferrous	738	370	10,039	1,520
Special flux, Ferroalloys, Primary magnesium	1,732	8,043	2,024	3,993
Iron foundry	11,810	7,969	10,053	4,778
Basic open-hearth steel	168,733		155,938	
Electric-furnace steel	45,613	154,244	48,894	134,450
Bessemer steel	217		10	
Total	229,929	170,762	228,181	144,919
All grades:				
Hydrofluoric acid	372,654	38,938	412,555	31,011
Glass	26,957	3,285	27,696	4,118
Enamel	4,815	544	4,761	761
Welding rod coatings	2,448	199	2,745	250
Nonferrous	738	370	10,146	1,675
Special flux	4,166	1,466	4,227	963
Ferroalloys	2,543	1,148	2,401	615
Primary aluminum, Primary magnesium	3,065	8,167	2,457	4,577
Iron foundry	11,810	7,969	10,053	4,778
Basic open-hearth steel	168,733		155,938	
Electric-furnace steel	45,613	154,244	48,894	134,450
Bessemer steel	217		10	
Total	643,759	216,330	681,883	183,198

[1] Glass, enamel, and other (including welding rod coatings, nonferrous, special flux, and ferroalloys) partly estimated from sample canvass of consumers who accounted for more than 95 percent of total usage in 1959.

[5] Agricultural Chemicals. Fluoride Firm Bought. V. 16, No. 8, August 1961, p. 66.

TABLE 6—Production of steel and consumption and stocks of fluorspar (domestic and foreign) at basic open-hearth and electric-furnace steel plants

	1952-56 (average)	1957	1958	1959	1960	1961
Production of basic open-hearth steel ingots and castings at plants consuming fluorspar thousand short tons	90,902	100,297	75,215	76,500	83,668	81,999
Consumption of fluorspar in basic open-hearth steel production thousand short tons	222	212	150	158	169	156
Consumption of fluorspar per short ton of basic open-hearth steel made pounds	5.0	4.2	4.0	4.1	4.0	3.8
Stocks of fluorspar at basic open-hearth steel plants at end of year thousand short tons	140	158	111	108	137	121
Production of electric-furnace steel ingots and castings at plants consuming fluorspar thousand short tons	7,095	9,551	6,462	7,953	7,883	8,187
Consumption of fluorspar in electric-furnace steel production thousand short tons	32	30	24	36	46	49
Consumption of fluorspar per short ton of electric-furnace steel made pounds	9.1	6.4	7.4	9.2	11.6	11.9
Stocks of fluorspar at electric-furnace steel plants at end of year thousand short tons	8	6	8	16	17	14

TABLE 7.—Flourspar (domestic and foreign) consumed in the United States, by States

(Short tons)

State	1960 [1]	1961	State	1960 [1]	1961
Alabama, Georgia, North Carolina, and South Carolina	12,927	8,220	Kentucky	33,691	39,330
Arkansas, Kansas, Louisiana, Mississippi, and Oklahoma	81,322	89,859	Maryland	5,212	5,012
California	14,086	43,030	Massachusetts	258	193
Colorado and Utah	19,859	19,592	Michigan	29,762	27,933
Connecticut	1,517	1,247	Missouri	3,393	3,190
Delaware and New Jersey	101,117	122,198	New York	16,152	15,266
Florida, Rhode Island, and Virginia	821	1,094	Ohio	66,280	49,516
Illinois	95,527	83,721	Oregon and Washington	753	1,045
Indiana	24,181	19,143	Pennsylvania	63,232	61,767
Iowa, Minnesota, South Dakota, and Wisconsin	4,329	3,388	Tennessee	504	1,167
			Texas	31,561	38,358
			West Virginia	37,275	47,614
			Total	643,759	681,883

[1] Consumption partly estimated from sample canvass of consumers who accounted for more than 95 percent of total usage in 1959.

STOCKS

Producers reported that fluorspar stocks at mines, mills, and shipping points, on December 31, 1961, totaled 230,916 short tons, of which 209,915 was crude mine-run fluorspar and 21,001 was finished fluorspar.

Consumers indicated that fluorspar stocks held at yearend totaled 183,198 tons, down 15 percent from 1960. Fluorspar stocks on hand at steel plants approximated a 6½-month supply based upon the December rate of consumption.

Stocks of fluorspar held in Government stockpiles totaled 655,000 short tons.

TABLE 8.—Fluorspar in Government inventories, as of Dec. 31, 1961

	Objective	National (strategic) stockpile	D.P.A. inventory	C.C.C. and supplemental stocks
Acid grade CaF_2	280,000	458,000	20,000	622,000
Metallurgical grade, CaF_2	375,000	369,000	----------	43,000

TABLE 9.—Stocks of fluorspar at mines or shipping points in the United States, by States, Dec. 31

(Short tons)

State	1960		1961	
	Crude [1]	Finished	Crude [1]	Finished
Illinois	114,470	8,972	197,518	13,271
Kentucky	3,654	3,819	(2)	3,819
California, Colorado, Nevada,[3] Montana, and Utah	19,599	3,222	12,397	3,911
Total	137,723	16,013	209,915	21,001

[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.

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 January through May, and $45 to $50 June through December; ceramic-grade concentrates, 95 percent CaF_2, bulk, carlots, f.o.b. Illinois, $45 to $48; in 100 pound paper bags $3 extra; European acid-grade, duty paid, c.i.f. port of entry, 0.3 percent maximum moisture, contracts, bags $50, spot, $1 more, large discount for high moisture; and European metallurgical-grade fluorspar, 72½ percent effective CaF_2, units, spot, $31 to $33, and contracts, $30 to $33.

FOREIGN TRADE [6]

Imports.—Fluorspar imports for consumption totaled 506,000 short tons valued at $13.6 million, a decrease of 5 percent from 1960. Mexico, the principal foreign source, supplied 68 percent of the 1961 imports; Spain supplied 17 percent; and Italy 12 percent. Remaining imports came from West Germany and Canada. The decrease in total imports resulted from a 25-percent drop in imports of metallurgical-grade material. Acid-grade fluorspar imports were up 7 percent from 1960. The U.S. Government imported 74,700 tons duty free from Spain, West Germany, and Mexico, compared with 83,000 tons in 1960.

Exports.—A total of 338 short tons of fluorspar valued at $30,419 was exported, compared with 458 tons valued at $38,250 in 1960.

[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 10.—Price quotations on selected fluorine chemical compounds in 1961

		Jan. 9	Dec. 25
Aluminum fluoride, technical, anhydrous, bags, carlots, works	pound	$0.16¼	Unchanged.
Bags, less carlots, works	do	0.17¼–0.19¼	Do.
Bulk, carlots, basis 80 percent	do	0.14½	Do.
In fiber drums 0.35 cent per pound higher.			
Ammonium bifluoride, drums, delivered	do	0.2145–0.2245	Do.
Ammonium silicofluoride, drums, works	do	0.12¼–0.13¾	Do.
Boron trifluoride, gas, cylinders, truckload, works	do	0.70	Do.
Cylinders, less truckload, works	do	0.70	Do.
Chromium fluoride, barrels, works	do	0.51–0.52	Do.
Cryolite, natural, industrial, bags, carlots, works	100 pounds	13.00	Do.
Bags, less carlots, works	do	14.25	Do.
Hydrofluoric acid, aqueous, 70 percent,[1] 55 or 30 gallon drums, carlots, truckload, delivered.	do	19.25	$17.25 [2]
55 gallon drums, less carlots, less truckload, delivered	do	20.75	18.75 [2]
20 gallon drums, carlots, truckload, delivered	do	21.00	19.00 [2]
20 gallon drums, less carlots, less truckload, delivered	do	22.50	20.50 [2]
Tanks, works, freight equaled	do	13.40	11.50 [2]
Hydrofluosilicic acid, drums, works, 30 percent basis	pound	0.07	Unchanged.
Hydrogen fluoride, anhydrous, cylinders, delivered, E [3]	do	0.30½–0.32½	0.29–0.31 [2]
Cylinders, delivered, W [3]	do	0.39	0.37 [2]
Tanks, works	do	0.18	0.16 [2]
Lithium fluoride, drums, 20,000 pound lots, delivered	do	1.75	Unchanged.
Barrels, ton lots and more delivered	do	1.85	Do.
Barrels, less ton lots, delivered	do	1.90	Do.
Magnesium silicofluoride, drums, works	do	0.10½–0.12	Do.
Potassium fluoborate, fiber drums, carlots, works	do	0.30	Do.
Fiber drums, less carlots, works	do	0.31	Do.
Potassium fluoride, drums, works	do	0.36–0.37	Do.
Potassium silicofluoride, bags, works	do	0.09½–0.10	Do.
In drums, 0.4 cent per pound higher.			
Sodium bifluoride, barrels, carlots, works, freight equaled	do	0.19½	Do.
Barrels, less carlots, same basis	do	0.2025	Do.
Sodium fluoride, white, 97 percent, fiber drums, carlots, works, freight equaled.	do	0.1390	Do.
Fiber drums, less carlots, works, freight equaled	do	0.1465	Do.
Sodium silicofluoride, bags, carlots, works	do	0.065	0.07 [4]
Bags, less carlots, works	do	0.725	0.0775 [4]
In drums, 0.4 cent per pound higher.			
Zinc fluoride, barrels, works	do	0.49–0.50	Do.
Zinc silicofluoride, drums, works	do	0.12½–0.14	Do.

[1] Delivered prices apply to all States east of Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Washington, and Wyoming. In those States add $2.70 per hundredweight for drum delivery.
[2] Decrease published June 19, 1961.
[3] E = East; W = West.
[4] Change published November 13, 1961.

Source: Oil, Paint & Drug Reporter.

WORLD REVIEW

The United States was the only country in North America where fluorspar production was less than last year. Production increased over last year in Canada and Mexico as well as several European countries.

NORTH AMERICA

Canada.—Newfoundland Fluorspar, Ltd., a wholly owned subsidiary of Aluminum Co. of Canada, announced plans to increase fluorspar shipments from its St. Lawrence mining operations about 15 percent during 1961. In 1960 shipments totaled 65,689 tons. All shipments went to company operations at Arvida, Quebec. Plans were underway to deepen a shaft to open two more levels down to the 950-foot horizon in the No. 2 shaft.[7]

[7] Engineering and Mining Journal. V. 162, No. 3, March 1961, pp. 151–152.

St. Lawrence Corp. of Newfoundland, Ltd., anticipated a yearly output of 20,000 tons of acid-grade fluorspar. The company resumed operations in 1960 after a 3-year lapse, following a development and rehabilitation program, and mined about 25,000 tons of ore from its several properties. Nearly all 1960 shipments, totaling 7,100 tons of metallurgical- and acid-grade material, went to plants of affiliates in the United States. The company was sinking a shaft on Valley vein, a new discovery that appeared to be the best yet located. The new vein, over 1,000 feet long, is about 1,000 feet west of, and parallel to, the Haypook Pond and Blue Beach vein systems. The company planned to deepen the Blue Beach shaft to expose about 150,000 tons of ore, and to extend the shaft on the Red Head vein and initiate a westward drifting program. Water was encountered in developing the Hares Ears vein so work there was temporarily curtailed.[8]

Mexico.—An estimated 970,024 short tons of fluorspar containing 0.45 percent beryllium oxide was found in a major, but unnamed, deposit in northern Mexico, according to Mexico's National Commission of Nuclear Energy. A practical recovery method was to be sought, and other fluorspar deposits in Mexico were to be checked, for possible contained beryllium.

SOUTH AMERICA

Chile.—A commercial fluorspar deposit was found near the Mercedes mine about 1 mile southeast of the village of Paihuano in Coquimbo Province. The mineral occurs in veins which cut across a granite batholith. The veins also contain calcite, galena, and topaz.[9]

ASIA

India.—Fluorspar requirements of the Indian aluminum industry were supplied by imports. In 1960, fluorspar imports totaled 4,928 short tons valued at US$164,220, compared with 1,377 tons valued at US$597,030 in 1959.

Exploration for fluorspar in Rajasthan continued during 1960 with encouraging results. At yearend the government of Rajasthan invited U.S. firms to examine and report on the feasibility of commercially exploiting fluorspar resources. Preliminary reports indicated a reserve of about 7 million tons.[10]

Korea, Republic of.—The Ministry of Commerce and Industry reported that production of fluorspar increased to 30,790 short tons in 1961, compared with 20,834 tons in 1960. Exports of fluorspar totaled 31,489 tons valued at US$831,482 in 1960, of which 29,972 tons was exported to Japan.

[8] Mining World. International News. V. 23, No. 4, April 1961, p. 44.
[9] Engineering and Mining Journal. In Latin America. V. 16, No. 7, July 1961, p. 132.
[10] Bureau of Mines. Mineral Trade Notes. V. 53, No. 5, November 1961, p. 17.

TABLE 11.—U.S. imports for consumption of fluorspar, by countries and customs districts

Country and customs district	1960						1961					
	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:												
El Paso			85	$1,703	85	$1,703						
Laredo			588	8,760	588	8,760			697	$12,809	697	$12,809
Michigan			2,172	81,678	2,172	81,678						
Ohio	3,909	$90,910	1,429	35,339	5,338	126,249	1,604	$39,800	49	4,725	1,653	44,525
St. Lawrence									1	100	1	100
Total	3,909	90,910	4,274	127,480	8,183	218,390	1,604	39,800	747	17,634	2,351	57,434
Mexico:												
Arizona	1,730	54,797			1,730	54,797	28,249	876,826			28,249	876,826
Buffalo			15,717	345,934	15,717	345,934			4,094	89,458	4,094	89,458
Chicago									4,489	97,636	4,489	97,636
El Paso	7,877	211,774	27,064	535,313	34,941	747,087	30,785	793,967	24,839	527,000	55,624	1,320,967
Galveston	333	10,730			333	10,730	150	4,844			150	4,844
Hawaii			18	1,341	18	1,341						
Laredo	89,815	3,017,632	79,189	1,322,489	169,004	4,340,121	125,643	3,903,675	66,220	1,178,122	191,863	5,081,797
Los Angeles			102	2,041	102	2,041						
Maryland			5,401	178,236	5,401	178,236			2,570	51,876	2,570	51,876
Massachusetts			113	2,256	113	2,256	74	1,879	21	432	95	2,311
Michigan			17,388	340,029	17,388	340,029	3,781	111,399	19,019	406,353	22,800	517,752
Mobile			10,662	190,454	10,662	190,454			6,693	157,948	6,693	157,948
Ohio			13,105	259,533	13,105	259,533	1,468	37,126	7,883	175,344	9,351	212,470
Philadelphia	3,492	100,335	15,363	262,957	18,855	363,292	2,565	83,330	14,067	284,117	16,632	367,447
Sabine							306	9,855			306	9,855
St. Louis	92	3,016			92	3,016	935	19,287			935	19,287
San Diego							290	8,375			290	8,375
Vermont	67	2,169			67	2,169						
Total	103,406	3,400,453	184,122	3,440,583	287,528	6,841,036	194,246	5,850,563	149,895	2,968,286	344,141	8,818,849
Total North America	107,315	3,491,363	188,396	3,568,063	295,711	7,059,426	195,850	5,890,363	150,642	2,985,920	346,492	8,876,283

Europe:												
France:												
New York	10	647			10	647						
Ohio	4,872	152,500			4,872	152,500						
Philadelphia	3,637	99,000			3,637	99,000						
Total	8,519	252,147			8,519	252,147						
Germany, West:												
Maryland							6,816	229,194			6,816	229,194
New Orleans	7,031	216,305			7,031	216,305						
Philadelphia	6,480	277,937			6,480	277,937						
Puerto Rico	200	13,100			200	13,100	299	19,995			299	19,995
Total	13,711	507,342			13,711	507,342	7,115	249,189			7,115	249,189
Italy:												
Michigan	2,907	95,245			2,907	95,245						
New Orleans	18,713	520,967			18,713	520,967	10,456	298,862			10,456	298,862
Ohio							6,001	198,000			6,001	198,000
Philadelphia	74,504	2,333,577			74,504	2,333,577	45,853	1,393,878			45,853	1,393,878
Total	96,124	2,949,789			96,124	2,949,789	62,310	1,890,740			62,310	1,890,740
Spain:												
Maryland	28,335	975,648	2,213	19,745	30,548	995,393	9,834	381,530			9,834	381,530
New Orleans							5,152	206,080			5,152	206,080
Ohio	23,313	654,190			23,313	654,190	18,269	464,126			18,269	464,126
Philadelphia	50,783	1,769,531	3,988	39,874	54,771	1,809,405	54,739	1,545,867			54,739	1,545,867
Total	102,431	3,399,369	6,201	59,619	108,632	3,458,988	87,994	2,597,603			87,994	2,597,603
Sweden: New York	1	145			1	145						
United Kingdom: Puerto Rico	100	7,404			100	7,404						
Total Europe	220,886	7,116,196	6,201	59,619	227,087	7,175,815	157,419	4,737,532			157,419	4,737,532
Africa: Union of South Africa: Maryland			11,222	157,647	11,222	157,647			1,848	30,247	1,848	30,247
Grand total	328,201	10,607,559	205,819	3,785,329	534,020	14,392,888	353,269	10,627,895	152,490	3,016,167	505,759	13,644,062

Source: Bureau of the Census.

TABLE 12.—Imported fluorspar delivered to consumers in the United States, by uses [1]

Use	1960			1961		
	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	164,512	$6,759,693	$41.09	230,884	$9,348,137	$40.49
Glass, ceramic, and enamel	9,003	359,490	39.93	5,380	244,243	45.40
Ferrous	125,511	3,712,452	29.58	73,048	2,362,767	32.35
Nonferrous	2,000	73,770	36.89	1,620	50,120	30.94
Other	4	160	40.00	15,568	350,556	22.52
Total	301,030	10,905,565	36.23	326,500	12,355,823	37.84

[1] Estimated in part.

TABLE 13.—U.S. exports of fluorspar

Year	Short tons	Value		Year	Short tons	Value	
		Total	Average per ton			Total	Average per ton
1952-56 (average)	631	$48,835	$77.39	1959	1,144	$69,204	$60.49
1957	754	80,703	107.00	1960	458	38,250	83.52
1958	3,374	191,386	56.72	1961	338	30,419	90.00

Source: Bureau of the Census.

TECHNOLOGY

Minerva Oil Co. described using fluorspar to control vanadium efflorescence in face brick. Technical data, methods of proper use, advantages of fluorspar as a chemical admix, economic aspects, and a brief résumé of the research involved in developing successful control of efflorescence were reported.[11]

Recovery of fluorine as sodium silicofluoride in the wet-process phosphoric acid method of manufacturing phosphatic fertilizers was described. Sodium silicofluoride was used in manufacturing vitreous enamels and opalescent glass, as a coagulant for latex, in insecticides, and in fluoridizing water.[12]

A method for determining fluoride concentrations in drinking water was developed by chemists at Milton Roy Co., St. Petersburg, Fla. The analysis for measuring fluorine was based on fluoride ion reactions with the chelate of lanthanum ion and 3-aminomethylalizarin-N,N-diacetic acid. Red lanthanum chelate changed to a blue lanthanum fluoride complex chelate. The chemists used the analysis in a colorimeter by modifying its reagent system to a single reagent. Connect-

[11] Ceramic Age. Fluorspar. V. 77, No. 11, November 1961, p. 16.
[12] Atkin, Sydney, Enrico Pelitti, Allan P. Vila, and John Hegedus. A Method for Recovering Fluorine as Sodium Silicofluoride. Ind. Eng. Chem. v. 53, No. 9, September 1961, pp. 705–707.

TABLE 14.—World production of fluorspar by countries [1] [2]

(Short tons)

Country [1]	1952–56 (average)	1957	1958	1959	1960	1961
North America:						
Canada	111,582	66,245	[3] 62,000	[3] 74,000	[3] 77,000	[3] 76,200
Mexico	226,160	471,478	462,049	362,456	399,859	425,596
United States (shipments)	300,839	328,872	319,513	185,091	229,782	205,083
Total	638,581	866,595	[3] 843,562	[3] 621,547	[3] 706,641	[3] 706,879
South America:						
Argentina	11,312	8,544	14,258	17,989	[3] 17,600	[3] 17,600
Bolivia (exports)	238	----------	----------	----------	----------	----------
Total	11,550	8,544	14,258	17,989	[3] 17,600	[3] 17,600
Europe:						
France	83,720	120,285	107,104	110,425	130,073	220,462
Germany:						
East [3]	88,000	68,000	72,000	72,000	80,000	80,000
West	172,470	149,289	137,048	133,715	143,521	120,614
Italy	96,333	159,405	162,916	174,091	178,957	166,214
Norway	506	331	----------	----------	----------	----------
Spain	72,259	97,439	99,743	98,318	122,377	[3] 155,000
Sweden (sales)	3,255	2,966	3,188	2,976	3,197	[3] 3,300
United Kingdom [4]	92,984	104,467	86,694	93,078	109,249	111,139
Total [1] [3]	614,000	710,000	675,000	690,000	775,000	865,000
Asia:						
China [3]	62,000	165,000	165,000	220,000	275,000	275,000
Japan	6,596	8,542	6,069	5,684	10,108	16,092
Korea:						
North	([5])	([5])	([5])	([5])	([5])	[3] 55,000
Republic of	8,515	5,644	1,786	6,748	20,834	30,790
Thailand	----------	----------	----------	----------	3,814	5,241
Turkey	82	----------	88	75	359	42
U.S.S.R. [3] [6]	112,500	165,000	180,000	190,000	210,000	230,000
Total [3]	200,000	400,000	410,000	48,000	575,000	615,000
Africa:						
Morocco	1,640	----------	----------	----------	----------	869
Rhodesia and Nyasaland, Federation of:						
Southern Rhodesia	383	97	6	10	19	----------
South-West Africa	2,849	24	4	141	----------	----------
Tunisia	994	----------	----------	----------	----------	----------
Union of South Africa	23,454	35,106	48,251	70,317	113,550	95,862
Total	29,320	35,227	48,261	70,468	113,569	96,731
Oceania: Australia	328	784	1,042	528	8	----------
World total (estimate) [1] [3]	1,495,000	2,020,000	1,990,000	1,880,000	2,190,000	2,300,000

[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 is reported as follows: 1957, 9,267 tons; 1958, 7,467 tons; 1959, 10,064 tons; 1960, 13,552 tons; 1961, data not available.
[5] Data not available; estimate 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 Helen L. Hunt, Division of Foreign Activities.

ing an alarm to the colorimeter told water plant operators when the fluoride ion concentration exceeded a predetermined level, and when attached to a recorder, it reported fluoride ion concentration every 8 minutes.[13]

[13] Chemical & Engineering News. Brief. V. 39, No. 38, Sept. 18, 1961, p. 90.

TABLE 15.—Production and trade of fluorspar in 1960, by major countries

(Short tons)

Exports, by countries of origin	Production	Exports	Exports by countries of destination								
			North America		South America	Europe		Asia		Africa	Oceania	Other countries
			Canada	United States		East	West	Japan	Other			
North America:												
Canada	[1] 77,000	10,312		10,310			2					
Mexico	399,859	385,779	70,472	312,886	672			1,749				
United States	229,782	457	314		143							
South America: Argentina	[1] 17,600	303			303							
Europe:												
Bulgaria	([2])	[3] 4,096					[4] 509	[4] 3,587				
France	130,073	20,276		5,682			13,926			206	288	174
Germany:												
East	[1] 80,000	[3] 3,202					[4] 3,202					
West	143,521	[3] 31,923		[4] 13,711			[4] 18,212					
Italy	178,957	78,517		73,318		[4] 606	[4] 4,593					
Spain	122,377	[1] 114,272		[5] 108,632			[4] 5,640					
Sweden	3,197	314					295					19
United Kingdom	[6] 109,249											
Asia:												
China	[1] 275,000	[4] 49,369				[4] 38,581		[4] 6,426	[4] 4,362			
Japan	10,108	96							96			
Korea, Republic of	20,834	31,489						29,972	1,517			
Thailand	3,814	1,016						1,016				
Turkey	359											
U.S.S.R.[7]	[1] 210,000	[4] 11,294						[4] 11,294				
Africa:												
Rhodesia and Nyasaland, Federation of:												
Southern Rhodesia	19											
Union of South Africa	113,550	77,771	6,827	8,585			12,871	42,744	164	5,115	1,465	
Oceania: Australia	8											
Other countries	[8] 64,693	[8] 44,423				44,423						
Total	2,190,000	864,909	77,613	533,124	1,118	83,610	59,250	96,788	6,139	5,321	1,753	193

[1] Estimate.
[2] Fluorspar is also produced in Bulgaria, data not available; estimate included in total.
[3] Incomplete data.
[4] Imports.
[5] U.S. imports.
[6] Includes fluorspar recovered from old lead and zinc mine dumps; production was 13,552 tons in 1960.
[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 detail.

Compiled by Corra A. Barry, Division of Foreign Activities.

Air Products, Inc., Allentown, Pa., made studies to determine compatibility and resistance to corrosion of various metals with liquid fluorine at −320° F. Metals tested included various aluminum alloys, stainless and high-strength steels, titanium alloys, copper alloys, nickel alloys, and magnesium alloys. It was found that total corrosion of titanium alloys was independent of time for periods up to 2 weeks. Corrosion of magnesium alloys increased for about 1 day, but longer exposures, up to 2 weeks, caused no further corrosion.

Increased corrosion of metals by fluorine-containing water did not occur at liquid fluorine temperatures but occurred in the gas phase when the system was warmed. Fluorine liquefied in glass cells was found to contain solid material. It was suggested that metal containers for holding liquid fluorine first be treated with fluorine gas to burn off surface contamination that could be dangerous to handlers when exposing the containers to liquid fluorine. Metal surfaces abraded with wire bristles under liquid fluoride showed no apparent increase in corrosion rate.[14]

Barium fluoride doped with assorted rare earths and transition elements was found to be useful as a laser material. Single crystals ¾ inch in diameter by 1 inch or more long sold for $400, with chips available to laboratories at $15 each.[15]

Loss of fluorine from slags and enamels is of practical interest in many ceramic and metallurgical processes. A study was made of the stabilities of sodium fluoride, potassium fluoride, magnesium fluoride, calcium fluoride, and zinc fluoride in dry and moist atmospheres at elevated temperatures by measuring the loss in weight of 0.25- to 2.0-gram samples. The primary reaction was hydrolysis of the salts in moist atmospheres; activation energies for the hydrolysis were calculated.

CRYOLITE

The only commercial cryolite deposit in the world was operated by a 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., Natrona, Pa., where it was upgraded.

The National Metallurgical Laboratory at Jamshedpur, India, was investigating ways to make cryolite from low-grade fluorspar that contains a high percentage of silica. Fluorspar of this type is available at Rajasthan, in Madhya Pradesh, and Bombay. About 7,500 tons of cryolite was imported annually into India from Denmark and Greenland.[16]

Synthetic cryolite was manufactured by action of hydrofluoric acid (made from fluorspar) on aluminum hydroxide in the presence of soda by Reynolds Metals Co., at Bauxite, Ark., Aluminum Co. of America, at Point Comfort, Tex., and Kaiser Aluminum & Chemical Corp., at

[14] Sterner, C. J., and Alan H. Singleton. The Compatibility of Various Metals With Liquid Fluorine. Res. Rept., U.S. Government, v. 36, No. 7, Oct. 5, 1961, pp. 72, 73.
[15] Chemical Engineering. CPI News Briefs. V. 68, No. 16, Aug. 7, 1961, p. 82. Materials in Design Engineering. What's New in Materials. V. 54, No. 2, August 1961, p. 186.
[16] Mining Journal (London). V. 257, No. 6575, Aug. 25, 1961, p. 193.

Chalmette, La. United Chemetries, Inc., formerly United Heckathorn Co., closed its synthetic cryolite plant at Garfield, Utah. Cryolite was made at the latter plant with fluorine recovered during fertilizer processing by Western Phosphates, Inc.[17] The aluminum companies recovered cryolite from scrapped pot linings of aluminum electrolytic reduction cells.

TABLE 16.—U.S. imports for consumption of cryolite

Year and country	Short tons	Value	Year and country	Short tons	Value
1952-56 (average)	26,815	$2,991,990	1961		
1957	32,712	4,001,481			
1958	24,186	2,332,459	North America: Greenland [1]	9,391	$425,475
1959	22,102	1,994,473	Europe:		
1960			France	364	59,409
			Italy	4,059	708,956
North America: Greenland [1]	9,733	429,650	Total	4,423	768,365
Europe:					
Denmark	110	5,835	Grand total	13,814	1,193,840
France	513	88,362			
Italy	6,890	1,145,994			
Total	7,513	1,240,191			
Grand total	17,246	1,669,841			

[1] Crude natural cryolite.

Source: Bureau of the Census.

Prices quoted throughout the year in Oil, Paint & Drug Reporter were as follows: Cryolite, natural, industrial, 100-pound bags, works, carlots, $13; 100-pound bags, less than carlots, $14.25. These listings, representing the lowest prices, were firsthand quotations prevailing on large lots, f.o.b. New York, and did not represent bid and asked prices or a range over the week.

Data on cryolite imports shown in table 16 do not distinguish between natural and manufactured material. Most of the imports from countries other than Denmark and Greenland are believed to have been manufactured cryolite.

Exports of cryolite in 1961 totaled 167 short tons valued at $40,890. Canada received 139 tons valued at $33,403, and Mexico received 10 tons valued at $2,604. The United Kingdom, India, Australia, and the Union of South Africa received the remainder.

A patent was issued for separating cryolite and fluorite by flotation. The process uses sodium fluoride and a collector to form a froth rich in fluorite and an underflow rich in cryolite and then separates the froth from the underflow.[18]

[17] Mining World. What's Going on in Mining—Utah. V. 23, No. 13, December 1961, p. 47.

[18] Goldenhar, Leonard E., Isador Mockrin, and Francis M. Doorely, Jr. (assigned to Pennsalt Chemicals Corp.). Flotation Separation of Cryolite and Fluorite. U.S. Pat. 2,965,231, Dec. 20, 1960.

A full color portrait and data on the crystallography, chemical, physical, and optical properties, tests and diagnosis, and occurrence and uses of cryolite were published.[19]

Allied Chemical International issued a 12-page illustrated brochure on fluorine. The brochure traced the growth in applications of elemental fluorine and described newly developed handling techniques.[20]

[19] Mining and Quarry Engineering (London). V. 27, No. 3, March 1961, pp. 110–111.
[20] Chemistry and Industry (London). No. 39, Sept. 16, 1961, p. 1497.

Gem Stones

By John W. Hartwell [1] and Betty Ann Brett [2]

GEM materials and mineral specimens produced in the United States during 1961 were estimated at $1,309,000—a $121,000 increase over 1960.

According to the U.S. Department of Commerce, there were 326 lapidary plants in 25 States in 1958.[3] New York, N.Y., had the greatest number with 205, followed by Providence County, R.I., 37; and Los Angeles, Calif., 11. The average number of employees in each plant was 6. Four of the larger plants, located in the counties of Westchester, N.Y., Middlesex, N.J., Rolette, N. Dak., and Tarrant, Tex., employed 100 to 249 workers each. Also listed were 249 plants in 15 States manufacturing "jewelry findings and materials." Most plants were in Rhode Island, with 144, followed by New York, 41, Massachusetts, 23, and New Jersey, 20. One plant in Massachusetts employed more than 500 workers. The average plant employed 20 workers.

The Internal Revenue Service amended its regulations covering the Federal retail excise tax on jewelry. The new regulations added to, amended, or superseded sections of Regulation 51 as amended and printed in 1956. The following stones, whether real or synthetic, cut, polished, rough, or in their natural state, were taxable when sold at retail: Amber, beryl (aquamarine, emerald, golden beryl, heliodor, and morganite), chrysoberyl (alexandrite, cat's eye, and chrysolite), corundum (ruby and sapphire), diamond, feldspar (moonstone), garnet, jadeite (jade), jet, lapis lazuli, nephrite (jade), opal, pearl (natural and cultured), peridot, quartz (amethyst, bloodstone, citrine, moss agate, onyx, sardonyx, and tiger's eye), spinel, topaz, tourmaline, turquoise, and zircon. In addition to these stones, the tax applied to all articles commonly or commercially known as jewelry, regardless of the substance of which they were made. In determining the retail price for tax purposes, any charge for the coverings or containers in which the stones or jewelry were delivered to the customer were to be included.[4]

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 is based on only a partial survey.

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.
[3] U.S. Department of Commerce. 1958 Census of Manufacturers: Lapidary Work. 1961, p. 72.
[4] Burnstine, Bernard N. A Jeweler's Guide. Jewelers' Circ.-Keystone, v. 131, No. 7, April 1961, pp. 86–89, 102, 104.

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Gem material and mineral-specimen production was reported from 45 States, 1 more than in 1960. California, Oregon, and Texas were the leading States. Eleven States—California, Oregon, Texas, Arizona, Nevada, Wyoming, Washington, Utah, New Mexico, Colorado, and Montana—produced 85 percent of the total value.

An amethyst mine in Roberta, Cabarrus County, N.C., began operating in 1961. Two weeks after mining started, three bushels of amethysts in clusters and single crystals were recovered.[5]

TABLE 1.—Estimated value of gem stone production in the United States

(Thousand dollars)

State	1960	1961	State	1960	1961
Arizona	$120	$119	North Carolina	$4	$6
Arkansas	38	19	North Dakota	1	1
California	150	200	Ohio	3	4
Colorado	45	36	Pennsylvania	4	5
Connecticut	7	9	Rhode Island		1
Delaware		1	South Dakota	20	18
Hawaii	(1)	18	Tennessee	1	1
Maine	15	20	Texas	100	150
Maryland	2	3	Utah	72	73
Massachusetts	1	2	Vermont	1	2
Nebraska	4	5	Virginia	5	6
Nevada	100	100	West Virginia	1	1
New Hampshire	15	(1)	Wyoming	68	83
New Jersey	7	9	Other States [2]	355	361
New Mexico	40	46			
New York	9	10	Total	1,188	1,309

[1] Included with "Other States."
[2] Includes Alaska, Idaho, Illinois, Indiana (1961), Michigan, Minnesota (1960), Missouri (1961), Montana, Oklahoma, Oregon, and Washington with a value of $1,000 or more and those States indicated by footnote 1.

A pink sapphire weighing 14 ounces, estimated to contain 2,000 carats of cuttable material, was found in the Cowee Valley gem field, Macon County, N.C. A 24-ounce ruby weighing 3,400 carats also was found. The ruby contained many flaws, but from the unflawed material within the stone 800 to 1,200 carats may be cut.[6]

New synthetic emeralds were available to U.S. jewelers as a result of a contract between Linde Co. and a Brazilian gem stone dealer, a worldwide distributor of Austrian-manufactured synthetic emeralds. The new synthetics were to retail for $62 to $75 per 1-carat stone, compared with the Chatham-created emeralds priced at $50 to $280 for the same size.[7]

Agate.—Nearly 180 tons of agate valued at $130,000 was reported produced in 23 States in 1961. Estimates were that an additional 200 tons valued at $150,000 was produced in States from which no reports were received. Principal States, in decreasing order of production, were Oregon, South Dakota, New Mexico, Arizona, Washington, Utah, California, and Montana.

Moss agate production was valued at $6,000; turritella, $8,000; and fire agate, $4,000. Plume agate was not reported produced.

[5] Rocks and Minerals. Amethyst Mine Opens in North Carolina. V. 36, Nos. 9, 10, September–October 1961, p. 458.
[6] The Evening Star, Washington, D.C. Carolina Gem-Hunter Finds 2 Giant Stones. No. 205, July 24, 1961, p. 24.
[7] Jewelers' Circular-Keystone. The New Synthetic Emeralds. V. 131, No. 12, August 1961, pp. 156, 158, 160, 161.

Diamond.—Production of diamond at "Crater of Diamonds" near Murfreesboro, Ark., was 121 carats valued at $7,260. Kimberlite was still being sold, but production and value were not reported. The two largest diamonds found during 1961 weighed 3.42 and 3.27 carats.

A washing and concentrating plant, capable of processing 100 cubic yards of diamond-bearing kimberlite per day, was in operation during 1961 at the Arkansas Diamond Mine near Murfreesboro, Ark. A total of 9 carats valued at $320 was reported recovered during the year.

Jade.—Jade production from Alaska, California, Nevada, and Wyoming was 24,000 pounds valued at $73,000. Wyoming was the leading State with 9,000 pounds valued at $42,000. Jade was reported discovered in the Lake Huron region, Mich. No other information on this new source was given.

Outcroppings of green, yellow, blue, gray, and brown jade were discovered southwest of Twenty Nine Palms, Calif.

Obsidian.—Obsidian production, totaling 90,000 pounds valued at $25,000, was reported from six States. Utah was the leading State with 42,000 pounds valued at $13,000. Some of the obsidian varieties collected included rainbow, golden sheen, snowflake, black, and white.

Petrified Wood.—About 80 tons of petrified wood valued at $69,000 was produced in 12 States. South Dakota led with nearly 26 tons, followed by Arizona, Wyoming, Utah, Nebraska, and Nevada. Petrified palm wood production was 5,300 pounds valued at nearly $4,000, and petrified bone produced was 11,000 pounds valued at $6,600.

Quartz Crystal.—Reports indicated that about 35 tons of quartz crystal and miscellaneous quartz specimens, except smoky and rose, was produced, valued at $20,000. Arkansas was the leading producing State with 26 tons valued at $8,000.

Smoky and rose quartz production was 10,000 pounds valued at $8,000.

Tourmaline.—Production of tourmaline from Maine was reported to be over 4,000 carats valued at $500, and 10,000 pounds of tourmaline specimens valued at more than $1,000 were produced. Most of the material came from the Harvard Mine near Greenwood, Maine, and from areas around Newry. Specimens of apatite, cookeite with quartz, and lepidolite also were obtained from the Harvard Mine.

Turquoise.—Five States reported production of 5,300 pounds of turquoise valued at $40,000. Arizona produced 2,900 pounds valued at $12,000; Nevada, 1,800 pounds, at $20,000; and Colorado 100 pounds, at $5,000. Minor values were reported from California and New Mexico.

The Blue Star mine, north of Carlin, Nev., a producer of turquoise for 25 years with an output of about $400,000, was being developed into a gold-producing property during 1961.

Miscellaneous Gem Material.—Mineral specimens produced in the United States were estimated at 350,000 pounds valued at $200,000. Principal producing States were Texas, South Dakota, California, Colorado, and New Mexico.

Rough garnet production was 1,700 pounds valued at $2,100, principally from California. Sales of 458 carats of cut and polished stones valued at $916 were reported from a garnet mine at North Creek, N.Y.

A few pounds of gem opal valued at $3,000 were reported produced from the Rainbow Ridge and Bonanza opal mines in Virgin Valley, Nev. Another producer from a locality south of Yerington, Nev., reported production of 1,500 pounds.

Output of 100 pieces of jet valued at $200 was reported from New Mexico for the first time in many years.

Production of black coral, obtained by divers off the islands of Kauai, Lanai, Maui, and between Maui and Molokini Islands in Hawaii, was about 3,200 pounds valued at $18,000. Due to the depths to which divers were required to go to recover the coral, prices were expected to increase from $5 to $8 per pound in 1961 to $12 in 1962.

The quantity and value of some other gem stones and mineral specimens produced were: Amethyst, 1,000 pounds, $1,000; beryl specimens, 1,000 pounds, $6,000; copper minerals, 10,000 pounds, $12,000; feldspar gems, 15,000 pounds, $3,000; fluorite, 2,000 pounds, $1,500; fossils, 5,000 pounds, $3,000; geodes, 25,000 pounds, $15,000; gold nuggets, 2 pounds, $1,000; idocrase, 3,000 pounds, $2,500; jasper, 75,000 pounds, $25,000; lepidolite, 2,000 pounds, $1,000; marcasite, 2,000 pounds, $1,500; onyx, 50,000 pounds, $10,000; ornamental stone, 50,000 pounds, $8,000; peridot, 10,000 pounds, $15,000; rhodonite, 30,000 pounds, $10,000; rhyolite, 5,000 pounds, $1,500; topaz, 1,000 pounds, $2,000; and verd-antique, 15,000 pounds, $1,500.

CONSUMPTION

Diamond consumption, $193 million was 16 percent greater than in 1960; sales of synthetic and imitation gem stones, $5.3 million were 12 percent lower; and sales of natural and cultured pearls, $17 million were 16 percent higher.

Apparant consumption (production plus imports minus exports and reexports) of gem stones in the United States was over $181 million, compared with $164 million in 1960.

PRICES

Prices quoted during October 1961 for cut and polished gem diamonds were: ¼ carat, $70 to $295; ½ carat, $170 to $540; 1 carat, $400 to $1,680; and 2 carats, $1,090 to $4,000. The range in price of each size depended upon quality (cut, clarity, and color).

The price of medium-grade, rough, green opal from Australia increased from US$45 per ounce in 1959 to US$90 in 1960, and to US$135 in 1961. Best-grade, rough, black opal was selling at US$448 or more per ounce in mid-1961.

A report on the diamond industry was published. This publication contained information on diamond marketing and world prices of gem and industrial diamonds during 1960.[8]

[8] Switzer, George. Thirty-Sixth Annual Report on the Diamond Industry—1960 Jewelers' Circ.-Keystone, 1961, 53 pp.

FOREIGN TRADE [9]

Imports.—Gem stone imports increased 16 percent in value over 1960. Gem diamonds accounted for 87 percent of the total imports and increased 947,000 carats in quantity and $28 million in value over 1960.

Diamonds, cut but unset, were principally imported from Israel and Belgium-Luxembourg, with 51 percent from the latter. The average values per carat of diamond imports from the principal exporting countries were Belgium-Luxembourg, $98.02; France, $96.24; Israel, $78.97; Netherlands, $112.46; Union of South Africa, $179.18; United Kingdom, $129.82; and West Germany, $66.73. Average value of all imports of these cut but unset diamonds was $93.67.

Imports of emeralds, cut but not set, increased 146,000 carats over 1960; 89 percent came from India. The average values per carat of emerald imports from the principal exporting countries were Brazil, $23.12; Ceylon, $48.53; Colombia, $78.35; France, $30.29; Hong Kong, $86.34; India, $5.36; Italy, $84.78; Pakistan, $87; Switzerland, $138.13; Union of South Africa, $114.64; United Kingdom, $16.91; and West Germany, $37.47.

The value of imported cultured pearls increased about $2.5 million over 1960, but the value of natural pearls decreased $129,000.

Rubies and sapphires, cut but not set, valued at $675,000 were imported from 13 countries. Imports from Colombia, the principal source, were valued at $506,000.

TABLE 2.—U.S. imports for consumption of precious and semiprecious stones, exclusive of industrial diamonds

Stones	1960		1961	
	Carats	Value (thousands)	Carats	Value (thousands)
Diamonds:				
Rough or uncut, suitable for cutting into gemstones, duty free	1,365,529	[1] $87,518	2,274,923	$114,670
Cut, but unset, suitable for jewelry, dutiable	801,945	78,037	839,150	78,605
Emeralds: Cut but not set, dutiable	81,207	1,463	227,284	2,090
Pearls and parts, not strung or set, dutiable:				
Natural		629		500
Cultured or cultivated		13,934		16,425
Other precious and semiprecious stones:				
Rough or uncut, duty free		620		1,169
Cut but not set, dutiable		3,967		3,899
Imitation, except opaque, dutiable:				
Not cut or faceted		74		54
Cut or faceted:				
Synthetic		334		346
Other		5,897		4,907
Imitation, opaque, including imitation pearls, dutiable		8		14
Marcasites: Real and imitation, dutiable		7		36
Total		[1] 192,488		222,715

[1] Revised figure.

Source: Bureau of the Census.

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

TABLE 3.—U.S. imports for consumption of diamonds (exclusive of industrial diamonds), by countries

Country	1960				1961			
	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	13,751	$1,004	936	$74	7,772	$833	79	$10
Mexico			173	16	257	3	160	14
Panama							23	3
Total	13,751	1,004	1,109	90	8,029	836	262	27
South America:								
Brazil	26,811	907	34	8	42,962	759	706	36
British Guiana	22,102	743	23	1	26,150	686	93	8
Venezuela	41,220	1,161			111,700	3,151		
Total	90,133	2,811	57	9	180,812	4,596	799	44
Europe:								
Austria			753	47				
Belgium-Luxembourg	207,225	14,354	435,284	44,462	210,419	15,391	428,054	41,957
France	45,965	1,803	13,337	1,181	47,857	1,522	10,578	1,018
Germany, West	553	13	59,703	3,974	896	28	52,154	3,480
Italy			66	15			541	59
Netherlands	22,512	1,432	33,869	3,762	50,563	2,360	28,756	3,234
Switzerland	2,501	138	99	10	6,526	269	349	205
U.S.S.R.							1,023	85
United Kingdom	829,523	[1] 59,555	7,133	1,094	1,561,423	81,702	5,238	680
Total	1,108,279	[1] 77,295	550,244	54,545	1,877,684	101,272	526,693	50,718
Asia:								
Hong Kong							1	[2]
India			86	15			9	3
Iran							56	4
Israel	54,894	1,801	213,013	17,453	50,744	1,938	278,229	21,971
Japan			6,398	81	244	26	942	91
Singapore, Colony of							38	11
Thailand							83	1
Total	54,894	1,801	219,497	17,549	50,988	1,964	279,358	22,081
Africa:								
Congo, Republic of the, and Ruanda-Urundi [3]	22	1			10,860	228	10	1
Western Africa, n.e.c. [4, 5]	7,180	259			80,243	2,097		
Western Equatorial Africa, n.e.c. [6]	3,494	105			3,863	51		
Ghana	7,104	47						
Liberia	23,567	879			8,113	280		
Union of South Africa	56,185	3,198	30,955	5,843	54,331	3,346	31,951	5,725
Total	97,552	4,489	30,955	5,843	157,410	6,002	31,961	5,726
Oceania: Australia	920	118	83	1			77	9
Grand total	1,365,529	[1] 87,518	801,945	78,037	2,274,923	114,670	839,150	78,605

[1] Revised figure.
[2] Less than $1,000.
[3] Effective July 1960; formerly Belgian Congo.
[4] Effective July 1960; formerly French West Africa and Republic of Togo.
[5] N.e.c.—not elsewhere classified.
[6] Effective July 1960; formerly French Equatorial Africa.

Source: Bureau of the Census.

Exports.—Exports of gem stones, precious and semiprecious, were $14.8 million, compared with $7.6 million in 1960. Diamonds, cut but unset, accounted for 76 percent of the total.

The value of gem stones exported, except diamonds, was over $2 million, of which 50 percent went to Switzerland and West Germany.

Reexports of gem stones, precious and semiprecious, were $28 million, compared with $21.7 million in 1960. Diamonds, rough, uncut, and suitable for cutting into gem stones, accounted for 80 percent of the total.

WORLD REVIEW

Gem and industrial diamond sales through the Central Selling Organization (London) were a record $268 million. No breakdown between gem and industrial sales was given. The previous sales record was $255.2 million, set in 1959.

TABLE 4.—World production of diamonds, by countries

(Thousand carats)

Country	1960		1961	
	Gem	Industrial	Gem	Industrial
Africa:				
Angola	658	400	688	460
Central African Republic	30	[1] 50	41	70
Congo, Republic of the	413	13,040	405	17,738
Ghana	[1] 773	[1] 2,500	740	2,300
Guinea [2]	447	670	490	730
Ivory Coast	80	120	219	330
Liberia [3]	577	400	595	500
Sierra Leone	912	1,050	887	1,050
South-West Africa	[1] 885	[1] 50	816	90
Tanganyika	287	250	340	345
Union of South Africa:				
Pipe mines:				
Premier	309	1,000	360	1,200
De Beers Group	717	580	953	760
Other "pipe" mines [2]	[1] 40	[1] 100	35	80
Alluvial mines [2 4]	240	160	240	160
Other regions:				
Brazil [2]	[1] 175	[1] 175	175	175
British Guiana	[1] 61	[1] 40	68	45
Venezuela	14	57	60	74
India, Borneo, Australia, U.S.S.R., and Others [2]	[1] 60	[1] 360	80	420
World total	[1] 6,700	[1] 21,000	7,200	26,500

[1] Revised figure.
[2] Estimate.
[3] Exports only.
[4] Including State-owned mines.

NORTH AMERICA

Canada.—The possibility of finding diamond in Canada was reported to be good because of the similarity between the diamond-bearing rocks in Siberia and those of northern Canada.[10]

SOUTH AMERICA

Brazil.—A deposit of tourmaline was discovered in pegmatites at Serra da Cacunda, Minas Gerais. Three other tourmaline mines were registered with the Government, one each in the States of Minas Gerais, Ceara, and São Paulo.[11] The quantity produced was unknown.

[10] Jewelers' Circular-Keystone. Diamond Finds in Canada Likely. V. 131, No. 7, April 1961, p. 134.
[11] Mining Journal (London). Mining News from Brazil. V. 257, No. 6593, Dec. 29, 1961, p. 675.

Reactivation of an old diamond mine, the Boa Vista, in the State of Minas Gerais, was planned by a group of investors from the United States. The new company's name was Diamonds of Brazil, Inc.[12]

Exports of semiprecious stones in 1960 were 533 tons valued at US$481,321, compared with 317 tons valued at US$27,173 in 1959. These figures were compiled from export licenses issued by the Brazilian Department of Mineral Production.[13]

British Guiana.—Diamond production was 112,679 carats in 1961, of which 67,600 was gem material. This was an increase of about 12,000 carats over 1960. A new diamond deposit was discovered during 1961 at Kurupung.

Chile.—Exports of lapis lazuli in 1961 were 1.8 short tons valued at US$6,400, compared with 4.4 tons valued at US$2,840 in 1960. In both years West Germany was the leading customer.[14]

Colombia.—A new company, Empresa de Esmeraldas, was formed by the Banco de la Republica to take over and work the existing emerald mines. Reports were received that new deposits of emerald were found in the western Department (State) of Boyaca.[15]

Venezuela.—Diamond production in 1961 was 134,000 carats, of which 60,500 carats was gem quality. Exports of 54,000 carats were to Bermuda and the United States. The discovery of several large deposits in the Caroni River bed resulted in increased production of all types of diamonds during the year.[16]

EUROPE

U.S.S.R.—After the discovery of the first kimberlite pipe in Yakutia in 1954, about 200 pipes and dikes were reported found. Only seven or eight had a diamond content high enough for economic exploitation. Two of these were in southern Yakutia; the rest were in the north or near the Arctic Circle.

It was estimated that 900,000 carats was produced in Yakutia and about 50,000 carats in the Ural Mountain region in 1960. Of the total produced, about 5.5 percent was gem diamond. Gem diamonds were being cut and polished in Leningrad and Sverdlovsk.[17]

ASIA

Bahrain.—Expectations were that the 1961 pearl harvest from the Persian Gulf would exceed the 1960 production of US$210,000. The pearling fleet consisted of 11 boats with 450 divers, compared with over 1,800 boats used 30 years ago. Most of the pearls were polished and drilled in India before being made into jewelry.[18]

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[12] Jewelers' Circular–Keystone. American Investors Seek Diamonds in Brazil Mine. V. 131, No. 9, June 1961, pp. 95–96.
[13] Mining Journal. Notes on the Mineral Potential of Brazil. V. 256, No. 6560. May 12, 1961, p. 535.
[14] U.S. Embassy, Santiago, Chile. State Department Dispatch 645. Apr. 17, 1962, p. 31.
[15] Mining Journal (London). Mining Miscellany. V. 257, No. 6580, Sept. 29, 1961, p. 317.
[16] Bureau of Mines. Mineral Trade Notes. V. 54, No. 5, May 1962, p. 10.
[17] Kowalewski, Jan. Mineral Resources Development in U.S.S.R.—II. Min. J., v. 257, No. 6571, July 28, 1961, p. 94.
[18] Foreign Commerce Weekly. Forecast for Bahrain Pearl Harvest Appears Optimistic. V. 67, No. 2, Jan. 8, 1962, p. 60.

Hong Kong.—The Colonial Government with the help of Japanese consultants was reviving its pearl industry. Although it was still in the experimental stage, the developers hoped to produce cultured pearls within a few years.[19]

India.—The National Mineral Development Corp., owned by the Government of India, proved a diamond deposit in the Panna region and planned production of 40,000 to 50,000 carats by 1963. It was estimated that 65 percent of total production would be gem diamonds.[20]

Emerald deposits in the Udaipur region at Gamgudha, Kalouman, and Tikhi had yielded high-grade gems in past years, and the possibilities of again producing in these areas were being explored.[21]

Israel.—A new diamond center, sponsored by the Government-controlled Diamond Development Corp. and the Jerusalem Economic Corp., was opened in Jerusalem in November 1960. The Israel diamond industry in 1961 employed about 8,000 people, with an expansion of an additional 4,000 people expected in the near future.

In 1960, Israel imported nearly 1.5 million carats of rough diamonds valued at US$51 million and exported about 618,000 carats valued at US$61 million, of which US$18 million were sent to the United States.[22]

The value of exports of polished gem diamonds increased 425 percent in the 10-year period, 1951–60. Total carats exported increased 365 percent in the same period. The United States was the largest customer for the cut stones.[23]

The finding of malachite in the King Solomon mine was reported. Some of the copper ores found in the mine contained blebs of minerals with a coloring of turquoise, beige, blue, and black with specks of white, and they were used for decorative purposes. Some of the softer nuggets were broken up and cemented together in a mosaic pattern for jewelry.

The entire gem stone industry was controlled by the Government, and those wishing to purchase malachite or other gem materials for jewelry were required to obtain a license from the Ministry of Development.[24]

AFRICA

British East Africa.—Tanganyika's production of diamond in 1961 was valued at US$17 million. Crude ruby and ruby-bearing corundum were sold for US$41,000.

Federal Ventures, Ltd., Tanganyika, finished preliminary examination of the ruby and sapphire occurrence in the Umba River area, Lushoto district in 1960. A processing plant was planned, and production was expected to start in 1962.

Specimens of semiprecious stones found by prospectors during 1961 included quartz, garnet, zircon, sphene, beryl, chrysoberyl, and tourmaline.

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[19] Foreign Trade (Ottawa). Commodity Notes. V. 116, No. 7, Sept. 23, 1961, p. 14.
[20] Engineering and Mining Journal. In India. V. 162, No. 10, October 1961, p. 182.
[21] Mining Journal (London). Udaipur's Mineral Wealth. V. 257, No. 2572, Aug. 4, 1961, p. 108.
[22] Bureau of Mines. Mineral Trade Notes. V. 53, No. 4, October 1961, pp. 19–21.
[23] Bureau of Mines. Mineral Trade Notes. V. 53, No. 4, October 1961, pp. 19–21.
[24] Gold, Gertrude. King Solomon's Mine Produces Riches Again. Jewelers' Circ.–Keystone, v. 131, No. 10, July 1961, pp. 48, 50.

Tanganyika Crystals, Ltd., at Anusha, was reported to be producing high-quality cut stones, especially amethysts.

Overseas companies were investigating opportunities for investments in the local precious and semiprecious gem stone industry.[25]

British West Africa.—During 1961 a report from Kenya indicated that 1,000 carats of sapphire valued at US$846 was produced.[26]

Cameroun, Republic of.—Three diamonds, the largest of which was 1.7 carats, were discovered in the Méré and Vina regions during 1960. Extensive prospecting during 1961 was proposed by the Government of Cameroun.[27]

Ivory Coast.—Ivory Coast Diamond Company, State-owned, was to be formed to mine diamond in the Ivory Coast and to help stop illegal mining. Exports of gem diamond for the first 11 months of 1961 were valued at US$2 million.[28]

Malagasy Republic.—One of the outstanding characteristics of the mineralization in Malagasy is the occurrence of a wide variety of semiprecious gem stones. The most highly prized gems came from deposits in the Sahatany Valley and from Antsirabe, Ankazobe, and Ikalamavony pegmatite fields. Domestic production during 1961 was sporadic and barely supplied local lapidaries. Some of the more important gems mined were beryl (morganite, aquamarine, and heliodor), tourmaline (rubellite, indicolite, and others having colors of green, brown, violet, and pink), spodumene (kunzite and others of yellow and greenish yellow color), garnet (spessartite and almandite), topaz (colors range from water clear to a slightly greenish tint), sapphire (cordierite), feldspar (amazonite, moonstone, and others water white to golden yellow in color), and quartz (rock crystal, citrine, smoky, amethyst, chalcedony, and jasper).

Other varieties of gems found in Malagasy that may be cut and polished are alabaster, chrysoberyl, danburite, diopside, epidote, ferropecotite, kornerupite, labradorite, opal, rhodonite, rhodizite, scapolite, serpentine, spinel, and turquoise.

Other mineralogical specimens highly prized by collectors included ampangabeite, befanamite, betafite, and grandidierite.

Rhodesia and Nyasaland, Federation of.—The Sandawana emerald deposits, owned by Rio Tinto Co., Ltd., were reported producing high-quality gems during 1960. Production and values were unknown. Two new emerald deposits were reported in the Fort Victoria district.[29] Another emerald discovery was reported in the Mazoe district 20 miles north of Salisbury.[30]

South-West Africa.—In June 1961, Marine Diamond Corp., Ltd., was formed to mine diamond by dredging in a coastal area extending from the mouth of the Orange River north 172 miles and extending from the low-water mark on the coast to the 3-mile limit.[31] Also, Atlantic

[25] Mining Journal (London). Tanganyika's Mining Industry in 1961. V. 258, No. 6605, Mar. 23, 1962, pp. 288–289.
[26] U.S. Consulate, Nairobi, Kenya. State Department Dispatch 400. Mar. 26, 1962, p. 2.
[27] Bureau of Mines. Mineral Trade Notes. V. 53, No. 3, September 1961, p. 16.
[28] Mining Journal (London). Mining Miscellany. V. 258, No. 6600, Feb. 16, 1962, p. 173.
[29] Rhodesian Mining and Engineering (Salisbury). News Concentrates. V. 26, No. 6, June 1961, pp. 30, 50.
[30] Bureau of Mines. Mineral Trade Notes. V. 53, No. 5, November 1961, p. 17.
[31] Bureau of Mines. Mineral Trade Notes. V. 53, No. 5, November 1961, pp. 14–15.

TABLE 5.—Production, exports, and value of gem stones from South-West Africa during 1961

Gem	Production	Exports	
	Quantity	Quantity	Value
Diamonds—carats	816	787,949	US$47,267,567
Amethyst—pounds	6,658	658	111
Chalcedony—do	30,200	2,600	1,960
Rose quartz—do	980	980	140
Tourmaline—do	73	11	4,900
Aragonite—do	400	400	280

Diamond Corp., Ltd., was seeking an 8-mile concession north of the Orange River along the coast to the 3-mile limit.[32]

Union of South Africa.—Emerald production from northeastern Transvaal increased to 3,600 pounds in 1960 from 1,800 pounds in 1959. African Emerald Mining Company (Pty.) Ltd., African Gem Company, and Gravelotte Emerald Mine were the only producers. Virtually all of the emerald was exported to Switzerland and the United Kingdom. Tiger's eye production was about 3 tons.[33]

Plans were made for reopening the famous de Beers' diamond mine at Kimberley.[34] This mine, also known as the "Big Hole," was mined to a depth of 3,520 feet and produced over 14 million carats before mining stopped in 1908.[35]

OCEANIA

Australia.—The value of opal reported in official statistics was the amount buyers reported to the Government as the price paid for rough material. Opal production in 1960 was valued at US$1.5 million, and exports were US$2.3 million.[36]

TECHNOLOGY

A list of mineral species, some of which were found only in California, was published.[37]

Information on jade gem material in Washington was given.[38]

A new book on opal, published in Australia, contained information on the history of opal mining and discussed modern methods of extraction. It was illustrated with drawings and photographs of different types of opal.[39]

Gem stones of South Africa and their locations were described.[40]

[32] Mining Journal (London). Mining Miscellany. V. 257, No. 6586, Nov. 10, 1961, p. 485.
[33] U.S. Consulate, Johannesburg, Union of South Africa. State Department Dispatch 7. July 7, 1961, p. 14, encl. 3, pp. 1, 2.
[34] Mining World and Engineering Record (London). De Beers Well Equipped to Meet Difficult Times Ahead in Africa. V. 177, No. 4551, June 1961, p. 243.
[35] Rocks and Minerals. Kimberley Diamond Mine May Reopen. V. 36, Nos. 1 and 2, January–February 1961, p. 41.
[36] Bureau of Mines. Mineral Trade Notes. V. 54, No. 1, January 1962, pp. 40, 41.
[37] Stinson, Melvin C. The Mineral Kingdom. Miner. Inf. Service, California Div. of Mines, San Francisco, Calif., v. 14, No. 8, August 1961, 16 pp.
[38] Waskey, Frank H. Washington State Jade. Rocks and Minerals, v. 36, Nos. 1 and 2, January–February 1961, pp. 30–31.
[39] Leechman, Frank. The Opal Book. Ure Smith Pty. Ltd., Sydney, Australia, 1961, 255 pp.
[40] Blignaut, Adi. Gemstones of Southern Africa. Geol. Museum of Johannesburg, Transvaal, South Africa, 1961, 28 pp.

Each monthly issue of Mine and Quarry Engineer (London) beginning with October 1953 described a mineral, giving the synonyms, nomenclature, varieties, composition, crystallography, physical and optical properties, tests, diagnoses, occurrences, and uses. Each mineral was illustrated in color. In the 1961 issues the minerals in chronological order were strontiamite, wavellite, cryolite, aurichalcite, datolite, hemimorphite, adularia, diopside, gibbsite, topaz, rutile, and opal.

A series of articles on quartz as a gem material were published.[41]

Data on gem stones having dichroism, the property of presenting different colors in two directions by transmitted light, were given.[42]

The origin of jadeite and experimental studies on its synthesis were described.[43]

Recent developments in the synthesis of gem material for jewelry and industrial applications were reviewed.[44]

Single crystals of corundum made by the Verneuil method were investigated to determine the quantity, color, and degree of oxidation of manganese which they contained. The crystals contained from 0.1 to 20 mole-percent manganese oxide. Chemical and microscopic examinations were reported.[45]

A Russian publication reviewed the history of emerald synthesis in Germany. Past and recent methods used to manufacture emeralds were described. The synthesis of phenakite, zircon, garnet, titanite, and rutile also was mentioned.[46]

Methods of growing crystals of synthetic ruby in a closed system[47] and of producing garnet synthetically were patented.[48]

An improvement in the color of pale yellow or brown gem diamonds by exposure to gamma radiation was described.[49]

The design of an apparatus for use in extraction of diamonds was patented in Russia.[50]

A method of producing diamonds by explosive force was described.[51]

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[41] Pough, Frederick H. The Many Faces of Quartz. Jewelers' Circ.–Keystone, v. 132, No. 1, October 1961, pp. 80, 82, 102–103; No. 2, November 1961, pp. 68, 70, 77–78; No. 3, December 1961, pp. 50, 52, 54, 56.

[42] Pough, Frederick H. Bi-Color, Parti-Color and Dichroic Stones. Jewelers' Circ.–Keystone, v. 131, No. 10, July 1961, pp. 52, 54.

[43] Moskaleva, V. N. The Problem of Jadeite. Econ. Geol., v. 56, No. 8, December 1961, p. 1480.

[44] Chemical Engineering. Flame-Grown Gem Stones Enjoy Broadened Use in Optics and Fashion Jewelry. V. 68, No. 26, Dec. 25, 1961, pp. 26–28.

[45] Baumgärtel, Rolf. (Investigations on Corundum Single-Crystals Containing Manganese.) Chem. Tech., No. 10, 1961, 615 pp.

[46] Espig, Hermann. (Emerald Synthesis.) Chem. Tech., No. 6, 1960, pp. 327–331.

[47] Ballman, Albert A., Anthony J. Caporaso, and Robert A. Laudise (assigned to Bell Telephone Laboratories, Inc.). Method of Growing Corundum Crystals. U.S. Pat. 2,979,413, Apr. 11, 1961.

[48] Van Uitert, L. G. G. (assigned to Bell Telephone Laboratories, Inc.). Polycrystalline Garnet Materials. U.S. Pat. 3,003,966, Oct. 10, 1961.

[49] Custers, J. F. H., H. B. Dyer, and R. W. Ditchburn (assigned to Industrial Distributors Ltd. (1946)). Treatment of Diamonds. U.S. Pat. 2,998,365, Aug. 29, 1961.

[50] Lomakin, G. A. Russian Pat. 129,146, June 15, 1960.

[51] Van Tilburg, J. Australian Pat. 226,337, Nov. 27, 1959.

Gold

By J. P. Ryan [1] and Kathleen M. McBreen [2]



UNITED STATES mine production of recoverable gold in 1961 was 1.5 million ounces valued at $54.2 million, a decrease in production of 7 percent from 1960. This output was the lowest since 1885, except for 4 years (1943–46) during and immediately following World War II. World gold production rose for the 8th successive year to a new high of 47.7 million ounces, valued at $1.7 billion.

The decline in domestic production reflected curtailed operations in some areas and continuing unfavorable economic conditions owing to rising costs in relation to the fixed price of gold. The gain in world output of gold, as in several preceding years, was attributed principally to expansion of gold mining operations in the Republic of South Africa, and to a lesser extent to an increase in the estimated output of the U.S.S.R.

Consumption of gold in domestic arts and industries, reversing the rising trend existing since 1954, decreased 7 percent to 2.8 million ounces, about 1.2 million ounces more than domestic mine production.

The outflow of gold from the United States, resulting from the continuing deficit in the balance-of-payments and conversion-of-dollar credits by foreign central banks, amounted to $857 million. The gold loss, about half that of 1960, reduced the U.S. gold stock to $16.9 billion at yearend. Although the balance-of-payments deficit of $2.4 billion was considerably less than in 1960, short-term bank liabilities to foreigners increased $1.4 billion to $18.7 billion at yearend, nearly 2 billion more than the U.S. gold stock. Free-world gold reserves totaled $41.1 billion, a gain of $600 million for the year.

Although speculative transactions on the London Gold Market were substantial, the average price quotation during most of the year did not vary much from the equivalent official price. An informal agreement by central banks not to purchase gold in the London Gold Market at prices above the official price contributed to price stability. The outgoing President's order prohibiting U.S. citizens from holding gold abroad and the new President's statement that U.S. official price would be maintained also contributed to price stability in the London Gold Market.

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LEGISLATION AND GOVERNMENT PROGRAMS

Hearings on bills and resolutions dealing with subsidy payments to domestic producers of gold were held in May by the Mines and Mining Subcommittee of the House Interior and Insular Affairs Committee. The bills and resolutions considered were H.R. 6375, 6734, 6804, and 9225, and H.J. Res. 185, 286, 293, and 356. S.J. Res. 44, also providing for subsidy payments to domestic producers, was introduced in the 87th Congress, 1st Session and referred to the Senate Interior and Insular Affairs Committee. No further action was taken on the bills and resolutions.

An Executive order,[3] issued on January 14th, amended the Treasury Department's Gold Regulations to prohibit U.S. citizens and those subject to the jurisdiction of the United States from holding abroad either gold or securities representing gold on deposit. Implementing amendments allowed U.S. holders of gold and securities abroad until June 1, 1961, to dispose of their holdings. The prohibition was aimed at improving the U.S. balance-of-payments.

Also bills similar to those introduced in 1960 to increase the price of newly mined domestic gold and to amend the Gold Reserve Act of 1934 to permit free marketing of nonmonetary gold by private owners were introduced and referred to the House Committee on Banking and Currency. Bills to provide for the coinage of gold, to eliminate gold-reserve requirements of Federal Reserve banks, to establish a gold standard with redeemable currency, and to provide for other revisions of the U.S. monetary system were also introduced in the House of Representatives and referred to the Committee on Banking and Currency. Other bills were introduced in the 87th Congress to amend the Internal Revenue Code and to increase the percentage of the depletion rate for gold; these bills were referred to the Committee on Ways and Means of the House of Representatives and the Committee on Finance of the Senate. Bills to facilitate protection of consumers from fraudulent misrepresentation concerning the quality of gold and silver articles of merchandise were introduced in Congress and referred to the respective Committees on Interstate and Foreign Commerce of the House and Senate.

DOMESTIC PRODUCTION

Domestic mine production of recoverable gold dropped 7 percent to 1.5 million ounces valued at $54.2 million, the lowest output (except for 1943–46) since 1885. The decrease in production was attributed principally to a decline in placer mining in Alaska and California and to a lower output of gold-bearing copper ores in Utah and Montana. Labor strikes represented a relatively minor factor. Gold-mining operations continued to be adversely affected by rising costs in relation to the fixed price of gold. Some mines were closed, and reserves at several mines neared depletion.

South Dakota and Utah, the two leading gold-producing States, contributed nearly 60 percent of the total domestic output. Except for small increases in Arizona and Colorado, all the major gold-

[3] Amendment of Executive Order 6260. Aug. 28, 1933.

producing States recorded lower outputs. Utah's output declined partly because of a production loss resulting from a labor strike in August at the Utah Copper mine. The closing of the Goldacres mine was the principal factor in the decline of Nevada's gold output. Alaska dropped from third to fifth place among the gold-producing States.

TABLE 1.—Salient gold statistics

	1952–56 (average)	1957	1958	1959	1960	1961
United States:						
Mine production						
thousand troy ounces	1,879	1,794	1,739	1,603	1,667	1,548
Value—thousands	$65,773	$62,776	$60,874	$56,103	$58,337	$54,189
Ore (dry and siliceous) produced:						
Gold ore—thousand short tons	2,255	2,359	2,411	2,289	2,267	2,060
Gold-silver ore—do	146	116	107	137	347	248
Silver ore—do	599	712	639	597	641	565
Percentage derived from:						
Dry and siliceous ores	42	43	47	50	47	48
Base-metal ores	37	38	32	28	37	39
Placers	21	19	21	22	16	13
Imports, general						
thousand troy ounces [1]	6,045	7,701	8,120	8,485	9,322	1,615
Exports [1]—do	606	4,806	886	50	47	22,146
Stocks Dec. 31: Monetary [2]						
millions		$22,857	$20,582	$19,507	$17,804	$16,947
Consumption in industry and the arts—thousand troy ounces	1,773	1,450	1,833	2,522	3,000	2,775
Price: Average—per troy ounce [3]	$35.00	$35.00	$35.00	$35.00	$35.00	$35.00
World: Production						
thousand troy ounces	35,600	[4] 39,500	40,600	[4] 42,800	[4] 45,400	47,700

[1] Excludes coinage.
[2] Owned by Treasury Department; privately held coinage not included.
[3] Price under authority of Gold Reserve Act of Jan. 31, 1934.
[4] Revised figure.

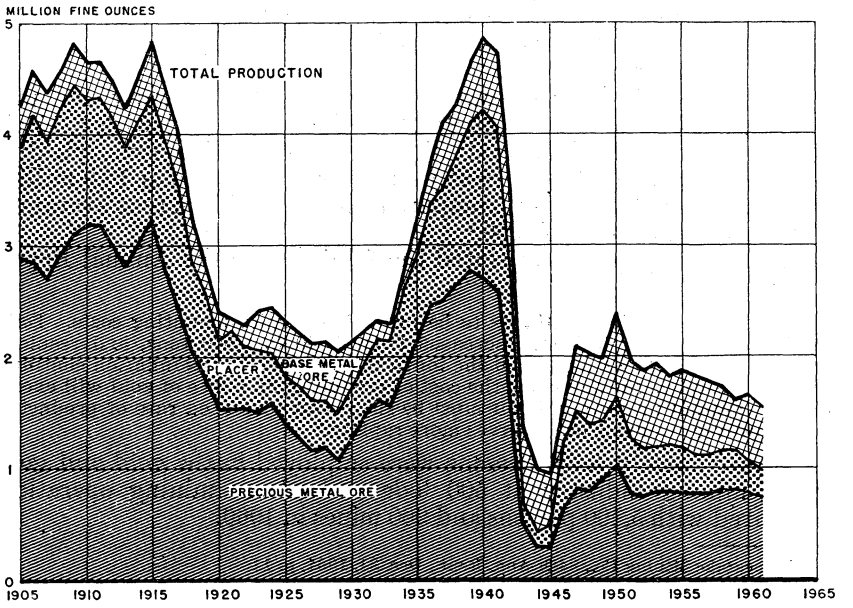


FIGURE 1.—Gold production in the United States, 1905–61.

TABLE 2.—Gold produced in the United States according to mine and mint returns
(Troy ounces of recoverable metal)

	1952–56 (average)	1957	1958	1959	1960	1961
Mine	1,879,233	1,793,597	1,739,249	1,602,931	1,666,772	1,548,270
Mint	1,899,606	1,800,000	1,759,000	1,635,000	1,679,800	1,566,800

TABLE 3.—Mine production of gold in the United States in 1961, by months

Month	Troy ounces	Month	Troy ounces
January	131,946	August	117,489
February	113,869	September	147,110
March	126,681	October	140,299
April	119,637	November	133,905
May	122,734	December	135,904
June	127,032		
July	132,264	Total	1,548,270

The Homestake mine in South Dakota contributed more than one-third of the nation's gold output, and most of Utah's output was recovered as a byproduct of copper ore at the Utah Copper mine. Arizona's gold output also was recovered chiefly from the treatment of copper ores. Virtually all of Alaska's gold came from placer deposits and was recovered by bucketline dredging. Forty-eight percent of the total domestic output was recovered from gold ores, about the same as in 1960; 13 percent from placers, a 3-percent drop; and 39 percent as a byproduct of base metal ores, a 3-percent gain.

The 25 leading U.S. gold producers included 5 lode gold mines, 5 placer gold mines, 9 copper mines, 3 copper-lead-zinc mines, and 3 lead-zinc mines. The 25 leading mines supplied 93 percent of the domestic output.

Homestake Mining Co. continued to expand ore output and produced gold bullion valued at $19.6 million, compared with $19.5 in 1960. Tons milled increased slightly to 1.8 million tons, yielding $11.00 a ton. The ore reserve at yearend was estimated at 15.0 million tons averaging $11.39 a ton, compared with 13.7 million tons averaging $12.35 a ton at the end of 1960.[4]

The company president stated the following in the Annual Report that:

"Our gold operation continues to be profitable despite mounting costs. Daily production capacity is being increased from 4,800 to 5,800 tons, and resulting savings will offset to some extent the inevitable rise in costs as inflation continues and will postpone the day when the cost of producing an ounce of gold will exceed $35, the present price at which it must be sold. Our increased rate of production will, however, consume ore reserves more rapidly."

Approximately 4,400 persons were employed in the gold and gold-silver mining industry at 500 lode and placer mining operations compared with 5,100 persons and 900 mines in 1960.

[4] Homestake Mining Co., 84th Ann. Rept., Dec. 31, 1961, p. 11.

Ore production and classification, methods of recovery, and metal yields embracing all ores that yielded gold in the United States in 1961 are given in tables 6 to 9. Terminology and definitions used in classifying ores are given in the gold chapter of the 1960 Minerals Yearbook.

TABLE 4.—Twenty-five leading gold-producing mines in the United States in 1961, in order of output

Rank	Mine	District or region	State	Operator	Source of gold
1	Homestake	Whitewood (Lead).	South Dakota	Homestake Mining Co.	Gold ore.
2	Utah Copper	West Mountain (Bingham).	Utah	Kennecott Copper Corp.	Copper ore.
3	Knob Hill & Gold Dollar.	Republic	Washington	Knob Hill Mines, Inc.	Gold ore.
4	Yuba Unit	Yuba River	California	Yuba Consolidated Industries, Inc.	Dredge.
5	Copper Queen-Lavender Pit.	Warren	Arizona	Phelps Dodge Corp	Copper ore.
6	Liberty Pit	Robinson	Nevada	Kennecott Copper Corp.	Do.
7	Fairbanks Unit	Fairbanks	Alaska	United States Smelting, Refining, and Mining Co.	Dredge.
8	New Cornelia	Ajo	Arizona	Phelps Dodge Corp	Copper, gold-silver ores.
9	Nome Unit	Nome	Alaska	United States Smelting, Refining, and Mining Co.	Dredge.
10	Idarado	Upper San Miguel-Eureka (Red Mountain).	Colorado	Idarado Mining Co	Copper-lead-zinc ore.
11	Ajax	Cripple Creek	do	The Golden Cycle Corp.	Gold ore.
12	Gold King	Wenatchee River	Washington	L-D Mines	Do.
13	San Manuel	Pioneer	Arizona	San Manuel Copper Corp.	Copper ore.
14	Iron King	Big Bug	do	Shattuck Denn Mining Corp.	Lead-zinc ore.
15	Magma	Pioneer	do	Magma Copper Co	Copper, gold-silver ores.
16	Natomas	American River (Folsom).	California	The Natomas Co	Dredge.
17	Mayflower and West Mayflower.	Renova	Montana	Estate of Peter Antonioli.	Gold ore.
18	Berkeley Pit	Summit Valley (Butte).	do	The Anaconda Company.	Copper ore.
19	Hogatza River	Hughes	Alaska	United States Smelting, Refining, and Mining Co.	Dredge.
20	Morenci	Copper Mountain	Arizona	Phelps Dodge Corp	Gold-silver, copper ores.
21	United States and Lark.	West Mountain (Bingham).	Utah	United States Smelting, Refining, and Mining Co.	Lead-zinc, gold-silver ores.
22	Camp Bird	Sneffels	Colorado	Camp Bird Colorado, Inc.	Copper-lead-zinc ore.
23	Eagle	Red Cliff (Battle Mountain).	do	The New Jersey Zinc Co.	Do.
24	Mayflower Unit	Blue Ledge	Utah	New Park Mining Co-Hecla Mining Co.	Lead-zinc ore.
25	Kelley	Summit Valley (Butte).	Montana	The Anaconda Company.	Copper ore.

TABLE 5.—Mine production of recoverable gold in the United States, by States

(Troy ounces)

State	1952-56 (average)	1957	1958	1959	1960	1961
Alaska	240,288	215,467	186,435	178,918	168,197	114,216
Arizona	122,743	152,449	142,979	124,627	143,064	145,959
California	235,241	170,885	185,385	145,270	123,713	97,644
Colorado	105,241	87,928	79,539	61,097	61,269	67,515
Idaho	16,731	12,301	15,896	10,479	6,135	5,718
Montana	27,767	32,766	26,003	28,551	45,922	35,377
Nevada	87,804	76,752	105,087	113,443	58,187	54,165
New Mexico	2,859	3,212	3,378	3,155	5,423	6,201
North Carolina	257	1,373	876	965	1,826	2,094
Oregon	4,993	3,381	1,423	686	835	1,054
Pennsylvania	1,449	(1)	(1)	(1)	(1)	(1)
South Dakota	531,471	568,130	570,830	577,730	554,771	557,855
Tennessee	232	172	124	99	123	152
Texas	8					
Utah	435,915	378,438	307,824	239,517	368,255	342,988
Vermont	168	62				
Washington	65,821	[1] 89,708	[1] 113,353	[1] 118,394	[1] 129,012	[1] 117,331
Wyoming	245	573	117		40	1
Total	1,879,233	1,793,597	1,739,249	1,602,931	1,666,772	1,548,270

[1] Production in Pennsylvania and Washington combined.

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 1961

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	452	1.659					152	
Arizona	30,450	.027	119,595	0.007	29,525		71,970,777	0.002
California	24,650	.349			13	0.615	19,449	.232
Colorado	56,418	.477	2,000	.042	373	.011	15,764	.332
Idaho	2,406	.452			409,037	.003	20,866	.027
Montana	10,531	1.292	10,592	.178	35,144	.018	12,533,042	.001
Nevada	36,944	.157			11,598	.155	12,008,578	.004
New Mexico	17	1.412	48,235	.027	2,445		7,405,692	.001
South Dakota	1,780,746	.313	19	21.421	8			
Utah	4	.250	66,881	.006	72,201	.010	27,856,459	.012
Undistributed [1]	116,890	.996	412	.279	4,165		1,749,063	.001
Total	2,059,508	.355	247,734	.021	564,509	.008	133,579,842	.004

State	Lead ore		Zinc ore		Zinc-lead, zinc-copper, and zinc-lead-copper ores		Total ore	
	Short tons	Average ounces of gold per ton	Short tons	Average ounces of gold per ton	Short tons	Average ounces of gold per ton	Short tons	Average ounces of gold per ton
Alaska	41	0.220					645	1.177
Arizona	1,258	.027	15,059		417,371	0.036	72,584,035	.002
California	1,720	.018	14	2.000	55	[2] 1.927	45,901	.289
Colorado	2,273	.251	18	4.333	861,394	.038	938,240	.070
Idaho	165,561	.009	50,847		847,938	.001	1,496,655	.003
Montana	12,747	.024	189,971	.003	361	.089	[3] 12,792,388	.003
Nevada	9,301	.155	283	.004	376		12,067,080	.004
New Mexico	7,588	.001	288,270		24,968	.004	7,777,215	.001
South Dakota							1,780,773	.313
Utah	1,233	.021	69,865	.002	487,180	.036	28,553,823	.012
Undistributed [1]	7				[4] 1,289,034		[5] 3,159,571	.038
Total	201,729	.019	614,327	.002	3,928,677	.017	141,196,326	.010

[1] Includes North Carolina, Oregon, Tennessee, Washington, and Wyoming.
[2] Includes gold recovered from tungsten ore.
[3] Includes manganese ore and gold therefrom.
[4] Includes tungsten ore and gold therefrom.
[5] Excludes magnetite-pyrite-chalcopyrite ore and gold therefrom in Pennsylvania.

TABLE 7.—Mine and refinery production of gold in the United States in 1961, 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	113,457	750		9			114,216	116,700
Arizona	108	1,696	129,295	34		14,826	145,959	147,280
California	84,367	8,608	4,504	31	28	[2] 106	97,644	98,250
Colorado	1,924	26,998	5,232	570	78	32,713	67,515	64,950
Idaho	541	2,198	564	1,408	16	991	5,718	6,000
Montana	132	16,123	18,133	308	649	[3] 32	35,377	38,720
Nevada	1,095	7,618	44,011	1,440	1		54,165	53,000
New Mexico	27	1,340	4,612	8	119	95	6,201	6,480
North Carolina		56	1,902			[2] 136	2,094	1,200
Oregon	705	343	1			5	1,054	880
Pennsylvania [4]								1,130
South Dakota		557,855					557,855	558,850
Tennessee			152				152	200
Utah		1,161	323,850	26	170	17,781	342,988	355,000
Washington [4]	10	116,103	1,218				117,331	118,160
Wyoming		1					1	[5]
Total	202,366	740,850	533,474	3,834	1,061	66,685	1,548,270	1,566,800
Percent	13.1	47.9	34.4	.2	.1	4.3	100	

[1] U.S. Bureau of the Mint.
[2] Includes gold recovered from tungsten ore.
[3] Includes gold recovered from manganese ore.
[4] Included with Washington.
[5] Includes gold recovered from magnetite-pyrite-chalcopyrite ores in Pennsylvania.
[6] Approximately 1 troy ounce.

TABLE. 8.—Gold produced in the United States from ore and old tailings in 1961, 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	645	447	720				198	39
Arizona	72,584,035	71,769,153	215	922	2,309,623	112,794	814,882	31,920
California	45,901	45,306	6,950	36	7,124	6,098	595	93
Colorado	938,240	921,227	4,299	26,152	131,596	29,256	17,013	5,884
Idaho	1,496,655	1,460,376	509		222,439	4,328	36,279	340
Montana	12,792,388	12,679,618	293		387,645	19,533	112,770	15,419
Nevada	12,067,080	11,987,533	333	6,764	259,117	43,072	79,547	2,901
New Mexico	7,777,215	7,639,330			328,714	4,809	137,885	1,365
South Dakota	1,780,773	1,780,746	420,796	136,652			27	407
Utah	28,553,823	28,324,908	1		817,578	341,539	228,915	1,448
Undistributed [1]	[2] 3,159,571	[2] 3,118,489	18	15,560	[2] 135,545	81,225	41,082	23,114
Total	141,196,326	139,727,133	434,134	186,086	4,599,381	642,654	1,469,193	83,030

[1] Includes North Carolina, Oregon, Pennsylvania, 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
1952-56 (average)	440,704	269,743	23.5	14.3	40.8	21.4
1957	435,387	257,008	24.3	14.3	42.3	19.1
1958	446,886	245,397	25.7	14.1	38.9	21.3
1959	459,857	236,046	28.7	14.7	34.3	22.3
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

[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	Value (thousands)	Average value per cubic yard
Bucketline dredging:						
1952-56 (average)	25	39	59,929	340	$11,903	$0.199
1957	18	33	45,489	297	10,402	.229
1958	17	31	43,693	287	10,038	.230
1959	16	30	36,998	251	8,767	.237
1960	17	24	33,464	228	7,986	.239
1961	19	24	33,806	177	6,192	.183
Dragline dredging:						
1952-56 (average)	16	12	882	4	144	.163
1957	13	14	378	2	55	.145
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
Hydraulicking:						
1952-56 (average)	42	----------	215	2	58	.280
1957	30	----------	100	2	75	.752
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
Nonfloating washing plants:						
1952-56 (average)	117	113	3,080	53	1,867	.606
1957	94	111	2,188	40	1,381	.631
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
Underground placer, small-scale hand methods, and suction dredging:						
1952-56 (average)	127	5	198	[2] 4	[2] 124	.626
1957	73	----------	63	2	81	1.270
1958	105	3	83	3	93	1.130
1959	79	4	47	[2] 2	[2] 82	1.732
1960	89	89	60	2	73	1.207
1961	103	103	141	2	73	.518
Grand total, placers:						
1952-56 (average)	327	169	64,304	[2] 403	[2] 14,096	.219
1957	228	158	48.218	343	11,994	.249
1958	289	163	46.857	371	12,984	.277
1959	231	178	39,873	[3] 358	[3] 12,520	.314
1960	239	246	34,888	264	9,244	.265
1961	238	243	[1] 35,616	202	7,083	.199

[1] Does not include commercial sand and gravel operations recovering byproduct gold.
[2] Includes 1,476 ounces of gold valued at $51,660 recovered from unclassified placers.
[3] Includes 103 ounces of gold valued at $3,605 recovered from electrostatic separation.

CONSUMPTION AND USES

Industry and the Arts.—After rising for 6 successive years, the quantity of gold consumed by domestic industries and in the arts declined moderately. Net consumption decreased 7 percent to 2.8 million ounces, about 1.2 million ounces more than domestic mine production.

In addition to the large quantity of gold consumed for traditional and established uses in the decorative arts, for dental and medical supplies and equipment, and for scientific instruments, the quantity of gold consumed for industrial use continued to increase, as newly developed applications were more widely adopted. Applications in structural components and instrumentation of space vehicles and jet aircraft included protective coatings on refractory metals and ceramics for reflection and reducing the rate of heat transfer in such structural components as engine shrouds, tail-cone assemblies, blast shields, drag-chute containers, and satellites. An expanding use of gold alloys was noted in the manufacture of electronic components such as silicon transistors diodes, rectifiers, microwave vacuum tubes, contacts, and printed circuity in communications and various control equipment.

Gold alloy contact points to withstand 300,000 revolutions were specified in designing an improved tuner for Zenith Radio Corporation's new television receiver. At the U.S. Naval Underwater Ordnance Station at Newport, R.I., gold sliprings were used to obtain superior power, and signal connections in a centrifuge were built for testing instruments and electronic parts and assemblies. Gold-coated porcelain enameled metal panels were made available in commercial quantities for architectural applications by Ingram-Richardson Manufacturing Co., Beaver Falls, Pa.

Thin films of gold on Teflon were used as interior protection for plastic containers of fuel-expulsion systems in missile and aerospace service, according to Quantum, Inc., Wallingford, Conn. The chemically deposited gold on Teflon was reported to greatly reduce permeability to high-energy fuels. Gold-coated Teflon also was developed by E. I. du Pont de Nemours & Co., Inc., Wilmington, Del., for protecting workers handling high-energy fuels and fuel equipment. The fabric, called "Armalon," has high reflectivity and will take a flash test at 3,000° F. The material is unaffected by most chemicals. Gold and other precious metals were used in a new high-temperature lubricant developed by General Magnaplate Corp., Belleville, N.J., for space capsules and jet engines. The new lubricant was applied in thin coatings that will function in temperatures up to 1,200° F and may have applications in high-speed industrial machinery.

Reports from domestic producers indicated that about 1,000 troy ounces of natural gold was sold to various buyers, chiefly for jewelry and ornamental use, at prices somewhat higher than the official price.

Monetary.—Central Bank gold purchases declined 30 to 40 percent below those of 1960, due in part to deferred conversion of foreign currencies into gold. Most of the gold sales resulting from currency conversions by Central Banks were made directly by the Bank of England and not through the market. The Bank of England, the largest seller in the London Gold Market, obtained most of its gold supply from South African mine production and from the United States reserve. Demand from the Far East and Middle East again increased.

Of a total market supply of new gold aggregating 42.5 million ounces, it was estimated that Central Banks and other official institutions, including the International Monetary Fund (IMF), absorbed 23 million ounces, industries and the arts about 8.5 million ounces, hoarding and investment buyers, the remaining 11 million ounces.[5]

TABLE 11.—Net 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
1952-56 (average)	2,646,388	873,282	1,773,106
1957	2,241,892	791,892	1,450,000
1958	2,602,512	769,261	1,833,251
1959	3,175,386	653,586	2,521,800
1960	3,700,000	700,000	3,000,000
1961	3,912,554	1,137,554	2,775,000

Source: U.S. Bureau of the Mint.

MONETARY STOCKS

The U.S. gold stock declined $857 million during 1961 to $16.9 billion at yearend, the lowest level since 1939. The loss, about half as much as in 1960, was the fourth successive annual decline in the nation's gold reserve. The smaller gold loss reflected a reduced balance-of-payment deficit, increased holding of dollar reserves by foreigners, and the purchase of $150 million in gold by the United States from IMF. The ratio of gold reserve to Federal Reserve note and deposits liabilities dropped 3 percent to 35 percent at yearend, as against 25 percent required for legal cover.

The U.S. balance-of-payment deficit was reduced from $3.8 to $2.4 billion. Although the net trade surplus, based on exchange of goods and services including military expenditures, declined slightly to $5.2 billion, this favorable balance was more than offset by the deficit arising from Government grants and private remittances, and from long- and short-term capital transfers and investments abroad by Government and private interests. About one-third of the overall deficit was paid in gold. The U.S. balance-of-payments and its relation to the gold reserve, stability of the dollar, and international financial cooperation were discussed by Government officials.[6]

The 1961 deficit in balance-of-payments resulted in increasing U.S. short-term bank liabilities to foreigners by $1.4 billion to $18.7 billion at yearend. These liabilities, payable in dollars, constituted a potential claim on the U.S. gold reserve. Two-thirds of the liabilities were payable to Western European countries and Canada.[7]

Central Banks and Governments and international banking institutions reported gold reserves totaling $41.1 billion, $600 million more than at the end of 1960. The U.S. reserve of $16.9 billion thus constituted about 41 percent of the total free-world gold reserve. Gold

[5] S. Montague & Co. Ltd. Ann. Rev. 1961. Pp 4–8.

[6] Roosa, Robert V. Under Secretary of the Treasury for Monetary Affairs. American Bankers Assn. Conf., New York, N.Y., Feb. 7, 1962, 15 pp.
Daane, J. Dewey. Deputy Under Secretary of the Treasury for Monetary Affairs. Minnesota Savings Bonds Conf., St. Paul, Minn., Mar. 9, 1962, 9 pp.

[7] Federal Reserve Bulletin. V. 48, No. 6, June 1962, pp. 768, 777.

reserves of the principal foreign countries in the free world in billions of dollars were as follows: West Germany, 3.7; United Kingdom, 3.3; Switzerland, 2.6; Italy, 2.2; France, 2.1; Netherlands, 1.6; Belgium, 1.3; and Canada, 0.9. The gold reserve of the International Monetary Fund was $2.1 billion.

PRICES

Purchases of gold by foreign Central Banks and governments again reduced the U.S. gold stock substantially and prompted speculation on possible revaluation. However, the President and other administration officials reiterated their previous statements that the official price of $35 an ounce would not be changed. In a message to the Congress [8] the President stated:

> The United States official dollar price of gold can and will be maintained at $35 an ounce. . . . Those who fear weakness in the dollar will find their fears unfounded. Those who hope for speculative reasons for an increase in the price of gold will find their hopes in vain.

United States mint institutions and licensed private refiners and dealers continued to buy virtually all newly mined domestic gold and gold offered by foreign countries at the official price less handling and refining charges. Similarly, Government and private sales of gold to domestic consumers were made at the official price plus handling charges.

On the London Gold Market the volume of transactions declined from the record high of 1960. Central Banks virtually withdrew from the market during most of the year. The price of gold on the London market reached a high of $35.75 to $35.90 an ounce in January before the Presidential Order prohibiting U.S. citizens from holding gold abroad. Prices declined sharply following the outgoing President's Order and subsequent reaffirmation of the new President's preelection pledge of maintaining the gold parity of the dollar. Liquidation of private U.S. holdings was a significant factor contributing to the decline in prices in midyear, when the quotation was $35.04 to $35.08. Increased demand from the Near East and other consumer centers and resumption of Central Bank buying led to rising prices in the second half of the year. The price quotation dropped slightly in December, and at yearend it was $35.14 to $35.16 an ounce.

Agreements among European Central Banks to support each other's currencies and defer their rights to convert foreign currencies into gold reduced market transactions and helped to stabilize the price on the London Gold Market. Agreements among members of the International Monetary Fund to make currency credits available to IMF also helped to maintain the gold reserves of the principal international reserve currencies and to stabilize market prices. The United States and the United Kingdom, in cooperation with the monetary authorities of other countries, established a gold pool of $250 million to stabilize the price of gold at or near the official price. Exports of gold by the U.S.S.R. to the United Kingdom for sale on the London market totaled 6.5 million ounces. This gold supply also was a major factor contributing to price stabilization.

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[8] Kennedy, John F. U.S. Balance of Payments and Gold Outflow from United States, Message from The President of the United States. Document 84, 87th Congress, 1st Session, Feb. 6, 1961.

The average price [9] of "free" gold bars (12.5 kg.) per fine troy ounce in the principal trading centers outside London did not vary greatly from the London price except in a few markets where trading was in local, inconvertible currencies that reflected local political conditions and monetary habits.[10] These prices were as follows:

Market:	*Price*	Market:	*Price*
Manila	$36.22	Beirut	$35.52
Hong Kong	39.21	Paris	35.61
Bombay	53.73	Buenos Aires	36.15

Demand for gold coins continued strong, and the premium over the gold content of most gold coins reached a record high. The premium on the U.S. $20 double eagle in London ranged from 18 percent in March to 28 percent at the end of December.

The relationship of the dollar to gold and suggested changes in monetary policy needed to reduce the gold outflow and preserve the value of the dollar as the world's leading currency were discussed by the president of a leading gold mining company.[11]

FOREIGN TRADE [12]

A record outflow of gold valued at $775.0 million was the salient feature in foreign trade. Nearly all of the gold exported went to the United Kingdom. A large part was sold to the Bank of England and represented conversion of U.S. dollars into gold by Central Banks. Imports declined sharply. Colombia and the Philippines supplied nearly three-fourths of the total imports; Canada provided 5 percent, and the remainder came from 17 other countries.

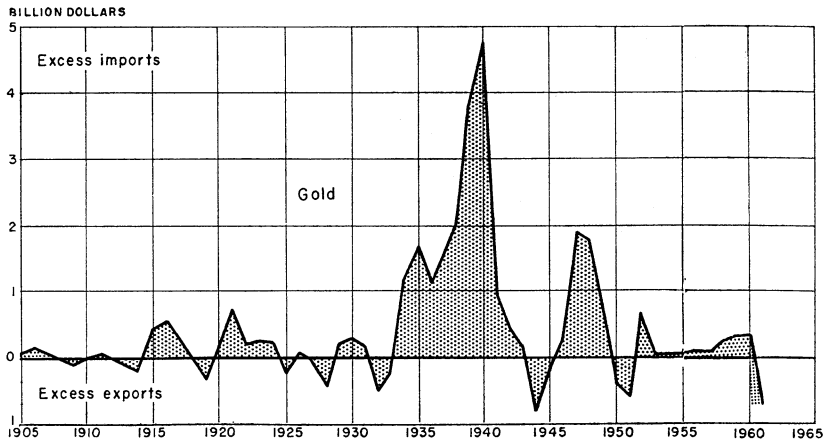


FIGURE 2.—Net imports or exports of gold, 1905–61.

[9] Prices quoted at "free" or black-market value of U.S. dollar in local markets.
[10] Engineering and Mining Journal. V. 162, Nos. 2–12, February–December 1961; v. 163, No. 1, January 1962. Markets section of each issue.
[11] McLaughlin, Donald H. The Dollar Versus Gold: Commercial and Financial Chronicle, Jan. 12, 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.

TABLE 12.—U.S. imports of gold in 1961, by countries

Country	Ore and base bullion		Refined bullion	
	Troy ounces	Value	Troy ounces	Value
North America:				
Canada	67,631	$2,364,152	14,404	$503,546
Honduras	1,685	58,965		
Mexico	38,843	1,352,515		
Netherlands Antilles	47	1,645		
Nicaragua	155,973	5,447,400		
Panama	118	4,151		
Total	264,297	9,228,828	14,404	503,546
South America:				
Argentina	1	34		
Bolivia	8	234		
Chile	20,585	720,873		
Colombia	1,750	57,812	634,628	22,147,996
Ecuador	15,032	523,106		
Peru	23,872	835,279	12,995	210,330
Venezuela			1,492	52,216
Total	61,248	2,137,338	649,115	22,410,542
Europe:				
Austria	37	1,301	538	18,840
Germany, West	435	16,319	122	4,256
Portugal	25,519	893,244		
United Kingdom	1,070	37,790	2,122	74,300
Total	27,061	948,654	2,782	97,396
Asia:				
Japan			25,431	890,125
Philippines	80,507	2,817,110	466,782	16,343,214
Total	80,507	2,817,110	492,213	17,233,339
Africa				
Liberia	6,683	233,922		
Mozambique	454	15,850		
Rhodesia and Nyasaland, Federation of	1,728	60,528		
Union of South Africa	224	7,840		
Total	9,089	318,140		
Oceania: Australia	13,937	487,710	806	28,436
Grand total	456,139	15,937,780	1,159,320	40,273,259

Source: Bureau of the Census.

TABLE 13.—U.S. exports of gold in 1961, by countries

Destination	Ore and base bullion		Refined bullion	
	Troy ounces	Value	Troy ounces	Value
North America:				
Canada			40,935	$1,429,370
Mexico	276	$9,900		
Total	276	9,900	40,935	1,429,370
Europe:				
Belgium-Luxembourg	3,415	119,525		
Portugal			23,789	833,867
United Kingdom	10,026	350,867	21,608,066	756,161,047
Total	13,441	470,392	21,631,855	756,994,914
Asia:				
Japan			5	181
Lebanon			300,000	10,500,002
Total			300,005	10,500,183
Africa: Ghana			159,897	5,596,385
Grand total	13,717	480,292	22,132,692	774,520,852

Source: Bureau of the Census.

WORLD REVIEW

World gold production rose for the eighth successive year, reaching a record high of 47.7 million ounces valued at $1.7 billion. The production gain (2.3 million ounces) was again attributed principally to expansion of gold mining operations in the Union of South Africa and to an increase in the estimated output of the U.S.S.R. South African output had nearly doubled in the past decade.

Production declined moderately in Canada, Mexico, Colombia, and Republic of the Congo, and it increased in Japan, the Philippines, Ghana, and Southern Rhodesia. Australia's output was virtually unchanged.

Australia.—Mine production of gold declined slightly to 1.07 million ounces, but it was only 4 percent less than the post-war peak output in 1954. Australia's gold output has been remarkably stable in the decade 1952–61, averaging 1.07 million ounces annually.

Western Australia, the leading gold-producing State, contributed about 81 percent of the Australian output. Northern Territory produced about 7 percent of the total; Queensland, 6 percent; Tasmania, 2 percent; and the other States, about 4 percent.

TABLE 14.—World production of gold by countries[1 2]

(Troy ounces)

Country[1]	1952–56 (average)	1957	1958	1959	1960	1961
North America:						
Canada	4,363,943	4,433,894	4,571,347	4,483,416	4,628,911	4,442,153
Central America and West Indies:						
Costa Rica[3]	[4] 535	705	310			
Cuba[3]	1,154	915	804	615	348	
Dominican Republic	124	286	780	513	[3] 308	
Guatemala[5]	253	360	370			
Honduras	20,469	2,025	1,714	[3] 2,798	[3] 2,172	[3] 1,685
Nicaragua	240,660	203,636	214,882	218,302	210,200	226,250
Salvador	11,985	2,508	2,372	2,474	1,121	
Mexico	412,643	346,328	332,246	313,663	300,256	268,694
United States[6]	1,899,606	1,800,000	1,759,000	1,635,000	1,679,800	1,566,800
Total	6,951,000	6,790,000	6,884,000	6,657,000	6,823,000	6,506,000
South America:						
Argentina	7,671	7,732	3,054	[3] 1,782	[3] 201	[3] 1
Bolivia	25,873	27,685	[7] 19,115	[7] 35,246	[7] 45,457	[7] 80,184
Brazil	153,400	150,000	186,000	180,000	[5] 180,000	[5] 180,000
British Guiana	21,944	16,490	17,500	3,448	2,364	1,702
Chile	130,835	103,590	110,952	78,640	109,055	[5] 110,000
Colombia	411,233	325,114	371,715	397,929	433,947	399,877
Ecuador	20,568	16,840	19,685	18,450	15,159	15,210
French Guiana	5,375	8,954	20,000	16,100	18,940	7,944
Peru	149,876	161,831	159,127	150,299	141,001	133,570
Surinam	6,665	6,516	4,258	5,826	4,932	4,011
Venezuela	43,828	89,654	76,009	53,766	46,868	30,071
Total[5]	977,000	914,000	987,000	941,000	998,000	963,000
Europe:						
Finland	18,654	22,377	22,152	23,374	20,351	20,602
France	42,053	35,173	35,559	42,150	39,545	41,796
Germany, West	4,256	3,681	[5] 4,000	[5] 4,000	[5] 4,000	[5] 4,000
Greece	[3] 4,957	7,877	5,787	4,340	4,823	[5] 4,800
Italy	9,184	6,334	4,802	3,261	3,310	600
Portugal	20,461	23,277	17,747	20,769	21,927	20,959
Spain	9,769	11,901	14,211	15,239	13,986	[5] 14,000
Sweden	91,784	97,063	127,574	103,000	91,160	[5] 110,000
U.S.S.R[5 8]	9,300,000	10,000,000	10,000,000	10,000,000	11,000,000	12,000,000
Yugoslavia	41,423	51,988	55,364	59,640	63,980	[5] 64,300
Total[5]	9,700,000	10,400,000	10,500,000	10,500,000	11,600,000	12,700,000

See footnotes at end of table.

TABLE 14.—World production of gold by countries[1 2]—Continued

(Troy ounces)

Country[1]	1952–56 (average)	1957	1958	1959	1960	1961
Asia:						
Burma	233	104	190	212	[7] 304	194
Cambodia	[4] 482	1,608	322	4,823	4,180	4,180
India	227,188	179.182	170,110	165,283	160,593	156,510
Japan	230,899	252,563	260,630	261,547	261,482	293,954
Korea:						
North[10]	130,000	130,000	130,000	130,000	130,000	130,000
Republic of	36,889	66,578	72,071	65,690	65,814	84,105
Malaya	20,427	11,157	22,484	26,739	20,745	12,486
Philippines	438,272	379,982	422,833	402,615	410,618	423,983
Sarawak	576	883	864	2,450	3,326	4,132
Saudi Arabia	37,052					
Taiwan	29,318	20,548	21,345	13,497	15,699	17,490
Total[1 5 9]	1,300,000	1,260,000	1,410,000	1,390,000	1,390,000	1,440,000
Africa:						
Angola	37		26	42	42	48
Bechuanaland	944	190	215	198	203	261
Cameroun, Republic of	1,066	10,899	2,009	971	415	538
Central Africa, Republic of	[6] 557	614	932	495	291	80
Congo, Republic of the (formerly Belgian)	365,749	371,020	352,276	347,967	316,195	232,611
Congo, Republic of	[6] 10,296	7,404	6,048	3,665	2,628	1,788
Eritrea	1,385	4,501	6,430	16,718	5,144	5,529
Ethiopia	27,128	[5] 25,000	36,369	41,439	40,915	[6] 41,500
Gabon, Republic of	[6] 143.336	22,727	15,921	16.172	17,696	15,286
Ghana	706,881	790,381	852,834	913,200	893,113	970,135
Kenya	9,958	7,388	7,753	9,145	8,646	[6] 12,122
Liberia	824	[11] 381	[5] 400	1,401	1,036	2,088
Malagasy Republic	1,353	842	804	193	273	347
Morocco	2,937				104	136
Mozambique	1,277	1,080	695	295	225	105
Nigeria	777	389	646	950	994	676
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia	2,776	3,270	3,729	4,685	5,527	4,279
Southern Rhodesia	518,947	536,849	554,838	566,883	562,703	570,095
Ruanda-Urundi	4,064	3,215	3,858	3,119	1,566	817
Sudan	1,980	1,158	1,571	1,419	2,605	1,500
Swaziland	51	7			806	1,325
Tanganyika[12]	72,095	63,280	68,250	95,794	107,009	101,067
Uganda (exports)	405	212	329	334	642	355
Union of South Africa	13,499,069	17,030,737	17,656,447	20,065,515	21,383,019	22,941,561
United Arab Republic (Egypt)	12,580	3,026	1,812	2,486	1,000	[5] 1,000
West Africa (formerly French)	959	331	3,247	[5] 8,000	[5] 8,000	[5] 8,000
Total	15,380,000	18,890,000	19,580,000	22,100,000	23,360,000	24,910,000
Oceania:						
Australia	1,050,444	1,083,941	1,103,980	1,085,104	1,086,014	1,070,467
Fiji	73,005	75,150	86,794	72,565	72,203	83,417
New Guinea	96.452	68,564	43,254	46,663	45,019	41,820
New Zealand	38,405	30,195	24,981	36,758	33,326	28,294
Papua	374	466	558	156	132	[5] 130
Total	1,258,680	1,258,316	1,259,567	1,241,246	1,236,694	1,224,128
World total (estimate)[1]	35,600,000	39,500,000	40,600,000	42,800,000	45,400,000	47,700,000

[1] In addition to countries listed, 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 the 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] One year only, as 1956 was first year of commercial production.

[5] Estimate.

[6] Refinery production.

[7] Exports.

[8] Average for 1953–56.

[9] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.

[10] Estimate according to Minerais et Metaux (France), except 1961.

[11] Purchases. Production may be greater.

[12] Including gold in lead concentrates exported amounting to: 5,526 ounces, 1952–56 (average); 9,192 ounces in 1957; 11,951 ounces in 1958; 10,391 ounces in 1959; 8,963 ounces in 1960; and 521 ounces in 1961.

Compiled by Augusta W. Jann and Richard W. Peters, Division of Foreign Activities.

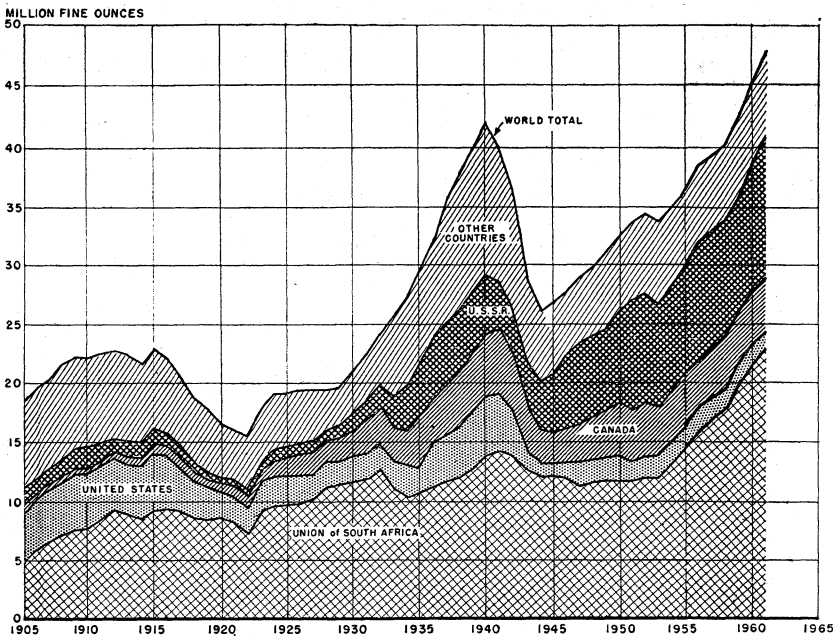


FIGURE 3.—World production of gold, 1905–61.

All gold was sold through the Commonwealth Bank by the Gold Producers Association. The average price received was equivalent to $35.21 an ounce, reflecting the premium paid for gold in world markets. Under the Gold Mining Assistance Act, the Commonwealth paid subsidies to gold producers totaling nearly £A700,000, equivalent to $1.6 million. Premiums received by producers on the sale of gold in world markets were offset against subsidy payments. Subsidy legislation was extended to June 1962. About 5,600 were employed in the gold mining industry.

Lake View and Star, Kalgoorlie, reported ore reserves of 3.7 million tons averaging 0.24 ounces of gold a ton. Operating costs increased slightly to $4.93 a ton. Great Boulder Gold Mines Ltd., reported reserves of 2.0 million tons, averaging 0.28 ounces a ton, and operating costs of $7.35 a ton. Gold Mines of Kalgoorlie increased its ore reserves to 2.3 million tons averaging 0.26 ounces a ton. Norseman Gold Corp. opened a 624-foot section of ore averaging 1.23 ounces a ton across 55 inches. In Queensland, Mount Morgan Ltd., produced 42,905 ounces of gold from blister copper and reported ore reserves of 12.3 million tons averaging 0.11 ounces of gold a ton and 1.1 percent copper.

Canada.—Gold production in Canada dropped 4 percent to 4.4 million ounces valued at Can$156.9 million, despite an increase in the price paid by the Royal Canadian Mint. The average mint price rose to $35.44, compared with $33.95 in 1960, reflecting a reduction in the quoted value of the Canadian dollar in relation to the U.S. dollar. The decrease in gold output resulted principally from the fact

that three mines were closed and only one new mine was brought into production. Lower production by Kerr-Addison Gold Mines, Ltd., Canada's leading producer, also contributed to the drop in production. Cost-assistance payments to lower grade, high-cost mines, under the Emergency Gold Mining Assistance Act (E.G.M.A.), continued to be an important factor in keeping production stable and in maintaining gold-mining communities. Of 53 lode mines operating, 41 received cost assistance under E.G.M.A.

Quebec, Manitoba, and Newfoundland were the only Provinces recording increased production. Ontario, the leading gold-producing Province, contributed 59 percent of the total output; next came Quebec, with 24 percent; the Northwest Territories, with 9 percent; and British Columbia, with 4 percent. About 86 percent of the total gold output came from lode and placer gold mines, and the remainder was recovered as a byproduct of base-metal ores. Approximately 15,600 were employed in lode gold mines.

After reaching a record high in 1960, gold production by the leading producer, Kerr-Addison Gold Mines Ltd., dropped 14 percent to 520,867 ounces valued at $18.6 million. The production drop reflected lower tonnage milled, and a lower grade of ore, which declined from $12.71 to $12.47 a ton. Average tons milled a day was 4,083, compared with 4,556 in 1960. However, the higher price received for gold more than compensated for the lower average grade of ore, resulting in a moderate increase in the value recovered per ton. The reserve of proved ore above the 4,500-foot level was 7.8 million tons averaging 0.415 ounce a ton ($14.50). Yukon Consolidated Gold Corp. operated five dredges and one hydraulicking operation in the Dawson City area of the Yukon Territory and produced nearly 80 percent of the total output in the Territory.

TABLE 15.—Canada: Geographical distribution of gold

(Troy ounces)

Province or Territory	1960 [1]	1961
British Columbia	212,859	156,207
Northwest Territories	418,104	404,798
Ontario	2,732,673	2,611,978
Prairie Provinces [2]	137,728	132,256
Quebec	1,035,914	1,056,315
Yukon	78,115	66,147
Newfoundland and Nova Scotia	13,518	14,452
Total	4,628,911	4,442,153

[1] Revised figures.
[2] Alberta, Saskatchewan, and Manitoba.

Source: Verity, T. W., Gold 1961 (Preliminary). Miner. Resources Division, Dept. Min. and Tech. Surveys, Ottawa, Canada, February 1962, 14 pp.

Colombia.—Production of gold decreased 8 percent to 399,900 ounces. South American Gold & Platinum Co. recovered 156,300 ounces of gold from dredging operations and underground mining, about 6 percent less than in 1960. In dredging operations, the volume of gravel treated increased 5 percent, but the average grade declined; in underground mining operations, the tonnage of ore milled decreased, but the average grade increased.

Six dredges were operated throughout the year, four in the Choco district and two in Narino. Dredging reserves at yearend were estimated at 64.2 million cubic yards, averaging 17.4 cents a yard, compared with 64.4 million yards averaging 20.0 cents in 1960. Underground reserves increased to 539,000 tons averaging 0.69 ounces of gold a ton, compared with 414,600 tons averaging 0.78 ounces of gold a ton in 1960.

The company sold its gold to the Bank of the Republic or through the Colombian Mining Association and received an average of $35.17 an ounce.[13]

Ghana.—Gold production reached a record high of 970,140 ounces, about 9 percent more than in 1960. Ashanti Goldfields Corp., Ltd., the leading producer, continued to increase its gold output for the fifth consecutive year, establishing a new high of 380,780 ounces valued at $13.3 million, nearly 40 percent of the country's total production. The company reported ore reserves of 3 million tons, averaging 0.94 ounces a ton, and a total value of $98 million. Operating costs were about $12.40 a ton. Output of gold by Amalgamated Blanket Areas, Ariston Gold Mines, Bikiani, Konongo, and Bremani declined, but increased production was reported by Ghana Main Reef.

India.—Continuing the declining trend existing since 1954, gold output dropped to 156,500 ounces, the lowest since 1946. The state-owned Kolar Gold Mines, which produce most of India's gold, were paid a subsidy by the Central Government to meet the difference between production costs and the international price of $35 an ounce. Arrangements were made for the Government of India to take over the mines from the Mysore Government. Mining methods and problems of ground support and ventilation in the deep mines of the Kolar Gold Field were described.[14]

Philippines.—Output of gold, the most important Philippine mineral commodity, rose 3 percent to 423,980 ounces valued at $14.8 million. Beguet Consolidated, the largest operator, produced about half of the total production. A bill extending Government subsidies to gold producers to mid-1964 was passed by the Philippine Congress in June. The subsidy bill provides for payments at rates ranging from ₱155 to ₱170 an ounce on gold sold to the Central Bank, approximately equivalent to $43 to $47 an ounce. The bill also directs that subsidy payments be made from taxes paid by gold producers.

Rhodesia and Nyasaland, Federation of.—Output of gold in Southern Rhodesia rose to a 17-year high of 570,100 ounces. The higher output was attributed largely to the mining of richer ore to offset rising costs. The Cam and Motor mine of Rio Tinto, the largest gold producers, reduced its operations one-third to extend the life of the mine. Monthly tonnage was lowered from 25,000 to 17,000. Rhodesian Corp., Ltd., closed the Fred and Redwing mines in the Bulaways district, as minable reserves were nearly depleted and working conditions had become unsafe. The Phoenix Prince mine in the Salisbury district also was closed. The Dolny mine reported increased ore reserves.

The Southern Rhodesia Legislative Assembly continued to pay a subsidy of $4.20 a ton on arsenical ores treated in its roasting plant.

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[13] South American Gold & Platinum Co., 45th Ann. Rept. 1961, pp. 17, 19.
[14] Taylor, J. T. M. Mining Practice on the Kolar Gold Field, India. Inst. Min. and Met. Bull. (London), vol. 70, No. 656, July 1961, pp. 575–604.

Union of South Africa.—Production of gold rose for the tenth successive year, setting a new record of 22.9 million ounces valued at $803 million, 7 percent more than in 1960. As in preceding years, the production gain reflected an increase in tons milled and in average grade of ore, particularly at newer mines in the Far West Rand and Kerksdorp areas of the Transvaal and in the Orange Free State. The supply of both European and African labor continued to improve; African labor was adequate to meet the requirements of the gold mining industry. The average number of employees was 49,150 Europeans and 399,000 Africans. Working profit on gold and uranium increased $13.2 million to $369.6 million. The estimated reserve of minable ore was 163.6 million tons averaging 0.38 ounce a ton.

Anglo American Corp. of South Africa, Ltd., reported that its group of mines produced 7.1 million ounces of gold, 32 percent of the total produced in the Union of South Africa and 20 percent of the gold produced in the free world. The company reported that Western Reefs Exploration and Development Co., Ltd. established a world shaft-sinking record by an advance of 1,118 feet in a month.[15]

Consolidated Gold Fields of South Africa, Ltd., reported that its Gold Fields' group of companies continued to expand output of gold and uranium; several mines reported record outputs and profits. The Gold Fields' group milled 12.1 million tons of ore, yielding 0.33 ounce a ton, at a cost of $21.51 an ounce.[16] Doornfontein Gold Mining Co., Ltd., increased production and grade of ore and reduced operating costs. The company reported 1.3 million tons milled, averaging about 0.41 ounce a ton, at a cost of $19.88 an ounce. West Driefontein Gold Mining Co., the world's leading gold producer, increased its ore output to 1.6 million tons and reduced operating costs to $10.64 an ounce. Working profit of US$38.4 million was a world record for a gold mining company. Ore reserves on the Carbon Leader were unchanged at 3.4 million tons, averaging 0.78 ounce a ton gold and 0.24 pound uranium oxide per ton. An additional 700,000 tons of ore, averaging 0.49 ounce a ton, was developed on the Ventersdorp Contact Reef.

Union Corp., Ltd., reported that its companies milled 10.5 million tons of ore, yielding $9.07 a ton, at a working cost of US$5.56 a ton.[17] representing a moderate increase in quantity, grade, and cost over 1960. Ore reserves totaled 32.2 million tons averaging 0.29 ounce a ton, also moderately higher, both in quantity and grade, than at the end of 1960. Grootvlei Proprietary Mines on the East Rand milled 2.6 million tons of ore, yielding 0.21 ounce a ton, at a cost of $4.41 a ton and reported an ore reserve of 10.8 million tons, averaging 0.21 ounce a ton across a stopeing width of 50 inches. Operating results for the past 5 years at St. Helena Gold Mines in the Orange Free State showed a continuous rise in tons milled, grade of ore, and yield of gold. In 1961, 2.2 million tons of ore was milled, averaging 0.35 ounce a ton, at a cost of $5.96 a ton. Ore reserves totaled 6 million tons averaging 0.44 ounce a ton across a stoping width of 57 inches.

[15] Anglo American Corp. of South Africa, Ltd. 45th Annual Report. 1961, pp. 8, 9.
[16] The Consolidated Gold Fields of South Africa, Ltd. 74th Annual Report. 1961, p. 24.
[17] Union Corp., Ltd. Reports and Accounts for the Year Ended 31st December, 1961. P. 22.

TABLE 16.—Union of South Africa: Salient statistics of the gold mining industry

	1952–56 (average)	1957	1958	1959	1960	1961
Ore milled—thousand tons	63,057	66,114	65,542	70,479	71,259	67,365
Gold recovered—thousand troy ounces	13,082	[1] 16,541	[1] 17,666	[1] 20,067	[1] 21,386	[1] 22,942
Gold recovered—ounces per ton	0.206	.250	.261	.278	.293	.130
Working revenue (gold)—thousands	$458,088	$595,271	$613,650	$700,426	$750,550	$773,892
Working revenue per ton milled	7.21	8.80	9.21	9.79	10.39	11.49
Working cost—thousands	340,587	419,642	430,715	448,130	464,386	476,208
Working cost per ton	5.39	6.35	6.57	6.35	6.51	7.06
Working cost per ounce of gold	26.25	25.38	25.03	22.74	22.13	21.63
Estimated working profit from gold—thousands	114,541	161,934	171,797	241,019	274,341	297,685
Estimated working profit per ton from gold	1.76	2.45	2.64	3.44	3.87	4.44
Tons treated for uranium [1]—thousands	8,968	22,364	24,297	24,658	24,781	17,093
Uranium oxide recovered—thousand pounds	3,960	11,408	12,497	12,889	12,817	10,937
Uranium oxide recovered—pounds per ton	.479	.510	.514	.523	.517	.637
Estimated uranium profits—thousands	$29,276	$93,263	$105,678	$76,268	$77,033	$67,136
Dividends—do	60,741	102,758	119,199	127,040	131,528	141,621

[1] Includes gold produced by nonmembers of Chamber of Mines.

Source: Transvaal Chamber of Mines and Orange Free State Chamber of Mines.

TECHNOLOGY

Mechanization and automation in the gold recovery plants on the Rand in the Union of South Africa reduced operating costs and extended the life of the older mines. At E.R.P.M. mines, automatic titrators, testing various plant solutions for cyanide and lime, regulated the addition of these reagents. These titrations were done at preset intervals, and results were recorded on circular charts; pneumatic signals controlled the feed of cyanide and lime. Adoption of the Steller filter and the introduction of electrically heated calcining furnaces to replace coal-fired furnaces increased efficiency of operations and reduced costs at some plants.[18]

Pilot-plant tests to recover gold from pulp electrolytically indicated that the filtration, clarification, and precipitation steps may be eliminated and gold losses in solution thereby reduced.[19]

Innovations in small-scale placer-mining methods, particularly the adoption of skindiving equipment and various suction devices for elevating gold-bearing gravel from stream bottoms to portable sluices, provided an effective means of reworking areas previously abandoned.

The replacement of sandfill by hydraulic fill, the adoption of natural-gas-fired boilers to replace coal-fired equipment, and the installation of automatically controlled crushing equipment increased efficiency and lowered operating costs at Dome mines.[20]

The devolpment of a method of plating gold on molybdenum to replace mechanical coating methods was announced by Platronics, Inc., at Linden, N. J. The application of the process may reduce the

[18] Chemical Trade Journal and Chemical Engineering (London). Gold Recovery Today. V. 149, No. 3877, Sept. 22, 1961, p. 647.

[19] South African Mining and Engineering Journal. Recent Advances in Gold Recovery. V. 72, pt. 2, No. 3572, July 21, 1961, pp. 123, 125, 127.

[20] Northern Miner (Toronto). Dome Reaps Benefits from Improvements in Mine Operation. V. 47, No. 25, Sept. 14, 1961, pp. 1–9.

cost of molybdenum discs used in electronic components. Gold electroplating may also be applied to silicon, germanium, and other semiconductor materials for brazing.[21]

A patent[22] was issued for a process of extracting a precious metal compound from an aqueous solution of a salt of the precious metal, using a water-insoluble macromolecular organic compound, such as paracyanogen, polymethacrylonitrile, or polyacrylonitrile, as a selective reagent.

A new electroplating compound, Orotemp 24, was developed to produce stress-free 24-karat deposits on ferroalloys used in transistors and printed circuits. The deposit is extremely ductile and has high resistance to corrosion at elevated temperatures.[23]

Papers presented at the Seventh Commonwealth Mining and Metallurgical Congress in Johannesburg, Union of South Africa, in April 1961, discussed many recent advances in mining and processing of gold ores in South Africa.[24]

Investigations of a resin-in-pulp ion-exchange process for treating cyanide-leached gold-bearing pulps indicated that when it is used in conjunction with a technique known as dynamic electrolution, the process may be economically feasible on clean gold ores.[25] The potential value of the process is enhanced for treating ores difficult to filter, for the filtration step is eliminated.

Fluid-bed roasting of flotation concentrate for subsequent treatment by cyanidation increased overall recovery of gold from arsenopyrite ores at three mines in the Red Lake Camp of Ontario. The roasting techniques and operating details, which increased overall recovery 10 percent to more than 90 percent, were described.[26]

A new solution, developed for electroless deposition of gold containing potassium gold cyanide, citric acid, tungstic acid, and N, N-diethylglycine sodium salt, was evaluated, and the optimum operating conditions were described.[27]

A method of treating small quantities of flotation concentrate and amalgamation residue at isolated gold mines by batch cyanidation to recover and convert the contained gold into bullion was described.[28]

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[21] American Metal Market. Gold Plating on Molybdenum Developed. V. 68, No. 243, Dec. 20, 1961, p. 14.

[22] Volker, T., and H. Zima (assigned to Rohm & Haas, Darmstadt, Germany). Extraction of Precious Metal Compounds From an Aqueous Solution. U.S. Patent 3,006,756, Oct. 31, 1961.

[23] Chemical Engineering. Gold Electroplating. V. 68, No. 19, Sept. 18, 1961, pp. 84–86.

[24] Krige, D. G. Developments in the Valuation of Gold Mining Properties from Borehole Results. Trans. Seventh Commonwealth Min. & Met. Cong., v. 2, 1961, pp. 537–561.

Barcza, M., and J. deV. Lambrechts. Ventilation and Air Conditioning Practice in South African Gold Mines. Trans. Seventh Commonwealth Min. & Met. Cong., v. 2, 1961, pp. 725–742.

Sichel, H. S., and R. St.J. Rowland. Recent Advances in Mine Sampling and Underground Valuation Practice in South African Gold Fields. Trans. Seventh Commonwealth Min. & Met. Cong., v. 2, 1961, pp. 563–586.

Jackson, O. A. E. A Review of Modern Milling Practice at the South African Gold and Uranium Mines. Trans. Seventh Commonwealth Min. & Met. Cong., v. 3, 1961, pp. 937–970.

Douglas, J. K. E., and A. T. Moir. A Review of the South African Gold Recovery Practice. Trans. Seventh Commonwealth Min. & Met. Cong., v. 3, 1961, pp. 971–1003.

[25] Davison, J., F. Read, F. D. L. Noakes, and T. V. Arden. Ion Exchange for Gold Recovery. Trans. Inst. Min. and Met., v. 70, pt. 5, 1960–61, pp. 247–290.

[26] Wright, K. P. Fluid-Bed Roasting Practice in the Red Lake Camp. Canadian Min. and Met. Bull., v. 54, No. 592, August 1961, pp. 595–600.

[27] Walton, Robert. Electroless Deposition of Gold from Aqueous Solution on Base Metals. J. Electrochem. Soc., v. 108, No. 8, August 1961, pp. 767–774.

[28] Deco Trefoil. Batch Cyanidation of Concentrates. V. 25, No. 5, November–December 1961, pp. 15–16.

An automatic gold-plating process, designed to improve printed circuits for modular systems, was described.[29] The process, which plates contact tabs, is capable of plating more than 100,000 circuit cards per day.

A new 24-karat neutral gold salt (Orotemp 24) was developed by Technic, Inc., Providence, R.I., for gold plating transistor headers and printed circuit boards. The company stated that the new salts produced a stress-free, ultra-pure 24-karat satin bright, extremely ductile, fine-grained deposit having exceptional heat corrosion resistance.[30]

A high-purity gold boron alloy was developed for the manufacture of silicon transistors by Alloys Unlimited, Inc., Long Island City, N.Y., a supplier of materials and subcomponents for the semiconductor industry.[31] The alloy can be clad to 2/10 mil on a suitable substrate, and it can be used in wire for fabricating gold-bonded silicon diodes. The company also reported that it had developed a gold-tin laminate for bonding silicon diodes to the dumet stud of the conventional glass diode package in one operation. The new laminate was reported to have advantages over conventional alloys for this use.

Closed-circuit television equipment was installed at the Harte-beestfontein gold mine in the Transvaal to aid mining operations. Cameras installed to monitor loading operations at the kibble in the No. 4 shaft and skip loading in the No. 2 shaft enable hoisting crews to observe these operations and thus contribute to increased efficiency and safety.[32]

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[29] Iron Age. Automatic Lines Deposit Gold on Printed-Circuit Cards. V. 188, No. 24, Dec. 14, 1961, pp. 114–115.
[30] Electronic News. Materials. V. 6, No. 278, Aug. 28, 1961, p. 30.
[31] American Metal Market. Newer Metals Making High-Purity Gold Boron. V. 68, No. 221, Nov. 17, 1961, p. 14.
[32] Mining Magazine (London), v. 106, No. 3, March 1962, p. 130.

Graphite

By Harold J. Drake [1] and Betty Ann Brett [2]

WORLD PRODUCTION of natural graphite decreased in 1961. Republic of Korea was the leading producer in the free world, followed by Austria and Mexico. The decreased world production was attributed to the major decline in output of Mexican graphite.

TABLE 1.—Salient graphite statistics

	1952-56 (average)	1957	1958	1959	1960	1961
United States:						
Consumption.....short tons..	36,100	41,000	28,800	40,200	37,300	35,700
Value.....thousands..	$5,085	$5,568	$3,972	$5,395	$4,773	$4,651
Imports for consumption..short tons..	46,300	41,500	27,100	37,000	[1] 48,300	29,700
Value.....thousands..	$2,586	$2,107	$1,203	$1,527	[1] $1,755	$1,332
Exports.....short tons..	1,400	1,300	1,200	1,400	1,900	1,600
Value.....thousands..	$175	$226	$193	$222	$289	$257
World: Production.....short tons..	235,000	410,000	350,000	410,000	465,000	450,000

[1] Revised figure.

DOMESTIC PRODUCTION

Crystalline flake graphite was produced by Southwestern Graphite Co. at Burnet, Tex., and by Graphite Corporation of America at Chester Springs, Pa.

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.; International Graphite & Electrode Division, Speer Carbon Co., St. Marys, Pa., and Niagara Falls, N.Y.; and Stackpole Carbon Co., St. Marys, Pa. The Dow Chemical Co. produced graphite anodes for its own use at Midland, Mich.

CONSUMPTION AND USES

Domestic consumption of natural graphite in 1961 decreased slightly. Use of graphite for batteries, carbon brushes, crucibles, and refractories increased, but for other purposes declined. The

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[2] Statistical clerk, Division of Minerals.

greatest decline in a major use, 11 percent, was in foundry facings. Crucibles, foundry facings, lubricants, pencils, refractories, and steelmaking used 89 percent of the total consumption.

TABLE 2.—Consumption of natural graphite in the United States

Year	Short tons	Value	Year	Short tons	Value
1952-56 (average)	36,096	$5,084,800	1959	40,239	$5,394,800
1957	41,029	5,568,000	1960	37,289	4,773,400
1958	28,823	3,971,800	1961	35,652	4,651,200

TABLE 3.—Consumption of natural graphite in the United States in 1961, by uses

Use	Crystalline flake		Ceylon amorphous		Other amorphous [1]		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Batteries	71	$21,251			833	$86,822	904	$108,073
Bearings	6	2,960	57	$25,819	70	24,655	133	53,434
Brake linings	375	130,333	228	64,638	246	62,884	849	257,855
Carbon brushes	121	44,397	317	162,491	348	54,725	786	261,613
Crucibles, retorts, stoppers, sleeves, and nozzles	[2] 3,141	[2] 499,238					3,141	499,238
Foundry facings	350	61,544	442	84,308	11,744	825,919	12,536	971,771
Lubricants	2,004	384,626	1,299	254,971	1,383	189,810	4,686	829,407
Packings	167	84,361	29	19,365	138	32,795	334	136,521
Paints and polishes					385	31,863	385	31,863
Pencils	622	197,813	516	152,859	447	59,811	1,585	410,483
Refractories	113	19,791			3,843	412,702	3,956	432,493
Rubber	[2] 50	[2] 23,388	79	10,954			129	34,342
Steelmaking	95	14,901			5,747	509,472	5,842	524,373
Other [3]	229	65,759	36	14,819	121	19,123	386	99,701
Total	7,344	1,550,362	3,003	790,224	25,305	2,310,581	35,652	4,651,167

[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, electrodes, electronic products, powdered-metal parts, specialties, and other uses not specified.

STOCKS

The Office of Emergency Planning released the quantities in short dry tons of natural graphite in Government stockpiles. The national (strategic) stockpile contained 4,500 tons of Ceylon amorphous lump graphite; the Commodity Credit Corporation and the supplemental stockpile contained 1,400 tons. The national stockpile contained 33,000 tons of Malagasy Republic crystalline graphite. Graphite other than Ceylon amorphous and Malagasy Republic crystalline amounted to 4,800 tons, all in the national stockpile.

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 21½ cents; 90 to 92 percent carbon, 21 to 24½ cents; 95 to 97 percent carbon, 29 to 31½ cents; and No. 1 flake, 90 to 95 percent carbon, 29 to 31 cents. Amorphous graphite prices per pound are shown by this publication as 6 to 9½ cents.

Prices shown by E&MJ Metal and Mineral Markets were: Flake and crystalline graphite. f.o.b. source, bags, per metric ton, Malagasy Republic, $70 to $200; Norway, $80 to $140; and West Germany, $110 to $320. Ceylon graphite was listed at $95 to $250 per long ton. Amorphous graphite was quoted as follows: Mexico (bulk) per metric ton, $17 to $20; Republic of Korea (bulk) per metric ton, $15; and Hong Kong (bags) per long ton, $21.

FOREIGN TRADE[3]

Imports for consumption decreased markedly. Mexico, West Germany, Norway, Ceylon, and Hong Kong reported decreases, and of the major suppliers only Malagasy Republic reported an increase. The total decline in imports was nearly equivalent to the decrease in graphite imported from Mexico.

Exports of natural graphite declined but remained relatively high.

[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 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
1952-56 (average)	8,578	[1]$1,259,497	233	$36,458	37,286	[1]$1,277,689	230	[1]$12,467	46,327	[1]$2,586,111
1957	5,456	636,684	47	14,870	36,019	1,453,051	8	2,197	41,530	2,106,802
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:										
North America:										
Mexico	------	----------	------	-------	[2]36,913	[2] 708,923	------	--------	[2]36,913	[2] 708,923
Europe:										
France	40	23,474	------	-------	------	----------	------	--------	40	23,474
Germany, West	220	39,917	121	36,630	727	85,418	176	53,280	1,244	215,245
Norway	------	----------	------	-------	1,637	129,805	------	--------	1,637	129,805
Switzerland	------	----------	------	-------	------	----------	9	3,672	9	3,672
Asia:										
Ceylon	------	----------	------	-------	2,836	341,202	------	--------	2,836	341,202
Hong Kong	------	----------	------	-------	2,027	45,347	------	--------	2,027	45,347
India	------	----------	------	-------	1	180	------	--------	1	180
Turkey	28	1,680	------	-------	------	----------	------	--------	28	1,680
Africa:										
British East Africa	------	----------	------	-------	124	10,262	------	--------	124	10,262
Malagasy Republic	3,465	275,682	------	-------	------	----------	------	--------	3,465	275,682
Total	3,753	340,753	121	36,630	[2]44,265	[2]1,321,137	185	56,952	[2]48,324	[2] 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	------	----------	------	-------	1,186	27,301	113	2,620	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	25,133	860,837	183	25,407	29,784	1,332,175

[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.

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.		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1960:								
North America:								
Canada	686	$75,559	36	$13,511	1	$1,114	723	$90,184
Cuba	10	1,466	25	5,089			35	6,555
El Salvador			3	620			3	620
Mexico	114	14,829	32	13,282	42	5,606	188	33,717
Netherlands Antilles					(1)	396	(1)	396
South America:								
Argentina	2	631					2	631
Bolivia			3	574			3	574
Brazil	110	16,055			169	24,672	279	40,727
Chile	3	448	2	868	2	825	7	2,141
Colombia			9	2,718			9	2,718
Peru			1	304			1	304
Venezuela			35	7,698	40	7,649	75	15,347
Europe:								
Austria	11	1,836					11	1,836
Czechoslovakia	12	1,978					12	1,978
Denmark	11	1,836					11	1,836
France	59	11,908			12	3,183	71	15,091
Germany, West	9	1,324			(1)	202	9	1,526
Greece					3	1,978	3	1,978
Italy	1	192			(1)	616	1	808
Netherlands			(1)	620			(1)	620
Sweden	5	952					5	952
United Kingdom	306	46,312			11	1,718	317	48,030
Asia:								
India	23	3,546	2	884			25	4,430
Pakistan	4	770					4	770
Philippines	11	1,708	16	4,621	18	5,595	45	11,924
Saudi Arabia			(1)	408			(1)	408
Turkey					1	824	1	824
Africa: United Arab Republic (Egypt)					15	1,911	15	1,911
Oceania: Australia					(1)	271	(1)	271
Total	1,377	181,350	164	51,197	314	56,560	1,855	289,107
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			(1)	216			(1)	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			(1)	125			(1)	125
Pakistan					4	828	4	828
Philippines			7	2,090	11	4,393	18	6,483
Saudi Arabia			(1)	228			(1)	228
Oceania: Australia	13	2,886					13	2,886
Total	1,328	185,863	91	34,428	139	36,670	1,558	256,961

[1] Less than 1 ton.

Source: Bureau of the Census.

WORLD REVIEW

World production of natural graphite decreased 3 percent from the peak of 1960. Of the major producing countries, increased production was reported in West Germany and Malagasy Republic, and decreased output was reported in Mexico, Austria, Ceylon, and Republic of Korea.

TABLE 6.—World production of natural graphite, by countries[1 2]

(Short tons)

Country[1]	1952–56 (average)	1957	1958	1959	1960	1961
North America:						
Canada	1,594					3
Mexico	29,813	25,938	21,564	30,684	37,826	[3] 21,500
United States	[4] 5,944	(5)	(5)	(5)	(5)	(5)
South America:						
Argentina	162	451	525	554	[3] 550	[3] 550
Brazil	806	890	1,323	1,334	1,433	(6)
Europe:						
Austria	19,466	20,857	23,318	68,444	97,043	89,255
Germany, West	10,589	12,554	12,021	12,361	12,768	[3] 13,600
Italy	4,104	3,093	4,393	3,412	4,098	4,484
Norway	4,664	6,266	4,927	5,396	6,589	[3] 6,600
Spain	470	304	227	457	288	[3] 330
Sweden	150	822	593	[3] 700	[3] 700	[3] 700
U.S.S.R.[3]	(6)	50,000	50,000	50,000	50,000	55,000
Yugoslavia	358	1,102	992	1,102	[3] 1,100	[3] 1,100
Asia:						
Ceylon (exports)	9,329	9,223	6,342	8,816	10,107	10,016
China[3]	(6)	(6)	35,000	45,000	45,000	45,000
Hong Kong	[7] 1,684	3,703	3,680	3,676	4,255	1,865
India	1,346	(6)	(6)	(6)	(6)	(6)
Japan	4,404	5,272	3,817	4,453	4,979	3,811
Korea:						
North	7,631	34,969	[3] 45,000	[3] 55,000	[3] 55,000	[3] 55,000
Republic of	43,991	162,703	103,806	91,045	101,722	97,542
Taiwan	612	2,756	915	621	550	[3] 550
Africa:						
Kenya	290	1,056	739	635	1,113	
Malagasy Republic (Madagascar)	16,679	16,989	13,427	12,614	15,923	[3] 17,000
Morocco	83			132		
South-West Africa	486					
Tanganyika	10			28	26	
Union of South Africa	1,177	1,750	875	617	894	963
Oceania: Australia	44					
World total (estimate)[1 2]	235,000	410,000	350,000	410,000	465,000	450,000

[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] Estimate.
[4] Average annual production 1952–53.
[5] Figure withheld to avoid disclosing individual company confidential data, included in world total.
[6] Data not available; estimate by senior author of chapter included in total.
[7] Average annual production 1953–56.

Compiled by Helen L. Hunt, Division of Foreign Activities.

Australia.—A graphite deposit about 30 miles from Cloncurry, Queensland, was reported to contain a large reserve. The deposit was to be mined by open-pit methods, and the product was to be exported to India.[4]

Brazil.—Production of graphite in recent years had been limited to Minas Gerais although occurrence of the mineral is widespread

[4] Queensland Government Mining Journal (Australia). Graphite Find in Cloncurry Area. V. 62, No. 716, June 1961, p. 275.

throughout the country. The graphite was used principally in pencils, foundries, dry cells, and greases.[5]

Ceylon.—Total exports of graphite declined slightly. The three major consumers of Ceylon graphite were the United States, the United Kingdom, and Japan. The average value per ton based on the first 9 months increased slightly.[6]

TABLE 7.—Ceylon: Exports of graphite by countries [1]

(Short tons)

Destination	1960	1961	Destination	1960	1961
North America:			Asia:		
Canada	28	46	India	494	492
United States	2,380	2,218	Japan	3,105	2,917
Europe:			Pakistan	69	108
Belgium	2	45	Philippines	37	56
Czechoslovakia	158	242	Oceania: Australia	480	355
France	224	196	Other countries	41	56
Germany, West	129	55			
Netherlands	79	45	Total	10,107	10,015
United Kingdom	2,881	3,184			

[1] This table incorporates some revisions.

Compiled from Ceylon Customs Returns by Bertha M. Duggan, Division of Foreign Activities

TABLE 8.—Ceylon: Exports [1] of graphite to the United States, by grades, in 1961 [2]

Grade	Short tons	Percent of total	Value per ton
97 percent carbon or higher	767	45	$142.10
90–96 percent carbon	837	50	103.87
Less than 90 percent carbon	84	5	100.00
Total	1,688	100	121.05

[1] First 9 months of 1961.
[2] U.S. Embassy, Colombo, Ceylon, State Department Dispatch 32: July 14, 1961, pp. 1–2, State Department Dispatch 235: Oct. 16, 1961, pp. 1–2, State Department Dispatch 914: Apr. 24, 1961, p. 1.

Hong Kong.—Exploitation of the amorphous graphite deposits on West Brother Island continued. Material with a fixed carbon content of 75 percent or more was exported, principally to the United States. Graphite containing less than 50 percent fixed carbon was used as a fuel in local brick plants.[7]

India.—The National Physics Laboratory in New Delhi developed a beneficiation process for Indian graphites that yields a fine, low-ash product. This made possible the use of previously unsuitable material in brushes, crucibles, dry cells, and other applications.[8]

Korea, Republic of.—In 1960, 55 percent of the 101,000 short tons of amorphous (75 percent carbon) and crystalline (80 percent carbon) graphite produced was exported. Nearly all the export tonnage was amorphous and was sent to Japan for use as a fuel. The 700 tons

[5] Bureau of Mines. Mineral Trade Notes. V. 53, No. 5, November 1961, pp. 21–22.
[6] U.S. Embassy, Colombo, Ceylon, State Department Dispatch 32: July 14, 1961, pp. 1–2, State Department Dispatch 235: Oct. 16, 1961, pp. 1–2, State Department Dispatch 914: Apr. 24, 1961, p. 1.
[7] Mining Journal (London). The Mineral Deposits of Hong Kong. V. 257, No. 6579, Sept. 22, 1961, p. 285.
[8] Mining Journal (London). Mining Miscellany. V. 257, No. 6568, July 7, 1961, p. 16.

of crystalline flake produced was used in crucibles, steelmaking, and other industrial applications.[9]

Mexico.—Production of graphite in 1961 declined 43 percent below production in 1960. Strikes, increased competition, and rising costs led to the curtailed production.[10] One of the effects of the curtailment was a decline of 47 percent in exports to the United States.

TABLE 9.—Malagasy Republic: Exports of graphite, by countries

(Short tons)

Destination	1959	1960	Destination	1959	1960
North America: United States	3,836	3,638	Europe—Continued		
Europe:			Spain	203	14
Belgium-Luxembourg	46	53	United Kingdom	2,542	3,947
France	1,919	3,663	Asia: Japan	121	368
Germany, West	2,472	4,156	Africa: Union of South Africa	13	24
Italy	644	1,372	Oceania: Australia	261	106
Netherlands	10	39	Other countries	12	14
Poland	65	11			
Rumania		38	Total	12,144	17,443

Compiled from Customs Returns of the Malagasy Republic by Bertha M. Duggan, Division of Foreign Activities.

TECHNOLOGY

Basic and applied research on oriented graphites continued, with considerable emphasis on missile and space-vehicle applications. The number of companies producing or investigating these special graphites is increasing rapidly, which should lead to lower prices and applications apart from the space field.

Armour Research Foundation announced the development of a strong, uniform, fine-bodied graphite.[11] The graphite can be loaded with 30 percent uranium dicarbide powder, which doubles the strength of the graphite matrix. Development of a new nuclear fuel, pyrolytic-graphite-coated uranium dicarbide particles, may lead to the elimination of many of the elaborate protective devices in present reactors.[12] Radioactive byproducts of the fission process are contained by the impervious graphite and do not contaminate most available coolants or the steam produced.

Graphite, a magnesium oxide, and boron oxide are the components of a new neutron shielding material.[13]

A new process was patented for preparing graphite, in which an oxygen-fed, hot, graphitizing zone is moved back and forth over a stationary bed of pelleted coke.[14] Control of the movement of the hot zone is maintained by the introduction of hot, inert gases at both ends of the reactor.

[9] Bureau of Mines. Mineral Trade Notes. V. 53, No. 4, October 1961, pp. 25–26.
[10] Bureau of Mines. Mineral Trade Notes. V. 54, No. 2, February 1962, pp. 20–21.
[11] Chemical & Engineering News. ARF Makes Strong, Fast-Molding Graphite. V. 39, No. 33, Aug. 14, 1961, p. 62.
[12] Ceramic Industry. Fossil Fuel Economy Promised by New Fuel Particles. V. 77, No. 1, July 1961, p. 32.
[13] Smith, Charles R. F., and Edward L. Reed (assigned to North American Aviation, Inc.). Graphite Boron Neutron Shielding. U.S. Pat. 2,988,522, June 13, 1961.
[14] Carr, Norman L. (assigned to Pure Oil Company). Graphite Forming Process. U.S. Pat. 3,013,864, Dec. 19, 1961.

New processes were reported using 10 to 90 percent graphite in combination with various metals to form self-lubricating materials,[15] which are expected to be employed in bearings, nuclear devices, graphite metal brushes, electrical contacts, and resistance elements.

A new grade of carbon-graphite material was developed that has greater resistance than previous grades to oxidation at higher temperatures.[16] For use in seals, bearings, valves, and other products, the material is chemically inert and self-lubricating.

Semiconducting diamonds were made by subjecting a mixture of graphite and a catalyst to pressures of about 1 million psi at temperatures exceeding 2,000° F.[17]

A new graphite lubricant was developed using synthetic colloidal graphite in a petroleum oil carrier.[18] Another type of graphite lubricant was introduced for use on conveyors, chains, wire ropes, cranes, and large open gears.[19] The material is applied with a brush and requires no mixing or thinning.

Research in graphite cloth resulted in tripled strength and doubled flexibility.[20] Graphite fiber research and development in Japan was carried out at Osaka and Yokohama by personnel of major manufacturing concerns.[21]

Electrostatic apparatus and the process for the concentration of low-grade ores such as graphite were improved.[22]

A patent was issued for a method of producing a formed, artificial graphite article using comminuted carbon, a carbonizable binder, and one or more carbides.[23]

An improved method [24] was developed for reacting columbium-titanium carbide and graphite to produce a columbium-coated refractory, and a method was patented [25] for treating a graphite body with a liquid eutectic mixture of carbon and a metal such as nickel or iron.

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[15] Chemical Engineering, Chementator. V. 68, No. 12, June 12, 1961, p. 90.
Engineering and Mining Journal. Watch These Trends. V. 32, No. 28, July 13, 1961, p. 6.
[16] Materials in Design Engineering. Carbon-Graphite Has Improved Properties. V. 53, No. 2, February 1961, p. 156.
[17] Chemistry and Industry (London). No. 40, Oct. 7, 1961, p. 1624.
[18] King, John L. (assigned to Arthur J. Wiesner, Lyndon Wilson, and Sherwin B. Harris). Process for Forming a Graphite Lubricant. U.S. Pat. 2,986,519, May 30, 1961.
[19] Construction Methods and Equipment. Graphite Lubricant for Heavy Equipment. V. 43, No. 8, August 1961, p. 154.
[20] Steel. Better Graphite Cloth. V. 149, No. 1, July 3, 1961, p. 53.
[21] Chemical Week. Technology Newsletter. V. 89, No. 1, July 8, 1961, p. 57.
[22] Whipple, E. L. (assigned to Bowen-McLaughlin, Inc.). Electrostatic Separation of Minerals. U.S. Pat. 3,009,573, Nov. 21, 1961.
[23] Fisher, Richard S., and Joseph W. Gartland (assigned to Union Carbide Corporation). Production of Artificial Graphite. U.S. Pat. 2,992,901, July 18, 1961.
[24] Halden, Frank A., William D. Smiley, and Frank M. Hruz (assigned to the U.S. Atomic Energy Commission). Process of Coating Graphite With Niobium-Titanium Carbide. U.S. Pat. 2,991,192, July 4, 1961.
[25] Gurinsky, David H. (assigned to the U.S. Atomic Energy Commission). Method for Treating Graphite Product. U.S. Pat. 2,995,471, Aug. 8, 1961.

Gypsum

By William V. Kuster [1] and Nan C. Jensen [2]

ALTHOUGH output of gypsum and gypsum products, which is closely allied to the building industry, declined in 1961 from the quantity produced in the preceding year, four new plants were put on stream to open up new market areas. Imports of gypsum also declined.

TABLE 1.—Salient gypsum statistics

(Thousand short tons and thousand dollars)

	1952-56 (average)	1957	1958	1959	1960	1961
United States:						
Active establishments [1]	88	84	85	93	96	98
Crude: [2]						
Mined	9,341	9,195	9,600	10,900	9,825	9,500
Value	$28,298	$29,871	$32,495	$39,231	$35,690	$34,950
Imports for consumption	3,593	4,334	4,047	6,132	[3] 5,301	4,967
Calcined:						
Produced	7,822	7,801	8,122	9,268	8,591	8,246
Value	$76,490	$83,455	$91,402	$111,740	$120,984	$117,579
Products sold (value)	$276,621	$301,095	$329,070	$388,335	$361,190	$358,811
Gypsum and gypsum products:						
Imports for consumption (value)	$5,937	$8,515	$7,864	$13,196	[3]$10,426	$10,306
Exports (value)	$1,475	$1,345	$2,465	$1,296	$1,293	$1,299
World: Production	31,985	[3] 37,655	[3] 38,320	[3] 43,680	43,200	43,035

[1] Each mine, calcining plant, or combination mine and plant is counted as 1 establishment.
[2] Excludes byproduct gypsum.
[3] Revised figure.

DOMESTIC CONSUMPTION

Crude.—Domestic gypsum output was 9.5 million short tons, a decrease of 3 percent from 1960. The production rate, low in the first three quarters of the year, increased sharply in the fourth quarter. Almost three-fourths of the crude gypsum mined in Iowa and Texas and one-third of that mined in Michigan was calcined; over half the California output was sold uncalcined for agricultural purposes. A total of 69 mines operated, of which 53 were open pits and 16 were underground. Plants with calcining equipment operated 39 of the mines and furnished 85 percent of the crude gypsum output in 1961.

Calcined.—Calcined gypsum was produced from domestic and imported ores by 65 plants that had 282 kettles and other pieces of calcining equipment. The 8.2 million tons of calcined gypsum, valued at $118 million, produced in 1961 was 4 percent below the 1960 output.

Oil, natural gas, and coal were the fuels used for calcining gypsum.

[1] Commodity specialist, Division of Minerals.
[2] Supervisory statistical assistant, Division of Minerals.

TABLE 2.—Crude gypsum mined in the United States, by States

(Thousand short tons and thousand dollars)

State	1960			1961		
	Active mines	Quantity	Value	Active mines	Quantity	Value
Arkansas	1	67	$208	1	167	$531
California	13	1,616	3,687	12	1,574	3,673
Colorado	4	82	296	4	85	320
Iowa	5	1,283	5,428	5	1,239	5,276
Michigan	4	1,463	5,609	4	1,295	5,095
Nevada	3	802	2,721	3	729	2,625
New Mexico	3	55	193	3	105	386
New York	5	755	3,928	5	663	3,441
South Dakota	1	22	89	1	22	89
Texas	7	1,131	3,960	7	1,074	3,846
Wyoming	1	13	46	(1)	(1)	(1)
Other States [2]	22	2,536	9,525	24	2,547	9,668
Total	69	9,825	35,690	69	9,500	34,950

[1] Included with "Other States."

[2] Includes the following States to avoid disclosing individual company confidential data: Louisiana, Virginia, and Washington, 1 mine each; Indiana, Kansas, Montana, Ohio, Utah, and Wyoming (1961), 2 mines each; Arizona (1960) 4 mines, (1961) 3 mines; and Oklahoma (1960) 5 mines, (1961) 6 mines.

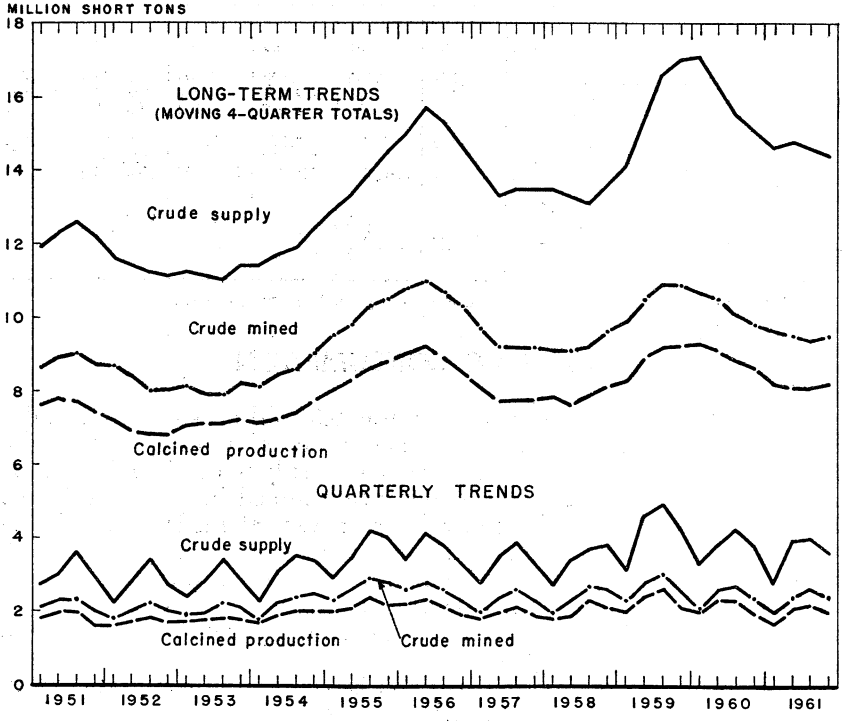


FIGURE 1.—Trends of new crude supply, domestic crude mined, and production of calcined gypsum, 1951–61, by quarters.

TABLE 3.—Calcined gypsum produced in the United States, by States

(Thousand short tons and thousand dollars)

State	1960					1961				
	Active plants	Quantity	Value	Calcining equipment		Active plants	Quantity	Value	Calcining equipment	
				Kettles	Other[1]				Kettles	Other[1]
California	6	838	$8,210	18	12	6	789	$7,514	18	12
Iowa	4	793	11,517	20	4	5	797	11,471	23	4
Michigan	4	442	6,573	18	1	4	382	5,887	18	1
New York	7	1,186	16,979	24	6	7	1,173	17,132	24	6
Ohio	3	299	4,289	9	1	3	287	4,221	9	1
Texas	6	789	12,445	31		6	756	11,370	29	
Other States[2]	31	4,244	60,971	97	36	34	4,062	59,984	100	37
Total	61	8,591	120,984	217	60	65	8,246	117,579	221	61

[1] Includes rotary and beehive kilns, grinding-calcining units, Holo-Flites, and Hydrocal cylinders.
[2] Comprises States and number of plants as follows: Arizona, 1; Colorado, 2; Connecticut, 1; Florida, 1; Georgia, 2; Illinois, 1; Indiana, 3; Kansas, 2; Louisiana (1960) 2, (1961) 3; Maryland, 1; Massachusetts, 1; Montana, 1; Nevada, 2; New Hampshire, 1; New Jersey, 2; New Mexico (1960) 1, (1961) 2; Oklahoma, 1; Pennsylvania, 1; Utah, 2; Virginia, 2; Washington, 1; and Wyoming (1961) 1.

Mine and Products-Plant Development.—The new plant of Big Horn Gypsum Co. at Cody, Wyo., was put on stream. It will employ about 100 people and have an annual payroll of over $600,000. The manufactured products will be marketed in 12 Northwest and Middle West States.

United States Gypsum Co. formally opened its new plant and mine at Sperry, Iowa, on March 29. The plant was to serve a four-State area and produce enough ceiling and wall products to construct an estimated 40,000 houses each year. The raw gypsum was mined from a deposit 600 feet below the surface. Underground, the ore is transported by diesel-powered haulage units from the working face to a crusher for primary reduction before being skip-hoisted to the surface. The plant had facilities for milling, calcining, mixing, and board forming. The products were wallboard, sheathing, plaster base lath, and other building products.

One man, one bulldozer, one shift—that's all it took to provide the 300 tons of raw gypsum needed each day for the new Kaiser Gypsum Co., Inc., plant at Rosario, N. Mex. Kaiser personnel conceived the idea of applying ripping to gypsum quarrying. After much experimentation it was found that a single bulldozer equipped with a 24-inch single straight-shank ripper with a narrow point could, in one shift, supply enough ore to run the wallboard plant for 24 hours. The deposit covers over 50 acres and rises as a sheer cliff about 110 feet above the mill site. No overburden occurs above the pure gypsum, and the seam, about 100 feet thick, pitches toward the mill at an angle of about 12°. The attitude of the bed aids in transporting the gypsum to the primary crusher at the base of the cliff. The ratio of ripping to bulldozing time is about 10:1. The single-roll primary crusher, 600 feet from the wallboard plant, normally operates only 2 hours per shift. A 24-inch conveyor carries the ore from the plant stockpile to the secondary crusher, a hammermill with a capacity of 50 tph. Since the two crushing units are never operated at the same

time, one man can control both units. The secondary crusher operates about 3 hours per shift. All conveyor belts used in the plant are of one width. The crushed material is stored in two bins having a total capacity of 175 tons. The 250-foot drier section of the board machine was converted from steam to natural gas heat before it was installed at Rosario. The calcining section contains three hammer-type impact mills and grinds, calcines, and classifies the gypsum in one continuous operation. The production schedule for 1961 called for only wallboard production. The wallboard was to be marketed throughout New Mexico, Colorado, Texas, and adjoining areas. The Rosario plant is 2½ miles east of U.S. Highway 85, about 42 miles north of Albuquerque and 20 miles south of Santa Fe. It is on the main line of the Santa Fe railroad, and both power and natural gas lines are along Highway 85. Skilled labor was not available in the area. Of a total plant force of 100 persons, about 75 were Indians from neighboring Santo Domingo and Coachete pueblos.[3]

American Gypsum Co. opened a new wallboard plant at Albuquerque, N. Mex., late in 1960. Since its beginning, the firm had shipped products to consumers in Arizona, Colorado, New Mexico, Texas, and Wyoming.

Plans of the Barrett Division, Allied Chemical Corp., to build a chemical gypsum plant at Claymont, Del., announced last year, were postponed indefinitely.

Late in February the new gypsum plant at Bestwall Gypsum Co. near Blue Rapids, Kans., went on stream, replacing a plant that had been operating since 1896 and that had to be relocated to make way for the Tuttle Creek dam and reservoir. This new plant produced industrial and wall plasters as well as gypsum board and lath.

Early in September, Bestwall Gypsum Co. opened a new $6.6 million wallboard plant adjacent to the new bulk-handling facility of the Port of New Orleans. It was the only plant on the new tidewater ship channel, a 76-mile waterway linking New Orleans to the Gulf of Mexico. The plant facilities included a plaster mill and packaging center, a wallboard manufacturing department, warehousing and shipping departments, a covered storage unit, crushing and screening units, transfer towers, and laboratory and office buildings. When in full operation, the plant will import 200,000 tons of gypsum ore annually in ship cargos, ranging from 14,000 to 20,000 tons each. The plant will have capacity to produce enough wallboard, lath, and sheathing for 30,000 homes per year, as well as wall plasters, graded commercial rock, and agricultural gypsum.

CONSUMPTION AND USES

A paradoxical situation existed in the ratio of building activity to gypsum consumption. The value of new construction put in place in the United States rose to a new peak of $57.4 billion in 1961, a 4-percent increase over 1960, but gypsum consumption declined. After annual construction had fluctuated between $54 and $56 billion during

[3] Rock Products. Desert Unfolds Its Gypsum Lode. V. 64, No. 2, February 1961, pp. 92–96.

1960 and the early months of 1961, the annual rate abruptly turned up in June and approximated or exceeded an annual rate of $59 billion during the later months of 1961. Both private and public construction increased. The physical volume of construction rose only slightly less than the value gain of 3 percent between 1960 and 1961 because construction costs were up less than 1 percent, indicative of relative price stability.

In private construction, the $40.4 billion expended represented a 2-percent increase in outlays over 1960. Nonfarm residential building activity amounted to $22.5 billion, virtually unchanged from 1960 despite a 27-percent upturn in hotel and motel construction, a minor segment of residential construction.

Total outlay for public construction at $17 billion in 1961 was up 7 percent; military facilities, the only major category, did not contribute to the increase.

Total private housing starts in 1961 amounted to 1.3 million units.

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	1960		1961	
	Quantity	Value	Quantity	Value
Uncalcined:				
Portland-cement retarder	2,543	$11,246	2,763	$11,791
Agricultural gypsum	1,126	3,706	1,088	3,808
Other uses [1]	47	534	48	562
Total	3,716	15,486	3,899	16,161
Calcined:				
Industrial:				
Plate-glass and terra-cotta plasters	62	895	45	677
Pottery plasters	49	1,057	46	1,006
Dental and orthopedic plasters	12	452	13	499
Industrial molding, art, and casting plasters	82	1,527	78	1,640
Other industrial uses [2]	79	2,431	76	2,506
Total	284	6,362	258	6,328
Building:				
Plasters:				
Base-coat	1,197	20,524	1,023	18,381
Sanded and premixed perlite	584	14,205	534	12,957
To mixing plants	2	33	2	31
Gaging and molding	128	2,610	116	2,386
Prepared finishes	12	1,029	11	961
Roof-deck	407	6,774	342	5,619
Other [3]	23	2,371	16	857
Keene's cement	40	1,028	35	931
Total	2,393	48,574	2,079	42,123
Prefabricated products [4]	[5] 7,120	290,768	[5] 7,023	294,199
Total building		339,342		336,322
Grand total, value		361,190		358,811

[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.

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TABLE 5.—Prefabricated products sold or used in the United States, by products

Product	1960			1961		
	Thousand square feet	Thousand short tons [1]	Value (thousands)	Thousand square feet	Thousand short tons [1]	Value (thousands)
Lath:						
⅜-inch	1,867,710	1,410	$49,054	1,601,303	1,199	$42,515
½-inch	42,510	43	1,332	44,203	45	1,439
Other [2]	(3)	(3)	(3)	956	2	65
Total	1,910,220	1,453	50,386	1,646,462	1,246	44,019
Wallboard:						
¼-inch	150,220	86	4,596	156,350	89	4,557
⅜-inch	2,055,077	1,578	73,189	1,991,365	1,522	71,520
½-inch	3,390,650	3,441	139,408	3,483,983	3,529	147,624
⅝-inch	236,791	310	13,203	299,670	391	17,107
1-inch [4]	1,855	3	116	4,233	9	374
Total	5,834,593	5,418	230,512	5,935,601	5,540	241,182
Sheathing	185,326	195	7,529	180,589	189	7,011
Laminated board	[5] 4,652	4	284	[5] 4,691	5	248
Formboard	47,651	50	2,057	40,999	43	1,739
Grand total [6]	7,982,442	7,120	290,768	7,808,342	7,023	294,199

[1] Includes weight of paper, metal, or other materials.
[2] Includes a small amount of ¼-inch, ⅝-inch, and 1-inch lath.
[3] A small amount of ¼-inch included with ⅜-inch lath.
[4] Includes a small amount of 5/16-inch, ¾-inch, 1⅝-inch, and 3¼-inch wallboard.
[5] Area of component board and not of finished product.
[6] Excludes tile, for which figures are withheld to avoid disclosing individual company confidential data.

Of the total number of units built, 73 percent were one-family dwellings, compared with 78 percent in 1960. This was the lowest percentage of one-family units since 1931. At the other end of the scale, the number of units in residential structures built for 3 or more families increased from 18 percent to 23 percent. In both years, two-family homes were 4 percent of all new housing units.

Thus, gypsum building-products sales appeared to be more closely keyed to the single-family type of construction than to the multiple-family type.

STOCKS

Producers reported that stocks of crude gypsum on hand December 31 totaled 3.65 million short tons, a slight increase over the 3.4 million tons at the end of 1960.

PRICES

According to reports from producers the average value of crude gypsum mined in the United States was $3.68 per short ton, compared with $3.63 in 1960. 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 portland cement retarder was $4.27 per ton, a decrease from 1960; average value of agricultural gypsum increased to $3.50. The average value of industrial plasters was 9 percent higher, that of building plasters and prefabricated gypsum products increased 3 percent.

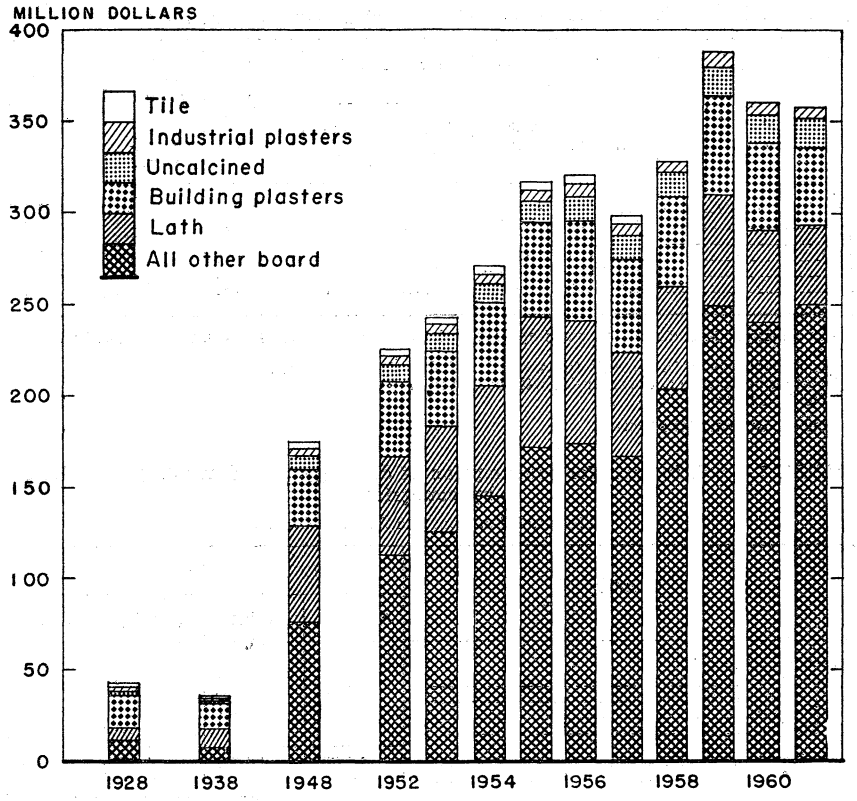


FIGURE 2.—Value of gypsum products sold or used in 1928, 1938, 1948, and 1952–61, by uses.

FOREIGN TRADE [4]

Imports of crude gypsum decreased 6 percent from 5.3 million tons in 1960 to 5.0 million tons. Canada provided 27 percent of the total U.S. supply.

WORLD REVIEW

NORTH AMERICA

Canada.—Shipments of crude gypsum decreased 12 percent in 1960 from the 1959 record of 5,878,630 short tons to 5,161,000 tons. However, in 1960 the output value of crude gypsum, at Can$9,308,340, was more than 10 percent greater than in 1959, mainly because the average value of Nova Scotian crude gypsum increased over the 1959 price of $1.28 a short ton to $1.62.

[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 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)			
1952–56 (average)	3,592,710	[3] $5,305	902	[3] $32	[3] $269	[3] $331	[3] $5,937
1957	4,334,467	[3] 7,571	870	[3] 33	[3] 577	[3] 334	[3] 8,515
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	[4] 5,301,224	[4] 8,990	1,159	48	963	425	[4] 10,426
1961	4,967,061	9,042	1,127	51	836	376	10,306

[1] In addition, Keene's cement was imported as follows: 1952–56 (average), 3 short tons ($292); 1957–61, none.
[2] Includes imports of jet manufactures, which are believed to be negligible.
[3] Data known to be not comparable with other years.
[4] Revised figure.

Source: 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	1960		1961	
	Quantity	Value	Quantity	Value
North America:				
Canada	[1] 4,166	[1] $7,037	3,909	$7,127
Dominican Republic	332	883	398	1,023
Jamaica	231	549	100	284
Mexico	572	521	560	608
Total	[1] 5,301	[1] 8,990	4,967	9,042
Europe [2]	([3])	([4])	([3])	1
Grand total	[1] 5,301	[1] 8,990	4,967	9,043

[1] Revised figure.
[2] 1960: United Kingdom; 1961: Italy and United Kingdom.
[3] Less than 1,000 tons.
[4] 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.,[1] value (thousands)	Total (thousands)
	Short tons (thousands)	Value (thousands)	Square feet (thousands)	Value (thousands)		
1952–56 (average)	22	$684	20,404	$648	$143	$1,475
1957	24	763	8,867	520	62	1,345
1958	29	921	([1])	([1])	1,544	2,465
1959	14	641	([1])	([1])	655	1,296
1960	17	687	([1])	([1])	606	1,293
1961	20	731	([1])	([1])	568	1,299

[1] Effective Jan. 1, 1958, plasterboard, wallboard, and tile not separately classified included with "gypsum manufactures, n.e.c."

Source: Bureau of the Census.

Imports of crude gypsum, mostly from Mexico, totaled 60,011 tons in 1960. Exports of crude gypsum in 1960 were 4,273,668 tons or nearly 12 percent less than in 1959.

Imports of gypsum products totaled 12,779 tons in 1960; exports were 33 tons.

In Quebec, gypsum occurs on the Magdalen Islands in the Gulf of St. Lawrence. The deposits crop out over wide areas and are up to 50 feet or more in thickness.

TABLE 9.—World production of gypsum, by countries [1] [2]

(Thousand short tons)

Country [1]	1952-56 (average)	1957	1958	1959	1960	1961
North America:						
Canada [3]	4,203	4,707	3,977	5,983	5,093	5,015
Cuba	‡ 32	‡ 45	‡ 45	‡ 45	(5)	(5)
Dominican Republic	42	80	84	175	358	‡ 330
Guatemala	----------	13	18	20	16	13
Jamaica	110	212	645	525	276	109
Mexico	(6)	900	821	913	871	857
Trinidad	‡ 1	3	3	5	7	‡ 7
United States	9,341	9,195	9,600	10,900	9,825	9,500
Total [4]	14,280	15,155	15,193	18,566	16,446	15,831
South America:						
Argentina	168	169	196	127	‡ 121	‡ 121
Brazil	104	121	143	202	114	‡ 110
Chile	83	‡ 66	‡ 55	87	45	88
Colombia	22	‡ 66	66	77	83	‡ 83
Peru	65	70	69	61	90	65
Venezuela	(5)	----------	----------	‡ 1	6	8
Total [4]	442	492	529	555	459	475
Europe:						
Austria [3]	379	579	597	621	730	750
Czechoslovakia	149	233	‡ 233	‡ 233	‡ 233	‡ 233
France, (salable) [3]	3,502	4,028	4,046	4,126	4,249	‡ 4,245
Germany:						
East [9]	217	255	249	279	‡ 275	‡ 275
West [9]	938	982	958	1,058	1,152	‡ 1,213
Greece	16	6	24	33	‡ 39	‡ 39
Ireland	116	131	116	141	164	‡ 165
Italy	823	1,053	1,366	2,184	2,205	‡ 2,205
Luxembourg	5	8	‡ 9	‡ 9	9	8
Poland	284	‡ 390	‡ 390	‡ 390	‡ 440	‡ 470
Portugal	54	71	48	60	68	‡ 66
Spain	1,267	1,538	2,104	2,357	‡ 2,360	‡ 2,360
Switzerland	184	259	99	‡ 110	‡ 110	‡ 11
U.S.S.R. [10]	2,873	‡ 3,860	‡ 3,860	‡ 3,860	‡ 4,500	‡ 5,000
United Kingdom [3]	3,154	3,751	3,641	3,794	4,026	4,102
Yugoslavia	75	93	84	102	117	138
Total [1] [4]	14,130	17,330	17,920	19,455	20,775	21,475
Asia:						
Burma	1	----------	----------	2	1	‡ 1
Ceylon	(5)	1	(5)	(5)	----------	----------
China [4]	205	390	440	550	660	550
Cyprus [4]	175	160	155	217	220	220
India	706	1,033	876	945	1,099	953
Iran [4] [11]	365	550	415	440	440	440
Iraq [4]	275	440	440	440	440	(6)
Israel [4]	39	56	44	66	66	44
Japan	337	527	528	596	810	798
Pakistan	34	72	74	109	100	112
Philippines	----------	----------	2	2	10	9
Taiwan	8	7	11	11	12	13
Thailand	----------	2	10	9	16	13
Turkey	23	‡ 42	50	‡ 57	67	‡ 66
United Arab Republic (Syria) [12]	2	‡ 2	‡ 3	‡ 7	15	‡ 15
Total [4]	2,136	3,282	3,048	3,451	3,956	3,674

See footnotes at end of table.

TABLE 9.—World production of gypsum, by countries [1] [2]—Continued

(Thousand short tons)

Country [1]	1952–56 (average)	1957	1958	1959	1960	1961
Africa:						
Algeria	91	[4] 84	140	189	180	[4] 175
Angola	10	8	5	15	[4] 11	[4] 11
Congo, Republic of the (formerly Belgian)	8	12	[4] 11			
Kenya	1	5	12	15	19	22
Morocco	18	[4] 28	[4] 28	[4] 28	[4] 28	[4] 28
Sudan	4	[4] 2	[4] 2	[4] 2		6
Tanganyika	5	11	10	8	5	1
Tunisia	27	18	18	13	[4] 13	[4] 13
Union of South Africa	178	180	256	224	216	191
United Arab Republic (Egypt)	188	512	584	577	441	[4] 440
Total	530	860	1,066	1,071	913	887
Oceania:						
Australia	461	536	566	579	651	694
New Caledonia	6					
Total	467	536	566	579	651	694
World total (estimate) [1] [2]	31,985	37,655	38,320	43,680	43,200	43,035

[1] Gypsum is produced in Bulgaria and Rumania, but production data are not available; estimates for these countries are included in the totals. Production in Ecuador, Finland, 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 estimate included in total.
[6] Data not available; estimate by senior author of chapter included in total.
[7] One year only as 1956 was first year of commercial production.
[8] Less than 500 tons.
[9] Crude production estimates based on calcined figures.
[10] Crude production for use in the construction industries only. In addition, substantial tonnages of gypsum are used in agriculture.
[11] Year ended March 20 of year following that stated.
[12] Some pure; some 60 percent gypsum and 20 percent limestone.

Compiled by Helen L. Hunt, Division of Foreign Activities.

In Ontario, the chief deposits are in the Moose River area, in the northeast, and in the Grand River area, south and west of Hamilton. The Moose River deposits, 15 to 20 feet thick, are usually covered by 10 to 30 feet of overburden; those in the Grand River area are thin and lenslike and occur at depths up to 200 feet.

Large gypsum deposits occur in both Manitoba and Alberta. In Manitoba, the main deposits are at Gypsumville, where beds 30 feet or more thick are exposed, and at Amaranth, where a 40-foot seam occurs at a depth of 100 feet. In Alberta, the main deposits are in Wood Buffalo Park where gypsum crops out along the banks of the Peace River between Peace Point and Little Rapids. Gypsum also occurs along the banks of the Slave and Salt Rivers north and west of Fort Fitzgearld, and narrow seams of gypsum have been found interbedded with anhydrite at a depth of 500 feet near McMurray, in the northeastern part of Alberta.

In British Columbia the chief deposits are at Windermere, Mayook, and Canal Flats in the southeast, and at Folkland, near Kamloops.

Gypsum deposits have been found also in the southern part of Yukon Territory and in the Northwest Territories, along the north shore of

Great Slave Lake; along the banks of the Mackenzie, Great Bear, and Slave Rivers; and on several of the Arctic Islands.[5]

A $3 million plant was to be erected by Western Gypsum Products, Ltd., in the Toronto, Ontario, area for producing plaster lath and wallboard.[6]

EUROPE

An association was formed in Geneva, Switzerland, by delegates from 11 European countries to promote the joint development of the gypsum industry. The group was formed under the name Eurogypsum (Association of the European Gypsum Industry).[7]

Bulgaria.—The gypsum resources in Bulgaria total over 50 million tons, according to an article that presented information on different methods of producing gypsum plaster and its use in construction.[8]

ASIA

India.—Rajasthan and Madras were the principal gypsum-producing States in India. Production increased to 109,900 short tons in 1960, 16 percent more than the 904,467 tons produced in 1959.

Imports of gypsum decreased to 56 tons valued at $210 in 1960, compared with 1,233 tons valued at $4,620 in 1959. No exports were reported in 1960.

During 1960 large deposits of gypsum, ranging in thickness from 15 to 45 feet, were discovered in the Nagaur district of Rajasthan by the Geological Survey of India. The reserve in the area was estimated at 1,763 million tons.[9]

OCEANIA

Australia.—The possibility of working the saline lakes of West Australia to recover brine, potash, alunite, and gypsum was investigated by the personnel of Mount Isa Mines, Ltd. The lakes are in an area between York and Southern Cross east of Perth.[10]

TECHNOLOGY

The manual for revised gypsum standards, announced by the American Society for Testing and Materials, contains specifications, methods of test, definitions relating to gypsum products and plaster aggregates, and related standards. Material added since the previous edition includes data on gypsum backing board and the test method for surface-burning characteristics of building materials.[11]

A simple method was presented for determining calcium sulfate dihydrate, hemihydrate, and soluble anhydrite in their mixtures. This

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[5] Collings, R. K. Gypsum and Anhydrite. Department of Mines and Tech. Surveys, Ottawa, Canada, rev. 38, 1960, 9 pp.
[6] Pit and Quarry. V. 59, No. 6, December 1961, p. 48.
[7] Chemical Trade Journal and Chemical Engineering (London). W. European Gypsum Development Association. V. 150, No. 3893, Jan. 12, 1962, p. 74.
[8] Georgiev, G. Stroyitelnyye Materialy i Silikáty Promyshlennosti (Construction Materials and Industrial Silicates). V. 2, No. 1, 1961, pp. 5–8; J. Am. Ceram. Soc., v. 44, No. 11, Nov. 1, 1961, p. 256.
[9] Bureau of Mines. Mineral Trade Notes. V. 53, No. 5, November 1961, p. 22.
[10] Mining World and Engineering Record (London), v. 177, No. 4550, May 1961, p. 185.
[11] American Society for Testing and Materials. Compilation of A.S.T.M. Standards on Gypsum and Plaster Aggregates. 1960, 152 pp.

method is applicable to mixtures of dehydration products from both natural and synthetic gypsums, provided impurities that change in weight below 225° C are absent.[12]

A staining test that can determine the components of raw gypsum was devised. The test specimens first were polished and then were treated successively with lead nitrate, alizarin red, p-nitrobenzene-azo-resorcinol and methyl blue. Gypsum, anhydrite, clay minerals, and carbonate rocks such as limestone, lime marl, dolomite, and magnesite can all be determined from the staining produced. The method is well-suited for either field or laboratory investigations.[13]

Efflorescence on gypsum plaster caused by sodium sulfate is usually the most damaging to a paint film. Ways in which some salts, such as sodium chloride, which could react with wet gypsum plaster to form sodium sulfate, could get into the plaster were discussed. A method of rapid analysis to determine if wall backing and plaster contain these salts and/or sodium sulfate was described. Injurious concentrations of sodium sulfate can be counteracted by applying a 15-percent solution of calcium chloride or bromide or by allowing a much longer drying time before painting. Some compounds used for cleaning and removing old paint can cause efflorescence if they are absorbed by the plaster.[14]

A mathematical description of the water absorption process in plaster was given after the action of a bundle of parallel round capillaries was studied. The relationship between capillary pressure and the diffusion constants of water in plaster (conductivity of water) was found to be hyperbolic. In the slip-casting process some but not all capillaries are transporting water during the actual ware formation. Because of the resistance and retarding effect of the forming body, the smaller pores are more effective.[15]

The influence of chloride on the phase transformation of calcium sulfate was studied. The effect was attributed to the fact that the chloride existed as an aqueous solution around crystals of calcium sulfate dihydrate in the mold, and then hemihydrate crystals grew under the hydrothermal reaction of the aqueous solution. Through this reaction the transformation of dihydrate into hemihydrate can occur in the course of heating. Nitrates or glycerin, readily soluble in water, reacted in the same manner as the chloride.[16]

A report was issued on a statistical study of the many variables leading to scattered results in compressive strength tests of gypsum plaster. The tests were made on 1-inch cubes according to Standards Association of Australia, Interim Specification 317; some were tested wet (2 hours after casting); some, dry; and others, after drying and

[12] McAdie, H. G., and R. A. Kuntze. Determination of Gypsum and Its Dehydration Products in Their Mixtures. Materials Research and Standards, v. 1, No. 1, January 1961, pp. 27–29.

[13] Bartosch, E. The Qualitative Determination of the Constituent Minerals in Raw Gypsum. Zement-Kalk-Gips (Basel), v. 13, No. 12, 1960, pp. 581–583; Building Science Abs. (London), v. 34, No. 7, July 1961, p. 193.

[14] Hoffman, E. Efflorescence Phenomena on Plaster. J. Oil Col. Chem. Assoc., v. 44, No. 1, 1961, pp. 32–41; Building Science Abs. (London), v. 34, No. 3, March 1961, p. 68.

[15] Deen, W. (The Absorbitivity of Gypsum). Ber. deut. keram. Gesell. (Berlin), v. 38, No. 3, 1961, pp. 107–110; Building Science Abs. (London), v. 34, No. 9, September 1961, p. 259.

[16] Chikara, Mitsuki, Naoyoshi Hayashi, Tatsuo Ito, and Toyohiko Izushi. Effect of Additives on the Heating Change of Dimension of Gypsum Plaster Molds. Nagoya Kogyo Gijutsu Shikensho Hokoku (Japan), v. 9, No. 10, 1960, pp. 505–515; J. Am. Ceram. Soc., v. 44, No. 5, May 1, 1961, p. 110.

rewetting. The results indicated that from three to five cubes from each of three separate mixes are necessary if the compressive strength is to be within 5 percent of the true mean (95 percent confidence limits). If the cubes were taken from one mix, the accuracy was only within 10 percent unless the tests were made by a very skillful operator. Testing more than five cubes per batch did not improve accuracy. For consistency and accuracy of results, there was little choice between machine- and hand-mixing. Strength of compression, increasing as time and rate of stirring increased was related somewhat to fluidity of the slurry. Specimens tested wet had only about 40 percent of the strength of those tested dry, but care should be exercised in wet-testing because of the different rates of strength development in plasters that have similar setting times.[17]

Moisture contents and compressive strengths were measured for 696 small cubes of gypsum plaster. Three water-to-plaster ratios and two proprietary brands of gypsum plaster were used. The results showed that from about 5 percent moisture content upward the compressive strength falls near the saturated wet compressive strength. Strength at equilibrium moisture content (about 0.2 percent) at 21° C and 50 percent relative humidity is near the oven-dry compressive strength, which is 2.5 times the wet compressive strength. Cubes at the relative humidities used were hygroscopic and showed a consequent decrease in compressive strength. The practical implication of the results was discussed.[18]

Investigations showed that the production of hard gypsum plasters by the wet process, without pressure, is valuable for mass-production purposes, and that the price of this hard gypsum is only a fraction of that of autoclaved gypsum. The wet process can also be used for manufacturing gypsum plasters for building purposes from poor dihydrate materials. The poor creep resistance of building plasters, especially when they are affected by moisture, is caused by the large amount of gypsum paste and by the weak structure of the coarse β-hemihydrate particles. The hard gypsum plaster does not show this bad structure and therefore possesses satisfactory resistance to creep, even when exposed to moisture.[19]

An autoclave fitting into an X-ray spectrometer diffraction unit thus permitting continuous X-ray diffraction studies at moderately elevated temperatures and steam pressures was described. The instrument was used to study the conversion of gypsum to hemihydrate. The temperature and steam pressure necessary and favorable for the conversion were given, and it was suggested that there is no intermediate step in the transition.[20]

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[17] Waters, E. H., and R. Birtwistle. Compression Testing of Gypsum Plaster. Mat. Res. and Standards, v. 1, No. 5, 1961, pp. 374–381; Building Science Abs. (London), v. 34, No. 11, November 1961, p. 324.

[18] Russell, J. J. The Effect of Moisture Content on the Compressive Strength of Small Cubes of Some Cast Gypsum Plasters. Zement-Kalk-Gips (Basel), v. 13, No. 8, 1960, pp. 345–351; Building Science Abs. (London), v. 34, No. 2, February 1961, p. 34.

[19] Eipeltauer, E. The Production of Creep-Resistant Hard Gypsum Plasters. Zement-Kalk-Gips (Basel), v. 13, No. 6, 1960, pp. 259–264; Building Science Abs. (London), v. 33, No. 12, December 1960, pp. 354–355.

[20] Drost, John B., and Ralph E. Grim. Continuous X-ray Investigation Using an Autoclave for the Conversion of Gypsum to Hemihydrate. Am. Mineralogist, v. 44, Nos. 7–8, 1959, pp. 731–737; J. Am. Ceram. Soc., v. 44, No. 3, March 1961, p. 73.

Gypsum from Rajasthan, India, that contains quartz and calcite as impurities was upgraded by using dry methods of beneficiation.[21]

Certain segments of the length-temperature curves of two kinds of plaster mold made of ordinary plaster of paris and of α-gypsum seem to be identical in phase transition of plaster. The overall shapes of the two curves, however, are considerably different. It was found that adding some chloride (such as chlorides of barium, magnesium, sodium, and lead) to the plaster decreases the shrinkage of molds at temperatures below 500° or 600° C. These critical temperatures become higher when the plasters are mixed with silica sand.[22]

Experimental work since 1953 in New Zealand was reported. Many favorable pasture effects previously attributed to superphosphate as a phosphorous supplier were in fact, due also to the sulfur provided by the fertilizer in the form of gypsum or finely ground elemental sulfur. Critical sulfur levels for white clover, mixed grasses, and lucerne (alfalfa) were established.[23]

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[21] Das Gupta, S. B., and P. I. A. Narayanan. Beneficiation of Gypsum. J. Su. Ind. Res. (India), v. 16A, No. 3, 1957, pp. 130–132; J. Am. Ceram. Soc., v. 44, No. 7, July 1, 1961, p. 158.

[22] Mitsuki, Chikara, and Tatsuo Ito. Heating Contraction of Set Gypsum Plaster. Nagoya Kogyo Gijutsu Shikensho Hokoku (Japan), v. 7, No. 12, 1958, pp. 904–911; J. Am. Ceram. Soc., v. 44, No. 4, April 1961, p. 82.

[23] McNaught, K. J., and P. J. E. Chrisstoffels. Sulfur and Pastures and Lucerne. N. Z. G. Agr. Res., v. 4, 1961, p. 177; Fertilizer and Feeding Stuffs J. (London), v. 55, No. 12, Dec. 13, 1961, p. 523.

Iodine

By Henry E. Stipp [1] and Victoria R. Schreck [2]

CRUDE IODINE production in the United States decreased for the second consecutive year, whereas consumption increased. U.S. imports of crude iodine increased substantially. Some of the imports were for the national stockpile.

DOMESTIC PRODUCTION

Output of crude iodine from oil-well brines in the United States decreased 20 percent in quantity and 13 percent in value compared with 1960. This marked the second year that domestic production had decreased sharply while imports increased, pointing to the plight of U.S. producers who were finding vigorous competition from foreign free world operations. Crude iodine was recovered by The Dow Chemical Co., with plants at Seal Beach, Venice, and Inglewood, Calif., and Midland, Mich.

A small quantity of iodine was recovered by Deepwater Chemical Co., at Compton, Calif., in 1960; none was reported in 1961.

CONSUMPTION AND USES

Domestic consumption of iodine and iodine compounds increased 33 percent compared with 1960. The element and its compounds were used principally in medicines, human and animal nutrition, germicides and disinfectants for general purpose, dairy, hospital, bottling plant, poultry and swimming pool applications, sterilization of drinking water, soaps, special papers, catalytic and analytic reagents, dyes, pigments, process engraving and lithography, metallurgy, cloud seeding, and rubber emulsifiers. Potassium iodide, the principal compound produced, was consumed chiefly in medicine, photography, and analytical chemistry. Sodium and ammonium iodide, other important iodine compounds, had uses similar to those of potassium iodide. Resublimed iodine, another large consumption category, was used chiefly for the preparation of inorganic and organic iodine compounds.

Iodine in combination with polyvinyl alcohol had bactericidal qualities that were reportedly many times higher than those of iodine.[3]

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[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.
[3] Chemistry. Powerful Germ Killer. V. 34, No. 6, February 1961, p. 41.

Radioactive iodine was used for physical therapy and examinations, process control, tracer studies, and general research. It was used to treat patients with some types of heart disease.[4] Iodine 125 was available for purchase from Oak Ridge National Laboratory. It has certain advantages over iodine 131, such as longer shelf life and no beta radiation.

TABLE 1.—Crude iodine consumed in the United States

Product	1960			1961		
	Number of plants	Crude iodine consumed		Number of plants	Crude iodine consumed	
		Thousand pounds	Percent of total		Thousand pounds	Percent of total
Resublimed iodine	4	132	7	5	104	4
Potassium iodide	10	897	46	10	1,467	56
Sodium iodide	4	(1)	(1)	4	(1)	(1)
Other inorganic compounds	16	495	26	21	566	22
Organic compounds	34	420	21	31	460	18
Total	[2] [3] 51	1,944	100	[3] 47	2,597	100

[1] Included with "Other inorganic compounds" to avoid disclosing individual company confidential data.
[2] Revised figure.
[3] Nonadditive total because some plants produce more than one product.

STOCKS

Government inventories of iodine on December 31, 1961, totaled 3,280,000 pounds, of which 2,977,000 pounds was in the national (strategic) stockpile and 303,000 pounds was in the CCC and supplemental stockpiles. Total Government stocks were 1,020,000 pounds below the maximum stockpile objective of 4,300,000 pounds.

PRICES

The following prices were quoted for iodine and iodine compounds by Oil, Paint and Drug Reporter:

	Per pound
Crude iodine, kegs: January through December	$1.10
Resublimed iodine, U.S.P., drums, f.o.b. works: January through December	$2.20–2.22
Ammonium iodide, N.F., 25-lb. jars, f.o.b. works:	
January through February 26	4.26
February 27 through December	4.51
Calcium iodide, 25 lb. jars., f.o.b. works: January through December	4.27
Potassium iodide, U.S.P., crystals, granular, 250 lb. drums, f.o.b. works: January through December	1.55
Sodium iodide, U.S.P., 300-pound drums, f.o.b. works: January through December	2.13

[4] Science Newsletter. Radioactive Iodine Helps in Certain Heart Ailments. V. 79, No. 2, Jan. 14, 1961, p. 24.

FOREIGN TRADE [5]

Imports.—Crude iodine imports increased 59 percent in quantity and 100 percent in value compared with 1960. This was the second consecutive year that imports increased. Imports from Japan more than doubled again in 1961. Shipments of resublimed iodine from West Germany were 220 pounds valued at $310.

Exports.—Exports of 175,781 pounds of iodine, iodides, and iodates valued at $282,072 were sent to 31 countries. Canada, West Germany, India, and the United Kingdom received the largest quantities. Iodine, iodides, and iodates reexported to six countries totaled 85,000 pounds valued at $94,000.

TABLE 2.—U.S. imports for consumption of crude iodine, by countries

(Thousand pounds and thousand dollars)

Country	1952–56 (average)		1957		1958		1959		1960		1961	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Chile	727	$997	2,149	$2,049	1,401	$1,180	1,243	$892	1,420	$1,011	1,964	$1,822
France	(1)	(2)										
Japan	399	542	536	720	160	149	223	191	474	414	1,053	1,030
Total	1,126	1,539	2,685	2,769	1,561	1,329	1,466	1,083	1,894	1,425	3,017	2,852

[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
1952–56 (average)	297	$462	1959 [1]	175	$249
1957	233	335	1960 [1]	251	353
1958 [1]	199	314	1961 [1]	176	282

[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
1952–56 (average)	87	$126	1959 [1]	35	$34
1957	70	79	1960 [1]	38	37
1958 [1]	30	30	1961 [1]	85	94

[1] Data not strictly comparable with earlier years.

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.

WORLD REVIEW

Brazil.—A plant for the manufacture of iodine products was to be established in the region of Mossoro and Areia Branca.[6]

Chile.—Anglo-Lautaro Nitrate Co. produced 1,746 short tons of crude iodine in the year ending June 30, 1960. Cia. Salitrera de Tarapaca y Antofagasta (COSATAN) produced 551 short tons during the same period. The Chilean Nitrate and Iodine Sales Corp. (COVENSA) reported sales of 2,072 short tons during fiscal year 1960.[7]

Indonesia.—Iodine production in 1960 totaled 7,922 pounds valued at US $48,000.[8]

Japan.—Elemental iodine recovery in 1960 totaled 1,047 short tons compared with 863 (revised figure) short tons in 1959.[9]

TECHNOLOGY

Water-soluble salts of iodine, as well as those of dysprosium, iridium, europium, and scandium, were used for tracing the flow of water, oil, or natural gas underground.[10] Fluid at an underground point was enriched with the salt and a sample of the fluid withdrawn at a second underground point. The sample was irradiated with a flux density of 10^7 neutrons per cm^2 per second to produce radioactive isotopes which were measured for radiation.

Vanadium of 99.95+ percent purity was prepared by the thermal decomposition of vanadium iodide.[11] Most metallic impurities in vanadium except iron and chromium were decreased. Nonmetallic impurities such as oxygen and carbon were greatly reduced and nitrogen was almost eliminated. Some of the properties of the refined vanadium were: Melting point, 1,890° C.±10°; lattice constant, 3,026 A.±0.001; ultimate tensile strength, 26,500 psi; yield point, 17,000 psi; reduction in area, greater than 99 percent; Diamond Pyramid Hardness 57; and resistivity at 20° C., 25.5 microhms per centimeter.

Ductile chromium that could be used as a structural metal was refined from iodide chromium.[12] The mechanics of iodide refining were studied with an improved laboratory device. One cycle of iodide refining removed 97 percent of the oxygen and all but 10 to 12 percent of the nitrogen and hydrogen. A study of the mechanical properties of chromium samples gave a threshold of cold brittleness for the cast metal at minus 25° C. The Brinell hardness ranged from 100 to 120. The yield point ranged from 13 to 20.5 kilograms per square millimeter

[6] U.S. Embassy, Rio de Janeiro, Brazil. State Department Dispatch 642, Feb. 13, 1962, p. 5.
[7] Bureau of Mines, Mineral Trade Notes. V. 53, No. 2, August 1961, p. 26.
[8] U.S. Embassy, Djakarta, Indonesia. State Department Dispatch 833, Apr. 28, 1961, p. 1, encl. 1.
[9] U.S. Embassy, Tokyo, Japan. State Department Dispatch 1172, Apr. 18, 1961, p. 3, encl. 1.
[10] Armstron, Frederick E. (assigned to the U.S. Department of the Interior). Method of tracing the Flow of Liquids by Use of Post Radioactivation of Tracer Substances. U.S. Pat. 3,002,091, Sept. 26, 1961.
[11] Carlson, O. H., and C. V. Owen. Preparation of High-Purity Vanadium Metal by the Iodide Refining Process. J. Electrochem. Soc., v. 108, No. 1, January 1961, pp. 88–93.
[12] Yemel'yanov, V. S., Ai. I. Yevstyukhin, and others. An Improved Method of Preparing Iodide Chromium and Its Properties, pt. 2, Production and Physical Metallurgy of Pure Metals, July 5, 1960, 23 pp.; U.S. Department of Commerce, Office of Tech. Serv., 60–11, 840, U.S. Joint Pub. Res. Serv., 2950.

at room temperature. Tensile strength was 19.5 to 28.2 kilograms per square millimeter, elongation 8.8 to 16.6 percent, and reduction of area 9.4 to 22.9 percent. Monocrystals of chromium iodide and arc-melted metal were body-centered cubic a=2.8790±.001 kx at room temperature.

Several biphenyls in good yield were prepared by ultraviolet photolysis of aromatic iodo compounds.[13] The reaction was performed without side reactions or destruction of functional groups. Industrial applications for the process could result from this research.

A process was patented for recovering anhydrous iodine from a water solution of hydrogen iodide and iodine.[14] Hydrogen iodide in a vapor phase was oxidized to iodine by contact with a gas containing oxygen. The iodine was condensed with an aqueous liquid and separated as an immiscible phase. Anhydrous iodine was withdrawn as a product. The remaining liquid phase was contacted with a stripping gas and the vapor product returned to the condensation zone.

Two iodine compounds were synthesized that were considered to be analogs of the metalloporphyrin sandwich compounds occurring in living matter.[15] The metalloporphyrin compounds benzenebisdipyridylchromium iodide and diphenylbisdipyridylchromium iodide were described as half-sandwich compounds in which four nitrogen atoms were bonded to the metal.

The effectiveness of potassium iodide, sodium bicarbonate, potassium bicarbonate, potassium oxalate momohydrate, and glass beads as extinguishing agents were studied with the aid of several sizes of small model fires.[16] Potassium iodide was more effective than potassium bicarbonate, but less effective than potassium oxalate. Potassium iodide was almost twice as effective when applied to a smaller model fire than it was when applied to two larger models. The study showed that the nature and particle size of the applied chemical powders influenced their rates of application.

Theoretical capacity and electrode efficiency data for iodosobenzene, iodoxybenzene, ortho iodosobensoic acid and iodosobenzene diacetate were presented.[17] Ortho iodosobenzoic acid had a lower cathode potential than other iodoso compounds. Iodosobenzene diacetate had poor electrode efficiency. Iodine, in a positive oxidation state, formed iodonium salts and iodyl compounds. The iodonium salt, diphenyliodonium chloride, was a weaker oxidizing agent than either iodoso or iodoxybenzene. The cathode potentials and coulombic capacities of iodoso-and iodoxybenzene in general increased with decreasing electrolyte pH. The low cathode potential for iodate compounds in alkaline electrolyte was attributed to hydrolysis with subsequent reduction of the iodate ion. Organic positive iodine cells did not compare favor-

[13] Chemical & Engineering News. Path to Aryl Radicals Aids Syntheses. V. 39, No. 3, Jan. 16, 1961, pp. 46, 47.
[14] Magovern, Robert L., Harold C. Ries, and Irwin L. Brierer (assigned to Shell Oil Co., Delaware). Process for the Recovery of Iodine. U.S. Pat. 3,006,731, Oct. 31, 1961.
[15] Chemical & Engineering News. New Class of Metallorganics Synthesized. V. 39, No. 16, Apr. 17, 1961, pp. 42–43.
[16] National Bureau of Standards. Small Models Aid Studies of Extinction of Fires Involving Liquids. Tech. News Bull., v. 45, No. 7, July 1961, pp. 120–121.
[17] Glickman, R., and C. K. Morehouse. Investigation of the Electrochemical Characteristics of Organic Compounds. J. Electrochem. Soc., v. 108, No. 4, April 1961, pp. 303–306.

ably with inorganic cells on light-drain tests, but were more suitable for use as reserve cells.

Compressed silver iodide powder pellets were tested for ionic conductivity by use of silver amalgam electrodes.[18] A deformed hexagonal phase was an important factor in pellet conductivity. Hexagonal deformation could be induced by proper preparation control or suitable thermal or mechanical pretreatment of silver iodide powder.

A method and filter were patented for removing iodine from gases.[19]

Lamps that contained iodine were used to improve athletic-field lighting.[20] The lamps delivered 12 more foot-candles of light than those previously used, and provided better distribution to the playing surface of the field.

The effectiveness of iodine for swimming pool disinfection was evaluated in the light of chemical reactions.[21] Iodine appeared to be an attractive disinfecting agent because its effectiveness over a wide pH range had been demonstrated. A smaller quantity of iodine was required for pools with high bathing load than was required for chlorine. Iodine did not form complexes with nitrogenous compounds which were irritating to the eye and mucosa of the nose. Odors and tastes were absent. Iodine was equally as effective as chlorine in killing algae.

A paper was published that reviewed the biocidal properties of iodine and compared them to properties of chlorine and other agents.[22] Iodophors, mixtures of iodine in surface-active agents, were reported to have all the germicide properties of iodine, low vapor pressure, lack of odor, and staining power, and low irritation properties.

Another paper was presented which reviewed the chemistry and uses of iodophors.[23] Two general types of iodophors were nonionic and cationic. The condensation of ethylene oxide with hydrophobic compounds containing active hydrogen such as polyglycols, alcohols, phenols, thiols, primary and secondary amines, and carboxylic and sulfonic acids and their amides were among the numerous nonionic iodophors that could be compounded with iodine. Among the cationic iodophors were quaternary ammonium compounds containing up to 25 percent iodine.

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[18] Mrgudich, J. M. Ionic Conductivity of Silver Iodide Pellets for Solid-Electrolyte Batteries. Lab. for Ins. Res., MIT, Cambridge, Tech. Rept. 138, June 1959, 23 pp.; U.S. Government Res. Repts., v. 35, No. 3, Mar. 10, 1961, p. 298.

[19] Silverman, Leslie (assigned to the U.S. Atomic Energy Commission). Method of Removing Iodine From Gases and Filter Medium Therefor. U.S. Pat. 2,994,577, Aug. 1, 1961.

[20] Electrical Construction and Maintenance. Relight School Stadium With Quartzline Lamps. V. 60, No. 9, September 1961, p. 120.

[21] Black, A. P. Swimming Pool Disinfection With Iodine. Water and Sewage Works, v. 108, No. 7, July 1961, pp. 286–289.

[22] Wilson, John L., William G. Mizuno, and Carl S. Bloomberg. Iodine Disinfectants. Soap and Chem. Spec., v. 36, No. 12, December 1960, pp. 100, 105–107, 141.

[23] Connor, J. J. Chemistry and Uses of Idophors. Am. Perfumer, v. 76, No. 5, May 1961, pp. 44–45, 58.

Iron Ore

By R. W. Holliday [1] and Helen E. Lewis [2]



ABUNDANCE of high-grade deposits and growing productive capacity throughout the world were noteworthy features of the iron-ore industry in 1961. In contrast, there were indications that world iron-ore consumption had reached a plateau. Consumption of iron ore in the United States fell from 108 million tons in 1960 to 99 million tons in 1961. Pig-iron production declined 1.9 million tons in the United States and 1.1 million tons in the United Kingdom. Although pig-iron production in the European Economic Community rose slightly, the rate of expansion was much lower than in previous years. However, Japanese production of pig iron increased from 13.6 million tons in 1960 to 18.1 million tons in 1961.

From the viewpoint of technologists, the abundance of high-grade iron ore represented a tremendous achievement—successful woldwide exploration and development programs plus successful research on beneficiation of low-grade ores. Economists, however, found many problems both in the abundance and in the shifting sources of iron-ore supply. To many of the newly developing nations, iron-ore resources provided the means, or the hope, of attracting investment capital for industrialization. To many of the older iron-ore producing regions, the new sources meant loss of income, unemployment, or vigorous programs to maintain markets. To the United States, Japan, and Western Europe, all with unprecedented high capacities for producing steel, the need to expand markets was a major problem, as high-grade ore became plentiful to all in a buyer's market.

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[2] Statistical assistant, Division of Minerals.

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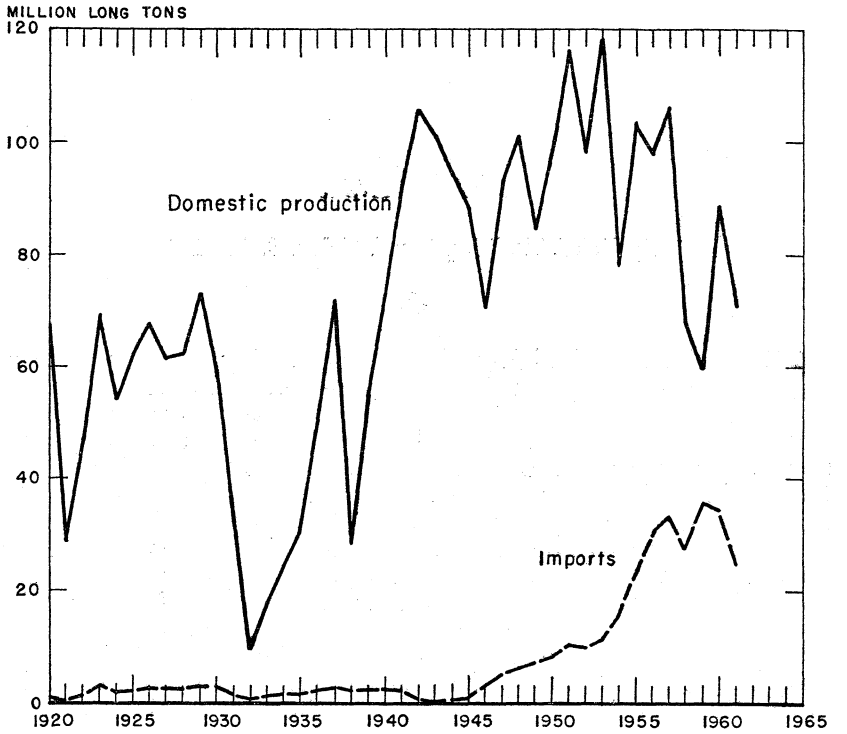


FIGURE 1.—Production of iron ore in the United States and iron-ore imports for consumption, 1920–61.

TABLE 1.—Salient iron ore statistics

(Thousand long tons and thousand dollars)

	1952–56 (average)	1957	1958	1959	1960	1961
United States:						
Iron ore (usable; [1] less than 5 percent Mn):						
Production [2]	98,984	106,148	67,709	60,276	[3] 88,784	71,329
Shipments [4]	98,577	104,157	66,288	59,164	[3] 32,963	72,379
Value [4]	$681,286	$865,703	$569,154	$514,067	[3] $724,131	$650,500
Average value at mines per ton	$6.91	$8.31	$8.59	$8.69	[3] $8.73	$8.99
Imports for consumption	18,102	33,651	27,544	35,617	[3] 34,578	25,805
Value	$145,410	$285,051	$231,617	$312,447	[3] $321,919	$250,226
Exports	4,509	5,002	3,573	2,967	5,273	4,916
Value	$36,082	$47,543	$34,898	$33,831	[3] $57,899	$53,823
Consumption	113,439	129,375	91,900	93,662	108,050	99,254
Stocks Dec. 31:						
At mines	5,612	6,776	7,033	7,358	[3] 12,337	10,626
At consuming plants	44,632	53,175	53,599	53,038	61,569	58,869
At Lake Erie docks	5,971	5,160	5,577	7,575	6,839	6,100
World: Production	336,879	[3] 426,677	[3] 398,697	[3] 431,360	[3] 512,329	497,610

[1] Direct shipping ore, washed ore, concentrates, agglomerates, and byproduct pyrites cinder and agglomerates.
[2] Includes byproduct ore.
[3] Revised figure.
[4] Excludes byproduct ore.

EMPLOYMENT

Employment in domestic iron mines and mills decreased less than 8,000 men between 1953 (35,301 men employed) and 1960 (27,583 men employed), but the trend from underground to open-pit mining brought economic dislocation and unemployment problems to some of the older producing areas.

Crude-ore production per man-shift had increased consistently since World War II, but usable ore production per man-shift changed very little because of the greater proportion of effort needed to beneficiate lower grade ores. In 1952, when less than 10 percent of the labor force was employed in beneficiation, 11.2 tons of usable ore per man-shift was produced. In 1958, when 24 percent of employment was in beneficiation, 11.5 tons per man-shift was produced and in 1960, with about the same division of the labor force, 13.1 tons per man-shift was produced.

TABLE 2.—Employment at iron ore mines and beneficiating plants, quantity and tenor of ore produced, and average output per man in 1960, by districts and States

District and State	Employment					Production [1]									
	Average number of men employed	Time employed				Crude ore (thousand long tons)	Usable ore			Average per man					
		Average number of days	Total man-shifts (thousands)	Man-hours			Thousand long tons	Iron contained		Crude ore		Usable ore		Iron contained	
				Average per shift	Total (thousands)			Thousand long tons	Natural (percent)	Per shift	Per hour	Per shift	Per hour	Per shift	Per hour
Lake Superior:															
Minnesota	12,975	269	3,491	8.01	27,949	110,626	57,892	31,313	54.09	31.69	3.96	16.58	2.07	8.97	1.12
Michigan	5,369	238	1,280	8.00	10,241	14,193	13,042	6,994	53.63	11.09	1.39	10.19	1.27	5.46	.68
Wisconsin	826	234	193	8.01	1,545	1,484	1,484	795	53.57	7.69	.96	7.69	.96	4.12	.51
Total	19,170	258	4,964	8.00	39,735	126,303	72,418	39,102	53.99	25.44	3.18	14.59	1.82	7.88	.98
Southeastern States:															
Alabama, Georgia, and North Carolina	2,711	201	545	8.24	4,492	7,627	4,365	1,714	39.27	13.99	1.70	8.01	.97	3.14	.38
Northeastern States:															
New Jersey and Pennsylvania	1,987	227	452	8.05	3,639	2,845	1,246	771	61.88	6.29	.78	2.76	.34	1.71	.21
New York	1,500	203	304	8.01	2,435	8,283	2,879	1,781	61.86	27.25	3.40	9.47	1.18	5.86	.73
Total	3,487	217	756	8.03	6,074	11,128	4,125	2,552	61.87	14.72	1.83	5.46	.68	3.38	.42
Western States:															
California, New Mexico, and Texas	800	251	201	8.05	1,619	5,127	2,608	1,354	51.92	25.51	3.17	12.98	1.61	6.74	.84
Idaho and Montana	26	154	4	8.75	35	63	63	36	57.14	15.75	1.80	15.75	1.80	9.00	1.02
Colorado, Nevada, Utah, and Wyoming	989	180	219	8.00	1,751	4,930	4,593	2,363	51.45	22.51	2.82	20.97	2.62	10.79	1.35
Total	1,815	234	424	8.01	3,405	10,120	7,264	3,753	51.67	23.87	2.97	17.13	2.13	8.85	1.10
Undistributed [2]	360	244	88	8.22	723	942	446	224	50.22	10.70	1.30	5.07	.62	2.55	.31
Grand total [3]	27,543	246	6,777	8.03	54,430	156,120	88,618	47,345	53.43	23.04	2.87	13.08	1.63	6.99	.87

[1] Includes manganese-bearing ore from the lake Superior district.
[2] Includes Missouri, South Dakota, and Tennessee to avoid disclosing individual company confidential data.
[3] In some instances data do not add to totals shown because figures have been rounded.

DOMESTIC PRODUCTION

Production of crude ore was 18 million tons less than in 1960, and output of usable ore declined about 17.4 million tons. In the latter category, direct-shipping ores dropped 13.0 million tons; concentrate, 4.0 million tons, and production of agglomerate at mines, 0.4 million tons. The approximate average recoverable iron content of the crude ore was only 28 percent.

Crude Ore.—(Mine product before any treatment to eliminate waste constituents.) More than 80 percent of the crude ore mined in the United States was sent to beneficiating plants, and the added cost that resulted brought increasing pressure for low-cost mining methods. Open-pit mines supplied 88 percent of the total domestic production, compared with 79 percent in 1951 and about 70 percent in 1941. Production in the Lake Superior district represented 75 percent of the Nation's total. Northeastern States produced 6 percent; Southeastern States, 5 percent; and Western States, 14 percent.

Open-pit mines accounted for 91 percent of the crude output in the Lake Superior district, and underground mines produced only 9 percent. Taconite and jaspilite ores comprised 39 percent; direct shipping ores, 19 percent; and ores shipped to beneficiation plants other than taconite and jaspilite, the remaining 42 percent.

Of the 206 domestic mines reporting production of iron ore, only 115 produced more than 100,000 tons; these accounted for 99.5 percent of the U.S. total. Of the 36 mines producing 1 million or more tons of crude ore, 22 were in Minnesota, 4 in Michigan, and 3 in Alabama.

Usable Ore.—Tables 6, 7, and 8 include direct-shipping ore (shipped directly from mines to consumers without any treatment for removal of waste constituents), concentrates (produced by washing, gravity methods, or other standard methods) and agglomerates produced at mines (produced by pelletizing, briquetting, or other methods of agglomerating).

Values of iron-ore shipments shown in table 8 are those reported by producers; they exclude transportation costs, but they include the cost of mining, concentrating, and agglomerating. Shipments are classified by use according to information supplied by the producer.

The growing importance of agglomerates produced at mine sites is shown in table 9, which gives current and projected productive capacity. Plants in Minnesota and Michigan produced 14.6 million tons of taconite and jaspilite pellets in 1961.

TABLE 3.—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	1960					1961				
	Number of mines	Hematite	Brown ore	Magnetite	Total	Number of mines	Hematite	Brown ore	Magnetite	Total
Lake Superior:										
Michigan	27	14,017			14,017	23	12,173			12,173
Minnesota	107	69,880	856	38,845	109,581	74	51,441	897	39,865	92,203
Wisconsin	2	1,484			1,484	2	1,129			1,129
Total	136	85,381	856	38,845	125,082	99	64,743	897	39,865	105,505
Southeastern States:										
Alabama	[1] 28	3,317	3,851		7,168	[1] 27	2,688	2,868		5,556
Georgia	9		457		457	11		594		594
North Carolina	1			2	2					
Tennessee	3	[2]	[3]		[2]	2	[2]	[3]		[2]
Total	41	3,317	4,308	2	7,627	40	2,688	3,462		6,150
Northeastern States:										
New Jersey and Pennsylvania	4			2,845	2,845	4			3,109	3,109
New York	5			8,283	8,283	5			6,697	6,697
Total	9			11,128	11,128	9			9,806	9,806
Western States:										
Arizona						2	[2]		[2]	[2]
California	3	[2]		[2]	[2]	5	[2]		[2]	[2]
Colorado	4		11		11	4		26	[2]	26
Idaho	3	3		6	9	3	5		7	12
Missouri	20	[3]	863		863	10	[3]	799		799
Montana	2			54	54	3	16		18	34
Nevada [4]	14	[3]		1,020	1,020	17	[3]		1,102	1,102
New Mexico	1			1	1	1			[2]	[2]
South Dakota	1	[2]			[2]	1	22			22
Texas	4	[2]	[3]		[2]	4	[2]	[3]		[2]
Utah	7	3,369		[3]	3,369	6	3,833		[3]	3,833
Wyoming	2	[2]		[3]	[2]	2	[2]		[2]	[2]
Total	61	3,372	874	1,082	5,327	58	3,876	825	1,127	5,828
Undistributed		5,736			5,736		8,741		555	9,296
Grand total [5]	247	97,806	6,038	51,057	154,901	206	80,048	5,184	51,353	136,585

[1] Excludes an undetermined number of small pits. Output of these pits included with tonnage given.
[2] Included with "Undistributed" to avoid disclosing individual company confidential data.
[3] Included with other varieties in the same State.
[4] Revised figures.
[5] In some instances data do not add to totals shown because of rounding.

TABLE 4.—Crude iron ore mined in the United States, by States and mining methods

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

State	1960			1961		
	Open pit	Underground	Total [1]	Open pit	Underground	Total
Alabama	4,014	3,154	7,168	2,878	2,678	5,556
Arizona				[2]		[2]
California	[2]		[2]	[2]	[3]	[2]
Colorado	11		11	26		26
Georgia	457		457	594		594
Idaho	9		9	12		12
Michigan	3,952	10,065	14,017	4,893	7,280	12,173
Minnesota	107,416	2,166	109,581	90,627	1,576	92,203
Missouri	863	[3]	863	799	[3]	799
Montana	54		54	34		34
Nevada [4]	1,020	[3]	1,020	1,102	[3]	1,102
New Jersey and Pennsylvania		2,845	2,845		3,109	3,109
New York	8,283	[3]	8,283	6,697	[3]	6,697
New Mexico	1		1	[2]		[2]
North Carolina		2	2			
South Dakota	[2]		[2]	22		22
Tennessee	[2]		[2]	[2]		[2]
Texas	[2]		[2]	[2]		[2]
Utah	3,369		3,369	3,833		3,833
Wisconsin		1,484	1,484		1,129	1,129
Wyoming	[2]	[2]	[2]	[2]	[3]	[2]
Undistributed	5,736		5,736	9,296		9,296
Total	135,185	19,716	154,901	120,813	15,772	136,585

[1] In some instances data do not add to totals shown because of rounding.
[2] Included with "Undistributed" to avoid disclosing individual company confidential data.
[3] Included with open pit.
[4] Revised figures.

TABLE 5.—Crude iron ore shipped from mines in the United States, by States and disposition

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

State	1960			1961		
	Direct to consumers	To beneficiation plants	Total [1]	Direct to consumers	To beneficiation plants	Total
Alabama	2,097	5,061	7,158	1,595	4,052	5,647
Arizona				[2]		[2]
California	[2]	[2]	[2]	[2]	[2]	[2]
Colorado	11		11	26		26
Georgia	[3]	457	457	[3]	594	594
Idaho	9		9	12		12
Michigan	7,503	5,967	13,469	6,041	6,120	12,161
Minnesota	21,542	88,060	109,602	12,635	79,825	92,460
Missouri		863	863		858	858
Montana	55		55	34		34
Nevada [4]	[3]	1,018	1,018	[3]	1,108	1,108
New Jersey and Pennsylvania		2,523	2,523		3,418	3,418
New York		8,283	8,283		6,696	6,696
New Mexico	1		1	[2]		[2]
North Carolina	[2]		[2]	[2]		[2]
South Dakota	[2]		[2]	22		22
Tennessee	[2]	[2]	[2]	[2]	[2]	[2]
Texas	[2]	[2]	[2]	[2]	[2]	[2]
Utah	3,334		3,334	3,742	[5]	3,742
Wisconsin	1,502		1,502	1,122		1,122
Wyoming	[2]	[2]	[2]	[2]	[2]	[2]
Undistributed	529	5,177	5,708	688	8,153	8,841
Total	36,583	117,409	153,994	25,917	110,824	136,741

[1] In some instances data do not add to totals shown because of rounding.
[2] Included with "Undistributed" to avoid disclosing individual company confidential data.
[3] Included with ore shipped to beneficiation plants.
[4] Revised figures.
[5] Included with direct shipping ore.

TABLE 6.—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	1960				1961			
	Hematite	Brown ore	Magnetite	Total [1]	Hematite	Brown ore	Magnetite	Total [1]
Lake Superior:								
Michigan	12,866			12,866	8,364			8,364
Minnesota	43,687	473	13,282	57,442	30,062	491	13,161	43,714
Wisconsin	1,484			1,484	1,129			1,129
Total	58,037	473	13,282	71,792	39,555	491	13,161	53,207
Southeastern States:								
Alabama	3,207	1,029		4,235	2,583	800		3,383
Georgia		128		128		156		156
North Carolina			2	2				
Tennessee	(2)	(3)		(2)	(2)	(3)		(2)
Total	3,207	1,157	2	4,365	2,583	956		3,539
Northeastern States:								
New Jersey and Pennsylvania			1,246	1,246			1,692	1,692
New York			2,879	2,879			2,356	2,356
Total			4,125	4,125			4,048	4,048
Western States:								
Arizona					(2)		(2)	(2)
California	(2)		(3)	(2)	(2)		(2)	(2)
Colorado		11		11		26	(3)	26
Idaho	3		6	9	5		7	12
Missouri	404	(3)		404	317	(3)		317
Montana			54	54	16		18	34
Nevada [4]	(3)		735	735	(3)		837	837
New Mexico			1	1			(2)	(2)
South Dakota	(2)			(2)	22			22
Texas	(2)	(3)		(2)	(2)	(3)		(2)
Utah	3,369		(3)	3,369	3,602		(3)	3,602
Wyoming	(2)		(3)	(2)	(2)		(2)	(2)
Total	3,776	11	796	4,583	3,962	26	862	4,850
Undistributed	3,127			3,127	4,783		224	5,007
Total all districts	68,147	1,641	18,205	87,993	50,883	1,473	18,295	70,653
Byproduct ore [5]				791				676
Grand total	68,147	1,641	18,205	88,784	50,883	1,473	18,295	71,329

[1] In some instances data do not add to totals shown because of rounding.
[2] Included with "Undistributed" to avoid disclosing individual company confidential data.
[3] Included with other varieties in the same State.
[4] Revised figures.
[5] Cinder and sinter obtained from treating pyrites. Ore was treated in Delaware, Colorado, Tennessee, Pennsylvania, Virginia, and Arizona.

TABLE 7.—Usable iron ore produced in the United States, by States and types of product

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

State	1960				1961			
	Direct shipping ore	Agglomerates [1]	Concentrates	Iron content (natural percent)	Direct-shipping ore	Agglomerates [1]	Concentrates	Iron content (natural percent)
Alabama	2,108	(2)	2,128	39.13	1,914	(2)	1,470	36.35
Arizona					(3)			(3)
California	(3)		(3)	(3)	(3)		(3)	(3)
Colorado	11			54.55	26			65.38
Georgia	(3)		128	43.75	(2)		156	46.15
Idaho	9			55.56	12			50.00
Michigan	9,076	905	2,885	53.79	5,041	1,475	1,849	54.86
Minnesota	21,589	13,436	22,417	54.22	12,579	13,161	17,973	55.39
Missouri			404	50.90			317	50.15
Montana	54			55.56	34			52.94
Nevada [4]	735		(2)	59.00	837		(2)	59.97
New Jersey and Pennsylvania		(2)	1,246	61.88		(2)	1,692	63.94
New York		2,043	837	61.86		1,463	893	60.82
New Mexico	1			64.97	(3)			(3)
North Carolina	2			(3)				
South Dakota	(3)			(3)	22			50.00
Tennessee	(3)		(3)	(3)	(3)		(3)	(3)
Texas	(3)	(2)	(3)	(3)	(3)	(2)	(3)	(3)
Utah	3,369			50.70	3,602		(2)	51.27
Wisconsin	1,484			53.57	1,129			53.58
Wyoming	(3)		(3)	(3)	(3)		(3)	(3)
Undistributed	529		2,598	50.76	728		4,280	52.83
Total	[5] 38,968	16,384	32,643	53.54	25,924	16,099	28,630	54.47
Byproduct ore [6]		791		66.58		676		67.15
Grand total	[5] 38,968	17,175	32,643	53.65	25,924	16,775	28,630	54.51

[1] Exclusive of agglomerates produced at consuming plants.
[2] Included with other types in the same State.
[3] Included with "Undistributed" to avoid disclosing individual company confidential data.
[4] Revised figure.
[5] Data do not add to total shown because of rounding.
[6] Cinder and sinter obtained from treating pyrites.

TABLE 8.—Shipments of usable iron ore from mines in the United States in 1961, by States and types of product

(Thousand long tons and thousand dollars; exclusive of ore containing 5 percent or more manganese)

State	Iron and steel			Total [1]	
	Direct shipping ore	Agglomerates	Concentrates	Quantity	Value (thousands)
Alabama	2,005	(2)	1,592	3,597	$20,510
Arizona	(3)			(3)	(3)
California	(3)		(3)	(3)	(3)
Colorado	27			27	190
Georgia	(2)		162	162	835
Idaho	12			12	70
Michigan	6,041	15,946	1,764	54,083	87,604
Minnesota	12,635		17,698		407,152
Missouri			341	341	3,633
Montana	34			34	209
Nevada	845		(2)	845	4,608
New Jersey and Pennsylvania	(2)	(2)	1,701	1,701	31,308
New Mexico	(3)			(3)	(3)
New York	(2)	1,469	503	1,973	25,548
North Carolina	(3)			(3)	(3)
South Dakota	22			22	100
Tennessee	(3)		(2)	(3)	(3)
Texas	(3)	(2)	(3)	(3)	(3)
Utah	3,533			3,533	25,493
Virginia	(3)			(3)	(3)
Wisconsin	1,122			1,122	(3)
Wyoming	(3)		(3)	(3)	(3)
Undistributed [4]	696		4,232	4,928	43,240
Total	26,971	17,415	27,993	72,379	650,500
Byproduct ore [5]		570		570	8,166
Grand total	26,971	17,985	27,993	72,949	658,666

[1] In some instances data do not add to totals shown because of rounding.
[2] Included with other types in the same State.
[3] Included with "Undistributed" to avoid disclosing individual company confidential data.
[4] Includes iron-oxide pigment material for Oregon not shown elsewhere in table.
[5] Cinder and sinter obtained from treating pyrites; they were treated in Delaware, Tennessee, Colorado, Pennsylvania, Virginia, and Arizona.

TABLE 9.—Current and announced capacity for producing high-grade iron-ore agglomerate

State, company, and plant	Product	Annual capacity (thousand long tons)	Iron, percent	First year of operation
Michigan:				
Humboldt Mining Co., Humboldt	Pellets	650	62.5	1955
Marquette Iron Mining Co., Republic	do	800	63.5	1955
Do. (expansion)	do	1,600	63.5	1962
Empire Iron Mining Co., Empire	do	1,200	65.0	1963
The Hanna Mining Co., Groveland	do	1,250	60.0+	1963
Minnesota:				
Erie Mining Co., Hoyt Lakes	do	7,500	62.5	1958
Reserve Mining Co., E. W. Davis	do	6,000	62.5	1955
Do. (expansion)	do	3,000	62.5	1963
United States Steel Corp., Pilotac and Extaca	Sinter and nodules.	900	63–66	1953
Missouri:				
Meramac Mining Co., Pea Ridge	Pellets	2,100	64.0	1962
New Jersey:				
Shamoon Industries, Mt. Hope	Blocks	200	67.2	1943
New York:				
Jones & Laughlin Steel Corp., Benson	Sinter	1,500	64.0	1944
National Lead Co., McIntyre	do	600	58.2	(1)
Republic Steel Corp., Port Henry	do	700	65.5	(1)
Republic Steel Corp., Chateaugay	do	450	66.0	(1)
Pennsylvania:				
Bethlehem-Cornwall Corp., Grace	Pellets	2,000	65.6	1961
Lebanon	do	600	62.9	(1)
Tennessee:				
Tennessee Copper Co., Copperhill	Sinter	550	69.1	(1)
Wyoming:				
United States Steel Corp., Atlantic City	Pellets	1,000	65.0	1962
Total		32,600		

[1] Data not available.

TABLE 10.—Iron ore produced in the Lake Superior district, by ranges

(Thousand long tons and exclusive after 1905 of ore containing 5 percent or more manganese)

Year	Marquette	Menominee	Gogebic	Vermilion	Mesabi	Cuyuna	Total [1]
1854–1956	289,298	253,845	298,753	93,566	2,095,499	58,842	3,089,803
1957	6,557	4,250	4,437	[2]	65,886	[3] 2,400	83,530
1958	4,111	2,896	2,549	[2]	40,860	[3] 1,360	51,777
1959	2,851	2,677	2,546	[2]	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
Total	312,641	271,844	314,128	96,821	2,332,442	66,184	3,394,059

[1] In some instances data do not add to totals shown because figures have been rounded.
[2] Included with Mesabi range to avoid disclosing individual company confidential data.
[3] Includes production from Spring Valley district not in the true Lake Superior district.

TABLE 11.—Average analyses of total tonnages (bill-of-lading weights) of all grades of iron ore from all ranges of Lake Superior district

Year	Long tons	Content (natural), percent					
		Iron	Phosphorus	Silica	Manganese	Moisture	Alumina[1]
1952–56 (average)	78,812,449	50.71	0.096	10.08	0.72	10.69	
1957	83,264,900	52.14	.089	9.39	.65	9.83	
1958	52,243,820	53.78	.086	8.76	.53	8.49	
1959	44,402,848	53.81	.085	8.93	.61	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

[1] Alumina analyses not available prior to 1961.

Source: American Iron Ore Association.

TABLE 12.—Beneficiated iron ore shipped from mines in the United States

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

Year	Beneficiated	Total	Proportion of beneficiated to total (percent)
1952-56 (average)	33,024	98,577	33.5
1957	42,027	104,157	40.3
1958	31,968	66,288	48.2
1959	30,363	59,164	51.3
1960	46,012	[1] 82,963	55.5
1961	46,125	72,379	63.7

[1] Revised figure.

CONSUMPTION AND USES

Consumption of iron ore increased in each quarter of 1961, reversing the trend of the preceding year, but total consumption was 9 million tons less than in 1960. Iron-ore consumption in blast furnaces decreased more than 6 million tons, and the tonnage of ore routed through agglomerating (sintering) plants prior to charging in the blast furnace decreased nearly 2 million tons.

Domestic ores comprised 78 percent of the ore charged to blast furnaces, 26 percent of the ore charged to steel furnaces, 61 percent of the ore agglomerated at consuming plants, and all of the ore agglomerated at mine sites.

Agglomerate produced at consuming plants, mostly sinter, totaled 36.0 million long tons, and agglomerate produced at mine sites, mostly pellets, totaled 17.9 million long tons.

Until about 1952 sinter was virtually the only type of agglomerate produced. Devised as a means of utilizing iron-ore fines, flue dust, and other waste materials accumulated at the blast-furnace site, sintering resulted in higher recovery through recirculation of raw materials that had already been "consumed" but lost in the processing. From this beginning, the sintering process expanded steadily, and current practice is to purchase ores specifically for sintering. In 1943, sinter comprised 12 percent of the total (iron ore plus sinter) consumption, compared with 41 percent in 1961.

With construction of the taconite and jaspilite plants in the Lake Superior district, beginning on a pilot-plant scale in 1952, the production of pellets at mine sites began to increase. In 1961, pellet consumption comprised 12 percent of total (iron ore plus sinter) consumption. Nodules, briquettes, block-iron ore, and unclassified imported agglomerates were used in smaller quantities.

TABLE 13.—Consumption of iron ore in the United States in 1961, by States and uses

(Long tons and exclusive of ore containing 5 percent or more manganese)

State	Metallurgical uses			Miscellaneous uses	Total
	Iron blast furnaces	Steel furnaces	Agglomerating plants		
Alabama, Kentucky, Tennessee, and Texas	4,703,159	324,959	3,291,740	100,019	8,419,877
California, Colorado, and Utah	3,742,331	482,049	3,079,931	65,234	7,369,545
Delaware, Maryland, and West Virginia	3,267,057	770,291	5,327,397	5,945	9,370,690
Illinois and Indiana	8,135,541	1,491,327	8,592,832	(1)	18,219,700
Michigan and Minnesota	2,766,505	283,203	18,066,000	121,037	21,236,745
New York, Ohio, Pennsylvania, and New Jersey	17,152,112	3,068,067	14,244,364	74,117	34,538,660
Undistributed [2]				98,725	98,725
Total	39,766,705	6,419,896	52,602,264	465,077	99,253,942

[1] Included with "Undistributed."
[2] Includes States indicated by footnote 1 plus the following: For cement, Arkansas, Florida, Georgia, Idaho, Iowa, Kansas, Louisiana, Missouri, Montana, Nebraska, New Mexico, Oklahoma, Oregon, South Carolina, South Dakota, and Washington; for paint, Georgia and Oregon.

TABLE 14.—Production and consumption of agglomerates in the United States in 1961, by States

(Thousand long tons)

State	Agglomerate produced	Agglomerate consumed [1]	
		In blast furnaces	In steel furnaces
Alabama, Kentucky, Tennessee, and Texas	2,027	5,496	(2)
California, Colorado, and Utah	3,320	3,310	
Delaware, Maryland, and West Virginia	5,489	5,674	
Illinois and Indiana	9,634	12,129	(2)
Michigan and Minnesota	17,771	4,642	
New York, Ohio, and Pennsylvania	15,754	24,363	386
Total [3]	53,995	55,613	764

[1] Includes 1.5 million tons of agglomerate produced in foreign countries.
[2] Included in total.
[3] In some instances data do not add to totals shown because figures have been rounded.

TABLE 15.—Production and consumption of agglomerates in the United States in 1961, by types

(Long tons)

Type	Agglomerate produced	Agglomerate consumed	
		In blast furnaces	In steel furnaces
Sinter [1]	38,463,697	41,950,813	46,788
Pellets	15,033,436	12,129,654	15,649
Nodules	419,741	(2)	270,948
Briquets			7,714
Other	78,388	472,853	4,365
Foreign		1,060,159	418,137
Total	53,995,262	55,613,479	763,601

[1] Includes self-fluxing sinter.
[2] Included with other.

STOCKS

Stocks of iron ore at domestic mines, docks, and consuming plants were 5 million tons less than the record high of 1960. Stocks at consuming plants and mines at yearend totaled 58.8 million and 10.6 million long tons, respectively, and according to the American Iron Ore Association, stocks of ore at U.S. docks totaled 6.1 million tons.

TABLE 16.—Stocks of usable iron ore at mines, Dec. 31, by States

(Thousand long tons)

State	1960 [1]	1961
Michigan, Minnesota, and Wisconsin	10,215	8,217
Alabama and North Carolina	258	44
New Jersey, New York, and Pennsylvania	1,081	1,463
Arizona, California, Nevada, and Utah	646	747
Colorado, Idaho, Missouri, Texas, and Wyoming	137	155
Total	12,337	10,626

[1] Revised figures.

PRICES

The average value of domestic usable ore per long ton f.o.b. mines excluding byproduct ore was $8.99, compared with $8.72 in 1960 and $8.69 in 1959. These data were taken from producers' statements and approximated the commercial selling price less the cost of mine-to-market transportation.

Lake Erie base prices per long ton for Lake Superior iron ores remained at the 1957–60 level: Mesabi non-Bessemer, $11.45; Mesabi Bessemer, $11.60; Old Range non-Bessemer, $11.70; and Old Range Bessemer, $11.85. These prices were for ores containing 51.5 percent iron, natural, delivered at rail of vessel at lower lake ports, and they were used as a basis for negotiating premiums or penalties to be applied for variations in the analyses and physical structure. Humboldt pellets in 1961 reportedly sold at a premium of $1.25 per gross ton over Old Range non-Bessemer. This was about equivalent to 25.2 cents per unit of iron at lower lake ports.

Swedish iron-ore pellets, 68-percent minimum iron content, were quoted at 24 to 25 cents per long ton unit (22.4 pounds of iron content), and Brazilian iron ore, 68–69 percent iron, was quoted at 22 to 22.5 cents per unit, both at Atlantic ports. Venezuelan iron ore, 58 percent iron, was quoted at $8.95 per metric ton ($9.09 per long ton), f.o.b. Puerto Ordaz.

Japanese importers were reportedly paying 23 to 24 cents per long ton unit at Japanese ports, with f.o.b. prices varying according to port facilities and distances. In some instances financing for mine and transportation development was supplied by the Japanese.

Imports (c.i.f.) to Western Europe ranged from about 84 shillings (US$11.76) to about 126 shillings (US$17.64).

TABLE 17.—Average value of iron ore shipped from mines in the United States in 1961

(Per long ton)

State	Direct-shipping ore			Iron ore concentrates			Iron ore agglomerates
	Hematite	Brown ore	Magnetite	Hematite	Brown ore	Magnetite	
Alabama	$5.85			$5.86	$5.20		$6.00
Michigan	8.58			9.32			12.21
Minnesota	7.65			8.17	(1)		11.56
Utah	7.22		(2)	(2)			
Other States	7.62	$4.64	$5.25	6.43	9.38	$13.24	14.91
Total	7.84	4.64	5.25	7.93	7.19	13.24	12.14

[1] Included with hematite concentrate.
[2] Included with direct-shipping hematite.

TRANSPORTATION

The Great Lakes shipping season began on April 15, with a shipment from Silver Bay, Minn., and closed December 4, with a shipment from Marquette, Mich. After a slow start, lake shipments increased as the season progressed, but the total tonnage, 53,925,637 long tons from domestic sources, was some 12 million tons less than in 1960. An additional 6,917,282 tons was imported into the Michigan, Chicago, Ohio, and Buffalo customs districts.

Transportation comprised as much as 40 percent of the total cost of iron ore, and venders throughout the world sought to improve their competitive position by lowering transportation costs. Where feasible, larger, specialized ore carriers and ship-handling facilities were in use or under construction.

In Great Lakes shipping, the trend was toward the use of the larger units and retirement of the smaller ships. The average iron-ore cargo loaded at U.S. Great Lakes ports reached a new high of 14,533 long tons, compared with 13,555 tons in 1960.[3] As of December 31, 1961, the U.S. Lakes fleet consisted of 210 vessels with an average carrying capacity of about 13,300 long tons. This total compared with 229 ships with an average capacity of 12,650 tons at the beginning of the year.

The new Poe Lock, at Sault Ste. Marie, was scheduled for completion in 1964. This lock will be 100-feet wide and 1,000-feet long, and will have a sill depth of 32 feet to permit passage of at least a 90-foot-beam ship. With this development, the existing loading and unloading docks and the lake fleet were seen to be approaching a stage of accelerating obsolescence.

The loading facility at Seven Islands and the new dock at Port Cartier, both on the Gulf of the St. Lawrence, were designed to load vessels up to 100,000-ton carrying capacity. Vessels transporting ore from Chile and Peru to the United States and Europe were limited to about 40,000 tons by the dimensions of the Panama Canal, but at least one shipment of 50,000 tons was sent from Peru to Japan, and future shipments of about 100,000 tons were foreseen.

[3] Lake Carriers Association. Annual Report, 1961. Pp. 65–80.

Possible future developments in transportation were widely discussed in 1961. These included the proposed pipeline transportation of iron ore, a Lake Erie to Ohio River canal, a new channel parallel to the Panama Canal, and a highly efficient "integral" train system.

RESERVES

Iron-ore reserves of Michigan and Minnesota given in tables 18 and 19 are recalculated each year as deposits are explored and mined, and they represent only taxable and State-owned reserves, excluding jaspilite and taconite resources.

TABLE 18.—Iron-ore reserves in Michigan, Jan. 1

(Thousand long tons)

Range	1953–57 (average)	1958	1959	1960	1961	1962
Gogebic	29,685	25,187	23,547	19,341	17,911	15,441
Marquette	65,628	64,027	58,719	55,575	54,001	45,205
Menominee	60,683	60,877	58,535	53,554	52,167	50,147
Total	155,996	150,091	140,801	128,470	124,079	110,793

Source: Michigan Department of Conservation.

TABLE 19.—Unmined iron-ore reserves in Minnesota, May 1

(Thousand long tons)

	1952–56 (average)	1957	1958	1959	1960	1961
Mesabi	809,454	697,267	618,606	564,253	520,269	468,925
Vermilion	11,840	9,641	9,044	8,307	8,887	9,234
Cuyuna	51,947	52,337	44,416	42,701	36,944	35,363
Total Lake Superior district (taxable)	873,241	759,245	672,066	615,261	566,100	513,522
Fillmore County	670	1,125	2,088	2,638	2,930	2,750
Morrison County	[1] 15					
Aitkin County	853	825	825	825	825	825
Mower County	[2] 71	118	173	152	68	1
Olmstead County			28	28	141	98
State ore (not taxable)	1,038	2,629	1,134	9,263	9,076	9,158
Grand total	875,888	763,942	676,314	628,167	579,140	526,354

[1] 1952 only.
[2] 1954–56 average.

Source: Minnesota Department of Taxation.

FOREIGN TRADE [4]

Imports were 25 percent below those of 1960 and the lowest since 1955. Exports, chiefly to Japan and Canada, were slightly lower than in 1960, but announced contracts with Japan indicated future shipments of about 2 to 3 million tons annually during the next several years.

[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 20.—U.S. imports for consumption of iron ore,[1] by countries

(Thousand long tons and thousand dollars)

Country	1952–56 (average)		1957		1958		1959		1960		1961	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
North America:												
Canada	6,200	$51,056	12,537	$111,777	8,289	$77,329	13,458	$128,940	[2] 10,595	[2] $104,709	9,683	$99,164
Costa Rica	([3])	1										
Cuba	91	858	33	346			4	40	3	30		
Dominican Republic	90	1,086	149	2,025	21	298	50	552				
Mexico	161	569	236	744	221	739	106	356	150	513	123	421
Panama	([3])	1			14	164						
Total	6,542	53,571	12,955	114,892	8,545	78,530	13,618	129,888	[2] 10,748	[2] 105,252	9,806	99,585
South America:												
Brazil	860	10,994	1,431	20,275	832	12,004	1,200	13,613	1,461	15,518	889	9,613
Chile	1,698	8,930	2,741	20,641	3,257	25,876	3,590	27,815	3,942	30,684	2,604	21,913
Peru	1,235	10,329	2,373	20,859	1,674	16,785	2,236	21,358	[2] 2,758	[2] 26,828	1,209	11,752
Surinam							2	23				
Venezuela	5,084	35,030	12,291	87,733	12,180	87,976	13,542	104,347	[2] 14,555	[2] 133,138	10,478	99,118
Total	8,877	65,283	18,836	149,508	17,943	142,641	20,570	167,156	[2] 22,716	[2] 206,168	15,180	142,396
Europe:												
Norway							15	147				
Spain	3	33			([3])	6	([3])	6	([3])	7	([3])	3
Sweden	1,595	18,040	677	9,575	113	1,640	136	1,737	94	1,543	78	1,156
United Kingdom	1	35	([3])	35	1	54	19	195	([3])	29	2	147
Other Europe	([3])	2	([3])	4	([3])	5	1	15	1	13	1	7
Total	1,599	18,110	677	9,614	114	1,705	171	2,100	95	1,592	81	1,313
Asia:												
India											([3])	1
Iran	3	168			2	167	3	187	2	133		
Philippines	5	76			54	1,131	71	1,491	1	22		
Portuguese Asia									57	367		
Total	8	244			56	1,298	74	1,678	60	522	([3])	1

See footnotes at end of table.

TABLE 20.—U.S. imports for consumption of iron ore,[1] by countries—Continued

(Thousand long tons and thousand dollars)

Country	1952–56 (average)		1957		1958		1959		1960		1961	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Africa:												
Algeria	29	$292										
British West Africa	200	1,134	170	$1,253	49	$351	62	$481	46	$315		
Liberia	838	6,678	1,013	9,784	837	7,092	1,105	10,981	907	8,034	715	$6,728
Other Africa	9	98					17	163	6	36	23	203
Total	1,076	8,202	1,183	11,037	886	7,443	1,184	11,625	959	8,385	738	6,931
Grand total	18,102	145,410	33,651	285,051	27,544	231,617	35,617	312,447	[2] 34,578	[2] 321,919	25,805	250,226

[1] In addition pyrites cinder (byproduct iron ore) were imported as follows: 1952–56 (average), 5,882 long tons ($25,506); 1957, 567 tons ($2,222); 1958, 2,721 tons ($9,212) all from Canada; 1959, Canada 6,741 tons ($22,988), Italy 3,416 tons ($24,812); 1960, 5,884 tons ($19,679); 1961, 3,504 tons ($17,822) all from Canada.

[2] Revised figure.

[3] Less than 1,000 tons.

Source: Bureau of the Census.

TABLE 21.—U.S. imports of iron ore in 1961, by customs districts

Customs district	Long tons	Value	Customs district	Long tons	Value
Connecticut	45	$800	Chicago	1,323,733	$14,038,680
St. Lawrence	489	50,564	Ohio	3,566,322	34,311,614
Buffalo	1,020,532	11,587,500	New York	4,398	43,361
Philadelphia	8,358,057	80,305,216	Mobile	1,492,939	13,805,873
Maryland	7,645,787	71,339,924	New Orleans	651,657	6,166,125
Virginia	455,710	4,484,128	Galveston	154,972	1,240,315
Laredo	123,081	421,823	San Francisco	15	1,512
Duluth and Superior	317	3,054			
Michigan	1,006,695	12,425,263	Total	25,804,749	250,225,552

Source: Bureau of the Census.

TABLE 22.—U.S. exports of iron ore, by countries

(Thousand long tons and thousand dollars)

Destination	1952-56 (average)		1957		1958		1959		1960		1961	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Canada	3,844	$29,525	3,958	$36,871	3,077	$29,701	2,453	$28,189	[1] 4,428	[1] $48,989	3,889	$42,269
Germany, West	[2]	[3]	[2]	6	[2]	[3]	-------	-------	[2]	[3]	130	1,732
Japan	664	6,495	1,041	10,532	493	5,044	507	5,247	839	8,622	883	9,510
Mexico	1	9	1	8	[2]	4	[2]	2	-------	-------	-------	-------
Union of South Africa	[2]	37	2	125	3	140	3	127	4	174	4	179
Other countries	[4]	16	[4]	1	[4]	9	4	266	2	114	10	133
Total	4,509	36,082	5,002	47,543	3,573	34,898	2,967	33,831	[1] 5,273	[1] 57,899	4,916	53,823

[1] Revised figure.
[2] Less than 1,000 tons.
[3] Less than $1,000.
[4] Includes countries receiving less than 1,000 tons each.

Source: Bureau of the Census.

WORLD REVIEW

World production of iron ore was 15 million tons below the record output of 1960, but productive capacity continued to expand. A list of new projects operating and under development was published.[5] World consumption of iron ore increased slightly, but it did not keep pace with the expanding productive capacity. Thus, the tendency was to use the higher grade ores, and mine production in a number of the older low-grade or high-cost mining areas was curtailed.

Imports to the United States declined nearly 9 million tons in 1961, and imports to Western Europe decreased nearly 4 million tons; however, imports to Japan increased 5 million tons.[6]

A forecast[7] was made that steel ingot production in Latin America (including Mexico) would increase from 5.3 million tons in 1960 to 20.7 million tons in 1972.

[5] Engineering and Mining Journal. Mine, Mill and Smelter Survey. V. 163, No. 1, January 1962, pp. 102–112.
[6] Westinform Shipping Report 205. World Iron Ore Trade in 1961. W. G. Westin, Ltd., London, 1962, 9 pp.
[7] Miller, J. R. The Expanding Latin American Steel Industry. J. Metals, v. 14, No. 1, January 1962, pp. 28–33.

TABLE 23.—World production of iron ore, iron-ore concentrates, and iron-ore agglomerates by countries [1]

(Thousand long tons)

Country	1952–56 (average)	1957	1958	1959	1960	1961
North America:						
Canada	10,317	19,886	14,042	21,864	19,242	18,199
Cuba	114	177	16	[2] 15	[2] 15	[2] [3] 10
Dominican Republic	95	180	30	[2] 12	121	[2] 138
Guatemala	3	4	5	[2] 4	[2] 4	[2] 5
Mexico	614	[2] 935	[2] 955	[2] 875	924	1,190
United States [4]	98,984	106,148	67,709	60,276	88,784	71,329
Total	110,127	127,330	82,757	83,046	109,090	90,871
South America:						
Argentina	67	66	65	108	[2] 135	118
Brazil	3,406	4,898	5,103	8,766	9,197	9,193
Chile	2,304	2,652	3,605	3,843	4,615	5,142
Colombia	[5] 272	584	553	399	645	[2] 640
Peru	[6] 1,870	3,522	3,532	3,519	6,880	5,567
Venezuela	5,754	15,054	15,240	16,929	19,182	14,425
Total	13,673	26,776	28,098	33,564	40,654	35,085
Europe:						
Albania	----------	(7)	88	173	[2] 175	[2] 225
Austria	2,800	3,441	3,356	3,329	3,486	3,635
Belgium	111	136	121	140	157	116
Bulgaria	135	267	340	370	400	411
Czechoslovakia	2,176	2,766	2,755	2,921	3,071	3,242
Finland [8]	[6] 133	207	212	224	269	280
France	45,291	56,873	58,534	59,976	65,907	65,525
Germany:						
East	1,382	1,455	1,482	1,574	1,618	1,673
West	14,895	18,031	17,704	17,778	18,571	18,568
Greece	166	424	275	154	[2] 295	[2] 295
Hungary	355	327	365	432	508	595
Italy	1,173	1,556	1,272	1,217	1,225	1,181
Luxembourg	6,909	7,719	6,533	6,406	6,867	7,340
Norway	1,153	1,567	1,617	1,558	1,665	1,624
Poland	1,377	1,757	1,931	1,982	2,148	2,348
Portugal	153	281	228	238	297	238
Rumania	642	634	731	1,047	1,437	1,710
Spain	3,356	5,155	4,954	4,536	5,549	5,941
Sweden	16,842	19,609	18,023	18,061	20,975	22,771
Switzerland	113	114	[2] 75	[2] 60	[2] 125	[2] 80
U.S.S.R. [9]	64,273	82,963	87,414	92,531	104,343	116,137
United Kingdom	16,006	16,902	14,613	14,870	17,088	16,512
Yugoslavia	1,123	1,846	1,965	2,062	2,165	2,150
Total [9]	180,564	[2] 224,070	224,588	231,639	258,341	272,597
Asia:						
Burma	[5] 3	4	6	4	16	[2] 16
China [2] [10]	6,594	14,800	29,500	44,300	54,100	44,300
Hong Kong	116	94	105	120	115	117
India	4,333	5,085	6,033	7,810	10,514	12,061
Iran [11]	10	[2] 10	138	59	57	----------
Japan [12]	1,574	2,204	2,056	2,508	2,809	2,779
Korea:						
North	(7)	[2] 1,040	1,527	2,660	3,059	[2] 3,400
Republic of	32	182	257	278	386	497
Lebanon	33	41	23	3	8	----------
Malaya	1,449	2,972	2,795	3,761	5,641	6,734
Pakistan [13]	2	24	8	2	6	4
Philippines	1,316	1,325	1,082	1,211	1,121	1,153
Portuguese India	1,489	2,901	2,889	3,025	5,764	[2] 5,900
Taiwan [14]	1	5	10	9	8	13
Thailand (Siam)	5	9	15	6	11	55
Turkey	643	1,146	936	859	723	746
Total [9]	18,100	31,850	47,400	66,600	84,350	77,800

See footnotes at end of table.

TABLE 23.—World production of iron ore, iron-ore concentrates, and iron-ore agglomerates by countries—Continued

(Thousand long tons)

Country	1952–56 (average)	1957	1958	1959	1960	1961
Africa:						
Algeria	3,078	2,746	2,298	1,897	3,384	2,822
Angola		104	282	343	649	799
Guinea, Republic of	[6] 613	1,074	405	337	764	533
Liberia	1,474	1,935	2,264	2,647	3,003	3,200
Morocco	1,488	1,839	1,514	1,245	1,552	1,439
Rhodesia and Nyasaland, Federation of:						
Southern Rhodesia	77	133	143	128	156	382
Sierra Leone	1,179	1,324	1,300	1,426	1,447	[3] 1,770
Sudan					3	
Tunisia	1,044	1,162	1,086	966	1,017	836
Union of South Africa	1,906	2,047	2,177	2,845	3,023	3,898
United Arab Republic (Egypt)	[15] 129	250	175	242	245	[2] 295
Total	10,988	12,614	11,644	12,076	15,243	15,974
Oceania:						
Australia	3,399	3,806	3,917	4,141	4,355	5,000
Fiji		1	3	12	24	10
New Caledonia	[15] 28	230	290	282	272	273
Total	3,427	4,037	4,210	4,435	4,651	5,283
World total (estimate)[1]	336,879	426,677	398,697	431,360	512,329	497,610

[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] Exports.
[4] Includes byproduct ore.
[5] Average annual production 1954–56.
[6] Average annual production 1953–56.
[7] Data not available; estimate included in the total.
[8] Iron concentrates and pellets.
[9] U.S.S.R. in Asia included with U.S.S.R. in Europe.
[10] Roughly equivalent of 50 percent iron.
[11] Year ending March 21 of year following that stated.
[12] Includes iron sand production as follows: 1952–56 (average), 527,472; 1957, 1,067,088; 1958, 898,913; 1959 1,335,655; 1960, 1,539,346; and 1961, 1,649,125 tons.
[13] Obtained principally during exploration activities.
[14] Principally magnetite sands with limonite.
[15] One year only, as 1956 was the first year of commercial production.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

TABLE 24.—World trade of iron ore, iron-ore concentrates, and iron-ore agglomerates in 1960

(Thousand long tons)

Exports by countries of origin	Fe (percent)[1]	Production	Exports	Exports by countries of destination																	
				North America		Europe													Asia	Oceania	Other countries
				Canada	United States	Austria	Belgium-Luxembourg	Czechoslovakia	France	Germany, East	Germany, West	Hungary	Italy	Netherlands	Poland	Rumania	United Kingdom	Other Europe	Japan	Australia	
North America:																					
Canada	55	19,242	16,942	------	10,433	------	164	------	------	------	[2] 1,598	------	74	272	------	------	3,360	------	1,041	------	----
Cuba	62	[1] 15	[2] 3	------	[2] 3	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	----
Dominican Republic	66	121	100	------	------	------	------	------	------	------	100	------	------	------	------	------	------	------	------	------	----
Mexico	60	924	153	------	153	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	----
United States	49	88,784	5,236	4,391	------	------	------	------	------	------	------	------	------	------	------	------	------	------	839	------	6
South America:																					
Brazil	70	9,197	5,079	136	1,407	------	------	424	120	------	1,361	------	50	165	302	------	667	------	366	15	66
Chile	60	4,615	5,109	21	3,750	------	11	------	------	------	836	------	------	4	------	------	------	------	303	------	184
Colombia	42	645	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	----
Peru	60	6,880	5,111	------	2,732	------	------	------	9	------	1,577	------	33	------	------	------	14	------	652	------	94
Venezuela	60	19,182	19,271	15	14,842	------	33	------	------	------	1,716	------	986	------	------	------	1,679	------	------	------	----
Europe:																					
Austria	30	3,486	20	------	------	------	------	20	------	------	(2)	------	------	------	------	------	------	------	------	------	----
Belgium-Luxembourg	35	7,024	126	------	------	------	------	------	125	------	------	------	------	------	------	------	------	------	------	------	----
Finland	30	269	283	------	------	------	------	------	------	------	[2] 144	------	------	------	[2] 128	------	------	------	------	------	11
France	35	65,907	26,726	------	------	------	16,563	------	------	------	9,625	------	------	6	------	------	531	------	------	------	1
Germany, West	30	18,571	240	------	------	230	3	------	2	------	------	------	1	2	------	------	------	2	------	------	----
Greece	49	[1] 295	302	------	------	163	------	------	------	------	81	------	34	24	------	------	------	------	------	------	----
Italy	47	1,225	7	------	------	------	------	------	------	------	[2] 1	------	------	------	------	------	------	[2] 1	------	------	5
Norway	65	1,665	1,173	------	------	95	1	------	------	------	712	------	------	4	110	------	244	6	------	------	1
Portugal	50	297	234	------	------	------	------	------	------	------	71	------	------	------	------	------	163	------	------	------	----
Spain	50	5,549	[2] 2,516	------	------	[2] 220	------	------	[2] 123	------	[2] 1,415	------	------	[2] 15	------	------	[2] 742	------	------	------	[2] 1
Sweden	60	20,975	19,406	------	94	242	3,618	166	490	23	8,215	------	292	592	675	30	4,824	145	------	------	(2)
Switzerland	40	[1] 125	121	------	------	------	------	------	(3)	------	121	------	------	------	------	------	------	------	------	------	----
U.S.S.R.	55	104,343	14,942	------	------	336	------	4,986	------	1,971	------	1,656	------	------	5,155	838	------	------	------	------	----
United Kingdom	30	17,088	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	----
Yugoslavia	45	2,165	89	------	------	------	------	------	------	------	------	89	------	------	------	------	------	------	------	------	----
Other East Europe	------	9,357	(4)	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	----

Asia:																						
China	50	[1] 54,100	[2 3 6] 129													[2] 129						
Hong Kong	56	115	122																	122		
India	61	10,514	3,415					799		102	94	48	135	(3)	63	59		138	1,966			11
Japan	55	2,809	(4)																			(4)
Korea, Republic of	50	386	230		3														227			(4)
Malaya	55	5.641	5,500								9		75						5,374			42
Philippines	54	1,121	1,132																1,132			
Portuguese India	55	5,764	5,585		19	108		9	69		2,157		452	147	9		51	(3)	2,564			
Turkey	60	723	301					69					143						6			
Other Asia		3,177	(4)																			
Africa:																						
Algeria	52	3,384	3,517			13	40		166		753		276	91			2,178					
Angola	65	649	537		(3)				31		496			10				(3)				
Guinea, Republic of	53	764	715	15				22		27	47				121		483					
Liberia	66	3,003	2,916	31	782				10		[2] 1,049		50	401	38		542	13				
Morocco	60	1,552	798						136		127						506	29				
Sierra Leone	60	1,447	1,541		46	19			17		307			365			787					(3)
Tunisia	50	1,017	1,039			31		29	122		27		141		20		669					
Union of South Africa	63	3,023	467			64			6		5		1	27				(3)	357			7
Oceania:																						
Australia	63	4,355																	[2] 18			4
Fiji	55	24	22																(3)	[2] 267		6
New Caledonia	55	272	273																			
Other countries		543	(5)																			
Total		512,329	151,428	4,609	34,264	1,521	20,433	6,524	1,426	2,123	32,727	1,793	2,743	2,125	6,621	1,056	17,440	334	14,967	282	440	

[1] Estimate.
[2] From import detail of customs returns of the respective country.
[3] Less than 500 tons.
[4] Data not available.
[5] Incomplete data.
[6] Trade agreements between China and Czechoslovakia indicate shipments of iron ore from China, but quantity is unknown.

Compiled by Corra A. Barry, Division of Foreign Activities.

NORTH AMERICA

Canada.—Production of iron ore declined in 1961 because of the low scale of operation by the United States consuming industry, but in terms of productive capacity, the year was one of growth.

British Columbia.—Production increased for the fifth consecutive year; however, the gains were minor compared with those of the eastern Provinces. The expansion was due primarily to financial support and long-range iron-ore purchase contracts from Japanese firms.[8] Three new plants under construction were scheduled to start operating in 1962, at rates totaling about 9,000 tons per day. The initial shipment from the new electric-furnace pig-iron plant of Consolidated Mining & Smelting Co. of Canada, Ltd., at Kimberley, was made in January. Feed for the 100-ton-per-day plant was produced from iron-sulfide tailings from the firm's Sullivan lead-zinc mine at Kimberley.

Ontario.—A preliminary engineering and feasibility study for a 1 million-ton-per-year pellet plant, near Kirkland Lake in northeastern Ontario, neared completion in 1961. The plant was being planned to produce pellets containing 66 to 68 percent iron from a magnetic taconite ore. The property was controlled by Jones & Laughlin Steel Corp.

A 100-ton-per-day pilotmill was operated by Anaconda Iron Ore (Ontario) Ltd., at a large, low-grade magnetic iron-ore deposit 260 miles northeast of Port Arthur. Favorable metallurgical characteristics, permitting production of a 70-percent-iron, 2-percent-silica concentrate, were proven. Although no schedule was announced for construction of a commercial plant, acquisition of the property for $10 million was reported.

Caland Ore Co., Ltd., shipped the first ore from its new Mink Point open-pit mine, made accessible by the dredging of Steel Rock Lake. Production from this pit and the Lime Point pit, opened in 1960, was expected to reach 2 million tons in 1962.

Newfoundland-Quebec.—The initial shipments of iron-ore concentrate from Port Cartier on the Gulf of St. Lawrence were made on July 5, 6, and 12. These shipments tested the dock and handling facilities for the Quebec-Cartier Mining Co.[9] mine and concentrator, 193 miles to the north, at Lac Jeannine. This plant was designed for an annual production of 8 million tons of high-grade concentrate from 20 million tons of crude ore.

The Iron Ore Company of Canada continued its mine development and mill construction at Carol Lake. The facility, scheduled for completion in 1962, was to produce annually 7 million tons of concentrate containing 64 to 65 percent iron. Announcement was made late in 1961 that construction of a 5.5-million-ton pelletizing plant near the Carol Lake concentrator was to begin immediately.

Wabush Iron Co., Ltd., announced a Can$20 million expenditure for 1961; about $15 million was marked for harbor and dock facilities at Pointe Noire on the Gulf of St. Lawrence. With participation of Italian and West German steel firms, new plans were announced for

[8] Elliott, Thomas. Japanese Market Activates Mineral Output. Precambrian Mining in Canada, v. 34, No. 6, June 1961, pp. 11–14.
[9] Metal Bulletin (London). Quebec-Cartier of Canada. No. 4654, Dec. 12, 1961, pp. i–iv.

increasing annual productive capacity to about 6 million tons of concentrate. Production was scheduled to start by late 1964.

Mexico.—Production of iron ore exceeded 1 million tons for the first time in 1961. Mining operations at the Penitas (El Encino) open pit near Colima on the West Coast began early in the year. Pending completion of an aerial tram, ore was being hauled 20 miles by truck from the mine to the National Railway line for transportation to the Hojalata y Lamina, S.A., (HyL) plant at Monterrey. The mining, crushing, and ore-handling facilities were operated by Empress Industriales, S.A., a firm associated with HyL.

SOUTH AMERICA

Argentina.—Production of iron ore was 118,000 tons; however, Argentina was the second largest market, after Brazil, for finished steel products.[10] Iron ore from Chile, Brazil, and Peru, and coal from the United States were consumed in a new integrated steel plant in San Nicolas on the Parana River. In January the Argentine Cabinet approved an agreement for a mineral survey and, if feasible, exploitation of the Sierra Grande iron-ore deposits in Rio Negro Province.

Brazil.—According to Brazilian press reports, a new iron-ore policy, which would permit greatly expanded production, was under consideration.[11] It was stated that the export policy should permit an annual sale of 20 to 30 million tons.

Various reports were issued concerning negotiations involving German, Japanese, and U.S. firms for construction of steel plants in exchange for iron ore. However, transportation continued as the major controlling factor in Brazilian production. Exports increased each year from 1958 through 1961, and the outlook was for additional increases in an approximate ratio to improvement in rail and port facilities.

Chile.—Bethlehem Chile Iron Mines Co. announced, in November, tentative plans to invest US$9 million to expand the firm's iron-ore mining and beneficiating plant for treating accumulated fines at the El Tofo mine. This expansion and that at the El Romeral mine were expected to increase the firm's output to 3 million tons per year.

A comprehensive survey of the Chilean iron-ore industry was published[12] by the Chilean Government.

Minerals & Chemicals Philipp Corp., a U.S. company, purchased a controlling interest in Compania Minera Santa Fe, Chile's largest iron-ore producer and exporter. Mechanization of the firm's Carmen mine (new mining equipment, a crushing and screening plant and a 7½-mile conveyor belt), completed in December 1960, increased the mine's productive capacity to 1 million tons per year.

Cia Minera Atacama (organized by the Japanese Mitsubishi firm) began producing at a rate of about 600,000 tons per year from the Adrianitas mine, and it negotiated contracts with Cia Acero del Pacifico and Cia Minera Sante Fe to expand exports to Japan.

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[10] Cass, Carl A. Latin America's Iron and Steel Industries. J. Metals, v. 14, No. 1, January 1962, pp. 34–42.

[11] U.S. Embassy, Rio de Janeiro, Brazil. State Department Dispatch 371, Nov. 1, 1961, p. 2.

[12] Ministerio de Mineria, Servicio de Minas del Estado Chile. La Mineria del Hierro en Chile. 1961, 49 pp.

Peru.—A 1.3-million-ton concentrating plant, at San Nicolas Bay, was completed late in 1961 by Marcona Mining Co. It included crude-ore stockpiling and reclaiming facilities, third and fourth stage crushing and screening operations, a scrubbing and magnetic cobbing plant, a single-unit heavy-medium plant, a 10,000-kw diesel power-plant, concentrate and product storage and reclaiming facilities, and a dock and shiploader. A pelletizing plant was scheduled for completion in 1963. By the mid-1960's the company expected to ship 10 million tons (total) of direct-shipping ore (lump ore), concentrate suitable for sinter feed, and pellets.

Electric-furnace production of pig iron at the Chimbote Steel Works was described.[13] A 3,850-short-ton per-month production of pig iron was reported.

Venezuela.—Decline in production of iron ore to 14 million tons, compared with 19 million tons in 1960 and 17 million tons in 1959, was attributed chiefly to low demand in the United States.

The Koppers Co. of Pittsburgh was reportedly called in to expedite construction of the Government steel plant at Matanza on the Orinoco River. The plant construction started more than 4 years before, and plans were for an annual capacity of 750,000 tons, using an electric-furnace process for producing pig iron and conventional open-hearth refinement to steel.

In President Bentancourt's message to Congress on March 11, he reiterated the Government policy that no new concessions for iron ore would be granted to private parties. The Government continued its program of appraisal of the Iron Quadrilateral of San Isidro and announced proven reserves of 380 million tons (62 percent Fe).[14]

EUROPE

The European Coal and Steel Community produced 93 million long tons of iron ore, compared with 116 million tons in the U.S.S.R. and 71 million tons in the United States. Production in Sweden (23 million tons), the United Kingdom (17 million tons), and other European nations brought the total for Western Europe to more than 140 million long tons.

Production of pig iron by the six-nation Coal and Steel Community (Germany, Belgium, France, Italy, Luxembourg, and the Netherlands) increased slightly to 61 million short tons, and output in the United Kingdom decreased slightly to 16.5 million tons.

France.—Although production of pig iron increased slightly to 16.4 million tons, and further expansion in productive capacity was planned, the demand showed some signs of weakening.

Iron-ore production was virtually equal to the 1960 output. Exports of nearly 26 million tons were valued at US$100 million, and imports of high-grade foreign ores increased to 1.7 million tons.[15]

The Fourth Modernization Plan of the French Iron and Steel Industry (1962–65) was announced,[16] it called for an increase in capacity

[13] Shapiro, William. The Chimbote Steel Works. Blast Furnace and Steel Plant, v. 49, No. 11, November 1961, pp. 1083–1100.
[14] U.S. Embassy, Caracas, Venezuela. State Department Dispatch 894. Mar. 21, 1961, p. 7.
[15] U.S. Embassy, Paris, France. State Department Dispatch 1472. May 9, 1962, p. 10.
[16] U.S. Embassy, Paris, France. State Department Dispatch 464. October 20, 1961, 2 pp.

by 1965 to 21 million tons through the construction of 12 new blast furnaces and the rebuilding of 26 existing furnaces. The current 6-million-ton sinter production was to be quadrupled by 1965. Production of iron ore was expected to reach 85 million tons by 1965.

Germany, West.—The trend toward increased use of high-grade foreign ores resulted in production curtailment or closure of some German mines. Production of iron ore dropped slightly in 1961, and production of pig iron was virtually equal to the 1960 output. German interest in foreign mines indicated that the trend toward greater use of imported ores would continue.

Sweden.—Production of iron ore exceeded that of the previous record year (1960) and totaled 22.8 million tons. Because of the high grade of ore and ready access to European markets, little if any curtailment was planned for 1962. Luossavaara-Kiirunavaara AB (LKAB), Sweden's principal iron-ore producer, announced plans for developing a new area in the Svappavaara district, in Arctic Sweden, by 1968.

United Kingdom.—Iron-ore imports declined more than 3 million tons, and domestic production decreased 0.6 million tons. Scandinavia replaced the Americas as the chief source of supply.

U.S.S.R.—A seven-year plan (1959–65) for development of the iron and steel industry was outlined.[17] Under this plan, a third metallurgical "base" was to be built east of the Urals in Siberia and Kazakhstan. In 1961, bases in the Ukraine and in the Urals were the major producers of iron and steel.

The seven-year plan reportedly would add 130 million short tons of iron ore annually, increasing output to 220 million tons. Trends in Soviet blast-furnace practice and new blast-furnace design were reviewed in the same article.

ASIA

China.—Iron and steel production figures were not published for 1961. With the announced emphasis on agriculture and the retrenchment in industrial development, there was undoubtedly some reduction from the 30-million-ton pig-iron production reported in 1960. One estimate[18] indicated that production of pig iron in 1961 may have been as low as 22 million tons.

India.—A review[19] of India's iron and steel industry was published. High-grade iron-ore reserves of 21.3 billion tons and coal and limestone resources adequate for many decades were estimated. A requirement for domestic consumption of 10 million tons of iron ore and exports of about 3.5 million tons were estimated for 1961. Except for possible transportation shortages, no difficulty was foreseen in meeting these goals.

Japan.—The continued expansion of steel production, up 27 percent from 1960, the previous record year, and the worldwide network of iron-ore sources were of interest in 1961. Production of pig iron totaled 18.0 million short tons. Japanese assisted in developing new

[17] Denisenko, Ivan, and Roman Belan. Development of U.S.S.R. Iron and Steel Industry. Iron and Steel Eng., v. 38, No. 9, September 1961, pp. 93–103.
[18] Wei, Anton W. T. Minerals in China in 1961. Min. J., v. 258, No. 6607, Apr. 6, 1962, pp. 334–337.
[19] Nahai, Lotfollah. India's Iron and Steel Industry. BuMines Inf. Circ. 8055, 1961, 40 pp.

iron-ore sources and transportation facilities, and they negotiated long-term purchase contracts in several areas.

Malaya.—Malaya continued as the largest supplier of iron ore to Japan, providing about 5.8 million long tons. The new Rompin Mining Company, Ltd., mine, at Bukit Ibam, neared the production stage in 1961. The development included townsites, docks, and a railway extending some 60 miles. Initial production of 1 million tons in 1962 was planned, with later expansion to 3 or 4 million tons per year.

AFRICA

Algeria.—Production, from seven mines in operation, was down 17 percent from 1960, and exports were 24-percent lower. Great Britain, with 56 percent of the total export quantity; West Germany, with 24 percent; and Italy, with 11 percent, were the principal purchasers.

Angola.—Production from the Cassinga and Cuima iron-ore deposits increased to nearly 800,000 long tons. Rail construction linking Cuima with an existing line to the coast was near completion at year-end. This rail line was expected to reduce the cost of transportation to the port at Lobito, a distance of 250 miles. Transportation from the Cassinga deposit to the port at Mocamedes, a distance of 360 miles, involved truck haulage for some 60 miles and rail haulage for the remaining distance.

Gabon.—Exploration of the Makambo iron deposit in northeast Gabon showed it to be one of the world's larger deposits of high-grade ore, with possibly 1 billion tons of 64-percent iron ore. No decision for its exploitation was announced, however, a 4-year survey of the transportation problem was begun. The concession is held by Société des Mines de Fer de Mekambo (SOMIFER), 50 percent of whose capital is held by Bethlehem Steel Co.[20]

Liberia.—As in 1960, Liberia Mining Co., at its Bomi Hills deposit, was the only large-scale producer of iron ore. However, within the next few years additional production by Liberian-American-Swedish Minerals Co. (LAMCO), National Iron Ore Co. (NIOC), and the German Liberian Mining Co. (DELIMCO) was expected to raise the annual output to some 20 million tons.

Mauritania.—Construction of the railroad from Fort Gouraud and handling facilities at Port Etienne, 440 miles distant, proceeded on schedule. The project, being conducted by a consortium of French, British, German and Italian interests, Mines de Fer de Mauritanie (MIFERMA), was expected to produce 4 million tons in 1963.

Union of South Africa.—An agreement was reached between African Metals Corp. Ltd., and Yawata Iron and Steel Co., Ltd., for an annual export of 500,000 long tons of pig iron to Japan during a 10-year period.

TECHNOLOGY

Research centered on beneficiating iron ores and increasing blast-furnace efficiency. New blast-furnace operating techniques resulted in fuel economy and greater furnace throughput, but the greatest ad-

[20] U.S. Embassy, Libreville, Republic of Gabon. State Department Dispatch 22. Sept. 16, 1961, 5 pp.

vances in productivity resulted from improvements in beneficiation of iron ore. In a report [21] summarizing current technology and the iron-ore supply situation, it was predicted that 86 million or more tons of iron ore, with an iron content exceeding 60 percent, would be available to U.S. consumers by 1965. Thus, the iron-ore producers and the consumers were well advanced in converting facilities to preparation and use of 60-percent-plus iron ore.

Research involved efforts to improve all types of ore, including even the taconite pellets of 62 to 63 percent iron, currently considered high-grade. Agglomerates with a silica content as low as 1 or 2 percent were being tested to determine slag requirements; the effects of incorporating flux in the agglomerate and the effects of size, porosity, and other physical properties of raw materials on blast-furnace productivity were investigated.

Resources.—Several State agencies were investigating iron-ore resources. Preliminary (unpublished) results indicated the possibility of substantial increases in the brown iron-ore reserves of Alabama, Georgia, and Louisiana. A paper [22] on the iron-ore potential of Idaho was presented at the Pacific Northwest Metals and Minerals Conference, Spokane, Wash., on April 14. Exploration of known deep-lying deposits in the Pea Ridge-Bourbon areas of Missouri continued. Under the stimulus of demand by Japanese consumers, a number of deposits in Far Western States were investigated.

Interest was shown in long-dormant, low-grade deposits; however, many mines operating on shipping-grade ore deposits were forced to close because the low-grade deposits offered the advantages of low-cost mining, large-scale operation, and ease of concentration.

Mining.—Aspects of the difficult taconite blasting problem were reviewed in three articles.[23] Continuing experimentation at the Erie and Reserve mines led to increased consumption of explosives, but it also improved overall mining efficiency. At both operations the explosives consumption reportedly increased from 0.5 pound per long ton of taconite to about 0.65 pound. Explosives, timing, and drill patterns varied, but spacing of about 22 by 22 feet was common for the 6½-inch (minimum diameter) holes. The average bench height at Reserve was about 35 feet, and at Erie it was about 40 feet.

Beneficiation.—Major research was devoted to procedures for treating nonmagnetic taconites and semitaconites. The problems of iron-ore beneficiation were reviewed.[24] Operation of the pilot plant for a $200 million development in Canada was described.[25] A simple method (spirals), with supplementary magnetic and possibly flotation procedures, proved feasible for treating the Wabush deposit, described as

[21] Rose, E. H. Iron Ore. The Big Picture. J. Metals, v. 13, No. 9, November 1961, pp. 814–819.
[22] Young, David W. Iron Ore Occurrences in Idaho. Skillings' Min. Rev., v. 50, No. 24, June 17, 1961, pp. 1, 6, 7, 26.
[23] Henderson, Bernard. How Heavier Drilling and Blasting Paid Off in Taconite. Eng. Min. J., v. 163, No. 1, January 1962, pp. 80–84.
Calaman, J. J., and H. C. Rolseth. New Look at Jet-Piercing Developments. Eng. Min. J., v. 162, No. 5, May 1961, pp. 100–104.
Bickel, F. D. Developments in Taconite Blasting at Erie. Min. Cong. J., v. 47, No. 11, November 1961, pp. 42–46.
[24] Volin, M. E., R. R. Beebe, and W. A. Hockings. Problems of Beneficiating the Oxidized Iron Formations. Mines, October and December 1961, pp. 16–20.
[25] Merklin, K. E., and F. D. DeVaney. The Wabush Pilot Plant: Stepping Stone to $200-Million Development. Eng. Min. J., v. 162, No. 4, April 1961, pp. 84–90.

"essentially a rather friable itabirite composed of medium grained specularite, sugary granular quartz, rather earthy limonite or goethite, martite, and fine magnetite."

A magnetic device for concentrating hematite was described.[26] Advances were made in autogenous grinding of iron ores, and a number of large units were installed. Improvement and increasing use of spirals and heavy-medium cyclones were noted.

Pilot-plant operations[27] were begun in Minnesota by two major companies to develop commercial procedures for the magnetic-oxide-conversion method of concentrating semi-taconite ores. In this method, the hematite in the low-grade ore is converted to artificial magnetite by reduction roasting, and concentration is then effected by magnetic methods.

Flotation of specular hematite from Michigan jaspilite ore was described,[28] and studies reportedly were in progress to develop a flotation procedure for reducing the silica content of magnetic taconite concentrate.

Trends in sintering equipment and operating practice were reported,[29] and a new single-strand sintering line, said to be the world's largest, was described.[30] The machine, with a grate width of 13 feet 2 inches, has a design capacity of 8,500 short tons per day of self-fluxing sinter. The other major method of agglomeration (pelletizing) also gained in use, and it was predicted that pellet production in the United States and Canada would increase to 50 million tons by 1968.[31]

Two meetings held in 1961 emphasized the importance of agglomeration. The published proceedings[32] of one meeting included 10 papers on the preparation and use of iron-ore agglomerates. The second meeting, an international symposium on agglomeration, considered the process, but many of the papers dealt specifically with iron ore. The combined papers of this symposium were scheduled for publication[33] in 1962.

Blast Furnace.—Blast-furnace productivity in 1961 began to reflect the great advances achieved in technology; however, the most desirable furnace feeds were in limited supply, and fuel-injection techniques were still under development for individual applications. The higher blast temperatures, up to 2,000° F, were used on relatively few furnaces. Growing acceptance of the new techniques, however, was shown by numerous papers, including a number presented in the Blast Furnace, Coke Oven, and Raw Materials Proceedings[34] cited earlier.

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[26] Stone, W. J. D. Jones Wet Magnetic Separator. Canadian Min. and Met. Bull., vol. 54, No. 593, September 1961, pp. 677–686.
[27] Skillings' Mining Review. Production Starts at Hanna Semi-Taconite Pilot Plant. V. 50, No. 11, Mar. 18, 1961, pp. 1, 4.
Skillings' Mining Review. Oliver Iron Mining's Semi-Taconite Plant. Vol. 50, No. 5, Feb. 4, 1961, 24 pp.
[28] Berkhahn, Robert W. How Flotation Makes High-Grade Specular Hematite Concentrate at Humboldt, pt. II of II. Min. World, v. 23, No. 12, November 1961, pp. 30–33.
[29] Porteus, J. H. A Review of Iron Ore Sintering. Iron and Steel Eng., v. 37, No. 5, May 1961, pp. 144–155.
[30] Blast Furnace and Steel Plant. Jones & Laughlin Starts Sintering Machine at Aliquippa. V. 49, No. 3, March 1961, pp. 259–264, 268.
[31] Craig, John J. The Use of Iron Ore Pellets. Skillings' Min. Rev., v. 50, No. 22, June 3, 1961, pp. 1, 4, 5.
[32] Blast Furnace, Coke Oven, and Raw Materials Proceedings, A.I.M.E. V. 20, 618 pp.
[33] Agglomeration, ed. by William A. Knepper. Interscience Publishers, Inc., 1962, 1109 pp.
[34] Work cited in footnote 32.

Additional evidence of the changing technology was found in the plans for two large-capacity blast furnaces. One under construction, at the Duquesne works near Pittsburgh, for United States Steel Corp., will have two tapping holes because of its capacity; it will have automatic probing of the stock column, a top pressure of 35 pounds, a hot blast temperature of 2,000° F, an air-cooled hearth, controlled sizing of the burden, and advanced instrumentation. Announced plans for immediate construction of a large furnace at the Jones & Laughlin Cleveland works presumably incorporated many of the same features.

Direct Reduction.—The more prominent direct-reduction processes were reviewed, at a meeting of the Institute of Chemical Engineers held in New York, N.Y., in December 1961. Publication of the review in a symposia series was planned for late 1962. A number of individual processes were described in the technical press.[35]

One variation of the direct-reduction process was under investigation by the Federal Bureau of Mines. Partially reduced taconite pellets, containing 80 percent or more iron, were prepared for use as a premium blast-furnace feed, and testing in the Bureau of Mines experimental blast furnace was scheduled for 1962. Preparation and preliminary evaluation of the pellets were described.[36]

Bureau of Mines Research.—Bureau of Mines resource investigations in the Lake Superior district and in several Western and Southeastern States involved sampling, metallurgical classifications of the deposits, and beneficiation studies. Three publications [37] were issued in 1961. Mining studies included basic and applied research on rock penetration, fragmentation, and mining methods. Fundamental research on the mechanics involved in drilling and breaking rock, using chemical, mechanical, and thermal energy, was conducted.

Beneficiation research in progress included flotation, conversion of nonmagnetic iron minerals to the magnetic form, treatment of slimes, removal of detrimental impurities, and agglomeration of fine-grained concentrate. Three reports [38] were published.

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[35] Braddock, W. R. Ocarb Electric Furnace Process for the Direct Reduction of Iron Ore. Iron and Steel Eng., v. 38, No. 4, April 1961, pp. 123–125.
Rowen, Harold E., and C. D. Thompson. Production Aspects of the Dwight-Lloyd McWane Ironmaking Process. Iron and Steel Eng., v. 38, No. 6, June 1961, pp. 90–97.
Skillings' Mining Review. Arkota Iron Ore Reduction in Arizona. V. 50, No. 21, May 27, 1961, pp. 1, 4, and 5.
Iron Age. H-Iron Passes the "Acid Test." V. 188, No. 5, Aug. 3, 1961, pp. 78–79.
Chemical Week. Double-Action Shrinks Route To Iron. V. 88, No. 12, Mar. 25, 1961, pp. 87–94.

[36] Hansen, J. P., N. B. Melcher, and M. M. Fine. Prereduced Iron Ore Pellets, Their Experimental Preparation. J. Metals, v. 13, No. 4, April 1961, pp. 314–315.

[37] Marovelli, R. L., D. W. Frommer, F. W. Wessel, L. F. Heising, P. A. Wasson, and R. E. Lubker. Lake Superior Resources. BuMines Rept. of Inv. 5670, 1961, 35 pp.
Becker, R. M., S. S. Shannon, Jr., and C. K. Rose. Iron Mountain Titaniferous Magnetite Deposits, Fremont County, Colo. BuMines Rept. of Inv. 5864, 1961, 18 pp.
Dow, V. T. Magnetite and Ilmenite Resources, Iron Mountain Area, Albany County, Wyo. BuMines Inf. Circ. 8037, 1961, 133 pp.

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The Bureau of Mines experimental blast furnace continued in use as one of the industry's outstanding research tools; it is used for evaluation of raw materials and for developing and demonstrating new operating procedures. Three Bureau of Mines publications [39] relating to blast furnace operations and one [40] on electric smelting of titaniferous magnetite were published.

An article [41] published in the technical press described Bureau of Mines research on fuel-oil injection.

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Iron and Steel

By James C. O. Harris [1]

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THE YEAR 1961 was one of slow but definite recovery for the U.S. steel industry, with uptrends in steel production and employment. However, pressure on prices and increases in labor cost raised the break-even point for producers despite advances in technology and the installation of improved equipment.

National pig iron and steel ingot (including steel castings made by ingot producers) outputs in 1961 were 65 million short tons and 98 million tons, respectively, slightly less than in 1960. Steel castings made by foundries that do not make ingots totaled 1 million tons, compared with 1.2 million tons in 1960. Shipments of gray and malleable iron castings were 11.5 million tons, compared with 12.4 million tons the preceding year. Indices for the above commodities in 1961 (1957–59=100) were as follows: Pig iron, 99.0; steel ingots, 100.9; steel castings, 85.5; and iron castings, 77.8. The corresponding figures for 1960 were 101.7, 102.9, 93.9, and 83.7, respectively.

The United States remained for the 72d consecutive year as the world leader in steel manufacture. Its production represented about one-fourth of world output and surpassed that of the U.S.S.R., the second largest producer, by 20 million tons, compared with a difference of 27 million tons in 1960.

Advances in technology included the development of new products, improvement of old products, and methods for speeding production. Among the new products were thin tin-plate, rectangular hot-rolled structural tubing, aluminized wire for fences, wire mat for concrete construction, high-strength structural steels, and various new alloy and stainless steels. New or improved products included differentially coated galvanized sheets and sheets coated on one side; steels for extreme temperatures, hot and cold; colored stainless steel; better enameling and plastic-coated steels; new high-strength steels; and many other new products. Nearly 4 million tons of steel, a record, was made in oxygen converters at furnace rates as high as 240 tons per hour. Oxygen also increased open-hearth output at some plants to 100 tons per hour. Vacuum melting gained, and new high-speed rolling mills were installed. The use of sinter and pellets in blast furnaces increased, and progress was made in the use of gas, oil, and powdered coal as supplementary blast-furnace fuels. Outlays

[1] Commodity specialist, Division of Minerals.

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for construction and new equipment were about $1.2 billion. Bethlehem Steel Corp. formally opened a new $35 million research center on October 9, 1961.

Shipments of steel-mill products including exports totaled 66.1 million tons, compared with 71.1 million tons in 1960 and 69.4 million tons in 1959. All major consumer industries bought less steel, except containers and contractor's products, which increased 6 and 7 percent, respectively. The automotive industry continued to be the leading consumer, receiving 12.6 million tons, or nearly 20 percent, of domestic shipments.

Imports of major iron and steel products totaled 3.3 million short tons, compared with 3.6 million tons in 1960 and 4.6 million tons in the peak year of 1959. The European Coal and Steel Community and Japan supplied 61 percent and 19 percent, respectively, of imports. Exports were 2.2 million tons, 31 percent lower than in 1960.

No change in the price of steel had occurred in 3 years, and lower priced foreign steels continued to penetrate domestic markets. According to the American Iron and Steel Institute (A.I.S.I.), the 1961 payroll of steel ingot producers was $3.7 billion, compared with the record $3.8 billion in 1960. The net billing value of steel products shipped and other services totaled $13.2 billion, compared with $14 billion in 1960. Net income was $692 million, the lowest since 1952.

Weekly hours per employee in the steel industry in 1961 averaged 38.6, compared with 38.0 in 1960. The average number of employees was 428,000, compared with 471,000 in 1960, and the average hourly wage was $3.19, compared with $3.08 in 1960. The 13th wage increase for steelworkers since World War II went into effect on October 1, 1961.

TABLE 1.—Salient iron and steel statistics

(Thousand short tons)

	1952–56 (average)	1957	1958	1959	1960	1961
United States:						
Pig iron:						
Production	69,198	78,404	57,155	60,210	66,501	64,853
Shipments	69,118	76,887	56,918	61,245	65,612	65,307
Imports for consumption	374	225	210	700	331	
Exports	69	882	103	10	112	416
Steel: [1]						
Production of ingots and castings (all grades):						
Carbon	95,540	103,803	78,591	84,539	90,864	89,339
Stainless	1,064	1,047	896	1,131	1,004	1,137
All other alloy	8,465	7,865	5,768	7,776	7,414	7,538
Total	105,068	112,715	85,255	93,446	99,282	98,014
Capacity, annual Jan. 1	120,931	133,459	140,743	147,634	148,571	[2]
Percent of capacity	86.9	84.5	60.6	63.3	66.8	[2]
Index (1952–56=100)	100.0	107.3	81.1	88.9	94.5	93.3
Total shipments of steel mill products	75,855	79,895	59,914	69,377	71,149	66,126
Imports of major iron and steel products [3 4]	1,279	1,295	1,820	4,615	3,570	3,309
Exports of major iron and steel products	4,002	5,917	3,225	1,973	[5] 3,247	2,235
World Production:						
Pig iron [6]	192,430	[5] 233,300	[5] 216,750	[5] 247,100	285,000	289,350
Steel ingots and castings	269,750	322,500	[5] 298,450	[5] 336,300	[5] 381,400	392,400

[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 exclusive of ferroalloys was 2 percent less than 1960 and 6 percent below the 1952–56 average. The number of blast furnaces operating increased from 112 in January to 168 in December. Production during the first 6 months was 28.5 million short tons, compared with 36.5 tons during the last half of the year. According to the American Iron Ore Association, average production per blast day was 1,305 tons, compared with 1,182 tons in 1960 and 1,090 tons in 1959. Pig iron production increased in 7 of the 16 States included in table 2 (see footnote 1). Pennsylvania, Ohio, Indiana, and Illinois led in production and supplied 23, 17, 14, and 7 percent, respectively, of the pig iron, compared with 25, 17, 13, and 8 percent in 1960.

Blast furnaces produced 27.1 million short tons of blast-furnace slag, or 835 pounds per ton of pig iron, compared with 867 pounds in 1960; 4.1 million tons of flue dust was recovered, or 126 pounds per ton of pig iron, compared with 145 pounds in 1960.

The number of blast furnaces in the United States was 259, 1 less than the previous year. The Interlake Iron Corp. furnace at Jackson, Ohio, was dismantled. In April, Granite City Steel Co. started its new 2,000-ton-per-day blast furnace; it had been completed in 1960. United States Steel Corp. was building a 28-ft.-hearth-diameter blast furnace at its Duquesne works. Jones & Laughlin Steel Corp. announced it would build a 28-ft.-hearth-diameter blast furnace at Cleveland. Completion was scheduled for 1963.

Shipments of pig iron (including onsite transfers) were virtually the same as in 1960. As over 90 percent of all pig iron made in the United States was used in the molten state for making steel ingots, castings, and iron castings, the values of pig iron shown in tables 2 and 4 are largely estimated and may differ from prices published in trade journals or other sources. Some companies reported lower values than in previous years.

Metalliferous Materials Used.—The production of pig iron excluding coke and fluxes required 108.4 million tons of iron ore, manganiferous ores, and agglomerates; 3.6 million tons of scrap; 86,182 tons of flue dust; and 6.6 million tons of miscellaneous materials. The combined total equals 1.829 tons of material per ton of pig iron produced. The scrap charge consisted of 2,748,226 tons of home and purchased scrap, 756,761 tons of slag scrap, and 79,331 tons of offgrade pig iron. Consumption of miscellaneous materials included 3.2 million tons of mill cinder and scale, 3.2 million tons of open-hearth and Bessemer slag, 33,064 tons of other metalliferous materials, and 210,725 tons of nonmetalliferous materials. Net totals shown in table 6 were computed by deducting 4.5 million tons of flue dust recovered and 698,509 tons of scrap produced at blast furnaces.

The agglomerate charge consisted of 45,058,719 tons of sinter, including 10,289,358 tons of self-flux sinter; 13,585,213 tons of pellets; 114,109 tons of nodules; and 1,626,791 tons of unclassified agglomerates; 1,187,378 tons came from foreign sources. Chile, Venezuela, Canada, and Peru were the leading suppliers of foreign iron and manganiferous ores used in blast furnaces. In addition to the agglomerate charge, 13.6 million tons of foreign iron ore was used

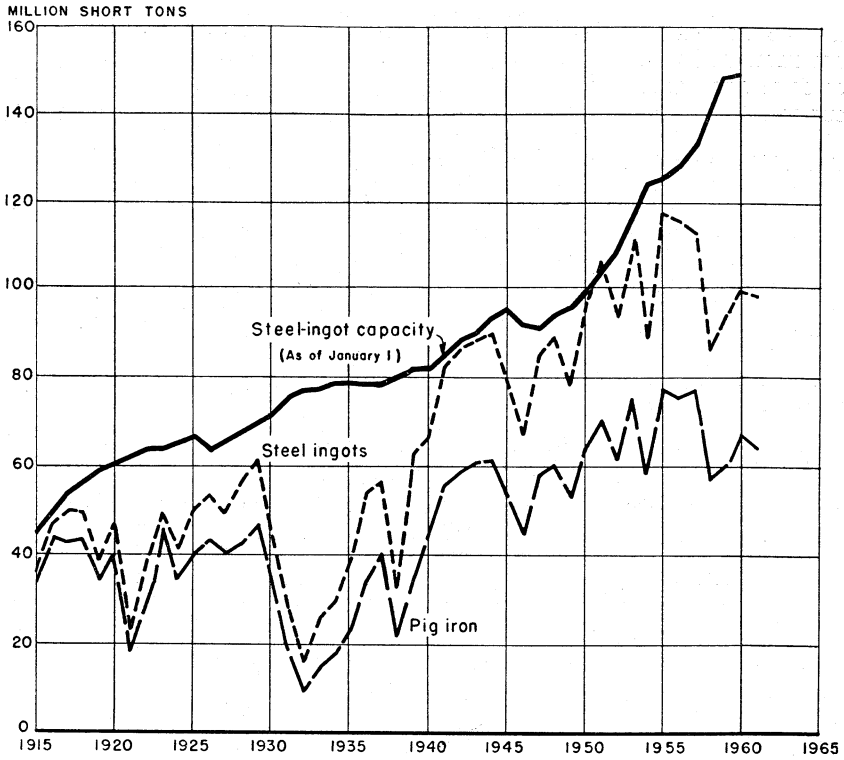


FIGURE 1.—Trends in production of pig iron and steel ingots, 1915–61, and steel-ingot capacity in the United States, 1915–60.

TABLE 2.—Pig iron produced and shipped in the United States, by States

(Thousand short tons and thousand dollars)

State	Produced		Shipped from furnaces			
	1960	1961	1960		1961	
	Quantity		Quantity	Value	Quantity	Value
Alabama	3,545	3,531	3,545	$200,366	3,585	$202,946
Illinois	5,307	4,725	5,247	316,382	4,775	288,469
Indiana	8,404	8,877	8,424	496,750	8,865	522,733
Ohio	11,788	10,984	11,561	688,038	11,007	669,033
Pennsylvania	16,539	15,205	16,199	973,815	15,272	908,363
California, Colorado, and Utah	3,735	4,657	3,700	221,002	4,700	237,348
Kentucky, Tennessee, and Texas	1,670	1,639	1,619	93,718	1,723	97,247
Maryland and West Virginia	6,318	6,418	6,338	395,955	6,493	397,606
Michigan and Minnesota	4,985	5,005	4,921	265,094	5,059	267,726
New York and Massachusetts [1]	4,210	3,762	4,058	254,608	3,828	229,890
Total	66,501	64,853	65,612	3,905,728	65,307	3,821,361

[1] No production in 1961.

in agglomerate plants; most of this tonnage was used in blast furnaces. According to AISI, 8.9 billion cubic feet of oxygen was used at blast-furnace plants, compared with 4.4 billion in 1960. According to

data collected by the Bureau of Mines, 16 blast-furnace plants also consumed 13.2 billion cubic feet of natural gas, 997.2 million cubic feet of coke-oven gas, and 2,636,071 gallons of fuel oil by injection through tuyeres.

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	1960	1961 [1]	Source	1960	1961 [1]
Brazil	30,692	32,546	Venezuela	5,160,601	4,175,675
Canada	5,645,373	5,107,871	Other countries	234,113	115,863
Chile	1,273,570	1,026,282			
Peru	1,888,866	633,931	Total	14,233,215	10,092,168

[1] Excludes 13,572,198 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	1960			1961		
	Quantity	Value		Quantity	Value	
		Total	Average per ton		Total	Average per ton
Foundry	1,526	$91,739	$60.10	1,402	$83,856	$59.81
Basic	57,806	3,433,263	59.39	58,601	3,413,110	58.24
Bessemer	3,230	193,456	59.90	2,641	160,518	60.78
Low-phosphorus	338	20,997	62.12	207	13,561	65.51
Malleable	2,427	149,426	61.57	2,213	137,844	62.29
All other (not ferroalloys)	285	16,847	59.11	243	12,472	51.33
Total	65,612	3,905,728	59.53	65,307	3,821,361	58.51

[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, 1961			January 1, 1962		
	In blast	Out of blast	Total	In blast	Out of blast	Total
Alabama	11	11	22	10	12	22
California	3	1	4	4		4
Colorado	2	2	4	3	1	4
Illinois	9	13	22	14	8	22
Indiana	11	12	23	19	4	23
Kentucky	1	2	3	2	1	3
Maryland	4	6	10	10		10
Michigan	5	4	9	9		9
Minnesota	1	2	3	1	2	3
New York	8	9	17	13	4	17
Ohio	18	33	51	29	21	50
Pennsylvania	32	43	75	46	29	75
Tennessee	1	2	3	1	2	3
Texas	1	1	2	2		2
Utah	3	2	5	4	1	5
Virginia	1	1	2	1	1	2
West Virginia	3	2	5	4	1	5
Total	114	146	260	172	87	259

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							Net coke	Fluxes	Pig iron produced	Metalliferous materials consumed per ton of pig iron made				Coke and fluxes consumed per ton of pig iron	
	Iron and manganiferous ores		Agglomerates	Net ores and agglomerates [1]	Net scrap [2]	Miscellaneous [3]	Net total				Net ores and agglomerates [1]	Net scrap [2]	Miscellaneous [3]	Total	Net coke	Fluxes
	Domestic	Foreign														
1960																
Alabama	4,937,610	181,317	2,169,705	7,025,942	117,744	84,154	7,227,840	3,376,924	1,102,905	3,544,862	1.982	0.033	0.024	2.039	0.953	0.311
Illinois	4,353,529	62,850	4,384,323	8,467,644	242,684	670,698	9,381,026	4,039,896	1,237,451	5,307,121	1.596	.046	.126	1.768	.761	.233
Indiana	4,811,611	323,408	9,141,807	13,760,797	175,231	1,031,745	14,967,773	5,684,307	1,311,714	8,403,794	1.637	.021	.123	1.781	.676	.156
Ohio	7,094,397	3,278,551	8,216,629	17,762,718	757,721	1,440,800	19,961,239	9,142,089	3,249,982	11,787,861	1.507	.064	.122	1.693	.776	.276
Pennsylvania	7,412,435	5,607,721	12,623,343	24,292,886	1,054,701	2,157,349	27,504,936	12,314,350	4,224,565	16,539,421	1.469	.064	.130	1.663	.745	.255
California, Colorado, and Utah	(4)	(4)	3,352,484	6,591,835	92,295	76,832	6,760,962	2,695,196	623,555	3,734,739	1.765	.025	.021	1.810	.722	.167
Kentucky, Tennessee, and Texas	436,333	386,032	1,696,204	2,479,299	143,022	219,990	2,842,311	1,248,495	436,366	1,670,360	1.484	.086	.132	1.702	.747	.261
Maryland and West Virginia	(4)	(4)	6,243,870	9,485,416	181,864	722,064	10,389,344	4,400,559	1,066,593	6,317,683	1.501	.029	.114	1.644	.697	.169
Michigan and Minnesota	(4)	(4)	4,647,801	8,183,625	186,625	245,901	8,616,151	3,698,981	1,367,341	4,985,388	1.642	.037	.049	1.728	.742	.274
New York and Massachusetts	2,098,026	305,496	4,549,065	6,650,608	231,640	228,404	7,110,652	3,274,181	1,311,521	4,209,993	1.580	.055	.054	1.689	.778	.312
Total	[5]38,193,563	14,233,215	57,025,231	104,700,770	3,183,527	6,877,937	114,762,234	49,874,978	[6]15,931,993	66,501,222	1.574	.048	.103	1.726	.750	.240
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	.047	.011	1.975	.926	.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, and 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, and 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	[7]13,587,913	64,852,726	1.582	.045	.101	1.728	.707	.210

[1] Net ores and agglomerates=ores+agglomerates+flue dust used−flue dust recovered.
[2] Excludes home scrap produced at blast furnaces.
[3] Does not include recycled material.
[4] Included in total.
[5] Corrected figure.
[6] Fluxes consisted of 11,500,741 tons of limestone, 4,431,252 tons of dolomite, excluding 3,389,992 tons of limestone and 1,243,203 tons of dolomite used in agglomerate production at or near steel plants and an unknown quantity used in making agglomerates at mines.
[7] The corresponding figures for 1961: [6] 9,401,285 tons of limestone, 4,186,628 tons of dolomite, 4,533,355 tons of limestone and 1,421,140 tons of dolomite—quantities used at mines are unknown.

PRODUCTION AND SHIPMENTS OF STEEL

United States production of steel in 1961 was 98 million short tons, compared with 99.3 million tons in 1960. Production increased each quarter. During the first quarter, 19.7 million short tons was made, compared with 18.8 million tons in the last quarter of 1960. Output for the second, third, and fourth quarters was 25.1, 25.7, and 27.5 tons, respectively. Steel castings made by independent foundries, not included in the production data, totaled 1,078,182 short tons, compared with 1,184,459 tons in 1960 and 1,366,328 tons in 1959.

Of the total tonnage of steel produced, 86.2 percent was made in open-hearth furnaces, 8.8 percent in electric furnaces, 4.1 percent in oxygen converters, and 0.9 percent in Bessemer converters. Corresponding figures for 1960 were 87, 8.4, 3.4, and 1.2, respectively. Pennsylvania led in steel production, and Ohio, Indiana, and Illinois ranked second, third, and fourth, supplying 23, 17, 14, and 9 percent, respectively, compared with 25, 17, 14, and 8 percent in 1960.

The steelmaking facilities constructed or improved during the year are shown in table 7.

The Louis Berkman open-hearth plant at Toronto, Ohio, and the Phoenix Steel Corp. open-hearth and electric-furnace plant at Harrisburg, Pa., were dismantled.

Shipments of steelmill products (table 11) decreased 5 million tons. Although shipments in most categories decreased, those to can and closure manufacturers were at a record high of 5.3 million tons. The largest decreases were to the automotive and rail transportation industries. Shipments for export dropped 0.8 million tons.

Alloy Steel.[2]—Domestic alloy-steel production was 8,674,726 short tons—8,628,533 tons of ingots and 46,193 tons of castings—an increase of 3 percent over 1960. Alloy steel supplied 8.9 percent of the steel output, compared with 8.5 percent in 1960.

Stainless-steel ingot production (13.1 percent of the total alloy-steel output) was 1,135,891 tons, 13.5 percent above 1960 and the highest since 1959. The production of austenitic stainless steel AISI 300 (nickel-bearing) and 200 series (manganese-nickel-bearing), representing 65.5 percent of stainless-steel production, was 15.4 percent above 1960; output of ferritic and martensitic, straight chromium types, AISI 400 series, increased 7.4 percent. Production of AISI 200 series (31,881 tons) established a new record. The output of type 501, 502, and other high-chromium, heat-resisting steels, included in the stainless-steel-production figure, increased 56.8 percent.

Output of carbon-steel ingots and castings was 89.3 million short tons, compared with 90.9 million tons in 1960.

Production of all grades of alloy-steel ingots, other than stainless, increased 2 percent. Production of chromium steels (1.2 million

[2] The Bureau of Mines uses the American Iron and Steel Institute specifications for alloy steels, which include stainless and any other steel containing one or more of the following elements in the designated percentages: Manganese in excess of 1.65 percent, silicon in excess of 0.60 percent, and copper in excess of 0.60 percent. It also includes steel, containing the following elements in any quantity specified or known to have been 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).

TABLE 7.—Partial listing of announced expansion plans for the steel industry

Company and plant	Additional ingot capacity, tons	Steelmaking facilities
Allegheny Ludlum Steel Corp.:		
Brackenridge Works, Brackenridge, Pa	(1)	Open-hearth furnaces expansion and technical improvement.
Dunkirk Works, Dunkirk, N.Y	(1)	Vacuum degassing chamber.[2]
Watervliet Works, Watervliet, N.Y	(1)	50-in.-diameter consumable-arc-electrode vacuum melting furnace.[2]
Armco Steel Corp.: Sheffield Div.:		
Sheffield Div., Kansas City, Kan	(1)	No. 3 electric furnace.[2]
Houston, Tex	(1)	Open-hearth improvements.
Bethlehem Steel Co.:		
Lackawanna, N.Y	400,000	310-ton oxygen plant.
Sparrows Point, Md	800,000	350-ton oxygen palnt.
The Colorado Fuel and Iron Corp.: Pueblo, Colo	(3)	Two 100-ton oxygen converter plant.[2]
Continental Steel Corp.: Kokomo, Ind	(1)	Revamping one open-hearth furnace.[2]
Copperwild Steel Co.: Aristoloy Steel Div., Warren, Ohio	(1)	Vacuum degassing unit. Melt shop improvements.
Detroit Steel Corp.: Portsmouth Div., Portsmouth, Ohio	400,000	Enlarge three open-hearth furnaces, and convert all five furnaces to all basic brick. Install oxygen jets.[2]
Firth Sterling, Inc.: McKeesport, Pa	(1)	Increase consumable electrode production 50 percent.[2]
Granite City Steel Co.: Granite City, Ill	(1)	Enlarge one open-hearth furnace to 600 tons and add oxygen roof lances.[2]
Hawaiian Western Steel, Ltd.: Ewa, Hawaii	(1)	One electric furnace.[2]
Inland Steel Co.: Indiana Harbor, Ind	(1)	Oxygen lances in open-hearth furnaces.[3]
Jones & Laughlin Steel Corp.: Cleveland Works Div., Cleveland, Ohio	(1)	Two basic oxygen furnaces.[2]
Latrobe Steel Co.: Latrobe, Pa	(1)	20 and 30-inch vacuum-melting furnace.[2]
Lukens Steel Co.: Coatesville, Pa	(1)	One 100-ton electric furnace.
Mississippi Steel Corp.: Jackson, Miss	(1)	12-ton electric furnace.
Great Lakes Steel Corp.: Ecorse, Mich	500,000	Two basic oxygen furnaces.
Pittsburgh Steel Co.: Monessen, Pa	(1)	Two oxygen converters.
Sharon Steel Corp.: Farrell, Pa	(1)	Vacuum degassing unit.[1]
	1,000,000	Stora-Kaldo two-converter steelmaking plant.
Soule Steel Co.: Long Beach, Calif	(1)	One electric furnace.[2]
United States Steel Corp.: Fairless Works, Fairless Hills, Pa	(1)	Enlarge nine open-hearth furnaces.[2]
Universal-Cyclops Steel Corp.:		
Bridgeville Plant, Bridgeville, Pa	(1)	35-ton electric furnace.
Empire-Reeves Steel Corp.: Mansfield, Ohio	100,000	100-ton electric furnace.
Washington Steel Corp.: Washington, Pa	(1)	Two 35-ton electric furnaces. Pressure-casting facilities.
Total	3,200,000	

[1] Not known.
[2] Completed in 1961.
[3] No net increase, 600,000 tons replacement of open-hearth capacity.

Source: Iron and Steel Engineer.

short tons) and nickel-chromium-molybdenum steels (1.2 million tons) was virtually the same as in 1960. High-strength steels (932,000 tons) decreased 1 percent. Chromium-molybdenum steel output (998,000 tons) increased 18.9 percent.

The percentages of alloy steel produced in the basic open-hearth, acid open-hearth, and electric furnaces were 56, 1, and 43 percent, respectively, compared with 61, 1, and 38 percent in 1960.

Metalliferous and Other Materials Used in Steelmaking.—Pig iron and scrap consumed in steelmaking furnaces totaled 108.9 million short tons; the percentage of each was 55 and 45, respectively, compared with 54 and 46 percent in 1960. Consumption of foreign iron ore decreased 16 percent; however, it was the third highest recorded. The principal sources of iron ore were Chile, Brazil, Liberia, Venezuela, and Peru. According to AISI, other materials used in steelmaking

excluding independent foundries included 4.8 million tons of limestone, 1.4 million tons of lime, 206,001 tons of fluorspar, and 507,604 tons of other fluxes. Oxygen consumption at steel plants, exclusive of blast furnaces, reached a record 60.5 billion cu. ft., used as follows (in cubic feet): Steelmaking, 44.2 billion conditioning, 10.4 billion; scrap preparation, 1.5 billion; other burning and welding, 1.8 billion; and all other, 2.6 billion.

TABLE 8.—Steel capacity, production, and percentage of operations in the United States [1]

(Thousand short tons)

Year	Annual capacity, Jan. 1	Production						
		Open hearth		Bessemer	Oxygen converter	Electric [2]	Total	Percent of capacity
		Basic	Acid					
1952–56 (average)	120,931	93,773	596	3,295	(3)	7,404	105,068	86.9
1957	133,459	101,028	630	2,475	612	7,970	112,715	84.5
1958	140,743	75,502	378	1,396	1,323	6,656	85,255	60.6
1959	147,634	81,225	444	1,380	1,864	8,533	93,446	63.3
1960	148,571	85,964	404	1,189	3,346	8,379	99,282	66.8
1961	(3)	84,108	394	881	3,967	8,664	98,014	(3)

[1] Includes only that steel for castings produced in foundries operated by companies manufacturing steel ingots. Omits about 2 percent of total steel production.
[2] Includes crucible: Oxygen converter steel, 1954–55.
[3] Data not available.

Source: American Iron and Steel Institute.

TABLE 9.—Production of steel by States and processes [1]

(Thousand short tons)

Year and State	Open hearth	Bessemer	Basic oxygen process	Electric	Total
1956	102,841	3,228	506	8,641	115,216
1957	101,658	2,475	611	7,971	112,715
1958	75,880	1,396	1,323	6,656	85,255
1959	81,669	1,380	1,864	8,533	93,446
1960	86,368	1,189	3,346	8,379	99,282
1961:					
New York	4,516			129	4,645
Pennsylvania	19,414	(2)	(2)	1,805	22,398
Rhode Island, Connecticut, New Jersey, Delaware, and Maryland	6,954			165	7,119
Virginia, West Virginia, Georgia, and Florida	(2)			(2)	3,423
Kentucky	(2)			(2)	1,463
Alabama, Tennessee, and Mississippi	(2)			(2)	3,539
Ohio	14,139	(2)	(2)	1,472	16,513
Indiana	(2)			(2)	14,010
Illinois	6,621		(2)	(2)	8,395
Michigan	(2)		(2)	395	6,661
Minnesota, Missouri, Oklahoma, and Texas	2,093			993	3,086
Arizona, Colorado, Utah, Washington, Oregon, and Hawaii	(2)		(2)	400	3,557
California	1,847		(2)	(2)	3,205
Total	84,502	881	3,967	8,664	98,014

[1] Includes only that steel for castings produced in foundries operated by companies manufacturing steel ingots. Omits about 2 percent of total steel production.
[2] Figure withheld to avoid disclosing individual company confidential data.

Source: American Iron and Steel Institute.

TABLE 10.—Steel electrically manufactured in the United States [1]

(Thousand short tons)

Year	Ingots	Castings	Total [2]	Year	Ingots	Castings	Total [2]
1952-56 (average)	7,343	61	7,404	1959	8,477	56	8,533
1957	7,902	68	7,970	1960	8,313	66	8,379
1958	6,606	50	6,656	1961	8,597	67	8,664

[1] Includes only that steel for castings produced in foundries operated by companies manufacturing steel ingots. See table 8.
[2] Includes a very small quantity of crucible steel, and for 1954-56, oxygen converter steel.

Source: American Iron and Steel Institute.

TABLE 11.—Shipments of steel products by market classifications, all grades including carbon, alloy, and stainless

Market classification	1960		1961	
	Thousand short tons	Percent of total	Thousand short tons	Percent of total
Steel for converting and processing [1]	2,928	4.1	2,373	3.6
Forgings	841	1.2	765	1.2
Bolts, nuts, rivets, and screws	1,072	1.5	995	1.5
Warehouses and distributors:				
Oil and gas industry	1,125	1.6	1,528	2.3
All other	11,355	15.9	10,837	16.4
Total	12,480	17.5	12,365	18.7
Construction, including maintenance:				
Rail transportation	51	.1	(2)	(2)
Oil and gas	2,166	3.0	2,020	3.1
All other	7,447	10.5	7,240	10.9
Total	9,664	13.6	9,260	14.0
Contractors' products	3,602	5.1	3,851	5.8
Automotive:				
Passenger cars, trucks, parts, etc	14,194	19.9	12,146	18.4
Forgings	416	.6	448	.7
Total	14,610	20.5	12,594	19.1
Rail transportation:				
Railroad rails, trackwork, and equipment	723	1.0	422	.6
Freight cars, passenger cars, and locomotives	1,763	2.5	1,139	1.7
Street railways and rapid-transit systems	39	----------	33	.1
Total	2,525	3.5	1,594	2.4
Shipbuilding and marine equipment	622	.9	680	1.0
Aircraft	78	.1	85	.1
Oil and gas drilling	404	.6	365	.6
Mining, quarrying, and lumbering	288	.4	275	.4
Agriculture:				
Agricultural machinery	765	1.1	717	1.1
All other agricultural	238	.3	333	.5
Total	1,003	1.4	1,050	1.6
Machinery, industrial equipment, and tools	3,958	5.6	3,756	5.7
Electrical machinery and equipment	2,078	2.9	1,972	3.0
Appliances, utensils, and cutlery	1,760	2.5	1,749	2.6
Other domestic and commercial equipment	1,959	2.8	1,811	2.7
Containers:				
Cans and closures	4,976	7.0	5,271	8.0
Barrels, drums, and shipping pails	842	1.2	810	1.2
All other containers	611	.8	542	.8
Total	6,429	9.0	6,623	10.0
Ordnance and other military	165	.2	182	.3
Shipments of nonreporting companies	2,120	3.0	2,051	3.1
Total domestic	68,586	96.4	64,396	97.4
Export (companies reporting to AISI only)	2,563	3.6	1,730	2.6
Total shipments	71,149	100.0	66,126	100.0

[1] Net total after deducting shipments to reporting companies for conversion or resale.
[2] Included with "All other."

Source: American Iron and Steel Institute.

TABLE 12.—Alloy-steel ingots and castings manufactured in the United States, by processes [1]

(Thousand short tons)

Process	1952–56 (average)	1957	1958	1959	1960	1961
Open hearth:						
Basic	5,992	5,746	3,926	5,144	5,109	4,892
Acid	184	170	85	89	89	85
Electric [2]	3,353	2,996	2,653	3,674	3,220	3,698
Total	9,529	8,912	6,664	8,907	8,418	8,675

[1] Includes only that steel for castings produced in furnaces operated by companies manufacturing steel ingots. See table 8.
[2] Includes a very small quantity of crucible steel, and for 1960–61, oxygen converter steel.

Source: American Iron and Steel Institute.

CONSUMPTION OF PIG IRON

Although all States used some pig iron, 85 percent was consumed in steelmaking centers in the East, North Central, Middle Atlantic and South Atlantic States. Pennsylvania (the leading consumer) used 23 percent of the total; Ohio, 17 percent; and Indiana, 14 percent; corresponding figures for 1960 were 24, 17, and 13 percent, respectively.

TABLE 13.—Metalliferous materials consumed in steel furnaces in the United States

(Thousand short tons)

Year	Iron ore		Sinter [1]	Pig iron	Ferro-alloys [2]	Iron and steel scrap
	Domestic	Foreign				
1952–56 (average)	3,412	3,747	1,569	61,077	1,526	56,287
1957	2,837	5,592	[3] 1,934	68,768	1,530	56,765
1958	2,092	4,742	[4] 1,261	51,299	1,115	43,024
1959	1,690	5,238	[5] 961	54,699	1,380	49,794
1960	1,570	6,251	[6] 931	60,092	1,395	51,140
1961	1,913	5,277	[7] 855	59,418	1,367	49,455

[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 other agglomerates (nodules, pellets, etc.) and 106,602 tons of foreign origin.
[4] Includes 601,509 tons of sinter, 238,040 tons of pellets, 281,390 tons of nodules, and 139,824 tons of other agglomerates. (325,268 tons of foreign origin.)
[5] Includes 271,736 tons of sinter, 215,109 tons of pellets, 255,448 tons of nodules, 32,039 tons of briquets, and 187,017 tons of other agglomerates. (314,507 tons of foreign origin.)
[6] Includes 121,946 tons of sinter, 49,422 tons of pellets, 314,958 tons of nodules, 35,025 tons of briquets, and 409,863 tons of other agglomerates. (403,705 tons of foreign origin.)
[7] Includes 52,402 tons of sinter, 17,527 tons of pellets, 303,462 tons of nodules, 8,640 tons of briquets, and 473,202 tons of other agglomerates. (468,313 tons of foreign origin.)

TABLE 14.—Consumption of pig iron in the United States, by type of furnace

Type of furnace or equipment	1960		1961	
	Thousand short tons	Percent of total	Thousand short tons	Percent of total
Open hearth	55,270	83.0	54,611	83.0
Bessemer	1,303	2.0	976	1.5
Oxygen converter	2,937	4.4	3,552	5.4
Electric	[1] 372	.5	[1] 279	.4
Cupola	3,822	5.7	3,438	5.2
Air	210	.3	178	.3
Direct castings	2,712	4.1	2,763	4.2
Total	66,626	100.0	65,797	100.0

[1] Includes a small quantity of pig iron consumed in crucible furnaces.

TABLE 15.—Consumption of pig iron in the United States, by districts and States

(Short tons)

District and State	1960	1961	District and State	1960	1961
New England:			South Atlantic—Cont.		
Connecticut	33,756	29,410	North Carolina	26,417	27,971
Maine and New Hampshire	4,929	4,136	South Carolina	17,986	15,882
Massachusetts	73,313	63,281	Virginia and West Virginia	2,129,461	2,143,204
Rhode Island	48,380	36,958	Total	6,578,984	6,617,408
Vermont	7,345	8,038			
Total	167,723	141,823	East South Central:		
			Alabama	3,144,319	3,222,653
Middle Atlantic:			Kentucky, Mississippi, and Tennessee	905,603	907,614
New Jersey	147,537	144,530	Total	4,049,922	4,130,267
New York	3,382,392	3,219,625			
Pennsylvania	16,295,129	15,315,543	West South Central:		
Total	19,825,058	18,679,698	Arkansas, Louisiana, and Oklahoma	8,183	7,749
			Texas	723,894	856,118
East North Central:			Total	732,077	863,867
Illinois	5,244,885	4,975,379			
Indiana	8,883,812	9,075,150	Rocky Mountain:		
Michigan	5,034,654	5,159,290	Arizona and Nevada	88	88
Ohio	11,503,557	10,937,800	Colorado, Idaho, Montana, and Utah	2,202,759	2,351,978
Wisconsin	195,801	175,747	Total	2,202,847	2,352,066
Total	30,862,709	30,323,366			
			Pacific Coast:		
West North Central:			California	1,649,991	2,191,936
Iowa	69,287	69,451	Oregon and Washington	6,606	3,720
Kansas and Nebraska	5,332	5,706	Total	1,656,597	2,195,656
Minnesota	431,151	393,744			
Missouri	44,649	24,246	otal United States	66,626,336	65,797,298
Total	550,419	493,147			
South Atlantic:					
Delaware and Maryland	4,392,072	4,418,830			
Florida and Georgia	13,048	11,521			

PRICES

Pig iron and steel prices remained virtually constant during 1961. The weighted average annual price of pig iron, as published by Iron Age, was $59.32 per short ton. The Iron Age composite price of finished steel for 1961 was 6.196 cents per pound, the same as in 1960.

TABLE 16.—Average value of pig iron at blast furnaces in the United States, by States

(Per short ton)

State	1952–56 (average)	1957	1958	1959	1960	1961
Alabama	$47.40	$53.94	$55.14	$56.81	$56.52	$56.62
California, Colorado, and Utah	51.53	57.44	57.53	60.47	59.73	50.50
Illinois	50.93	58.04	61.32	60.12	60.30	60.42
Indiana	50.39	58.33	58.41	58.82	58.90	58.96
New York	51.41	63.09	64.48	61.01	62.54	60.05
Ohio	49.67	55.88	57.93	59.50	57.79	60.78
Pennsylvania	51.47	59.25	62.45	59.84	60.12	59.48
Other States [1]	50.58	60.37	60.53	58.38	58.06	57.44
Average	50.55	58.43	59.60	59.33	59.53	58.51

[1] Comprises Kentucky, Maryland, Michigan, Minnesota, Tennessee, Texas, West Virginia, and Massachusetts (1952–60).

TABLE 17.—Average prices of chief grades of pig iron

(Per short ton)

Month	Foundry pig iron at Birmingham furnaces	Foundry pig iron at Valley furnaces	Bessemer pig iron at Valley furnaces	Basic pig iron at Valley furnaces
	1958–61	1958–61	1958–61	1958–61
January–December	$55.80	$59.38	$59.82	$58.93

Source: Metal Statistics.

TABLE 18.—Free-on-board value of steel-mill products in the United States, in 1960

(Cents per pound)

Product	Carbon	Alloy	Stainless	Average
Ingots	4.571	8.471	31.553	7.909
Semifinished shapes and forms	5.842	10.444	43.697	6.646
Plates	6.675	11.348	60.341	7.450
Sheets and strips	7.132	14.781	44.943	8.100
Tinmill products	9.081			9.081
Structural shapes and piling	6.392	8.291		6.417
Bars	7.682	13.605	64.531	9.272
Rails and railway-track material	7.695			7.695
Pipes and tubes	10.593	19.773	154.422	11.840
Wire and wire products	13.013	38.678	86.430	14.079
Other rolled and drawn products	10.448	45.180	67.382	16.004
Average total steel	7.763	14.148	53.717	8.657

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.

Source: Computed from figures supplied by the U.S. Department of Commerce, Bureau of the Census.

FOREIGN TRADE [3]

For the third consecutive year, imports of foreign steel-mill products exceeded exports. Prior to 1959, exports exceeded imports, and the AISI estimated that the steel industry would have about 40,000 more jobs if the import-export trend of former years could be reestablished.

Imports.—Imports of iron and steel products were the third highest on record, totaling 3.3 million short tons, compared with 3.6 million tons in 1960 and 4.6 million in 1959, the other 2 record years. The European Coal and Steel Community and Japan were the leading suppliers of foreign steel, with 2.0 and 0.6 million short tons, respectively. Imported steel supplied 53 percent of the domestic barbed-wire market, 43.5 percent of nails and staples, 28.1 percent of wire rods, 20.4 percent of the woven-wire fence, and 19.3 percent of concrete reinforcement bars. The percentages were virtually the same in 1960. Imports of pig iron (93 percent from Canada) were 377,180 tons, compared with 330,847 tons in 1960.

Exports.—Exports of iron and steel products totaled 2.2 million short tons, compared with 3.2 million short tons in 1960. Exports of pig iron, of which 77 percent to Japan, were 415,668 tons (value $19,243,057), compared with 111,773 tons (value $5,174,437) in 1960.

[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 19.—U.S. imports for consumption of pig iron, by countries

(Short tons)

Country	1952-56 (average)	1957	1958	1959	1960	1961
North America: Canada	272,229	221,166	182,128	437,095	281,593	349,403
South America:						
Brazil	3,924		2			
Chile	515					
Total	4,439		2			
Europe:						
Austria	2,214					
Belgium-Luxembourg	609				4,408	
Finland	34			10,253		
France	69					
Germany, West	10,319	34	13,933	[1] 71,805	386	719
Netherlands	8,094		1,125	4,427	1,575	
Norway	2,621		334	168		
Portugal				4,395		
Spain	8,919		7,867	78,499	21,551	19,113
Sweden	12,850	3,135	1,615	1,071	1,445	1,201
U.S.S.R.				1,550	1,298	396
Other Europe	[2]			51		
Total	45,729	3,169	24,874	172,219	30,663	21,429
Asia:						
India	6,336			56	6,742	
Japan				10,674		
Turkey	124					
Total	6,460			10,730	6,742	
Africa:						
Rhodesia and Nyasaland, Federation of [3]	1,758			4,863	392	
Union of South Africa	1,414			70,519	7,543	4,096
Total	3,172			75,382	7,935	4,096
Oceania: Australia	42,171	1,052	2,739	4,167	3,914	2,252
Grand total:						
Short tons	374,200	225,387	209,743	699,593	330,847	377,180
Value	$18,307,071	$13,527,813	$12,026,015	$35,493,259	$18,351,333	$20,511,391

[1] Includes 110 tons from East Germany.
[2] Less than 1 ton.
[3] Classified as Southern Rhodesia through June 30, 1954; 1,562 short tons was produced from January through June 1954.

Source: Bureau of the Census.

TABLE 20.—U.S. imports for consumption of major iron and steel products

Product	1960		1961	
	Short tons	Value	Short tons	Value
Iron products:				
Bar iron, iron slabs, blooms, or other forms	73	$21,942	60	$18,971
Pipes and fittings:				
Cast-iron pipe and fittings	18,390	2,112,097	21,956	2,450,013
Malleable cast-iron pipe fittings	[1] 7,520	[1] 2,919,692	2,300	917,052
Casting and forgings	[1] 15,373	[1] 3,634,642	6,841	2,408,145
Total	[1] 41,356	[1] 8,688,373	31,157	5,794,181
Steel products:				
Steel bars:				
Concrete reinforcement bars	515,522	47,353,942	582,807	48,468,456
Solid and hollow, n.e.s.	[1] 133,500	[1] 19,159,207	112,663	14,276,382
Hollow and hollow drill steel	1,848	651,189	1,486	631,019
Wire rods, nail rods, and flat rods up to 6 inches in width	408,201	46,763,683	451,209	59,015,135

See footnotes at end of table.

TABLE 20.—U.S. imports for consumption of major iron and steel products—Con.

Product	1960		1961	
	Short tons	Value	Short tons	Value
Steel products—Continued				
Boiler and other plate iron and steel, n.e.s.	301,885	$34,970,619	71,045	$8,407,821
Steel ingots, blooms, and slabs; billets, solid and hollow	67,762	8,780,659	178,915	12,536,560
Die blocks or blanks, shafting, etc.	2,195	652,737	1,083	439,999
Circular saw plates	51	52,437	37	39,837
Sheets of iron or steel, common, or black and boiler or other plate iron or steel	274,335	42,508,732	64,700	8,993,987
Sheets and plates and steel, n.s.p.f.	12,977	3,194,914	6,823	2,397,182
Tinplate, terneplate, and taggers' tin	19,726	3,846,437	15,151	2,651,937
Structural iron and steel	607,161	73,445,439	553,155	59,775,317
Rails for railways	7,831	656,430	14,231	1,172,742
Rail braces, bars, fishplates, or splice bars and tie plates	875	109,936	472	67,573
Steel pipes and tubes	[1] 479,704	[1] 77,599,020	521,264	79,845,253
Wire:				
Barbed	52,964	7,849,830	82,457	11,810,235
Round wire, n.e.s.	206,564	35,764,109	172,026	31,036,899
Telegraph, telephone, etc., except copper, covered with cotten jute, etc.	3,013	783,701	1,441	507,815
Flat wire and iron and steel strips	[1] 63,373	[1] 15,632,488	59,881	14,244,943
Rope and strand	35,974	11,981,995	34,178	10,164,586
Galvanized fencing wire and wire fencing	51,881	7,920,155	59,955	8,340,744
Iron and steel used in card clothing	[2]	518,122	[2]	250,364
Hoop and band iron and steel, for baling	22,592	[1] 3,063,390	18,432	2,367,807
Hoop, band and strips, or scroll iron or steel, n.s.p.f.	15,003	2,821,964	10,576	1,957,941
Nails	239,577	39,041,521	252,713	36,930,374
Steel castings and forgings	3,945	679,156	10,619	1,936,801
Total	[1] 3,528,459	[1] 485,801,812	3,277,319	418,267,709
Advanced manufactures:				
Bolts, nuts, and rivets	[1] 48,304	[1] 15,461,468	43,684	13,583,140
Chains and parts	[1] 9,025	[1] 5,116,938	7,052	4,784,443
Hardware, builders'	----------	1,712,324	----------	1,709,896
Hinges and hinge blanks	----------	[1] 1,852,802	----------	1,594,101
Screws (wholly or chiefly of iron or steel)	----------	[1] 2,034,779	----------	1,656,075
Tools	----------	[1] 18,557,007	----------	18,070,497
Other	----------	[1] 545,762	----------	694,652
Total	----------	[1] 45,281,080	----------	42,092,804
Grand total	----------	[1] 539,771,265	----------	466,154,694

[1] Revised figure.
[2] Weight not recorded.
Source: Bureau of the Census.

TABLE 21.—U.S. exports of major iron and steel products

Product	1960		1961	
	Short tons	Value	Short tons	Value
Semimanufactures:				
Steel ingots, blooms, billets, slabs, and sheet bars	74,524	$7,664,271	138,044	$13,981,224
Iron and steel bars and rods:				
Carbon-steel bars, hot-rolled, and iron bars	43,832	8,223,429	51,712	9,058,636
Concrete reinforcement bars	15,467	2,235,889	15,688	2,121,988
Other steel bars	25,542	9,710,031	23,915	11,093,061
Wire rods	10,238	1,326,981	5,378	1,893,402
Iron and steel plates, sheets, skelp, and strips:				
Plates, including boiler plate, not fabricated	91,434	20,473,441	97,398	19,594,111
Skelp iron and steel	44,370	5,338,650	42,025	4,264,356
Iron and steel sheets, galvanized	46,341	9,957,398	65,933	13,061,939
Steel sheets, black, ungalvanized	[1] 1,324,233	[1] 248,312,185	492,830	105,590,390
Strip, hoop, band, and scroll iron and steel:				
Cold-rolled	[1] 40,293	[1] 19,088,365	35,259	16,227,719
Hot-rolled	[1] 32,210	[1] 8,801,175	34,958	8,697,759
Tinplate and terneplate	565,536	101,356,117	401,752	66,811,505
Tinplate circles, cobbles, strip, and scroll shear butts	22,949	2,679,757	23,475	2,491,455
Total	[1] 2,336,969	[1] 445,167,689	1,428,367	274,887,545

See footnotes at end of table.

TABLE 21.—U.S. exports of major iron and steel products—Continued

Product	1960		1961	
	Short tons	Value	Short tons	Value
Manufactures-steel-mill products:				
Structural iron and steel:				
Water, oil, gas, and other storage tanks (unlined), complete and knockdown material	18,367	$7,576,258	18,536	$7,192,752
Structural shapes:				
Not fabricated	[1] 284,033	39,473,511	209,030	28,450,781
Fabricated	76,068	18,977,810	58,992	23,911,001
Plates, sheets, fabricated, punched, or shaped	9,505	3,110,125	8,374	2,708,165
Metal lath	1,176	450,996	1,379	514,187
Frames, sashes, and sheet piling	11,615	2,398,121	14,423	3,097,900
Railway-track material:				
Rails for railways	108,768	14,290,683	94,680	12,218,490
Rail joints, splice bars, fishplates, and tie-plates	24,100	5,088,184	14,084	3,793,503
Switches, frogs, and crossings	3,132	1,507,246	1,175	579,105
Railroad spikes	941	224,524	1,047	293,371
Railroad bolts, nuts, washers, and nut locks	571	348,467	1,050	476,422
Tubular products:				
Boiler tubes	9,783	6,355,181	12,093	8,245,480
Casing and line pipe	[1] 96,090	31,584,691	92,197	30,225,951
Seamless black and galvanized pipe and tubes, except casing, line and boiler, and other pipes and tubes	22,502	6,544,562	25,589	7,931,028
Welded black pipe	12,247	3,760,584	9,510	2,631,292
Welded galvanized pipe	3,606	1,136,258	4,480	1,240,594
Malleable-iron screwed pipe fittings	933	1,183,782	1,223	1,277,355
Cast-iron pressure pipe and fittings	16,075	3,334,748	14,414	2,852,644
Cast-iron soil pipe and fittings	6,892	1,599,636	5,457	1,362,743
Iron and steel pipe, fittings, and tubing, n.e.c.	[1] 49,569	[1] 38,816,779	69,877	45,483,796
Wire and manufactures:				
Barbed wire	565	115,227	969	266,219
Galvanized wire	6,463	1,538,762	8,312	2,366,257
Iron and steel wire, uncoated	13,950	5,039,484	9,814	4,105,670
Spring wire	1,656	942,005	1,301	892,997
Wire rope and strand	9,400	5,175,155	8,322	4,940,903
Woven-wire screen cloth	1,349	[2] 1,604,638	1,659	[2] 1,951,917
All other	16,676	10,197,772	13,692	9,865,044
Nails and bolts, iron and steel, n.e.c.:				
Wire nails, staples, and spikes	4,675	3,352,351	3,469	2,967,169
Bolts, screws, nuts, rivets, and washers, n.e.c.	13,329	16,109,025	12,784	16,842,185
Tacks	644	446,048	612	411,871
Castings and forgings: Iron and steel, including car wheels, tires, and axles	[1] 85,435	[1] 26,161,078	79,461	23,976,477
Total	[1] 910,115	[1] 258,443,691	798,005	253,073,269
Advanced manufactures:				
Buildings (prefabricated and knockdown)	----------	7,244,540	----------	6,930,535
Chains and parts	8,432	10,100,501	8,410	9,992,243
Construction material	6,650	4,962,240	8,259	6,179,827
Hardware and parts	----------	22,199,037	----------	22,152,741
House-heating boilers and radiators	----------	7,696,062	----------	6,650,939
Oil burners and parts	----------	8,162,330	----------	8,709,159
Plumbing fixtures and fittings	----------	3,206,255	----------	3,525,125
Tools	----------	53,865,508	----------	55,114,510
Utensils and parts (cooking, kitchen, and hospital)	----------	3,449,296	----------	3,338,624
Other	----------	36,800,258	----------	37,532,316
Total	----------	157,686,027	----------	160,126,021
Grand total	----------	[1] 861,297,407	----------	688,086,835

[1] Revised figure.
[2] Includes wire cloth as follows—1960: $1,152,568 (5,339,940 square feet); 1961: $1,418,345 (8,213,881 square feet).

Source: Bureau of the Census.

WORLD REVIEW

World production of pig iron (including ferroalloys) and steel reached new highs, with a 2-percent increase in pig iron and a 3-percent rise in steel. The steel increase was small, compared with gains of 13 percent in each of the previous 2 years. The United States led, and the European Coal and Steel Community and the U.S.S.R. ranked second and third in both pig-iron and steel output. The United States produced 23 percent of the pig iron and 25 percent of the steel, the same as in 1960, compared with 25 and 28 percent in 1959.

TABLE 22.—World production of pig iron (including ferroalloys) by countries [1] [2]

(Thousand short tons)

Country [1]	1952-56 (average)	1957	1958	1959	1960	1961
North America:						
Canada	3,020	3,923	3,172	4,318	4,416	5,043
Mexico	344	473	547	617	733	837
United States	71,455	80,920	58,867	62,135	68,620	66,717
Total	74,819	85,316	62,586	67,070	73,769	72,597
South America:						
Argentina	37	37	32	39	198	220
Brazil	1,119	1,400	1,550	1,750	1,965	[3] 2,200
Chile	327	421	336	320	293	314
Colombia	[4] 111	158	164	138	194	209
Total	1,594	2,016	2,082	2,247	2,650	[3] 2,950
Europe:						
Austria	1,564	2,161	2,004	2,025	2,460	2,493
Belgium	5,462	6,160	6,084	6,575	7,223	7,104
Bulgaria	9	60	100	195	212	220
Czechoslovakia	3,117	3,928	4,160	4,679	5,176	5,480
Denmark	50	65	49	64	76	71
Finland	106	142	111	119	116	163
France	11,094	13,316	13,400	13,951	15,835	16,367
Germany:						
East	1,355	1,833	1,957	2,092	2,198	2,237
West (including Saar)	18,616	23,726	21,784	23,814	28,372	28,021
Hungary	842	923	1,213	1,236	1,393	1,440
Italy	1,710	2,432	2,389	2,416	3,113	3,528
Luxembourg	3,306	3,713	3,621	3,795	4,173	4,226
Netherlands	678	773	1,011	1,259	1,485	1,606
Norway	354	624	575	686	794	837
Poland	2,972	4,059	4,259	4,822	5,030	5,258
Portugal			19	40	45	132
Rumania	531	756	812	933	1,118	1,163
Spain	995	1,101	1,479	1,889	2,124	2,458
Sweden	1,285	1,701	1,559	1,656	1,797	1,941
Switzerland	46	50	[3] 40	[3] 50	[3] 60	[3] 55
U.S.S.R. [5]	33,400	40,830	43,650	47,370	51,540	56,100
United Kingdom	13,311	15,997	14,532	14,092	17,655	16,540
Yugoslavia	466	812	860	995	1,123	1,163
Total [5]	101,269	125,162	125,668	134,753	153,118	158,603
Asia:						
China	3,410	6,060	[6] 10,470	[6] 22,600	30,300	[3] 24,300
India	2,116	2,141	2,352	3,427	4,621	5,170
Japan	5,441	7,864	8,510	10,908	13,604	18,061
Korea, North	71	300	350	765	940	[3] 1,030
Taiwan (Formosa)	11	22	19	36	26	67
Thailand	3	4	6	8	7	6
Turkey	227	239	254	260	272	207
Total [5]	11,279	16,630	21,961	38,004	49,770	48,841

See footnotes at end of table.

TABLE 22.—World production of pig iron (including ferroalloys) by countries—Continued

(Thousand short tons)

Country [1]	1952–56 (average)	1957	1958	1959	1960	1961
Africa:						
Rhodesia and Nyasaland, Federation of:						
Southern Rhodesia	51	88	94	79	94	99
Union of South Africa	1,368	1,574	1,744	1,992	2,204	2,601
United Arab Republic, (Egypt)	[7] 4	[3] 13	[3] 45	130	163	[3] 110
Total	1,423	1,675	1,883	2,201	2,461	2,810
Oceania: Australia	2,043	2,474	2,553	2,806	3,228	3,538
World total (estimate)	192,430	233,300	216,750	247,100	285,000	289,350

[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 1954–56.
[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 4,000,000 tons produced of 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, 1955–56.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

TABLE 23.—World production of steel ingots and castings by countries [1]

(Thousand short tons)

Country	1952–56 (average)	1957	1958	1959	1960	1961
North America:						
Canada	4,170	5,068	4,359	5,901	5,790	6,466
Mexico	733	1,136	1,144	1,442	1,713	1,846
United States [2]	105,068	112,715	85,255	93,446	99,282	98,014
Total	109,971	118,919	90,758	100,789	106,785	106,326
South America:						
Argentina	223	[3] [4] 400	269	236	305	486
Brazil	1,319	1,523	1,672	1,910	2,186	[4] 2,600
Chile	342	428	384	457	465	400
Colombia	39	126	133	120	173	194
Peru				43	[4] 55	[4] 65
Total	1,923	2,477	2,458	2,766	3,184	[4] 3,745
Europe:						
Austria	1,741	2,766	2,638	2,769	3,487	3,418
Belgium	5,894	6,917	6,626	7,096	7,923	7,728
Bulgaria	[5] 64	175	233	254	277	364
Czechoslovakia	4,794	5,695	6,074	6,764	7,460	7,764
Denmark	235	289	281	322	351	358
Finland	186	229	209	262	285	310
France	12,617	15,398	15,947	16,617	19,049	19,401
Germany:						
East	2,564	3,191	3,354	3,535	3,678	3,796
West (including Saar)	23,818	30,805	28,930	32,446	37,589	36,881
Greece	60	[4] 80	125	99	[4] 140	[4] 150
Hungary	1,661	1,516	1,793	1,939	2,078	2,263
Ireland [4]	29	28	31	44	44	50
Italy	4,970	7,481	6,913	7,454	9,071	10,057
Luxembourg	3,344	3,850	3,725	4,038	4,502	4,534
Netherlands	995	1,306	1,585	1,841	2,141	2,173
Norway	174	386	409	470	527	536
Poland	4,447	5,847	6,242	6,790	7,585	7,974
Rumania	791	952	1,030	1,564	1,991	2,345
Spain	1,252	1,526	1,734	1,995	2,157	2,434
Sweden	2,158	2,737	2,653	3,155	3,547	3,921
Switzerland [6]	176	247	256	270	303	309
U.S.S.R. [7]	45,862	56,412	60,539	66,107	71,973	77,933
United Kingdom	20,830	24,303	21,914	22,609	27,222	24,752
Yugoslavia	720	1,156	1,233	1,432	1,590	1,689
Total [7]	139,382	173,292	174,474	189,872	214,970	221,140

See footnotes at end of table.

TABLE 23.—World production of steel ingots and castings by countries—Con.

(Thousand short tons)

Country [1]	1952–56 (average)	1957	1958	1959	1960	1961
Asia:						
China	2,792	5,897	8,820	14,720	20,340	[4] 16,540
India	1,840	1,920	2,030	2,726	3,623	4,488
Israel			[3] 29	26	45	[4] 80
Japan	9,461	13,856	13,358	18,330	24,403	31,160
Korea:						
North [4]	87	305	400	500	710	850
Republic of	6	19	22	42	55	52
Philippines		63	73	[4] 70	[4] 70	[4] 80
Taiwan (Formosa)	44	98	118	175	220	218
Thailand	3	6	6	7	8	9
Turkey	195	194	176	236	293	356
Total [7]	14,428	22,358	25,032	36,832	49,767	53,833
Africa:						
Rhodesia and Nyasaland, Federation of:						
Southern Rhodesia	45	72	79	51	88	88
Union of South Africa	1,556	1,915	2,019	2,090	2,328	2,738
United Arab Republic, (Egypt) [4]	65	110	110	110	150	165
Total	1,666	2,097	2,208	2,251	2,566	2,991
Oceania: Australia	2,382	3,377	3,509	3,803	4,129	4,338
World total (estimate)	269,750	322,500	298,450	336,300	381,400	392,400

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[2] Data from American Iron and Steel Institute. Excludes production of castings by companies that do not produce steel ingots.
[3] Including castings. [4] Estimate. [5] Average annual production, 1953–56.
[6] Including secondary [7] U.S.S.R. in Asia included with U.S.S.R. in Europe.
[8] 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 in 1961 were at record highs of 4.6 million short tons and 6.5 million tons, respectively. Open-hearth furnaces and oxygen converters accounted for 91 percent of steel output, with the remaining 9 percent made in electric furnaces. Canada had two oxygen converter plants with a combined capacity of 1.8 million short tons as of January 1, 1961. Production of hot-rolled products totaled 4.9 million tons, compared with 4.6 million tons in 1960. Imports of selected steel products were 838,388 tons, compared with exports of 731,183 tons. Pig-iron exports totaled 599,358 tons. Consumption of coke per ton of pig iron was 1,418 pounds, virtually the same as the U.S. rate, compared with 1,538 pounds in 1960. Oxygen consumption at steel plants was 5.4 billion cubic feet, an increase of over 1 billion cubic feet over 1960. Consumption in steelmaking furnaces increased from 3,900 million cubic feet in 1960 to 4,969 cubic feet in 1961. Blast furnaces used 7 million cubic feet, 2 million less than the previous year.[4]

In addition to new steel-plant facilities described in the 1960 chapter, Steel Company of Canada completed a 950-foot-long sendzimir-type continuous galvanizing line and announced that an 80-inch cold-reduction mill would be constructed. Dominion Foundries and Steel,

[4] American Iron and Steel Institute. Ann. Statistical Rept. 1961, pp. 120–124.
Dominion Bureau of Statistics. Primary Iron and Steel. v. 16, No. 12, December 1961, 29 pp.
Dominion Bureau of Statistics. Primary Iron and Steel. v. 17, No. 3, March 1962, 23 pp.

Ltd., at Hamilton, Ontario, relined its No. 1 blast furnace and replaced its 50-ton oxygen converters with 105-ton-capacity units.

Consolidated Mining and Smelting Co. of Canada, Ltd., started a new iron plant at Kimberley, British Columbia. This plant produced the first iron in western Canada from western ores. Estimated cost of the first stage of the plant was US$7.5 million.

Atlas Steel, Ltd., announced construction of a 48-inch-wide stainless stripmill at Tracy, Quebec, at an estimated cost of US$40 million.[5]

Mexico.—Mexico had sufficient raw materials to support a heavy iron and steel industry. Iron ore reserves with a minimum of 50 percent iron, from five major locations, were estimated to be 585 million short tons. Manganese reserves were 13 million short tons, including a deposit at Autlan with an average content of about 35 percent manganese. Ores of chromium, molybdenum, tungsten, and vanadium occur only in small quantities, and their reserves were not known. Coal occurs in the valley of Coahuila, where an estimated 4,400 million tons was available. Most of the coal was of coking grade. Coke was being made at three plants-Compania Mexicana de Coque y Derivados S.A. at Monclova (Coah.), Compania Carbonifera de Salinas S.A. at Nueva Rosita (Coah.), and Compania de Combustibles de Agujitas S.A. in Coahuila; capacity was 1,263,000 short tons. The Mexican petroleum industry could supply the oil and gas needed for its iron and steelmaking. Because a high percentage of the steel was made at nonintegrated plants, iron and steel scrap was an important raw material. Imports of scrap were 300,000 to 400,000 tons annually.

There were two fully integrated steel plants, Altos Hornos de Mexico S.A. at Monclova (Coah.) and Compania Monterrey S.A. at Monterrey (N.L.), and two semi-integrated works, Hojalata y Lamina S.A. at Monterrey and La Consolidada S.A. at Piedras Negras (Coah.). The last-named plant was recently acquired by Altos Hornos de Mexico. The capacity of pig iron and sponge iron are given in table 24; steel capacity by type of plant follows:

Plants:	*Short tons*
Integrated plants	1,580,000
Semi-integrated plants	640,000
Others	825,000
Total	3,045,000

TABLE 24.—Mexico: Capacity of pig iron and sponge iron

Plant	Works	Number of blast furnaces	Total annual capacity (short tons)
Pig iron:			
Altos Hornos de Mexico	Monclova	2	617,000
Fundidora de Fierro y Acero	Monterrey	2	386,000
La Consolidada	Piedras Negras	1	77,000
Total		5	1,080,000
Sponge iron: Hojalata y Lamina	Monterrey		275,000

[5] Iron and Steel Engineer, v. 39, No. 1, January 1962, p. 104.

The capacity of the two blast furnaces at Altos Hornos de Mexico S.A. was 1,760 short tons per day. During 1961 a seventh open-hearth furnace was added, and an eighth was to follow. With this additional steelmaking equipment, annual capacity in this plant will be 880,000 short tons. A 90-ton oxygen plant also was purchased, and construction of a third blast furnace and a 72 inch-wide hot-strip mill was underway.

Funidora de Fierro y Acero de Monterrey S.A. installed two new 250-ton open hearths during 1961, bringing its total to seven and increasing steelmaking capacity to 690,000 tons. This company planned to increase its No. 1 blast furnace output to 500 tons per day and that of its No. 2 furnace to 700 tons. Plans were underway to construct a third blast furnace. A new blooming mill had been operating about a year. The company's subsidiary, Aceros Planos de Monterrey S.A., reportedly started production of plate and hot-sheet products in 1960, and production of cold-reduced sheets in March 1961.

Hojalata y Lamina installed two electric furnaces with an annual capacity of 100,000 short tons. The furnaces are 18 feet in diameter; each is powered by a 20,000-kva substation of equipment and has 24-inch-diameter electrodes. Sponge iron and steel scrap will be used as a metallic charge in these furnaces. Accessory equipment installed includes cranes, pouring cars, and ladles.

Plans were underway to make Tubos de Acero de Mexico (TAMSA) an integrated operation by installing electric furnaces to produce 80,000 tons of pig iron per year. There would be a corresponding increase in steel output to 165,000 tons a year.

In addition to the plans already mentioned, new projects were underway at Manzanillo (Col.), Las Truchas (Mic.), Durango, and the Tehuantepec Isthmus. The latter project was to include installation of Linz-Donawitz oxygen converters and electric furnaces and the development of new coal deposits. A forecast of Mexico's steelmaking capacity in 1963 and 1965 follows:

Company:	*Short tons* 1963	1965
Altos Hornos de Mexico (incl. La Consolidada)	1, 300, 000	1, 200, 000
Fundidora de Fierro y Acero de Monterrey	660, 000	1, 100, 000
Hojalata y Lamina	550, 000	825, 000
Total of integrated works	2, 500, 000	3, 625, 000
Total of other works	660, 000	825, 000
Total steel capacity	3, 170, 000	4, 450, 000

Source: Metal Bull. 4579, Mar. 14, 1961, pp. 11–12; Metal Bull. 4580, Mar. 17, 1961, pp. i–iv.

SOUTH AMERICA

Argentina.—Considerable progress was made in Argentina's first integrated steel plant described in Minerals Yearbook, volume I, 1960 Iron and Steel chapter, p. 618. The first steel was produced on May 5, 1961, from one of the four open-hearth furnaces. The blooming mill and slabmill were also started in May, and the billet mill began operating in June. The structural mill started operations in October. The continuous hot-rolling mill was scheduled to start in April 1962, and cold-rolling facilities and tinning lines were to be

in operation by the end of 1962. Rolling-mill facilities included a rail-mill and splice-bar mill, which reportedly could produce all the rail requirements for North and South America. Even before full operations were achieved, plans were made to increase the output from open-hearth furnaces from 715,000 short tons to 1.3 million tons by adding a fifth open hearth and using oxygen in the furnaces. Future plans called for constructing another blast furnace and expanding steelmaking capacity to 2.2 million short tons.[6]

Acecor Witten Rheinstahl, a newly formed Argentine company, planned to erect a plant in Cordoba to produce special steels for the automotive, railway-equipment, tractor, machine-tool, and petroleum industries. The new company was a joint enterprise composed of local investors and the West German steel firms, Gussstahlwerk Witten, A.G., and Rheinstahl Industrie Planung.

The project will cost $12 million, with $8 million used to purchase machinery from West Germany, $3 million for building costs, and $1 million for working capital.

According to company officials, this plant would have an annual productivity capacity of 44,000 short tons of special steel, which will be equivalent to half the quantity imported in 1961. Gussstahlwerk Witten was to provide technical administration services for the first 10 years of operation.[7]

Brazil.—The Government commission in Brazil recommended the building of a new steel plant in the newly formed State of Guanabara. The plant's initial capacity would be 385,000 short tons of raw steel a year; this capacity would later be increased to 1.1 million short tons annually. The steelworks was to utilize high-grade iron ores from Minas Gerais and water and electrical power from Santa Cruz. A new rail line was planned to the ore-rich Paraopeba Valley, and a new coal and ore port was to be built on the Guanabara Coast.

The new plant reportedly would be in production in 3 or 4 years. Its financing would require US$19 to US$22 million, as well as US$15 million for purchase of plant equipment from abroad. This plant would produce mainly special steels.[8]

Negotiations were underway with the German Krupp group for the erection of a $250-million steel plant, with a capacity of 550,000 short tons per year, near Rio de Janeiro.[9]

Air Products and Chemicals, Inc., a United States firm, started a new oxygen-producing facility for Companhia Siderurgicca Nacional (Brazilian National Steel Co.) at the latter company's Volta Redonda works, 60 miles northwest of Rio de Janeiro. The 25-million-cubic-feet-per-month plant was one of the first facilities to supply oxygen for open-hearth steelmaking in South America. The plant was built for continuous operation and had a storage system for 125 short tons of liquid oxygen plus a 9-ton oxygen gas storage tank. Air Products designed and built eight oxygen control systems to regulate the introduction of gas into open-hearth furnaces.[10]

Companhia Siderurgica Nacional announced a 1.4-million-ton steel production goal for 1963 and that its blast furnace to be installed at

[6] Journal of Metals, v. 14, No. 1, January 1962, pp. 43-45.
[7] Bureau of Mines. Mineral Trade Notes. V. 53, No. 3, September 1961, p. 24.
[8] Iron and Coal Trades Review (London), v. 183, No. 4851, July 7, 1961, p. 54.
[9] Iron and Coal Trades Review (London), v. 183, No. 4858, August 25, 1961, p. 386.
[10] Journal of Metals, v. 13, No. 9, September 1961, p. 595.

Volta Redonda would increase steelmaking capacity by 2.5 million tons by 1967.[11]

Chile.—Chile's only integrated steel plant was at Huachipato, on San Vincente Bay. It was owned by Cia de Acero del Pacifico S.A. (CAP), and represented about 85 percent of Chile's iron and steel industry.

Because of strikes on March 1, March 8–20, and June 29–30, 1961, steel ingot production by CAP was 14 percent lower than in 1960; semifinished products decreased 18 percent, and finished products declined 5 percent. A comparative analysis of 1961 and 1960 sales volume and revenue showed that a 28-percent increase in volume led to only a 16-percent increase in sales revenue in the domestic market. This was due to a 5-percent decrease in the average price of steel, made possible through CAP's exemption from sales taxes by court order. CAP also was protected by tariffs, and imports of some products were prohibited. Prices of some products, such as galvanized sheet and tinplate, were reduced 12 percent. Foreign sale prices also were lower than in 1960 due to worldwide competition. Some neighboring countries were able to purchase steel products from CAP at an average price $20 below the price to local consumers.

The CAP plant occupied 800 acres and had a pier which could handle all raw materials and exported steel products. The coke plant was composed of 70 Koppers-Becker ovens. A 20-foot, 9–inch hearth-diameter blast furnace was capable of producing 1,200 short tons of pig iron per day. Steelmaking facilities consisted of three 110-short-ton-capacity and one 220-ton-capacity open-hearth furnaces. Ingot output was about 520,000 tons per year. The rolling-mill facilities included mills for the production of rods, plates, hot- and cold-rolled sheets, galvanized sheets, and tinplate. The plant also had a Yoder-type pipemill for making API specification pipe of 6⅝, 8⅝, and 10¾-inch sizes.

CAP planned to expand production to 660,000 short tons per year by 1965; its plan follows:

	Thousand short tons	
	Capacity, 1961	*Planned capacity, 1965*
Ingots	500	660
Salable products:		
Merchant	155	155
Flat	200	325
Semi-finished	15	15
Total	370	495

The program called for increased blast-furnace output, improved burdens, additional sintering facilities, and other improvements. Open-hearth furnaces were to be enlarged, and oxygen injection was to be employed. Rolling mills were expanded to take care of additional ingot output; particular emphasis was placed on cold-rolling facilities. Silicon steel sheets for electrical uses, produced at this plant, were used with great success in Chile and Argentina. The fact that the Huachipato plant operated only with virgin iron ore and its own scrap ensured a steel relatively free from tramp elements. Steel of this purity has optimum electrical properties. Studies were underway for installing electrolytic tinplate lines.

[11] Foreign Commerce Weekly, v. 67, No. 5, January 29, 1962, p. 147.

The outlook for steel output in 1962 was encouraging, as domestic demand was expanding rapidly, particularly for public housing and private construction. Based on orders booked, the Chilean market for steel in 1962 should be 360,000 tons, or about 50 percent higher than 1961 consumption. Increased construction, expansion, and improvement of railroad lines and the new Armco plant's production of grinding-mill balls accounted for some of the increased demand.[12]

Colombia.—The Government's Acerias Paz del Rio S.A. plant near Bogota was close to iron ore, limestone, and coking coal deposits. Plant facilities included one 43-oven battery Disicoke coke plant, one 550-ton blast furnace, three 25-ton Thomas converters, and one 20-ton electric furnace. Rolling mills had been operating for about 5 years, producing wire, round, and shapes. Plans were initiated to increase capacity substantially and to provide additional equipment for rolling steel products. Colombia imported a large variety of steel products.[13]

Peru.—The steelmaking industry in Peru was concentrated essentially in the Sociedad de Gestion de la Planta Siderurgica de Chimbote y de la Central Hidroelectrica del Canon del Pato, S.A. (SOGESA), located in a seaport about 260 miles north of Lima on the Pan-American Highway. Production in 1961 was about 65,000 short tons, with expansion plans calling for 265,000 tons in 1962. Pig iron for this plant was made in two electric furnaces with a daily output of 220 short tons. About 77 percent of the pig iron was delivered to electric furnaces for refining to steel, and the balance was sold to foundries. The byproduct gas from the submerged-arc ironmaking furnaces was sufficient to meet plant requirements. SOGESA was the only plant in the Western Hemisphere to use electric-arc furnaces for refining hot metal (50 to 60 percent molten iron and the remainder scrap). Tap-to-tap time for low-carbon steels, using molten pig iron, was 5 to 5.5 hours per heat.

The $38-million expansion program called for building a 500-ton-per-day blast furnace to utilize imported coke. Steelmaking equipment would include two 22-ton L-D oxygen furnaces. An oxygen plant was to be built near the plant site to supply 70,000 cubic feet of oxygen per hour. The program also called for construction of a four-strand continuous casting machine, the acquisition of a new wire rodmill and a sheetmill, and the replacement of galvanizing equipment for the production of 165,000 short tons per year. About 65,000 tons of billets would be available for export. A belt conveyor was to be installed for transporting coke and ore from dock bins to the storage area in the plant. A 16,000-kva thermoelectric powerplant, which would utilize blast-furnace gas and anthracite fines, was to be constructed.[14]

Venezuela.—Per-capita steel consumption in Venezuela was high compared with that in most other South American countries, mainly because of Venezuela's large, highly specialized petroleum industry. Siderurgica Venezolana S.A. (SIVENSA) more than quadrupled its output in the 1950's. This semi-integrated company had electric melting furnaces and rolling mills for producing rod, wire, and bars from domestic scrap and imported billets.

[12] Pages 48–50 of work cited in footnote 6.
U.S. Embassy, Santiago, Chile, State Dept. Dispatch 699, May 9, 1962.
[13] Pages 41–42 of work cited in footnote 6.
[14] Pages 46–47 of work cited in footnote 6.

Construction of Planata Siderurgica del Orinoco, an integrated steel mill, was nearing completion. This plant had nine electric pig-iron furnaces with a daily capacity of 220 short tons each; four open-hearth furnaces; a 44-inch blooming mill; and rolling mills for billets, structurals, rails, wire, rod, light shapes, and seamless tubing. Other facilities included a foundry, wire-drawing equipment, and associated departments. Upon completion, annual capacity was estimated at about 715,000 short tons.[15] During 1961 work was started to convert one of the electric furnaces at this plant to the Strategic-Udy process. A kiln, 11 feet in diameter and 275 feet long, was to be used. The electric energy requirement utilizing the Strategic-Udy process will be about half that of the installed furnaces because a hot prereduced charge is used.[16]

EUROPE

The European Coal and Steel Community (ECSC).—Crude steel production in 1961 was 80.8 million short tons, or 0.6 million tons more than for 1960. It decreased 2 to 3 percent in Belgium and Germany; it increased 1 to 2 percent in Luxembourg, Netherlands, and France, and it rose 11 percent in Italy. Steel furnaces in the Community operated at 92.4 percent of capacity, compared with 98.1 percent in 1960. The demand for steel lessened during the last half of the year, as users reduced their stocks. Exports were about the same as in 1960, ranging from 716,000 tons per month to 1.1 million tons.

Production of pig iron during the first half of 1961 was about 7 percent above 1960. However, during the second half sales decreased, and by yearend monthly production was about the same as in 1959. The Community produced 60.2 million tons of pig iron in 1961, compared with 60 million in 1960. Consumption of pig iron per ton of steel was 1,384 pounds, compared with 1,392 pounds in 1960 and 1,398 pounds in 1959. Imports from other countries decreased slightly in 1961, dropping from 1.1 million tons in 1960 to 1 million in 1961. Exports were small and totaled 0.3 million tons, compared with 0.4 million in 1960.

The agglomerate portion of the blast-furnace charge was 1,400 pounds per ton of pig iron, compared with 1,272 pounds in 1960. The use of coke in blast furnaces decreased 60 pounds per ton, and the Community coke rate in 1961 was 1,712 pounds per ton of pig iron. Coke consumption by the steel industry was 55.7 million tons, or 0.7 million tons less than in 1960. The use of scrap in the blast furnace was 112 pounds per ton of pig iron during 1960 and through midyear 1961, but it decreased to 80 pounds per ton by yearend.

The percentages of total steel made by the several processes during 1961 were as follows: Basic Bessemer, 48.5; acid Bessemer, 0.3; open hearth, 37.0; electric, 11.0; and other (including L–D Rotor and Kaldo), 3.2. Corresponding figures for 1960 were 49.3, 0.3, 37.8, 10.4, and 2.2. The production of "new steel" by oxygen processes was 3.6 million tons, or 3.2 percent of total production, compared with 1.8 million tons in 1960.[17]

[15] Page 41 of work cited in footnote 6.
[16] Page 115 of work cited in footnote 5.
[17] European Coal and Steel Community. Tenth General Rep. on the Activities of Community. Jan. 31, 1962, pp. 51–64.

The Community continued to expand iron and steelmaking capacities through construction and modernization. In Italy, industrial investments made and planned for 1961 and 1962 totaled US$474 million; US$140 million was for blast furnaces, US$96 million for open-hearth furnaces, and US$238 million for steel-rolling facilities. In addition, some United States companies had invested in Italy. Armco International Corp. and Società Finanziaria Siderurgica per Azioni (Finsider) jointly established a plant at Naples in the late 1950's. In 1960, Crucible Steel acquired 75 percent of the stock of Fonderie Milanesi Vanzetti. In 1961, U.S. Steel Corp. signed a US$16 million accord with Finsider. Republic Steel's trademark appeared on stainless steel produced by Fiat.[18]

During 1960, French investments by iron and steel producers for new facilities reached a new high of US$267 million. In addition to the complexes under construction at Dunkirk and Joeuf, French plans through 1965 called for construction of 12 new blast furnaces and the reconstruction of 26 existing units. Paralleling this measure, sinter production, currently at 7 million tons annually, was to be quadrupled. Expansion in steel capacity included the construction of 30 new electric furnaces which would increase electric-furnace steel capacity 30 percent. Construction of 12 new oxygen converters was also planned.[19]

Despite the leveling off of the steel boom in West Germany, some US$400 million was spent in 1961 in new investments in the steel industry, and outlays were expected to reach about the same level in 1962. In West Germany, there was a growing emphasis away from increasing crude steel production and toward increasing investments in finishing mills. Hüettenwerke Oberhausen AG, Bochum Verein fuer Gussstahl Fabrikation AG, and Deutsche Edelstahlwerke AG, for example, had major programs calling for the expenditures of a total of US$81.5 million; all but a few million of the dollars was to be spent on such projects as wire, small sections, plates, and broad strip mills. This trend also was favored by other major German steel producers.[20]

Portugal.—The first blast furnace in Portugal, owned by Siderurgia Nacional, was blown in at Tagus in August 1961. The initial annual capacity of the steelworks, built by a German-Belgian group under the leadership of Demag, was 275,000 short tons of rolled steel products Its target was 550,000 tons by 1964. Products included bars, rods, strip, and certain sections.[21]

Spain.—The Export-Import Bank of Washington, D.C., authorized a US$13 million loan to Empresa Nacional de Siderurgica, S.A. (ENSIDESA), in Madrid, for the purchase of a cold-reduction mill to be installed at its integrated iron and steel plant at Aviles. The loan also covered pickling, annealing, shearing, and temper pass mill facilities. Construction of the mill was expected to be completed late in 1963.

In steelmaking, the 60-ton electric furnace at the Altos Hornos Baracaldo works, the largest in Spain, had a daily capacity of 300 tons. Altos Hornos' new blooming and slabbing mill were fully operational,

[18] U.S. Embassy, Rome, Italy. State Department Dispatch 843, May 3, 1962.
[19] U.S. Embassy, Paris, France. State Department Dispatch 1,472, May 9, 1962.
U.S. Embassy, Paris, France. State Department Dispatch 464, Oct. 20, 1961.
[20] U.S. Embassy, Duesseldorf, West Germany State Department Dispatch 325, May 11, 1962.
[21] Mining World and Engineering Record (London), v. 177, No. 4550, May 1961, p. 185.

and the installation of a billet mill transferred from Baracaldo was reportedly near completion.[22]

United Kingdom.—A drastic change was predicted for the British steel industry if the United Kingdom joins the European Economic Community, as indicated by several sources. The ECSC had broad powers, was financially independent, and had authority to take disciplinary action. As a member of the Community, the United Kingdom Iron and Steel Board could no longer set prices because the ECSC treaty called for free pricing. Also, the United Kingdom would be required to permit the export of scrap; that is now prohibited.

Steelmaking capacity in the United Kingdom was expected to increase 25 percent by 1965. Ingot capacity in 1961 was about 30 million tons and was expected to increase to 38 million tons by 1965. Estimated outlay for 1961 was US$420 million, compared with US$364 million in 1960.

A large project was scheduled for completion in 1962 at the new Spencer works being built by Richard Thomas and Baldwins Ltd. at Llanwern in a tidewater area just outside Newport in South Wales. The project included two 30-foot hearth-diameter blast furnaces, each with a daily capacity of 2,200 short tons; four batteries of coke ovens, totaling 140 ovens; three 110-short-ton L-D oxygen converters, supplied by three 200-ton oxygen plants; 20 soaking pits; a universal slabmill, with two slab reheating furnaces; a six stand continuous 68-inch fully automated hot-strip mill, with output speeds of 3,000 fpm; a 66-inch cold-reduction mill, with speeds up to 4,000 fpm; two high-speed temper mills; and sheet and strip processing equipment.

The South Durham Iron and Steel Co., Ltd., was installing a 28-foot, 3-inch hearth-diameter blast furnace and two additional batteries of coke ovens at its South works. This company also planned to construct a universal beammill, capable of rolling a wide range of beam sizes, at its Cargo Fleet works. The estimated cost of the mill was US $12 million, and the plant was scheduled to start operating early in 1962.

Shelton Iron and Steel Company, Ltd., at Stoke-on-Trent, placed an order early in the year for a Kaldo oxygen steelmaking plant for its Etruria works. A continuous casting machine was to be constructed at this plant.

In May, the Millom Hematite Ore and Iron Company, Ltd., at Millom, England, lit its new 20-foot hearth-diameter blast furnace with a rated capacity of 880 short tons per day.

The Tinsley Park works in Sheffield, England, was spending an estimated US$73 million for construction of a 42-by 102-inch blooming and slab mill, two 32-inch reversing billet mills, an 18-inch bar roughing mill with extensive finishing equipment, two 110-short-ton-capacity electric-arc furnaces, and vacuum casting equipment. This project was scheduled for completion in early 1963.

In June 1961, Appleby-Frodingham Steel Company started a new universal beammill designed by a German firm. The mill consists of a universal roughing stand with edger, a finishing stand, roller tables, transfers, and a saw.

[22] Foreign Commerce Weekly, v. 65, No. 14, Apr. 3, 1961, p. 35.
Foreign Commerce Weekly, v. 65, No. 21, May 22, 1961, p. 43.
Iron and Coal Trades Review, v. 182, No. 4832, Feb. 24, 1961, p. 405.
Iron and Coal Trades Review, v. 182, No. 4827, Jan. 20, 1961, p. 142.

New facilities to increase the British capacity for producing stainless steel products of various types included a 60-inch Sendzimir mill for Burys & Co., Ltd.; processing equipment for Samuel Fox & Co., Ltd.; a 19-inch Sendzimir mill for Authur Lee & Sons, Ltd.; a 42-inch Sendzimir mill for Shepcote Lane Rolling Mills, Ltd.; a 49-inch Sendzimir mill, a planishing mill, and a pickle line for Richard Thomas & Baldwins, Ltd.; an 88-ton electric furnace for Clyde Alloy Steel Co., Ltd., a division of Colvilles, Ltd.; and the new works at Tinsley Park for English Steel Corp., Ltd.

Firth-Vickers Stainless Steel, Ltd., in Sheffield, was spending US$12.6 million modernizing its plate and wide-sheet facilities. This project will double the company's stainless steel output, which was 40 percent of the United Kingdom's total production in 1961. The project called for a new 80-inch-wide hot reversing mill for plate and for sheet up to 73 inches wide.

In Scotland, Colvilles, Ltd., was planning to expand its steelmaking capacity from 2.5 million to 3.6 million tons per year. Part of the program included a new hot-strip mill at Ravenscraig and a cold-reduction mill at Gartcosh.[23]

Yugoslavia.—Yugoslavia's current 5-year plan called for increasing steel production from 1.2 million short tons in 1961 to 2.5 million tons in 1965. This increase was to be accompanied by modernization and expansion of the Niksic, Ilisjas, Store, Zenica, Sisak, and Jesenica plants. As part of the expansion, new steelworks with a combined capacity of 600,000 tons were to be built at Zenica and Sisak. The following capacities were to be increased: Pig iron, from 1.1 million tons to 1.8 million tons; heavy and medium plates, from 115,000 tons to 360,000 tons; sheets, from 115,000 tons to 165,000 tons; sections, from 560,000 tons to 700,000 tons; and tubular products, from 90,000 tons to 175,000 tons.

In financing this expansion, the British consortium Metallurgical Equipment Export Co., Ltd. (MEECO), reached a preliminary agreement for a contract of about US$78.4 million for the building of a new plant. The consortium included six British construction companies. In addition, an $8.5-million loan was approved by the U.S. Development Loan Fund in January 1961. The U.S. loan would help provide a skelp mill and a welded tubemill, which was secured from a U.S. supplier for the Sisak Iron and Steel Works. The steel industry expansion will increase import requirements for coking coal and reduce requirements for imported steel.[24]

ASIA

Ceylon.—A new steel plant costing about US$17 million was authorized. In the first stage, a 40,000-ton-per-year rolling mill was to be built to process imported billets. In the second stage, two open hearths were to be built to melt steel scrap and imported pig iron. Later, a charcoal blast furnace was planned to utilize Ceylon's iron ore, estimated to be at least 2.8 million tons. Russian technicians reportedly tested samples of Ceylon's rubber-tree timber and indicated

[23] Pages 105–106 of work cited in footnote 5.
[24] Foreign Commerce Weekly, v. 66, No. 15, Oct. 9, 1961, p. 39.

that rubber-wood charcoal would be a suitable substitute for coke in the blast furnace.[25]

China.—The processing of more than 40 types of new steel and some 30 new rolled products was reported in 1961. Production was 24.3 million tons of pig iron and 16.5 million tons of steel, compared with 30.3 and 20.3 million tons, respectively, in 1960. Iron and steel production was reduced because of a lack of iron ore and coke. However, the United Nations estimated that China's production of steel would be 58 million tons in 1962; China predicted the production of some 77 million tons for that year.

During 1961 greater emphasis was placed on improved preparation of the burden for blast furnaces, high wind rates, and use of oxygen. More electric steel was produced, and converter steel, made mostly in side-blown basic converters, accounted for approximately one-third of total output. One report claimed improved smelting techniques had made it possible to supply converters with high-temperature molten metals of low-phosphorus content. Evidently, this type of metal was not produced in the blast furnace. A second report disclosed that about 20-percent scrap could be used in converters, making it possible to produce high-quality steel and also to reduce pig-iron requirements per ton of steel made. This implied that the pig iron was low in quality.

Plants participating in diversification of products and quality control included Anshan, Shanghai, Taiyuan, Chungking, Tientsin, Kunming, and Anyang.

Anshan, China's largest steel plant had the capacity to produce 5.5 million short tons of pig iron, 6 million tons of crude steel, and 5.5 million tons of rolled products. This complex operated more than 40 mines, mills, and fabricating plants and employed 170,000. The tenth blast furnace, constructed in 1958, reportedly could make 1 million tons of pig iron annually. Transportation difficulties and shortages of mechanical equipment caused by heavy rains and flood damage during August 1961 forced four blast furnaces and eight open hearths to curtail operations as long as 13 days. Iron ore and coal shortages also limited 1961 production. To overcome this problem, 1,600 workers from the steel plant were drafted to work in nearby mines.

Shanghai, perhaps the fourth largest steel center, planned to produce about 2.8 million short tons in 1961, mostly from Bessemer converters. Available information however, indicated that steel output at this plant would be below the 1960 level and would be between 1.7 and 2.2 million tons. During 1961, Shanghai reportedly was making many kinds of high-grade steels and new products never before produced. Pig-iron requirements were reported to have declined. Two blast furnaces, each with an annual capacity of 130,000 tons, were completed in 1959, and two similar furnaces were under construction in 1961. Some sources indicated that construction of the latter two furnaces may have been completed during 1961.

Construction of the Wuhan and Paotow steel complexes began early in 1957, and each of the integrated steel plants was to have a capacity of 3.3 million short tons. Reportedly, construction of the Wuhan plant had begun as of the end of 1960 or early 1961. Facilities at this plant were to include two blast furnaces (1,386 and 1,436

[25] Iron and Coal Trades Review (London), v. 183, No. 4863, Sept. 29, 1961, p. 708.

cubic meters in size); four open-hearth furnaces, with a combined capacity of 2,200 tons per year; rolling mills; and coke ovens. A report of a third blast furnace and two additional open hearths was not confirmed. Efforts were made towards maximum utilization of existing capacity in 1961, reportedly 1.5 million tons. However, due to repairs and other difficulties, output from this plant was not expected to exceed the 825,000 tons produced in 1960.

Information on developments at Paotow was not available. Facilities completed by mid-1960 included a blast furnace, a 725-ton open hearth, two coke-oven batteries, and a refractories plant. Construction of a second blast furnace was started in May 1960, and the erection of two additional open hearths was scheduled for the second half of the year.

Output at the four plants just mentioned (Ansham, Shanghai, Wuhan, and Paotow) was probably about 8.8 million tons in 1961, half of China's output. China claimed to have iron and steel industries in each of its 27 provinces and regions. Those producing between 500,000 and 1 million tons included Shihchingshan, Penhsihu, Taiyuan, the Tientsin area, and possibly several others. Many smaller plants, with capacities ranging from 50,000 to 500,000 tons per year, accounted for 4.5 million to 5.5 million tons per year.[26]

Japan.—Japan ranked fourth (after the United States, the U.S.S.R., and West Germany) in iron and steel production and was the foremost producer in Asia. Japan produced 7 percent of the world steel output, and production was still rising. In 1961, 17,439,331 short tons of pig iron, 31,159,816 tons of crude steel, and 22,478,816 tons of hot-rolled ordinary steel were produced.

Exports in 1960–61 averaged 2,755,750 short tons per year.

Steelmaking capacity in 1962 was 32 million short tons, and it was to be increased to 53 million tons by 1970. Estimated capacity in 1970 by type of furnace was: Basic oxygen converter, 28 million short tons; open hearth, 15 million tons (no increase); and electric furnace, 10 million tons (a 5-million-ton increase). Estimated cost of the program was US$8.3 billion.

During 1961, four blast furnaces were built: A 1,875-short-ton-per-day furnace in Muroran, by Fuji Iron and Steel Co., Ltd.; a 1,650-ton furnace at the Chiba works of Kawasaki Steel Corp.; a 1,100-ton furnace at the Nadahama works of Kobe Steel Works, Ltd.; and a 1,320-ton furnace at the Wakayama works of Sumitomo Metal Industries, Ltd. Some 20 additional blast furnaces, with capacities up to 2,500 tons per day, were planned for the next 4 years. Virtually all the blast furnaces in Japan are near seaports, facilitating the importation of raw materials and the marketing of pig iron and finished steel products.

Although some open hearths were enlarged during 1961, the emphasis toward increasing steelmaking capacities was placed in basic oxygen converters. New equipment included two 65-short-ton converters at the Hirohata works and two 75-ton converters at the Muroran works of Fuji Iron and Steel Co., Ltd.; two 45-ton converters at the Kokura works and two 90-ton converters at the Wakayama works of Sumitomo Metal Industries, Ltd.; and two 65-ton converters

[26] Wei, W. T. Mineral Developments in Communist China During 1961, Min. J. (London), v. 258, No. 6607, April 6, 1962, pp. 334–337.

at the Nadahama works of Kobe Steel Works, Ltd. Expansion plans for the next 4 or 5 years called for some 20 oxygen converters with 65- to 145-short-ton heat capacities.[27]

TABLE 25.—Oxygen converters installed or scheduled for construction in Japan, as of April 1962

(Short tons)

Company and works	Number	Capacity per heat	Completion date
Yawata Iron and Steel Co., Ltd.:			
Yawata	2	55	September 1957.
Kukioka	2	65	September 1959.
Tobata	1	75	October 1960.
	2	145	April 1962.
Sakai	3	145	1965.
Fuji Iron and Steel Co., Ltd.:			
Hirohata	2	65	November 1961.
	1	90	1963.
Muroran	2	75	July 1961.
Tsurusaki	(1)		[2] 1965.
Nippon Kokan K. K. (Nippon Steel Tube):			
Kawasaki	2	45	January 1958.
Mizue	2	65	March 1960.
	1	65	1962.
Tsurumi	(1)		1965.
Fukuyama	1	120	September 1964.
	1	220	Do.
Kawasaki Steel Corp.:			
Chiba	2	165	May 1962.
Mizushima	2	220	1965.
Sumitomo Metal Industries, Ltd.:			
Kokura	2	45	June 1961.
Wakayama	2	90	May 1961.
	2	90	March 1963.
	1	90	March 1965.
Kobe Steel Works, Ltd.:			
Nadahama	2	65	October 1961.
	1	65	March 1964.
Kagogawa	(1)		September 1965.
Tokai Iron Manufacturing Co., Ltd.: Nagoya	2	130	April 1963.
Amagasaki Iron and Steel Manufacturing Co., Ltd.:			
Amagasaki	2	35	September 1960.

[1] Unknown.
[2] 1965 or later.

Source: Japan's Iron and Steel Industry 1961 and Far East Iron and Steel Trade Reports.

Japan had eight hot-strip rolling mills, 36 to 86 inches wide, with a rated capacity of 8 million short tons. Table 26 gives major rolling-mill equipment scheduled for completion in 1961–62.

Considerable research had been done in Japan on continous casting, and Sumitomo Metal Industries, Ltd., in 1955, was the first to install a continuous casting unit for blooms and billets. This operation aided research and production. In December 1960, Yawata Steel Works completed a large-type casting machine for manufacturing wide slab castings for stainless steel. Vacuum casting, which had been in the experimental stage for several years, was in practical use, and 31 units of vacuum-casting equipment, each with a maximum operation capacity of 285 short tons, were in operation.

Japan utilizes three direct ore processes—the Krupp-Renn, Kamijima, and Wiberg-Soderfors. Four rotary kilns at the Fuji plant, with an estimated output of 60,000 short tons in 1961, and three

[27] Japan Iron and Steel Federation. Monthly report of the Iron and Steel Statistics. V. 5, No. 1, January 1962, pp. 1-3.

TABLE 26.—Major rolling-mill equipment under construction in 1961

Company and works	Kind of mill	Completion date
Yawata Iron and Steel Co., Ltd.:		
Tobata	56-inch, 6-stand Tandem coldmill	September 1961.
Do	3d electric tinning line	June 1962.
Hikari	Cold Sendzimir line	March 1962.
Sakai	Wide-flange beammill	NA.
Tokai Iron Manufacturing Co., Ltd.:		
Nagoya	68-inch continuous hot-strip mill	July 1961.
Do	56-inch Tandem cold-strip mill	October 1960.
Do	56-inch 4-H. skin pass mill	NA.
Nippon Kokan K. K. (Nippon Steel Tube):		
Mizue	56-inch 5-stand Tandem coldmill	March 1961.
Do	Continuous galvanizing line	June 1961.
Kawasaki Steel Corp.:		
Chiba	166-inch 4-high platemill	NA.
Do	Universal slabbing mill	December 1961.
Do	Continuous galvanizing line	July 1961.
Fukiai	2d cold Sendzimir mill	January 1962.
Do	Medium section mill	June 1961.
Chita	Spiral-weld tube machine	Do.
Sumitomo Metal Industries, Ltd.: Wakayama	80-inch semicontinuous hot-strip mill	March 1962.
Kobe Steel Works, Ltd.:		
Kobe	Slabbing mill	Do.
Do	5th continuous wire rodmill	May 1961.

Source: Japan's Iron and Steel Industry 1961.

kilns at the Ohyeyama plant, with an estimated output of 24,000 tons in 1961, employed the Krupp-Renn process. Rinkagaku-Kogyo Co., Ltd., utilized the Kamijima process. The equipment for this process; is virtually the same as that for the Wiberg-Soderfors process, however, the Japanese did not use reducing gas made from producer gas in carburetors. Instead, waste gas, discharged from electric furnaces during production of pig iron and ferroalloys, was used as the reductant. The capacity of the Rinkagaku-Kogyo plant was about 16.5 tons per day. Wiberg-Soderfors sponge-iron plants were planned by Hitachi Metal Industries, Ltd., 11,000 short tons capacity, and Sanyo Special Steel Co., Ltd., 28,000 short tons capacity. Research projects underway included the study of a fluidized-bed reduction method and the industrialization of the Nakajima process for making sponge iron. [28]

Korea, Republic of.—A private economic development program was submitted to the Supreme Council for National Reconstruction by the Korean Businessmen's Association (KBA) on September 14, 1961, for the construction of an integrated steel plant. Outlays were estimated to be US$32 million. This plant was to be erected on the east coast between April 1962 and 1965; it was to have an annual capacity of 270,000 short tons of pig iron, 238,000 tons of steel ingots, and 181,000 tons of finished steel products. Raw materials were to be obtained locally. [29]

Philippines.—The Export-Import Bank of Washington D.C., granted $62.3 million credit for establishing a steel mill at Iligan City, Mindanao Island. The loan was scheduled for payment in 16 years beginning in 1966. In accordance with basic policy of the Philippine Government, a new corporation with authorized capital of $60 million was to be formed, with the government subscribing

[28] Tokyo Foreign Service. Japan's Iron and Steel Industry 1961. 301 pp.
[29] Bureau of Mines. Mineral Trade Notes V. 54, No. 2, February 1962, p. 25.

51 percent and private industry 49 percent. Jacinto Steel, Inc., was the private investor.

Initially, annual capacity of the plant was to be 275,000 short tons of finished steel products. Koppers Company International was designated by the Philippine Government to supply technical and managerial assistance during construction and the initial operations. Filipino contractors and local engineers and labor were to be used. It was anticipated that more than 6,000 persons would be employed.

A second integrated steel plant, partially described in the 1960 Iron and Steel Chapter, page 626, was approved in August 1961. This plant, to be built on the shores of Luzon Laguna de Bay, south of Manila, was to utilize iron ore from the Santa Inez deposits in the mountainous area near the Rizul-Quezon provincial boundary, about 25 miles from Manila. The project would require an outlay of about US$50 million. West German firms will subscribe US$28 million, and Philippine industry will provide the remaining US$22 million. The proposed plant will employ 2,000. [30]

AFRICA

Union of South Africa.—The South African Iron and Steel Industrial Corp., Ltd. (ISCOR), announced a program to increase annual steel ingot capacity to nearly 4 million tons by 1969. Annual capacity in 1962 was about 2,350,000 tons. Export markets would be sought for production in excess of domestic needs. In the year ended June 30, 1961, ISCOR sold in export markets 85,342 tons of steel and 62,275 tons of pig iron. [31]

African Metals Corp., Ltd. (AMCOR), concluded a contract with Yawata Iron & Steel Company of Japan; by its terms AMCOR would supply Yawata with 5.6 million short tons of pig iron. Delivery, which was to begin in 1964, was to be 500,000 tons annually. AMCOR was to build a fourth furnace. Its 1962 pig-iron capacity was 350,000 tons annually. [32]

OCEANIA

Australia.—Construction of the first unit of the long-projected Whyalla (South Australia) $90-million steel plant began in February. The existing blast furnaces were to be altered to provide hot-metal feed for two oxygen coverters. The blooming mill was to be installed at the same time as the converters, and the installation of a merchant mill was to follow. Other facilities included an oxygen plant, precipitators for air-pollution control, and enlargement of existing buildings. Construction of the 500,000-short-ton plant was scheduled for completion in 1964.

The Federal and West Australian Governments were to spend $92 million on railways to help establish a steel plant in West Australia. Broken Hill Pty. Ltd., agreed to build a US$99-million steel plant at Kwinana when the railroad is completed.

[30] Mining Newsletter (Philippines), v. 12, No. 5, May-June, 1961, pp. 26-40.
Foreign Commerce Weekly, v. 66, No. 25, Dec. 18, 1961, p. 47.
[31] U.S. Embassy, Pretoria, Republic of South Africa State Department Dispatch 205, Nov. 20, 1961.
South African Iron and Steel Industrial Corp., Ltd. Annual Report. 1961.
[32] U.S. Embassy, Pretoria, Republic of South Africa State Department Dispatch 281, Jan. 9, 1962.
U.S. Consul, Johannesburg, Republic of South Africa State Department Dispatch 268, Jan. 9, 1962.

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Construction of a new 600-ton open-hearth furnace late in 1960 raised Port Kembla's steelmaking capacity to 3 million short tons. The furnace, one of the largest in the free world, was equipped with oxygen-blowing equipment. A second electric furnace, with a rated capacity of 50 tons, began operating at Port Kembla.

During 1961 steel officials from Canada and France were in Australia in connection with the construction of a second stainless steel strip, which reportedly was to be built in Sydney.

A new sinter plant at Newcastle, completed in April 1961, was producing more than 1 million tons of sinter annually. Rehabilitation of the open-hearth furnace at Newcastle was almost completed, and work on the blooming mill was underway; foundations were prepared for two oxygen steelmaking furnaces. Other work at Newcastle included installation of a high-capacity rodmill, construction of a fourth blast furnace, and the rebuilding of the No. 2 battery of coke ovens.[33]

TECHNOLOGY

Highlighting developments in U.S. blast-furnace research was the use of fuel injection—natural gas, fuel oil, and coal. Experiments at Colorado Fuel and Iron Corp. showed that 1,000 standard cubic feet of natural gas replaces 75 pounds of coke (worth about 60 cents). However, technical factors limited natural gas use to 4 to 6 percent of the airblast without oxygen injection. Tests at various locations demonstrated that coke consumption can be decreased up to 25 percent and production increased 30 percent. In 1961, 13.2 billion cubic feet of natural gas was used in U.S. blast furnaces.[34]

Fuel oil was first used as a fuel in the No. 3 blast furnace in Pompey, France in January 1960 under the sponsorship of the European Coal and Steel Community, and the results of the 1960 experiments on the use of fuel oil in the Liege experimental blast furnace were given in the 1960 Iron and Steel Chapter, page 634.

At National Tube Division, U.S. Steel Corp., McKeesport Works, a slurry containing 60 percent coal and 40 percent oil was injected in the blast-furnace tuyeres, and large savings were realized. Oil atomized and coal particles disintegrate when the slurry passes through the tuyeres and into the furnace. One pound of the slurry replaced 1.4 pounds of coke, and the estimated daily saving for a 1,500-ton-per-day blast furnace was $1,000. Coke was assumed to cost $16 per ton, coal $8 per ton, and fuel oil $0.08 a gallon. Estimated savings can be as high as $3 per ton of hot metal, provided oxygen, a beneficiated burden, and higher hot-blast temperatures are used.[35]

During 1960, the Bureau of Mines, in cooperation with U.S. Steel Corp. and ESSO Research and Engineering Co., conducted experiments on the use of fuel oil in the Bureau's 4-foot-hearth-diameter blast furnace at Bruceton, Pa. Results of these tests showed that

[33] Iron and Coal Trades Review, v. 182, No. 4842, May 5, 1961, p. 971.
Steel, v. 149, No. 12, Sept. 18, 1961, p. 63.
Mining Journal, v. 256, No. 6550, Mar. 3, 1961, p. 250.
Iron and Coal Trades Review, v. 182, No. 4850, June 30, 1961, p. 1412.
Iron and Coal Trades Review, v. 182, No. 4854, July 28, 1961, p. 176.
Steel, v. 149, No. 5, July 31, 1961, p. 17.
[34] Chemical Week, July 8, 1961, pp. 63–68.
[35] Steel. The Metalworking Weekly. V. 150, No. 15, Apr. 9, 1962, pp. 67–69.

when the furnace was operated with the minimum amount of oil (90 pounds per ton of hot metal) required to utilize the maximum hot-blast temperatures, the coke rate was decreased 197 pounds per ton of hot metal. Under these conditions, pig-iron output was increased 19 percent over the base period.[36]

In Canada, Dominion Foundries and Steel, Ltd., of Hamilton, Ontario, used 58 pounds of oil per ton of hot metal produced, with a high pellet burden. This resulted in a 7-percent decrease in coke and a 2-percent increase in productivity.[37]

During a 2-month experiment at The Colorado Fuel and Iron Corp., using oxygen in the blast furnace, mixtures of natural gas and oil were added. Natural gas was injected at rates up to 3,000 cubic feet per ton of hot metal and fuel oil at 5 gallons per ton of hot metal. Production increased from 800 to 1,300 tons per day, and coke rates decreased to as little as 967 pounds per ton.

At the Weirton, W. Va., plant of National Steel, tests were conducted in which the amount of coal injected into the furnace was 10, 15, 20, 25, and 30 percent of the total fuel requirement. High-volatile and low-volatile bituminous coals were used, and brief experience was obtained using anthracite coal. Substantial reductions in coke rates were realized when injecting coal.[38]

Some of the advantages of fuel injection are: (1) Substantial savings in the cost of blast-furnace fuel; (2) additional savings from a reduced need for investment in coke-oven capacity; (3) improved operating efficiency; (4) higher production with no increase in furnace size; and (5) ability to use the abundant natural gas, fuel oil, and lower quality noncoking coals instead of the more scarce and costly metallurgical grades now required in blast-furnace operation.[39]

Ford Motor Co. continued an experiment similar to that of Great Lakes Steel Corp. (see 1960 Iron and Steel Chapter, Page 630) and produced a 427-ton heat at a rate of 105.1 tons per hour, with a total oxygen consumption of 1,533 cubic feet per ton. Some of the advantages of oxy-fuel lances were: (1) Scrap melting efficiency was greatly increased over that of nominal end-burner firing; (2) higher flame temperatures were realized; (3) vertical directed flames were superior to horizontal flames from end burners; (4) the lance facilitated rapid charging of low-density scrap; (5) firing continued while the direction of firing was being reversed from one end of the furnace to the other, therefore, it was more efficient than from end burners; and (6) the maximum firing potential of the furnace was greatly increased. The general conclusion to be drawn from utilizing oxygen fuel lances is that scrap must be charged at a very rapid rate to take full advantage of the high-flame temperatures.[40]

Armco Steel, which had been emphasizing prepared burdens for several years, produced over 3,100 tons of pig iron per day in its Middletown No. 3 blast furnace, using a 100-percent-pellet metallic charge, and established a new monthly record of 2,942 tons per day. Armco officials predicted that, with some alterations of the blowers, they could produce 3,200 tons per day. The Middletown plant had

[36] Blast Furnace and Steel Plant, v. 49, No. 12, December 1961, pp. 1189-1196.
[37] Blast Furnace and Steel Plant, v. 50, No. 1, January 1962, pp. 35-39.
[38] Journal of Metals, v. 14, No. 4, April 1962, pp. 295-298.
[39] Iron and Steel Engineer, v. 38, No. 10, October 1961, p. 175.
[40] Duffett, Jr., Ralph. Some Aspects of High-Oxygen Practice at Great Lakes. Open Hearth Proceedings, AIME. V. 44, 1961, pp. 46-52.

one blast furnace with a hearth diameter of 28 feet. Blowing equipment consisted of two turboblowers, each rated at 110,000 cfm. Some observations on the use of pellets were: (1) They could withstand high wind rates without sacrificing chemical or physical efficiency; (2) fines, which materially reduce effectiveness of high wind rates, were not present; (3) the material permitted high hot-blast heats and was particularly adaptable to high-moisture practice; (4) some effective means of stack cooling was required if high wind rates were to be used with conventional refractories; and (5) pellets were most effective when used as 100 percent of the ore burden as compared with using even small percentages of raw ore.[41]

During 1961, U.S. Steel built a small experimental blast furnace at the Universal Atlas Cement Division plant in Universal, Pa., for use in studying chemical reactions within the furnace. The furnace was equipped with modern instruments and probes to permit a complete analysis of the operation. It was designed to operate at top pressures up to 50 pounds per square inch with a 500-cubic-feet-per-minute blast heated to a maximum of about 2,500° F. The diameter was 4 feet, and the working height from tuyeres to stock line was 19½ feet. Results of several mathematical model studies of the blast furnaces led to the development of equations which will predict complete blast-furnace behavior. Excellent agreement was obtained between predicted and actual results.[42]

In open-hearth steelmaking, new record outputs were registered, using oxygen and fuel-oxygen lances, which exceeded hourly outputs of oxygen converters operated during the year. At Great Lakes Steel Corp., 152.5 tons of steel per hour was made utilizing oxy-gas (natural) and regular jet oxygen lances. The end burners of the furnace also had facilities for delivering undershot oxygen. Oxygen requirements for this 432-ton heat were 1,603 cubic feet per ton. Although oxygen requirements were slightly higher than for an average oxygen converter, approximately 15 percent more scrap was utilized than is normally used in LD converters.

In another experiment at Great Lakes, in making a 460-ton heat, composed of a charge consisting of 50 percent scrap, 2 tons of coke was charged on top of the scrap burden under the oxygen roof lances. After ignition of the coke, a stream of high-purity oxygen was directed on the coke; this operation produced a very high temperature and facilitated rapid melting of the scrap, much in the same way that an oxygen oxy-fuel lance provided. The production rate for this experiment was 137 tons per hour, and the oxygen requirement was 1,162 cubic feet per ton.

The first installation that was to use the Kaldo process was under construction by Sharon Steel Corp. at its Roemer works in Farrell, Pa. Each of the furnaces will be 25-feet long and 18 feet in diameter at the center. The furnaces will rotate at speeds up to 27 rpm and are inclined at an angle of 17° from the horizontal during refining. Oxygen will be supplied through a 20-foot-long, water-cooled oscillating lance mounted in the exhaust hood. This process provides

[41] Haley, K. R. Operating Results, Using Taconite Pellets on Armco's Middletown Blast Furnace. Blast Furnace Coke Oven & Raw Materials Proc., AIME. V. 20, 1961, pp. 15-25.
[42] Madsen, I. E. Developments in the Iron and Steel Industry During 1961. Iron and Steel Eng., v. 39, No. 1, January 1962, p. 113.

selectivity in the elimination of metalloids and excellent control of carbon, phosphorus, nitrogen, sulfur, and final tapping temperatures. The thermal efficiency of the process permits scrap additions of up to 50 percent of total metallics charged or 1⅞ tons of steel per ton of hot metal used. The L–D converter utilizes a normal 25- to 30-percent scrap. If ore is used as a coolant, 1 ton of steel per ton of hot metal is produced. The life of refractories in this furnace was said to be less than in the basic oxygen converter.[43]

Another process which readily removes phosphorus is the Oxygen Lime Powder Process (OLP), which was developed in France. Steels with up to 0.5 percent carbon could be made from hot metal containing 1.8 percent phosphorus. Two 140-ton converters utilizing this process were under construction at Dunkirk, France.

The Rotor process, developed at one of the plants of the Klockner Werks, Inc., West Germany, is another rapid method for refining molten pig iron. The elliptical-shaped vessel, which rotates in a horizontal position, reportedly refines heats in 10 to 15 minutes.[44]

The steel industry continued its program to reduce air pollution. Bethlehem Steel Corp. started three open hearths with dust precipitators at its Lackawanna, N.Y., plant. Seven furnaces were included in the company's total program. Republic Steel ordered a dust-cleaning system for its Chicago plant. Overall cost of the project was more than $3.5 million. This system was to handle 300,000 cfm of gas at temperatures of 550° F., with an efficiency of 98 percent.

Jones and Laughlin Steel Corp. started its new air-pollution reduction system at Pittsburgh. The system was to service 11 furnaces and was designed to reduce dust admission almost 99 percent. Jones and Laughlin also put into operation, at Cleveland, gas-cleaning equipment for three 220-ton roof-lance oxygen open-hearth furnaces. The system also included equipment for cleaning gases from 200-ton basic oxygen converters.

National Steel Corp., Weirton, W. Va., developed a new technique which appeared to be relatively inexpensive as compared with other processes. The company injected water into the oxygen lances in the furnaces, thus reducing the amount of smoke and fumes at the source. Weirton planned to extend this technique to all furnaces in the shop.[45]

At the Geneva, Utah, plant of U.S. Steel, reports indicated that the air-pollution reduction system installed several years before was working at high efficiency.

At U.S. Steel's Duquesne plant, air-pollution reduction equipment was being installed for five electric-arc furnaces; the gasses were to be filtered through glass-fiber bags.[46]

Kaiser, the first steel company to install electrostatic precipitators on large open-hearth furnaces, described its oxygen-converter, air-pollution reduction facilities at Fontana, Calif. Each furnace was equipped with precipitators 53 feet, 3¼ inches long; 52 feet, 2¾ inches wide; and 56 feet, 2¾ inches high. Discharge electrodes were 25

[43] Steel and Coal, v. 184, No. 4884, Feb. 23, 1962, pp. 359-360.
[44] Page 117 of work cited in footnote 41
[45] Rengstorff, George. Formation and Suppression of Emissions from Steelmaking Processes. Open Hearth Proceedings, AIME. V. 44, 1961, pp. 120-147.
[46] Pages 118-119 of work cited in footnote 41.

feet, 6 inches long; collecting plates were 6 feet long and 23 feet, 6 inches high. Each precipitator was designed to handle 202,000 standard cubic feet per minute. Gas analysis for maximum blow conditions was CO_2, 5 percent; 0_2, 14 percent; N, 61 percent; and H_2O, 20 percent. About 6,000 gpm of cooling water was used in each hood, and the gases entered the precipitator inlet header from 315° to 507° F. Average heat transfer to the hoods was 535,000 to 1,029,000 Btu per minute. Dust samples obtained from other installations showed that 5 to 15 percent of the particles were larger than 1.0 micron, 45 to 65 percent between 0.5 and 1.0 micron, and 20 to 50 percent less than 0.5 micron. Analysis of the dust samples showed that about 93 percent was ferric oxide and that the remainder was mainly manganese oxide; small quantities of calcium oxide and silica were present. About 4,400 pounds of dust were generated during a 22-minute heat blow. Precipitator efficiency tests showed dust removal to be greater than 99.8 percent.

About $7.5 billion was being spent annually in the United States on air pollution. Kaiser budgeted $10,500 per month for its oxygen-precipitator facilities and operating and maintenance labor.[47]

Inland Steel conducted experiments on the effects of columbium on steel properties and reported the following results. (1) Small additions of columbium to plain carbon steels increase the tensile and yield strengths, up to 25,000 psi, of the as-rolled finished products. (2) Steels containing up to 0.035 percent columbium can be produced satisfactorily by ladle additions. (3) As a deoxidizer, columbium behaves like manganese when added to molten steel. (4) Columbium segregates slightly to the outer-rim zone in rimming steels but evidences no segregation in the semikilled steels. However, in the fully killed grades, the columbium tends to segregate to the bottom portion of the ingot. (5) The mechanism by which columbium refines the grain is not known. (6) Columbium in semikilled steel tends to partition almost completely to the carbide phase, with only about 10 percent tying up as a nitride. This carbide phase, which precipitates at the grain boundaries, contributes to the increased physical properties found in the hot-rolled products. (7) Columbium in the quantities studied evidences no apparent effect on quality or ingot structure. (8) Small additions of columbium, 0.5 to 2 pounds per ton to rimmed steel, weakens the rimming action. In semikilled grades, additions of 1 pound of columbium per ton of steel reduces the requirements of aluminum to ingot molds by 1 ounce per ton.[48]

Interest in continuous casting increased. A number of U.S. producers were taking a closer look at the process, and in Europe 34 machines, with an estimated annual capacity of about 1 million tons, were operating. At least 20 more machines were being built (see table 27).[49]

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[47] Smith, J. H. Air Pollution Control in Oxygen Steelmaking. Open Hearth Proceedings, AIME. V. 44, 1961, pp. 351-357.
[48] Mareta, J. T. and Joseph, R. W. Behavior of Columbium in Liquid Steel. Open Hearth Proceedings, AIME. V. 44, 1961, pp. 421-430.
[49] Iron Age, v. 189, No. 3, Jan. 18, 1962, pp. 75-78.

TABLE 27.—World continuous casting installations

Country and company	Type	Strands	Capacity, net tons per hour (unless otherwise indicated)	Types of steel	Sizes cast
Austria:					
Boehler	Boehler	2		Stainless, alloy	4-in and 6-in squares and rounds; 7- by 20-in slabs.
Breitenfeld	Leitner	2	10	Carbon, alloy	4½-in and 5-in rounds; 3¾-in squares; 2½- by 10¾-in slabs.
Schoeller-Bleckmann	Rossi-Junghans	3	50	Stainless	6- by 24-in slabs; 3½-in squares.
Schmidstahl	do	1	10	Carbon, low alloy, stainless	4-in squares.
Canada:					
Atlas Steels	do	3	60	Stainless, alloy, low carbon	6½- by 21-in slabs; 5, 6¼, 7, and 8½ in squares.
Premier Steel	do	2	45	Carbon, killed and rimmed	4- to 6-in squares.
France:					
Forges D'Allevard	do	1	17	Spring	3-in squares; 3- by 5-in billets.
Soc. Fr. de Constructions Mec.	Junghans	4	60	Carbon	9½-in squares.
Forges De La Loire	Vergniaud	2	4	Special, alloy	2½- by 3½-in and 3½- by 4-in ovals.
Pont-a-mousson [1]	Rossi-Junghans	1	85	Carbon	8- by 50-in slabs.
Germany, West:					
Mannesmann	Junghans	4	94	Low alloy	5½-in rounds; 6¼-in polygons; 3- by 12-in slabs; 12-in squares, 8- by 9½-in slabs.
Kloeckner-Werke [2]	do	1	8	Rimmed	3-, 4¼-, and 7-in squares.
Phoenix-Rheinrohr	do	2	12	Low alloy	4¼-in squares; 5- and 6¼-in rounds.
Gebr. Benteler	Rossi-Junghans	2	16	Carbon	4-, 9-, and 15-in squares.
Deutsche Edelstahl [2]	Rossi-Tessman horizontal	1	30	Alloy	4-in squares; 3- by 12-in squares.
Dillingen	Rossi-Junghans	1	135	Rimmed	8- to 10-in by 60-in slabs.
F. Meyer [1]	Demag	3	[3] 6,000	Structural, tube	4- to 6¼-in squares; 19¾- by 4-in slabs.
Grillo-Funke [1]	do	6	[3] 12,000	Open hearth killed	11-in squares, 59- by 8⅞-in slabs.
Italy:					
SAFAU	Rossi-Junghans	1	15	Carbon	5- and 7-in squares.
Terni	Mannesmann-Junghans	8	90	do	4-in squares.
Riva [1]	Boehler	3	[3] 6,000	do	4- to 6¼-in squares.
Japan:					
Sumitomo	Rossi-Junghans	1 or 2	12	Carbon, alloy	3- by 8-in and 3- by 12-in slabs; 3- to 5-in squares.
Yawata	do	1	75	Carbon and stainless	5- by 48-in slabs; 6- by 50-in slabs.
Norway: Stavanger	do	1	12	Alloy	5- to 7-in squares.
Peru: Chimbote [1]	do	2–4	[3] 12,000	Carbon, low alloy	3½-in squares and larger.
Spain: Del Besos	do	1	12	Carbon	5- to 7-in squares.
Sweden:					
Nyby Bruks	do	1	16	Carbon, tool and stainless	3½-in squares, 6- to 7¼-in rounds; 2¼- by 13-in slabs.
Upsala	(4)	1	6	Carbon	5-in diamond billets.

See footnotes at end of table.

TABLE 27.—World continuous casting installations—Continued

Country and company	Type	Strands	Capacity, net tons per hour (unless otherwise indicated)	Types of steel	Sizes cast
U.S.S.R.:					
Ministry of Red Fleet[2]	Three-stage oscillation	1	1½	Gray iron	4-in rounds.
Novo Tula	Junghans-type oscillation	1	32	Carbon, alloy	6- by 20-in slabs; 8- by 24-in slabs.
Krasnof Sornovo	Taniichermet	2	60	Carbon	7- by 16½-in slabs.
Hammer & Sickle	Goldobin belt type	1	35	do	4- to 5½-in squares; 5½- by 20-in slabs.
Stalinski Works	Junghans	4	375	Carbon, low alloy	4¾- by 24-in slabs; 10- by 40-in slabs.
Rovda	Uichermet			Rimmed	9- by 5-in slabs.
Gorki[1]	Stalproekt	2	[3] 11,000	Carbon, tool, stainless	12- by 7-in, 19½- by 8-in slabs.
Uzbezii[1]	do	4	[3] 17,000	Carbon.	
Krasnyi Sulin	Goldobin belt type	2	70	do	4- to 5½-in squares; 5½- by 20-in slabs.
United Kingdom:					
Barrow	Rossi-Junghans	2	16	do	2-in squares; 4¼ by 2 in, 7- by 3-in slabs.
	do	3	50	Carbon, rimmed	5- by 36-in slabs; 9-in squares.
BISRA[2]	BISRA	1	30	Low alloy	4-in rounds; 4-in squares; 1¾- by 9-in slabs.
Wm. Jessop & Sons	do	2	8	Tool, stainless, special	4-in squares.
Barrow	Rossi-Junghans	2	16	Carbon	2- to 4-in squares; 6- by 2-in and 4¼- by 2-in slabs.
Appleby Frodingham	do	4	100	do	9-in squares.
Shelton[1]	do	10 to 13	[3] 67,000	Carbon, low alloy, rimmed	17- by 30-in slabs, 37- by 8-in slabs.
Steel Co. of Wales[1]	BISRA	2	[3] 17,000	Rimmed	33- by 7-in to 48- by 8-in slabs.
R.T. & B.	Rossi-Junghans	1		Carbon	6- to 8-in by 66-in slabs.
United States:					
Allegheny-Ludlum[2]	do	1	11	Stainless, alloy	3½-in squares; 5½-in rounds; 3- by 13-in slabs.
B. & W.	Williams	1	11	Carbon, low alloy, stainless	4¼- by 9-in oval; 6- and 7-in squares; 5- by 15-in slabs.
Braeburn Alloy[2]	Tocco-Goss	1	10	Alloy, tool	4-in squares.
Roanoke[1]	B. & W.	2	[3] 6,000	Carbon	4½-in squares.

[1] Under construction.
[2] Experimental.
[3] Tons per month.
[4] Data not available.
[5] Total of 4 machines with 10 to 13 strands, to start operating 1963–64.

Source: Iron Age.

A brief description of the Rossi-Junghans type machine, which was operated in Canada by Atlas Steel Co., at Welland, Ontario, and Allegheny-Ludlum Steel Corp., follows: This process consists of teeming molten steel into a tundish which feeds the molten metal at a specified rate into a water-cooled oscillating copper-cooled mold. Four pinch or withdrawal rolls pull the partially solidified billet or slab downward. The oscillation and pinch roll speed is controlled by a variable speed regulator (P.I.V.). When the bar reaches a designated distance, movable twin oxy-acetylene powder torches cut the billets or slabs into the desired lengths. Mold sizes vary from 4½ inches square up to 6⅝ inches by 24 inches. Casting speeds vary from 50 to 80 inches per minute, and when small sizes are cast, two-strand molds are used. Production rates vary from 8 to 60 tons per hour. According to Atlas, large savings can be realized if 1,500 to 2,500 tons of steel are continuously cast each month. The reason for this saving is that ingot molds, stripping facilities, blooming-mill soaking pits, and the blooming mill or slabmill are not required. Also, yield can be increased up to 15 percent.

Steel companies utilizing continuous casting equipment required considerably more purchased scrap because the production of home scrap by this process is less than half that made by all other processes. Atlas used a continuous casting machine for making all types of carbon, alloy, and stainless steels, but it reported some center shrinkage cavities and blowholes (pinholes) near the billet or slab surface; these holes were attributed to the high gas content of the steel. The extremely high humidity in Welland increases hydrogen in steel. Hydrogen in steel also increases on rainy days. To alleviate this problem, a D-H (Dortmund Horder) vacuum degassing unit was to be installed. Other companies attributed the subcutaneous blowholes and surface pinholes to overuse of mold lubricants and inadequate control of steelmaking, but they had virtually eliminated this problem through proper controls.[50]

U.S. Steel's South Works, Chicago, Ill., reported encouraging results on experimental work on control pressure pouring of molten steel. The process was used to make railroad car wheels, slabs, tube rounds, billets, and blooms. Equipment was designed to cast slabs about 25 feet long and up to 65 inches wide.[51]

In another experiment using high oxygen flow rates, Youngstown Sheet and Tube Company, Youngstown, Ohio, obtained production rates of up to 82 tons per hour in open-hearth furnaces. Fuel uses were reduced to 1.3 million Btu per ton, compared with 3 billion Btu with non-oxygen practices.

Tests conducted at Granite City Steel Co., Granite City, Ill., in its recently enlarged 600-ton furnace in which oil and oxygen were introduced through roof lances, gave flame temperatures of 5,000° F. From 300 to 500 gallons per hour of oil and 90,000 to 150,000 cubic feet of oxygen per hour were used.[52]

In all cold-metal-charged open-hearth and electric furnaces, oxygen fuel burners were used to increase productivity. At the Buckeye Steel Casting Company, Columbus, Ohio, which operated six 30-ton

[50] Journal of the Iron and Steel Institute, v. 190 pt. 1, September 1958, pp. 40–50.
[51] Page 120 of work cited in footnote 42.
[52] Pages 117-118 of work cited in footnote 42.

basic open-hearth furnaces, the use of oxy-fuel burners reduced the charge-to-tap interval from 6 hours to 3 hours and 40 minutes with a 100-percent steel-scrap-plus-coke charge and from 5 hours and 15 minutes to 2 hours and 45 minutes with a charge consisting of 20-percent cold pig iron and 80-percent scrap. This company normally used producer gas as a fuel, but it used producer gas with natural gas when employing the oxygen fuel burner. The advantages of using oxy-fuel burners in the electric furnace were reported on page 606 of the 1959 Iron and Steel Chapter.[53]

New steelmaking facilities continued to emphasize various basic oxygen converters. Oxygen steelmaking facilities were lower in installation and operating costs, and lower cost tonnage oxygen had become available in recent years. Some 25 countries were using or installing the oxygen steelmaking process. The basic oxygen converter process was the fastest-known method for making high-quality low-nitrogen steel. It was particularly adaptable to the usual run of pig iron produced in the United States. It was not adaptable to high-phosphorus pig iron because of the large slag volume required to remove phosphorus. Table 28 gives estimated world oxygen steelmaking capacities.

TABLE 28.—Estimated world capacity of basic oxygen steel
(Short tons per year)

	1960	1962
Vertical top-blown furnaces:		
United States	4,652,630	9,802,630
Other countries	11,377,000	33,412,000
Total	16,029,630	43,214,630
Rotor furnaces	2,700,000	3,300,000
Kaldo furnaces	1,200,000	1,700,000
Grand total	19,929,630	48,214,630

Source: Steel Magazine.

The United States led in oxygen steelmaking capacity (9.8 million tons). Japan had a capacity of 4 million tons, 3 million tons under construction. Austria had 2 million tons, and programs involving over 1 million-ton capacities were underway in Australia, Brazil, Great Britain, Italy, Netherlands, and West Germany.

Colorado Fuel and Iron's new basic oxygen shop, at Pueblo, Colo., with a rated capacity of 50,000 short tons of steel per month and consisting of two 100-ton basic oxygen converters, was described. This plant poured its first steel on July 11, 1961. Other plants under construction included one of Jones and Laughlin Steel Corp. at Cleveland, Ohio, with converters with a 200-ton capacity, and one of National Steel Corp. at Detroit, Mich., with a 300-ton basic converter plant. These two installations should make 200- and 300-ton heats in 1 hour.[54]

New high-strength steels developed during 1961 offered cost savings, longer spans, and greater opportunities for imaginative combinations of materials. Among the new techniques were: Hybrid girders, with

[53] Work cited in footnote 40.
[54] Pages 336–339 of work cited in footnote 42.

high-strength steels used in regions of high stress; carbon steel girders, prestressed with welded plates of high-strength steels; and composite construction, with new possibilities for economy. Bridge designers called for heat-treated alloy steel (100,000 psi yield strength), maximum negative bending moment, high-strength steel (50,000 yield) for intermediate stress ranges, and carbon steel (32,000 yield) for regions of low bending stress. Skyscraper frames were constructed of columns with heat-treated alloy steel at the bottom, high-strength low-alloy steel for intermediate sections, and carbon steel in the upper stories.

Automatic welding techniques made built-up sections up to 6 feet wide economical because of reduced cost. In composite construction, the added stiffness resulting from the use of sections made of concrete slabs and steel virtually eliminated the problem of excessive flexibility. Prestressing reduced steel requirements in structures by 25 percent.[55]

During 1961, Kaiser Steel Corp., Fontana, Calif., announced the manufacture of a wide variety of welded structural beam shapes from 10 inches to nearly 6 feet deep. Some 6,000 tons of all-welded wide-flange bearing piles were used in the substructure of the San Pedro, Calif., Terminal Island bridge foundation.

A market study by Kaiser had showed that the market in the West Coast area was not large enough to warrant the construction of a wide-flange beam structural mill which would cost up to $50 million. Therefore, the use of welded structures was one way of entering the West Coast market.[56]

Virtually all major steel companies with research laboratories continued working on methods for increasing the strength of ultra-high-strength steel. Among the techniques being examined were: Ausforming (Bureau of Mines Minerals Yearbook, Iron and Steel Chapter, 1959, p. 605); increasing the quantity of such elements as chromium and molybdenum to increase hardenability; reducing the temper temperature from above 800° to as low as 400° (for example, the tensile strength of AISI 4340 can be increased from about 200,000 psi to more than 275,000 psi by reducing the temper temperature while the toughness is almost unchanged); purification by vacuum melting, which would give maximum mechanical properties; and rolling steel before austenite can transform without recrystallizing the austenite. By the latter procedure, tensile strengths of 400,000 psi and a reduction area of 42 percent was obtained for a 4.5 percent Ni, 1.5 percent Cr, and 0.3 percent C.[57] In a project financed by the U.S. Air Force, iron whiskers were grown in an argon atmosphere with tensile strengths up to 1.5 million psi.[58]

Also, in the Bassett process, exceptionally high strengths were reported (heat treatment in a magnetic field).

The International Nickel Company of Canada, Ltd., announced a series of mar-aging alloys containing nickel, cobalt, and molybdenum in substantial quantities with additions of boron, zirconium, and calcium for conditioning and small amounts of titanium and silicon. Heat treatment consists of complete transformation of martensite

[55] Engineering News Record, Feb. 15, 1962, p. 42.
[56] Steel Magazine, v. 150, No. 14, April 1962, pp. 127-129.
[57] Metal Progress, v. 66, August 1954, p. 103.
[58] Emrick, J. E. Studies on Iron Whiskers of High Average Strength Grown in a Hydrogen Contaminated Argon Atmosphere. Wright Air Development Center Tech. Note 61-54, 1961, 16 pp.

and a precipitation hardening treatment to produce high strength. Tensile strengths of 400,000 psi are possible in mar-aged steels.[59]

Several producers predicted that steels with useful tensile strengths up to 500,000 psi would be produced within 5 to 10 years. The Bureau of Mines initiated a program on the development of high-strength steel in July 1961.

The British Iron and Steel Research Association (BISRA) made considerable progress in iron and steel research, and expenditures for the year were US$2.8 million, compared with US$2.5 million in 1960. Included in the expenditures was $285,000 for purchasing equipment and improving laboratory facilities. The major items of equipment delivered were an experimental rodmill and an electron microscope. In burden preparation, the laboratory work was extended to include a study of the production and blast-furnace test of highly basic sinters with basicity ratios up to 5. In one experiment foreign ores were used with silica levels of 4½ and 9 percent. In the first case, up to 28 percent limestone was added, giving a basicity of 5; and in the second mix, 39 percent limestone was added, giving a basicity of 4. In both cases the coke rate had to be increased from 4 to 7 percent as basicity increased. It was also determined that siliceous sinters with a basicity of 1½ percent were weaker than either the more or less basic ones. In anticipation of a possible shortage of coke breeze for sintering, a study was initiated to find a substitute; anthracite fines were found to be at least as satisfactory as coke breeze.

In blast-furnace research tests conducted using Malmberget pellets, coke rates of about 1,200 pounds per ton were obtained. These pellets are ideal charge materials because they do not deteriorate during storage. A series of tests were made on fluxed sinter that had been stored in sealed drums, and the results were compared with results obtained with freshly made flux sinter. Further studies were conducted on the failure of certain blast-furnace slags, and investigations suggested that failure may be due to the formation of calcium sulfate through the oxidation of the sulfide. To increase the bulk densities of slags, trials were carried out with the addition of various materials to the ladles, and it was found that small percentages of iron ore increased the bulk density. Other studies included the determination of coefficients at various temperatures and flow rates for variously shaped blast-furnace stove bricks. With the aid of an analog computer and field tests, tentative designs for a new type of checker brick were promulgated; these designs would increase stove effectiveness without an appreciable increase in pressure drop across the stove. With a steady increase in interest of injection of solid and gaseous materials into the blast-furnace hearth, computers were used for evaluating the benefits of various fuel injections. These calculations were only possible if the course of the reduction reaction is known, that is, direct reduction (giving CO) and indirect reduction (giving CO^2). As a result of these calculations, emperical relationships were derived, linking changes in blast temperature, humidity, and increased hydrogen input with changes in top-gas composition. The collation and tabulation of data for a 1961 survey of British blast-furnace practices was completed, and publication was expected early in 1962.

[59] Allegheny Ludlum Steel Corp. Technical Horizions. 1961, pp. 1-2.

In oxygen steelmaking, laboratory tests were conducted using the spray refining procedure, which involves atomizing a falling stream of molten pig iron with high velocity jets of oxygen. From this study it was apparent that rapid removal of silicon was possible with relatively little carbon removal and a high efficiency of oxygen usage. With the use of powdered lime, it was determined that phosphorus could be removed and that iron losses could be reduced. In pilot-plant tests using this method, it was found that an annular swirling stream produced by inserting a core in the tundish nozzle and introducing a horizontal-velocity component into the stream resulted in improved efficiency of desiliconization. The basic objective of this method had been to devise a flexible pretreatment process for the removal of silicon, phosphorus, and carbon at a rate on the order of 5 tons of metal per minute. On the use of oxygen in open hearths, research was centered on flame enrichment, fuel economy, refractory costs, jet penetration, splash caused by jet thrust, passage of gas through the furnace, and the use of oxygen fuel lances to accelerate the melting of scrap.

Experimental slabs were continuously cast on the BISRA machine installed at the Abbey Works of the Steel Co. of Wales, Ltd. Investigations included control of the state of oxidation of low-carbon steels during casting, improved surface quality and shape, and assessment of various mold constructions. Studies on controlling the state of oxidation showed that with a thin-rimmed zone, blowholes would be exposed on reheating and rolling and would result in surface defects in the rolled product. Slabs were cast at speeds of 18 to 42 inches per minute, with aluminum additions varying from 0 to 14 ounces per ton in excess of that added to conventional ingots. Examinations of the cast sections showed that primary blowholes were not present within one-half inch of the surface until aluminum additions exceeded 8 ounces per ton. Optimum excess aluminum additions for controlling the boiling in the mold and blowhole depth appeared to be 4 to 6 ounces per ton. Subsurface blowholes decreased as casting progressed, that is, the latter part of the heat had less blowholes than the first part, and it was observed that blowholes were less apparent at the center of the long face of the slab which corresponds to positions to the area of turbulence in the mold. It was surmised that hydrogen was a contributing factor to the presence of subsurface blowholes.

At high casting speeds, the initial ingot shell was thinner, and bulging occurred across the wide face of the slab. Previously bulging had been confined to mechanically capped slabs and was attributed to gas pressure. Bulging was decreased by increasing the secondary cooling, accelerating the rate of skin growth and lowering the skin temperature. The Weybridge multiple mold process was successfully used to cast 3-inch square sections simultaneously. Physical testing and metallurgical examination of the bars confirmed that the process yields sound and commercially acceptable steel. To prevent uncontrolled rupture of the steel-ingot surface in continuous casting, which is caused from a reciprocating mold, an oil hydraulic system was installed for smoothing out the up-and-down cyclic motion of the mold.[60]

[60] The British Iron and Steel Research Association. Annual Report. 1960, pp. 13–55.

Research financed by the European Coal and Steel Community's High Authority in 1961 included the following: Studies to increase production of minerals within the Community and exploration of several foreign deposits; utilization of liquid fuels and powdered coal in the blast furnace and oxygen enrichment of the blast; continuation of research on direct reduction and dedusting of reddish brown fumes from the Thomas converter; improvement of the thermal balance sheet; and continuation of the work on the preparation of a metallographic atlas.

Research on the introduction of liquid fuels in the low-shaft blast furnace at Liege was conducted to determine optimum conditions for liquid-fuel combustion with oxygen enrichment through the blast-furnace tuyeres. Oxygen enrichment was increased to 27 percent, as opposed to 24 percent during 1960. These experiments were designed to increase blast-furnace output and reduce coke consumption. Detailed results were not given. The High Authority allocated US$850,000 for this work and US$2,100,000 for work on the injection of powdered coal. Tests on the use of liquid fuels were continued in a blast furnace of the Société Cockerill-Ougrée, which operated with a prepared burden containing from 40 to 90 percent agglomerates. Outstanding productivity increases were realized. The financial aid for these tests was US$180,000. Tests involving the use of injected gasified fuels caused many difficult technical problems, and the research was abandoned. Investigations in direct reduction included making low sulfur sponge iron for direct utilization in steelmaking furnaces. A provisional report covering this research was published.

Other work included the treatment of magnetites with special reducers, such as semicoke, for the production of partially reduced sponge iron for use as a coolant in basic oxygen converters. A pilot plant was under construction at the Finsider Metallurgical Center, Genoa, Italy, for direct reduction in a shaft furnace. The objective of this work was to make fundamental studies of reactions occurring in the hearth of a blast furnace at temperatures lower than 1,000° to 1,200° C. Research on the dedusting of reddish brown fumes from a Thomas converter blown with oxygen enriched air was continued. A report covering this work, which will contain details of how an economical and technical procedure can be applied for dedusting fumes, was to be published in 1962. Studies on the constitution and reactions of flames of different combustibles had been underway for 5 years. Investigations included tests with high-pressure pulverization of coal, utilizing oxygen in open-hearth furnaces.

Further studies involved the combustion of semiclean blast-furnace gas in a cyclone furnace for melting ash in blast-furnace gas with coke-oven gas or pulverized coal. In an effort to melt the ash with blast-furnace gas alone, a preheater was under construction to assure preheating to temperatures of 800° to 900° C. Work on the preparation of a metallographic atlas was continued, and the first volume was scheduled for publication early in 1963.[61]

[1] Pages 34–42 of work cited in footnote 17.

Iron and Steel Scrap

By James E. Larkin [1]

RECORD exports, the higher scrap-to-pig-iron ratio during the first 4 months of 1961, and the increased domestic demand during the third quarter served to offset the drop from 1960 in the use of iron and steel scrap.

The decreased demand for domestic scrap that existed during the last 6 months of 1960 continued throughout the first 3 months of 1961, when steel mills operated at their lowest level for the year. Scrap requirements fluctuated each month for the remainder of the year and were at their highest level during the last quarter, when increased demand resulted from steel mills operating at a higher rate. The peak month for consumption during the year was December, when 6.2 million short tons of scrap was consumed for all purposes.

The combined use of scrap and pig iron in steelmaking furnaces was 2 percent lower than in 1960. Scrap used in these furnaces decreased 3 percent, whereas the use of pig iron showed only a slight drop. The use of scrap in steelmaking furnaces comprised 45 percent of the combined total of scrap and pig iron used, 1 percent lower than in 1960. In December, with steel production at its highest level, steelmaking furnaces consumed 78 percent of the scrap used for all purposes.

TABLE 1.—Salient ferrous scrap and pig iron statistics in the United States

(Short tons)

	1960	1961
Stocks Dec. 31:		
Scrap at consumer plants	[1] 9,287,881	8,741,245
Pig iron at consumer and supplier plants	3,770,431	3,183,115
Total	[1] 13,058,312	11,924,360
Consumption:		
Scrap	66,468,708	64,326,698
Pig iron	66,626,336	65,797,298
Imports for consumption, scrap, (including tinplate scrap)	[1] 179,401	268,389
Exports, iron and steel scrap	[1] 8,039,668	9,715,755
Price: Scrap, No. 1 heavy-melting, Pittsburgh, average, per long ton	[1] [2] $32.97	$34.83
Value: Scrap, all grades, for export [3]	[1] $33.65	$40.82

[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 continuing suspension of import duties on metal scrap to June 30, 1962, was enacted on July 26, 1961, and made retroactive to midnight June 30, 1961, the expiration date of the previous law.

AVAILABLE SUPPLY

During 1961, consumers of ferrous scrap had a net supply made available at their plants of 63.8 million short tons, a 3-percent decrease from the supply made available during the preceding year. Home scrap produced and scrap received from dealers and other sources were each 3 percent lower than in 1960. These data exclude scrap on hand at dealers' yards.

TABLE 2.—Ferrous scrap supply [1] available for consumption in 1961, 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	72,638	76,917	149,555	7,064	142,491
Maine and New Hampshire	7,594	10,513	18,107	687	17,420
Massachusetts	106,269	107,035	213,304	25,269	188,035
Rhode Island	42,485	40,311	82,796	1,692	81,104
Vermont	10,518	13,135	23,653	----------	23,653
Total:					
1961	239,504	247,911	487,415	34,712	452,703
1960	262,479	282,123	544,602	34,993	509,609
Middle Atlantic:					
New Jersey	195,057	459,352	654,409	19,969	634,440
New York	1,649,416	1,155,277	2,804,693	52,168	2,752,525
Pennsylvania	8,813,510	4,414,739	13,228,249	782,260	12,445,989
Total:					
1961	10,657,983	6,029,368	16,687,351	854,397	15,832,954
1960	11,137,842	6,593,698	17,731,540	738,697	16,992,843
East North Central:					
Illinois	3,403,763	3,389,752	6,793,515	147,081	6,646,434
Indiana	4,840,021	2,568,199	7,408,220	169,873	7,238,347
Michigan	3,083,173	2,366,326	5,449,499	29,845	5,419,654
Ohio	6,746,892	4,031,291	10,778,183	276,703	10,501,480
Wisconsin	447,788	376,362	824,150	105,997	718,153
Total:					
1961	18,521,637	12,731,930	31,253,567	729,499	30,524,068
1960	19,294,739	13,269,268	32,564,007	887,749	31,676,258

See footnotes at end of table.

TABLE 2.—Ferrous scrap supply[1] available for consumption in 1961, 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	159,822	249,295	409,117	1,903	407,214
Kansas and Nebraska	47,927	107,308	155,235	5,497	149,738
Minnesota	204,328	238,679	443,007	8,254	434,753
Missouri	187,816	650,869	838,685	14,898	823,787
Total:					
1961	599,893	1,246,151	1,846,044	30,552	1,815,492
1960	618,917	1,168,402	1,787,319	17,183	1,770,136
South Atlantic:					
Delaware and Maryland	2,309,538	765,339	3,074,877	77,985	2,996,892
Florida and Georgia	79,061	232,040	311,101	1,157	309,944
North Carolina	25,324	42,057	67,381	5,523	61,863
South Carolina	15,381	17,788	33,169	58	33,111
Virginia and West Virginia	776,088	979,832	1,755,920	24,637	1,731,283
Total:					
1961	3,205,392	2,037,056	5,242,448	109,365	5,133,083
1960	3,317,301	1,962,542	5,279,843	129,722	5,150,121
East South Central:					
Alabama	1,426,263	1,227,769	2,654,032	152,454	2,501,578
Kentucky, Mississippi, and Tennessee	596,717	1,032,146	1,628,863	78,267	1,550,596
Total:					
1961	2,022,980	2,259,915	4,282,895	230,721	4,052,174
1960	1,904,414	2,166,273	4,070,687	259,499	3,811,188
West South Central:					
Arkansas, Louisiana, and Oklahoma	46,370	127,037	173,407	2,356	171,051
Texas	700,971	964,933	1,665,904	36,506	1,629,398
Total:					
1961	747,341	1,091,970	1,839,311	38,862	1,800,449
1960	679,619	1,066,938	1,746,557	57,911	1,688,646
Rocky Mountain:					
Arizona and Nevada	19,983	57,428	77,411	1,179	76,232
Colorado, Idaho, Montana, and Utah	1,051,998	426,782	1,478,780	[3] 4,683	1,483,463
Total:					
1961	1,071,981	484,210	1,556,191	[3] 3,504	1,559,695
1960	1,102,363	556,763	1,659,126	11,589	1,647,537
Pacific Coast:					
California	1,305,712	1,093,975	2,399,687	213,474	2,186,213
Oregon and Washington	102,639	330,453	433,092	9,861	423,231
Total:					
1961	1,408,351	1,424,428	2,832,779	223,335	2,609,444
1960	1,314,426	1,403,118	2,717,544	236,835	2,480,709
U.S. total:					
1961	38,475,062	27,552,939	66,028,001	2,247,939	63,780,062
1960	39,632,100	28,469,125	68,101,225	2,374,178	65,727,047

[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. 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 ferrous scrap and pig iron in the United States in 1961, by type of consumer and type of furnace or equipment

(Short tons)

Type of furnace or equipment	Type of consumer		
	Manufacturers of steel ingots and castings [1]		
	Scrap	Pig iron	Total
Open-hearth	37,414,064	54,532,794	91,946,858
Basic oxygen converter	1,370,998	3,551,921	4,922,919
Bessemer	97,477	975,114	1,072,592
Electric [2]	8,391,600	226,391	8,617,991
Total steelmaking furnaces	47,274,139	59,286,220	106,560,360
Cupola	748,437	321,389	1,069,825
Air	32,539	11,271	43,810
Blast [3]	3,550,901		3,550,901
Direct castings		1,773,696	1,773,696
Miscellaneous	166,230		166,230
Total:			
1961	51,772,246	61,392,576	113,164,822
1960	53,209,457	61,780,758	114,990,215
	Manufacturers of steel castings [4]		
Open-hearth	458,225	78,456	536,681
Bessemer	9,855	558	10,412
Electric	1,531,178	28,739	1,559,917
Total steelmaking furnaces	1,999,258	107,753	2,107,010
Cupola	337,149	19,193	356,343
Air	205,203	39,313	244,516
Miscellaneous	41		41
Total:			
1961	2,541,651	166,259	2,707,910
1960	2,725,700	223,130	2,948,830
	Iron foundries and miscellaneous users		
Bessemer	1,325	495	1,820
Electric [2]	180,152	23,586	203,738
Total steelmaking furnaces	181,477	24,081	205,558
Cupola	8,424,932	3,098,057	11,522,989
Air	747,397	127,130	874,527
Direct castings		989,195	989,195
Ferroalloy	245,118		245,118
Miscellaneous	413,877		413,877
Total:			
1961	10,012,801	4,238,463	14,251,264
1960	10,533,551	4,622,448	15,155,999
	Total		
Open-hearth	37,872,289	54,611,250	92,483,539
Basic oxygen converter	1,370,998	3,551,921	4,922,919
Bessemer	108,657	976,167	1,084,824
Electric [2]	10,102,930	278,716	10,381,646
Total steelmaking furnaces	49,454,874	59,418,054	108,872,928
Cupola	9,510,518	3,438,639	12,949,157
Air	985,139	177,714	1,162,853
Blast [3]	3,550,901		3,550,901
Direct castings		2,762,891	2,762,891
Ferroalloy	245,118		245,118
Miscellaneous	580,148		580,148
Total:			
1961	64,326,698	65,797,298	130,123,996
1960	66,468,708	66,626,336	133,095,044

[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.

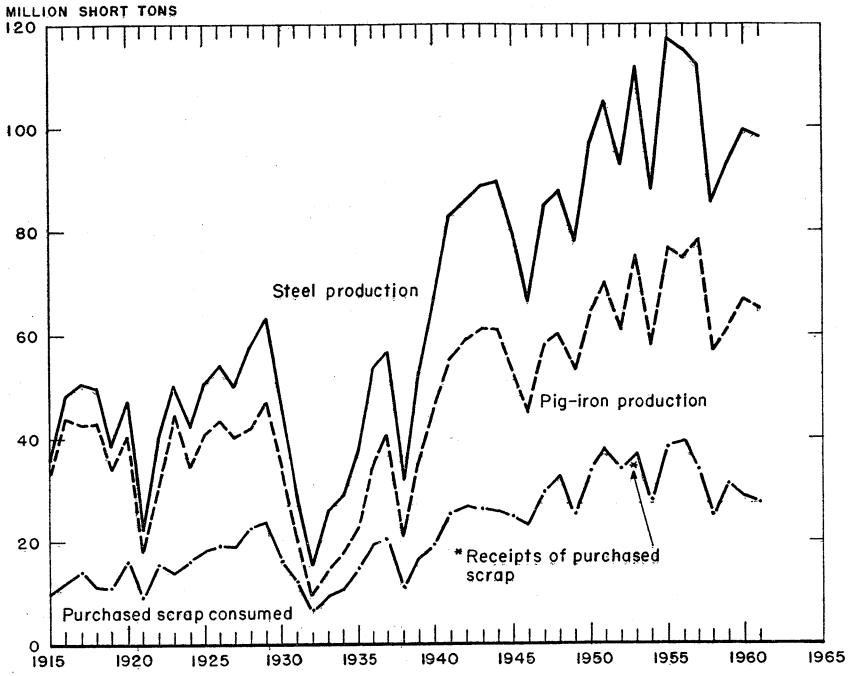


FIGURE 1.—Consumption of purchased scrap in the United States, 1915–52, and output of pig iron and steel, 1915–61. Figures on consumption of purchased scrap from 1915–32 are from *State of Minnesota v. Oliver Iron Mining Co., et al.*, Exhibits, vol. 5, 1935, p. 328; those for 1933–34 are estimated by authors; and those for 1935–52 are based on Bureau of Mines records. Data for 1953–61 represent receipts of purchased scrap by consumers, based on Bureau of Mines records. Data on steel output were supplied by the American Iron & Steel Inst.

TABLE 4.—Proportion of ferrous scrap and pig iron used in furnaces in the United States

(Percent)

Type of furnace	1960		1961	
	Scrap	Pig iron	Scrap	Pig iron
Open-hearth	41.7	58.3	41.0	59.0
Basic oxygen converter	28.1	71.9	27.8	72.2
Bessemer	10.1	89.9	10.0	90.0
Electric [1]	96.4	3.6	97.3	2.7
Cupola	72.4	27.6	73.4	26.6
Air	83.8	16.2	84.7	15.3

[1] Includes crucible furnaces.

CONSUMPTION BY DISTRICTS AND STATES

Use of domestic scrap for all purposes decreased in six of the nine geographical areas. The largest tonnage decrease was in the Middle Atlantic district, whereas the greatest percentage decrease occurred in the New England district. Of the three districts reporting an increase in the use of scrap, the Pacific Coast district was the greatest in both tonnage and percent. As in previous years the largest consuming districts for scrap were East North Central, Middle Atlantic, and South Atlantic. The States using the largest quantities of scrap, and the percentages consumed, were: Pennsylvania, 19 (20 in 1960); Ohio, 17 (17 in 1960); Indiana, 11 (11 in 1960); and Illinois, 11 (10 in 1960).

TABLE 5.—Consumption of ferrous scrap and pig iron in the United States in 1961, by districts and States

(Short tons)

District and State	Scrap	Pig iron	Total
New England:			
Connecticut	139,013	29,410	168,423
Maine and New Hampshire	17,016	4,136	21,152
Masschusetts	201,008	63,281	264,289
Rhode Island	84,451	36,958	121,409
Vermont	23,678	8,038	31,716
Total:			
1961	465,166	141,823	606,989
1960	514,718	167,723	682,441
Middle Atlantic:			
New Jersey	631,031	144,530	775,561
New York	2,689,970	3,219,625	5,909,595
Pennsylvania	12,482,727	15,315,543	27,798,270
Total:			
1961	15,803,728	18,679,698	34,483,426
1960	17,245,874	19,825,058	37,070,932
East North Central:			
Illinois	6,792,843	4,975,379	11,768,222
Indiana	7,355,776	9,075,150	16,430,926
Michigan	5,479,315	5,159,290	10,638,605
Ohio	10,664,979	10,937,800	21,602,779
Wisconsin	725,924	175,747	901,671
Total:			
1961	31,018,837	30,323,366	61,342,203
1960	31,718,342	30,862,709	62,581,051
West North Central:			
Iowa	407,179	69,451	476,630
Kansas and Nebraska	150,883	5,706	156,589
Minnesota	415,674	393,744	809,418
Missouri	869,002	24,246	893,248
Total:			
1961	1,842,738	493,147	2,335,885
1960	1,836,448	550,419	2,386,867
South Atlantic:			
Delaware and Maryland	3,037,345	4,418,830	7,456,175
Florida and Georgia	324,507	11,521	336,028
North Carolina	64,149	27,971	92,120
South Carolina	41,713	15,882	57,595
Virginia and West Virginia	1,733,381	2,143,204	3,876,585
Total:			
1961	5,201,095	6,617,408	11,818,503
1960	5,299,530	6,578,984	11,878,514

TABLE 5.—Consumption of ferrous scrap and pig iron in the United States in 1961, by districts and States—Continued

(Short tons)

District and State	Scrap	Pig iron	Total
East South Central:			
Alabama	2,440,348	3,222,653	5,663,001
Kentucky, Mississippi, and Tennessee	1,516,213,	907,614	2,423,827
Total:			
1961	3,956,561	4,130,267	8,086,828
1960	3,862,350	4,049,922	7,912,272
West South Central:			
Arkansas, Louisiana, and Oklahoma	172,722	7,749	180,471
Texas	1,558,249	856,118	2,414,367
Total:			
1961	1,730,971	863,867	2,594,838
1960	1,742,059	732,077	2,474,136
Rocky Mountain:			
Arizona and Nevada	77,015	88	77,103
Colorado, Idaho, Montana, and Utah	1,510,222	2,351,978	3,862,200
Total:			
1961	1,587,237	2,352,066	3,939,303
1960	1,669,376	2,202,847	3,872,223
Pacific Coast:			
California	2,249,944	2,191,936	4,441,880
Oregon and Washington	470,421	3,720	474,141
Total:			
1961	2,720,365	2,195,656	4,916,021
1960	2,580,011	1,656,597	4,236,608
U.S. total:			
1961	64,326,698	65,797,298	130,123,996
1960	66,468,708	66,626,336	133,095,044

TABLE 6.—Consumption of ferrous scrap and pig iron by districts and States, by type of manufacturers in 1961

(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	45,853	----------	5,170	217	87,990	29,193
Maine and New Hampshire	----------	----------	2,679	86	14,337	4,050
Massachusetts	----------	----------	12,490	326	188,518	62,955
Rhode Island	43,965	20,625	----------	----------	40,486	16,333
Vermont	----------	----------	----------	----------	23,678	8,038
Total:						
1961	89,818	20,625	20,339	629	355,009	120,569
1960	95,520	25,849	25,870	1,736	393,328	140,138
Middle Atlantic:						
New Jersey	177,267	23,751	55,324	2,402	398,440	118,377
New York	2,064,470	3,076,363	103,112	7,390	522,388	135,872
Pennsylvania	11,507,445	14,625,012	344,304	57,005	630,978	633,526
Total:						
1961	13,749,182	17,725,126	502,740	66,797	1,551,806	887,775
1960	15,045,534	18,783,978	593,010	92,965	1,607,330	948,115

See footnotes at end of table.

TABLE 6.—Consumption of ferrous scrap and pig iron by districts and States, by type of manufacturers in 1961—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
East North Central:						
Illinois	5,651,908	4,529,815	264,034	13,914	876,901	431,650
Indiana	6,685,891	8,863,353	130,385	12,788	539,500	199,009
Michigan	3,436,998	4,585,997	150,909	1,902	1,891,408	571,391
Ohio	9,162,179	10,362,457	366,946	38,781	1,135,854	536,562
Wisconsin	----------	----------	220,051	7,813	505,873	167,934
Total:						
1961	24,936,976	28,341,622	1,132,325	75,198	4,949,536	1,906,546
1960	25,075,116	28,587,692	1,238,366	101,957	5,404,860	2,173,060
West North Central:						
Iowa	----------	----------	35,629	513	371,550	68,938
Kansas and Nebraska	----------	----------	105,916	386	44,967	5,320
Minnesota	268,707	350,148	28,566	83	118,401	43,513
Missouri	689,703	1,008	60,012	3,725	119,287	19,513
Total:						
1961	958,410	351,156	230,123	4,707	654,205	137,284
1960	961,816	390,822	241,232	8,705	633,400	150,892
South Atlantic:						
Delaware and Maryland	2,931,886	4,407,211	25,683	368	79,776	11,251
Florida and Georgia	276,788	----------	10,239	85	37,480	11,436
North Carolina	----------	----------	----------	----------	64,149	27,971
South Carolina	----------	----------	----------	----------	41,713	15,882
Virginia and West Virginia	1,421,092	2,033,802	75,445	8,201	236,844	101,201
Total:						
1961	4,629,766	6,441,013	111,367	8,654	459,962	167,741
1960	4,709,457	6,391,249	110,262	8,805	479,811	178,930
East South Central:						
Alabama	1,652,849	2,509,021	67,860	201	719,639	713,431
Kentucky, Mississippi, and Tennessee	1,057,254	756,118	25,942	1,306	433,017	150,190
Total:						
1961	2,710,103	3,265,139	93,802	1,507	1,152,656	863,621
1960	2,629,053	3,199,593	105,793	2,097	1,127,504	848,232
West South Central:						
Arkansas, Louisiana, and Oklahoma	78,715	413	48,554	1,099	45,453	6,237
Texas	1,187,479	804,618	85,259	545	285,511	50,955
Total:						
1961	1,266,194	805,031	133,813	1,644	330,964	57,192
1960	1,292,603	687,931	131,059	1,313	318,397	42,833
Rocky Mountain:						
Arizona and Nevada	----------	----------	57,316	88	19,699	----------
Colorado, Idaho, Montana, and Utah	1,300,536	2,340,954	29,232	807	180,454	10,217
Total:						
1961	1,300,536	2,340,954	86,548	895	200,153	10,217
1960	1,404,313	2,173,410	77,089	825	187,974	28,612
Pacific Coast:						
California	1,768,495	2,101,409	161,834	4,922	319,615	85,605
Oregon and Washington	362,766	501	68,760	1,306	38,895	1,913
Total:						
1961	2,131,261	2,101,910	230,594	6,228	358,510	87,518
1960	1,996,045	1,540,234	203,019	4,727	380,947	111,636
U.S. total:						
1961	51,772,246	61,392,576	2,541,651	166,259	10,012,801	4,238,463
1960	53,209,457	61,780,758	2,725,700	223,130	10,533,551	4,622,448

[1] Includes only those castings made by companies producing steel ingots.
[2] Excludes companies that produce both steel ingots and steel castings.

TABLE 7.—Consumption of ferrous scrap and pig iron in open-hearth furnaces in the United States in 1961, by districts and States

(Short tons)

District and State	Scrap	Pig iron	Total
New England and Middle Atlantic:			
New Jersey and Rhode Island	219,883	44,375	264,258
New York	1,743,125	3,078,559	4,821,684
Pennsylvania	8,389,638	12,879,206	21,268,844
Total:			
1961	10,352,646	16,002,140	26,354,786
1960	11,985,451	17,080,793	29,066,244
East North Central:			
Illinois	3,534,476	3,758,472	7,292,948
Indiana	6,550,860	8,845,343	15,396,203
Michigan and Wisconsin	2,262,481	3,267,554	5,530,035
Ohio	6,298,571	9,237,630	15,536,201
Total:			
1961	18,646,388	25,108,999	43,755,387
1960	18,459,025	25,171,861	43,630,886
West North Central:			
Minnesota and Missouri	521,776	354,025	875,801
Total:			
1961	521,776	354,025	875,801
1960	586,580	397,608	984,188
South Atlantic:			
Delaware, Maryland, and West Virginia	3,968,781	6,443,592	10,412,373
Total:			
1961	3,968,781	6,443,592	10,412,373
1960	4,003,151	6,378,567	10,381,718
East and West South Central:			
Alabama, Kentucky, Tennessee, and Texas	2,113,735	3,677,717	5,791,452
Total:			
1961	2,113,735	3,677,717	5,791,452
1960	2,269,309	3,510,887	5,780,196
Rocky Mountain and Pacific Coast:			
California, Colorado, and Utah	2,268,963	3,024,777	5,293,740
Total:			
1961	2,268,963	3,024,777	5,293,740
1960	2,309,530	2,730,688	5,040,218
U.S. total:			
1961	37,872,289	54,611,250	92,483,539
1960	39,613,046	55,270,404	94,883,450

TABLE 8.—Consumption of ferrous scrap and pig iron in Bessemer converters in the United States in 1961, by districts and States

(Short tons)

District and State	Scrap	Pig iron	Total
New England and Middle Atlantic:			
Connecticut and Pennsylvania	52,194	318,562	370,756
Total:			
1961	52,194	318,562	370,756
1960	59,584	330,836	390,420
East North Central:			
Illinois and Ohio	52,058	657,538	709,596
Total:			
1961	52,058	657,538	709,596
1960	81,509	971,580	1,053,089
South Atlantic and West South Central:			
Delaware and Louisiana	4,059	27	4,086
Total:			
1961	4,059	27	4,086
1960	5,521	86	5,607
Rocky Mountain and Pacific Coast:			
Colorado and Washington	346	40	386
Total:			
1961	346	40	386
1960	369	29	398
U.S. total:			
1961	108,657	976,167	1,084,824
1960	146,983	1,302,531	1,449,514

TABLE 9.—Consumption of ferrous scrap and pig iron in electric[1] steel furnaces in the United States in 1961, by districts and States

(Short tons)

District and State	Scrap	Pig iron	Total
New England:			
Connecticut and New Hampshire	57,958	954	58,912
Massachusetts	18,773	810	19,583
Total:			
1961	76,731	1,764	78,495
1960	74,677	1,962	76,639
Middle Atlantic:			
New Jersey	29,137	2,065	31,202
New York	174,178	3,439	177,617
Pennsylvania	1,933,812	31,945	1,965,757
Total:			
1961	2,137,127	37,449	2,174,576
1960	1,909,143	30,465	1,939,608
East North Central:			
Illinois	1,516,544	87,745	1,604,289
Indiana	96,800	2,311	99,111
Michigan	472,927	5,027	477,954
Ohio	1,745,116	24,298	1,769,414
Wisconsin	147,547	4,488	152,035
Total:			
1961	3,978,934	123,869	4,102,803
1960	4,339,015	212,226	4,551,241
West North Central:			
Iowa, Kansas, and Nebraska	143,815	1,013	144,828
Minnesota	16,360	83	16,443
Missouri	494,022	446	494,468
Total:			
1961	654,197	1,542	655,739
1960	579,087	1,761	580,848
South Atlantic:			
Delaware and Maryland	104,419	1,524	105,943
Florida, Georgia, and North Carolina	287,188	263	287,451
Virginia and West Virginia	155,743	149	155,892
Total:			
1961	547,350	1,936	549,286
1960	531,016	1,454	532,470
East South Central:			
Alabama	552,290	68,831	621,121
Kentucky, Mississippi, and Tennessee	476,281	7,803	484,084
Total:			
1961	1,028,571	76,634	1,105,205
1960	921,113	116,548	1,037,661
West South Central:			
Arkansas, Louisiana, and Oklahoma	122,978	1,741	124,719
Texas	499,941	23,748	523,689
Total:			
1961	622,919	25,489	648,408
1960	559,158	3,927	563,085
Rocky Mountain:			
Arizona, Colorado, Nevada, and Utah	76,340	428	76,768
Total:			
1961	76,340	428	76,768
1960	66,691	399	67,090
Pacific Coast:			
California	552,270	8,183	560,453
Oregon and Washington	428,491	1,422	429,913
Total:			
1961	980,761	9,605	990,366
1960	940,464	3,331	943,795
U.S. total:			
1961	10,102,930	278,716	10,381,646
1960	9,920,364	372,073	10,292,437

[1] Includes small quantities of scrap and pig iron consumed in crucible furnaces.

TABLE 10.—Consumption of ferrous scrap and pig iron in cupola furnaces in the United States in 1961, by districts and States

(Short tons)

District and State	Scrap	Pig iron	Total
New England:			
Connecticut	50,839	21,513	72,352
Maine and New Hampshire	10,708	1,967	12,675
Massachusetts	165,502	60,002	225,504
Rhode Island	32,527	15,222	47,749
Vermont	23,678	8,038	31,716
Total:			
1961	283,254	106,742	389,996
1960	314,805	127,642	442,447
Middle Atlantic:			
New Jersey	358,037	118,058	476,095
New York	411,648	128,136	539,784
Pennsylvania	485,471	183,767	669,238
Total:			
1961	1,255,156	429,961	1,685,117
1960	1,312,762	475,235	1,787,997
East North Central:			
Illinois	743,382	165,300	908,682
Indiana	478,826	194,186	673,012
Michigan	2,205,891	658,480	2,864,371
Ohio	1,163,079	336,688	1,499,767
Wisconsin	444,995	144,123	589,118
Total:			
1961	5,036,173	1,498,777	6,534,950
1960	5,505,137	1,789,702	7,294,839
West North Central:			
Iowa	262,508	65,680	328,188
Kansas and Nebraska	44,967	5,320	50,287
Minnesota	125,589	41,011	166,600
Missouri	73,363	17,780	91,143
Total:			
1961	506,427	129,791	636,218
1960	507,031	143,186	650,217
South Atlantic:			
Maryland	93,826	10,890	104,716
Florida	7,076	2,284	9,360
Georgia	29,291	9,153	38,444
North Carolina	63,934	27,792	91,726
South Carolina	33,962	15,881	49,843
Virginia	233,246	42,588	275,834
West Virginia	11,284,	57,052	68,336
Total:			
1961	472,619	165,640	638,259
1960	491,907	190,584	682,491
East South Central:			
Alabama	667,508	716,627	1,384,135
Kentucky	153,238	31,573	184,811
Tennessee	255,814	119,388	375,202
Total:			
1961	1,076,560	867,588	1,944,148
1960	1,040,587	851,539	1,892,126
West South Central:			
Arkansas, Louisiana, and Oklahoma	45,980	6,009	51,989
Texas	291,509	100,791	392,300
Total:			
1961	337,489	106,800	444,289
1960	339,233	78,123	417,356
Rocky Mountian:			
Colorado, Idaho, Montana, and Utah	186,683	44,616	231,299
Total:			
1961	186,683	44,616	231,299
1960	162,584	53,671	216,255
Pacific Coast:			
California	322,748	86,441	409,189
Oregon and Washington	33,409	2,283	35,692
Total:			
1961	356,157	88,724	444,881
1960	370,984	112,345	483,329
U.S. total:			
1961	9,510,518	3,438,639	12,949,157
1960	10,045,030	3,822,027	13,867,057

TABLE 11.—Consumption of ferrous scrap and pig iron in air furnaces in the United States in 1961, by districts and States

(Short tons)

District and State	Scrap	Pig iron	Total
New England:			
Connecticut	32,067	6,936	39,003
Massachusetts, New Hampshire, and Rhode Island	17,995	5,664	23,659
Total:			
1961	50,062	12,600	62,662
1960	55,468	12,174	67,642
Middle Atlantic:			
New Jersey and New York	24,677	9,755	34,432
Pennsylvania	122,181	42,364	164,545
Total:			
1961	146,858	52,119	198,977
1960	179,705	57,351	237,056
East North Central:			
Illinois	145,028	11,309	156,337
Indiana	69,736	13,938	83,674
Michigan	107,048	2,265	109,313
Ohio	308,853	47,657	356,510
Wisconsin	83,212	21,580	104,792
Total:			
1961	713,877	96,749	810,626
1960	775,931	122,017	897,948
West North Central:			
Iowa, Minnesota, and Missouri	11,290	7,533	18,823
Total:			
1961	11,290	7,533	18,823
1960	10,810	7,666	18,476
South Atlantic:			
Delaware, North Carolina, and West Virginia	9,991	6,213	16,204
Total:			
1961	9,991	6,213	16,204
1960	14,356	8,294	22,650
East and West South Central:			
Alabama and Texas	43,447	1,576	45,023
Total:			
1961	43,447	1,576	45,023
1960	40,638	1,905	42,543
Pacific Coast:			
California	9,614	924	10,538
Total:			
1961	9,614	924	10,538
1960	9,026	754	9,780
U.S. total:			
1961	985,139	177,714	1,162,853
1960	1,085,934	210,161	1,296,095

TABLE 12.—Consumption of ferrous scrap in blast furnaces in the United States in 1961, 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	235,587	Alabama	213,528
Pennsylvania	1,121,991	Kentucky, Maryland, Tennessee, Texas and West Virginia	336,728
Total:		Total:	
1961	1,357,578	1961	550,256
1960	1,317,240	1960	536,441
East and West North Central:		Rocky Mountain:	
Illinois	384,219	Colorado and Utah	81,845
Indiana	153,144	Total:	
Michigan and Minnesota	144,733	1961	81,845
Ohio	879,126	1960	88,743
Total:		U.S. total:	
1961	1,561,222	1961	3,550,901
1960	1,651,403	1960	3,593,827

TABLE 13.—Consumption of ferrous scrap by ferroalloy producers in the United States in 1961, by districts

(Short tons)

Districts	Scrap	District	Scrap
Middle Atlantic:		East South Central:	
1961	20,751	1961	52,407
1960	35,348	1960	65,922
East North Central:		Pacific Coast:	
1961	41,627	1961	8,023
1960	52,464	1960	7,408
West North Central:		U.S. total:	
1961	103,596	1961	245,118
1960	107,287	1960	283,777
South Atlantic:			
1961	18,714		
1960	15,348		

TABLE 14.—Consumption of ferrous scrap in miscellaneous uses in the United States in 1961, by districts and States

(Short tons)

District and State	Scrap	District and State	Scrap
New England and Middle Atlantic:		East South Central and West South Central:	
Massachusetts and New York	91,698	Alabama and Texas	39,197
New Jersey	66,826	Total:	
Pennsylvania	83,206	1961	39,197
Total:		1960	61,751
1961	241,730	Rocky Mountain:	
1960	235,585	Arizona, Colorado, Montana, and Utah	30,131
East North Central:		Total:	
Illinois and Indiana	97,667	1961	30,131
Michigan and Wisconsin	3,302	1960	42,571
Ohio	82,197	Pacific Coast:	
Total:		California and Washington	42,030
1961	183,166	Total:	
1960	192,871	1961	42,030
West North Central:		1960	48,500
Minnesota and Missouri	41,362	U.S. total:	
Total:		1961	580,148
1961	41,362	1960	629,713
1960	39,946		
South Atlantic:			
Georgia, Virginia, and West Virginia	2,532		
Total:			
1961	2,532		
1960	8,489		

TABLE 15.—Consumption of ferrous scrap by type of manufacturers, by grades, in 1961

(Short tons)

Grades	Steel ingots and castings	Steel castings	Iron foundries and miscellaneous users
No. 1 heavy-melting steel	19,944,235	258,048	314,774
No. 2 heavy-melting steel	4,318,201	18,282	174,316
No. 1 and electric furnace bundles	5,463,626	46,629	140,982
No. 2 and all other bundles	3,455,269	35,641	77,963
Low phosphorus scrap	1,859,679	1,136,956	888,453
Cast iron scrap, other than borings	3,394,173	211,516	5,814,847
Turnings and/or borings, alloy free	1,973,353	29,352	641,891
Rerolling rails	109,564		262,045
Scrap rails	20,296	15,900	245,562
High speed steel	26,204		712
Stainless steel	619,592	25,890	17,967
All other alloy iron and steel	1,952,912	127,709	97,563
All other prepared scrap	7,231,928	425,212	823,759
Unprepared scrap	1,403,214	210,516	511,967
Total	51,772,246	2,541,651	10,012,801

TABLE 16.—Consumption of ferrous scrap, by grades, by districts and States, in 1961

(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	2,634	----------	1,616	465	33,158	33,495	67,645
Maine and New Hampshire	2,961	----------	----------	----------	266	10,496	3,293
Massachusetts	5,595	1,115	----------	----------	12,964	149,216	32,118
Rhode Island	3,604	22,959	2,864	----------	10,155	18,112	26,757
Vermont	4,339	476	----------	----------	----------	18,863	----------
Total:							
1961	19,133	24,550	4,480	465	56,543	230,182	129,813
1960	23,573	34,119	4,607	395	57,793	252,174	142,057
Middle Atlantic:							
New Jersey	12,845	19,396	55,424	22,250	43,667	329,220	148,229
New York	819,791	27,878	161,516	217,806	110,408	351,409	1,001,162
Pennsylvania	4,837,996	563,203	882,053	386,651	729,353	1,294,190	3,789,281
Total:							
1961	5,670,632	610,477	1,098,993	626,707	883,428	1,974,819	4,938,672
1960	6,485,147	701,675	1,286,593	864,710	873,469	2,020,203	5,014,077
East North Central:							
Illinois	1,666,878	945,503	619,114	683,267	589,905	765,752	1,522,424
Indiana	3,693,657	108,752	1,072,165	371,320	165,252	603,751	1,310,879
Michigan	792,452	2,250	859,657	326,668	389,134	1,318,558	1,790,596
Ohio	3,157,866	359,379	1,100,085	437,187	972,492	1,253,545	3,384,425
Wisconsin	55,655	15,926	852	10,077	194,142	260,439	188,833
Total:							
1961	9,366,508	1,431,810	3,651,873	1,828,519	2,310,925	4,202,045	8,227,157
1960	9,612,557	1,570,648	3,404,691	1,792,461	2,189,411	4,416,898	8,731,676
West North Central:							
Iowa	31,686	8,831	----------	3,133	49,338	168,550	145,641
Kansas and Nebraska	2,142	----------	----------	----------	58,284	41,558	48,899
Minnesota	99,704	40,096	3,358	39,969	13,548	120,861	98,138
Missouri	14,875	611,085	----------	11,455	19,933	134,099	77,555
Total:							
1961	148,407	660,012	3,358	54,557	141,103	465,068	370,233
1960	180,529	624,080	4,270	47,285	120,139	481,849	378,296
South Atlantic:							
Delaware and Maryland	1,503,825	92,779	216,532	120,311	33,499	322,097	748,302
Florida and Georgia	80,714	141,202	81	3,400	1,686	31,392	66,032
North Carolina	----------	----------	----------	----------	1,055	60,080	3,014
South Carolina	----------	----------	----------	----------	----------	26,834	14,879
Virginia and West Virginia	174,468	64,331	196,536	310,739	80,924	222,570	683,813
Total:							
1961	1,759,007	298,312	413,149	434,450	117,164	662,973	1,516,040
1960	1,755,470	337,058	323,136	581,662	116,660	609,834	1,575,710
East South Central:							
Alabama	717,716	143,776	126,123	249,030	96,450	624,653	482,600
Kentucky, Mississippi, and Tennessee	591,591	138,500	139,392	129,697	59,933	292,130	164,970
Total:							
1961	1,309,307	282,276	265,515	378,727	156,383	916,783	647,570
1960	1,333,780	275,763	234,254	370,522	154,915	911,836	581,280
West South Central:							
Arkansas, Louisiana, and Oklahoma	----------	64,399	----------	16,643	44,403	35,798	11,479
Texas	103,826	858,434	52,410	2,634	75,940	317,575	147,430
Total:							
1961	103,826	922,833	52,410	19,277	120,343	353,373	158,909
1960	62,939	916,500	15,672	79,831	105,604	373,728	187,785

TABLE 16.—Consumption of ferrous scrap, by grades, by districts and States, in 1961—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	7,141	----------	----------	----------	----------	2,281	67,593
Colorado, Idaho, Montana, and Utah	843,911	58,512	20,683	45,159	3,125	205,874	332,958
Total:							
1961	851,052	58,512	20,683	45,159	3,125	208,155	400,551
1960	898,163	71,903	29,189	69,737	3,875	196,378	400,131
Pacific Coast:							
California	1,077,199	128,996	127,111	146,761	77,379	375,196	317,302
Oregon and Washington	211,986	93,021	13,665	34,251	18,695	31,942	66,861
Total:							
1961	1,289,185	222,017	140,776	181,012	96,074	407,138	384,163
1960	1,138,337	246,174	159,444	177,390	80,057	417,351	361,258
U.S. total:							
1961	20,517,057	4,510,799	5,651,237	3,568,873	3,885,088	9,420,536	16,773,108
1960	21,490,495	4,777,920	5,461,856	3,983,993	3,701,923	9,680,251	17,372,270

TABLE 17.—Ferrous scrap production, receipts, consumption, consumer stocks, imports and exports, 1935–61

(Short tons)

	Home scrap produced	Purchased scrap received from dealer and all others	Consumption	Stocks Dec. 31	Imports [1]	Exports [2]
1935	[3]	[3]	29,585,170	[3]	[3]	2,358,434
1936			40,721,109	[3]	[3]	2,163,468
1937			42,567,025	[3]	103,134	4,598,735
1938			23,906,326	5,147,625	41,851	3,353,422
1939			36,326,536	5,310,098	47,180	4,014,572
1940			44,529,671	5,471,554	20,808	3,159,283
1941			59,216,256	3,726,030	97,087	904,249
1942			60,265,151	6,316,138	125,849	141,736
1943			61,650,956	5,872,251	165,314	54,894
1944			61,349,201	4,418,719	131,376	95,682
1945			56,191,085	3,924,203	66,511	82,053
1946			49,484,111	3,397,421	57,701	141,597
1947			60,864,361	4,430,940	70,681	170,327
1948			64,963,875	6,458,136	480,724	212,194
1949			54,338,223	5,640,859	1,151,294	298,594
1950			68,901,275	5,420,326	785,230	216,964
1951			76,728,099	4,366,057	416,853	245,340
1952			69,023,124	6,902,314	153,674	352,710
1953			77,130,502	7,148,766	173,660	316,542
1954			61,354,449	7,348,896	239,035	1,695,861
1955	45,501,181	38,591,954	81,375,099	7,210,329	228,539	5,171,774
1956	43,675,614	39,424,571	80,315,170	7,416,055	255,569	6,446,463
1957	43,996,309	33,861,684	73,548,823	8,949,386	238,610	6,765,992
1958	33,713,535	25,109,513	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	66,463,708	9,287,881	179,401	8,039,668
1961	38,475,062	27,552,939	64,326,698	8,741,245	268,389	9,715,755

[1] Includes tinplate scrap.
[2] Includes all types from 1935–57; excludes circles, cobbles, strip, and scroll shear butts from tinplated scrap after 1957.
[3] Data not available.

STOCKS

Consumer Stocks.—Total ferrous-scrap stocks held by consumers decreased during the first 5 months of 1961, reaching a low for the year of 8,293,000 short tons on May 31. Beginning in June these stocks increased continuously to a high of 9,108,000 short tons on November 30. In December they decreased and by the end of the month were 6 percent less than at the beginning of the year. At yearend they were equivalent to a 50-day supply at an average daily scrap-consumption rate of 176,000 short tons. Decreases occurred in seven of the nine geographical districts; the largest decrease—494,000 tons—was in the East North Central district. Stocks of pig iron held by consumers and suppliers on December 31 were 16 percent less than those on hand December 31, 1960.

Supplier Stocks.—The Bureau of Mines discontinued canvassing dealers, brokers, and automobile wreckers on June 30. Therefore, figures for yearend stocks held by this segment of the industry were not available.

TABLE 18.—Consumer stocks of ferrous scrap and pig iron Dec. 31, in the United States by districts and States

(Short tons)

District and State	1960		1961	
	Scrap	Pig iron	Scrap	Pig iron
New England:				
Connecticut	11,812	4,639	12,822	4,002
Maine and New Hampshire	1,432	456	1,742	387
Massachusetts	40,749	12,805	27,286	9,430
Rhode Island	9,895	6,673	8,805	6,676
Vermont	855	610	1,419	578
Total	64,743	25,183	52,074	21,073
Middle Atlantic:				
New Jersey	78,399	29,598	80,829	36,406
New York	564,589	509,681	622,878	431,394
Pennsylvania	[1] 1,935,904	801,657	1,845,868	736,936
Total	2,578,892	1,340,936	2,549,575	1,204,736
East North Central:				
Illinois	1,161,191	317,944	1,006,971	242,107
Indiana	940,510	128,604	832,401	127,353
Michigan	498,125	299,374	424,059	242,207
Ohio	1,467,753	620,145	1,304,833	536,692
Wisconsin	52,896	17,006	57,991	17,138
Total	4,120,475	1,383,073	3,626,255	1,165,497
West North Central:				
Iowa	25,358	36,681	28,196	31,882
Kansas and Nebraska	17,558	843	16,032	555
Minnesota	95,302	83,149	122,407	62,561
Missouri	238,587	14,289	194,021	14,414
Total	376,805	134,962	360,656	109,412
South Atlantic:				
Delaware and Maryland	239,923	118,131	202,256	58,390
Florida and Georgia	22,923	2,010	17,592	1,852
North Carolina	4,298	1,588	2,001	810
South Carolina	7,589	3,145	5,348	2,936
Virginia and West Virginia	146,414	46,608	143,053	44,466
Total	421,147	171,482	370,250	108,454

[1] Revised figure.

TABLE 18.—Consumer stocks of ferrous scrap and pig iron Dec. 31, in the United States by districts and States—Continued

(Short tons)

District and State	1960		1961	
	Scrap	Pig iron	Scrap	Pig iron
East South Central:				
Alabama	311,324	350,776	375,470	279,403
Kentucky, Mississippi, and Tennessee	188,700	93,048	222,005	90,486
Total	500,024	443,824	597,475	369,889
West South Central:				
Arkansas, Louisiana, and Oklahoma	31,704	1,648	25,301	1,855
Texas	286,259	78,254	368,075	53,351
Total	317,963	79,902	393,376	55,206
Rocky Mountain:				
Arizona and Nevada	14,538	92	14,033	119
Colorado, Idaho, Montana, and Utah	287,488	124,317	262,657	97,701
Total	302,026	124,409	276,690	97,820
Pacific Coast:				
California	474,648	64,611	412,178	49,124
Oregon and Washington	131,158	2,049	102,716	1,904
Total	605,806	66,660	514,894	51,028
U.S. total	[1]9,287,881	3,770,431	8,741,245	3,183,115

[1]Revised figure.

TABLE 19.—Consumer stocks of ferrous scrap, by grades, by districts and States, Dec. 31, 1961

(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 phosphorous scrap	Cast iron scrap, other than borings	All others
New England:							
Connecticut	35	----------	147	23	2,352	2,985	7,280
Maine and New Hampshire	179	----------	----------	----------	41	1,234	288
Massachusetts	315	352	----------	----------	1,128	10,242	15,249
Rhode Island	1,199	3,396	33	----------	184	1,717	2,276
Vermont	192	15	----------	----------	----------	1,212	----------
Total:							
1961	1,920	3,763	180	23	3,705	17,390	25,093
1960	5,606	4,377	336	22	8,468	18,446	27,488
Middle Atlantic:							
New Jersey	3,764	2,343	14,123	1,220	11,220	32,634	15,525
New York	333,406	3,691	75,766	31,357	14,574	35,105	128,979
Pennsylvania	611,628	98,281	187,620	88,556	156,313	144,658	558,812
Total:							
1961	948,798	104,315	277,509	121,133	182,107	212,397	703,316
1960 [1]	844,063	116,347	301,488	162,440	156,872	278,183	719,499

[1] Revised figures.

TABLE 19.—Consumer stocks of ferrous scrap, by grades, by districts and States, Dec. 31, 1961—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 phosphorous scrap	Cast iron scrap, other than borings	All others
East North Central:							
Illinois	219,578	81,586	115,160	182,814	93,774	95,422	218,637
Indiana	335,776	22,264	50,019	56,890	16,488	147,202	203,762
Michigan	80,807	92	129,582	12,352	52,000	47,053	102,173
Ohio	351,426	30,659	171,046	70,671	101,500	157,204	422,327
Wisconsin	3,098	525	56	71	27,899	13,047	13,295
Total:							
1961	990,685	135,126	465,863	322,798	291,661	459,928	960,194
1960	1,158,304	155,729	694,877	337,805	468,512	378,011	927,237
West North Central:							
Iowa	2,758	385	----------	----------	3,109	11,325	10,619
Kansas and Nebraska	75	----------	----------	----------	4,206	7,934	3,817
Minnesota	17,326	24,983	----------	23,421	1,448	11,870	43,359
Missouri	3,249	100,072	----------	576	1,671	47,094	41,359
Total:							
1961	23,408	125,440	----------	23,997	10,434	78,223	99,154
1960	16,738	116,353	22	11,787	10,264	117,697	103,944
South Atlantic:							
Delaware and Maryland	103,246	4,064	6,872	3,461	5,174	39,428	40,011
Florida and Georgia	10,977	826	745	753	52	1,543	2,696
North Carolina	----------	----------	----------	----------	218	1,679	104
South Carolina	----------	----------	----------	----------	----------	926	4,422
Virginia and West Virginia	2,435	23,492	280	50,576	8,605	16,737	40,928
Total:							
1961	116,658	28,382	7,897	54,790	14,049	60,313	88,161
1960	120,486	21,043	6,635	63,467	15,418	128,527	65,571
East South Central:							
Alabama	195,758	22,255	14,263	16,197	16,714	53,066	57,217
Kentucky, Mississippi, and Tennessee	80,871	25,924	34,732	32,863	1,042	17,128	29,445
Total:							
1961	276,629	48,179	48,995	49,060	17,756	70,194	86,662
1960	178,771	33,080	35,029	54,849	21,682	83,460	93,153
West South Central:							
Arkansas, Louisiana, and Oklahoma	----------	13,484	----------	11	4,190	5,801	1,815
Texas	18,891	242,480	36,714	218	8,482	24,111	37,179
Total:							
1961	18,891	255,964	36,714	229	12,672	29,912	38,994
1960	4,365	183,606	29,304	230	10,009	30,512	59,937
Rocky Mountain:							
Arizona and Nevada	580	----------	----------	----------	----------	281	13,172
Colorado, Idaho, Montana, and Utah	84,358	31,766	14,732	35,600	942	63,702	31,557
Total:							
1961	84,938	31,766	14,732	35,600	942	63,983	44,729
1960	61,201	65,820	33,253	64,266	734	46,272	30,480
Pacific Coast:							
California	172,699	47,198	41,852	34,426	3,922	47,471	64,610
Oregon and Washington	40,778	30,368	1,903	3,896	2,414	5,301	18,056
Total:							
1961	213,477	77,566	43,755	38,322	6,336	52,772	82,666
1960	257,294	81,425	67,587	35,125	10,381	49,855	104,139
U.S. total:							
1961	2,675,404	810,501	895,645	645,952	539,662	1,045,112	2,128,969
1960 [1]	2,646,828	777,780	1,168,531	729,991	702,340	1,130,963	2,131,448

[1] Revised figures.

TABLE 20.—Consumer stocks, production, receipts, consumption, and shipments of ferrous scrap, by grades, in 1961

(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	2,646,828	15,382,658	4,703,243	20,517,057		2,675,404
No. 2 heavy-melting steel	777,780	1,655,588	2,962,916	4,510,799		810,501
No. 1 and electric furnace bundles	1,168,531	1,046,777	4,275,242	5,651,237	254,952	895,645
No. 2 and all other bundles	729,991	545,658	3,129,654	3,568,873		645,952
Low phosphorus scrap	702,340	1,228,405	2,596,012	3,885,088		539,662
Cast iron scrap, other than borings	1,130,963	5,863,236	3,874,996	9,420,536		1,045,112
Turnings and/or borings, alloy free	258,226	550,185	2,319,168	2,644,596	218,692	264,291
Rerolling rails	125,335	2,522	398,368	371,609	11,462	143,154
Scrap rails	53,231	22,930	269,884	281,758	11,296	52,991
High speed steel	5,904	16,442	8,807	26,916	460	3,777
Stainless steel	159,478	459,157	207,702	663,449	27,568	135,320
All other alloy iron and steel	355,426	1,863,925	370,407	2,178,184	84,833	326,741
All other prepared scrap	687,253	5,960,652	1,981,189	8,480,899	1,638,676	722,823
Unprepared scrap	486,595	3,876,927	455,351	2,125,697		479,872
Total: All grades	9,287,881	38,475,062	27,552,939	64,326,698	2,247,939	8,741,245

[1] Revised figures.

TABLE 21.—Stocks of ferrous scrap and pig iron at major consuming industries plants, Dec. 31

(Short tons)

Year	Manufacturers of steel ingots and castings	Manufacturers of steel castings	Iron foundries and miscellaneous users	Total
	Scrap stocks			
1961	7,529,861	383,792	827,592	8,741,245
1960	[1] 7,910,572	450,187	927,122	[1] 9,287,881
	Pig iron stocks			
1961	2,715,271	33,584	434,260	3,183,115
1960	3,233,513	37,691	499,227	3,770,431

[1] Revised figures.

PRICES [2]

In January the price of No. 1 Heavy-Melting scrap at Pittsburgh was lowest for the year at $29.75 per long ton, $14.00 less than in January 1960. Prices for this grade of scrap fluctuated during the remainder of the year and reached a high of $37.50 in September—$6.25 below the highest price during the previous year. In December this grade of scrap was quoted at $35.50 per long ton, 19 percent higher than in January.

No. 1 Heavy-Melting scrap at Chicago averaged $35.52 per long ton for the year—$4.74 higher than the average for the previous year. The highest price was $40.25 in September, and the lowest price was $29.50 in January.

The average composite price of No. 1 Heavy-Melting iron and steel scrap was $36.21 for the year, $3.26 higher than the 1960 average. The composite price ranged between a low of $31.50 per long ton in January and a high of $39.42 in September. The quoted average price for this grade of scrap was $34.33 in December, 9 percent greater than at the beginning of the year.

The composite price for No. 2 Bundles averaged $24.69 per long ton for the year. The highest price was $27.42 in March, and the lowest price was $22.08 in January.

The average value of exports (see table 1), including all grades of scrap, from the United States during 1961 was $40.82 per long ton, $7.17 higher than the 1960 average.

TABLE 22.—Average monthly price and composite price for No. 1 heavy melting scrap in 1961

(Per long ton)

Month	Chicago	Pittsburgh	Philadelphia	Composite price [1]
January	$29.50	$29.75	$35.25	$31.50
February	30.75	32.00	37.75	33.50
March	37.25	35.25	41.00	37.83
April	38.25	36.00	41.25	38.50
May	35.50	34.50	39.50	36.50
June	36.84	36.17	39.17	37.39
July	36.12	35.50	38.75	36.79
August	38.75	35.75	39.50	38.00
September	40.25	37.50	40.50	39.42
October	37.50	36.50	39.70	37.90
November	31.50	33.50	33.50	32.83
December [2]	34.00	35.50	33.50	34.33
Average:				
1961 [2]	35.52	34.83	38.29	36.21
1960 [3]	30.78	32.97	35.10	32.95

[1] Composite price, Chicago, Pittsburgh, and Philadelphia.
[2] Estimate.
[3] Revised figures.

[2] Iron Age, v. 189, No. 1, Jan. 4, 1962, p. 230

FOREIGN TRADE [3]

The export-licensing regulations governing exportation of ferrous scrap remained in effect through 1961.

Imports.—Imported ferrous scrap, including tinplate, rose 50 percent in quantity and 45 percent in value when compared with 1960. Virtually the entire tonnage of scrap imported, 99.4 percent, came from Canada. Of the total imports, 12 percent was tinplate, mostly from Canada, compared with 23 percent during 1960.

TABLE 23.—U.S. imports for consumption of ferrous scrap, by countries

(Short tons)

Country	1960	1961	Country	1960	1961
North America:			Europe—Continued:		
Bahamas	150	343	German, West	130	66
Canada	160,561	266,873	Ireland	6,720	----------
Cuba	3,152	600	Netherlands	3,992	----------
El Salvador	349	----------	United Kingdom	[1] 228	79
French West Indies	720	----------	Other	11	3
Mexico	222	209			
Netherlands Antilles	155	----------	Total	[1] 13,904	148
Other	53	----------	Asia: Japan	105	13
			Oceania: Australia	30	203
Total	165,362	268,025			
			Grand total:		
Europe:			Short tons	[1] 179,401	268,389
Belgium-Luxembourg	2,823	----------	Value	[1] $6,273,043	$9,084,698

[1] Revised figure.

SOURCE: Bureau of the Census.

Exports.—Continued high demand resulted in record total exports of ferrous scrap from the United States, an increase of 21 percent over 1960. Ferrous scrap exported, excluding rerolling materials, rose 19 percent in quantity and 44 percent in value over 1960. Scrap exported to Japan, including rerolling materials, totaled 6.3 million short tons, an increase of 79 percent over 1960 and the largest quantity ever purchased by that country. Italy, the second largest importer of U.S. scrap, received 1.2 million short tons, slightly higher than in 1960 but less than during some previous years. Japan and Italy together received 77 percent of the total scrap exported from the United States. The third largest quantity exported went to 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 24.—U.S. exports of ferrous scrap, by countries

(Short tons)

Destination	Iron and steel scrap, including tinplate and terneplate scrap [1]		Rerolling material	
	1960	1961	1960	1961
North America:				
Canada	[2] 532,260	305,075	570	398
Mexico	399,766	374,627	26,370	13,956
Nicaragua	9,390	12,070	----------	----------
Other	61	196	2	----------
Total	[2] 941,477	691,968	26,942	14,354
South America:				
Argentina	[2] 859,983	4,269	----------	----------
Brazil	27	11,106	----------	----------
Chile	18,175	36	----------	11
Other	36	213	----------	22
Total	[2] 878,221	15,624	----------	33
Europe:				
Belgium-Luxembourg	9,127	9,873	----------	----------
Finland	25,697	8	----------	----------
France	112,902	247,028	----------	----------
Germany, West	559,138	504,980	----------	----------
Greece	----------	14,696	----------	----------
Italy	[2] 1,031,938	1,202,772	----------	----------
Netherlands	34,716	32,401	----------	----------
Norway	7,880	42,654	----------	----------
Spain	148,598	206,615	----------	----------
Sweden	224,619	148,177	----------	----------
Switzerland	12,509	----------	----------	----------
United Kingdom	249,099	534	1,051	989
Yugoslavia	20,377	134,921	----------	----------
Other	----------	261	----------	----------
Total	[2] 2,436,600	2,544,920	1,051	989
Asia:				
Hong Kong	107,868	20,095	----------	----------
India	199	5,179	----------	----------
Israel	8,099	47	----------	----------
Japan	[2] 3,422,646	6,051,548	[2] 81,385	222,001
Nansei and Nanpo Islands	----------	----------	3,189	16,546
Taiwan	118,572	107,686	13,247	23,247
Other	110	881	----------	598
Total	[2] 3,657,494	6,185,436	[2] 97,821	262,392
Africa	62	31	----------	----------
Oceania	----------	----------	----------	8
Grand total:				
Short tons	[2] 7,913,854	9,437,979	[2] 125,814	277,776
Value	[2] $234,972,536	$338,525,881	[2] $6,599,778	$15,491,368

[1] Excludes circles, cobbles, strip, and scroll shear butts from tinplated scrap.
[2] Revised figure.

SOURCE: Bureau of the Census.

TABLE 25.—U.S. imports for consumption and exports of ferrous scrap by classes

Class	1960		1961	
	Short tons	Value	Short tons	Value
Imports:				
Iron and steel scrap	138,687	$5,281,452	235,350	$8,315,133
Tinplate scrap	[1] 40,714	[1] 991,591	33,039	769,565
Total	[1] 179,401	[1] 6,273,043	268,389	9,084,698
Exports:				
Nos. 1 and 2 heavy-melting steel scrap	[1] 4,056,190	[1] 143,431,889	5,565,983	213,991,658
Nos. 1 and 2 baled steel scrap	[1] 2,529,033	[1] 46,889,663	2,391,441	72,426,002
Borings, shovelings, and turnings	[1] 115,742	[1] 2,556,257	163,014	4,509,035
Iron scrap	[1] 626,827	[1] 22,460,788	634,097	23,133,538
Rerolling material	[1] 125,814	[1] 6,599,778	277,776	15,491,368
Other steel scrap (terneplated and tinplated) [2]	[1] 586,062	[1] 19,633,939	683,444	24,465,648
Total	[1] 8,039,668	[1] 241,572,314	9,715,755	354,017,249

[1] Revised figure.
[2] Excludes circles, cobbles, strip, and scroll shear butts from tinplated scrap.

SOURCE: Bureau of the Census.

WORLD REVIEW

European Coal and Steel Community (ECSC).—Easing of prices for Heavy-Melting scrap, a decline in scrap consumption attributed to reduced steel production, and increased use of pig iron caused suppliers to seek a temporary suspension of the ban on scrap exports from European Coal and Steel Community countries.[4] Suppliers further stated that comparatively large stocks held by consumers was another reason for suspending the ban on exports.

Trade in the scrap markets of some of the European Coal and Steel Community countries nearly came to a standstill during the latter part of the year.[5] This situation was caused largely by surpluses at consumer plants in the Community and had some effect on trade with dealers in the United States because Europe was a large importer of U.S. scrap.

Record stocks of scrap at consumer plants in West Germany and France caused concern to dealers in those countries. Large stock supplies did not exist in Italy where steel production had risen in recent years. However, this did not help the Community dealers because Italian consumers turned to Britain for much of their imports.

Another factor affecting the scrap market, in addition to lower steel production, was a drop in the ratio of scrap to pig iron used.

According to the High Authority of the ECSC the consumption of scrap by the iron and steel industry within the Community was greater than in 1960—totaling 35.3 million short tons. This increase occurred despite reduced steel production in the latter part of the year. Of this total 33.1 million tons was from markets within the ECSC, with approximately 2 million tons, mostly high-grade scrap, being imported.[6]

[4] American Metal Market. Seek Temporary Suspension of ECSC Ban on Exports of Scrap. V. 68, No. 208, Oct. 30, 1961, p. 19.
[5] American Metal Market. European Steel Scrap Trade Near Standstill. V. 68, No. 225, Nov. 24, 1961, pp. 1-2.
[6] American Metal Market. E.C.S.C. Ferrous Scrap Use Rose Last Year. V. 69, No. 48, Mar. 12, 1962, p. 26.

Australia.—The Minister for Trade in referring to the export quotas on iron and steel scrap in the second half of 1961 announced that there would be no further reduction in the quotas because some new scrap-using projects have been modified or delayed.[7]

Japan.—A split of Japanese steel mill operators into two groups as a result of differences of opinion in the method of import purchases, caused the Japanese Scrap Steel Coordinating Committee to announce that it would cease acting as sole agent for scrap steel imports.[8] One group favored importing scrap from the United States under long-term contracts; the other, advocated increased spot purchases.

Due to plans to increase output by most steel mills, the Committee stated that Japan's scrap import requirements were expected to increase during the 1962 financial year.

New Zealand.—Beginning January 1, 1961, export controls of ferrous scrap from New Zealand were strengthened considerably to insure sufficient scrap to meet the requirements of a new bar mill at Auckland.[9]

TECHNOLOGY

The world's largest scrap-charging machine for steel mill service was being built at a plant in New Castle, Pa. When completed, it will be put in service at a steel plant in Ecorse, Mich., where two of the world's largest oxygen converters will begin operating in 1962. The self-propelled scrap-charging car will be equipped with two scrap boxes, each having a capacity of 55 tons, and was designed to charge its entire load into a furnace in approximately 1 minute. Operation will be by hydraulic power, but in the event of a power or mechanical failure overhead cranes may be used to dump the scrap boxes.[10]

As part of the effort to comply with air-pollution ordinances in some States and communities, and to further improve scrap quantity, two New York University research scientists investigated the smokeless burning of automobile bodies.[11] Several designs for incinerators were created and evaluated by the scientists and as a result of their studies a prototype burner was built and tested at a scrap yard in Connecticut. Tests were made by using automobile bodies, insulated copper wire, and mixed municipal refuse, demonstrating that the furnace could successfully burn a wide variety of smoke-producing combustibles.

The investigations and research were supported by a grant from the National Institutes of Health, U.S. Public Health Service.

An investigation of extracting strategic components from S–816 alloy scrap was reported.[12] The investigation began after the need became apparent for a method of reclaiming high-temperature alloys from an increasing accumulation of rejected and wornout jet engine turbine buckets.

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[7] Iron and Coal Trades Review. Australian Scrap Export Quotas Unchanged. V. 182, No. 4850, June 30, 1961, p. 1417.
[8] Metal Bulletin. Dispute over Japanese Imports. No. 4577, Mar. 7, 1961, p. 18.
[9] Waste Trade Journal. New Zealand Will Tighten Export Controls on Scrap. V. 110, No. 11, Nov. 26, 1960, p. 55.
[10] American Metal Market. Biggest Scrap Charging Machine. V. 68, No. 183, Sept. 22, 1961, p. 18.
[11] American Metal Market. 1961 Equipment Highlight: Auto Burner. V. 68, No. 202, Oct. 20, 1961, p. 31.
[12] Kenworthy, H., V. A. Nieberlein, and A. G. Starliper. Experimental Extraction of Strategic Components from S–816 Alloy Scrap. BuMines Rept. of Inv. 5786, 1961, 27 pp.

Iron Oxide Pigments

By John W. Hartwell [1] and Betty Ann Brett [2]

CRUDE IRON oxide pigments mined and sold or used in the United States during 1961 dropped 35 percent below the comparative 1960 figures, which is the lowest since 1954. Sales of finished pigments increased slightly over 1960 but were still almost 10 percent below the record sales of 1959.

TABLE 1.—Salient iron oxide pigments statistics in the United States

	1952-56 (average)	1957	1958	1959	1960	1961
Mine production:						
Iron oxide pigment mines, short tons	[1] 22,700	20,300	30,100	29,000	29,600	20,900
Iron ore mines, do	[1] 29,200	29,000	24,600	24,900	40,700	25,100
Crude pigments sold or used:						
Iron oxide pigment mines, do	[1] 18,600	18,400	30,700	29,100	30,400	20,800
Value, thousands	[1] $168	$193	$234	$251	$262	$198
Iron ore mines, short tons	[1] 29,200	29,000	24,600	24,900	40,700	25,100
Value, thousands	[1] $252	$269	$211	$219	$373	$255
Finished pigments sold or used, short tons	108,100	104,900	98,400	117,600	106,000	106,500
Value, thousands	$15,213	$16,405	$15,822	$19,037	$17,948	$18,345
Imports for consumption, short tons	11,500	13,100	11,700	14,800	14,500	10,500
Value, thousands	$949	$1,314	$1,160	$1,495	$1,422	$1,059
Exports, short tons	4,300	3,700	3,900	4,300	3,900	3,200
Value, thousands	$762	$1,038	$1,065	$1,040	$1,113	$855

[1] Average for 1954-56 only.

DOMESTIC PRODUCTION

Demand for pigment-grade iron oxide in 1961 remained steady. Production from iron ore mines dropped about 38 percent under 1960 and iron oxide from pigment mines dropped about 29 percent. Finished pigments sold or used increased slightly in quantity and about 2 percent in value.

Nine companies in eight States mined and sold or used crude iron oxide pigments. Sales of finished iron oxide pigments were made by 16 producers in 9 States.

PRICES

The fluctuations in the quoted prices shown in table 4 for metallic brown, raw Turkey umber, and natural Peruvian ocher were probably due to differences in quantity, quality, locality, or individual suppliers' views. Changes in prices for pure brown, American raw and burnt umber, raw and burnt sienna, 40-percent Venetian red, and natural French ocher occurred in December 1961. All other iron oxide pigment prices remained constant.

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.

TABLE 2.—Crude iron oxide pigments produced and sold or used by processors in the United States, by kinds

Pigment	1960			1961		
	Mined (short tons)	Sold or used		Mined (short tons)	Sold or used	
		Short tons	Value		Short tons	Value
Brown iron oxide:						
Sienna	14,293	13,627	$109,800	3,882	4,313	$45,100
Umber	495	724	7,200	1,199	1,032	14,500
Red iron oxide	46,396	46,396	454,200	30,234	30,234	331,900
Ocher	6,072	6,072	28,300	5,713	5,713	28,200
Other [1]	3,077	4,335	35,800	4,920	4,631	33,600
Total	70,333	71,154	635,300	45,948	45,923	453,300

[1] Includes metallic brown, natural yellow iron oxide, sulfur mud, and miscellaneous pigments.

TABLE 3.—Finished iron oxide pigments sold by processors in the United States, by kinds

Pigment	1960		1961	
	Short tons	Value	Short tons	Value
Natural:				
Black: Magnetite	196	$16,500	84	$7,300
Brown:				
Iron oxide (metallic)	6,297	666,700	6,150	670,600
Umbers:				
Burnt	2,786	445,700	2,754	432,300
Raw	662	96,800	869	155,600
Vandyke brown	353	65,500	283	54,700
Red:				
Iron oxide	16,068	841,800	14,820	743,100
Sienna, burnt	970	209,000	961	213,000
Pyrite cinder	888	50,700	1,595	72,100
Yellow:				
Iron oxide	18	2,300	13	1,800
Ocher	4,133	178,900	3,891	170,700
Sienna, raw	779	155,000	781	175,000
Total natural	33,150	2,728,900	32,201	2,696,200
Manufactured:				
Black: Magnetic	1,945	581,700	1,840	546,900
Brown: Iron oxide	2,060	603,500	2,123	655,500
Red:				
Pure red iron oxides:				
Calcined copperas	15,192	4,355,400	16,193	4,584,400
Other chemical processes	6,445	1,887,200	7,019	2,041,500
Other manufactured red iron oxides	21,125	2,369,900	19,563	2,170,800
Venetian red	2,536	305,500	2,509	308,900
Yellow: Iron oxide	14,304	3,488,600	15,287	3,722,100
Total manufactured	63,607	13,591,800	64,534	14,030,100
Mixtures of natural and manufactured red iron oxides	6,348	1,110,000	7,064	1,177,100
Other and unspecified	2,917	517,300	2,703	441,600
Grand total	106,022	17,948,000	106,502	18,345,000

FOREIGN TRADE [3]

Crude ocher was not imported in 1961. Refined ocher, with an average value of about 3 cents per pound, was imported from the Union of South Africa (57 tons) and Sweden (34 tons).

[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.—Prices quoted on finished iron oxide pigments, per pound, in bags, unless otherwise specified, in 1961

Pigment	High	Low	Pigment	High	Low
Black:			Red:		
Pure	$0.1475	$0.1475	Domestic (pure)	$0.1425	$0.1425
Synthetic	(1)	(1)	Natural (75–85 percent ferric oxide) [2]	.0625	.0625
Brown:			Persian Gulf	.0875	.0875
Pure	.1575	.1475	Spanish (barrels) [2]	.0575	.0575
Metallic	.0575	.0550	Sienna, burnt	.0725	.0650
Umber, American, burnt	.0850	.0750	Venetian, 40 percent	.0725	.0675
Umber, Turkey, burnt [2]	.0825	.0825	Yellow:		
Umber, American, raw	.0850	.0775	Ocher, natural, French	.0700	.0675
Umber, Turkey, raw [2]	.0875	.0850	Ocher, natural, Peruvian	.0250	.0230
Vandyke (barrels)	.0850	.0850	Ocher, hydrated, pure	.1250	.1250
			Sienna, raw	.0750	.0675

[1] Data not available.
[2] Not quoted after December 1961.

Source: Oil, Paint and Drug Reporter.

Malta and Italy supplied all the crude sienna imported, with 130 and 278 tons, respectively; refined sienna with an average value of about 6 cents per pound came from the United Kingdom (22 tons), Malta (16 tons), and Italy (100 tons).

All crude umber imports came from Malta. The refined umber was from the United Kingdom (67 tons) and Malta (122 tons) with an average value of about 4 cents per pound.

West Germany was the only country from which the United States imported Vandyke brown during 1961. The average value of the pigment was about 4 cents per pound.

TABLE 5.—U.S. imports for consumption of selected iron oxide pigments

Pigment	1960		1961	
	Short tons	Value	Short tons	Value
Natural:				
Ocher, crude and refined	230	$13,703	[1] 91	$5,171
Siennas, crude and refined	649	63,983	546	56,910
Umber, crude and refined	2,894	97,969	2,685	93,240
Vandyke brown	195	14,214	168	13,042
Other [2]	2,976	132,078	2,248	113,710
Total	6,944	321,947	5,738	282,073
Manufactured (synthetic)	7,516	1,099,736	4,806	776,780
Grand total	14,460	1,421,683	10,544	1,058,853

[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.

WORLD REVIEW

The United States produced and used more pigment-grade iron oxides than any other country.

Canada.—Production, imports, and exports of all grades and classes of iron oxide pigments declined in 1960. Natural iron oxide pigment production decreased to 865 short tons valued at Can $80,000, the

TABLE 6.—U.S. imports for consumption of iron oxide and iron hydroxide pigments, n.s.p.f., by countries

Country	Natural				Synthetic			
	1960		1961		1960		1961	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
North America: Canada					1,130	$219,303	1,177	$240,677
Europe:								
Belgium-Luxembourg							(1)	504
France	1	$413			(1)	153	1	1,991
Germany, West	8	994	29	$3,520	5,252	720,289	2,728	396,315
Italy					(1)	522		
Netherlands							45	7,500
Spain	2,838	119,494	2,131	101,422	104	4,247		
Sweden					1	798	(1)	266
United Kingdom	129	11,177	88	8,768	1,029	154,424	832	128,395
Total	2,976	132,078	2,248	113,710	6,386	880,433	3,606	534,971
Asia: India							23	1,132
Grand total	2,976	132,078	2,248	113,710	7,516	1,099,736	4,806	776,780

[1] Less than 1 ton.

Source: Bureau of the Census.

lowest quantity since 1894. This was 29 percent less in quanity than in 1959 and 94 percent less than in 1950, the record year. Imports of ochers, siennas, and umbers declined 26 percent in quantity from 1959; other iron oxide imports declined nearly 20 percent. Exports were about 4 percent less in quantity. Consumption of natural and synthetic iron oxide for paints remained relatively stable in 1960, but data were not available.[4]

Cyprus.—Exports of umber during 1960 were 19 percent more than in 1959 and were valued at nearly US $175,000.[5] Umber was produced from an area near Larnaca on the south coast. Most umber was sold as crude ore.

India.—A deposit of ocher was discovered near Kharidhunga. The deposit was mapped and pit-tested in detail, and 100,000 tons of ore was blocked out. The ore was reported to have a low specific gravity and to be relatively free from clay or other impurities. It was valued at US $40 per ton in Calcutta.[6]

Morocco.—Production of iron oxide pigments from the Kettara hematite mine by Cie. Minière et Métallurgique decreased to 1,565 short tons in 1960 compared with 2,323 tons in 1959. These pigments were produced as a byproduct. The 1960 exports of nearly 1,500 tons were to Algeria, Australia, the Republic of the Congo (formerly Belgian Congo), France, Guinea, and Netherlands. The value of exports was about US $65,000.[7]

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[4] Ross, J. S. Mineral Pigments and Fillers, 1960 (Prelim.). Canadian Min. Ind., Dept. Mines and Tech. Surveys, Ottawa, Rev. 44, 1960, pp. 1–4.
[5] Bureau of Mines, Mineral Trade Notes. V. 53, No. 2, August 1961, p. 28.
[6] Mining World. Nepal. V. 23, No. 4, April 1961, p. 25.
[7] Bureau of Mines, Mineral Trade Notes. V. 53, No. 4, October 1961, pp. 29, 30.

TABLE 7.—U.S. exports of iron oxide pigments, by countries

Destination	1960		1961	
	Short tons	Value	Short tons	Value
North America:				
Bahamas	2	$500	15	$3,172
Canada	2,304	418,770	1,748	392,081
Costa Rica	8	3,351	13	4,680
Cuba	88	26,811	1	212
Guatemala	35	9,399	33	6,451
Mexico	30	20,601	61	25,842
Netherlands Antilles	14	4,046	3	1,258
Other North America	36	11,776	19	7,851
Total	2,517	495,254	1,893	441,497
South America:				
Argentina	----	----	18	11,340
Brazil	13	4,294	31	11,760
Chile	6	2,438	18	6,529
Colombia	65	23,301	110	40,758
Ecuador	12	3,118	9	4,002
Peru	14	7,271	14	5,690
Venezuela	52	13,822	111	24,463
Other South America	7	2,552	----	----
Total	169	56,796	311	104,542
Europe:				
Belgium-Luxembourg	31	35,043	10	7,578
France	82	30,225	67	21,889
Germany, West	35	16,913	94	29,637
Iceland	2	700	1	268
Italy	24	22,622	29	7,917
Netherlands	277	75,279	73	4,888
Portugal	13	3,931	14	4,021
Sweden	4	1,725	----	----
Switzerland	26	12,655	26	8,322
United Kingdom	53	24,358	95	30,490
Other Europe	4	1,744	13	5,877
Total	551	225,195	422	120,887
Asia:				
Afghanistan	----	----	14	3,331
Hong Kong	16	5,417	5	2,229
Japan	52	17,573	165	48,359
Philippines	225	84,108	215	77,278
Other Asia	15	10,424	22	10,177
Total	308	117,522	421	141,374
Africa:				
Union of South Africa	99	32,570	49	13,437
Other Africa	----	----	1	266
Total	99	32,570	50	13,703
Oceania	218	185,787	116	32,688
Grand total	3,862	1,113,124	3,213	854,691

Source: Bureau of the Census.

TECHNOLOGY

A book published on pigments and pigmented coatings contained information on the chemistry, manufacture, and use of organic and mineral pigments.[3]

Exposure-fence testing of protective paints for metals was described in an article. The exposure program which was used required con-

[3] Payne, Henry F. Organic Coating Technology, v. III. Pigments and Pigmented Coatings. John Wiley & Sons, Inc., New York, 1961, 1363 pp.

venient methods for handling the specimens and simplified techniques for recording exposure inspection data.[9]

The effects of iron oxide on the swelling of enamels were investigated.[10]

The investigation of control problems in whiteware manufacturing plants with glazes containing brown and tan stains was made. Four families of stain containing combinations of iron oxide and other minerals were discussed. Factors within the whiteware plants which affect brown colors were listed and control procedures suggested.[11]

A glass polishing composition consisting of finely divided iron oxide and other minerals was patented.[12]

A patent was granted on a method of manufacturing red iron oxide. A color range from light red to deep maroon was produced by chemical precipitation. The precipitates consisted of 88 to 98 weight-percent ferric oxide chemically combined with water.[13]

A dehydrogenation catalyst was patented consisting of iron oxide, minor amounts of an alkaline compound of an alkali metal, chromium oxide, and hydraulic cement containing free calcium oxide.[14]

A Russian book on the chemistry and technology of pigments was published. This book contained two chapters of 72 pages on synthetic and natural iron oxide pigments. As of December 1961 an English translation was not available.[15]

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[9] Lominska, C. A. Exposure Testing of Protective Paints for Metals. Mat. Res. & Standards, v. 1, No. 8, August 1961, pp. 620–625.

[10] Azarov, K. P., and S. B. Grechanova. (On the Effect of Iron Oxides on Swelling of Enamels.) Tr. Novocherk, politekhn. in-ta., No. 47/61, 1958, pp. 243–258; transl. from Referativnyy zhurnal, Khimiya, No. 16, 1960, p. 371 (a Russian abs.).

[11] Marquis, John E., and Robert E. Carpenter. Plant Control Problems with Whiteware Glazes Containing Brown and Tan Stains. Am. Ceram. Soc. Bull., v. 40, No. 1, January 1961, pp. 19–24.

[12] Kroner, Gerhard (assigned to Farbenfabriken Bayer A.G.). Glass Polishing Compositions. U.S. Pat. 2,967,096, Jan. 3, 1961.

[13] Bennetch, Leonard M. (assigned to C. K. Williams & Co., East St. Louis, Ill.). Red Oxide of Iron. U.S. Pat. 3,009,821, Nov. 21, 1961.

[14] Fleming, Harold W., and William R. Gutmann (assigned to the Chemetron Corp.). Iron Oxide Hydraulic Cement Dehydrogenation Catalyst. U.S. Pat. 2,990,432, June 27, 1961.

[15] Belen'kiy, Ye. F., and I. V. Riskin. (The Chemistry and Technology of Pigments). Khimiya i Teckhnologiya Pigmentov, Leningrad, 1960, 756 pp.

Kyanite and Related Minerals

By James D. Cooper [1] and Gertrude E. Tucker [2]

PRODUCTION of domestic kyanite in 1961 increased 7 percent over 1960. There was no reported output of other natural minerals of the kyanite group. Synthetic mullite production in 1961 was down 31 percent from 1960. Apparent consumption of kyanite and related minerals, including synthetic mullite, was approximately the same as in 1960.

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 7 percent over that of 1960 and established a new peak. Output of kyanite ore increased only 2 percent over 1960. These data indicated an improvement in the recovery ratio over that of 1960. Data on output are withheld to prevent disclosure of individual production of the two producing companies—Commercialores, Inc., with mines near Clover, S.C., and Kyanite Mining Corp., with mines near Farmville and Dillwyn, Va.

Synthetic mullite production decreased 31 percent in quantity and 22 percent in value in 1961. Although consumption of synthetic mullite was down somewhat from 1960, a second major factor in the reduced output was disposal of several thousand tons of surplus kyanite and mullite from the Government stockpile in 1960 and 1961. Further sales of stockpiled kyanite and mullite were planned for 1962.

TABLE 1.—Synthetic mullite production in the United States

Year	Short tons	Value (thousands)
1952–56 (average)	[1] 17,000	[1] $1,700
1957	19,873	2,009
1958	16,280	1,632
1959	18,218	2,017
1960	21,497	2,212
1961	14,798	1,720

[1] Estimate.

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

The following six companies manufactured synthetic mullite in the United States in 1961:

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.).
Remmey Division of 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.).

CONSUMPTION AND USES

Most of the kyanite and mullite used went into superduty refractory brick and shapes, mortars, cements, plastics, and ramming mixtures. Nonrefractory use of domestic kyanite concentrate appeared to be increasing, particularly in ceramic articles where the expansion of kyanite is used to overcome firing shrinkage of the ceramic products.

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 1961: 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.

STOCKS

As of December 31, 1961, the national (strategic) stockpile contained 10,100 short dry tons of kyanite and mullite, which was 110.4 percent in excess of the maximum objective of 4,800 tons. No kyanite or mullite was contained in the Defense Production Administration, Commodity Credit Corp., or supplemental stockpiles.

Data were not available on importers', producers', and consumers' stocks of kyanite group minerals and mullite in the United States.

TABLE 2.—U.S. imports for consumption and exports of kyanite and related minerals

Imports			Exports		
Year and country	Short tons	Value	Year and country	Short tons	Value
1952–56 (average)	7,007	[1]$304,006	1952–56 (average)	1,271	$58,872
1957	5,999	263,375	1957	2,588	129,963
1958	1,965	95,489	1958	2,493	126,862
1959	5,633	251,638	1959	2,734	167,432
1960:			1960:		
Asia: India	4,684	213,764	North America:		
Africa: Union of South Africa	1,368	51,600	Canada	1,630	108,718
Total	6,052	265,364	Mexico	788	39,983
1961:			South America:		
Europe: Netherlands	255	19,143	Chile	5	330
Asia: India	3,809	173,307	Venezuela	65	4,759
Africa: Union of South Africa	1,351	51,739	Europe:		
Total	5,415	244,189	Austria	17	941
			Belgium-Luxembourg	2	533
			France	143	8,403
			Germany, West	288	17,893
			Italy	63	3,660
			United Kingdom	86	11,442
			Asia:		
			Japan	163	12,452
			Jordan	5	836
			Total	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	4,362
			United Kingdom	878	50,536
			Asia:		
			Indonesia	89	5,200
			Japan	880	64,668
			Viet-Nam	30	2,559
			Africa: Union of South Africa	34	2,590
			Oceania: Australia	20	1,040
			Total	4,000	317,633

[1] 1954 data known to be not comparable with other years.

Source: Bureau of the Census.

FOREIGN TRADE [3]

Imports of kyanite and related minerals declined 11 percent in quantity and 8 percent in value from 1960. Exports increased 23 percent in quantity and 51 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 3.—World production of kyanite and related minerals, 1928–60

(Short tons)

Year	United States, kyanite and sillimanite	Africa						India		Australia	
		Bechuanaland, kyanite	Federation of Rhodesia and Nyasaland, kyanite	Kenya, kyanite	South-West Africa, kyanite and sillimanite	Tanganyika, kyanite	Union of South Africa andalusite and sillimanite	Kyanite	Sillimanite	Kyanite	Sillimanite
1928	[1]							2,510			
1929	[1]							4,052			
1930	[1]							9,678			
1931	[1]							3,821			
1932	[1]							6,250			34
1933	[1]							4,797			146
1934	[1]							10,540			179
1935	[1]							22,291			17
1936	[1]							27,761	155		34
1937	[1]							30,168			50
1938	[1]							31,791	183	22	
1939	[2] 4,950							11,106			84
1940	4,241							9,542	248		278
1941	8,335							14,078	228		1,072
1942	8,708							17,154	263		1,727
1943	9,561							14,015	273		1,222
1944	[3]			685				14,671	46		874
1945	[3]			178				15,117	34		1,025
1946	[3]			2,947			6,056	15,108	74	157	844
1947	[3]			16,215			11,546	16,073	264	3,283	503
1948	14,552			16,352			3,793	14,118	239	1,260	780
1949	12,115			26,054			4,622	22,343	1,091		1,076
1950	[3]			11,922			8,320	39,747	1,652		1,771
1951	[3]	2,222		11,917	65		12,663	47,601	4,534		976
1952	[3]	2,385	45	9,448	3,000		21,477	30,108	5,685		1,493
1953	[3]	1,960	1,353	6,086	2,717	22	11,772	17,219	6,150		3,984
1954	[3]	2,054	1,624	4,500	140		18,174	47,410	3,434		2,617
1955	[3]	840		3,031	240		19,359	13,150	2,714		3,000
1956	[3]	981			2,196		30,244	22,551	5,193		2,443
1957	[3]	120			3,890		49,509	26,324	8,307		2,578
1958	[3]			600	2,985		34,499	28,689	15,506		1,900
1959	[3]			1,639	3,243		49,591	18,187	8,483		4,069
1960	[3]			1,417	1,438		69,137	22,218	9,083		1,707

[1] Data not available.
[2] Estimate.
[3] Figure withheld to avoid disclosing individual company confidential data.

WORLD REVIEW

World production of kyanite and related minerals from 1928 to 1960 inclusive, is shown in table 3.

Australia.—Preliminary figures showed production of 722 tons of sillimanite during the first 6 months of 1961. Imports for the same period totaled 1,296 tons of kyanite and sillimanite. There were no reported exports of kyanite-group minerals.[4]

Bulgaria.—A rich deposit of kyanite, discovered in the Rhodope Mountains of Bulgaria, reported to contain about 900,000 tons of kyanite, was being examined.[5]

India.—An improved process was proposed for recovery of heavy minerals from the Chavara beach sands in Kerala State, India. Its use reportedly would recover large quantities of valuable minerals presently being wasted, including approximately 30,000 tons of sillimanite a year.[6]

South-West Africa.—Production of kyanite and sillimanite totaled 3,000 tons for the first 9 months of 1961. Exports were 3,040 tons in the same period.[7]

Union of South Africa.—Total production of sillimanite and andalusite was 102,301 tons in 1961, an increase of 48 percent over the preceding record production of 1960. Exports were 102,633 tons in 1961.[8] Principal countries of destination were United Kingdom, Japan, Netherlands, and West Germany.[9]

TECHNOLOGY

A comprehensive report on kyanite and related minerals was published. The report contains descriptions of the major deposits of the world, together with data on geology, mining, processing methods, technology, research, and industry structure. Abstracts of U.S. patents from 1920 through 1959 are included.[10]

Secondary expansion of certain high-alumina refractories containing calcined bauxite was found to result from mullite crystal growth, due principally to titanium dioxide and ferric oxide impurities, which reduced the viscosity of the liquid phase and caused vacancies in the

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[4] Australia Bureau of Mineral Resources, Geology, and Geophysics. The Australian Mineral Industry. V. 14, No. 2, pt. 2, December 1961, pp. 9, 17, 18.

[5] Mining Journal (London). Mining Miscellany, Kyanite Discovered-Rhodope, Bulgaria. V. 256, No. 6564, June 9, 1961, p. 662.

[6] Viswanathan, P. Improved Flowsheet for Concentration of Minerals From Chavara Beach Sands. J. Mines, Metals and Fuels (Calcutta, India), v. 9, No. 8, August 1961, pp. 13–15, 23.

[7] Republic of South Africa, Department of Mines (Minerals). Quarterly Information Circular. July-September 1961, pp. 71, 74, 83.

[8] U.S. Consulate, Johannesburg, Republic of South Africa, State Department Dispatch 390. Mar. 14, 1962, p. 1.

[9] Republic of South Africa, Department of Mines (Minerals). Quarterly Information Circular. July-September 1961, p. 26.

[10] Klinefelter, T. A., and J. D. Cooper. Kyanite, A Materials Survey. BuMines Inf. Circ. 8040, 1961 55 pp.

crystalline phase at temperatures above 1,400° C. Sodium fluoride was an effective additive for control of the secondary expansion.[11]

High-temperature strength and elastic properties for relatively pure sintered mullite bodies of 3:2 and 2:1 alumina-silica ratios were determined for the range from room temperature to 1,200° C.[12]

Kyanite-group minerals and synthetic aluminum silicates were studied at pressures up to 90,000 atmospheres, and temperatures to 2,000° C. Previous research had been limited to pressures in the range of 30,000 atmospheres and temperatures of about 1,500° C. The results should be of particular interest to geologists and mineralogists.[13]

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[11] McGee, Thomas D., and C. M. Dodd. Mechanism of Secondary Expansion of High-Alumina Refractories Containing Calcined Bauxite. J. Am. Ceram. Soc., Ceram. Abs., v. 44, No. 6, June 1961, pp. 277-283.

[12] Fenstermacher, J. E., and F. A. Hummel. High-Temperature Mechanical Properties of Ceramic Materials: IV, Sintered Mullite Bodies. J. Am. Ceram. Soc., Ceram. Abs., v. 44, No. 6, June 1961, pp. 284-289.

[13] Claussen, W. F., R. C. Devries, and J. D. MacKenzie. The Influence of High Pressures and High Temperatures on Transformations and Coordination in Crystalline and Vitreous Ceramic Materials. WADD Tech. Rept. 60-304, November 1960, pp. 13-38; reproduced by ASTIA, Arlington Hall Sta., Arlington, Va., unclassified repr. AD 251 749, Materials Central Contract A.F. 33(616)-6295, Project 7351; Task 73517—General Electric Company Research Laboratory.

Lead

By Richard N. Spencer,[1] Edith E. den Hartog,[2] and Mary E. Graves [2 3]

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MINE output of recoverable lead increased 6 percent, and production of lead at primary refineries increased substantially in 1961; production at secondary smelters declined. Consumption of lead in battery uses and in leaded gasoline additives together increased 4 percent; most other items of lead consumption declined slightly to moderately. Import quotas remained in effect during the entire year. Some barter transactions were negotiated for lead from two foreign countries, and partial deliveries were received. The price of common grade lead (New York market) remained at 11 cents a pound until November 1 when it declined to 10.5 cents. It dropped again, to 10 cents, on November 13; on November 28 a small gain brought the price to 10.25 cents, where it held for the remainder of the year.

LEGISLATION AND GOVERNMENT PROGRAMS

Import quotas established in October 1958 continued in effect without revision through 1961. The U.S. Tariff Commission submitted a report to the President on October 2, in accordance with Executive Order 10401, to advise concerning developments in the trade pertinent to lead and zinc quotas as required by escape clause procedure. The Tariff Commission reported that trade conditions had

[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.

TABLE 1.—Salient lead statistics

	1952–56 (average)	1957	1958	1959	1960	1961
United States:						
Production:						
Domestic ores, recoverable lead content—short tons	349,815	338,216	267,377	255,586	246,669	261,921
Value—thousands	$103,218	$96,730	$62,566	$58,785	$57,722	$53,956
Primary lead (refined):						
From domestic ores and base bullion—short tons	340,792	347,675	269,082	225,270	228,899	288,078
From foreign ores and base bullion—short tons	148,992	185,858	201,074	115,661	153,537	161,487
Antimonial lead (primary lead content)—short tons	16,159	19,870	16,446	12,402	2,385	24,966
Secondary lead (lead content) short tons	489,552	489,229	401,787	451,387	469,903	452,792
Imports, general:						
Lead in ores and matte short tons	160,150	198,479	201,599	138,834	[1] 145,692	147,186
Lead in base bullion—do	266	84	460	80	293	422
Lead in pigs, bars, and old short tons	352,726	333,492	375,022	271,695	213,671	261,794
Exports of refined pig lead—do	1,638	4,339	1,359	2,756	1,967	2,133
Stocks Dec. 31 (lead content):						
At primary smelters and refineries—short tons	110,020	143,916	234,290	171,079	250,142	262,102
At consumer plants—do	120,477	129,310	122,900	126,496	97,268	99,140
Consumption of metal, primary and secondary—short tons	1,169,926	1,138,115	986,387	1,091,149	1,021,172	1,027,216
Price: New York, common lead, average, cents per pound	15.03	14.66	12.11	12.21	11.95	10.87
World:						
Production:						
Mine	2,330,000	2,640,000	2,590,000	2,560,000	2,610,000	2,660,000
Smelter	2,190,000	2,515,000	2,500,000	2,410,000	2,550,000	2,660,000
Price: London, common lead, average, cents per pound	13.42	12.05	9.13	8.88	9.04	8.03

[1] Revised figure.

not altered sufficiently to justify relaxing the protective measures in effect and that a formal investigation was not warranted.

Surplus agricultural barter contracts were negotiated with Canada for 55,000 tons of lead and with Australia for 50,000 tons of lead by the U.S. Department of Agriculture, Commodity Credit Corporation (CCC). These contracts were made in exchange for agreements by producers in those two countries to curtail lead production in 1961. No acquisitions of lead were made for the national (strategic) stockpile.

A bill to subsidize small lead-zinc mines became Public Law 87–347 on October 3, 1961 after being passed by both Houses of Congress and approved by President Kennedy. The law calls for subsidy payments to small producers (less than 3,000 tons combined lead and zinc) amounting to 75 percent of the difference between 14½ cents per pound of lead and the market price for common lead at New York. The maximum amount of payments which may be made under this Act during its 4-year duration was specified as $16,500,000. No funds had been appropriated by yearend to implement this program.

The Office of Minerals Exploration (OME), which limited Government participation to 50 percent of the approved costs and a maximum of $250,000 for any one contract, continued its program of assistance for long-range exploration and received 25 applications for assistance for lead-bearing ore deposits. Five new contracts were executed, authorizing total expenditures of $350,410, of which

the maximum Government participation was $175,205. Eleven applications received in 1961 were denied, five were withdrawn. Two OME contracts were terminated. Two contracts from the Defense Minerals Exploration Administration (DMEA), predecessor to OME, were terminated. One discovery was certified, making a total of 95 certified discoveries or developments in lead-bearing ore under the DMEA-OME program.

The International Lead-Zinc Study Group met for its third session in Mexico City, Mexico, from March 20 to 24 and for its fourth session in Geneva, Switzerland, from October 18 to 24. The Study Group continued its efforts to find generally acceptable means to bring free-world production and consumption more nearly into balance. In the third session, delegations from several countries announced the intention of curtailing lead production during 1961 by definite quantities. At yearend, it was evident that few of the announced reductions in lead production were effected; free-world lead production increased substantially over that of 1960, while consumption rose only slightly, thus leaving a substantial increase in lead stocks. Market reaction to this growing imbalance was a series of price declines late in the year. No solution to the problem seemed forthcoming at yearend; however, the Lead-Zinc Study Group continued its efforts to reach an equitable solution and continued its statistical work.

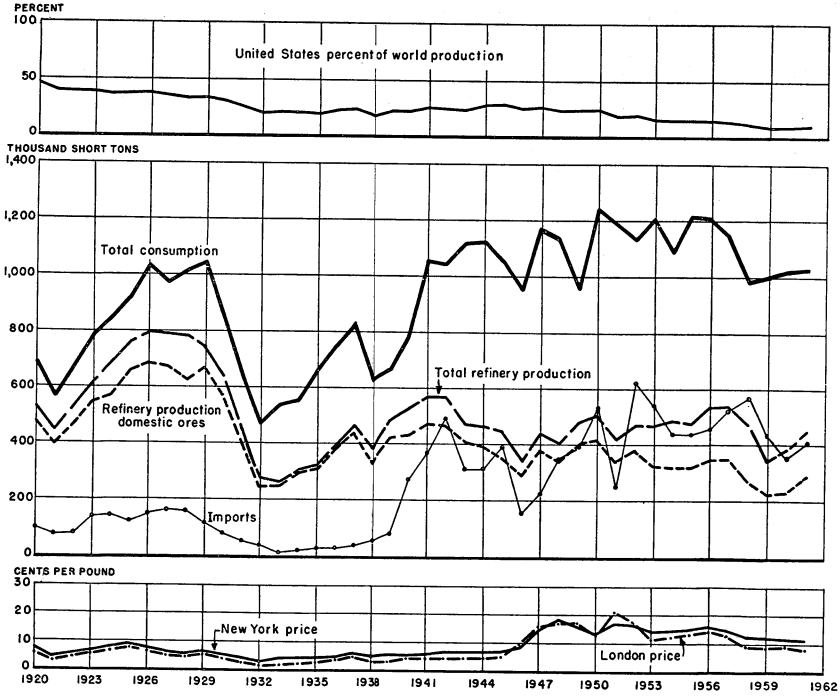


FIGURE 1.—Trends in the lead industry in the United States, 1920–61. Consumption includes primary refined, antimonial, and secondary lead, and lead in pigments made directly from ore. Imports are factored to include 95 percent of the lead content of ores, mattes, and concentrates and 100 percent of pigs, bars, base bullion, and scrap.

DOMESTIC PRODUCTION

MINE PRODUCTION

Mines in the United States produced 262,000 short tons of recoverable lead in 1961, 8,000 tons less than in 1900. Since 1900, only in 1959 and 1960 was mine production less than that of 1961. Production increased considerably during the first and second quarters (compared to the two preceding quarters), then decreased in both the third and fourth quarters. Production in 1961 was 6 percent more than in 1960. Mine output was not materially affected by labor strikes during the year.

The four largest producing States were Missouri, 98,800 short tons; Idaho, 71,500 tons; Utah, 40,900 tons; and Colorado, 17,800 tons. Mines in these four States produced 229,000 tons or 87 percent of the total U.S. output. The remaining 13 percent came from 16 States. Major producers in these minor producing States, with a combined total of 26,100 tons and representing about 10 percent of total output, were mines in Washington, Arizona, Virginia, Illinois, Montana, and New Mexico.

Missouri remained the major lead producing State; output of mines of the Southeast Missouri Lead Belt was 38 percent of the U.S. total. Missouri production was 12 percent less than that during 1960.

Extensions of the Southeast Missouri lead belt were receiving more favorable mining-company interest than any other U.S. area containing lead resources. Fifteen or more major mining firms had acquired leases or had purchased property for exploration. Most of this exploration was south of the Viburnum district, some as many as 30 miles south. Although little reliable news of exploration results had been made public, it was known that significant new discoveries had been made in the area east of Bunker. The imbalance of lead

TABLE 2.—Mine production of recoverable lead in the United States, by States

(Short tons)

State	1952–56 (average)	1957	1958	1959	1960	1961
Arizona	11,230	12,441	11,890	9,999	8,495	5,937
Arkansas	[1] 4			38		
California	8,019	3,458	140	227	440	103
Colorado	21,061	21,003	14,112	12,907	18,080	17,755
Idaho	69,223	71,637	53,603	62,395	42,907	71,476
Illinois	3,852	2,970	1,610	2,570	3,000	3,430
Kansas	5,286	4,257	1,299	481	781	1,449
Kentucky	84	411	516	409	558	656
Missouri	125,917	126,345	113,123	105,165	111,948	98,785
Montana	18,344	13,300	8,434	7,672	4,879	2,643
Nevada	4,775	5,979	4,150	1,357	987	1,791
New Mexico	4,038	5,294	1,117	829	1,996	2,332
New York	1,277	1,667	579	481	775	879
North Carolina	3	9			424	318
Oklahoma	13,024	7,183	3,692	601	936	980
Utah	47,342	44,471	40,355	36,630	39,398	40,894
Virginia	3,387	3,143	2,934	2,770	2,152	3,733
Washington	10,949	12,734	9,020	10,310	7,725	8,053
Wisconsin	1,977	1,900	800	745	1,165	680
Other States	26	14	3		23	27
Total	349,815	338,216	267,377	255,586	246,669	261,921

[1] 1952 only.

TABLE 3.—Ores yielding lead and zinc in the United States in 1961

(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	1,250	74	5	15,059	------	2,210	260,547	5,851	17,547	156,824	3	9,592	19,948,404	9	231	20,382,084	5,937	29,585
Arkansas	------	------	------	1,400	------	37	------	------	------	------	------	------	------	------	------	1,400	------	37
California	1,720	70	7	14	------	1	55	7	10	------	------	------	19,462	26	286	21,251	103	304
Colorado	1,026	26	------	18	------	1	338,975	7,037	28,077	522,419	10,466	14,505	34,233	226	64	896,671	17,755	42,647
Idaho	165,561	15,997	1,315	[2]	------	------	[2] 871,185	51,839	53,137	------	------	------	459,909	3,640	3,843	1,496,655	71,476	58,295
Illinois	------	------	------	594,102	1,205	18,425	------	------	------	------	------	------	371,439	2,225	8,370	965,541	3,430	26,795
Kansas	33,110	812	------	17,959	56	1,169	49,030	581	1,277	------	------	------	------	------	------	100,099	1,449	2,446
Kentucky	------	------	------	------	------	------	------	------	------	------	------	------	89,994	656	1,147	89,994	656	1,147
Missouri	[3] 5,241,079	98,785	5,821	1,700	------	26	------	------	------	[3]	------	------	------	------	------	5,242,779	98,785	5,847
Montana	12,747	1,058	250	132,072	870	3,929	361	65	18	------	------	------	114,117	650	6,065	259,297	2,643	10,262
Nevada	3,778	451	75	283	11	70	376	16	38	------	------	------	12,061,943	1,313	270	12,066,380	1,791	453
New Mexico	88	7	------	[2] 313,238	2,134	22,845	[2]	------	------	------	------	------	7,437,294	191	55	7,750,620	2,332	22,900
Oklahoma	11,117	291	15	56,540	469	2,726	12,575	220	407	------	------	------	------	------	------	80,232	980	3,148
Tennessee	------	------	------	2,211,514	------	72,620	------	------	------	------	------	------	1,452,330	------	9,114	3,663,844	------	81,734
Utah	1,014	174	33	924	11	121	476,857	39,414	32,441	10,183	381	581	208,696	914	4,063	697,674	40,894	37,239
Washington	6	2	------	------	------	------	981,646	8,032	20,215	------	------	------	5,494	19	2	987,146	8,053	20,217
Wisconsin	------	------	------	465,506	680	13,865	------	------	------	------	------	------	------	------	------	465,506	680	13,865
New York						10,238		879	44,525								879	54,763
New Jersey						112		------	------								------	112
North Carolina	------	------	------	734,018	------	------	1,153,683	------	------	------	------	------	307,253	318	------	2,194,954	318	------
Pennsylvania						23,428		------	------								------	23,428
Virginia						6,577		3,733	22,586								3,733	29,163
Other States	------	------	------	------	------	------	------	------	------	------	------	------	491	27	3	491	27	3
Total	5,472,496	117,747	7,521	4,544,347	5,436	178,400	4,145,290	117,674	220,278	689,426	10,850	24,678	42,511,059	10,214	33,513	57,362,618	261,921	464,390

[1] Lead and zinc recovered from other ores (copper, gold, silver, etc.) and from mill slags, tailings, and dumps.
[2] Zinc and lead-zinc combined to avoid disclosing individual company confidential data.
[3] Lead and copper-lead combined to avoid disclosing individual company confidential data.

production and consumption, with the attendant low lead metal price, tended to slow exploration; however, most or all of the mining firms were retaining their leases, and some were acquiring exploration rights in new areas.

The Bonne Terre mine of St. Joseph Lead Co., which started operating in 1864, closed in August because of low metal prices and exhaustion of commercial ore reserves; the company also closed its National mine for the same reasons. However, lead mine production of St. Joseph Lead Co. was kept nearly constant by new mine production from the Viburnum district. The second shaft of the Viburnum Project, No. 28, was completed and ready for production at yearend.

National Lead Co. closed its mine and mill at Fredricktown, Mo., on January 31.

Idaho again placed second as a lead-producing State. Mine output increased substantially over that of 1960 as production was uninterrupted by strikes, and was greater than it had been for several years. The Bunker Hill Co. operations were maintained at an accelerated pace for several months after the 7½-month labor strike of 1960; then in May production was reduced to a more normal level. The Bunker Hill Co. started an extensive and accelerated 5-year program of mine development. Most of the other mines in the Idaho Coeur d'Alene district maintained a stable rate of production; however, the Hercules mine of Day Mines, Inc., was allowed to fill partly with water because extensive exploration had not been successful.

Lead output of Utah was slightly more than in 1960. Deposits of lead ore, mainly in the Tintic and Park City districts, were being explored. Development by Bear Creek Mining Co., domestic exploration affiliate of Kennecott Copper Corp., of the newly discovered Tintic lead-zinc-silver ore body, was reported to have proven about 1.5 million tons of high grade ore. In United Park City Mines Co. Daly Judge mine, a high-grade silver-lead-copper-zinc ore body was found. Grand Deposit Mining Co. encountered a high-grade silver-lead-copper-zinc ore body below the Wasatch drainage tunnel in the Alta district near Salt Lake City. Regular production of 70 to 100 tons per day of lead-zinc-copper ore came from the section of the Ophir Hill mine, explored under a DMEA contract by McFarland and Hullinger of Tooele, Utah.

Output of lead from mines in Colorado remained nearly the same as in 1960. The Silverton Project of Standard Metals Corp., to open the Shenandoah-Dives and Sunnyside mines, continued as planned.

TABLE 4.—Mine production of recoverable lead in the United States, by months

(Short tons)

Month	1960	1961	Month	1960	1961
January	21,423	23,305	August	19,857	23,011
February	22,776	20,948	September	18,268	20,822
March	25,690	24,681	October	18,339	21,327
April	24,105	22,098	November	19,089	20,405
May	20,871	22,867	December	20,152	19,792
June	19,686	23,070			
July	16,413	19,595	Total	246,669	261,921

The low-level American Tunnel was completed, and connections were made with the workings of the Sunnyside. The tunnel encountered three new veins containing ore deposits; exploration was started to evaluate these bodies and to prepare the known ore bodies of the Sunnyside for production. The Leadville smelter, American Smelting and Refining Co., closed and was dismantled; this ended an important period of Colorado mining history. The Eagle mine of The New Jersey Zinc Co. at Gilman, the San Miguel property of Idarado Mining Co., the Emperius Mining Co. operation at Creede, the mines of Rico Argentine Mining Co. at Rico, and the Camp Bird mine near Ouray, of Camp Bird Colorado, Inc., continued producing and were significant contributors to the Colorado lead output.

The Iron King mine of Shattuck-Denn Mining Corp. again was the leading lead-producing mine in Arizona. The Flux mine in the Harshaw district and the Pride of the West mine in the Duquesne district yielded lead-containing ores that were treated in the Trench concentrator of the Harshaw district.

The Pend Oreille mine of Pend Oreille Mines and Metals Co. and the Grandview mine of American Zinc, Lead and Smelting Co. remained the leading lead-producing mines in Washington. Superior

TABLE 5.—Twenty-five leading lead-producing mines in the United States in 1961, in order of output

Rank	Mine	District or region	State	Operator	Source of lead
1	Federal	Southeastern Missouri.	Missouri	St. Joseph Lead Co.	Lead ore.
2	Bunker Hill	Coeur d'Alene	Idaho	The Bunker Hill Co.	Lead-zinc ore.
3	United States & Lark.	West Mountain (Bingham).	Utah	United States Smelting, Refining and Mining Co.	Lead-zinc, gold-silver ore.
4	Leadwood	Southeastern Missouri.	Missouri	St. Joseph Lead Co.	Lead ore.
5	Viburnum	do	do	do	Do.
6	Indian Creek	do	do	do	Lead-copper ore.
7	Lucky Friday	Coeur d'Alene	Idaho	Lucky Friday Silver-Lead Mines Co.	Lead ore.
8	Star	do	do	The Bunker Hill Co.	Lead-zinc ore.
9	Idarado	Upper San Miguel.	Colorado	Idarado Mining Co.	Copper-lead-zinc ore.
10	Page	Coeur d'Alene	Idaho	American Smelting and Refining Company.	Lead-zinc ore.
11	Pend Oreille	Metaline	Washington	Pend Oreille Mines and Metals Co.	Do.
12	Bonne Terre	Southeastern Missouri.	Missouri	St. Joseph Lead Co.	Lead ore.
13	United Park City	Blue Ledge	Utah	United Park City Mines Co.	Lead-zinc ore.
14	Iron King	Big Bug	Arizona	Shattuck-Denn Mining Corp.	Do.
15	Eagle	Red Cliff (Battle Mountain).	Colorado	The New Jersey Zinc Co.	Copper, lead-zinc ore.
16	Austinville and Ivanhoe Mines.	Austinville	Virginia	do	Zinc-lead ore.
17	Mayflower Unit	Blue Ledge	Utah	New Park Mining Co.	Lead-zinc ore.
18	Camp Bird	Sneffels	Colorado	Camp Bird Colorado, Inc.	Copper-lead-zinc ore.
19	Sunshine	Coeur d'Alene	Idaho	Sunshine Mining Co.	Silver ore.
20	Emperius	Creede	Colorado	Emperius Mining Co.	Lead-zinc ore.
21	Grandview	Metaline	Washington	American Zinc, Lead and Smelting Co.	Do.
22	Linchburg Group	Magdalena	New Mexico	The New Jersey Zinc Co.	Do.
23	Gray	Upper Mississippi Valley.	Illinois	Tri-State Zinc Co.	Zinc ore.
24	Three Kids	Las Vegas	Nevada	Manganese, Inc.	Lead residue.
25	Ophir Unit	Ophir	Utah	United States Smelting, Refining and Mining Co.	Lead-zinc, silver ore.

Mining and Dredging Co. started exploration and development of the Electric Point and Bechtol mines in Stevens County; satisfactory results of exploration may result in lead production from these mines.

Montana lead production remained low throughout the year, largely because of the continued inactivity of The Anaconda Co. zinc mines in Butte.

New Mexico lead production increased 17 percent over that of 1960 to 2,300 tons, resulting from additional output at the Hanover and Linchburg mines operated by The New Jersey Zinc Co.

The 4 percent of U.S. lead output from States east of the Mississippi River was recovered largely as a byproduct of zinc mining. California, Nevada, Kansas, and Oklahoma produced a total of 4,300 tons, almost 2 percent of the U.S. output.

The 25 leading lead-producing mines in the United States in 1961 accounted for 92 percent of total domestic output; the 10 leading mines yielded 75 percent, and the 4 largest mines 47 percent.

SMELTER AND REFINERY PRODUCTION

Refined lead was produced in the United States from domestic and foreign sources at primary refineries that mainly treated base bullion, small quantities of scrap, and intermediate primary smelter products. Some antimonial (hard) lead was produced at primary refineries. The principal product of secondary smelter-refineries was antimonial lead because a large portion of the market was for storage battery lead, and the major secondary smelter feed source was from easily reclaimed battery scrap. Refined pig lead and lead-tin and other alloys formed 31 and 69 percent, respectively, of total secondary lead production.

Three smelters, five combination smelter-refineries, and two refineries comprised the primary lead production facilities in the United States. The Leadville, Colo. (Arkansas Valley) smelter of American Smelting and Refining Co., which had operated nearly continuously since its construction in 1879, closed in January 1961 and was dismantled.

A list of domestic primary lead smelters and refineries can be found in the Lead chapter of the 1960 Minerals Yearbook. The only change is deletion of Leadville (Arkansas Valley) smelter of American Smelting and Refining Co. Major secondary smelting firms that report to the Bureau of Mines are listed:

American Smelting and Refining Co. (including Federated Metals Division) plants:
- Los Angeles, San Francisco, and Selby, Calif.
- Whiting, Ind.
- Omaha, Nebr.
- Newark and Perth Amboy, N.J.
- Houston, Tex.

Bers & Co., Inc., Philadelphia, Pa.
The Bunker Hill Co., Seattle, Wash.
Continental Smelting & Refining Co., McCook, Ill.
Electric Storage Battery Co., Philadelphia, Pa.
Goldsmith Bros. Division of National Lead Co., Chicago, Ill.
Gopher Smelting & Refining Co., St. Paul, Minn.
Imperial Type Metals Co. plants: Chicago, Ill., and Philadelphia, Pa.
Industrial Metal Melting Co., Inc., Baltimore, Md.
Inland Metals Refining Co., Chicago, Ill.

Nassau Smelting & Refining Co., Inc., Tottenville, N.Y.
National Lead Co. (including Magnus Metal Division, Morris P. Kirk & Son, Inc., and Master Metals, Inc.) plants:
Los Angeles, Calif.
Atlanta, Ga.
Chicago and Granite City, Ill.
Indianapolis, Ind.
Topeka, Kans.
Baltimore, Md.
Boston and Fitchburg, Mass.
St. Louis Park, Minn.
St. Louis, Mo.
Fremont and Omaha, Nebr.
Perth Amboy, N.J.
Depew, N.Y.
Cincinnati and Cleveland, Ohio.
Portland, Oreg.
Pittsburgh, Pa.
Dallas and Houston, Tex.
National Metal & Smelting Co., Fort Worth, Tex.
North American Smelting Co., Wilmington, Del.
Price Battery Corp., Hamburg, Pa.
Revere Smelting & Refining Co., Newark, N.J.
Schuylkill Products Co., Baton Rouge, La.
Southeastern Lead Co., Tampa, Fla.
Southern Lead Co., Dallas, Tex.
United States Smelting Lead Refinery, Inc., East Chicago, Ind.
Hyman Viener & Sons, Richmond, Va.
Western Lead Products Co., City of Industry, Calif.
Winston Lead Smelting Co., Winston-Salem, N.C.

Refined Lead—Primary and Secondary.—Domestic primary lead smelters and refineries produced 451,100 tons of refined lead and 33,200 tons of lead in antimonial lead. Lead content of primary raw materials consumed for this production was 503,800 tons, and that of scrap was 8,800 tons.

Domestic ores were the source of 64 percent of the refined lead produced from primary sources; in 1960 this percentage was 60. Foreign ores and bullion supplied the remainder.

Primary lead smelters also produced 1,569 tons of refined lead from scrap, and secondary smelters 139,100 tons of lead metal from scrap. Refined and remelt lead produced from all sources was 590,200 tons.

Antimonial Lead—Primary and Secondary.—Antimonial lead production at primary and secondary smelters was 245,300 tons with a

TABLE 6.—Refined lead produced at primary refineries in the United States, by source material

(Short tons)

	1952–56 (average)	1957	1958	1959	1960	1961
Refined lead:						
From primary sources:						
Domestic ores and base bullion	340,792	347,675	269,082	225,270	228,899	288,078
Foreign ores	148,821	185,798	200,299	115,616	153,537	161,487
Foreign base bullion	171	60	775	45		
Total	489,784	533,533	470,156	340,931	382,436	449,565
From secondary sources	4,099	3,263	2,338	1,194	4,776	1,569
Grand total	493,883	536,796	472,494	342,125	387,212	451,134
Average sales price per pound	$0.147	$0.143	$0.117	$0.115	$0.117	$0.103
Calculated value of primary refined lead thousands [1]	$143,996	$152,590	$110,017	$78,414	$89,490	$92,610

[1] Excludes value of refined lead produced from scrap at primary refineries.

lead content of 230,500 tons; 33,200 tons from primary smelters, and 197,300 tons from secondary smelters. Scrap was the source of 25 percent of primary smelter output (mostly battery-lead plates); 39 percent came from domestic ores, and 36 percent came from foreign ores. Battery-lead plates accounted for 61 percent of the total lead-base scrap melted, and the major product from smelting scrap was antimonial lead.

Other Secondary Lead.—Lead-base, copper-base and tin-base scrap were the source materials for recovering 452,800 tons of secondary lead, a 4-percent decrease from that of 1960. Secondary lead smelters recovered 91 percent of the total in 230 plants; primary lead smelters 2 percent in 4 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		Lead content by difference (short tons)			
		Short tons	Percent	From domestic ore	From foreign ore	From scrap	Total
1952–56 (average)	62,264	3,871	6.3	8,099	8,060	42,234	58,393
1957	67,786	3,064	4.5	10,271	9,599	44,852	64,722
1958	50,246	2,803	5.6	8,256	8,190	30,997	47,443
1959	37,487	1,924	5.1	6,447	5,955	23,161	35,563
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

TABLE 8.—Stocks and consumption of new and old lead scrap in the United States in 1961

(Short tons, gross weight)

Class of consumers and type of scrap	Stocks Jan. 1 [1]	Receipts	Consumption			Stocks Dec. 31
			New scrap	Old scrap	Total	
Smelters and refiners:						
Soft lead	3,479	49,883	----------	50,717	50,717	2,645
Hard lead	952	16,053	----------	15,661	15,661	1,344
Cable lead	1,654	30,527	----------	30,278	30,278	1,903
Battery-lead plates	18,102	357,851	----------	359,835	359,835	16,118
Mixed common babbitt	1,144	4,923	----------	5,692	5,692	375
Solder and tinny lead	434	8,375	----------	8,579	8,579	230
Type metals	1,794	24,226	----------	24,723	24,723	1,297
Drosses and residues	18,052	80,240	82,099	--------	82,099	16,193
Total	45,611	572,078	82,099	495,485	577,584	40,105
Foundries and other manufacturers:						
Soft lead	91	460	136	327	463	88
Hard lead	181	214	4	188	192	203
Cable lead	86	155	----------	139	139	102
Battery-lead plates	55	618	----------	507	507	166
Mixed common babbitt	271	8,305	----------	8,297	8,297	279
Solder and tinny lead	4	91	42	50	92	3
Type metals	----------	----------	----------	----------	----------	----------
Drosses and residues	328	47	----------	----------	----------	375
Total	1,016	9,890	182	9,508	9,690	1,216
Grand total:						
Soft lead	3,570	50,343	136	51,044	51,180	2,733
Hard lead	1,133	16,267	4	15,849	15,853	1,547
Cable lead	1,740	30,682	----------	30,417	30,417	2,005
Battery-lead plates	18,157	358,469	----------	360,342	360,342	16,284
Mixed common babbitt	1,415	13,228	----------	13,989	13,989	654
Solder and tinny lead	438	8,466	42	8,629	8,671	233
Type metals	1,794	24,226	----------	24,723	24,723	1,297
Drosses and residues	18,380	80,287	82,099	----------	82,099	16,568
Total	46,627	581,968	82,281	564,993	587,274	41,321

[1] Revised figures.

TABLE 9.—Secondary metal recovered [1] from lead and tin scrap in the United States in 1961, by type of products

(Short tons, gross weight)

	Lead	Tin	Antimony	Other	Total
Refined pig lead	110,422				110,422
Remelt lead	30,247				30,247
Total	140,669				140,669
Refined pig tin		3,016			3,016
Remelt tin		347			347
Total		3,363			3,363
Lead and tin alloys:					
Antimonial lead	205,569	435	12,418	238	218,660
Common babbitt	14,715	830	1,730	113	17,388
Genuine babbitt	57	322	31	14	424
Solder	23,264	5,395	343	43	29,045
Type metals	30,362	1,757	4,561	7	36,687
Cable lead	24,726	55	244		25,025
Miscellaneous alloys	1,209	531	139	91	1,970
Total	299,902	9,325	19,466	506	329,199
Composition foil					
Tin content of chemical products		1,144			1,144
Grand total	440,571	13,832	19,466	506	474,375

[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)

	1952–56 (average)	1957	1958	1959	1960	1961
As refined metal:						
At primary plants	4,099	3,263	2,338	1,194	4,776	1,569
At other plants	125,580	123,308	113,719	124,185	143,443	139,100
Total	129,679	126,571	116,057	125,379	148,219	140,669
In antimonial lead:						
At primary plants	42,235	44,852	30,997	23,161	26,270	8,220
At other plants	197,491	195,299	151,956	181,185	179,217	197,349
Total	239,726	240,151	182,953	204,346	205,487	205,569
In other alloys	120,147	122,507	102,777	121,662	116,197	106,554
Grand total:						
Quantity	489,552	489,229	401,787	451,387	469,903	452,792
Value (thousands)	$143,957	$139,919	$94,018	$103,819	$109,957	$93,275

TABLE 11.—Lead recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

Kind of scrap	1960	1961
New scrap:		
Lead-base	55,856	56,808
Copper-base	5,214	4,981
Tin-base	436	465
Total	61,506	62,254
Old scrap:		
Battery-lead plates	255,879	240,896
All other lead-base	134,011	132,495
Copper-base	18,502	17,142
Tin-base	5	5
Total	408,397	390,538
Grand total	469,903	452,792

Form of recovery	1960	1961
As soft lead:		
At primary plants	4,776	1,569
At other plants	143,443	139,100
Total	148,219	140,669
In antimonial lead [1]	205,487	205,569
In other lead alloys	101,258	94,276
In copper-base alloys	14,897	12,221
In tin-base alloys	42	57
Total	321,684	312,123
Grand total	469,903	452,792

[1] Includes 26,270 tons of lead recovered in antimonial lead from secondary sources at primary plants in 1960 and 8,220 tons in 1961.

CONSUMPTION AND USES

According to the Federal Reserve Board, industrial activity, which had declined steadily through 1960, began 1961 on a low ebb and rose consistently all year to a December level 13 percent higher than the previous yearend; however, lead metal production was comparatively high for the first 4 months, decreased markedly during the second 4 months, and then rose substantially in the last 4 months. Producer stocks increased sharply during the first months, decreased during midyear, then rose again during the last 4 months. Total production increased 8 percent over 1960 to 927,300 tons, consumption increased slightly to 1,027,200 tons, producer and consumer stock inventories rose 4 percent to a new high of 361,200 tons, and prices dropped to a 15-year low in November because of an imbalance between production and consumption. Consumption decreased for 15 of the 25 major uses tabulated by the Bureau of Mines. Lead consumption in three of the largest uses increased over 1960 as follows: batteries, 4 percent; tetraethyl lead, 4 percent; and calking lead, 1 percent. Use in red lead and in cable covering decreased 4 and 5 percent, respectively.

Soft lead, primary and secondary, accounted for 65 percent of the total consumed, 26 percent was lead content of antimonial lead, 4 percent was lead in alloys, 1 percent was lead in copper-base scrap, 3.5 percent was lead content of scrap that went directly to an end product, and 0.5 percent was lead recovered from ore in producing leaded zinc oxide and other pigments. Consumption varied greatly in the first 7 months from a low of 72,300 tons in July to a high of 89,700 tons in May, showing no distinguishable trend. Consumption in the last 5 months was unusually constant, varying only from a low of 89,700 tons in September to a high of 93,500 in October.

Of the lead consumed during the year, 71 percent was used in metal products of which the major item was storage batteries using antimonial lead for grids and posts and soft lead for oxides (36 percent of all lead consumed). Tetraethyl lead, 98 percent of the chemicals classification, accounted for 17 percent of total lead consumption. Lead pigments accounted for 9 percent of lead consumption, and 76 percent of that was for the manufacture of red lead and litharge. Batteries and tetraethyl lead were related directly to the automobile industry; together they represented 53 percent of total lead consumption.

The Association of Battery Manufacturers, Inc., reported shipments of 28,276,000 units of replacement batteries or 7 percent more than in 1960, almost 3 percent more than the previous battery shipment record in 1959.

Nine States accounted for 73 percent of the total lead consumed (excluding scrap), as follows: New Jersey, 15 percent; Louisiana and Texas together, 13 percent; California, 10 percent; Illinois, 10 percent; Indiana, 9 percent; Pennsylvania, 6 percent; Missouri, 5 percent; and New York, 5 percent.

TABLE 12.—Lead consumption in the United States, by products

(Short tons)

Product	1960	1961	Product	1960	1961
Metal products:			Pigments—Continued		
Ammunition	43,577	45,837	Pigment colors	11,445	11,273
Bearing metals	20,717	17,757	Other [1]	3,763	3,914
Brass and bronze	20,485	20,114	Total	98,541	94,824
Cable covering	60,350	57,458			
Calking lead	66,527	67,379	Chemicals:		
Casting metals	7,023	6,873	Tetraethyl lead	163,826	169,802
Collapsible tubes	8,705	11,220	Miscellaneous chemicals	2,806	2,588
Foil	3,684	2,968	Total	166,632	172,390
Pipes, traps, and bends	22,119	19,098			
Sheet lead	26,607	28,102	Miscellaneous uses:		
Solder	60,013	54,838	Annealing	5,153	5,066
Storage batteries:			Galvanizing	1,383	1,444
Antimonial lead	175,458	186,028	Lead plating	218	243
Lead oxides	177,738	181,970	Weights and ballast	9,045	8,890
Terne metal	1,765	965	Total	15,799	15,643
Type metal	28,159	26,693	Other, unclassified uses	17,273	17,059
Total	722,927	727,300	Grand total [2]	1,021,172	1,027,216
Pigments:					
White lead	8,432	7,615			
Red lead and litharge	74,901	72,022			

[1] Includes lead content of leaded zinc oxide and other pigments and chemicals.
[2] Includes lead which went directly from scrap to fabricated products.

TABLE 13.—Lead consumption in the United States, by months

(Short tons)

Month	1960	1961	Month	1960	1961
January	86,781	83,579	August	90,069	91,150
February	84,563	79,586	September	86,640	89,735
March	91,055	83,266	October	85,806	93,504
April	83,011	78,201	November	83,022	90,020
May	90,321	89,679	December	77,263	89,664
June	87,197	86,520			
July	75,444	72,312	Total [1]	1,021,172	1,027,216

[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 1961, 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	198,017	74,175	36,957	14,515	323,664
Storage batteries	186,030	181,954	14	----	367,998
Pigments	90,909	126	----	----	91,035
Chemicals	171,921	----	----	----	171,921
Miscellaneous	9,390	6,161	92	----	15,643
Unclassified	13,778	1,484	853	----	16,115
Total	670,045	263,900	37,916	14,515	[1] 986,376

[1] Excludes 36,583 tons of lead that went directly from scrap to fabricated products and 4,257 tons of lead contained in leaded zinc oxide and other pigments and chemicals.

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TABLE 15.—Lead consumption in 1961, by States [1]

(Short tons)

State	Refined soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
California	69,902	25,165	2,041	863	97,971
Colorado	1,809	1,705	126	----	3,640
Connecticut	14,285	11,838	23	857	27,003
District of Columbia	99	12	----	----	111
Florida	1,888	3,460	----	----	5,348
Illinois	58,530	31,385	6,206	1,717	97,838
Indiana	51,526	31,784	2,253	630	86,193
Kansas	7,176	10,295	14	391	17,876
Kentucky	6	3,161	3	----	3,170
Maryland	5,843	13,328	509	----	19,680
Massachusetts	6,123	4,118	450	355	11,046
Michigan	11,369	10,995	1,335	674	24,373
Missouri	47,879	2,863	132	1,147	52,021
Nebraska	9,901	2,964	[2]	210	13,075
New Jersey	114,790	20,169	9,075	659	144,693
New York	35,374	4,936	7,437	931	48,678
Ohio	11,604	4,266	2,777	1,136	19,783
Pennsylvania	35,121	20,716	640	2,237	58,714
Rhode Island	2,657	299	----	----	2,956
Tennessee	261	7,831	215	289	8,596
Virginia	2,438	1,102	496	746	4,782
Washington	7,830	4,220	----	----	12,050
West Virginia	13,841	4,480	2	----	18,323
Wisconsin	733	3,007	95	143	3,978
Alabama,[3] Georgia, and Mississippi	28,091	10,777	1,496	569	40,933
Arkansas and Oklahoma	3,096	2,642	22	----	5,760
Hawaii and Oregon	749	2,338	20	258	3,365
Iowa and Minnesota	1,073	6,821	746	159	8,799
Louisana and Texas	113,909	12,533	1,462	339	128,243
Montana and Idaho	9,235	----	----	----	9,235
New Hampshire, Maine and Delaware	2,387	571	336	203	3,497
North and South Carolina	15	2,923	----	----	2,938
Utah, Nevada, and Arizona	98	588	----	----	686
Undistributed	407	608	5	2	1,022
Total	670,045	263,900	37,916	14,515	986,376

[1] Excludes 36,583 tons of lead which went directly from scrap to fabricated products and 4,257 tons of lead contained in leaded zinc oxide and other nonspecified pigments.
[2] Included with "Undistributed" to avoid disclosing individual company confidential data.
[3] The following States are grouped to avoid disclosing individual company confidential data.

LEAD PIGMENTS [4]

Production of lead pigments declined slightly in 1961. Activity of major lead-pigment-consuming industries varied as follows: Production of automobiles and trucks decreased 15 percent, the value of public and private construction increased less than 1 percent, paint sales decreased slightly, production of natural and synthetic rubber decreased 5 percent, and lead battery production rose 2 percent.

Production.—Lead consumed by manufacturers to produce lead pigments was 270,300 tons, compared with 268,000 tons during 1960.

All the white lead, red lead, and litharge pigments as well as the 147,100 tons of black oxide were made from refined lead and represented 99 percent of the 270,300 tons of lead used. The remaining 1 percent was consumed in the form of lead ore to produce leaded zinc oxide. Basic lead sulfate production is withheld to avoid disclosing individual company confidential data. Lead silicate, a derivative of litharge, is included with litharge.

[4] Prepared by Richard N. Spencer, commodity specialist, and Esther B. Miller, statistical assistant, Division of Minerals.

Consumption and Uses.—*White Lead.*—Shipments of white lead decreased 10 percent. The paint-making industry used 74 percent of the white lead, and the ceramic industry used 1 percent. A substantial part of the remaining 25 percent was used also in the paint industry; however, other uses for white lead were in chemicals, greases, plasticizers and stabilizers for plastics.

Basic Lead Sulfate.—Most lead sulfate was used in making leaded zinc oxide, but to avoid disclosing individual company confidential data, production figures are withheld.

Red Lead.—The paint industry used 56 percent of red lead consumed, compared with 57 percent in 1960. Other uses were in colors, lubricants, petroleum, rubber, and miscellaneous categories.

Orange Mineral.—No consumption was reported.

Litharge.—To avoid disclosing individual company confidential data, a large percentage (79 percent) of litharge shipped to industry is found 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 accounted for the remainder. Battery makers produced 147,100 tons of leaded litharge, known to the trade as black oxide or gray suboxide; this black oxide forms the basis of the lead paste filling for the interstices of battery plates.

Prices.—The quoted price of white lead ranged from 18 cents per pound ($360 a ton) down to 16.5 cents ($330 a ton) in carlots in 1961. The average value of shipments of dry white lead was $419 a ton, up $11 from 1960; white lead in oil averaged $470 per ton, up $15 from 1960. The quoted price of red lead ranged from 14.75 cents per pound to 13.75 cents, or $295 a ton to $275 a ton, in less than carlots; the average value of red lead shipments decreased $10 to $292 a ton. The quoted price of litharge ranged from 14.25 cents to 13.25 cents per pound, or $285 to $265 a ton, in less than carlots; average value of shipments decreased $32 to $241 per ton.

TABLE 16.—Production and shipments of lead pigments [1] in the United States

Pigment	1960				1961			
	Production (short tons)	Shipments			Production (short tons)	Shipments		
		Short tons	Value [2]			Short tons	Value [2]	
			Total	Average per ton			Total	Average per ton
White lead:								
Dry	11,409	11,770	$4,805,726	$408	10,354	10,523	$4,407,280	$419
In oil [3]	6,115	6,172	2,810,238	455	5,892	5,700	2,679,785	470
Total	17,524	17,942	7,615,964	-------	16,246	16,223	7,087,065	-------
Red lead	22,518	22,631	6,843,301	302	22,708	22,856	6,675,990	292
Litharge	98,786	98,640	26,951,157	273	98,817	98,950	23,841,808	241
Black oxide	139,847	----------	----------	-------	147,136	----------	----------	-------

[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] produced by domestic manufacturers, by sources

(Short tons)

Pigment	1960				1961			
	Lead in pigments produced from—			Total lead in pigments	Lead in pigments produced from—			Total lead in pigments
	Ore		Pig lead		Ore		Pig lead	
	Domestic	Foreign			Domestic	Foreign		
White lead			14,019	14,019			12,997	12,997
Red lead			20,491	20,491			20,664	20,664
Litharge			96,810	96,810			91,900	91,900
Black oxide			133,638	133,638			140,973	140,973
Leaded zinc oxide	2,355	667		3,022	2,717	1,071		3,788
Total	2,355	667	264,958	267,980	2,717	1,071	266,534	270,322

[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	1952–56 (average)	1957	1958	1959	1960	1961
Paints	20,659	19,253	15,288	15,148	14,145	12,086
Ceramics	694	667	268	243	219	141
Other	4,592	[2] 3,654	[2] 2,804	[2] 3,833	[2] 3,578	3,996
Total	25,945	23,574	18,360	19,224	17,942	16,223

[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	1952–56 (average)	1957	1958	1959	1960	1961
Paints	13,785	15,993	13,726	12,098	12,903	12,895
Storage batteries	12,357	(1)	(1)	(1)	(1)	(1)
Ceramics	987	(1)	(1)	(1)	328	(1)
Other	2,205	11,005	8,266	9,807	9,400	9,961
Total	29,334	26,998	21,992	21,905	22,631	22,856

[1] Included with "Other."

TABLE 20.—Distribution of litharge shipments, by industries

(Short tons)

Industry	1952–56 (average)	1957	1958	1959	1960	1961
Ceramics	19,585	18,071	(1)	15,340	15,753	14,393
Chrome pigments	6,223	3,955	3,731	4,682	(1)	(1)
Floor covering	(1)	(1)	(1)	(1)	(1)	(1)
Insecticides	(1)	(1)	(1)	(1)	(1)	(1)
Oil refining	3,915	3,359	2,598	3,096	2,371	2,147
Rubber	2,064	1,298	1,247	1,808	1,373	1,243
Storage batteries	93,680	(1)	(1)	(1)	(1)	(1)
Varnish	4,485	3,227	3,223	4,725	3,471	3,394
Other	13,094	76,878	81,366	76,362	75,672	77,773
Total	143,046	106,788	92,165	106,013	98,640	98,950

[1] Included with "Other."

Foreign Trade.—Imports of lead pigments and salts increased 8 percent in value and 15 percent in quantity, compared with 1960. Imports of white lead increased 25 percent over 1960, red lead imports decreased 15 percent, litharge imports increased 15 percent, no imports occurred in the classification "other lead pigments," and imports of other lead compounds increased 45 percent.

Exports of lead pigments increased 8 percent in value and 9 percent in quantity, compared with 1960, while exports of lead arsenate decreased 48 percent in value and 51 percent in quantity.

TABLE 21.—U.S. imports for consumption of lead pigments and compounds

Kind	1960		1961	
	Short tons	Value (thousands)	Short tons	Value (thousands)
White lead	1,497	$461	1,872	$535
Red lead	537	111	457	88
Litharge	13,371	2,581	15,390	2,791
Other lead pigments	23	9		
Other lead compounds	301	62	436	84
Total	15,729	3,224	18,155	3,498

Source: Bureau of the Census.

TABLE 22.—U.S. exports of lead pigments and compounds

Kind	1960		1961	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Lead pigments [1]	2,118	$705	2,302	$764
Lead arsenate	944	355	464	183
Total	3,062	1,060	2,766	947

[1] Includes white lead, red lead, and litharge.

Source: Bureau of the Census.

STOCKS

Stocks of refined lead at primary producing plants increased substantially through April; then a decline began, continuing from May through August. An increase in stocks that began in September continued through the remainder of the year; the net increase of refined lead stocks at yearend amounted to 46,800 tons. Total yearend stocks, representing physical inventories at plants irrespective of ownership but not including material in process or in transit, were 262,100 tons compared with 250,100 at the close of 1960.

Stocks reported by the American Bureau of Metal Statistics showed an additional 19,700 tons of bullion was in process at, or in transit to, refineries, and about 26,300 tons of ore was in process at smelters—making a total of 308,100 tons of primary raw materials in stocks at these plants.

Consumer and secondary smelter stocks of lead decreased from 97,300 tons on December 31, 1960 to 94,800 tons on March 31, increased to 106,400 tons on June 30 and to 107,700 tons on September 30, then dropped to 99,100 tons on December 31, 1961. The yearend stocks were 2 percent more than in 1960.

On December 31 the total lead inventory of all Government stockpiles was 1,302,000 tons including 1,050,000 tons in the national (strategic) stockpile, and 244,000 tons in the CCC and Supplemental stockpiles. Government lead stockpile inventories on December 31 were 355.2 percent over maximum stockpile objectives.

TABLE 23.—Stocks of lead at primary smelters and refineries in the United States, Dec. 31

(Short tons)

Stocks	1952-56 (average)	1957	1958	1959	1960	1961
Refined pig lead	45,495	74,194	176,098	107,683	148,415	195,200
Lead in antimonial lead	11,695	11,079	11,811	11,361	10,483	10,354
Lead in base bullion	13,734	8,855	9,485	12,840	26,025	16,978
Lead in ore and matte	39,096	49,788	36,896	39,195	65,219	39,570
Total	110,020	143,916	234,290	171,079	250,142	262,102

TABLE 24.—Consumer stocks of lead in the United States, Dec. 31, by types of material

(Short tons, lead content)

Year	Refined soft lead	Antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
1957	80,708	39,375	7,651	1,576	129,310
1958	76,924	37,511	7,056	1,409	122,900
1959	80,277	38,688	6,435	1,096	126,496
1960	49,725	39,230	7,216	1,097	97,268
1961	55,951	33,633	8,298	1,258	99,140

TABLE 25.—Average monthly and yearly quoted prices of lead at St. Louis, New York, and London [1]

(Cents per pound)

Month	1960			1961		
	St. Louis	New York	London [2]	St. Louis	New York	London [2]
January	11.80	12.00	9.35	10.80	11.00	7.99
February	11.80	12.00	9.24	10.80	11.00	8.17
March	11.80	12.00	9.55	10.80	11.00	8.24
April	11.80	12.00	9.72	10.80	11.00	8.38
May	11.80	12.00	9.70	10.80	11.00	8.31
June	11.80	12.00	9.18	10.80	11.00	8.06
July	11.80	12.00	8.93	10.80	11.00	8.07
August	11.80	12.00	8.90	10.80	11.00	8.09
September	11.80	12.00	8.78	10.80	11.00	8.03
October	11.80	12.00	8.44	10.80	11.00	7.87
November	11.80	12.00	8.56	10.01	10.21	7.59
December	11.18	11.38	8.14	10.05	10.25	7.58
Average	11.75	11.95	9.04	10.67	10.87	8.03

[1] St. Louis: Metal Statistics, 1962, p. 469. New York: Metal Statistics, 1962, p. 463. London: E&MJ, Metal and Mineral Markets.

[2] Based on monthly rates of exchange by Federal Reserve Board.

PRICES

The quoted New York price for common lead was 11 cents a pound on January 1. This price held firm until November 1 when the price dropped to 10.5 cents per pound, on November 13 it dropped again to 10 cents, and on November 28 made a small gain to 10.25 cents, a price remaining in effect the remainder of the year. The average sales price for lead in the United States during the year was 10.3 cents per pound.

Quotations on the London Metal Exchange ranged from a high of £68.25 per long ton on May 9 (equivalent to 8.51 cents per pound U.S. currency—computed on the average monthly rate of exchange) to a low of £57.50 (7.23 cents per pound) on November 14. The quotation on December 29 was £60.25 per long ton (7.56 cents per pound), and the year average was £64.21 (8.03 cents per pound).

FOREIGN TRADE

Imports.—General imports of total lead were 14 percent more than 1960. Imports for consumption were 391,200 tons, an increase of 9 percent over 1960. Import quotas were filled for ore and concentrate, pigs, bars, and base bullion. Pigs and bars accounted for 63 percent of imports for consumption, ores and concentrates 35 percent, and scrap and bullion 2 percent. Mexico, Australia, Canada, Yugoslavia, Peru, and Spain, in that order, were the major suppliers of lead metal. The major suppliers of ores and concentrates were Peru, Canada, Union of South Africa, Australia, Bolivia, and Guatemala.

Exports.—Total lead exported was more than double that of 1960, amounting to 11,700 tons. All classes of exports increased substantially with scrap about double and ore, matte, and base bullion about three times that of 1960.

Tariff.—Import duties on pig lead and lead content of ores and concentrates remained unchanged at 1 1/16 cents and 3/4 cent a pound, respectively. Duties on scrap were the same as on pig lead.

TABLE 26.—U.S. imports [1] of lead, by countries

(Short tons, lead content)

Country	1952–56 (average)	1957	1958	1959	1960	1961
Ore, flue dust, and matte:						
North America:						
Canada	31,133	25,193	22,270	32,226	[2] 26,473	34,361
Greenland			5,276			
Guatemala	4,982	8,965	5,019	153	1,809	9,817
Honduras	1,809	2,955	3,581	3,639	4,906	5,512
Mexico	2,835	3,835	1,786	489	1,249	1,166
Other North America	27	113	45	195		
Total	40,786	41,061	37,977	36,702	[2] 34,437	50,856
South America:						
Bolivia	16,678	18,319	14,715	11,221	9,021	11,370
Chile	1,448	35	367	113	1,283	610
Colombia	521	1	851	570	[2] 705	722
Peru	39,837	55,756	70,757	36,777	[2] 36,300	28,970
Other South America	110	1,078	145	53	103	
Total	58,594	75,189	86,835	48,734	[2] 47,412	41,672
Europe	229	264	246	221	222	300

See footnotes at end of table.

TABLE 26.—U.S. imports [1] of lead, by countries—Continued

(Short tons, lead content)

Country	1952-56 (average)	1957	1958	1959	1960	1961
Ore, flue dust, and matte—Continued						
Asia:						
Philippines	2,489	783	1,169	310	[2] 228	238
Other Asia	146	246	317	25	504	----
Total	2,635	1,029	1,486	335	[2] 732	238
Africa:						
Morocco [3]	527	----	----	----	[2] 5,238	----
Union of South Africa	34,722	43,916	49,215	27,879	39,352	34,089
Other Africa	39	25	1	----	----	----
Total	35,288	43,941	49,216	27,879	[2] 44,590	34,089
Oceania: Australia	22,618	36,995	25,839	24,963	[2] 18,299	20,031
Total ore, flue dust, and matte	160,150	198,479	201,599	138,834	[2] 145,692	147,186
Base bullion:						
North America	207	----	8	34	254	362
South America	59	84	452	46	39	60
Europe	(4)	----	----	----	----	(4)
Asia	----	(4)	----	----	----	----
Total base bullion	266	84	460	80	293	422
Pigs and bars:						
North America:						
Canada	52,818	28,607	40,926	41,533	26,088	54,717
Mexico	115,846	102,504	122,864	86,827	69,930	81,328
Other North America	50	(4)	----	324	9	3
Total	168,714	131,111	163,790	128,684	96,027	136,048
South America:						
Peru	34,496	34,999	42,473	29,311	25,197	26,195
Other South America	173	1,601	146	----	----	----
Total	34,669	36,600	42,619	29,311	25,197	26,195
Europe:						
Belgium-Luxembourg	1,115	1,852	5,872	1,503	610	----
Germany, West	2,304	1,550	3,118	2,893	551	842
Spain	5,688	3,119	14,237	9,395	4,115	8,529
United Kingdom	1,582	2,666	8,836	988	7	----
Yugoslavia	43,770	40,262	36,789	32,731	30,027	30,347
Other Europe	3,102	2,584	2,139	4,872	1,388	----
Total	57,561	52,033	70,991	52,382	36,698	39,718
Asia	41	----	----	----	----	----
Africa: Morocco [3]	[5] [6] 9,432	9,018	10,537	[5] 5,384	[5] 1,328	----
Oceania: Australia	69,359	95,517	80,515	47,655	46,783	54,891
Total pigs and bars	339,776	324,279	368,452	263,416	206,033	256,852
Reclaimed, scrap, etc.:						
North America:						
Canada	4,587	2,558	1,908	2,251	4,059	1,441
Mexico	3,618	2,583	1,939	1,293	1,054	2,294
Other North America	1,298	652	420	245	160	45
Total	9,503	5,793	4,267	3,789	5,273	3,780
South America:						
Peru	199	4	48	(4)	----	----
Venezuela	416	----	----	----	----	----
Other South America	4	53	----	120	----	----
Total	619	57	48	120	----	----
Europe:						
Belgium-Luxembourg	179	----	7	----	----	----
Denmark	268	84	----	----	----	----
Germany, West	81	168	----	1	1	----
Netherlands	245	----	----	----	----	----
Other Europe	415	32	----	----	4	2
Total	1,188	284	7	1	5	2

See footnotes at end of table.

TABLE 26.—U.S. imports [1] of lead, by countries—Continued

(Short tons, lead content)

Country	1952–56 (average)	1957	1958	1959	1960	1961
Reclaimed, scrap, etc.—Continued						
Asia:						
Japan (including Nansei and Nanpo Islands)	77	----------	19	18	5	----------
Other Asia	84	----------	----------	----------	----------	----------
Total	161	----------	19	18	5	----------
Africa	3	----------	----------	----------	----------	----------
Oceania:						
Australia	1,389	3,079	2,229	4,351	2,355	1,160
Other Oceania	87	----------	----------	----------	----------	----------
Total	1,476	3,079	2,229	4,351	2,355	1,160
Total reclaimed, scrap, etc	12,950	9,213	6,570	8,279	7,638	4,942
Grand total	513,142	532,055	577,081	410,609	[2] 359,656	409,402

[1] Data are general imports; that is, they include lead imported for immediate consumption plus material entering the country under bond.
[2] Revised figure. [3] French Morocco before Jan. 1, 1957. [4] Less than 1 ton.
[5] Includes 90 tons from Northern Rhodesia in 1952–56 (average) and from the Federation of Rhodesia and Nyasaland, 1,052 tons in 1959, and 224 tons in 1960.
[6] 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	1952–56 (average)	1957	1958	1959	1960	1961
Ore, flue dust, and matte (lead content):						
North America:						
Canada	29,334	30,302	31,394	28,633	27,944	31,519
Greenland	----------	----------	5,276	----------	----------	----------
Guatemala	4,121	12,129	4,944	157	1,519	5,527
Honduras	1,169	6,108	3,577	3,649	4,457	4,803
Mexico	2,404	6,602	3,167	627	943	1,060
Other North America	95	16	12	8	----------	----------
Total	37,123	55,157	48,370	33,074	34,863	42,909
South America:						
Bolivia	14,002	14,874	22,501	10,822	10,581	10,470
Chile	4,696	1,758	88	113	27	401
Colombia	299	1,000	850	370	628	514
Peru	36,776	50,506	92,027	38,872	[2] 33,571	32,318
Other South America	293	676	465	56	103	----------
Total	56,066	68,814	115,931	50,233	[2] 44,910	43,703
Europe	213	----------	21	107	([3])	----------
Asia:						
Philippines	2,489	816	1,169	293	[2] 187	380
Other Asia	104	308	311	25	427	----------
Total	2,593	1,124	1,480	318	[2] 614	380
Africa:						
Morocco [4]	526	----------	----------	----------	[2] 5,238	----------
Union of South Africa	28,024	65,289	37,993	28,939	30,784	29,736
Other Africa	37	25	1	1,821	----------	----------
Total	28,587	65,314	37,994	30,760	[2] 36,022	29,736
Oceania:						
Australia	19,074	44,207	33,829	22,034	20,894	20,132
Other Oceania	32	----------	----------	----------	----------	----------
Total	19,106	44,207	33,829	22,034	20,894	20,132
Total ore, flue dust, and matte	143,688	234,616	237,625	136,526	[2] 137,303	136,860

See footnotes at end of table.

TABLE 27.—U.S. imports for consumption[1] of lead, by countries—Continued

(Short tons)

Country	1952–56 (average)	1957	1958	1959	1960	1961
Base bullion (lead content):						
North America	209	----------	8	34	254	134
South America	10	25	408	----------	39	102
Europe	(3)	----------	----------	----------	----------	(3)
Asia	----------	(3)	----------	----------	----------	----------
Oceania	534	----------	----------	----------	----------	----------
Total base bullion	753	25	416	34	293	236
Pigs and bars (lead content):						
North America:						
Canada	52,818	28,607	40,926	41,478	26,154	54,902
Mexico	113,968	99,208	117,938	82,762	[2] 73,748	71,289
Other North America	50	----------	----------	261	29	6
Total	166,836	127,815	158,864	124,501	[2] 99,931	126,197
South America:						
Peru	34,474	34,999	42,533	29,311	25,197	26,195
Other South America	173	1,601	146	----------	----------	----------
Total	34,647	36,600	42,679	29,311	25,197	26,195
Europe:						
Belgium-Luxembourg	1,115	1,852	4,604	1,569	1,733	41
Denmark	1,802	1,916	1,452	187	88	----------
Germany, West	2,304	1,550	3,008	2,613	654	911
Spain	5,688	3,119	9,505	11,270	6,056	8,775
United Kingdom	1,582	2,666	8,556	1,035	133	16
Yugoslavia	43,769	40,262	36,789	32,376	30,159	30,130
Other Europe	1,296	667	507	2,984	1,877	----------
Total	57,556	52,032	64,421	52,034	40,700	39,873
Asia	41	----------	----------	----------	----------	----------
Africa:						
Morocco[4]	[5] 9,342	9,018	9,760	5,032	1,243	4
Other Africa	280	726	----------	703	460	113
Total	9,622	9,744	9,760	5,735	1,703	117
Oceania: Australia	69,359	95,517	76,035	51,051	45,816	54,945
Total pigs and bars	338,061	321,708	351,759	262,632	[2] 213,347	247,327
Reclaimed, scrap, etc. (lead content):						
North America:						
Canada	4,582	2,558	1,787	2,396	4,053	1,441
Mexico	3,700	4,000	2,433	1,350	1,189	2,291
Other North America	1,305	645	228	602	220	91
Total	9,587	7,203	4,448	4,348	5,462	3,823
South America:						
Peru	199	4	274	(3)	----------	----------
Venezuela	416	----------	----------	----------	----------	----------
Other South America	4	53	34	120	----------	----------
Total	619	57	308	120	----------	----------
Europe:						
Belgium-Luxembourg	179	----------	7	----------	----------	----------
Denmark	268	84	----------	----------	----------	----------
Germany, West	81	168	278	1	1	----------
Netherlands	245	----------	----------	----------	----------	----------
Other Europe	415	32	172	----------	15	2
Total	1,188	284	457	1	16	2
Asia	161	----------	19	17	5	1
Africa	3	----------	----------	----------	----------	----------
Oceania:						
Australia	685	32	3,387	3,411	115	68
Other Oceania	86	----------	----------	----------	----------	----------
Total	771	32	3,387	3,411	115	68
Total reclaimed, scrap, etc.	12,329	7,576	8,619	7,897	5,598	3,894

See footnotes at end of table.

TABLE 27.—U.S. imports for consumption[1] of lead, by countries—Continued

(Short tons, lead content)

Country	1952–56 (average)	1957	1958	1959	1960	1961
Sheets, pipe, and shot:						
North America:						
Canada	165	101	252	452	213	114
Canal Zone	----------	19	----------	----------	----------	----------
Mexico	1,638	4,770	559	----------	----------	55
Total	1,803	4,890	811	452	213	169
Europe	255	1,027	1,813	3,156	2,641	2,639
Asia	----------	----------	1	(3)	1	37
Total sheets, pipe, and shot	2,058	5,917	2,625	3,608	2,855	2,845
Grand total	496,889	569,842	601,044	410,697	[2] 359,396	391,162

[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] 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)		
1952–56 (average)	143,688	[3] $36,943	753	$291	338,061	[3] $95,895	2,058	$550	[3] $192	[3] $136,806
1957	234,616	62,284	25	8	321,708	85,146	5,917	1,377	[3] 360	[3] 150,816
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	[4] 137,303	27,816	293	[5] 62	[4] 213,347	[4] 45,065	2,855	696	710	[4] 75,383
1961	136,860	24,347	236	[5] 51	247,327	45,863	2,845	641	807	72,301

[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—1952–56 (average), 12,329 tons,[3] $2,934,594; 1957, 7,576 tons, [3] $1,640,902; 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.
[3] Data known to be not comparable with other years.
[4] Revised figure.
[5] 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.

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		
	Gross weight (short tons)	Lead content (short tons)	Value (thousands)	Gross weight (short tons)	Lead content (short tons)	Value (thousands)
1952–56 (average)	2,523	1,545	[2] $2,087	9,107	7,902	[2] $2,894
1957	3,502	2,100	[2] 3,049	5,275	4,858	1,527
1958	4,244	2,049	4,677	5,170	4,525	1,190
1959	11,840	3,751	16,820	5,612	5,020	1,204
1960	9,274	1,512	16,024	[3] 4,560	[3] 3,915	[3] 970
1961	7,990	1,409	14,207	6,430	5,765	1,340

[1] 1960–61 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	1952–56 (average)	1957	1958	1959	1960	1961
Ore, matte, base bullion (lead content):						
North America:						
Canada	382	54	----------	3	16	3
Mexico	474	851	912	108	107	----------
Total	856	905	912	111	123	3
Europe	----------	----------	30	----------	----------	77
Asia	17	1	70	113	1,174	4,357
Total ore, matte, base bullion	873	906	1,012	224	1,297	4,437
Pigs, bars, anodes:						
North America:						
Canada	28	266	19	11	24	80
Cuba	37	62	33	37	10	----------
Mexico	13	18	4	28	60	24
Other North America	77	136	79	153	149	39
Total	155	482	135	229	243	143
South America	373	194	96	93	18	794
Europe	432	560	3	9	30	3
Asia:						
Japan	241	2,305	----------	5	----------	----------
Nansei and Nanpo Islands	2	16	7	3	----------	3
Philippines	191	451	427	473	34	227
Taiwan	9	224	566	1,916	1,536	874
Other Asia	232	106	125	27	103	75
Total	675	3,102	1,125	2,424	1,673	1,179
Africa	3	1	----------	1	2	12
Oceania	(2)	----------	(2)	----------	1	2
Total pigs, bars, anodes	1,638	4,339	1,359	2,756	1,967	2,133
Scrap:						
North America	86	----------	5	7	1,220	54
South America	----------	----------	----------	(2)	2	2
Europe:						
Belgium-Luxembourg	176	----------	----------	----------	6	688
Germany, West	225	264	292	51	129	253
Netherlands	187	304	157	460	297	251
United Kingdom	910	125	382	513	851	1,167
Other Europe	110	55	178	110	74	162
Total	1,608	748	1,009	1,134	1,357	2,521
Asia:						
Japan	665	137	----------	----------	----------	2,579
Other Asia	----------	----------	1	----------	(2)	7
Total	665	137	1	----------	(2)	2,586
Total scrap	2,359	885	1,015	1,141	2,579	5,163
Grand total	4,870	6,130	3,386	4,121	5,843	11,733

[1] In addition foreign lead was reexported as follows: Ore, matte, and base bullion 1952–56 (average), 2 tons; 1957, 4 tons; 1958–61, None. Pigs, bars, anodes, 1952–56 (average), 170 tons; 1957, 300 tons; 1958, 25 tons; 1959: 83 tons; 1960: None; 1961: 294 tons. Scrap: 1952–56 (average), 24 tons; 1957–58, None; 1959, 11 tons; 1960–61, None.

[2] Less than 1 ton.

WORLD REVIEW

World mine production increased 2 percent over that of 1960. Discussions continued in the Lead-Zinc Study Group in an effort to reduce production by voluntary curbs. World smelter production was estimated to be 2.7 million short tons, compared with 2.6 million short tons in 1960, while free-world consumption was estimated at 2.5 million short tons. The Lead-Zinc Study Group met twice during

the year, once in Mexico City, Mexico, from March 20 to 24, and once in Geneva, Switzerland, from October 18 to 24. As a result of agreements reached at the Mexico City meeting by Australia and Canada to curtail production, the U.S. Government made barter purchases for the CCC Stockpile of 50,000 tons of lead metal from Australia and 55,000 tons from Canada. These purchases were made to reduce the supply of lead to commercial markets which, together with U.S. negotiated production curtailments by producers of those two countries, were expected to tend toward stabilizing lead prices. U.S. import quotas remained in effect even though a large part of the U.S. lead industry expressed dissatisfaction with the effectiveness of quotas in protecting U.S. producers.

According to the International Lead-Zinc Study Group there was a 67,300-ton increase in world consumption of refined lead. Despite this consumption increase, the influence of U.S. quotas, barter purchases, and other efforts to decrease production, world stocks of refined lead increased 18,600 tons. Thus, the major problem of the lead industry continued to be imbalance between supply and demand.

TABLE 31.—World mine production of lead (content of ore), by countries [1] [2]

(Short tons)

Country	1952–56 (average)	1957	1958	1959	1960	1961
North America:						
Canada [3]	194,532	181,484	186,680	186,696	205,650	232,704
Cuba	42	90	[4] 70			
Greenland	[4] 5,043	8,212	9,619	11,633	7,635	10,104
Guatemala [3]	5,816	12,535	8,788	6,381	9,433	9,458
Honduras	1,401	[5] 2,955	3,380	4,604	5,913	6,762
Mexico	241,323	236,860	222,582	210,188	210,177	199,875
United States [3]	349,815	338,216	267,377	255,586	246,669	261,921
Total	797,972	780,352	698,496	675,088	685,477	720,824
South America:						
Argentina	23,700	32,100	32,000	33,000	31,500	30,600
Bolivia (exports)	24,850	28,948	25,149	24,293	23,610	22,378
Brazil [6]	3,264	3,878	4,781	4,850	4,421	[7] 4,400
Chile	5,101	3,237	2,815	2,560	2,694	[8] 1,879
Colombia (U.S. imports)	520	1	851	570	705	722
Ecuador	119	121	132	118	119	122
Peru	125,276	151,184	147,888	127,003	145,097	147,629
Total	182,830	219,469	213,616	192,394	208,146	207,730
Europe:						
Austria	5,487	5,969	6,012	5,906	5,758	6,051
Bulgaria	52,500	69,600	[7] 77,900	[7] 88,700	[7] 92,600	[7] 88,000
Czechoslovakia [7]	3,600	6,600	6,600	7,000	7,200	7,200
Finland	635	2,623	2,482	2,126	1,755	3,439
France	11,892	13,541	14,727	18,335	21,600	[7] 20,400
Germany:						
East [7]	5,000	7,700	7,700	7,700	7,700	7,700
West	69,256	78,395	67,213	57,929	54,999	54,586
Greece	4,670	7,200	11,200	11,000	[7] 12,000	[7] 10,800
Ireland	2,021	2,074	412	1,476	1,552	908
Italy	49,119	59,300	61,700	54,600	54,200	52,600
Norway	697	990	2,351	2,487	2,780	2,500
Poland	40,500	33,100	36,500	39,000	43,200	41,700
Portugal	1,780	1,518	994	35	34	
Rumania [6] [7]	11,700	13,200	13,200	13,200	13,200	13,200
Spain	60,646	72,224	76,710	77,271	80,353	[7] 92,800
Sweden	31,027	40,200	46,595	51,257	58,753	[7] 68,500
U.S.S.R. [7]	229,000	310,000	330,000	340,000	340,000	[6] 390,000
United Kingdom	8,306	9,069	4,814	2,632	1,549	1,655
Yugoslavia	93,841	99,305	99,035	101,909	100,554	106,571
Total [7]	681,700	832,600	866,100	882,600	900,000	968,600

See footnotes at end of table.

TABLE 31.—World mine production of lead (content of ore), by countries [1] [2]—Con.

(Short tons)

Country	1952–56 (average)	1957	1958	1959	1960	1961
Asia:						
Burma	12,829	16,366	21,180	21,200	19,500	17,600
China [7]	25,000	45,000	55,000	75,000	90,000	100,000
India	2,514	3,666	4,356	5,292	4,991	4,478
Iran [7] [9]	15,741	18,700	18,700	16,500	16,500	16,500
Japan	25,281	39,533	40,448	39,844	43,577	51,014
Korea:						
North [7]	35,000	45,000	45,000	50,000	55,000	55,000
Republic of	552	1,016	1,343	256	1,012	1,014
Philippines	2,429	897	1,415	391	134	[7] 111
Thailand	4,173	3,346	1,032	1,455	2,028	2,437
Turkey	2,897	4,465	3,250	2,300	827	1,370
Total [7]	126,400	178,000	191,700	212,200	233,600	249,500
Africa:						
Algeria	9,797	11,349	11,095	12,173	11,571	10,141
Congo, Republic of	3,922	2,034	3,611	5,448	4,741	3,628
Morocco	93,403	102,185	103,476	101,082	104,444	97,299
Nigeria	29	504	546	424	223	7
Rhodesia and Nyasaland, Federation of: Northern Rhodesia [6]	15,761	16,887	14,608	16,128	16,160	16,956
South-West Africa [10]	78,098	[3] 88,763	[3] 83,796	[3] 77,551	71,500	70,000
Tanganyika (exports)	3,575	5,433	5,001	6,401	6,927	457
Tunisia	27,276	25,371	25,920	19,997	19,676	18,698
Uganda (exports)	61	17	256	59		
Union of South Africa	568	1,223	36	168	136	102
United Arab Republic (Egypt Region)	172	280	[7] 330	770	88	40
Total	232,662	254,046	248,675	240,201	235,466	217,328
Oceania: Australia	304,185	373,256	366,652	354,249	345,160	300,341
World total (estimate)	2,330,000	2,640,000	2,590,000	2,560,000	2,610,000	2,660,000

[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] One year only, as 1956 was first year of commercial production.
[5] U.S. imports.
[6] Smelter production.
[7] Estimate.
[8] Exports.
[9] Year ended Mar. 21 of year following that stated.
[10] Includes lead content of lead-vanadium concentrates.

Compiled by Augusta W. Jann, Division of Foreign Activities.

European demand for lead continued heavy through the year, and considerable lead from Soviet countries was traded on the London Metal Exchange. December lead quotations on the London Metal Exchange declined 0.40 U.S. cent from those of January, although quotations until October were higher than in the opening month of the year.

NORTH AMERICA

Canada.—Mine production from complex lead-zinc-copper ores was 232,700 tons of recoverable lead. Refined lead production was from Canada's only primary lead smelter, a unit of the smelting-refining complex of Consolidated Mining & Smelting Co. of Canada, Ltd., (Cominco) at Trail, British Columbia, which processed concentrates from the company-owned Sullivan, Bluebell, H. B., and Con

TABLE 32.—World smelter production of lead, by countries [1] [2]

(Short tons)

Country	1952–56 (average)	1957	1958	1959	1960	1961
North America:						
Canada	163,036	144,017	134,827	140,881	160,079	172,365
Guatemala	[3] 265				200	62
Mexico	233,538	231,745	218,290	206,134	205,263	194,476
United States (refined) [4]	489,613	533,473	469,381	340,886	382,436	449,565
Total	886,452	909,235	822,498	687,901	747,978	816,468
South America:						
Argentina	22,287	28,600	36,200	34,200	28,300	31,000
Bolivia (exports) [5]	1,442	2,482	877	250	119	
Brazil	3,264	3,878	4,781	4,850	4,421	[3] 4,400
Chile	[6] 201		321	892	660	
Peru	63,641	76,231	71,045	62,619	81,726	84,312
Total	90,835	111,191	113,224	102,811	115,226	119,712
Europe:						
Austria [7]	12,564	13,156	13,756	13,610	13,717	13,605
Belgium [7]	91,003	109,423	105,685	97,489	102,190	110,110
Bulgaria	4,740	21,300	28,800	36,050	44,500	45,000
Czechoslovakia [3]	8,600	9,900	9,900	10,000	10,000	10,000
France	65,854	81,345	77,870	77,082	81,998	78,768
Germany:						
East [3] [7]	26,200	24,800	27,500	27,500	27,500	27,500
West	117,896	151,945	147,985	164,833	162,772	155,008
Greece	2,998	3,987	4,330	4,122	[3] 4,000	[3] 4,400
Italy	42,033	43,703	52,912	49,638	48,057	49,769
Poland	34,568	39,354	39,488	42,645	43,762	43,874
Portugal	1,272	829	743	877	998	1,664
Rumania [3]	11,700	13,200	13,200	13,200	13,200	13,200
Spain	62,603	64,981	77,729	75,497	78,464	85,068
Sweden	20,291	27,421	36,453	40,619	49,112	42,745
U.S.S.R. [3]	230,000	320,000	340,000	350,000	350,000	390,000
United Kingdom	6,937	8,322	4,156	1,580	1,224	1,178
Yugoslavia	78,501	86,536	92,904	94,132	98,263	99,650
Total [3]	817,800	1,020,200	1,073,400	1,098,900	1,129,800	1,171,500
Asia:						
Burma	13,622	21,816	19,150	21,768	19,441	17,376
China [3]	20,000	30,000	40,000	65,000	80,000	95,000
India	2,033	3,556	3,735	4,363	4,161	4,039
Iran [8]	998	[3] 770	1,047	[3] 1,000	1,280	[3] 1,100
Japan	27,646	50,214	42,412	67,152	76,465	88,503
Korea, North [3]	10,000	19,000	20,600	21,000	35,000	45,000
Turkey [3]	1,299	2,000	3,000	1,808	440	550
Total [3]	75,700	127,400	130,000	182,100	216,800	251,600
Africa:						
Morocco	30,648	34,441	36,513	31,361	33,871	26,994
Rhodesia and Nyasaland, Federation of: Northern Rhodesia	15,761	16,887	14,608	16,128	16,160	16,956
Tunisia [5]	28,647	27,068	27,718	24,039	21,894	20,342
Total	75,056	78,396	78,839	71,528	71,925	64,292
Oceania: Australia:						
Refined lead	204,230	215,516	214,451	209,638	212,687	181,807
Pb content of lead bullion	42,326	52,518	64,032	56,745	59,466	54,240
Total	246,556	268,034	278,483	266,383	272,153	236,047
World total (estimate)	2,190,000	2,515,000	2,500,000	2,410,000	2,550,000	2,660,000

[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 1954–56.

[7] Includes scrap.

[8] Year ended Mar. 21 of year following that stated.

Compiled by Augusta W. Jann, Division of Foreign Activities.

mines; the Rycon Mines, Ltd., (a subsidiary company of Cominco); and some purchased concentrates. Total refined lead produced from the Cominco smelter-refinery was 172,400 tons, an 8-percent increase over 1960. Pine Point Mines, Ltd., a subsidiary, reached an agreement with the Canadian government regarding construction of a railway from Grimshaw to Great Slave Lake with a branch line to the Pine Point lead-zinc property. Mine development was to be synchronized with rail construction so that both would be completed by December 31, 1966.[5]

Other large lead ore and concentrate producers in British Columbia were Canadian Exploration, Ltd., from the Jersey mine; Reeves MacDonald Mines, Ltd., from the Reeves MacDonald mines; Sheep Creek Mines, Ltd., from the Mineral King mine; Silbak Premier Mines, Ltd., from the Premier mine; New Cronin Babine Mines, Ltd.; and Western Exploration, Ltd., from the Black Fox, Kootenay Belle, Ottawa, Utica, and Victor mines in the Slocan Area. The Chisel Lake mine had been treating 1,000 tons of ore a day since September 1960 in its new concentrator, and Geco Mines, Ltd., added a lead-zinc recovery unit to its plant in July 1961.

In Yukon Territory, United Keno Hill Mines, Ltd., produced a significant tonnage of lead-zinc-silver ore from its Calumet, Elsa, and Hector mines.

Important producers in Quebec were New Calumet Mines, Ltd., from the New Calumet mine; Manitou-Barvue Mines, Ltd., from the Golden Manitou mine; and The Coniagas Mines, Ltd., from the Coniagas mine.

American Smelting and Refining Co. in the Atlantic Provinces continued its considerable production from the Buchans lead-zinc-copper mine. During the year Magnet Cove Barium Corp. commenced production of lead in a bulk concentrate from its new 125-ton mill at Walton, Nova Scotia. Considerable activity began during the year in the Bathurst area of New Brunswick to bring several mines, concentrators, and a smelter into production in 1963. Several mining firms were exploring and developing mines in this area.[6]

Mexico.—Lead production decreased during 1961, as did output of all other metallic minerals except iron ore, bismuth, tin, and zinc. Decline in production reflected the impact of lower metal prices and labor strikes. Total mine production of lead was 199,900 short tons; smelter output was 194,500 short tons. Consumption of lead increased 4,300 tons in 1961; however, total consumption was only 20,000 tons. Most of the increased consumption was for refined lead to process into lead oxide for export and not for local consumption. No major exploration was done in Mexico during 1961.

Regulations to implement the mining law, passed by the Mexican Congress in December 1960, had not been issued at the end of 1961. Lack of regulations to define and clarify this law left foreign mining firms uncertain of its full significance, except for the section requiring 51-percent-Mexican ownership of all operations dealing with nonrenewable resources. Compania Minera de Penoles and Compania Metalurgica Penoles, S.A. (both subsidiaries of American Metal

[5] Consolidated Mining and Smelting Co. of Canada, Ltd. Annual Report. 1961, pp. 6-7.
[6] Mineral Resources Division, Department of Mines and Technical Surveys. A Preliminary Survey of the Canadian Mineral Industry in 1961. Min. Inf. Bull. MR 56, March 1961, pp. 28-31.

Climax), The Fresnillo Co., and San Francisco Mines of Mexico, Ltd., disposed of majority control to Mexican investors. Others, such as Compania Minera ASARCO (American Smelting and Refining Company) were seeking actively Mexican investors to participate, but the size of the required Mexican investment made a reorganizational sale extremely difficult.

Compania Minera ASARCO continued to operate its lead producing mines during the year at about normal rate. The Esmeralda mine of Eagle Picher, operated by ASARCO, was closed during the year according to plan. Smelting continued at the San Luis Potosi and Chihuahua units, and in April lead production had decreased according to plan to about 6,800 tons per month. Concentrate in excess of the quantity smelted at these two ASARCO units was sent to Torreon for smelting in the plant of Compania Metalurgica Penoles, S.A. Smelter products were refined in the ASARCO refinery in Monterrey.

San Francisco Mines of Mexico, Ltd., at San Francisco del Oro, Chihuahua, milled 917,800 short tons of lead-zinc-silver-copper ore in 1961, a new record for the third consecutive year. A considerably increased tonnage of lead concentrate was sold in 1961 as stockpiled material was liquidated, and a new smelting contract was executed with Metalurgica Mexicana Penoles, S.A., by which concentrates were purchased on arrival at the smelter. Lead sales increased 78 percent over 1960. Firm arrangements had been made to meet new mining law requirements by selling 51 percent of the company to Mexican investors, forming the operating company Minera Frisco, S.A. A large part of the purchase price was on a long-term payment plan.[7]

In April 1961 Metalurgica Mexicana Penoles, S.A., was formed with 51 percent Mexican ownership of the mines and plants that were formerly subsidiaries of American Metal Climax. Mexican cash investment was being used for expansion. A zinc smelter and refinery costing US$12 million was to be built at Torreon, and a sodium sulphate plant costing US$2.4 million was to be built at Laguan del Rey.[8] The Fresnillo Company, with the Fresnillo, Plateros, Naica, Sombrerete, and Ziapan mines and plants, also was consolidated within the structure of the new firm.

The Fresnillo mill treated 607,000 tons of ore, producing 24,300 tons of concentrate that contained 52.6 percent lead. The Naica mill treated 345,700 tons of ore, producing 40,800 tons of concentrate that contained 63.9 percent lead.[9]

SOUTH AMERICA

Argentina.—Cia. Minera Aguilar, S.A., a 99.9 percent owned subsidiary of St. Joseph Lead Co., produced 31,250 short tons of lead concentrate.[10] Cia. Minera Castano Viejo, S.A., a partially owned affiliated company of National Lead Company, produced most of the remaining lead from Argentine mines. Refined lead production in Argentina was 31,000 short tons, a 10-percent increase over 1960. All of this production was derived from Argentine ores and was consumed locally.

[7] San Francisco Mines of Mexico, Ltd. Annual Report. 1961, pp. 6, 7, 14.
[8] American Metal Climax. Annual Report. 1961, p. 26.
[9] The Fresnillo Co. Annual Report. 1961, pp. 2–4.
[10] St. Joseph Lead Co. Annual Report. 1961, p. 9.

Bolivia.—Mine production of lead was 22,400 short tons, and lead smelter production remained very small. Fundicion Metabol, a Government-owned company, and Asociada a la Compagnia Metalurgica, S.A. la Lima, both in Oruro, produced metallic lead. The latter company, which was mainly a tin producer, reported lead output as lead content of solder.

Brazil.—Mine production of lead was estimated at 4,400 short tons. Total primary and secondary smelter-refinery output of lead was 11,000 short tons.[11] Most of the requirements for consumption were supplied by imports; lead consumption was estimated at 27,600 short tons. Consumption continued to increase, largely because of the growth of the automotive industry. Cia. Plumbum, S.A., and Cia Accumalatores Prest-O-Lite merged to form the smelting firm of Cia Brasileira de Chumbo, the only producer of lead metal.

Peru.—Cerro de Pasco Corp. produced 83,900 short tons of refined lead at its La Oroya smelter-refinery—again setting a new production record, an increase of 5 percent over 1960, and 35 percent more than in 1959. During 1961, lead production from the Cerro de Pasco Corp. mines was reduced, but the total smelter-refinery output increased owing to the greater quantity of custom ore treated. Twin bores of the 7-mile-long Graton tunnels for drainage and ventilation of the Casapalca mine of Cerro de Pasco Corp. advanced satisfactorily during the year. These low level tunnels will permit work below the 3,900-foot level.[12]

The St. Joseph Lead Co. wholly owned subsidiary, Cia. Minerales Santander, Inc., produced 6,700 short tons of lead concentrate, 33 percent more than in 1960.[13]

Other important lead producers in Peru were Cia. Minera Atacocha, S.A.; Northern Peru Mining Corp.; Mauricio Hochschild and Co., Compagnie des Mines de Huaron; Cia. Minera Milpo, S.A.; Cia. de Minas Buena Ventura, S.A.; Cia. Minas de Cercapuquio, S.A.; Sindicato Minero Pacococha; Sindicato Minero Rio Pallanga, S.A.; and Volcan Mines Co. Some of the independent lead mining companies sold their lead concentrates to Cerro de Pasco Corp. for smelting and refining in Peru, but most of this output was exported to the United States, Europe, and Japan. Total lead content of Peruvian mine production was 147,600 short tons.

EUROPE

Bulgaria.—Lead production of both concentrate and metal increased slightly. Mine production contained 88,000 short tons of lead, and the output of lead metal was 45,000 tons. The new secondary lead smelter at Plovdiv went on stream in late 1961; nominal capacity of the unit was 33,000 short tons of metal.[14]

Germany, West.—West German mine production of lead was 54,600 short tons, and primary metal output was 155,000 short tons. The secondary metal industry, proportionately, was more significant than in most European countries, and during 1961 it recovered 69,400 short tons of lead.[15] Lead mine production continued to decline

[11] International Lead-Zinc Study Group. Monthly Bulletin of Statistics. V. 2, No. 6, June 1962.
[12] Cerro Corp. Annual Report. 1961, pp. 10–11.
[13] St. Joseph Lead Co. Annual Report. 1961, p. 10.
[14] Razvedka I Ikrana Nedr, No. 11, 1961, pp. 56–61.
[15] Ne—Metalle, No. 1, Feb. 9, 1962. 27 pp.

slightly even though productivity per man was 370 percent of the productivity in 1950.[16]

Sweden.—Mine production of lead was 68,500 short tons, and the primary smelter-refinery of Boliden Mining Co. produced 43,000 tons of refined lead. Boliden Mining Co., one of Sweden's largest mining, metal, and chemical industries, started the largest project of its history—to build slag-fuming facilities with an output of more than 6,000 tons of leached lead dust and more than 20,000 tons of zinc clinkers per year.[17]

United Kingdom.—Mine output of lead was only 1,655 short tons. Combined primary and secondary metal production was 96,600 tons from a scrap and remelt lead content of 109,000 tons. United Kingdom consumption of domestically produced lead plus imports of refined lead increased and was 304,000 short tons.[18] Despite an active secondary lead recovery industry, most lead for consumption was imported in the form of concentrates and refined metal.

Yugoslavia.—Lead-zinc-antimony mine production continued to increase and amounted to a lead production of 106,600 short tons; refined lead output was 99,600 tons. A lead-zinc mine with 7 million tons of ore having 8 to 10 percent combined lead-zinc content was reopened in the Trepca area near Novo Brodo.[19] This was reported to be the oldest lead mine in the world, first having been exploited by the Romans.[20] Production also began at the Kisnica mine near Pristina, and production was increased at the Suplja Stijena and the Lece mines. Three years of lead smelter expansion and modernization were completed.

ASIA

Burma.—Refined lead production decreased 11 percent from that of 1960 to 17,400 short tons. Mine output decreased correspondingly to 17,600 tons of contained lead. The United Nations Special Projects Fund and the Government of Burma, as a joint venture, started a project to increase efficiency of the mining industry of Burma, which had been operating at a loss.

China.—Total refined lead output for China was estimated to be 95,000 short tons. China had a surplus of lead; an estimated 10,000 short tons of lead metal and a similar tonnage of lead concentrate was exported to U.S.S.R. An increased quantity of secondary lead also was recovered. Lead-zinc mines of Sinkiang were the principal sources of lead-zinc concentrate shipments to U.S.S.R. because the district is far from domestic smelting centers. Leading lead mining and smelting districts were Shenyang, Skao-kuan, Hu-lu-tao, and Shui-k'ou-shan. A new district being developed, T'ao-lin, in Hunam, was expected to produce at a rate of 1 million tons of ore annually for many years. Several flotation plants were built for lead-zinc concentration; capacities ranged from 400 to 1,000 tons of ore per day.

India.—The only producing lead mine in India, the Zawar mine in Rajasthan, yielded 4,500 short tons of contained lead in ores.

[16] Mining Journal, v. 258, No. 6598, Feb. 2, 1962, p. 122.
[17] Mining Journal, v. 256 No. 6596, Jan. 19, 1962, p. 61.
[18] British Bureau of Non-Ferrous Metal Statistics. World Non-Ferrous Metal Statistics. V. 15, No. 4, Bull. April 1962, p. 30.
[19] Mining Journal, v. 257, No. 6585, Nov. 3, 1961, p. 455.
[20] Engineering and Mining Journal, v. 162, No. 10, November 1961, p. 180.

This output represented a decrease of 10 percent from 1960. Domestic production satisfied only 12 percent of the requirements. Metal Corporation of India, Ltd., operating the Zawar mine, smelted and refined all the output in its plants at Tundoo near Katrasgarh, Bihar. A number of other lead-zinc deposits were known but were not being exploited.

Iran.—Details were not reported concerning lead production in Iran or the progress or compliance to satisfy contracts negotiated with U.S.S.R. and Japan.

Japan.—Activity in Japanese lead-zinc industries continued to expand. Japanese mining firms were negotiating to purchase four lead-zinc mines in Australia. Several Japanese firms also were negotiating for lead mines in Peru and other foreign countries and were negotiating long term contracts to assure an adequate supply of lead concentrates for their expanding smelting and refining plants. Mine production was 51,000 short tons of contained lead; primary smelter output was 88,500 tons, a 16 percent increase over 1960. Secondary lead recovery was 51,000 tons. Even so, the growing demand for lead caused Japan to increase imports of pig lead markedly; 1959 pig lead imports were 2,300 tons, those of 1960 were 23,800 tons, and those of 1961 were 48,800 tons. Smelting and refining industries are mechanizing and modernizing their plants to increase efficiency. Japan was considering some kind of tariff-quota system to protect its domestic industry.

Korea, North.—Mine production of lead was 55,000 short tons. About 45,000 tons was smelted and refined in the country, and much of the output was exported to U.S.S.R. The principal lead smelting center was Munpyong on the southeast coast.

AFRICA

Morocco.—Production of lead ore and concentrate declined from 104,400 short tons in 1960 to 97,300 tons, and lead metal output decreased from 33,900 tons to 27,000 tons. Societe des Mines de Zellidja and Societe Nord-Africaine du Plomb were the principal lead mining companies. The Oued-el-Heimer smelter, owned jointly by Societe des Mines de Zellidja and Societe Minere et Metallurgique de Penarroya, produced lead metal in the country's only lead smelter. Newmont Mining Corp. and St. Joseph Lead Co. are part owners of these firms.

Rhodesia and Nyasaland, Federation of.—Rhodesia Broken Hill Development Co., Ltd., continued to be the only lead and zinc metal producer in the Federation; 17,000 short tons of refined lead was produced. Construction of the sintering plant and the new Imperial process smelter was virtually completed. The Imperial smelter process was chosen because of its adaptability to smelting high grade complex ore produced at the mine. Ore processed during 1961 averaged 17.8 percent lead and 31.3 percent zinc. Measured and indicated ore reserves at yearend totaled 6.2 million tons averaging 13.7 percent lead and 27 percent zinc.[21]

[21] Rhodesia Broken Hill Development Co., Ltd. Annual Report. 1961, p. 10.

South-West Africa.—Tsumeb Corp., Ltd., mined and milled 652,000 tons of ore that averaged 4.46 percent copper, 12.91 percent lead, and 4.35 percent zinc. During the fiscal year ending June 30, 62,600 tons was sold and for 6 months ending December 31, 31,000 tons was sold. The Kombat mine, 65 miles from Tsumeb, was being equipped for an initial production of 1,000 tons of copper-lead ore, starting in mid-1962. Exploration of this mine proved existence of 2.6 million tons of ore averaging 3.1 percent copper and 3.4 percent lead. Both a copper and a lead smelter and refineries were under construction; the copper unit was to be finished in late 1962, but the lead unit was not scheduled for completion until late 1963.[22] Newmont Mining Corp. and American Metal Climax, Inc., each owned slightly more than 29 percent of Tsumeb Corp.

Total mine production of lead ores contained 64,300 short tons of lead. An additional 5,000 tons, lead content, of lead vanadium concentrate and 700 tons of lead in zinc concentrate was produced.

OCEANIA

Australia.—Australia continued as the leading free-world producer of lead ore and concentrate, even though mine production of lead decreased 13 percent from 1960 to 300,300 short tons. Refined lead production was 181,800 tons. Lead bullion, amounting to 54,200 tons of contained lead, also was produced. The remainder of lead in concentrates was exported for smelting and refining.

Mine production had declined for 4 consecutive years from a record of 373,300 short tons in 1957. The decline in 1961 was the greatest during the 4-year period. The Broken Hill District remained the leading lead-producing district, supplying 69 percent of the total production. Four companies that contributed toward the district production were New Broken Hill Consolidated, Ltd., Broken Hill South, Ltd., North Broken Hill, Ltd., and Consolidated Zinc Corp., Ltd. (Australia). The new Imperial process smelter at Cockle Creek functioned satisfactorily. The Consolidated Zinc Corp., Ltd., and The Rio Tinto Co., Ltd., planned to merge the two companies during 1962; the new firm was to be Rio Tinto-Zinc Corp., Ltd.[23]

Mount Isa Mines, Ltd., (53.8 percent owned by American Smelting and Refining Co.) produced 53,400 short tons of refined lead and 5,000 tons of antimonial lead.[24]

Lake George Mines Pty., Ltd., of Lake George Mining Corp., produced 8,800 tons of lead in concentrates from the Elliot, Keating, and Central ore bodies of Captain's Flat district of New South Wales. Due to exhaustion of ore bodies and unsafe conditions, the mine was closed March 11, 1962.[25]

E. Z. Industries, Ltd., produced 223,100 tons of complex gold, silver, zinc, copper, and lead ore from the Rosebery and Hercules mines. Lead concentrate was produced containing 6,500 short tons of lead. Copper concentrate contained 32.53 percent lead with a lead content of 2,300 tons. Full scale mine operations resumed April 10 at the Hercules mine after a shutdown for reconstruction.[26]

[22] Newmont Mining Corp. Annual Report. 1961, pp. 6-7.
[23] The Consolidated Zinc Corp., Ltd. Annual Report. 1961, pp. 15, 26, 36, 37.
[24] American Smelting and Refining Co. Annual Report. 1961, p. 15.
[25] Lake George Mining Corp., Ltd. Annual Report. 1961, pp. 4, 12, 13.
[26] E. Z. Industries, Ltd. Annual Report, 1961, pp. 14-15.

TECHNOLOGY

New lead-copper alloys had tensile strengths up to 8,000 pounds per square inch together with improved elongation and creep-strength characteristics; these alloys also retained good corrosion resistance.[27]

It was predicted that tetramethyl lead might gain half the anti-knock additive market within 5 years.[28]

Differential thermal analyses were made on natural and artificial lead-sulfur-selenium compounds.[29]

A new fabric comprised of lead and textile strands was developed for use as acoustical room dividers.[30]

Sound-proofing lead-covered wall paper and lead-backed acoustical tile became available.[31]

A report on sound-attenuation properties of lead was published.[32]

Research findings on several metallurgical, chemical, and electrochemical projects of significant interest in lead utilization were described.[33]

A newly designed interlocking lead brick was made available for nuclear radiation-shielding construction; the design of the bricks gives an effective barrier to radiation.[34]

Advantages of large scale lead smelting in oil-fired reverberatory hearths were presented.[35]

A process using ultrasonic vibration to obtain uniformity proved advantageous in forming tungsten-carbide lead alloys by powder dispersion.[36]

Battery-powered trucks, automobiles, and small vehicles gained rapidly in acceptance. Lead-zirconate-titanate proved to be an important piezoelectric.[37]

An improved tin-lead solder was reported that permits better work and reduces manufacturing rejects to 1/400 of those rejected when using normal solder.[38]

A lead-cadmium-nickel alloy with some special properties was described. The alloy can be cast, extruded, and rolled by conventional techniques.[39]

Optimum conditions were given for extraction of lead from difficult ores by using caustic soda.[40]

The Federal Bureau of Mines reported three recessions in copper, lead, and zinc following World War II.[41]

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[27] Lead Industries Association. Look for Stronger Lead Alloys. Mat. in Design Eng., v. 54, No. 2, August 1961, p. 7.

[28] Chemical Engineering. To Metal Organics, Now Add TML. V. 68, No. 1, Jan. 9, 1961, pp. 85–86.

[29] Dunne, James A., and Paul F. Kerr. Differential Thermal Analysis of Galena and Clausthalite. Am. Mineralogist, v. 46, Nos. 1 and 2, January-February 1961, pp. 1–11.

[30] American Metal Market. New Lead Fabric Developed. V. 68, No. 30, Feb. 13, 1961, p. 12.

[31] South African Mining & Engineering Journal (Johannesburg). Lead Wallpaper. V. 72, pt. 1, No. 3551, Feb. 24, 1961, p. 419.

[32] Canadian Mining Journal. Lead As A Sound Barrier. V. 82, No. 3, March 1961, pp. 94–95.

[33] Lead, v. 25, Nos. 1, 2, 3, 4, 1961.

[34] American Metal Market. Patent for Gamma Ray Shielding. V. 68, No. 72, Apr. 17, 1961, p. 12.

[35] Downie, C. C. Large Scale Lead Smelting. Min. J. (London), v. 256, No. 6557, Apr. 21, 1961, pp. 447–449.

[36] Pogodin-Alekseer, G. I., and V. V. Zaboleev-Zotov. A New Alloy Production Process. Metal Prog., v. 79, No. 5, May 1961, pp. 162, 164.

[37] Stafford, James V. Industry Uses of Lead Seen Ready to Expand. Am. Metal Market, v. 68, No. 85, May 4, 1961, p. 11.

[38] Materials in Design Engineering. Tin-Lead Solder. V. 54, No. 6, November 1961, p. 182.

[39] Williams, D. N., and R. I. Jaffee. Wrought Lead-Cadmium-Nickel Alloys. Metal Prog., v. 80, No. 4, October 1961, pp. 190–191.

[40] Sokolova, R. I. Extraction of Lead from Minerals by Caustic Soda Solutions. Metallurgiya Metallovendeniye Fiziko-Khjmcheskiye Metody Issledovaniya, (Akad. Nauk USSR, Inst. Metallurg. Trudy), No. 4, 1960, pp. 89–93.

[41] Bureau of Mines. Copper, Lead and Zinc in Three Recessions Following World War II. Information Circ. 8064, 1961, 79 pp.

Lime

By C. Meade Patterson [1] and Victoria R. Schreck [2]

OPEN-MARKET lime production continued in 1961, as it had in recent years, on a slightly rising "plateau." Excess capacity of commercial lime plants had a depressing effect on lime prices compared with the general price level. Captive lime production received greater recognition of its importance in the economy.

TABLE 1.—Salient lime statistics in the United States [1]

(Thousand short tons and thousand dollars)

	1952-56 (average)	1957	1958	1959	1960	1961
Active plants	155	146	145	156	158	259
Sold or used by producers:						
Quicklime	5,361	5,942	5,538	7,756	[2] 8,271	10,577
Hydrated lime	2,066	2,031	2,014	2,766	2,715	2,633
Dead-burned dolomite	2,060	2,251	1,659	1,986	1,949	1,983
Total	9,487	10,274	9,211	12,508	[2] 12,935	15,193
Value [3]	$114,397	$135,323	$121,193	$164,211	[2] $172,748	$210,141
Average value per ton	$12.06	$13.17	$13.16	$13.13	$13.35	$13.83
Open-market	8,163	8,516	7,388	8,405	[2] 8,190	8,313
Captive [4]	1,324	1,758	1,823	4,103	[2] 4,746	6,880
Imports for consumption	36	50	26	35	32	37
Exports	77	65	46	53	61	30

[1] Includes Puerto Rico.
[2] Revised figure.
[3] Selling value f.o.b. plant, excluding cost of containers.
[4] Incomplete figures; before 1961 the coverage of captive plants was only partial.

DOMESTIC PRODUCTION

Annual open-market lime production, the reliable barometer of the lime industry, fluctuated between 7 and 9 million short tons from 1950 through 1961. In the same period, the total annual lime production (annual open-market lime production plus captive lime production) rose from 7.5 to 15.2 million tons. Such a disproportionate gain in total annual lime output (compared to that of open-market lime) resulted from reporting captive lime production since 1952 and extending the canvass to include lime production in other industries besides the lime industry.

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.

Canvassing captive lime production, wherever found and whenever possible, gave quantitative substance to the essential role of lime in alkali manufacture, calcium carbide-acetylene manufacture, nonferrous metals production, municipal water treatment, and now, for the first time, in beet-sugar and pulp manufacture. Therefore, most of the reported increase in U.S. total annual lime production in 1961 resulted from more complete coverage of existing lime production.

Reported lime production increased 17 percent above that of 1960 to 15.2 million short tons. Open-market lime output rose 2 percent, and reported captive lime output increased 44 percent. Captive lime production amounted to 45 percent of the total. Lime sold or used for all major use categories increased. Hydrated lime constituted 17 percent of the total lime production.

Thirty-nine States and Puerto Rico reported lime production. The three leading States, Ohio, Michigan, and Missouri, in descending order, accounted for 36 percent of the U.S. total. The next five States were Pennsylvania, Louisiana, Texas, New York, and Virginia.

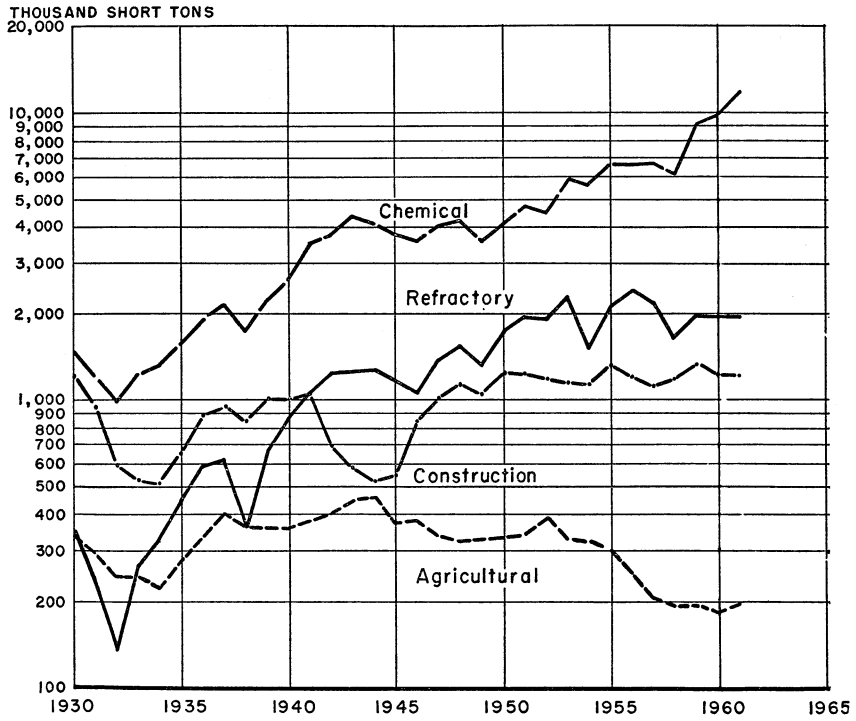


FIGURE 1.—Trends in major uses of lime, 1930–61.

Most domestic lime plants calcined limestone and dolomite, but some lime plants in Louisiana, Texas, and Virginia calcined oystershell and clamshell. Most of the quicklime and hydrated lime from

shell was manufactured in Texas; five plants produced 425,000 tons, or 48 percent, of all the lime produced in that State. Three lime plants in Louisiana produced 328,000 tons of lime from shell, and two small lime plants in tidewater Virginia burned shell to quicklime. Reef oystershell for limekilns was dredged from coastal bays of Louisiana and Texas. Fossil clamshell was dredged from the shallow bottom of Lake Ponchartrain, La., for a rotary kiln at New Orleans. Calcining oystershell on the shores of Chesapeake Bay in Maryland and Virginia had been discouraged, because it was necessary to return shell to the Bay to maintain a suitable bottom for oyster beds. Five percent of the United States lime production was derived from shell.

Quicklime in steadily increasing quantities was produced from calcium carbonate sludge and waste lime sludge at municipal water-treatment plants, calcium carbide-acetylene plants, and pulpmills and papermills. All of the lime derived from sludge was not reported to the Federal Bureau of Mines, but what was reported accounted for 11 percent of the U.S. lime production. Calcining sludge was ordinarily a captive operation; however, if excess lime was produced, it was sold. Wherever waste sludge was calcined, lime purchases were reduced or became unnecessary, and a troublesome sludge-disposal problem was reduced or eliminated. Sludge or slurry was converted to quicklime in a rotary kiln. A chain system inside the feed end of the kiln accelerated dewatering, promoted heat transfer, and prevented clogging of the kiln by the entering sludge or slurry. The tonnage of lime from sludge was expected to constitute a higher percentage of total lime production in the future.

Rotary kilns were used to calcine carbonate sludge at pulpmills and papermills. Preliminary inquiries revealed that approximately 1 ton of quicklime was necessary to manufacture 4 tons of pulp or paper by the sulfate or kraft process. To fulfill the lime requirements of kraft pulpmills, 95 to 98 percent of the high-calcium quicklime was produced at the pulpmill by calcining calcium carbonate sludge returned from the causticizing of soda ash, and 2 to 5 percent makeup lime was purchased from commercial lime plants. Captive quicklime tonnage produced from processed sludge at pulpmills and papermills had not been canvassed by the Federal Bureau of Mines until recently. Complete returns of this recycled captive quicklime production would probably establish pulp and paper manufacture as the outstanding single use of lime in the United States, exceeding the 3 million tons of captive lime that annually enters the manufacture of alkalies. The less than 1 million tons of lime reported for pulp and paper manufacture in recent years included all the makeup lime produced by the lime industry, but very little of the captive lime produced within the pulp and paper industry. There were 85 sulfate pulpmills and 11 soda pulpmills in the United States.[3]

Rotary kilns were operated by the following companies to produce captive quicklime from recycled sludge in pulping circuits.

[3] U.S. Department of Agriculture, Forest Service, Division of Forest Economics Research. Woodpulp Mills in the United States by State and Type of Product. June 1961, 23 pp.

Company:	*Location*
Boise Cascade Kraft Corp	Wallula, Wash.
Bowater Carolina Corp	Catawba, S.C.
Bowaters Southern Paper Corp	Calhoun, Tenn.
Brown Co	Berlin, N.H.
Brunswick Pulp and Paper Co	Brunswick, Ga.
Buckeye Cellulose Corp	Foley, Fla.
Calcasieu Paper Co., Inc	Elizabeth, La.
Champion Papers, Inc	Canton, N.C.
Do	Pasadena, Tex.
Container-Corp. of America	Brewton, Ala.
Continental Can Co	Augusta, Ga.
Do	Savannah, Ga.
Do	Hodge, La.
Do	Hopewell, Va.
Coosa River Newsprint Co	Coosa Pines, Ala.
Crossett Paper Mills	Crossett, Ark.
Crown Zellerbach Corp	Bogalusa, La.
Do	St. Helens, Oreg.
Do	Camas, Wash.
Do	Port Townsend, Wash.
Dierks Paper Co	Pine Bluff, Ark.
East Texas Pulp & Paper Co	Evadale, Tex.
Fibreboard Paper Products Corp	Antioch, Calif.
Georgia Kraft Co	Macon, Ga.
Georgia Pacific Paper Co	Toledo, Oreg.
Gulf States Paper Corp	Demopolis, Ala.
Do	Tuscaloosa, Ala.
Halifax Paper Co., Inc	Roanoke Rapids, N.C.
Hudson Pulp & Paper Corp	Palatka, Fla.
International Paper Co	Mobile, Ala.
Do	Camden, Ark.
Do	Pine Bluff, Ark.
Do	Panama City, Fla.
Do	Bastrop, La.
Do	Springhill, La.
Do	Moss Point, Miss.
Do	Natchez, Miss.
Do	North Tonawanda, N.Y
Do	Ticonderoga, N.Y.
Do	Georgetown, S.C.
Longview Fibre Co	Longview, Wash.
Marathon Southern Corp	Naheola, Ala.
The Mead Corp	Chillicothe, Ohio
Do	Kingsport, Tenn.
Mosinee Paper Mills Co	Mosinee, Wis.
Olin Mathieson Chemical Corp	West Monroe, La.
Owens-Illinois Glass Co	Jacksonville, Fla.
Do	Valdosta, Ga.
Packaging Corp. of America	Filer City, Mich.
Potlatch Forests, Inc	Lewiston, Idaho
Rayonier, Inc	Jessup, Ga.
Riegel Carolina Corp	Acme, N.C.
Rome Kraft Co	Rome, Ga.
St. Joe Paper Co	Port St. Joe, Fla.
St. Marys Kraft Corp	St. Marys, Ga.
St. Regis Paper Co	Jacksonville, Fla.
Do	Pensacola, Fla.
Do	Tacoma, Wash.
Scott Paper Co	Mobile, Ala.
Southland Paper Mills, Inc	Lufkin, Tex.
Southwest Forest Industries, Inc	Snowflake, Ariz.
Tennessee River Pulp & Paper Co	Counce, Tenn.
Thilmany Pulp & Paper Co	Kaukauna, Wis.

Company:	Location
Union Bag-Camp Paper Corp	Savannah, Ga.
Do	Franklin, Va.
West Virginia Pulp and Paper Co	Luke, Md.
Do	Tyrone, Pa.
Do	Williamsburg. Pa.
Do	Charleston, S.C.
Do	Covington, Va.
Western Kraft Co	Albany, Oreg.
Weyerhaeuser Co	Plymouth, N.C.
Do	Everett, Wash.
Do	Longview, Wash.
Weyerhaeuser Timber Co	Springfield, Oreg.

These were mainly sulfate pulpmills, but a few were soda pulpmills.

Captive, high-calcium quicklime for beet-sugar manufacture was produced in vertical limekilns at many beet-sugar plants in Western and Midwestern States. Both carbon dioxide and lime are necessary in the production of beet sugar, and the calcination of limestone is conducted at each beet-sugar plant to produce these chemicals. Approximately 500,000 short tons of captive quicklime that had not been reported to the Federal Bureau of Mines had been produced at beet-sugar plants to manufacture the 2,465,000 short tons of beet sugar reported for the year 1960–61.[4] Cane-sugar plants also used lime. Their lime requirements, being much less than in beet-sugar manufacture, did not justify plantsite kilns, and lime was purchased as needed.

Beet sugar was produced at the following plants,[5] and coke-fired vertical kilns were used to produce captive quicklime and carbon dioxide for beet-sugar manufacture.

Company:	Location
The Amalgamated Sugar Co	Nampa, Idaho
Do	Preston, Idaho
Do	Rupert, Idaho
Do	Twin Falls, Idaho
Do	Nyssa, Oreg.
Do	Lewiston, Utah
American Crystal Sugar Co	Clarksburg, Calif.
Do	Rocky Ford, Colo.
Do	Mason City, Iowa
Do	Chaska, Minn.
Do	Crookston, Minn.
Do	East Grand Forks, Minn.
Do	Moorhead, Minn.
Do	Missoula, Mont.
Do	Grand Island, Nebr.
Buckeye Sugars, Inc	Ottawa, Ohio
The Great Western Sugar Co	Brighton, Colo.
Do	Eaton, Colo.
Do	Ft. Morgan, Colo.
Do	Greeley, Colo.
Do	Longmont, Colo.
Do	Loveland, Colo.
Do	Ovid, Colo.
Do	Sterling, Colo.
Do	Windsor, Colo.

[4] U.S. Department of Agriculture. Foreign Agriculture Circular. Sugar FS 2–61, July 1961, p. 5.

[5] U.S. Department of Agriculture, Sugar Division, Commodity Stabilization Service. Beet Sugar Factories of the United States. March 1961, pp. 26–27.
U.S. Department of Agriculture. Sugar Reports. No. 107, March 1961, pp. 7–9, 12.

Company:	*Location*
The Great Western Sugar Co	Billings, Mont.
Do	Bayard, Nebr.
Do	Gering, Nebr.
Do	Mitchell, Nebr.
Do	Scottsbluff, Nebr.
Do	Lovell, Wyo.
Holly Sugar Corp	Alvarado, Calif.
Do	Carlton, Calif.
Do	Dyer, Calif.
Do	Hamilton City, Calif.
Do	Tracy, Calif.
Do	Delta, Colo.
Do	Hardin, Mont.
Do	Sidney, Mont.
Do	Torrington, Wyo.
Do	Worland, Wyo.
Menominee Sugar Co	Green Bay, Wis.
Michigan Sugar Co	Caro, Mich.
Do	Carrollton, Mich.
Do	Croswell, Mich.
Do	Sebewaing, Mich.
Monitor Sugar Div., Robert Gage Coal Co	Bay City, Mich.
The National Sugar Manufacturing Co	Sugar City, Colo.
Northern Ohio Sugar Co	Findlay, Ohio
Do	Fremont, Ohio
Spreckels Sugar Co	Manteca, Calif.
Do	Spreckels, Calif.
Do	Woodland, Calif.
Union Sugar Div., Consolidated Foods Corp	Betteravia, Calif.
Utah-Idaho Sugar Co	Idaho Falls, Idaho
Do	Belle Fourche, S. Dak.
Do	Garland, Utah
Do	West Jordan, Utah
Do	Moses Lake, Wash.
Do	Toppenish, Wash.

Alabama Metallurgical Corp., Selma, Ala., quarried dolomite (18 to 20 percent $MgCO_3$) at Montevallo, Ala., and calcined it to dolomitic quicklime in a natural-gas-fired 8½- by 170-foot rotary kiln. Magnesium was extracted from the dolomitic quicklime.

Ray Mines Division, Kennecott Copper Corp., completed a 90-ton-a-day lime plant, costing $700,000, at Hayden, Ariz., in March. Five Ellernan vertical kilns (5¼ feet by 11¾ feet by 17½ feet high) produced pebble quicklime at 2,200° F from limestone quarried 1 mile east of Hayden. Daily capacity was 18 tons of quicklime per kiln. Each kiln had two parallel calcining chambers containing 40 baffles to tumble the charge, check its downward movement, and insure uniform calcination. A hydrator, 16 feet in diameter, converted quicklime to milk of lime of 1.08 specific gravity for pH control in the Hayden flotation plant. Five to 10 pounds of quicklime was consumed per ton of copper ore mined 22 miles away at Ray, Ariz.

Ordinarily the new 7- by 100-foot rotary kiln at the City of San Diego (Calif.) Water Department was fired by natural gas, but it could be converted to oil or to firing by both fuels combined when necessary. Calcium carbonate sludge, precipitated by processing Colorado River water, was partially dewatered by centrifuging and then calcined at 2,200° to 2,300° F to produce 25 tons of quicklime daily.

A chain system, that extended for 9 feet inside the kiln near the feed end, accelerated further water reduction in the sludge from 35 to 10 percent by weight and increased the thermal efficiency of the kiln. Expensive sludge disposal and lime purchases at more than $25 a ton had been eliminated by this $535,000 lime plant that operated intermittently for 10 days a month in the winter but for as much as 20 days a month in the summer. Continuous, year-round lime production was anticipated after sludge also became available from a water-treatment plant being built at nearby Miramar.

Holly Sugar Corp. installed a modern natural-gas-fired vertical limekiln at its Carlton, Calif., beet-sugar plant.

Colorado Fuel & Iron Corp. began erecting a $2.5 million lime plant at Pueblo, Colo., to produce quicklime for its new basic-oxygen steelmaking plant.

Chemical Lime, Inc., Brooksville, Fla., began producing quicklime from Eocene Ocala limestone in a vertical fluidized-bed calciner. The $2.5 million plant was owned by Camp Concrete Rock, Inc., Ocala, Fla., and Lee Lime, Inc., Lee, Mass.

American-Marietta Co., Chicago, Ill., and The Martin Co., Baltimore, Md., were consolidated into the Martin Marietta Corp. on October 10. Three divisions were planned: Construction materials, chemicals, and Martin. The construction materials division would operate in the former American-Marietta Co. headquarters, Chicago. Standard Lime & Cement Co., Baltimore, and Southern Cement Co., Birmingham, Ala., formerly divisions of American-Marietta Co., became divisions of Martin Marietta Corp. The seven Standard Lime & Cement Division lime plants were at La Grange, Ill., Woodville, Ohio, Pleasant Gap, Pa., Knoxville, Tenn., Kimballton, Va., and Martinsburg and Millville, W. Va. The two Southern Cement Division lime plants were at Keystone and Roberta, Ala. Quicklime produced at Keystone was transferred to Roberta and reported as part of the Roberta quicklime and hydrated lime production.

Quicklime production was reported in Kansas for the first time since 1920. Midwest Lime Co., Inc., Bonner Springs, Kans., began production of open-market quicklime in February. High-calcium, Pennsylvanian Upper Farley limestone, purchased from Loring Quarries, Inc., was calcined at about 2,300° F in a natural-gas-fired, 57½-foot vertical kiln. Daily capacity, initially 60 tons of quicklime, rose to 75 tons, and it was expected to reach 100 tons. Fuel consumption was only 4.5 million Btu per ton of quicklime. The quicklime was sold for municipal water treatment at Kansas City, Mo.

Lime production was reported from Kentucky for the first time since 1940. Air Reduction Chemical & Carbide Co., a division of Air Reduction Co., Inc., began operating a rotary kiln at Calvert City, Ky., in 1960 to produce captive quicklime for calcium carbide manufacture. Waste sludge from former calcium carbide production was the kiln feed. Hydrated lime, a byproduct of calcium carbide operations, was offered in an exclusive spray-dried form that was economical to ship and handle. This lime hydrate was recommended as a neutralizing agent for acids and acidic wastes, as a causticizing agent for aluminum and paper manufacture, as a flux in sintering iron ore, as a construction material, and for sewage treatment.

TABLE 2.—Lime sold or used by producers in the United States,[1] by States

State	1960			1961		
	Active plants	Short tons	Value	Active plants	Short tons	Value
Alabama	7	[2] 536,083	[2] $6,593,406	8	579,311	$6,870.559
Arizona	5	147,758	2,429,746	6	166,706	2,686,326
Arkansas	2	(3)	(3)	6	191,700	3,168,354
California	7	345,344	5,628,223	19	517,951	9,412,021
Colorado	2	(3)	(3)	14	74,955	1,318,572
Connecticut	1	34,664	615,718	1	32,987	589,165
Florida	4	150,958	2,610,505	5	213,155	3,554,686
Hawaii	2	(3)	(3)	2	14,306	354,428
Idaho [4] [5]				5	46,760	657,656
Illinois	5	(3)	(3)	5	(3)	(3)
Iowa	1	(3)	(3)	2	(3)	(3)
Kansas [4]				1	15,494	192,900
Kentucky [4]				2	(3)	(3)
Louisiana	3	(3)	(3)	10	926,542	11,893.039
Maryland	3	(3)	(3)	4	96,127	1,301,871
Massachusetts	3	153,710	2.370,059	3	144,831	2,306,710
Michigan	7	1,177,431	15,730,384	13	1,210,675	15,959,768
Minnesota	1	(3)	(3)	5	(3)	(3)
Mississippi [4]				3	(3)	(3)
Missouri	6	1,254,269	14,701,377	6	1,172,557	13,873.492
Montana	2	(3)	(3)	6	117,742	985,744
Nebraska [4]				5	(3)	(3)
Nevada	4	(3)	(3)	4	(3)	(3)
New Jersey	1	(3)	(3)	1	(3)	(3)
New Mexico	1	35,707	496,327	1	25,210	350.419
New York	4	(3)	(3)	6	(3)	(3)
Ohio	20	3,116,891	44,403,404	23	3,123,054	42,158,203
Oklahoma	1	(3)	(3)	1	(3)	(3)
Oregon	2	(3)	(3)	7	221,463	5,157,173
Pennsylvania	24	1,120,463	16,276,512	23	1,124,158	16,896,334
Puerto Rico	1	581	14,985	1	600	15,000
South Dakota	1	(3)	(3)	2	(3)	(3)
Tennessee	3	(3)	(3)	3	(3)	(3)
Texas	10	821,442	9,087,109	12	879,749	9,735,646
Utah	4	127,210	2,671,923	7	142,430	2,625,919
Vermont	2	(3)	(3)	2	(3)	(3)
Virginia	10	711,039	8,027,986	11	738,706	8,595,625
Washington [4] [5]				9	349,247	8,480,877
West Virginia	3	(3)	(3)	3	(3)	(3)
Wisconsin	6	(3)	(3)	9	160,988	2,480,152
Wyoming [4]				3	(3)	(3)
Undistributed		3,201,648	41,090,065		2,905,725	38,520,262
Total	158	[2] 12,935,198	[2] 172,747,729	259	15,193,129	210,140,901

[1] Includes Puerto Rico.
[2] Revised figure.
[3] Included with "Undistributed" to avoid disclosing individual company confidential data.
[4] Not canvassed before 1961.
[5] Incomplete total.

TABLE 3.—Lime sold or used by producers in the United States,[1] by types and major uses

(Short tons)

Type and use	1960			1961		
	Sold	Used	Total	Sold	Used	Total
By type:						
Quicklime	6,251,373	[2] 3,969,060	[2] 10,220,433	6,140,827	6,418,765	12,559,592
Hydrated lime	1,937,963	776,802	2,714,765	2,172,597	460,940	2,633,537
Total lime	8,189,336	[2] 4,745,862	[2] 12,935,198	8,313,424	6,879,705	15,193,129
By use:						
Agricultural:						
Quicklime	76,530	----------	76,530	77,030	----------	77,030
Hydrated lime	110,239	----------	110,239	121,327	----------	121,327
Total	186,769	----------	186,769	198,357	----------	198,357
Construction:						
Quicklime	92,869	[2] 5,651	[2] 98,520	78,212	5,809	84,021
Hydrated lime	1,036,115	73,995	1,110,110	1,068,467	71,221	1,139,688
Total	1,128,984	[2] 79,646	[2] 1,208,630	1,146,679	77,030	1,223,709
Chemical and other industrial:						
Quicklime	4,159,932	3,936,191	8,096,123	4,081,669	6,334,113	10,415,782
Hydrated lime	791,609	702,807	1,494,416	982,803	389,719	1,372,522
Total	4,951,541	4,638,998	9,590,539	5,064,472	6,723,832	11,788,304
Refractory (dead-burned dolomite)	1,922,042	27,218	1,949,260	1,903,916	78,843	1,982,759

[1] Includes Puerto Rico.
[2] Revised figure.

TABLE 4.—Number and production of domestic lime plants by size of operation[1]

Annual production (short tons)	1960			1961		
	Plants	Production		Plants	Production	
		Short tons	Percent of total		Short tons	Percent of total
Less than 10,000	40	132,610	1	88	356,174	2
10,000 to less than 25,000	18	309,505	2	44	729,355	5
25,000 to less than 50,000	37	[2] 1,329,279	11	47	1,731,372	12
50,000 to less than 100,000	26	1,865,399	14	38	2,602,955	17
100,000 to less than 200,000	21	3,197,794	25	24	3,339,530	22
200,000 and over	16	6,100,611	47	18	6,433,743	42
Total	158	[2] 12,935,198	100	259	15,193,129	100

[1] Includes captive tonnage.
[2] Revised figure.

TABLE 5.—Number of open-market and captive lime plants, annual calcining capacity, kilns, hydrators, and fuel used in calcining by States,[1] in 1961

State	Active plants	Annual calcining capacity (thousand short tons)	Kilns			Hydrators		Kind of fuel used in calcining by number of plants[4]					
			Vertical[2]	Rotary	Pot	Batch[3]	Continuous	Natural gas	Coke	Bituminous coal	Fuel oil	Other	Unspecified
Alabama	8	834	29	15		2	4	8		2	1	[5] 1	
Arizona	6	198	5	8			3	4			1		1
Arkansas	6	387	1	7	1		3	6					
California	19	759	17	13		3	8	9	11		6		
Colorado	14	274	18	2	1		3	2	12		1		
Connecticut	1	50		2			1				1		
Florida	5	284	11	3		1	1	2			2	[6] 1	
Hawaii	2	32		2			2				2		
Idaho	5	140	5	3			3	1	4				
Illinois	5	966	5	10			3	2		3			
Iowa	2	72	1	1			1	1	1	1			
Kansas	1	20	1					1					
Kentucky	2	133		2				1			2	[7] 1	
Louisiana	10	1,032	13	22		1	3	9					1
Maryland	4	136		2	34		2	1	2	1			
Massachusetts	3	204	17	4			4	2		2	1	[7] 1	
Michigan	13	1,602	29	6			8	2	6	1	2	[8] 1	1
Minnesota	5	175	4	1		1			4	1			
Mississippi	3	239		6			3	3					
Missouri	6	1,564	48	5		1	7	3		2	1		2
Montana	6	206	8	1		1	2	2	4				
Nebraska	5	101	5		2		1		5				
Nevada	4	243	13	6		2		2	1				
New Jersey	1												
New Mexico	1	36		1			1	1					
New York	6	1,053	2	7		1				2	2	[9] 2	2
Ohio	23	5,178	286	34		11	14	5	4	14		[10] 3	2
Oklahoma	1	85	4	1			2	1					
Oregon	7	351	5	7			3	4			4		
Pennsylvania	23	1,442	17	21	34	1	9	3	1	12		[11] 7	1
Puerto Rico	1	11	1						1				
South Dakota	2	9	3						1			[6] 1	
Tennessee	3	147	19				2	2				[7] 1	
Texas	12	1,333	25	18		4	14	12	1				
Utah	7	273	16	4		1	4	1	4	1	1		
Vermont	2	33		1		1							1
Virginia	11	895	27	9	9	3	5	3	1	8			

Washington	9	578	2	15	2	1	6	5	2		2	[7] 1	
West Virginia	3	312	2	5		1	1	1		2			
Wisconsin	9	289	18	5		2	1	5	1	3		[7] 1	1
Wyoming	3	74	4				2		3				
Total	259	21,750	661	249	83	38	126	104	69	55	29	21	12

[1] Includes Puerto Rico.
[2] Includes Ellernan and FluoSolids kilns.
[3] Includes pressure hydrators.
[4] Some plants reported more than 1 kind of fuel, including mixed fuels.
[5] Coke-oven gas.
[6] Wood, including chips and sawdust.
[7] Producer gas.
[8] Carbon monoxide.
[9] 1, producer gas; 1, carbon monoxide.
[10] 1, producer gas; 1, carbon monoxide; 1, anthracite.
[11] 2, producer gas; 5, anthracite

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Air Reduction Chemical & Carbide Co.'s second carbide lime reclamation plant was being completed at Bell's Lane, Louisville, Ky., to provide additional quicklime for calcium carbide manufacture. Both lime plants had been announced in 1957, but construction of the Louisville plant had been postponed until the Calvert City plant had been built and placed in operation. This second lime reclamation plant, costing $2.75 million, was to begin operation early in 1962 with an 11- by 220-foot rotary kiln rated at 330 tons of quicklime daily. Kiln feed would be waste lime from an 80-acre deposit 75 to 80 feet thick that had accumulated since 1942. This captive quicklime production would eliminate the need for purchased quicklime from Missouri.

Elliston Lime Co., Elliston, Mont., was expected to double production of quicklime and hydrated lime under new management.

Captive dolomitic lime was produced by H. K. Porter Co., Inc., Pascagoula, Miss. This lime was used to produce magnesia. Dolomite from Alabama was calcined at 2,300° F in a 9- by 300-foot rotary kiln fired by natural gas. Dolomitic quicklime was ground and combined with magnesium chloride from sea water in a reactor tank to form magnesium hydroxide which was calcined to magnesia. Some dolomitic quicklime was hydrated and used to soften sea water.

Ash Grove Lime & Portland Cement Co., Kansas City, Mo., was erecting a limekiln with a traveling grate at its Springfield, Mo., lime plant.

The pharmaceuticals firm, Chas. Pfizer & Co., Inc., New York, N.Y., purchased New England Lime Co., with lime plants at Adams, Mass., and Canaan, Conn., for about $13 million on October 18. Plans to increase capacity were announced. High-purity lime is used in the manufacture of citric acid, and Pfizer was a major citric acid producer.[6]

Cuyahoga Lime Co., Cleveland, Ohio, a joint venture of Minerals & Chemicals Philipp Corp., Menlo Park, N.J., and Neville Lime Co. of Ohio began producing high-calcium, metallurgical quicklime for the steel industry. Limestone (over 97.5 percent $CaCO_3$) was brought by boat from Michigan, where it had been quarried by Presque Isle Corp. The four natural-gas-fired, vertical kilns, each rated at 100 tons a day, had been designed by Chemstone Corp., Strasburg, Va., the limemaking subsidiary of Minerals & Chemicals Philipp Corp. The first kiln was started January 9, and all four kilns were operating in May.

Gibsonburg Lime Products Co., Gibsonburg, Ohio, acquired the building and industrial lime business of Woodville Lime and Chemical Co., Woodville, Ohio.

National Lime and Stone Co., Findlay, Ohio, purchased the Scioto Lime and Stone Co., Delaware, Ohio, that had operated since 1860. Plant improvement was planned.

A new natural-gas-fired vertical limekiln was installed at the Nyssa, Oreg., beet-sugar plant of The Amalgamated Sugar Co.

Some lime from South Puerto Rico Sugar Co., Enseñada, was sold or used. Virtually all lime used in Puerto Rico for sugar refining,

[6] Pfizer News. Pfizer Acquires New England Lime, Announces Capital Expansion Program. Oct. 18, 1961, 4 pp.

for other chemical and industrial applications, and for construction was imported.

Established 42 miles west of Salt Lake City at Dolomite in 1914, The Utah Lime & Stone Co. lime plant had been purchased by The Flintkote Co. in 1958 and enlarged. Both dolomite quarried near the plant and high-calcium limestone from Flux, 2 miles east, were calcined. A new 9- by 140-foot, oil-fired rotary kiln calcined the dolomite, and five old Ellernan vertical kilns calcined the limestone. Dolomitic quicklime had been produced previously in vertical kilns. Introduction of the rotary kiln and a pressure hydrator had so stimulated the calcining of dolomite that a new quarry was started in rock containing 44 percent $MgCO_3$.

No open-market lime had been produced in Washington since 1956. Dominion Tar & Chemical Co., Vancouver, British Columbia, announced plans for a $3 million lime plant, Pacific Lime Co., Ltd., at Tacoma, to be operated by its subsidiary, Gypsum, Lime & Alabastine, Ltd. Limestone barged from Blubber Bay, Texada Island, British Columbia, would be calcined to produce up to nearly 200 tons of quicklime daily. A flat-glass plant to be built at Tacoma was expected to consume some of the lime.

The Mosinee Paper Mills Co., Mosinee, Wis., installed a $500,000 lime recovery system that reduced from 630 to 50 pounds the amount of purchased lime required to produce a ton of pulp. Waste lime sludge was calcined in a rotary kiln 140 feet long.[7]

The lime industry had more excess productive capacity at the end of the year than at any time since the end of World War II, yet three lime companies planned to increase annual capacity by an average of 35,000 tons per company in 1962. The open-market lime industry operated at about 75 percent capacity, and the unused capacity had a depressing effect on prices. In addition to the intense competition caused by excess capacity, the industry also was faced with increasing operating costs, reduced markets in masonry construction and agriculture, and depletion of high-grade limestone formations. Lime plants at Frederick, Md., Luckey and Woodville, Ohio, York, Pa., and Knoxville, Tenn., had shut down. Rotary kilns produced about 80 percent of the commercial quicklime, according to one estimate.[8]

CONSUMPTION AND USES

Seventy-eight percent of the U.S. lime production was used by chemical and industrial plants, 13 percent as refractory material, 8 percent in construction, and 1 percent in agriculture. Disregarding refractory lime or dead-burned dolomite, chemical and industrial uses consumed 89 percent, construction 9 percent, and agriculture 2 percent.

There were gains in some leading uses of lime: Soil stabilization, metallurgy other than steel, petroleum refining, and the manufacture of petrochemicals, pulp and paper, and sugar. The apparent gains in the manufacture of pulp, paper, and sugar were mainly the result

[7] Rock Products. Reconstituted Lime Used in Paper Processing. V. 64, No. 2, February 1961, p. 53.

[8] Rock Products. Lime: Marking Time in '62? V. 65, No. 1, January 1962, p. 84. Mining Engineering. Lime Production at 75% of Capacity. V. 14, No. 2, February 1962, p. 56.

of more complete coverage in canvassing. Consumption remained virtually unchanged from 1960 in agriculture, in masonry and refractory lime, in ore concentration, sewage and trade-wastes treatment, tanning, softening and purification of water, and in the manufacture of alkalies, calcium carbide, glass, and steel. Less lime was used in producing precipitated calcium carbonate, insecticides, fungicides, and disinfectants, in food and food byproducts, and as finishing lime.

TABLE 6.—Lime sold or used by producers in the United States,[1] by major uses

Use	1960			1961		
	Short tons	Value [2]		Short tons	Value [2]	
		Total	Average per ton		Total	Average per ton
Agricultural	186,769	$2,488,945	$13.33	198,357	$2,588,059	$13.05
Construction	[3] 1,203,620	[3] 21,281,943	[3] 17.61	1,223,709	21,042,725	17.20
Chemical and industrial uses	9,590,539	116,509,442	12.15	11,788,304	153,996,870	13.06
Refractory (dead-burned dolomite)	1,949,260	32,467,399	16.66	1,982,759	32,513,247	16.40
Total	[3] 12,935,198	[3] 172,747,729	13.35	15,193,129	210,140,901	13.83

[1] Includes Puerto Rico.
[2] Selling value, f.o.b. plant, excluding cost of container.
[3] Revised figure.

TABLE 7.—Lime sold or used by producers in the United States, by uses

(Short tons)

Use	1960			1961		
	Open-market	Captive	Total	Open-market	Captive	Total
Agriculture	186,769	----------	186,769	198,357	----------	198,357
Construction:						
Finishing lime	470,438	3,875	474,313	427,129	4,641	431,770
Mason's lime	473,585	[1] 68,447	[1] 542,032	479,472	71,769	551,241
Soil stabilization	171,248	691	171,939	223,304	620	223,924
Other	13,713	6,633	20,346	16,774	----------	16,774
Total	1,128,984	[1] 79,646	[1] 1,208,630	1,146,679	77,030	1,223,709
Chemical and other industrial:						
Alkalies (ammonium, potassium, and sodium compounds)	8,898	3,008,399	3,017,297	7,058	2,978,053	2,985,111
Brick, sand-lime and slag	9,751	----------	9,751	10,249	----------	10,249
Brick, silica	20,356	----------	20,356	12,481	----------	12,481
Calcium carbide	668,899	410,149	1,079,048	590,508	475,072	1,065,580
Calcium carbonate (precipitated)	[2]	[2]	77,282	[2]	[2]	43,403
Coke and gas (gas purification and plant by-products)	18,218	3,012	21,230	12,007	3,007	15,014
Food and food byproducts	40,782	----------	40,782	18,983	----------	18,983
Glass	247,997	----------	247,997	259,099	----------	259,099
Insecticides, fungicides, and disinfectants	39,236	1,905	41,141	28,109	1,991	30,100
Metallurgy (other) [3]	86,206	----------	86,206	112,150	24,733	136,883
Oil well drilling	9,262	----------	9,262	1,757	----------	1,757
Ore concentration [4]	237,711	540,654	778,365	166,146	600,007	766,153
Paint	[2]	[2]	11,605	[2]	[2]	9,366
Paper and pulp	701,221	136,932	838,153	681,703	1,568,870	2,250,573
Petrochemicals (glycol)	[2]	[2]	146,905	316,331	47,501	363,832
Petroleum refining	42,755	----------	42,755	57,150	----------	57,150
Rubber	1,272	----------	1,272	855	----------	855
Sewage and trade-wastes treatment	128,191	4,142	132,333	120,518	21,391	141,909
Steel (open-hearth, basic oxygen, and electric furnace flux)	1,510,000	95,864	1,605,864	1,491,543	95,208	1,586,751
Sugar	28,470	13,001	41,471	52,570	472,153	524,723
Tanneries	62,899	----------	62,899	59,348	----------	59,348
Water softening and purification	710,407	67,123	777,530	732,235	67,736	799,971
Wire drawing	3,751	----------	3,751	9,140	----------	9,140
Undistributed [5]	375,259	357,817	497,284	324,532	368,110	639,873
Total	4,951,541	4,638,998	9,590,539	5,064,472	6,723,832	11,788,304
Refractory lime (dead-burned dolomite)	1,922,042	27,218	1,949,260	1,903,916	78,843	1,982,759
Grand total	8,189,336	[1] 4,745,862	[1][2] 12,935,198	8,313,424	6,879,705	15,193,129

[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.

TABLE 8.—Apparent consumption of lime sold and used in the United States

(Short tons)

State	1960			1961		
	Quicklime	Hydrated lime	Total	Quicklime	Hydrated lime	Total
Alabama	257,262	75,830	333,092	267,404	76,381	343,785
Alaska		231	231		137	137
Arizona	135,570	25,259	160,829	147,025	15,735	162,760
Arkansas	63,027	9,333	72,360	166,537	13,151	179,688
California	409,590	97,941	507,531	569,190	103,974	673,164
Colorado	17,471	11,526	28,997	87,626	14,024	101,650
Connecticut	46,096	25,107	71,203	40,802	24,837	65,639
Delaware	35,783	9,587	45,370	36,970	10,641	47,611
District of Columbia		8,635	8,635	93	8,225	8,318
Florida	248,866	57,096	305,962	301,212	61,977	363,189
Georgia	75,139	22,623	97,762	65,062	19,487	84,549
Hawaii		(1)	(1)		15,306	15,306
Idaho	2,315	2,649	4,964	48,714	11,430	60,144
Illinois	373,461	108,728	482,189	414,365	129,071	543,436
Indiana	528,847	62,530	591,377	542,131	38,815	580,946
Iowa	80,381	18,130	98,511	79,314	19,606	98,920
Kansas	37,896	15,478	53,374	40,269	20,216	60,485
Kentucky	503,653	18,094	521,747	542,544	34,052	576,596
Louisiana	617,640	35,668	653,308	845,443	131,837	977,280
Maine	48,526	10,404	58,930	38,777	10,060	48,837
Maryland	168,902	26,586	195,488	210,389	28,904	239,293
Massachusetts	35,098	46,731	81,829	35,994	44,320	80,314
Michigan	806,390	595,599	1,401,989	1,068,172	79,783	1,147,955
Minnesota	95,372	19,910	115,282	118,403	19,092	137,495
Mississippi	39,750	10,578	50,328	268,773	11,642	280,415
Missouri	110,703	53,255	163,958	118,656	50,763	169,419
Montana	78,054	5,989	84,043	115,535	5,923	121,458
Nebraska	10,499	11,556	22,055	37,667	8,742	46,409
Nevada	356	36,546	36,902	2,153	24,848	27,001
New Hampshire	4,861	5,465	10,326	4,737	3,697	8,434
New Jersey	33,254	71,258	104,512	52,770	96,025	148,795
New Mexico	4,869	50,886	55,755	6,020	42,044	48,064
New York	1,271,977	124,103	1,396,080	1,009,243	115,427	1,124,670
North Carolina	102,007	27,174	129,181	67,638	29,576	97,214
North Dakota	7,357	1,532	8,889	7,691	2,145	9,836
Ohio	1,671,747	117,163	1,788,910	1,941,099	149,330	2,090,429
Oklahoma	38,397	12,680	51,077	36,592	13,925	50,517
Oregon	49,454	8,975	58,429	230,618	9,730	240,348
Pennsylvania	1,028,769	238,498	1,267,267	1,023,402	184,904	1,208,306
Rhode Island	8,707	6,342	15,049	7,344	6,423	13,767
South Carolina	12,790	7,711	20,501	11,504	6,893	18,397
South Dakota	8,429	1,058	9,487	13,674	14,664	28,338
Tennessee	47,036	27,019	74,055	44,673	28,953	73,626
Texas	441,058	400,968	842,026	541,649	386,290	927,939
Utah	86,672	23,762	110,434	94,855	26,359	121,214
Vermont		1,825	1,825	1,700	1,716	3,416
Virginia	272,516	37,199	309,715	392,333	37,787	430,120
Washington	19,007	11,536	30,543	330,697	120,314	451,011
West Virginia	166,218	20,578	186,796	125,817	224,732	350,549
Wisconsin	94,981	55,464	150,445	95,401	51,344	146,745
Wyoming	502	4,017	4,519	23,901	5,489	29,390
Total	10,197,255	2,676,812	12,874,067	12,272,578	2,590,746	14,863,324

[1] Figure withheld to avoid disclosing individual company confidential data, not included in total.

PRICES AND SPECIFICATIONS

The average price of open-market and captive quicklime and hydrated lime, f.o.b. plant, excluding the cost of containers, increased from $13.35 a ton in 1960 to $13.83. Unchanged lime prices were reported throughout the year by Oil Paint and Drug Reporter.[9] Bulk quicklime was $14.25 a ton, bagged hydrated lime, $17.25 a ton, and bagged hydrated spray lime, $18.25 a ton. These prices, which

[9] Oil, Paint and Drug Reporter. V. 179, Nos. 1–26; v. 180, Nos. 1–26; Jan. 2–Dec. 25, 1961.

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 a ton higher when the freight charge from the nearest producing point was added.

Chemical & Engineering News reported bagged agricultural lime at $14.50 a ton, lump quicklime and pebble quicklime in bulk for chemical uses at $9.50 to $25.10 a ton, bagged hydrated lime at $10.00 to $17.50 a ton, and bagged hydrated spray lime at $11.00 to $17.00 a ton. All prices were at the lime plant.[10] Three-fourths of the lime companies did not raise prices in 1961, and two-thirds of the lime companies did not expect to raise prices in 1962.[11]

FOREIGN TRADE [12]

Imports.—Six border States (Maine, New Hampshire, Vermont, New York, Michigan, and Washington) imported Canadian quicklime, hydrated lime, and dead-burned dolomite or refractory lime. Fifty-three percent of the Canadian lime entered Washington; 37 percent, New York; 8 percent, Michigan; 2 percent, Vermont; and less than 1 percent, Maine and New Hampshire combined. More than 99 percent of the imported lime came from Canada. Some refractory lime was shipped into Los Angeles, Calif., from the United Kingdom and West Germany, and into New York City from France. Puerto Rico imported 251 short tons of hydrated lime from Colombia.

TABLE 9.—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
1952-56 (average)	1,132	$16,301	29,097	$506,162	5,534	$374,399	35,763	$896,862
1957	245	4,603	39,002	687,421	10,419	639,741	49,666	1,331,765
1958	1,000	20,646	18,822	318,495	5,686	322,386	25,508	661,527
1959	530	9,346	26,374	442,330	8,468	495,952	35,372	947,628
1960	[3] 676	14,597	18,445	369,051	[4] 12,932	[4] 550,365	[3] 32,053	934,013
1961	950	21,710	31,418	491,352	4,256	233,271	36,624	746,333

[1] Dead-burned basic refractory material consisting chiefly of magnesia and lime.
[2] Includes weight of immediate container.
[3] Revised figure.
[4] Adjusted by Bureau of Mines.

Source: Bureau of the Census.

Exports.—Lime was exported to 33 countries. Canada received 57 percent of the exported lime; Canada, Mexico, Costa Rica, Panama, Nicaragua, and the Bahama Islands, in decreasing order, received 92 percent. The other 8 percent went to 27 countries in North America, Asia, Africa, South America, Oceania, and Europe, in decreasing order.

[10] Chemical & Engineering News. V. 39, No. 26, June 26, 1961, p. 66.
[11] Rock Products. Lime: Marking Time in '62? V. 65, No. 1, January 1962, p. 84.
[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.

TABLE 10.—U.S. exports of lime

Year	Short tons	Value	Year	Short tons	Value
1952-56 (average)	76,666	$1,377,815	1959	52,780	$1,000,337
1957	65,195	1,328,575	1960	61,076	991,769
1958	45,844	1,047,310	1961	29,969	920,668

Source: Bureau of the Census.

WORLD REVIEW

NORTH AMERICA

Bahamas.—Only 2,960 short tons of lime (74,000 bushels) valued at US$51,000 was produced in 1960. The decline from 4,120 tons produced in 1959 was attributed to a slowdown in private construction during 5 months of political uncertainty. Some lime plants reported production 50 percent below 1959. Quicklime was obtained from coral limestone, the only stone quarried in the Bahamas.[13]

Barbados.—Quicklime production in 1960 was 11,200 short tons valued at US$88,500.[14]

Canada.—The preliminary estimate of total lime production in 1961 was 1,385,953 short tons valued at Can$17,275,787 (Can$12.46 a ton). The final 1960 lime production total was 1,529,568 tons valued at Can$19,301,790 (Can$12.62 a ton).[15] Average values per ton in 1960 were Can$13.06 for quicklime and Can$12.42 for hydrated lime. Output declined 9 percent again; 1960 production had been 9 percent below that of the record year, 1959. Reduced consumption by uranium, pulp and paper, alkali, and calcium carbide industries was responsible.

The 36 lime plants that operated in 1960 had 120 vertical kilns, 27 rotary kilns, and an overall daily capacity of 8,100 tons of quicklime. There were, in addition, two hydrating plants in Manitoba. Numerous pulpmills and papermills produced an undetermined quantity of captive lime from calcium carbonate sludge. Canada Department of Mines and Technical Surveys designated quicklime produced from byproduct calcium carbonate sludge as secondary lime to distinguish it from primary quicklime derived from limestone and dolomite. Chemical and industrial uses accounted for 88 percent, construction 11 percent, and agriculture 1 percent of the second 1,685,725 short tons of lime consumed in 1959. In descending order, the major lime consumers in 1959 were: Uranium mills, pulpmills and papermills, iron and steel mills, and nonferrous smelters.[16] During 1959, 14,654 short tons of hydrated lime, costing Can$149,704 (Can$10.22 a ton) at works, and 38,796 tons of quicklime, costing

[13] U.S. Consulate, Nassau, Bahamas, British West Indies. State Department Dispatch 75. May 3, 1961, p. 1.
[14] U.S. Consulate, Barbados. State Department Dispatch 59. Mar. 27, 1961, p. 1.
[15] Dominion Bureau of Statistics (Ottawa). Preliminary Estimate of Canada's Mineral Production, 1961. Jan. 2, 1962, p. 4.
[16] Ross, J. S. Lime, 1960. Canada Dept. of Mines and Tech. Surveys, Ind. Min. Div. Rev. 39, May 1961, 7 pp.

Can$614,929 (Can$15.85 a ton) at works, were used in chemicals and allied products.[17]

The Canadian Lime Association was organized with 11 charter-member companies that produced 80 percent of the Canadian lime. One aim of the Association, which met in Ottawa in February, was to encourage the use of lime in soil stabilization.[18] Resumption of lime production in Nova Scotia was anticipated after a lapse of 18 years.[19]

The following beet-sugar plants reported captive high-calcium quicklime production in 1960: Raffinerie de Sucre de Quebec, St. Hilaire, Quebec; Canada & Dominion Sugar Co. Ltd., Chatham and Wallaceburg, Ontario; The Manitoba Sugar Co. Ltd., Fort Garry, Manitoba; and Canadian Sugar Factories Ltd., Raymond, Picture Butte, and Taber, Alberta. Two pulpmills and papermills reported lime production: Bathurst Power & Paper Co. Ltd., Bathurst, New Brunswick, and Crown Zellerbach Canada Ltd., Ocean Falls, British Columbia.

Standard Lime Co., a subsidiary of Gypsum, Lime & Alabastine Ltd., was installing a second rotary kiln at its Joliette, Quebec, lime plant. This 200-ton-a-day kiln was expected to begin producing quicklime in 1962. Coba Minerals, Ltd., installed a 170-ton-a-day rotary limekiln at Coboconk, Ontario, in 1960. Dominion Lime Ltd. replaced coal-gas producers by oil-gas producers at its Lime Ridge, Quebec, plant. Ontario Building Materials, Ltd., manufactured lime putty at Toronto.[20]

Costa Rica.—During 1960, 4,189 short tons of lime valued at $31,670 was produced.[21]

Haiti.—Approximately 180,000 short tons (120,000 cubic meters) of lime was produced in 1960.[22]

Mexico.—Yeso y Material, S.A., planned to produce lime in 1962.[23]

Nicaragua.—The 1960 lime production was 27,363 short tons valued at US$574,898.[24]

SOUTH AMERICA

Brazil.—Production of lime in 1960 was estimated at 1.4 million short tons.[25]

Paraguay.—Lime output was 14,800 short tons in 1960.[26]

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[17] Dominion Bureau of Statistics (Ottawa). Chemicals and Allied Products, 1959. General Rev., January 1962, p. 12.
[18] National Lime Association. Limeographs. V. 27, February 1961, p. 57.
Pit and Quarry. New Canadian Lime Assn. Promotes New Lime Uses, Sets Up Working Goals. V. 54, No. 2, August 1961, p. 30.
[19] Canadian Mining Journal (Gardenvale). Nova Scotia. V. 82, No. 5, May 1961, p. 128.
[20] Work cited in footnote 16.
[21] U.S. Embassy, San Jose, Costa Rica. State Department Dispatch 622. Apr. 24, 1961, p. 1.
[22] U.S. Embassy, Port-au-Prince, Haiti. State Department Dispatch 365. Mar. 15, 1961, p. 1.
[23] U.S. Consulate, Guadalajara, Mexico. State Department Dispatch 11. Oct. 30, 1961, p. 3.
[24] U.S. Embassy, Managua, Nicaragua. State Department Dispatch 354. Mar. 8, 1961, encl. 1, p. 1.
[25] U.S. Consulate, Sao Paulo, Brazil. State Department Dispatch 454. June 5, 1961, p. 2.
[26] U.S. Embassy, Asuncion, Paraguay. State Department Dispatch 363. May 9, 1961, p. 1.

Peru.—Lime production in 1960 was 84,700 short tons: 37,500 tons for construction, 23,700 tons for mineral concentration, 16,100 tons for agriculture, and 7,400 tons for chemical and industrial uses.[27]

Venezuela.—Lime production was 43,500 short tons in 1960.[28]

EUROPE

Belgium.—Production of lime was 2.1 million short tons in 1960.[29]

Czechoslovakia.—Lime production was 2.2 million short tons in 1959. Four Hungarian vertical-kiln plants began producing lime in 1960–61.[30]

Denmark.—Quicklime production was 143,300 short tons in 1960.[31]

Finland.—Output of quicklime was 242,500 short tons valued at US$2.9 million in 1960.[32]

France.—Lime and limestone production in 1960 was 8.9 million short tons, and calcined dolomite production was 220,000 tons.[33]

Germany, West.—During 1960, 10.4 million short tons of quicklime, hydrated lime, and dead-burned dolomite valued at US$101.6 million was produced (excluding Saar production), and 9.5 million short tons was marketable.[34] A survey of lime manufacturing costs was completed by the German Lime Federation (Bundesverband der Deutschen Kalkindustrie e.V.). The results enabled 29 participating lime producers to compare costs.[35] The German Lime Federation held its 5th Technical Conference at Bad Kissingen, Upper Bavaria, in October, and the delegates represented the lime industries of Austria, Belgium, France, Germany, Italy, Sweden, Switzerland, Union of South Africa, United Kingdom, and the United States.[36]

Greece.—Output of lime as a building material was 146 percent higher in 1961 than in 1939.[37]

Hungary.—The first rotary limekiln in Hungary was under construction at the Danube Cement and Lime Works, Vac. Annual plant capacity was expected to reach 1 million tons after this rotary kiln began operating.[38] Four vertical-kiln lime plants were manufactured and exported to Czechoslovakia in 1960–61. Another lime plant was exported to Italy, and eight additional lime plants for Italy were being negotiated. Yugoslavia ordered four Hungarian lime plants.[39]

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[27] U.S. Embassy, Lima, Peru. State Department Dispatch 586. Mar. 23, 1961, encl. 1, p. 2.
[28] Banco Central de Venezuela, Memoria 1960 (Caracas), p. 276.
[29] U.S. Embassy, Brussels, Belgium. State Department Dispatch 1178. June 2, 1961, encl. 1, p. 2.
[30] East Europe, April 1960, p. 47.
Cement, Lime and Gravel (London). V. 37, No. 2, February 1962, p. 34.
[31] U.S. Embassy, Copenhagen, Denmark. State Department Dispatch 761. May 12, 1961, encl. 1, p. 1.
[32] U.S. Embassy, Helsinki, Finland. State Department Dispatch 492. Apr. 26, 1961, p. 2.
[33] U.S. Embassy, Paris, France. State Department Dispatch 1538. May 4, 1961, encl. 1, p. 2.
[34] Statistisches Bundesamt, Die Industrie der Bundesrepublik Deutschland (Wiesbaden). Die industrielle Produktion. Jahrezahlen 1958–1960, pt. 3, July 1961, p. 9.
[35] National Lime Association. Limeographs. V. 27, April 1961, p. 76.
[36] Cement, Lime and Gravel (London). Fifth Technical Conference of the German Lime Federation. V. 37, No. 1, January 1962. pp. 24–25.
[37] Federation of Greek Industries, Minerals Division (Athens). Production for the Year 1961 as Compared to That of the Years 1939 and 1957. Feb. 24, 1962, p. 1.
[38] Cement, Lime and Gravel (London). V. 37, No. 1, January 1962, p. 28.
National Lime Association. Limeographs. V. 28, February 1962, p. 56.
[39] Cement, Lime and Gravel (London). V. 37, No. 2, February 1962, p. 34.

Italy.—Calcificio Triestino, Trieste, planned quicklime and hydrated lime production from high-calcium limestone.[40] A Hungarian lime plant was under construction at Lecco. Negotiations were underway for the erection of eight more Hungarian lime plants, each having four vertical kilns to be fired by gas made from low-grade coal.[41]

Malta.—Lime production was valued at US$83,440 in 1960.[42]

Poland.—Increased mechanization of the lime industry was in progress. The ratio of circular kilns to shaft kilns was expected to decline from 60:40 to 30:70. New limekilns for 1961–65 included 20 circular kilns, 21 airblast shaft kilns, 35 automatic shaft kilns, and 2 rotary kilns. By 1965, production of construction quicklime was expected to increase to 1.35 million tons, hydrated lime to 0.8 million tons, and agricultural lime to 0.6 million tons.

By 1965, the Piechcin and Strzelce lime plants would be finished, three more lime plants built, and the Gorazdze lime plant expanded by three Bipro Krakow automatic shaft kilns, rated at 200,000 tons of quicklime annually, and by Knibbs hydrators and air-separators, capable of producing 190,000 tons of hydrated lime annually. A lime plant at Bukowa, which would be operating in 1963, was to have an annual capacity of 295,000 tons, a bank of Beckenbach automatic shaft kilns, and Knibbs hydrators. An automatic shaft-kiln plant would be built at Trzuskawica by 1965.[43]

Sweden.—In 1960, 55,887 short tons of dolomitic quicklime was produced.[44]

United Kingdom.—In 1959, 2.24 million short tons of lime was produced.[45] Lime had been produced as long ago as the 13th century to repair many castles. Every farmer spread lime a century ago, but agricultural liming had virtually disappeared by 1900. Recent Government lime subsidies had helped to restore proper liming, but the decline in agricultural liming had curtailed progress in the lime industry for about 50 years.[46]

Lime associations included the Northern Ireland Lime Association, Belfast, the Scottish Lime and Limestone Association, Edinburgh, The South West of England Lime Association, Bristol, and The Southern Lime Association, London.[47]

Three gas-fired vertical kilns, each capable of producing 75 tons of quicklime daily for calcium carbide manufacture, were installed at the Maydown Works of Carbide Industries Ltd., near Londonderry, by Priest Furnaces Ltd., Middlesbrough. The fuel was either gas from a carbide furnace or a mixture of carbide-furnace gas and coke-producer gas. The kilns were automatically charged and discharged.[48]

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[40] National Lime Association. Limeographs. V. 28, September 1961, p. 13.
[41] Work cited in footnote 39.
[42] U.S. Consulate, Valletta, Malta. State Department Dispatch 50. Feb. 8, 1961, encl. 1, p. 1.
[43] Twardosz, Tadeusz. (Development of the Lime and Gypsum Industry in the Period 1961–1965). Cement Wapno Gips (Krakow). V. 15/25, No. 5, May 1960, pp. 121–123.
[44] U.S. Embassy, Stockholm, Sweden. State Department Dispatch 407. Nov. 13, 1961, encl. 1, pp. 1–2.
[45] Central Statistical Office (London). Annual Abstract of Statistics. No. 98, September 1961, p. 163.
[46] Cement, Lime and Gravel (London). Lime Burning Progress. V. 36, No. 2, February 1961, p. 29.
[47] Cement, Lime and Gravel (London). V. 36, No. 1, January 1961, pp. 24–25.
[48] Cement, Lime and Gravel (London). V. 36, No. 9, September 1961, p. 32a.

Beswick's Lime Works Ltd., near Buxton, installed an oil-fired vertical kiln (over 10 feet in diameter and 72 feet high). Fuel oil was gasified in the kiln rather than in an external-combustion chamber.[49]

At Crawford Priory, Scotland, Cults Lime Ltd. produced about 200 tons of quicklime a week from Carboniferous limestone obtained underground. Each of the two producer-gas-fired Priest vertical kilns could produce 250 to 300 tons of quicklime a week, but they operated alternately, a year at a time, because of the reduced demand for lime. Hydrated lime capacity was 2 tons an hour, but output was only 30 to 40 tons a week. Highest quality quicklime was sold to papermills, and ordinary quicklime was kibbled and ground for agriculture.[50]

Harrison's Limeworks Ltd. calcined Carboniferous limestone at Flusco and Shap. The five coal-fired vertical kilns (18 feet in diameter and 40 feet high) at Flusco had a total daily capacity of 250 tons of quicklime. Lump, kibbled, and ground quicklime were produced; part of the ground quicklime was hydrated; and daily output was 200 tons or more of quicklime and 40 tons of hydrated lime. At Shap, four coke- and coal-fired vertical kilns (18 feet in diameter and 60 feet high) could produce 1,000 tons of lump and kibbled quicklime weekly. Most of the lime went into steelmaking and agriculture.[51]

Settle Limes Ltd., Horton-in-Ribblesdale, calcined Carboniferous limestone (over 98 percent $CaCO_3$) in four Priest vertical kilns, each capable of producing 100 tons of quicklime daily. Two of the producer-gas-fired kilns were installed in August 1954, and the last two were installed in April 1960. The kilns were 17½ feet in outside diameter and 83 feet high. The production rate for 24 hours was 0.8 ton of quicklime per square foot of kiln cross section. Refractory lining in the calcining zone lasted for 65,000 to 80,000 tons of quicklime production. Each of the two Sturtevant-Knibbs continuous hydrators could produce 4 tons of hydrated lime an hour. Air-separated hydrated lime was packed in 50-pound bags; the lime was 96 percent $Ca(OH)_2$ and 98 percent minus 200-mesh. Lime was supplied to agriculture and the steel industry. Lime consumption per ton of steel had declined, fuel costs (one-half of the lime manufacturing costs) had risen, the working week had been reduced from 44 to 42 hours, and railroad freight rates were expected to rise.[52]

Yugoslavia.—Four Hungarian vertical-kiln lime plants were ordered.[53]

ASIA

Japan.—Hokuriku Salt Industry, Tokyo, used lime sludge from calcium carbide-acetylene operations to produce magnesia from sea water.[54]

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[49] Cement, Lime and Gravel (London). V. 36, No. 6, June 1961, pp. 166, 195.
[50] Cement, Lime and Gravel (London). A Limestone Mining and Processing Installation in Scotland. V. 36, No. 7, July 1961, pp. 199–203.
[51] Cement, Lime and Gravel (London). Harrison's Limeworks Limited. V. 36, No. 3, March 1961, pp. 65–73.
[52] Cement, Lime and Gravel (London). Settle Limes Meet Higher Costs. V. 36, No. 1, January 1961, p. 28; Producer-Gas Fired Kilns, Modern Plant at Settle Limes, v. 36, No. 2, February 1961, pp. 31–38.
[53] Work cited in footnote 39.
[54] Chemical Engineering, v. 68, No. 5, Mar. 6, 1961, p. 54.

Lebanon.—Lime production in 1960 was an estimated 7,700 short tons valued at US$88,328.[55]

Philippines.—Hydrated lime production was 14,442 short tons valued at US$498,957, and quicklime production was 6,669 tons valued at US$194,992 in 1960. Lime imports amounted to 1,950 tons valued at US$32,580 in 1960.[56]

Taiwan.—Output of lime was 48,617 short tons in 1960.[57]

Viet-Nam.—The Long Tho lime plant on the Perfume River near Huê was expected to produce 22,000 short tons of lime annually during 1961–65.[58]

AFRICA

Cape Verde Islands.—Lime output was 1,433 short tons in 1960.[59]

Kenya.—Production of lime in 1958 was 17,702 short tons.[60]

Libya.—An estimated 17,100 short tons of lime was produced in 1960.[61]

South-West Africa.—Lime production was 3,311 short tons valued at US$57,638 in 1960.[62]

Tanganyika.—In 1960 production of lime was 4,071 short tons valued at US$49,414.[63]

Tunisia.—Lime output was 138,760 short tons in 1960.[64]

Uganda.—Lime production in 1960 was 16,986 short tons valued at US$299,600. The principal producer, Uganda Cement Industry, had an output of 14,700 short tons.[65]

Union of South Africa.—Lime and limestone production was 8,016,626 short tons in 1960. Local sales of lime and limestone were 6,684,097 tons valued at US$11,783,366. Exports of lime and limestone amounted to 7,198 tons valued at US$85,277. Domestic sales of lump quicklime were 587,384 tons valued at US$4,510,058 (US$7.68 a ton) and of air-separated hydrated lime, 169,447 tons valued at US$1,855,456 (US$10.95 a ton). "Blue lime," "agricultural lime," and "other lime" were listed under "sales of burnt lime products," but the corresponding low prices per ton (US$3.61, US$3.47, and US$1.57, respectively) suggested that uncalcined limestone products may have been designated "lime."[66] Umzimkulu Lime Co. had suspended operations on the Umzimkulu River near Port Shepstone in 1959 as a

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[55] U.S. Embassy, Beirut, Lebanon. State Department Dispatch 767. Apr. 11, 1961, p. 1.
[56] U.S. Embassy, Manila, Philippines. State Department Dispatch 728. May 26, 1961, pp. 18, 77.
[57] Industry of Free China (Taipei). V. 17, No. 1, January 1962, p. 78.
[58] U.S. Embassy, Saigon, Viet-Nam. State Department Dispatch 47. July 28, 1961, encl. 2, p. 1.
[59] U.S. Embassy, Lisbon, Portugal. State Department Dispatch 376. Apr. 25, 1961, encl. 1, p. 1.
[60] Mine & Quarry Engineering (London). Mineral Resources of Kenya. V. 27, No. 11, November 1961, p. 525.
[61] U.S. Embassy, Tripoli, Libya. State Department Dispatch 403. Mar. 23, 1961, p. 1.
[62] Bureau of Mines. Mineral Trade Notes. V. 53, No. 1, July 1961, p. 28.
[63] Mining Magazine (London). Tanganyika's Mineral Exports. V. 104, No. 3, March 1961, p. 132.
U.S. Consulate, Dar es Salaam, Tanganyika. State Department Dispatch 203. Mar. 30, 1961, encl. 1, p. 1.
[64] U.S. Embassy, Tunis, Tunisia. State Department Dispatch 511. May 3, 1961, encl. 1, p. 8.
[65] U.S. Consulate, Kampala, Uganda, British East Africa. State Department Dispatch 253. Apr. 24, 1961, p. 1.
Uganda Protectorate (Entebbe). Annual Report of the Mines Department for the Year Ended 31st December 1960. 1961, pp. 5, 21.
[66] U.S. Consulate, Johannesburg, Union of South Africa. State Department Dispatch 358. May 4, 1961, p. 2; State Department Dispatch 7. July 7, 1961, encl. 3, p. 1; encl. 4, p. 1; encl. 5, p. 1.

result of floods. It opened a new lime plant in the Oribi Gorge, Natal.[67]

TECHNOLOGY

PROCESSING

Calcination.—"Investigation of the Lime Burning Process" by Dr. Rune Hedin, Royal Institute of Technology, Stockholm, Sweden, won the 1961 Azbe Lime Award. Calcite crystals were calcined at various temperatures for various periods. The resulting quicklime was examined with an electron microscope to determine volume change, degree of dissociation, and surface structure.[68]

Good-quality, soft-burned quicklime was produced in a vertical kiln as long as the correct temperature was maintained. When a vertical kiln that had been shut down was put back into operation, unsatisfactory, hard-burned quicklime was produced at first, and occasionally the kiln lining was damaged.[69] To calcine quicklime completely, a small vertical kiln was attached to the discharge outlet of a rotary kiln. Secondary calcining of any residual calcium carbonate took place in a rotary drum within the upper part of the attached terminal kiln. The quicklime was cooled by air in the lower part of the shaft.[70]

To produce 1 ton of quicklime, a properly functioning rotary limekiln consumed from 7 to 7.5 million Btu, and a vertical limekiln consumed 5 million Btu or less. An identical amount of heat entered the calcining reaction regardless of kiln type, but the additional heat used by the rotary kiln was lost to lime production through kiln-shell radiation.[71] Temperature fluctuations occurred in rotary kilns; abrasion took place at the feed end; quicklime fluxed and fused with the refractory lining to form rings in the calcining zone; and sometimes when the kiln was cooled to remove a ring, spalling of the refractory brick resulted from the temperature change. Fireclay brick was used throughout many rotary kilns: High-duty brick in the intermediate zone and super-duty brick in the calcining zone. High-alumina brick was necessary if severe conditions prevailed in the calcining zone.[72]

An automatic kiln-scanning pyrometer or heat-radiation detector scanned up to 60 feet along the rotary kiln and detected impending hot spots in the kiln shell before visual detection was possible and before refractory lining had been badly damaged. Without any direct contact, the instrument continuously measured and recorded the shell temperatures while the kiln rotated. If a hot spot developed, an alarm sounded, scanning stopped, and the pyrometer pointed to the spot; the temperature change of the spot was recorded, and corrective action could be taken without stopping the kiln. Remedial

[67] South African Mining and Engineering Journal (Johannesburg). V. 70, No. 3463, June 26, 1959, p. 1573; v. 72, pt. 2, No. 3591, Dec. 1, 1961, p. 1313.
[68] National Lime Association. Limeographs. V. 28, October 1961, p. 21 and attached press release.
[69] Work cited in footnote 36.
[70] Azbe, Victor J. (assigned to Azbe Corp., Clayton, Mo.). Terminal Calcining Kiln. U.S. Pat. 2,994,521, Aug. 1, 1961.
[71] Azbe, Victor J. Lime Technology Moves Ahead, Pt. 1. Rock Products, v. 64, No. 8, August 1961, pp. 111–112, 114, 122.
[72] Brick and Clay Record. The Cement & Lime Industries. V. 140, No. 1, January 1962, pp. 59, 79–80.

measures might involve changing the dimensions of the calcining zone, reducing the fuel rate, increasing the combustion air, or changing the kiln speed. Then the pyrometer recorded the effectiveness of the corrections taken. The operator was enabled to save fuel, extend refractory life, locate the calcining zone and follow its changes, and know at once when the kiln was running too hot.[73]

Hydration.—A research report on the reaction between calcium oxide and water [74] won the 1960 Azbe Lime Award. Settling time, specific surface (mean particle diameter), and viscosity of aqueous lime suspensions were investigated at water temperatures from 4° to 90° C. Higher reaction temperatures and hydrated lime of high specific surface characterized low weight ratios of water to quicklime. Specific surfaces varied less with changes in water temperatures at low water-to-quicklime ratios, and less at high water temperatures for all water-to-quicklime ratios. The range of specific surfaces was very wide for water-to-quicklime ratios from 7.5 to 25 at 4° to 60° C. Settling times did not correlate with changes in water-to-quicklime ratios, water temperatures, and observed specific surfaces. A change of viscosity of lime suspensions was reported. These were the first data on control of specific surface or mean particle diameter of hydrated lime by varying either the water-to-quicklime ratio or the water temperature at any water-to-quicklime ratio.

Hot milk of lime from the dust collector was the hydrating agent in the premixer of the British Sturtevant-Knibbs continuous hydrator. The hydrating lime was completely wetted in the premixer and then passed into the main hydrator in an excess of hot water. The heat of hydration evaporated the excess water, and hydrated lime was discharged over a weir as a powder. The atmosphere of the hydrator was steam and hydrated lime dust, which was precipitated continuously in a washer preheater and returned as hot milk of lime to the premixer, thereby eliminating dust.[75]

USES

Agriculture.—Loss of lime from soil was caused more by drainage than by crop extraction. Lime lost by drainage annually averaged between 200 and 400 pounds per acre at Rothamsted Experiment Station, Rothamsted, England, at Aberdeen, Scotland, and at Cornell University Agricultural Experiment Station, Ithaca, N.Y. The annual lime loss at the Soil Fertility Research Station, Hamilton, New Zealand, however, amounted to only 61 pounds per acre. More frequent liming, spreading smaller quantities of liming materials each time, resulted in a lower loss of lime by drainage.[76]

Chemical and Industrial.—Quicklime was the least expensive of the common alkalies. Although its pH (12.5) was below that of caustic

[73] Leeds & Northrup Co. L & N Rayoscan System for Monitoring Kiln Shell Temperatures. Rotary Kiln Operation, Process Data Sheet 705(3), 1961, 4 pp.
[74] Miller, Thomas C. A Study of the Reaction between Calcium Oxide and Water. National Gypsum Co., Buffalo, N.Y., 1961, 42 pp.
[75] Cement, Lime and Gravel (London). Lime Hydrating. V. 36, No. 2, February 1961, p. 56.
[76] Fertiliser and Feeding Stuffs Journal (London). Loss of Minerals by Leaching. V. 55, No. 8, Oct. 18, 1961, pp. 327–328.

soda (pH 14), it cost only one-half cent to neutralize a pound of sulfuric acid with quicklime, compared to 5 cents with caustic soda.[77]

At the modernized Holly Sugar Corp. plant, Carlton, Calif., 2,400 tons of sliced sugar beets a day (35 percent of the daily beet feed) was leached by water at 140° F to yield 455 gallons a minute of raw beet juice, which was treated with 72 gallons a minute of hydrated lime slurry agitated by 74 pounds a minute of carbon dioxide in the first-stage carbonation tank. Both the lime and carbon dioxide were produced at the beet-sugar plant by calcining high-calcium limestone in a new vertical limekiln.[78]

Smog over cities and industrial areas could be counteracted by dispersing colloidal hydrated dolomitic lime in the atmosphere as either a powder or slurry. The suspended 0.1- to 10-micron lime particles neutralized airborne, acidic waste particles that acted as condensation nuclei in smog formation.[79]

The Dow Chemical Co., Midland, Mich., experimented with a series of polymeric flocculants that may displace lime in municipal waste treatment. Only 3.6 pounds of the new agents performed the work of 350 pounds of lime and 85 pounds of ferric chloride combined, and the reaction was three times as fast.[80]

Badische Anilin- und Soda-Fabrik, Ludwigshafen am Rhein, West Germany, developed an oxy-thermal method of continuously manufacturing calcium carbide at temperatures up to 3,000° C. One ton of 80.5 percent calcium carbide was produced from 1.2 tons of 92 percent quicklime, 1.9 tons of 88 percent carbon coke (1.3 tons for heat and 0.6 ton for carbide formation), and 1.8 tons of oxygen supplied through copper jets.[81]

Colloidal calcium carbonate was formed by mixing a sodium carbonate solution with a hydrated lime suspension between 20° to 40° C.[82] Calcium hypochlorite bleach was produced by a continuous process of chlorinating lime slurry.[83] A filter composition for exhaust gases was made by coating vermiculite with an aqueous mixture of hydrated lime and salt.[84]

If refractory shapes containing 50 to 100 percent quicklime were heated to 1,000° F in 5 minutes or less, and to 1,500° F in 15 minutes or less, hydration did not occur. Water vapor in the kiln atmosphere was unable to penetrate and hydrate the quicklime during such a brief period of flash firing. It was advisable to spray fired lime refractories with oil, wrap them, and keep them in containers to minimize contact

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[77] The Chemical Market Research Association. Chemicals and Metals—Their Industrial Relationship. Pittsburgh, Pa., Nov. 9–10, 1960, p. 3.

[78] Havighorst, C. R. Beet Sugar: A Radical New Look. Chem. Eng., v. 68, No. 20, Oct. 2, 1961, pp. 76–78.

[79] Minnick, Leonard John (assigned to G. & W. H. Corson, Inc., Plymouth Meeting, Pa.). Method for Controlling Smog. U.S. Pat. 2,991,014. July 4, 1961.

[80] Chemical & Engineering News. New Experimental Flocculants Speed Treatment of Waste. V. 39, No. 48, Nov. 27, 1961, pp. 49–51.

[81] Chemical Age (London). B.A.S.F. Oxy-Thermal Method for Calcium Carbide Uses Calcium, Coke and Oxygen. V. 85, No. 2172, Feb. 25, 1961, p. 327.

[82] Miller, Thomas C. Carbonate Manufacture. U.S. Pat. 2,979,380, Apr. 11, 1961.

[83] Osborne, Wesley M., Dexter Edge, Jr., and Arthur D. Johnston (assigned to Hooker Chemical Corp., Niagara Falls, N.Y.). Process for Production of Calcium Hypochlorite Bleach Liquor. U.S. Pat. 2,965,443, Dec. 20, 1960.

[84] Duncan, Daymond D., and Don E. Wood. Method of and Filter for Purifying Exhaust Gases of Internal Combustion Engines. U.S. Pat. 3,000,692, Sept. 19, 1961.

with the air. Once lime refractories had been installed as furnace lining, the heat of the operating furnace prevented hydration.[85]

Construction.—One percent (never more than 2 percent) by weight of hydrated lime was incorporated in asphalt paving mixes. Hydrated lime had been used in asphalt paving as early as 1910, but subsequently less expensive, pulverized limestone had been substituted. Yet 3 to 5 percent limestone only partially accomplished what 1 percent of hydrated lime could do. Hydrated lime in asphalt paving rendered submarginal on-site aggregates usable and kept down haulage costs. Bulk or bagged hydrated lime was added dry to hot asphalt mixes, or as a slurry (4.5 pounds of hydrated lime per gallon of water) to the aggregate, which was dried and then mixed with asphalt. Colorado led all States in mixing hydrated lime with asphalt and aggregate for paving. Hydrated lime also had been used in asphalt mixes in Michigan, Minnesota, Montana, New Mexico, Texas, and Virginia.[86]

Some hot asphalt mixes in Colorado consisted of 1 percent hydrated lime, 6.6 percent asphalt, and 92.4 percent gravel. Amounting to only 2 pounds per square yard of pavement, lime served as a void filler, increased the strength and stability, promoted water resistance (a higher percentage of asphalt could be used with hydrated lime without a corresponding loss in stability), toughened the mix, and permitted faster compaction and higher pavement densities. Bulk hydrated lime was delivered to the job in tank trucks.[87]

To pave streets and parking areas in Helena, Mont., graded, crushed aggregate was mixed with 1 percent hydrated lime and 6.25 percent asphalt. Twenty pounds of hydrated lime per ton of hot mix amounted to 1 pound per square yard of pavement per inch of compacted depth. Hydrated lime prevented stripping, reduced swelling of the asphalt mix, and increased the strength of the asphalt mat from 1,800 to 2,600 psi.[88]

Hydrated lime (5 percent) and fly ash (10 percent) were mixed in place with existing cinders and bank-run gravel and soil to pave a truck-train terminal in Baltimore, Md.[89]

Ferrous Metallurgy.—The 1.4 million tons of fluxing lime used in the steel industry in 1959 was divided about as follows: 1 million tons in open-hearth furnaces, 0.3 million tons in basic-oxygen-process furnaces, and 0.1 million tons in electric and blast furnaces. After oxygen, lime was the next largest tonnage chemical used in the steel industry. It was predicted that lime would equal oxygen in tonnage by 1970, when 3 million tons of each would be consumed annually in steelmaking, based on the predicted annual output of basic-oxygen-process steel.[90]

The pulverized quicklime-oxygen injection process for making steel from pig iron was spreading rapidly throughout Europe. The per-

[85] Renkey, Albert L. (assigned to Harbison-Walker Refractories Co., Pittsburgh, Pa.). Firing of Lime Refractories. U.S. Pat. 2,971,240, Feb. 14, 1961.
Ceramic Age. Firing of Lime Refractories. V. 77, No. 8, August 1961, pp. 59–60.
[86] National Lime Association. Hydrated Lime in Asphalt Paving. Bull. No. 325, January 1961, 14 pp.
[87] Brakey, Bud A. Colorado Upgrades Gravel Hot Mixes With Lime. Roads and Streets, v. 104, No. 4, pp. 115–116, 118–119, 122–124, 126.
[88] Gallagher, A. Leo. Lime Used to Improve Hot Mix. Public Works, v. 92, No. 2, February 1961, p. 93.
[89] Hallstead, William F. Truck-Train Terminal Area Stabilized with Lime-Flyash. Roads and Streets, v. 104, No. 3, March 1961, pp. 108–109.
[90] Pages 21 and 24 of work cited in footnote 77.

centage of lime in the oxygen blast was controlled accurately, and lime consumption in some instances amounted to one-half ton a minute.[91] Injection of lime through the tuyeres raised the cost of pig iron and had to be abandoned.[92] Handling of lime in open-hearth mills became faster by means of pneumatic systems. Powdered ore and lime were blown through lances into molten steel.[93]

Nonferrous Metallurgy.—Domestic copper production required from 2 to 10 pounds of quicklime per ton of ore to control the pH of flotation circuits. Probably more than 300,000 tons of quicklime was used to concentrate the 135 million tons of copper ore produced in 1960. American Smelting and Refining Co. used 350 pounds of quicklime for each ton of copper recovered in 1959. Hydrated lime consumption averaged 6.3 pounds per ton of copper, 3.1 pounds per ton of lead, and 10.1 pounds per ton of zinc. Hydrated lime was used in lead smelting to neutralize acidic flue gases. Approximately 10,000 to 12,500 tons of lime was required annually to regulate the pH of flotation circuits that concentrated nickel ore at Falconbridge Nickel Mines, Ltd., The International Nickel Co. of Canada, Ltd., and Sherritt Gordon Mines, Ltd. Refining nickel required additional lime.[94]

In Australia, Great Western Consolidated N.L. changed to bagged hydrated lime from quicklime delivered by tankers to reduce the cost of operating the milk-of-lime circuit. Lower freight costs, safe handling and storage, and no risk of fire made hydrated lime superior to quicklime. Electrolytic Zinc Co. of Australasia Ltd. changed its zinc flotation circuit from soda and lime to all lime.[95]

Soil Stabilization.—According to the National Lime Association, 1961 construction contracts specified lime stabilization of 34.9 million square yards, or 25 percent more than those awarded in 1960. This called for nearly 300,000 short tons of hydrated lime, on the average basis of 17 pounds of hydrated lime per square yard to a 6-inch depth. In practice, weight percentages of lime ranged from one-half percent to modify plastic base materials up to 6 percent to stabilize highly plastic subbases. Secondary roads constituted 30 percent of the area to be stabilized; interstate highway systems, 26 percent; primary roads, 22 percent; and city streets, runways, military roads, and parking areas, 22 percent. Approximately 60 percent involved stabilizing plastic subbases, and 40 percent stabilizing plastic and granular bases. Since stabilization began in 1945, over 1 million tons of lime (128 million square yards) had been used and contracted for, and lime stabilization had spread into 35 States and more than 25 countries.[96]

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[91] Chemical Week. Oxygen Blowing Iron. V. 88, No. 5, Feb. 4, 1961, p. 41.
[92] Morrison, Donald M. Injection of Flue Dust, Lime, and Hydrocarbons into Pig-Iron Blast Furnaces. Mines, v. 52, No. 2, February 1962, pp. 25–26, 34.
[93] Steel. Air Power Speeds Handling of Open Hearth Materials. V. 149, No. 5, July 31, 1961, p. 66.
[94] Pages 33–34 and 39–40 of work cited in footnote 77.
[95] Mining and Chemical Engineering Review (Melbourne). V. 53, No. 6, Mar. 15, 1961, pp. 55, 57.
[96] Chemical Week. Lime Looks Up. V. 90, No. 7, Feb. 17, 1962, p. 140.

Lithium

By Milford L. Skow [1] and Victoria R. Schreck [2]

OUTPUT of lithium raw materials in the United States increased sharply in 1961. The number of producers declined as no production was reported from South Dakota. Imports of lithium minerals decreased almost 50 percent.

DOMESTIC PRODUCTION

Domestic production of lithium raw materials increased more than 60 percent over 1960; North Carolina again furnished most of the output. Foote Mineral Co. continued to produce spodumene concentrate from its Kings Mountain, N.C. quarry, and American Potash & Chemical Corp. recovered coproduct dilithium sodium phosphate from its operations at Searles Lake in California. In South Dakota, no production was reported, and the Etta Mine was sold by the Maywood Chemical Works, Division of Stepan Chemical Co., early in 1961.

Exploration of a dry lakebed near Silver Peak, Nev., by Leprechaun Mining and Chemical Co., Inc., disclosed two major lithium-bearing brine deposits. The company reported that more than 275,000 tons of lithia are contained in the upper horizon of the deposit.[3]

TABLE 1.—Shipments of lithium ores and compounds from mines in the United States

Year	Ore		Li_2O, short tons	Year	Ore		Li_2O, short tons
	Short tons	Value			Short tons	Value	
1950	9,306	$579,922	747	1953	27,240	$2,134,000	1,767
1951	12,897	896,000	956	1954	37,830	3,126,000	2,459
1952	15,611	1,052,000	1,088	1955–61	(1)	(1)	(1)

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

Foote Mineral Co. began recovering lithium aluminate formerly lost in stack effluent at its Sunbright, Va., plant. The 54 tons re-

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.
[3] Engineering and Mining Journal. Leprechaun Mining Begins Large Lithia Development. V. 162, June 1961, pp. 293, 295.

covered daily is recycled to the process for producing hydroxide.[4] A butyllithium plant with a single-shift capacity of 100,000 pounds per year was completed at New Johnsonville, Tenn., by Foote Mineral Co.,[5] and a plant with a capacity of 120,000 pounds per year was completed at Bessemer City, N.C., by Lithium Corporation of America.[6]

Late in the year Foote Mineral Co. began moving its Cold River, N.H., grinding mill to Kings Mountain, N.C. Imported petalite and domestically produced spodumene were to be processed for ceramic uses.

CONSUMPTION AND USES

Domestically produced lithium minerals were consumed chiefly in manufacturing various lithium chemicals, and to a lesser extent some were used directly in producing ceramics and glass. The ceramics and glass industries along with a variety of others, also used lithium chemicals.

Manufacturers of multipurpose greases converted large quantities of lithium hydroxide to the stearate or other soap for incorporation in the grease. Lithium hydroxide also was an additive in the electrolyte of alkaline storage batteries. Lithium carbonate continued to be used extensively in producing 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, as bleaches,[7] and in organic chemical synthesis.

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 1961 the price of lithium metal, 99.5 percent pure, was quoted in E&MJ Metal and Mineral Markets at $9 to $11 per pound.

Prices for lithium carbonate and hydroxide were cut sharply during the year, but quotations for other lithium compounds remained steady.

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[4] Mining World. How Foote Mineral Cuts Stack Loss With Electrostatic Precipitators. V. 23, November 1961, p. 38.

[5] Chemical Week. Butyllithium Steps Out. V. 88, May 13, 1961, pp. 73–74, 77.

[6] Chemical & Engineering News, Butyllithium: Capacity to Spare. V. 39, Feb. 6, 1961, pp. 46–47.

[7] Ellestad, R. B. Lithium Hypochlorite Bleaches. Soap & Chem. Specialties, v. 37, September 1961, pp. 77–79.

TABLE 2.—Range of prices on selected lithium compounds, in 1961

(Per pound)

Compound	January	December
Lithium bromide, NF, gran. bags, works, freight equalized	$2.60	$2.60
Lithium carbonate, technical, drums, ton lots	.76	[1] .57
Drums, smaller lots [2]	.81	[1] .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	.72	[3] .54
Less than carlots, same basis	.73	[4] .58
Lithium nitrate, technical, drums, 100-pound lots	1.15–1.25	1.15–1.25
Lithium stearate, drums, carlots, works	.47½	.47½
Ton lots, works	.48½	.48½
Less than ton lots, works	.53½	.53½

[1] Price changed February 6.
[2] Quotation changed February 6 to read: "Technical, drums, 1,999 pounds or less."
[3] Price changed to $0.60 on February 6, $0.59 on August 28, and $0.54 on September 18.
[4] Price changed to $0.64 on February 6, $0.63 on August 28, and $0.58 on September 18.

Source: Oil, Paint and Drug Reporter.

FOREIGN TRADE [8]

Imports of lithium minerals—spodumene, lepidolite, petalite, and amblygonite—declined 48 percent. Southern Rhodesia continued to

TABLE 3.—U.S. imports for consumption of lithium, by countries, and customs districts

Country and customs district	1960		1961	
	Short tons	Value	Short tons	Value
Lithium ores: [1]				
North America: Canada:				
Michigan	1,347	$66,671	2,115	$112,769
Ohio	62	4,920	----------	----------
Total	1,409	71,591	2,115	112,769
South America:				
Argentina: New York	110	5,150	----------	----------
Brazil: New York	33	1,331	----------	----------
Total	143	6,481	----------	----------
Africa:				
Rhodesia and Nyasaland, Federation of:				
Galveston	18,166	330,168	8,966	168,513
Maryland	20,202	618,090	13,496	392,490
Massachusetts	5,622	120,616	----------	----------
Philadelphia	5,557	211,627	----------	----------
Total	49,547	1,280,501	22,462	561,003
Union of South Africa: Maryland	----------	----------	2,252	102,806
Total	49,547	1,280,501	24,714	663,809
Grand total	51,099	1,358,573	26,829	776,578

[1] In addition, 14 pounds ($395) of metallic lithium was imported from Canada through the Vermont customs district in 1960.

Source: Bureau of the Census.

[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.

be the major supplier, but the imports from this source were only 45 percent of those in 1960. Much of the decrease resulted from reduced requirements for lepidolite at San Antonio, Tex., by American Lithium Chemicals, Inc., which reduced operations after completing its contract in 1960 to supply the Atomic Energy Commission with lithium hydroxide.

WORLD REVIEW

Based on figures that were partly estimated, production of lithium minerals in the free world declined in 1961. Production in the Federation of Rhodesia and Nyasaland—the leading supplier—was 37 percent lower than in 1960.

TABLE 4.—Free world production of lithium minerals, by countries

(Short tons)

Country	Mineral produced	1957	1958	1959	1960	1961
North America:						
Canada [1]	Spodumene	2,570	1,927	1,378	102	258
United States	Lithium minerals	(2)	(2)	(2)	(2)	(2)
South America:						
Argentina	do	22	175	187	(3)	(3)
Brazil	Spodumene (exports)	----	176	468	----	(3)
	Amblygonite (exports)	552	----	590	55	(3)
Europe: Spain	Amblygonite	7	----	----	28	----
Africa:						
Congo, Republic of the (formerly Belgian Congo) and Ruanda-Urundi	do	2,318	11	2,965	2,569	(3)
	Spodumene (exports)	1	----	----	----	----
Mozambique	Lepidolite	379	96	99	1	[4] 75
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	Eucryptite	56	398	----	1,334	1,879
	Amblygonite	122	1,835	----	----	86
	Lepidolite	93,545	64,699	----	15,485	24,037
	Petalite	9,934	13,166	[5] 57,901	63,336	27,698
	Spodumene	5,599	5,238	----	7,690	1,627
South-West Africa	Amblygonite	535	534	242	161	[4] 160
	Lepidolite	882	1,043	2,168	972	[4] 1,240
	Petalite	5,325	7,405	2,787	3,909	[4] 2,810
Uganda	Amblygonite	6	----	----	----	----
Union of South Africa	Lithium minerals	30	----	10	173	260
Oceania: Australia	Petalite	----	76	----	----	----
Free world total [3]		121,883	96,779	68,795	95,815	(3)

[1] Tons of lithia in spodumene concentrates.
[2] United States figure withheld to avoid disclosing individual company confidential data. No estimates included in total.
[3] Data not available.
[4] Estimate.
[5] Exports.

Compiled by Helen L. Hunt, Division of Foreign Activities.

Canada.—Commercial production was begun in January at the new lithium carbonate plant of Quebec Lithium Corp. about 30 miles north of Val d'Or.[9] During the year the company began installing facilities to produce lithium hydroxide and planned to install other facilities to produce lithium bromide, lithium chloride, lithium hydride, and lithium metal.[10]

[9] Northern Miner. Quebec Lithium Expanding Plant To Produce Lithium Hydroxide. V. 47, July 6, 1961, pp. 1, 5.
[10] Northern Miner. Quebec Lithium Plans New Plant To Produce Metallic Lithium. V. 47, Aug. 31, 1961, pp. 1–2. Quebec Lithium Sees Profits In Near Future. V. 47, Dec. 7, 1961, pp. 13, 18.

Chemalloy Minerals, Ltd., suspended operations at its Bernic Lake property early in 1961.[11] Large tonnages of high-grade lithium and cesium ores were outlined in the same area in an extensive exploration program.[12]

North American Rare Metals Co. planned additional diamond drilling at its lithium-rare metal property in the Bernic Lake area and also on its Whiteshell lithium mines property in the East Braintree area, where a reserve of lepidolite was indicated.[13]

Sirmac Mines planned to conduct exploratory drilling on a property in the Assinica Lake district in northwestern Quebec where previous surface mapping and exploration work indicated 4 million tons of spodumene ore, averaging more than 2.5 percent lithium oxide.[14]

Rhodesia and Nyasaland, Federation of.—Bikita Minerals Ltd., Fort Victoria, Southern Rhodesia, continued to be the only producer of lithium minerals in the Federation. Most of the material was exported to the United States; the remainder went to consumers in several European countries and Japan.

TABLE 5.—Federation of Rhodesia and Nyasaland: Exports of lithium ores, by countries

Destination	1960		1961 [1]	
	Short tons	Value [2]	Short tons	Value [2]
Belgium	681	$16,801		
France	230	12,932		
Germany, West	6,679	154,629	981	$32,396
Japan	3,258	72,374	1,368	28,885
Netherlands	2,331	49,060	5,253	106,545
Union of South Africa			44	544
United Kingdom	11,690	167,313	4,371	56,557
United States	103,056	2,359,313	20,232	305,611
Total	127,925	2,832,422	32,249	530,538

[1] January through June, inclusive.
[2] Converted to U.S. currency at the rate of £1 equals US$2.8076 (1960) and US$2.8022 (1961).

Compiled from Customs Returns of the Federation of Rhodesia and Nyasaland by Corra A. Barry, Division of Foreign Activities.

United Kingdom.—Lithium hypochlorite was made available by the Pfizer Group, Sandwich, Kent.[15]

[11] Canadian Mining and Metallurgical Bulletin. Monthly Correspondence. V. 54, March 1961, p. 289.
[12] Canadian Mining Journal. Chemalloy Minerals Progress Report. V. 82, July 1961, p. 107.
[13] Canadian Mining Journal. Lithium Property Gets More Drilling. V. 82, July 1961, p. 109.
[14] Northern Miner. Bracemac Is Active Through Interests and on Own Behalf. V. 47, Apr. 13, 1961, pp. 13, 18.
[15] Chemical Age (London). Pfizer Offer Bulk Supplies of Lithium Hypochlorite. V. 86, July 1, 1961, p. 10.

TABLE 6.—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]
1960:						
Germany, West			2	$56		
Japan			263	5,608		
Netherlands			491	10,386	1,901	$34,651
United Kingdom					62	1,127
Total			756	16,050	1,963	35,778
1961: [2]						
Belgium					1,847	43,727
Germany, West	47	$2,808				
Japan	12	586	545	11,907	47	1,061
Netherlands			277	6,631	219	4,810
United Kingdom	17	938				
Total	76	4,332	822	18,538	2,113	49,598

[1] Converted to U.S. currency at the rate of SA£1 equals US$2.7971 (1960) and one rand equals US$1.3957 (1961). Effective Feb. 14, 1961, the new currency unit, the rand, replaces the pound. It is equivalent to 10 shillings or one-half the former pound.
[2] January through September, inclusive.

Compiled from Quarterly Information Circular on Minerals for the Union of South Africa and the territory of South-West Africa by Corra A. Barry, Division of Foreign Activities.

TECHNOLOGY

An article about the Foote Mineral Co. mine in the spodumene-bearing pegmatites near Kings Mountain, N.C., discussed the geology, exploration methods, and future of the deposit.[16] The geology of the Lacorne district, a spodumene producing area in Quebec, Canada, was described in another report.[17]

Laboratory and pilot-plant studies indicated that satisfactory recoveries of acceptable product could be obtained by flotation of weathered spodumene ore only after high-intensity attritioning and conditioning.[18] A new and improved method for separating and recovering spodumene, mica, and beryl from pegmatites was developed in laboratory and pilot-plant tests. Results were reported briefly[19] and in detail.[20]

A number of patents were issued on recovering lithium values from various ores. In one process, crushed spodumene ore was heated to form beta-spodumene, slurried in water, and reacted with a strongly alkaline compound of sodium or potassium. Solids recovered from the reaction mixture contained chemically reactive lithium which was treated with dilute sulfuric acid and recovered as the sulfate.[21]

In another process, lithium sulfate was produced by contacting pulverized alpha- or beta-spodumene for 1 to 4 hours at 700° to 900°

[16] Kesler, T. L. Exploration of the Kings Mountain Pegmatites. Min. Eng., v. 13, September 1961, pp. 1062–1068.
[17] Brett, R. A Magmatic-Pegmatitic-Hydrothermal Sequence at Lacorne, Quebec. Econ. Geol., v. 56, June–July 1961, pp. 784–786.
[18] Quarterly of the Colorado School of Mines. Attritioning and Conditioning in Spodumene Flotation. V. 56, July 1961, pp. 323–332.
[19] Browning, J. S. Flotation of Spodumene-Beryl Ores. Min. Eng., v. 13, July 1961, pp. 706–708.
[20] Browning, J. S., B. H. Clemmons, and T. L. McVay. Beneficiating North Carolina Spodumene-Beryl Ores. BuMines Rept. of Inv. 5750, 1961, 20 pp.
[21] Kawecki, H. C., and A. J. Cole (assigned to Kawecki Chemical Co.). Extraction of Lithium. U.S. Patent 3,007,770, Nov. 7, 1961.

C. with gaseous mixtures of sulfur dioxide, sulfur trioxide, and oxygen prior to leaching with water.[22]

Two patents called for reacting finely ground alpha-spodumene with sulfuric acid at elevated temperature and pressure followed by leaching the lithium sulfate with water.[23] Another patent disclosed a method involving sulfuric acid digestion of lepidolite and like minerals, calcination of the digested product, leaching with water, and purification and recovery of lithium sulfate.[24]

In a process for recovering lithium and other values from pegmatites, heavy minerals and quartz were removed from a ground slurry of the ore by gravity separation and flotation, respectively; the remaining complex silicates were fused with sodium and potassium sulfates, quenched in water, ground, treated with ammonium bisulfate, and leached with water. The solution was separated from the hydrated silica and treated to recover the various metallic values.[25]

The use of ion exchange resins was proposed for recovering lithium from ores [26] and from lithium aluminate complexes obtained from brines.[27]

An apparatus for the continuous production of lithium metal by reducing a lithium halide with an alkaline earth metal was described.[28] Lithium of a purity previously available only in laboratory quantities was produced commercially by a novel electrolytic technique. Principal improvement was reduction in nitrogen content.[29] Reaction rates of lithium with oxygen and nitrogen were measured as a function of temperature and pressure,[30] the melting point of lithium was measured in the pressure range from 1 to 29,000 atmospheres,[31] and mass-transfer properties of molten lithium were studied.[32]

Lithium-magnesium and lithium-magnesium-aluminum alloys showed promise as structural materials for space vehicles and ordnance

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equipment.[33] The use of lithium as an alloying constituent to harden lead also was being studied.[34]

Lithium was a constituent in alloys developed for brazing stainless steels [35] and was proposed as a propellant.[36]

A lithium alloy and an organolithium compound in a solvent mixture were patented as catalysts for polymerizing certain unsaturated organic compounds.[37] Butyllithium was compared with other catalysts for polymerizing synthetic rubber, and other aspects of its production, handling, and marketing were considered.[38] Properties of butyllithium and information on handling it safely in various operations were discussed.[39]

Anhydrous, oxyhalide-free lithium chloride or bromide was formed by direct halogenation of lithium hydroxide at a temperature above 150° C. but below the melting point of the reaction mixture.[40] A process for producing granular lithium carbonate comprised reacting aqueous sodium carbonate with aqueous lithium hydroxide, carbonating the sodium hydroxide formed, and recovering the precipitated lithium carbonate.[41] Lithium isotopes were recovered by ion exchange methods.[42]

The advantages and disadvantages of lithium perchlorate as a propellant oxidizer were discussed, and a means of converting present ammonium perchlorate plants to its production was indicated.[43] A process was developed to prepare lithium perchlorate by boiling an aqueous solution of ammonium perchlorate and lithium hydroxide, heating the reaction mixture until the ammonia is driven off, and recovering the lithium perchlorate either as the trihydrate or the anhydrous salt.[44]

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Sodium aluminum hydride produced by direct synthesis could be reacted with lithium chloride to give lithium aluminum hydride at a lower cost than by present methods.[45] Processes were proposed for producing lithium aluminum hydride as a suspensoid in a hydrocarbon,[46] lithium borohydride,[47] lithium decaborane,[48] and lithium-substituted oxides having predetermined resistivity.[49]

The utility of lithium aluminum hydride as a reductant was increased by using pyridine as a solvent, and the mechanism of the reaction was explained.[50] Lithium hydroxide was found to react with silica in a different manner than sodium and potassium hydroxides and appeared to have an inhibiting effect on their reaction with silica.[51]

The study of the physical properties of lithium fluoride single crystals continued to be an approach to understanding the mechanical behavior of nonmetallic materials and so further the development of ductile ceramics. Attempts were made to relate mechanical properties of lithium fluoride crystals to such factors as pretreatment, environment, and impurities.[52]

Dense ceramic specimens were fabricated successfully by hot pressing a petalite-clay body.[53] Preparation of a dense, mechanically strong, electrically insulating ceramic material from lithium silicate and lithium aluminum silicate crystals was disclosed.[54]

Continued research on systems containing lithium oxide furnished additional basic data on phase relationships.[55] In a study of devitrification of a lithium glass at three different temperatures, the crystals

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were identified and their growth rate determined.[56] The controlled nucleation and crystallization of glass components to form crystalline glass ceramics were described,[57] and a method of forming a grid from light-sensitive glass was developed.[58] Lithium was a required constituent in a number of enamel and glaze compositions.[59]

Certain lithium compounds were found to be effective mineralizers needed to produce fluorescent germania.[60] The preparation and properties of magnesium lithium antimonate phosphors were described and their fluorescence explained.[61] Experimental metallic hydride fuel cells were operated with lithium metal as one electrode and molten lithium halides as the electrolyte.[62] Lithium and platinum were reacted at about 200° C. and treated with water to form a very active hydrogenation catalyst.[63]

Patents were issued on the use of lithium hydroxide in improving the rheological properties of a kaolin slurry,[64] lithium citrate in a drilling mud,[65] lithium chloride as a desiccant,[66] lithium bromide in refrigeration,[67] lithium stearate in an explosive foam,[68] and various lithium compounds in greases.[69]

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Magnesium

By H. B. Comstock [1] and Jeannette I. Baker [2]

DOMESTIC production of primary magnesium in 1961 was 675 short tons more than in 1960, and consumption rose 8,433 tons, exceeding production by 4,788 tons. Primary magnesium as an ingredient in aluminum alloys accounted for most of the increase in consumption.

World production of the primary metal rose 12 percent above 1960. The greatest increases were in Norway, the U.S.S.R., Canada, and the United States.

Progress in research included development of new magnesium-lithium alloys that are 20 percent lighter than standard magnesium alloys.

TABLE 1.—Salient magnesium statistics

(Short tons)

	1952–56 (average)	1957	1958	1959	1960	1961
United States:						
Production:						
Primary	79,621	81,263	30,096	31,033	40,070	40,745
Secondary	10,486	10,658	8,707	10,090	10,348	8,039
Imports for consumption	1,180	982	537	593	401	1,005
Exports	3,700	1,219	207	1,601	4,467	6,160
Consumption	45,704	44,442	35,352	41,551	37,100	45,533
Price per pound, cents	27.6	35.25	35.25	35.25	35.25	35.25
World: Primary production	114,800	128,700	78,500	[1] 82,400	[1] 102,600	115,400

[1] Revised figure.

DOMESTIC PRODUCTION

Primary.—Production of primary magnesium in the United States rose 2 percent in 1961. The Canaan, Conn., Selma, Ala., and Freeport, Tex., plants were in operation throughout the year except for a 2 weeks' shutdown of the Freeport plant in September because of damage from Hurricane Carla. Shipments continued without interruption.[3]

During the latter part of 1961, The Dow Chemical Co. began to rehabilitate its primary magnesium plant at Velasco, Tex., and prepared to have the cells operating in two of the eight cell buildings

[1] Commodity specialist, Division of Minerals.
[2] Research assistant, Division of Minerals.
[3] American Metal Market. Hurricane Damage in the Millions. V. 68, No. 179, Sept. 18, 1961, p. 9.

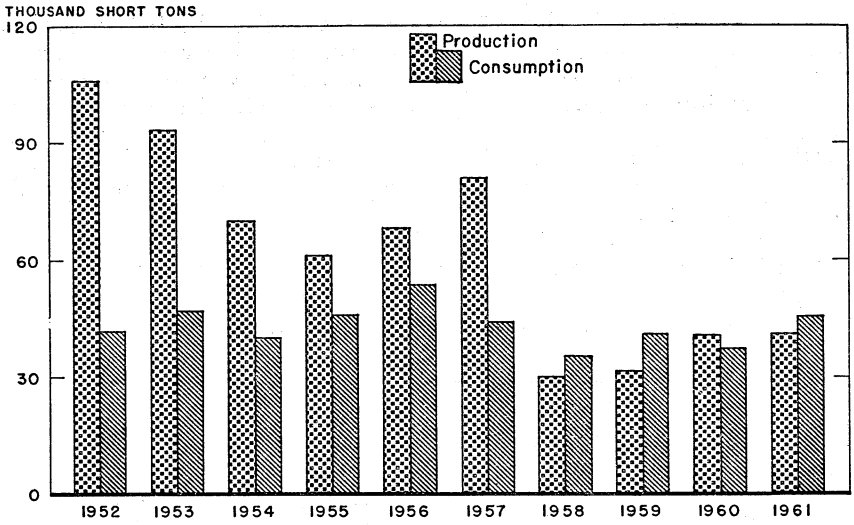


FIGURE 1.—Domestic production and consumption of primary magnesium, 1952–61.

by January 1962.[4] The plant had been closed since 1958. Titanium Metals Corp. of America (TMCA) recycled magnesium continuously as an integrated operation of its production of titanium at Henderson, Nev.

TABLE 2.—Production and shipments of primary magnesium in the United States, by months

(Short tons)

Month	1952-56 (average)		1957		1958	
	Production	Shipments	Production	Shipments	Production	Shipments
January	7,041	6,849	7,391	7,529	5,272	3,367
February	6,657	6,338	6,617	7,776	3,526	2,060
March	7,416	6,872	7,383	5,318	3,235	2,260
April	6,539	6,779	7,222	4,251	2,772	3,043
May	7,061	6,056	7,227	3,870	2,469	2,415
June	6,600	6,552	6,718	4,668	1,784	2,844
July	5,607	5,810	6,777	2,596	1,799	2,645
August	6,201	6,088	7,152	3,097	1,845	2,610
September	6,375	5,754	6,486	5,130	1,791	2,942
October	6,700	5,950	6,468	3,147	1,927	3,151
November	6,648	7,325	5,995	2,114	1,814	2,911
December	6,776	5,201	5,827	2,074	1,862	3,908
Total	79,621	75,574	81,263	51,570	30,096	34,156

Month	1959		1960		1961	
	Production	Shipments	Production	Shipments	Production	Shipments
January	1,877	2,976	3,355	3,775	3,255	4,090
February	1,725	3,671	3,180	3,675	3,265	4,880
March	1,925	3,681	3,600	5,625	3,470	4,395
April	1,808	4,176	3,290	4,105	3,435	3,560
May	2,668	3,995	3,240	4,465	3,490	4,655
June	2,778	4,271	3,075	4,335	3,440	4,145
July	2,850	4,559	3,120	2,435	3,675	2,270
August	2,967	4,367	3,200	5,310	3,930	4,870
September	2,846	3,026	3,290	4,785	1,525	5,190
October	3,018	3,556	3,535	4,925	3,505	5,165
November	3,042	4,718	3,200	4,470	3,900	7,165
December	3,529	4,536	3,985	6,445	3,855	5,130
Total	31,033	47,532	40,070	54,350	40,745	55,515

[4] Modern Metals. Dow to Increase Magnesium Production. V. 17, No. 11, December 1961, p. 82.

Secondary.—Most of the decrease in recovery of magnesium from scrap in 1961 was in recovery from new scrap.

TABLE 3.—Magnesium recovered from scrap processed in the United States, by kinds of scrap and forms of recovery [1]

(Short tons)

	1952–56 (average)	1957	1958	1959	1960	1691
Kind of scrap:						
New scrap:						
Magnesium-base	3,318	3,360	2,280	3,073	3,179	1,902
Aluminum-base	1,880	2,237	1,653	2,105	2,825	1,394
Total	5,198	5,597	3,933	5,178	6,004	3,296
Old scrap:						
Magnesium-base	4,636	4,350	4,156	4,133	3,560	4,262
Aluminum-base	652	711	618	779	784	481
Total	5,288	5,061	4,774	4,912	4,344	4,743
Grand total	10,486	10,658	8,707	10,090	10,348	8,039
Form of recovery:						
Magnesium alloy ingot [1]	4,823	4,200	2,976	3,881	3,828	1,085
Magnesium alloy castings (gross weight)	381	75	78	219	103	345
Magnesium alloy shapes	3	----	3	2	3	350
Aluminum alloys	2,980	3,383	2,701	3,507	3,208	1,861
Zinc and other alloys	37	22	30	21	54	1,094
Chemical and other dissipative uses	23	29	53	600	255	1,345
Cathodic protection	2,239	2,949	2,866	1,860	2,897	1,959
Total	10,486	10,658	8,707	10,090	10,348	8,039

[1] 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 1961

(Short tons, gross weight)

Scrap item	Stocks, Jan. 1 [1]	Receipts	Consumption			Stocks, Dec. 31
			New scrap	Old scrap	Total	
Cast scrap	397	5,036	725	4,105	4,830	603
Solid wrought scrap	137	749	661	----	661	225
Borings, turnings, drosses, etc	203	1,536	1,551	----	1,551	188
Total	737	7,321	2,937	4,105	7,042	1,016

[1] Revised figures.

CONSUMPTION AND USES

Use of primary magnesium as an ingredient in aluminum alloys accounted for most of the increase in consumption in 1961. Increased use of magnesium tooling plate was reflected in the slight rise in consumption of the metal in sheet and plate. Boeing Co.[5] was one of the larger users of tooling plate.[6]

[5] Changed May 2, 1961, from Boeing Airplane Co.
[6] Modern Metals. Boeing Will Use More Magnesium Tooling Plate. V. 17, No. 3, April 1961, p. 94.

Although shipments of magnesium die castings increased during the latter half of 1961, consumption of the metal to produce the castings during the entire year fell 200 tons below 1960.[7]

Large satellite containers were forged from magnesium alloys.[8] They were formed on a 50,000-ton closed-die forging press.

TABLE 5.—Domestic consumption of primary magnesium (ingot equivalent and magnesium content of magnesium-base alloys), by uses

(Short tons)

Use	1952–56 (average)	1957	1958	1959	1960	1961
For structural products:						
Castings:						
Sand	10,343	6,076	5,698	4,770	2,561	2,408
Die	2,283	1,649	[1] 1,553	[1] 1,772	[1] 1,528	[1] 1,328
Permanent mold	983	571	889	981	745	464
Wrought products:						
Sheet and plate	5,109	4,916	4,061	6,128	4,112	4,434
Extrusions (structural shapes, tubing)	4,050	5,081	2,624	3,074	2,580	3,990
Forgings	185	7	141	1,913	893	767
Total	22,953	18,300	14,966	18,638	12,419	13,391
For distributive or sacrificial purposes:						
Powder	991	386	352	456	430	244
Aluminum alloys	10,287	11,236	10,746	14,780	12,511	19,754
Zinc alloys	[2]	[2]	[2]	[2]	[2]	[2] 27
Other alloys	389	587	446	840	421	1,017
Scavenger and deoxidizer	650	867	708	292	788	344
Chemical	235	325	148	351	276	297
Cathodic protection (anodes)	3,419	2,997	2,028	3,005	3,264	2,406
Reducing agent for titanium, zirconium, hafnium, uranium, and beryllium [3]	5,549	9,695	5,953	3,175	6,978	7,950
Other [4]	1,231	49	5	14	13	103
Total	22,751	26,142	20,386	22,913	24,681	32,142
Grand total	45,704	44,442	35,352	41,551	37,100	45,533

[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.
[4] Includes primary metal consumed for experimental purposes, debismuthizing lead, and producing nodular iron and secondary magnesium alloys.

STOCKS

On December 31, 1961, producer and consumer stocks were 6,790 tons of primary magnesium and 1,950 tons of primary magnesium alloy ingot—decreases of 15,630 tons for primary magnesium and 2,525 tons for primary magnesium alloy ingot below stocks at the beginning of the year. At the end of the year, the only Government stocks of magnesium were 179,000 tons of the 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 a pound, f.o.b. plant.[9]

[7] American Metal Market. Magnesium Casting Shipments. V. 69, No. 37, Feb. 23, 1962, p. 10
[8] American Metal Market. Forging Satellite Containers. V. 68, No. 134, July 14, 1961, p. 10.
[9] E&MJ Metal and Mineral Markets. Magnesium. V. 33, No. 1, Jan. 4, 1962, p. 4.

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FOREIGN TRADE [10]

Imports of magnesium were more than twice the quantity imported in 1960. About 67 percent of the total 1,041 tons was scrap metal. These imports came from nine countries: 257 tons from Canada, 8 tons from Denmark, 1 ton from the Dominican Republic, 29 tons from West Germany, 55 tons from Japan, 1 ton from Norway, 17 tons from Sweden, 51 tons from Taiwan, and 622 tons from the United Kingdom. Throughout 1961, the duty on magnesium metal remained at 50 percent ad valorem. For magnesium powder, ribbon, sheets, tubing, manufacturers, and so forth, the duty remained at 17 cents per pound on metallic content plus 8.5 percent ad valorem. Suspension of duty on magnesium scrap was extended to June 30, 1962.

Exports of magnesium from the United States increased 30 percent above those of 1960; 35 percent of the total went to West Germany, and deliveries to Canada were about four times the quantity delivered in 1960.

TABLE 6.—U.S. imports for consumption and exports of magnesium

Year	Imports					
	Metallic and scrap		Alloys (magnesium content)		Sheets, tubing, ribbons, wire, and other forms (magnesium content)	
	Short tons	Value	Short tons	Value	Short tons	Value
1952-56 (average)	1,180	$526,873	9	$60,435	12	[1] $31,077
1957	982	479,855	35	283,099	8	16,952
1958	537	280,316	9	38,096	16	97,194
1959	593	303,307	26	154,775	26	120,630
1960	401	202,087	28	287,916	4	60,623
1961	1,005	482,907	31	170,304	5	80,419
	Exports					
	Metal and alloys in crude form, and scrap		Semifabricated forms, n.e.c.		Powder	
	Short tons	Value	Short tons	Value	Short tons	Value
1952-56 (average)	3,700	$2,179,739	[2] 242	[2] $607,681	34	$55,717
1957	1,219	1,122,164	[2] 355	[2] 767,656	22	39,469
1958	[3] 207	[3] 225,522	[3] 834	[3] 1,053,844	11	16,147
1959	[3] 1,601	[3] 881,514	[3] 776	[3] 1,146,180	12	31,536
1960	[3] 4,467	[3] 2,658,480	[3] 658	[3] 1,037,325	7	23,048
1961	[3] 6,160	[3] 3,639,669	[3] 488	[3] 878,815	33	78,297

[1] Owing to changes in tabulating procedures by the Bureau of the Census, data known to be not comparable with other years.
[2] Owing to changes in items included in each classification 1954–57, data are not strictly comparable to earlier years.
[3] 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.

[10] 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. exports of magnesium, by classes and countries

(Short tons)

Destination	1960			1961		
	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	177	205	2	1,363	156	1
Mexico	358	32	----	387	53	----
Other North America	(1)	51	----	----	9	----
Total	535	288	2	1,750	218	1
South America:						
Brazil	----	----	----	169	----	(1)
Colombia	----	2	----	----	8	----
Venezuela	9	29	----	4	44	----
Other South America	13	24	----	----	42	----
Total	22	55	----	173	94	(1)
Europe:						
Belgium-Luxembourg	36	8	(1)	2	10	1
France	66	11	----	67	35	(1)
Germany, West	2,049	29	----	2,297	20	(1)
Italy	(1)	8	----	19	5	2
Netherlands	214	17	(1)	667	2	(1)
Norway	437	10	1	----	----	1
Spain	13	3	----	72	----	----
Sweden	33	36	----	----	6	4
Switzerland	152	67	----	----	11	1
United Kingdom	393	17	(1)	616	7	1
Other Europe	321	5	1	341	2	(1)
Total	3,714	211	2	4,081	98	10
Asia:						
India	67	----	----	41	----	----
Indonesia	----	3	----	----	2	----
Israel	4	9	3	9	21	1
Japan	6	46	----	----	32	----
Turkey	(1)	30	----	----	----	21
Other Asia	----	15	----	6	13	----
Total	77	103	3	56	68	22
Africa	20	(1)	----	6	7	----
Oceania	99	1	----	94	3	----
Grand total	4,467	658	7	6,160	488	33

[1] Less than 1 ton.

Source: Bureau of the Census.

WORLD REVIEW

Increased output of magnesium in Norway, the U.S.S.R., Canada, and the United States, accounted for the 12-percent rise in world production above that of 1960.

Canada.—Dominion Magnesium, Ltd., sole producer of the primary metal in Canada, expanded the annual capacity of its silicothermic plant at Haley, Ontario, from 8,000 to 10,000 tons.[11]

Germany, West.—The small production of magnesium in West Germany was confined to two firms: Knapsack-Griesheim, A.G., near Cologne, and the government-owned plant, Vereinigte Aluminium Werke

[11] American Metal Market. Canada Optimistic in Outlook. V. 69, No. 29, Feb. 9, 1962, p. 9.

A.G., in Pocking, Bavaria.[12] Engineers at Knapsack-Griesheim, A.G., reported development of a continuous ferrosilicon reduction process to produce magnesium from dolomite.[13]

TABLE 8.—World production of primary magnesium, by countries[1]

(Short tons)

Country	1952–56 (average)	1957	1958	1959	1960	1961
Canada	[2] 7,200	8,385	6,796	6,102	7,288	7,740
China	([3])	([3])	[2] 1,100	[2] 1,100	[2] 1,100	[2] 1,100
France	1,372	1,753	1,897	1,938	2,359	2,288
Germany, West	[4] 147	330	660	550	[2] 330	[2] 330
Italy	2,358	4,170	4,607	4,960	6,003	[2] 6,100
Japan	[4] 86	[5] 472	[5] 1,106	[5] 1,724	[5] 2,363	[2] 2,400
Norway	4,998	9,504	10,132	10,567	11,373	[2] 16,500
Switzerland	120					
U.S.S.R.[2]	13,300	18,800	19,400	22,000	27,600	34,000
United Kingdom [6]	5,333	3,831	2,691	2,387	4,119	[2] 4,200
United States	79,621	81,263	30,096	31,033	40,070	40,745
World total (estimate) [1]	114,800	128,700	78,500	82,400	102,600	115,400

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[2] Estimate.
[3] Data not available; estimates by senior author included in total.
[4] Average annual production 1954–56.
[5] In addition, the following amounts of remelted magnesium were produced: 1957, 1,906 tons; 1958, 2,567 tons; 1959, 2,694 tons; and 1960, 3,327 tons.
[6] Primary metal and remelt alloys.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

Japan.—The Dow Chemical Co. made a 15-year exchange agreement with Kobe Steel Works, Ltd., Tokyo, to provide the Japanese company with technical information on the fabrication of magnesium.[14]

Norway.—During the latter half of 1961, Norsk-Hydro Elektrisk, sole producer of primary magnesium in Norway, began investigating the feasibility of delivering molten metal to Volkswagen Werke, its principal consumer in West Germany.[15]

United Kingdom.—In October 1961, Magnesium Elektron, Ltd., announced plans to erect a 5,000-ton thermic plant at Hopton in Derbyshire to produce magnesium from dolomite.[16] Magnesium Elektron planned to continue operation of the electrolytic magnesium plant at Clifton Junction, near Manchester.

TECHNOLOGY

Research to develop new and improved magnesium alloys continued. New magnesium-lithium alloys were developed that were 20 percent lighter than standard magnesium alloys.[17] Pilot tests

[12] Bureau of Mines. Mineral Trade Notes. V. 52, No. 6, June 1961, p. 24.
[13] Chemical Week. Backing Germany's Magnesium Bid. V. 88, No. 24, June 17, 1961, pp. 71–72.
[14] American Metal Market. Dow to Extend Aid to Japanese. V. 68, No. 154, Aug. 11, 1961, p. 10.
[15] American Metal Market. Norwegian Magnesium: Hot Metal for VW? V. 68, No. 193, Oct. 6, 1961, pp. 1, 21.
[16] Light Metals (London). Magnesium—A New Dawn. V. 24, No. 281, October 1961, pp. 258–259.
Metallurgia. Magnesium Elektron, Ltd. V. 64, No. 384, October 1961, p. 190.
[17] Bryer, T. G., P. D. Frost, and Others. Magnesium-Lithium Alloys. Light Metal Age, v. 19, Nos. 3 and 4, April 1961, p. 15.

indicated that the new alloys had excellent resistance to spalling and penetration by high-velocity fragments and that they gave promise of sufficient strength to carry loads in space structures.

Work on single crystals of magnesium was described, with comparison of their properties with those of zinc single crystals.[18] A permanent loss in strain hardening accompanied continued strain of magnesium crystals. The investigations covered the plastic flow of magnesium crystals at low temperatures and determined creep and constant strain rates.

The Bureau of Mines continued research at its Rolla, Mo., Metallurgy Research Center to develop new and improved magnesium alloys, with special emphasis on the magnesium-zirconium system. The work included studies of the vibration-damping properties of magnesium and its alloys and covered investigation of damping by single crystals of magnesium and by polycrystalline magnesium and magnesium alloys.

A bibliography was published that covered magnesium-thorium alloys and listed their physical properties.[19] It included papers describing tests and metallurgical analyses employed to establish the properties.

Increasing interest in the effects of low temperatures upon metals was reflected in studies to determine the tensile strength of magnesium alloys in the temperature range of minus 196° to plus 200° C.[20] The alloys tested contained cadmium, silver, and indium. The flow and fracture stresses were given for various temperatures. An investigation was conducted to compare the hardness of single magnesium crystals and polycrystalline magnesium, when rolled.[21]

Research was reported on magnesium casting. Work at The Dow Chemical Co. new laboratory at Midland, Mich., was directed toward developing better magnesium die castings and improved casting techniques.[22] Increased use of light metals in jet engines and space vehicles encouraged development of new and improved inspection practices in magnesium foundries.[23] Improvements were described for forming magnesium sand castings.[24] A new technique enabled foundrymen to produce sound investment castings from eight magnesium alloys, as well as the AZ92A alloy (containing aluminum, manganese, and zirconium) that has been used exclusively for this type of castings.[25]

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[18] Conrad, H., and Others. On the Rate-Controlling Mechanism for Plastic Flow of Magnesium Crystals at Low Temperatures. Acta Metallurgica, v. 9, No. 4, April 1961, pp. 367–378.
Phillips, W. L., Jr. Shear Deformation of Magnesium and Zinc Single Crystals. Metal Prog., v. 80, No. 4, October 1961, p. 186.

[19] Hollister, William L. Properties of Magnesium-Thorium Alloys, An Annotated Bibliography. Off. Tech. Services, U.S. Dept. Commerce, Special Bibliography No. SB–61–29, June 1961, 21 pp.

[20] Tegart, W. J. McG. The Tensile Properties of Some Polycrystalline Magnesium Alloys at Low Temperatures. J. Inst. Met., v. 89, No. 6, February 1961, pp. 215–218.

[21] Schwartz, M., and Others. Hardness Anistropy in Single Crystal and Polycrystalline Magnesium. Trans. AIME, v. 221, No. 3, June 1961, pp. 554–560.

[22] American Metal Market. Die Casting Research. V. 68, No. 139, July 21, 1961, p. 10.

[23] Boehm, Robert C. Magnesium Castings. Foundry, v. 89, No. 5, May 1961, pp. 148–151.

[24] Foundry. Gating Magnesium Sand Castings. V. 89, No. 2, February 1961, pp. 80–87.
Boehm, Robert C. Risering Magnesium Sand Castings. Foundry, v. 89, No. 3, March 1961, pp. 76–80.

[25] Iron Age. Investment Casting Technique Widens Magnesium Usage. V. 188, No. 22, Nov. 30, 1961, pp. 142–143.
Herrick, Kenneth, and Harry Matthieson. Most Magnesium Alloys Can Be Investment Cast. Precision Metal Molding, v. 19, No. 3, March 1961, pp. 53–55.

Improved gating systems for magnesium die castings were described.[26] Preparation of thin-walled permanent-mold magnesium castings with intricate configurations was described.[27] A centrifuge fitted with permanent molds formed the castings at 220 rpm.

Magnesium alloy sheet was deep-drawn at the same speeds on mechanical presses used for steel and aluminum sheet.[28]

Improvements were developed for joining magnesium parts to each other and to other metals.[29] A new flux was used for welding a magnesium alloy to stainless steel.[30] The welded units were used to hold canisters containing radioactive material used in producing nuclear energy.

Improvements in surface finishing and coating of magnesium were described.[31]

A new method was described for introducing magnesium into molten iron to produce high quality gray or ductile iron.[32] The method permitted normal cupola operation in standard foundry equipment.

Small additions of magnesium to zinc galvanizing solutions improved corrosion resistance of the galvanized metal products.[33] The method of preparing the solutions was described, and test data were given.

Electrochemical processes in magnesium anodes were measured and recorded.[34] Service records of magnesium anodes attached to U.S. Navy vessels for one- and two-year periods showed that cathodic protection was 90 to 100 percent effective in eliminating corrosion of the underwater steel hulls of the ships.[35]

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[26] Bennett, Foster C. Gating Magnesium Die Castings. Foundry, v. 89, No. 11, November 1961, pp. 104–107.

[27] Smith, Warren C. Centrifugal Casting of Thin-Walled Magnesium Parts. Metal Prog., v. 80, No. 2, August 1961, pp. 101–102.

[28] Crane, E. V. Deep-Drawing Magnesium. Mod. Metals, v. 17, No. 7, August 1961, pp. 58, 60, 62.

[29] Modern Metals. Joining Magnesium, Pt. 1: Arc Welding. V. 17, No. 9, October 1961, pp. 38–40, 42, 44, 46; Pt. 2: Resistance Welding. V. 17, No. 10, November 1961, pp. 60, 62, 65–66; Pt. 3: Mechanical Fastening. V. 17, No. 11, December 1961, pp. 64, 66, 70.

[30] Chemical Engineering. Flux Permits Joining Magnesium to Stainless Steel. V. 68, No. 6, Mar. 20, 1961, p. 192.

[31] American Metal Market. New Finishing System Described. V. 68, No. 202, Oct. 20, 1961, p. 10.

Rhoden, R. A. Finish System for Magnesium Aircraft. Tech. Abst. Bull. U61–1–2, Jan. 15, 1961, pp. 57–58.

Steel. Improved Magnesium Protection. V. 149, No. 24, Dec. 11, 1961, p. 91.

[32] Steel. Magnesium for Iron Founders. V. 149, No. 7, Aug. 14, 1961, p. 127.

[33] Steel. Stirring Magnesium Into a Zinc Bath. V. 148, No. 24, June 12, 1961, pp. 154, 157.

[34] Robinson, J. L., and P. F. King. Electrochemical Behavior of the Magnesium Anode. J. Electrochem. Soc., v. 108, No. 1, January 1961, pp. 36–41.

[35] Waldron, L. J., and M. H. Peterson. Magnesium Anodes for the Cathodic Protection of Naval Vessels. Corrosion, v. 17, No. 7, July 1961, pp. 125–127.

Magnesium Compounds

By H. B. Comstock [1] and Jeannette I. Baker [2]

EXPANDING requirements for basic refractories in steel furnaces accounted for the 19-percent increase in the world output of crude magnesite above 1960. Although domestic production of some of the magnesium compounds decreased slightly below 1960, output of crude magnesite and magnesia rose. Research on the properties of magnesium oxide crystals developed a high-strength, high-melting-point ceramic material for insulating heat exchangers and electrical equipment.

TABLE 1.—Salient magnesium compounds statistics

(Thousand short tons and thousand dollars)

	1952–56 (average)	1957	1958	1959	1960	1961
United States:						
Crude magnesite:						
Production:						
Quantity	[1] 504	[2] 678	[2] 493	[2] 594	[2] 499	[2] 604
Value [3]	$2,540	$3,258	$2,409	$2,401	$2,051	$3,129
Caustic-calcined magnesia:						
Sold or used by producers:						
Quantity	37	61	45	54	66	80
Value [4]	$2,917	$3,161	$2,648	$3,533	$4,292	$5,004
Imports for consumption:						
Value	$153	$265	$115	$264	$213	$226
Exports: Value	(5)	$4,033	$844	$667	$686	$535
Refractory magnesia:						
Sold or used by producers:						
Quantity	385	468	415	518	506	599
Value	$18,627	$26,319	$23,375	$31,458	$30,863	$35,408
Imports: Value	$4,122	$4,033	$5,095	$9,606	$7,576	$3,611
Exports: Value	(5)	$1,436	$2,838	$5,160	$5,988	$7,988
Dead-burned dolomite:						
Sold or used by producers:						
Quantity	2,059	2,251	1,659	1,988	1,949	1,983
Value	$29,737	$35,871	$27,378	$33,069	$32,522	$32,513
Imports: Value	$375	$640	$322	$496	$550	$233
World: Crude magnesite: Production:						
Quantity	4,670	5,650	6,100	6,700	7,200	8,600

[1] Includes crude ore, heavy-medium concentrate and flotation concentrate.
[2] All run-of-mine material.
[3] Partly estimated: most of the crude is processed by mining companies, and very little enters the open market.
[4] Includes specialty magnesia of high unit value.
[5] Data not available.

[1] Commodity specialist, Division of Minerals.
[2] Research assistant, Division of Minerals.

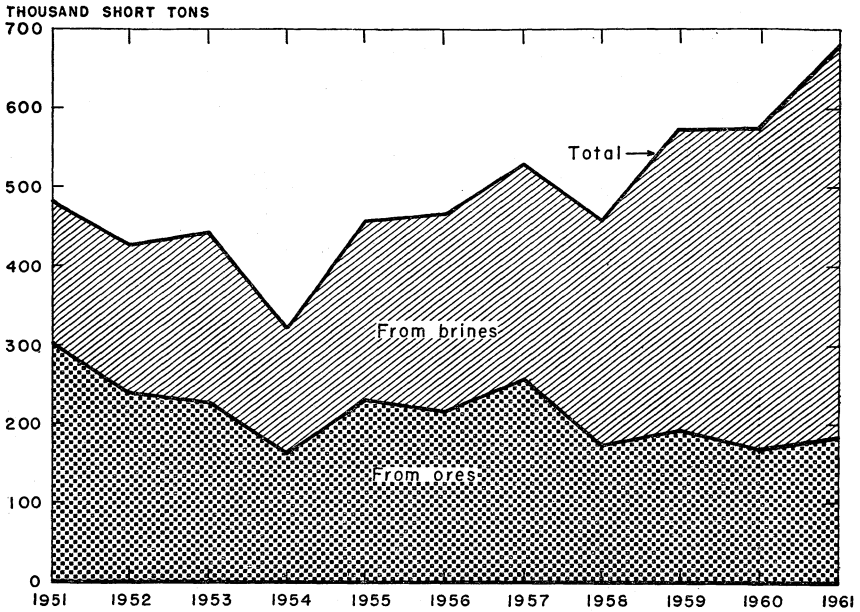


FIGURE 1.—Domestic production of magnesia from ores and brines, 1951–61.

DOMESTIC PRODUCTION

Production of crude magnesite increased 21 percent above 1960. The quantity of crude olivine mined was more than double the 1960 output. No brucite was mined during 1961.

Production of dead-burned dolomite, specified magnesias, magnesium chloride, and magnesium trisilicate was slightly higher than in 1960. Output of caustic-calcined magnesia increased 21 percent and refractory magnesia 18 percent.

There was a 24-percent decrease in production of precipitated magnesium carbonate, and a small decrease in magnesium sulfate production.

TABLE 2.—Mines and plants producing magnesite, brucite, and other magnesium compounds in the United States in 1961

State and company	Location of mine or plant	Products	Raw materials
Alabama:			
Norton Co	Huntsville	Heavy magnesium oxide	Magnesite.
Tennessee Coal & Iron Division, U.S. Steel Corp.	Fairfield	Dead-burned dolomite	Raw dolomite.
California:			
Fibreboard Paper Products Corp.	Emeryville	Precipitated magnesium carbonate.	Sea water, dolomite.
Mother Lode Rock Industries, Inc.	Western mine (near Livermore).	Magnesite	
Kaiser Industries Corp.	Moss Landing	Caustic-calcined magnesia; refractory magnesia; magnesium hydroxide; magnesium oxide, extra-light, light, and heavy.	Sea water, dead-burned dolomite.
Do	Natividad	Dead-burned dolomite	Raw dolomite.

TABLE 2.—Mines and plants producing magnesite, brucite, and other magnesium compounds in the United States in 1961—Continued

State and company	Location of mine or plant	Products	Raw materials
California—Continued			
Marine Magnesium Division, Merck & Co., Inc.	South San Francisco.	Magnesium oxides, extra-light, light, and heavy; magnesium hydroxide; precipitated magnesium carbonate; magnesium trisilicate.	Sea water, seawater bitterns, dead-burned dolomite.
Philadelphia Quartz Co. of California.	Alameda County	Epsom salt	Magnesite, brucite, calcined magnesia.
FMC Corp. (formerly Westvaco Chem. Div., Food Machinery and Chemical Corp.)	Newark	Caustic-calcined magnesia; refractory magnesia; magnesium chloride crystals; magnesium hydroxide.	Seawater bitterns, dead-burned dolomite, magnesite.
Delaware:			
E. I. du Pont de Nemours & Co., Inc.	New Castle	Magnesium chloride	Byproduct from reducing titanium tetrachloride with magnesium.
Florida:			
Michigan Chemical Corp.	Port St. Joe	Caustic-calcined magnesia; refractory magnesia.	Sea water, oystershells.
Illinois:			
Johns-Manville Products Corp.	Waukegan	Precipitated magnesium carbonate.	Dolomite.
Marblehead Lime Co.	Thornton	Dead-burned dolomite	Raw dolomite.
Standard Lime & Cement Co.	LaGrange	do	Do.
Massachusetts:			
New England Lime Co.	Adams	do	Do.
Michigan:			
The Dow Chemical Co.	Ludington	Magnesium chloride crystals; magnesium chloride fluxes; magnesium hydroxide.	Well brines.
Do	Midland	Epsom salt, magnesium hydroxide, magnesium oxide, light.	Do.
Harbison-Walker Refractories Co.	Ludington	Refractory magnesia	Magnesium hydrate.
Kaiser Industries Corp.	Midland	Refractory magnesia; periclase.	Magnesium hydroxide.
Michigan Chemical Corp.	St. Louis	Precipitated magnesium carbonate; magnesium hydroxide; magnesium oxide, extra-light, light, and heavy.	Well brines, dead-burned dolomite.
Morton Chemical Co.	Manistee	Precipitated magnesium carbonate; magnesium oxide, extra-light, light.	Well brines.
Standard Lime & Cement Co.	do	Refractory magnesia	Do.
Mississippi:			
H. K. Porter Co., Inc.	Pascagoula	do	Raw dolomite, sea water.
Do		Dead-burned dolomite	Raw dolomite.
Missouri:			
Valley Dolomite Corp.	Bonne Terre	do	Do.
Nevada:			
Basic, Inc	Gabbs	Brucite, magnesite, refractory magnesia, caustic-calcined magnesia.	Magnesite and brucite.
Standard Slag Co	do	Magnesite, refractory magnesia, caustic-calcined magnesia.	Magnesite.
New Jersey:			
J. T. Baker Chemical Co.	Phillipsburg	Magnesium chloride crystals; epsom salt; other high purity magnesium chemicals, magnesium trisilicate.	Magnesium carbonate.
Northwest Magnesite Co.	Cape May	Refractory magnesia	Sea water, calcined dolomite.
New Mexico:			
International Minerals & Chemical Corp.	Carlsbad	Magnesium oxide, heavy	Potash-reject brines.
New York:			
Carborundum Metals Co.	Erie	Magnesium chloride	Byproduct from producing zirconium.

TABLE 2.—Mines and plants producing magnesite, brucite, and other magnesium compounds in the United States in 1961—Continued

State and company	Location of mine or plant	Products	Raw materials
North Carolina:			
Balsam Gap Co.	Balsam Gap mine (near Sylva).	Olivine	
Harbison-Walker Refractories Co.	Addie mine (near Sylva).	do	
Wiseman Mining Co., Inc.	Wray mine (near Burnsville).	do	
Georgia Talc Co.	Spruce Pine	do	
Ohio:			
J. E. Baker Co.	Millersville	Dead-burned dolomite	Raw dolomite.
Basic, Inc.	Maple Grove	do	Do.
Dolite Co.	Gibsonburg	do	Do.
Moores Lime Co.	Springfield	do	Do.
Ohio Lime Co.	Woodville	do	Do.
Standard Lime & Cement Co.	do	do	Do.
U.S. Gypsum Co.	Genoa	do	Do.
Pennsylvania:			
J. E. Baker Co.	York	do	Do.
Philip Carey Mfg. Co.	Plymouth Meeting.	Precipitated magnesium carbonate; magnesium oxide, extra-light and light.	Dolomite.
G. & W. H. Corson	do	Dead-burned dolomite	Raw dolomite.
Texas:			
The Dow Chemical Co.	Freeport	Magnesium chloride, caustic-calcined magnesia, magnesium hydroxide.	Sea water.
E. J. Lavino & Co.	do	Refractory-grade periclase	Magnesium hydroxide.
Utah:			
Marblehead Lime Co.	Delle	Dead-burned dolomite	Raw dolomite.
Washington:			
Agro Minerals, Inc.	Tonasket	Epsom salt	Lake brine.
Northwest Magnesite Co.	Chewelah	Magnesite, caustic-calcined magnesia, refractory magnesia.	Magnesite.
Northwest Olivine Co.	Twin Sisters quarry (near Clear Lake).	Olivine	
West Virginia:			
Carborundum Metals Co.	Parkersburg	Magnesium chloride	Byproduct from producing zirconium.
Standard Lime & Cement Co.	do	Refractory magnesia, dead-burned dolomite.	Dolomite.

CONSUMPTION AND USES

Consumption of crude magnesite, caustic-calcined and refractory magnesia, and magnesium hydroxide increased about 20 percent above 1960, and consumption of dead-burned dolomite and specified magnesias increased slightly. Use of brucite decreased about 25 percent below 1960, and the consumption of precipitated magnesium carbonate, magnesium chloride, magnesium sulfate, and magnesium trisilicate declined.

Greater quantities of high-purity magnesia used for making basic refractory brick and shapes for oxygen steel furnaces required increased consumption of magnesium hydroxide.[3]

A new use for magnesium chloride was reported.[4] During cold weather copper ore cars were sprayed with magnesium chloride solution to prevent the ore from freezing in the cars, so that it did not have to be thawed when it was unloaded.

[3] Blast Furnace and Steel Plant. High Purity Magnesite. V. 50, No. 2, February 1962, p. 187.
[4] Engineering and Mining Journal. Magnesium Chloride Spray Prevents Frozen Ore Cars. V. 162, No. 4, April 1961, p. 104.

TABLE 3.—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)
1960:						
Caustic-calcined	20,076	$902	45,979	$3,390	66,055	$4,292
Refractory	148,404	7,054	357,507	23,809	505,911	30,863
Total	168,480	7,956	403,486	27,199	571,966	35,155
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

[1] Magnesia made from a combination of dolomite and sea water is included with that from sea water.

TABLE 4.—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)
1952-56 (average)	2,059,313	$29,737	5,534	$375
1957	2,251,428	35,871	10,419	640
1958	1,659,184	27,378	5,686	322
1959	1,987,767	33,069	8,468	496
1960	1,949,260	32,522	12,932	550
1961	1,982,759	32,513	4,256	233

[1] Dead-burned basic refractory material comprising chiefly magnesium and lime.
[2] Includes weight of immediate container.

TABLE 5.—Specified magnesium compounds produced, sold, and used by producers in the United States

Year and product [1]	Plants	Produced (short tons)	Sold		Used (short tons)
			Short tons	Value (thousands)	
1960:					
Specified magnesias (basis, 100 percent MgO), U.S.P. and technical:					
Extra-light and light	5	2,429	2,486	$1,426	----------
Heavy	3	21,765	17,899	2,348	----------
Total	[2] 6	24,194	20,385	3,774	----------
Precipitated magnesium carbonate	5	17,524	5,666	1,192	11,988
Magnesium hydroxide, U.S.P. and technical (basis, 100 percent $Mg(OH)_2$)	5	319,935	146,710	3,756	167,473
Magnesium chloride	7	160,123	17,629	964	[3] 144,917
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

[1] In addition, magnesium phosphate, nitrate, sulfate, and trisilicate were produced.
[2] A plant producing more than 1 grade is counted only once in arriving at total.
[3] Greater part used for magnesium metal.

TABLE 6.—Domestic consumption of caustic-calcined magnesia by uses

(Percent)

Use	1957	1958	1959	1960	1961
Oxychloride and oxysulphate cement	30	50	49	47	33
Rayon	1	2	2	3	3
Fertilizer	(1)	(1)	(1)	1	(2)
85-percent-MgO insulation	6	10	4	3	8
Rubber	2	4	1	4	3
Fluxes	(1)	(1)	(1)	(1)	(2)
Refractories	29	(1)	1	9	27
Chemical processing		2	2	3	1
Uranium processing		6	9	7	5
Miscellaneous (including chemicals and paper industry)	32	26	32	23	20
Total	100	100	100	100	100

[1] Less than 1 percent.
[2] Less than 0.5 percent.

TABLE 7.—Domestic consumption of U.S.P. and technical-grade magnesias by uses

(Percent)

Use	1957	1958	1959	1960	1961
Rayon	17	18	17	21	17
Rubber (filler and catalyst)	18	12	11	9	8
Refractories	11	11	14	14	22
Medicinal	3	(1)	(1)	(1)	(2)
Uranium processing	4	5	1	(1)	(2)
Fertilizer	(1)	1	1	1	1
Electrical		21	14	16	17
Neoprene compounds		2			
Oxychloride and oxysulphate cement			7	2	2
Miscellaneous (including chemicals industry)	47	30	35	37	33
Total	100	100	100	100	100

[1] Less than 1 percent.
[2] Less than 0.5 percent.

PRICES

There were no changes in prices of magnesium compounds in 1961 except for magnesium trisilicate, U.S.P. micronized powder, which increased from 65 cents to 80 cents a pound early in October.

FOREIGN TRADE [5]

Imports.—Imports of caustic-calcined magnesia rose 8 percent in 1961, but imports of refractory magnesia decreased more than 50 percent below 1960. Imports of magnesium compounds not specifically provided for increased 25 percent, but imports of other magnesium compounds decreased.

Exports.—Exports of magnesite, magnesia, and manufactures (except refractories) were valued at $8.5 million, a 28-percent increase above 1960.

Tariff.—The tariff on crude magnesite, based on the Geneva Agreement of 1947, remained at 1¾ cent per pound, an ad valorem equivalent of 12.8 percent. Duty on dead-burned and grain magnesite and

[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.

periclase was 2³⁄₁₀ cent per pound, an ad valorem equivalent of 11.04 percent; duty on caustic-calcined magnesia was 1⁵⁄₃₂ cent per pound, an ad valorem equivalent of 18.47 percent. Duty on magnesium oxide was 2½ cents per pound, an ad valorem equivalent of 20.26 percent. Duty on dead-burned dolomite was 15 percent ad valorem.

TABLE 8.—U.S. imports for consumption of crude and processed magnesite, by countries

Country	1960		1961	
	Short tons	Value	Short tons	Value
Crude magnesite:				
Oceania: Australia	21	$538	58	$2,124
Total	21	538	58	2,124
Lump or ground caustic-calcined magnesia:				
Europe:				
Austria	282	11,451	378	13,427
Netherlands	1,251	71,534	839	48,949
United Kingdom	22	5,660	8	2,158
Yugoslavia	656	23,494	331	11,813
Total	2,211	112,139	1,556	76,347
Asia: India	1,920	100,955	2,898	149,772
Grand total	4,131	213,094	4,454	226,119
Dead-burned and grain magnesia and periclase:				
North America: Canada	678	108,098	685	255,515
South America: Brazil	55	2,100	----------	----------
Europe:				
Austria	48,670	3,339,345	23,494	1,636,183
Czechoslovakia	17	773	----------	----------
Germany, West	[1] 2,801	[1] 161,634	----------	----------
Greece	26,834	2,106,941	12,117	873,829
Switzerland	6,633	428,908	----------	----------
U.S.S.R.	1	476	----------	----------
Yugoslavia	28,939	1,427,420	15,713	845,536
Total	[1] 113,895	[1] 7,465,497	51,324	3,355,548
Grand total	[1] 114,628	[1] 7,575,695	52,009	3,611,063

[1] Adjusted by Bureau of Mines.

Source: Bureau of the Census.

TABLE 9.—U.S. imports for consumption of magnesium compounds

Year	Oxide or calcined magnesia		Magnesium carbonate precipitated		Magnesium chloride (anhydrous and n.s.p.f.)		Magnesium sulfate (epsom salt)		Magnesium salts and compounds, n.s.p.f. [1]		Manufactures of carbonate of magnesia	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1952–56 (average)	64	[2] $21.587	236	[2] $61,801	229	$6,710	8,741	[3] $204,883	489	[3] $68,869	8	$1,760
1957	412	152,395	307	59,638	431	11,778	10,570	248,948	839	33,867	23	3,769
1958	355	119,012	326	66,174	685	28,038	9,908	238,236	1,202	52.814	1	660
1959	273	71,498	351	93,721	949	28,114	12,350	302,036	1,925	66,096	1	830
1960	266	65,973	346	83,737	1,174	53,920	10,121	240,661	3,036	94,267	28	[3] 6,896
1961	248	61,208	342	73,602	1,012	31,375	10,031	231,022	3,796	117,393	6	3,155

[1] Includes magnesium silicofluoride or fluosilicate and calcined magnesia.
[2] Data known to be not comparable with other years.
[3] Revised figure.

Source: Bureau of the Census.

TABLE 10.—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.	
	1960		1961		1960	1961
	Short tons	Value	Short tons	Value	Value	Value
North America:						
Canada	11,638	$985,257	12,362	$1,153,317	$247,242	$184,080
Honduras					4,300	942
Mexico	7,090	566,865	7,088	478,421	24,453	52,815
Other	12	2,730	5	709	27,066	12,646
Total	18,740	1,554,852	19,455	1,632,447	303,061	250,483
South America:						
Argentina	139	12,959	75	12,907	17,303	
Brazil	1	732	10	6,063	25,510	20,467
Chile	158	10,901	218	15,570	3,871	81,335
Peru			990	80,732	4,816	10,174
Venezuela					30,595	24,534
Other	10	1,434	1	616	7,417	13,222
Total	308	26,026	1,294	115,888	89,512	149,732
Europe:						
Denmark	56	38,950	51	21,861	5,582	
France	83	24,943	200	70,018	17,240	498
Germany, West	1,318	179,835	6,434	439,587	7,083	15,002
Hungary	1,727	120,939				
Italy	87	19,604	97	29,952		1,093
Spain			5	2,280	650	5,768
Sweden	25	16,618	21	13,365	19,927	24,527
Switzerland	6	4,507	12	8,454	1,947	1,992
United Kingdom	5,707	399,547	41,989	2,559,739	72,327	36,974
Other	36	12,165	431	43,870	17,392	16,029
Total	9,045	817,108	49,240	3,189,126	142,148	101,883
Asia:						
Iran	50	5,500			516	
Japan	63,676	3,430,074	52,258	2,927,261	5,412	2,454
Korea, Republic of	2	836			2,115	
Kuwait	149	21,350				
Philippines	30	2,089			8,309	6,517
Other			4	1,286	19,445	17,661
Total	63,907	3,459,849	52,262	2,928,547	35,797	26,632
Africa:						
Congo, Republic of the, and Ruanda-Urundi [1]					39,452	
Mozambique					57,168	
Rhodesia and Nyasaland, Federation of					9,509	
Union of South Africa	18	11,425	46	27,394	7,284	2,591
Other						2,970
Total	18	11,425	46	27,394	113,413	5,561
Oceania:						
Australia	149	103,837	325	80,072	1,843	
New Zealand	20	14,749	19	14,230	434	460
Total	169	118,586	344	94,302	2,277	460
Grand total	92,187	5,987,846	122,641	7,987,704	686,208	534,751

[1] Belgian Congo before July 1, 1960.

Source: Bureau of the Census.

WORLD REVIEW

Output of crude magnesite rose in nearly all producing countries, resulting in a world increase of 19 percent above 1960. The U.S.S.R. was the leading producer; Austria ranked second; China, third; and the United States, fourth.

EUROPE

Austria.—Exports of refractory magnesia and magnesite brick increased approximately 10 percent above 1960. The principal markets were France and West Germany.

TABLE 11.—World production of magnesite by countries [1 2]

(Short tons)

Country [1]	1952–56 (average)	1957	1958	1959	1960	1961
North America: United States	504,114	678,489	492,982	594,307	498,528	603,656
Total [1 3]	840,000	970,000	740,000	890,000	810,000	890,000
South America: Brazil	[3] 11,000	[3] 11,000	53,116	53,378	69,793	[3] 66,000
Europe:						
Austria	985,370	1,292,567	1,346,023	1,324,106	1,791,701	1,982,704
Bulgaria	102,338	[3] 155,000	[3] 165,000	[3] 165,000	[3] 165,000	[3] 165,000
Czechoslovakia	(4)	(4)	(4)	[3] 440,000	[3] 470,000	[3] 550,000
Greece	91,027	52,392	97,742	123,566	[3] 193,000	[3] 220,000
Italy	3,344	8,512	6,500	7,562	6,584	7,478
Norway	1,318					
Poland	25,148	18,850	15,432	18,188	23,920	[3] 30,000
Spain	23,966	40,454	38,442	44,569	53,239	[3] 55,000
U.S.S.R.	(4)	(4)	(4)	(4)	(4)	[3] 2,750,000
Yugoslavia	141,343	233,983	246,032	269,851	277,613	301,002
Total [3]	3,250,000	3,750,000	3,900,000	4,050,000	4,650,000	6,050,000
Asia:						
China	(4)	(4)	(4)	(4)	(4)	[3] 1,100,000
India	89,940	99,552	114,900	174,129	172,332	231,485
Korea, Republic of	73					
Pakistan		24		443	486	180
Turkey	696	1,439	717		17	2,414
Total [1 3]	470,000	780,000	1,270,000	1,550,000	1,550,000	1,390,000
Africa:						
Kenya		117	551	3,145	33	1,930
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	10,182	2,910			8,031	13,880
Tanganyika (exports)	158	284	337	118	126	46
Union of South Africa	26,446	35,414	80,200	58,883	66,793	67,732
Total	36,786	38,725	81,088	62,146	74,983	83,588
Oceania:						
Australia	56,906	93,490	77,718	67,856	69,626	106,234
New Zealand	657	675	1,344		891	[3] 880
Total	57,563	94,165	79,062	67,856	70,517	107,114
World total (estimate) [1 3]	4,670,000	5,650,000	6,100,000	6,700,000	7,200,000	8,600,000

[1] Quantities in this table represent crude magnesite mined. Magnesite is also produced in 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.

Compiled by Liela S. Price, Division of Foreign Activities.

Greece.—A list of the magnesite producers with a description of the facilities was published, showing that one was a subsidiary of a company in the United States.[6]

Hungary.—A large deposit of dolomite, mined in northern Hungary, near Ujmassa, was expected to supply most of the domestic requirements for basic refractories, enabling users to reduce imports of the materials.[7]

Italy.—Plans were announced for erection at St. Antioco, Sardinia, of Italy's first plant to extract magnesium oxide from sea water.[8]

TABLE 12.—Austria: Exports of magnesia and magnesite brick by countries[1]

(Short tons)

Destination	Magnesia				Magnesite brick	
	Caustic-calcined		Refractory			
	1960	1961	1960	1961	1960	1961
North America: United States	326	402	57,034	40,328	83	23
South America:						
Argentina	11	44	2,082	1,853	2,359	2,500
Brazil	13	29		61	549	1,470
Chile		5	389	526	660	1,333
Venezuela	73	88	34	615	130	239
Europe:						
Belgium-Luxembourg	174	214	1,542	1,958	8,432	6,606
Bulgaria			30	43	131	548
Czechoslovakia	5,526	4,381			1,351	98
Denmark	133	252	461	767	2,808	3,437
Finland			459	433	2,010	2,562
France	2,875	3,186	10,072	11,225	20,657	29,199
Germany, West	89,055	88,421	66,010	76,876	35,833	32,491
Greece			168	204	1,462	1,218
Hungary	1,533	1,753	6,583	13,584	22	20
Italy	4,427	4,738	22,615	35,606	10,351	10,740
Netherlands	37	87	174	208	2,190	1,268
Norway		35	387	680	1,847	3,167
Poland			5,512	12,737	2,076	3,670
Portugal	39	19	100	1,731	598	3,541
Rumania			168	228	1,968	2,319
Spain		35	265	112	3,724	998
Sweden	117	164	1,328	1,351	10,018	10,257
Switzerland	2,254	2,998	489	675	1,395	1,814
United Kingdom	3	19	54,813	54,339	10,980	9,956
Asia:						
India			20	107	198	930
Israel			440	1,239	30	658
Japan			202	2,766		16
Korea, Republic of			712	7	122	14
Turkey			143	80	2,055	1,499
Africa:						
Union of South Africa			610	41	607	646
United Arab Republic (Egypt)			216	5	594	73
Oceania: Australia			4,074	1,182	6,016	9,352
Other countries	61	83	467	654	8,630	8,697
Total	106,657	106,953	237,599	262,221	139,886	151,359

[1] This table incorporates some revisions.

Compiled from Customs Returns of Austria by Corra A. Barry, Division of Foreign Activities.

[6] Bureau of Mines. Mineral Trade Notes. V. 53, No. 6, December 1961, pp. 28–31.
[7] Refractories Journal. New Dolomite Mine. No. 8, August 1961, p. 258.
[8] Chemical Age (London). Magnesium Oxide Plant in Sardinia. V. 86, No. 2208, Nov. 4, 1961, p. 721.

TABLE 13.—Greece: Exports of magnesite and calcined magnesia by countries

(Short tons)

Destination	Crude magnesite		Calcined magnesia	
	1960	1961	1960	1961
Canada			24,109	3,411
France	5,423	3,307	1,824	2,147
Germany:				
East	1,158			
West		876	11,667	13,005
Italy	8,223	9,713		
Netherlands	2,261	2,370	23,469	31,999
Poland		772		
United Kingdom		2,425	6,522	7,531
United States				21,803
Other countries	3,471	883	4,396	4,624
Total	20,536	20,346	71,987	84,520

Compiled from Customs Returns of Greece by Corra A. Barry, Division of Foreign Activities.

TABLE 14.—Netherlands: Exports of refractory magnesia, by countries

(Short tons)

Destination	1960	1961
Belgium-Luxembourg	728	1,012
France	503	556
Germany, West	5,257	7,180
Other countries	12,349	18,067
Total	18,837	26,815

Compiled from Customs Returns of the Netherlands by Corra A. Barry, Division of Foreign Activities.

ASIA

India.—Preliminary investigations of magnesite deposits in the Pungar and Lahore Valleys of Almora disclosed potentially large resources.[9] The increase in production of magnesite in India reflected the expanding development of the refractory industry, begun early in 1961.[10]

Israel.—Plans were started by Dead Sea Works, Ltd., to build a 72,000-ton magnesia plant at Sodom. During 1961, the pilot plant produced 1 ton a day from the Dead Sea.[11]

Japan.—Hokuriku Salt Company's US$4 Million plant at Kourbi City began producing magnesium hydroxide, magnesium bicarbonate, and other chemicals from sea water.[12]

[9] Mining Journal (London). Mining Miscellany. V. 257, No. 6578, Sept. 15, 1961, p. 267.
[10] Mining Journal (London). Expansion of India's Refractory Industry. V. 256, No. 6553, Mar. 24, 1961, pp. 323, 325.
[11] Chemical Trade Journal and Chemical Engineer (London). Magnesite from Dead Sea Works. V. 149, No. 3879, Oct. 6, 1961, p. 758.
[12] Chemical Engineering. Chementator. V. 68, No. 5, Mar. 6, 1961, p. 54.
Chemical Week. Chemicals/Japan. V. 88, No. 5, Feb. 4, 1961, p. 25.

OCEANIA

Australia.—Howe Sound Co., Philadelphia, Pa., purchased and began working a magnesite deposit in Western Australia. Some of the raw ore was sold as mined, and some was crushed. Plans were underway to install a furnace for calcining the ore.[13]

TECHNOLOGY

Most of the research conducted in 1961 on magnesium compounds related to magnesium oxide. However, some investigations were reported on production and use of olivine. Improved techniques and equipment were developed for producing olivine foundry sand.[14]

Techniques were developed for producing magnesium oxide crystals to specified quality and sizes up to three-fourths inch, for use in electronics applications.[15]

Studies of magnesium oxide single crystals were continued at the University of California, Berkeley, Calif., to develop new ductile ceramic material for application in high temperature areas of space vehicles and nuclear units.[16]

A new ceramic material, translucent magnesium oxide, with tensile strength of 45,000 pounds per square inch, was developed for use in heat exchangers and for electrical insulation at high temperature.[17] The melting point of this ceramic was 5,100° F.

The formation of single-crystal magnesia whiskers during compressive deformation of single crystals at room temperatures was described.[18] These whiskers could be bent at room temperature, and tests showed that the strength of a number of them was as high as 3,500,000 psi.

A new induction furnace was built that readily permitted determination of melting points and basic phase studies of materials in controlled atmospheres.[19] The melting point of magnesium oxide was redetermined to be 2,825° C., rather than 2,784° C. determined by Kanolt in 1913.

A quenching technique was developed to investigate phase relations in liquidus temperature regions of the system magnesium oxide-iron oxide.[20] More complete fundamental data on this system should help to solve refractories problems in steel plants.

An improved process was developed for producing magnesia refractory material that was 98 percent MgO.[21] Brick made from the material withstood temperatures above 4,000° F., 800° F. above the limit for standard basic brick.

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[13] American Metal Market. Howe Sound Buys Australian Mine. V. 68, No. 235, Dec. 8, 1961, p. 18.
[14] McMillan, W. D. New Sand Practices Produce Five-Way Profits. Mod. Castings, v. 39, No. 2, February 1961, pp. 33–35.
[15] American Metal Market. Firm Develops Technique for Oxide Crystals. V. 68, No. 230, Dec. 1, 1961, p. 10.
[16] Chemical & Engineering News. U.C. Work Gives Clues to Ductile Ceramics. V. 39, No. 9, Feb. 27, 1961, pp. 38–39.
[17] Ceramic Industry. Strong New Ceramic Combines Purity, Density. V. 77, No. 2, August 1961, p. 31.
[18] Hulse, Charles O. Formation and Strength of Magnesia Whiskers. J. Am. Ceram. Soc., v. 44, No. 11, November 1961, pp. 572–575.
[19] McNally, R. N., and others. Laboratory Furnace for Studies in Controlled Atmospheres; Melting Points of MgO in a N_2 Atmosphere and of Cr_2O_3 in N_2 and in Air Atmospheres. J. Am. Ceram. Soc., v. 44, No. 10, October 1961, pp. 491–493.
[20] Phillips, Bert, and others. Melting Relations of Magnesium Oxide-Iron Oxide Mixtures in Air. J. Am. Ceram. Soc., v. 44, No. 4, April 1961, pp. 167–169.
[21] Iron Age. New High-Density Refractory Takes Higher Temperatures. V. 188, No. 20, Nov. 16, 1961, pp. 112–113.

The effects of some processing practices in manufacturing basic brick were investigated.[22] The study showed the critical relation between the physical and mechanical properties of basic brick and the total water content, bond content, ratio of chemical bond to total water content, and pressing pressure used in making the brick.

A method was introduced for forming large refractory blocks, each of which would replace as many as 300 conventional lining bricks in a steel-making furnace.[23] The blocks were in use in open hearths in Europe in 1961.

Techniques for studying the grain size and mineralogical phases of dolomite, magnesite, and chrome-magnesite refractory materials were described.[24] The investigation included studies of the raw materials as well as changes that occurred in the refractories during service in steel furnaces.

Improvements were developed for slip-casting magnesia to form items such as crucibles.[25] The variables of slip density and temperature were discussed, and examples were given of designs of molds for casting specialized, complicated shapes.

Improved techniques were developed for preparing and installing basic refractories for glass furnaces.[26] Specifications were given for refractories in each area of the furnaces. Studies were made of service records of basic refractory brick in a glass furnace over a 2-year period, and comparisons were given of brick composed of 89 and 95 percent MgO periclase, forsterite, and magnesite-chrome.[27]

Properties of refractory materials were studied to evaluate the materials that would be satisfactory for use as containers for uranium tetrafluoride.[28] Magnesia-alumina spinel was found to be the most satisfactory refractory material for use in uranium reduction systems.

An improved magnesia material was developed for insulating hot-water pipes.[29]

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[22] Eusner, G. R., and D. H. Hubble. Effects of Some Processing Variables in Basic-Brick Manufacture Am. Ceram. Soc. Bull., v. 40, No. 11, November 1961, pp. 698–701.
[23] Steel. Up to 300 Bricks Nudged Aside by Refractory Block. V. 149, No. 21, Nov. 20, 1961, p. 98.
[24] Andrews, K. W. Researches on the Constitution of Steelworks Refractories. Refractories J. (London), v. 37, No. 3, March 1961, pp. 66–77.
[25] Whiteway, S. G., and others. Slip Casting Magnesia. Am. Ceram. Soc. Bull., v. 40, No. 7, July 1961, pp. 432–438.
[26] Fabianic, W. L. Basic Refractories in the Tank. Ceram. Ind., v. 76, No. 3, March 1961, pp. 62–64, 79–80, 82, 87.
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Manganese

By Gilbert L. DeHuff [1] and Teresa Fratta [2]

THE last Government contract for purchase of domestic manganese ore came to an end when the Manganese, Inc., operation closed at Henderson, Nev. This lack of Government support was reflected in total 1961 domestic production of only 46,000 short tons—ore, concentrate, and nodules containing 35 percent or more manganese. Both domestic consumption and imports were lower than for the preceding year, while industrial ore stocks remained high—2¼ million tons at the end of the year, compared with 2½ million tons at the end of 1960. Growing competition from imported ferromanganese and manganese metal faced domestic producers of these items.

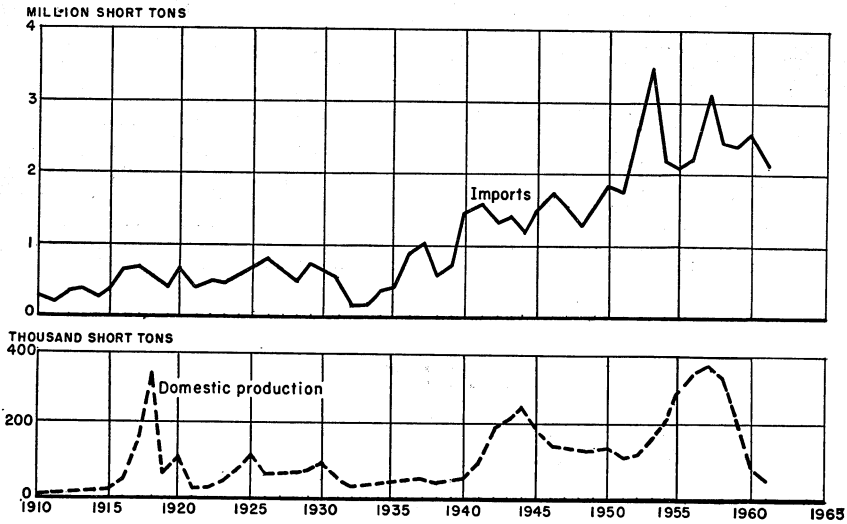


FIGURE 1.—General imports and domestic production (shipments) of manganese ore, 1910–61.

LEGISLATION AND GOVERNMENT PROGRAMS

Financial assistance for exploration of domestic manganese deposits continued to be offered by the Office of Minerals Exploration (OME) to the extent of 50 percent of approved exploration costs.

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Both manganese ore and ferromanganese continued to be acquired for the Government's supplemental stockpile in exchange for surplus U.S. agricultural products under the barter program of Commodity Credit Corporation, U.S. Department of Agriculture. The Government's various stocks of manganese items are shown under Consumption, Uses, and Stocks.

National Stockpile Specifications were issued for Silicomanganese (P–109, May 17, 1961), and for Ferromanganese, Low- and Medium-Carbon (P–108, May 16, 1961). Revisions of existing specifications were issued for Ferromanganese, Standard High-Carbon (P–30a–R2, July 26, 1961); Manganese Metal, Electrolytic (P–98–R2, May 17, 1961); and Manganese Dioxide, Battery Grade (P–29–R3, June 16, 1961).

TABLE 1.—Salient manganese statistics in the United States

	1952–56 (average)	1957	1958	1959	1960	1961
Manganese ore (35 percent or more Mn):						
Production (shipments):[1]						
Metallurgical....short tons	209,834	364,227	327,309	223,164	70,905	39,246
Battery....do	12,361	2,107	(2)	6,011	9,116	6,832
Miscellaneous....do	12			24		10
Total[1]....do	222,207	366,334	327,309	229,199	80,021	46,088
Value....thousands	$16,910	$29,363	$23,637	$17,904	$5,352	$3,264
Imports, general....short tons	2,530,447	3,105,172	2,452,578	2,397,804	[3]2,543,841	2,098,438
Consumption....do	2,023,872	2,361,460	1,497,574	1,605,507	1,946,389	1,717,805
Manganiferous ore (5 to 35 percent Mn):						
Production (shipments)[1]....do	879,805	865,127	520,601	470,600	658,455	225,004
Value....thousands	$4,851	$5,413	$3,532	$3,153	$4,466	$1,480
Ferromanganese:						
Production....short tons	835,593	963,814	636,736	629,307	842,818	732,813
Imports for consumption....do	94,542	338,079	63,932	90,062	120,222	221,936
Exports....do	1,667	7,395	1,406	947	751	469
Consumption....do	864,960	935,725	674,495	755,229	800,430	778,003

[1] Shipments are used as the measure of manganese production for compiling U.S. mineral-production value. They are taken at the point that the material is considered to be in marketable form to the consumer.
[2] Battery ore included in metallurgical.
[3] Revised figure.

DOMESTIC PRODUCTION

Except for some commercial shipments of manganese concentrate produced in Arizona from stocked mill tailings, virtually all manganese ore produced in the United States in 1961, other than battery ore, consisted of nodules from Nevada and Montana. The Nevada supply ended in July when Manganese, Inc., at Henderson closed; the plant later was sold at auction. Cessation of these Nevada shipments completed the only remaining Government contract for purchase of domestic manganese ore. The Anaconda Company at Butte, Mont., did not operate the Emma mine during the year; its nodules were produced from stockpiled Emma carbonate ore. Taylor-Knapp Co. and Trout Mining Co. coordinated activities in producing natural battery-grade concentrate and miscellaneous concentrate at Philipsburg, Mont. Manganese Chemicals Corp. continued to use the ammonium carbamate leach process to produce synthetic battery ore and synthetic

miscellaneous ore (high-purity manganese carbonate) from Cuyuna manganiferous ores and tailings.

Low-grade manganese ores, containing 10 to 35 percent manganese, were shipped from Georgia, Minnesota, Montana, and New Mexico. Manganiferous iron ore, containing 5 to 10 percent manganese, was shipped from Michigan and Minnesota. Total shipments of manganiferous ores, containing 5 to 35 percent manganese, were only 225,000 short tons, a decrease of 66 percent from 1960 and the lowest since 1933.

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	1960			1961		
	Metallurgical manganese ore	Ferruginous manganese ore	Manganiferous iron ore	Metallurgical manganese ore	Ferruginous manganese ore	Manganiferous iron ore
Arizona	1,626	8,677			(4 5)	
California		96				
Georgia		(4 6)			(4 6)	
Michigan			180,460			17,083
Minnesota		54,151	386,877		91,560	90,275
Montana	19,920	676		10,673	2,236	
Nevada	49,076	(4)		28,573		
New Mexico		(4)			(4)	
Tennessee	283	(4 6)				
Undistributed		27,518			23,850	
Total	70,905	91,118	567,337	39,246	117,646	107,358

[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) produced from stocked tailings.
[6] All miscellaneous.

CONSUMPTION, USES, AND STOCKS

Consumption of manganese ore decreased 12 percent from 1960, with domestic sources continuing to supply only 1 percent of the total. Industrial ore stocks declined, but were still high with 2¼-million short 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 13.4 pounds, compared with 13.3 pounds in 1960. Of the 13.4 pounds, 11.7 pounds was ferromanganese; 1.3 pound, silicomanganese; 0.1 pound, spiegeleisen, and 0.3 pound, manganese metal.

Stocks of the various manganese items in Government inventories, as of December 31, 1961, are presented in table 6; industrial stocks of manganese ore, in table 4; and industrial stocks of manganese ferroalloys and manganese metal, in table 5.

Electrolytic Manganese and Manganese Metal.—The total metal consumed in 1961 was 16,000 short tons, the same as in 1960, and virtually all was electrolytic manganese metal. Foote Mineral Co. and Union Carbide Metals Co. were the only two domestic producers of electrolytic metal. American Potash & Chemical Corp. proceeded with construction of its Aberdeen, Miss. plant, but Foote Mineral Co. deferred building the new plant it had planned for New Johnsonville, Tenn.

TABLE 3.—Manganese and manganiferous ore shipped[1] in the United States in 1961, by States

Type and State	Short tons		Value (thousands)
	Gross weight	Manganese content	
Manganese ore:[2]			
Montana	17,515	8,805	$1,412
Nevada	28,573	12,518	1,852
Total	46,088	21,323	3,264
Manganiferous ore:			
Ferruginous manganese ore:[3]			
Minnesota	91,560	11,250	(4)
Montana	2,236	505	33
Arizona, Georgia and New Mexico [5]	23,850	2,976	169
Total	117,646	14,731	(4)
Manganiferous iron ore:[6]			
Michigan	17,083	924	(4)
Minnesota	90,275	8,136	(4)
Total	107,358	9,060	(4)
Total manganiferous ore	225,004	23,791	1,480

[1] Shipments are used as the measure of manganese production for compiling U.S. mineral-production value. They are taken at the point where the material is considered to be in marketable form to 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 that shipped from Montana, which includes 6,832 short tons of battery ore (concentrate), containing 2,769 tons of manganese, and 10 short tons of miscellaneous ore (concentrate) containing 4 tons of manganese. Does not include production of synthetic battery ore and synthetic miscellaneous ore in Minnesota. Instead, the low-grade Minnesota ore and tailing used to make these items are included under ferruginous manganese, ore, and manganiferous iron ore.

[3] Containing 10 to 35 percent manganese (natural).

[4] Included in total.

[5] Arizona data are for manganese ore (concentrate) (containing more than 35 percent manganese) produced from stocked tailings. All Georgia manganiferous ore was miscellaneous.

[6] Containing 5 to 10 percent manganese (natural).

Ferromanganese.—U.S. production of ferromanganese was by 18 plants of 11 companies. Montana Ferro-Alloys Co., Woodstock, Tenn., and the Graham, W. Va., plant of Vanadium Corporation of America became producers during the year. Plants that produced in 1960 but did not produce in 1961 were Pittsburgh Metallurgical Co., Charleston, S.C.; Union Carbide Metals Co., Niagara Falls, N.Y.; Vanadium Corporation of America, Cambridge, Ohio, and Niagara Falls, N.Y. The quantity of ferromanganese made in blast furnaces was twice that made in electric furnaces. Shipments of ferromanganese totaled 757,000 short tons, valued at $159 million, compared with 782,000 tons, valued at $166 million in 1960.

TABLE 4.—Consumption and stocks of manganese ore[1] in the United States

(Short tons, gross weight)

Use and ore source	Consumption		Stocks Dec. 31, 1961[2] (including bonded warehouses)
	1960	1961	
Manganese alloys and manganese metal:			
Domestic ore	17,844	9,446	265
Foreign ore	1,828,728	1,577,519	2,166,888
Total	1,846,572	1,586,965	2,167,153
Steel ingots:			
Domestic ore			
Foreign ore	697	1,047	294
Total	697	1,047	294
Steel castings:			
Domestic ore			
Foreign ore	180	61	284
Total	180	61	284
Pig iron:			
Domestic ore			
Foreign ore	5,805	9,961	5,755
Total	5,805	9,961	5,755
Dry cells:			
Domestic ore	4,285	4,567	376
Foreign ore	22,930	23,734	12,964
Total	27,215	28,301	13,340
Chemicals and miscellaneous:			
Domestic ore	6,951	5,991	504
Foreign ore	58,969	85,479	33,177
Total	65,920	91,470	33,681
Grand totals:			
Domestic ore	29,080	20,004	1,145
Foreign ore	1,917,309	1,697,801	2,219,362
Total	1,946,389	1,717,805	[3] 2,220,507

[1] Containing 35 percent or more manganese (natural).
[2] Excluding Government stocks.
[3] Excludes small tonnages of dealers' stocks.

Silicomanganese.—Production of silicomanganese in the United States was 120,000 short tons, compared with 101,000 tons in 1960. Shipments from furnaces totaled 121,000 tons valued at $25,238,000, compared with 104,000 tons valued at $23,983,000 in 1960. All plants that produced silicomanganese in 1960 also produced in 1961, except the Niagara Falls plants of Union Carbide Metals Co. and Vanadium Corporation of America. Montana Ferro-Alloys Co., Woodstock, Tenn., became a new producer. Consumption of silicomanganese was 14.4 percent that of ferromanganese, compared with 12.3 percent in 1960, and 13.1 percent in 1959.

Spiegeleisen.—Inland Steel Co., East Chicago, Ind., and The New Jersey Zinc Co., Palmerton, Pa., produced spiegeleisen in 1961.

TABLE 5.—Consumption, by end uses, and stocks of manganese ferroalloys and metal in the United States in 1961

(Short tons, gross weight)

Use	Ferromanganese		Silico-manganese	Spiegeleisen	Manganese metal [1]	Briquets
	High carbon	Medium and low carbon				
Steel ingots:						
Stainless steel	541	2,069	3,915	14	7,481	----
Other alloy steel	119,567	8,807	27,974	8,228	899	----
Carbon steel	566,485	46,463	64,927	16,107	4,309	----
Other	410	118	787	----	31	----
Total	687,003	57,457	97,603	24,349	12,720	----
Steel castings:						
Stainless steel	265	243	233	----	80	----
Other alloy steel	6,523	1,585	3,284	255	101	16
Carbon steel	5,781	2,264	4,888	866	15	117
Other	2,707	189	714	165	6	2
Total	15,276	4,281	9,119	1,286	202	135
Steel mill rolls	764	144	504	475	----	----
Gray and malleable castings	4,419	595	3,561	10,666	1	7,326
Alloys (include welding rods)	7,002	809	727	83	3,265	2
Other	186	67	323	----	98	13
Grand total	714,650	63,353	111,837	36,859	16,286	7,476
Stocks, Dec. 31: [2]						
Consumer	140,241	7,657	13,372	7,784	1,580	982
Producer	(3)	(3)	(3)	31,471	(3)	----

[1] Virtually all electrolytic.
[2] Including bonded warehouses. Excluding Government stocks.
[3] Producer stocks of ferromanganese, silicomanganese, and manganese metal totaled 146,528 short tons.

TABLE 6.—Manganese items in Government inventories as of December 31, 1961

(Thousand short dry tons)

Material	Total	National (strategic) stockpile	DPA inventory	CCC and supplemental stockpile
Manganese:				
Battery grade:				
Natural ore	274	145	----	129
Synthetic dioxide	25	21	4	----
Chemical grade:				
Type A ore	103	29	----	74
Type B ore	73	2	----	71
Metallurgical grade	9,116	5,230	1,324	2,562
(Ferromanganese, standard high carbon) [1]	(790)	(144)	----	(646)
(Manganese metal, electrolytic) [1]	(10.7)	(1.4)	(5.3)	(4.0)

[1] Figures in parentheses are upgraded forms of preceding item and are included in the figure for that item (manganese, metallurgical grade).

TABLE 7.—Ferromanganese produced in the United States and metalliferous materials consumed in its manufacture

Year	Ferromanganese produced			Materials consumed			Manganese ore used per ton of ferromanganesemade (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)		
1952–56 (average)	835,593	76.6	639,918	[1] 1,711,270	[1] 60,211	12,014	[1] 2.1
1957	963,814	77.2	743,634	2,066,693	36,692	503	2.2
1958	636,736	77.7	494,761	1,228,769	42,061	1,091	2.0
1959	629,307	77.3	486,549	1,275,138	3,829	3,935	2.0
1960	842,818	77.7	654,825	[1] 1,801,038	[1] 17,819	1,821	[1] 2.2
1961	732,813	77.3	566,432	[2] 1,577,519	[2] 9,446	1,685	[1] 2.1

[1] Includes ore used in producing silicomanganese.
[2] 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	1960		1961	
	Gross weight (short tons)	Mn content, natural (percent)	Gross weight (short tons)	Mn content, natural (percent)
Domestic	17,819	56.2	9,446	56.6
Foreign:				
Africa	570,576	46.2	454,189	46.0
Brazil	509,201	45.7	448,176	46.7
British Guiana			70,923	43.8
Chile	15,635	43.9	16,125	44.4
Cuba	39,216	40.0	10,774	45.8
India	440,988	43.8	260,796	44.8
Mexico	206,845	40.5	212,588	42.1
Philippines	3,133	43.6	6,400	44.2
Turkey	2,588	48.5		
Other or unidentified [1]	12,856	46.6	97,548	
Total	1,818,857	44.8	1,586,965	45.3

[1] For 1961, includes ore used in producing metal.

Manganiferous Pig Iron.—Pig-iron furnaces used 1,051,000 short tons of manganese-bearing ores containing over 5 percent manganese (natural). Of this quantity, 556,000 tons was of domestic and 495,000 tons was of foreign origin. Of the domestic ore, 472,000 tons contained 5 to 10 percent manganese (natural), and 84,000 tons contained 10 to 35 percent manganese. Of the foreign ore, 485,000 tons contained 5 to 10 percent manganese (natural), and 10,000 tons contained 35 percent or more manganese. Canada supplied all the foreign manganiferous iron ore.

Battery and Miscellaneous Industries.—Manufacturers of dry-cell batteries used 28,000 short tons of manganese ore containing more than 35 percent manganese (natural); 4,600 tons was of domestic origin. Chemical plants and miscellaneous industries used 91,000 tons of manganese ore containing 35 percent or more manganese. Of this quantity 6,000 tons came from domestic sources. The domestic ore and an appreciable part 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, were nominal throughout the year at $0.87 to $0.90 per long-ton unit of manganese, c.i.f. U.S. ports, import duty extra. Brazilian ore containing 48 to 50 percent manganese was quoted throughout the year by the same source on the same terms at $0.91, nominal. Both of these quotations were unchanged from those of 1960.

Manganese Alloys.—The average value, f.o.b. producers' furnaces, for ferromanganese shipped in 1961 was $210.01 per short ton, compared with $212.10 in 1960. The price of standard ferromanganese, 74 to 76 percent manganese, at eastern furnaces, carlots, held at 11 cents per pound of alloy until the middle of December when it was reduced to 9.5 cents per pound, or $190 per short ton. Prices of imported ferromanganese, delivered to the United States and after duties, were reported to run as low as $146 per short ton. Spiegeleisen containing 19 to 21 percent manganese remained at $100.00 per long ton, carlots, f.o.b. Palmerton, Pa., according to Iron Age.

Manganese Metal.—The price of electrolytic manganese metal remained unchanged throughout the year at 35 cents per pound for carlots and 37 cents per pound for ton lots, in both instances packed in steel drums. Variations in these prices for different packaging, quantities, and special grades continued as before, including palletized standard carlots at 33¾ cents, and palletized ton lots at 36¼ cents. The premium of 0.75 cent per pound for hydrogen-removed metal and the premium of 3.5 cents per pound for nitrided electrolytic manganese metal containing a minimum of 5.5 percent nitrogen continued unchanged throughout the year.

FOREIGN TRADE [3]

Imports.—The average grade of imported manganese ore was 47 percent manganese, compared with 47.7 percent for each of the years 1960 and 1959. Brazil provided 35 percent of the total ore received in 1961; Union of South Africa, 12 percent; Ghana, 11 percent; Mexico, 9 percent; India and Republic of the Congo, each 8 percent; British Guiana and Morocco, each 6 percent. General imports of ore containing more than 10 percent and less than 35 percent manganese totaled 3,605 short tons, all of which came from Mexico; imports for consumption consisted of this ore and 2,555 tons from Ghana.

Imports for consumption of ferromanganese were almost double those of 1960, Government acquisitions accounting for more than half of the total. Imports for consumption classified as "manganese silicon (includes silicon manganese)" totaled 13,471 short tons (manganese content). This came from Norway, 4,684 tons; Belgium-Luxembourg, 3,754 tons; Spain, 2,210 tons; Yugoslavia, 1,678 tons; Italy, 476 tons; Japan, 366 tons; Chile, 154 tons; West Germany, 111 tons; and Canada, 38 tons. Manganese metal imports for consumption were 565 short tons, of which 564 tons came from Japan and 1 ton, presumably thermic metal, from West Germany. No imports for consumption of spiegeleisen were reported.

Exports.—Ferromanganese exports totaled 469 short tons valued at $146,000, compared with 751 tons in 1960 valued at $202,000. Exports classified as "manganese metal and alloys in crude form and scrap," believed to be almost entirely electrolytic manganese metal, were 2,234 tons valued at $1,327,000, compared with 2,430 tons valued at $1,501,000 in 1960, and 1,260 tons valued at $752,000 in 1959. Spiegeleisen exports in 1961 were 525 tons valued at $47,000 and went to Canada. Exports classified as "manganese ore and concentrates, containing 10 percent or more manganese" totaled 7,528 tons valued at $1,054,000 and were believed to be almost entirely imported manganese dioxide ore exported after grinding, blending, or otherwise classifying.

Tariff.—Duty on manganese ore remained unchanged at one-fourth cent per pound of contained manganese with ore from Cuba and the Philippines exempt from duty, and ore from the U.S.S.R. and certain neighboring countries dutiable at 1 cent per pound of contained manganese.

[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			
	1960	1961	1960	1961	1960	1961	1960	1961	1960	1961
North America:										
Cuba	17,644		9,073		17,644		9,073		$688,983	
Mexico	[3] 174,656	181,640	[3] 79,945	82,471	[3] 200,660	181,161	[3] 92,348	81,988	6,740,797	$5,233,654
Panama		1,109		510		1,109		510		40,481
Total	[3] 192,300	182,749	[3] 89,018	82,981	[3] 218,304	182,270	[3] 101,421	82,498	7,429,780	5,274,135
South America:										
Brazil	874,809	744,896	421,331	361,096	682,183	793,890	323,468	387,783	24,383,092	29,065,210
British Guiana	21,720	135,410	8,797	55,537		6,096		2,665		185,783
Chile	19,498	12,786	8,606	5,745	22,559	12,786	10,093	5,745	812,623	348,063
Venezuela					2,798		1,085		118,517	
Total	916,027	893,092	438,734	422,378	707,540	812,772	334,646	396,193	25,314,232	29,599,056
Europe: Greece	28,501	21,796	13,780	10,478	6,756	57,818	3,255	27,917	412,834	3,109,257
Asia:										
India	479,279	174,221	222,066	79,519	475,178	257,800	216,880	120,689	14,356,995	7,765,112
Philippines	11,370	6,590	5,418	3,144	14,063	7,700	6,662	3,649	433,559	247,807
Turkey	2,909	3,168	1,271	1,492	2,909		1,271		97,921	
Total	493,558	183,979	228,755	84,155	492,150	265,500	224,813	124,338	14,888,475	8,012,919
Africa:										
Angola	30,353	13,432	15,242	6,762	24,237	18,397	12,090	9,291	909,637	721,,677
Congo, Republic of the,[4] and Ruanda-Urundi	164,679	174,085	80,756	83,257	141,221	160,942	69,610	77,415	4,940,001	5,049,972
Ethiopia		6,630		3,432		6,630		3,432		245,550
Ghana	318,656	223,835	162,819	113,245	341,043	268,908	173,364	135,591	15,785,817	13,029,411
Morocco	[3] 75,301	117,036	[3] 40,449	62,737	[3] 76,332	108,286	[3] 40,855	57,877	[3] 4,190,809	5,954,722
Rhodesia and Nyasaland, Federation of	24,354	11,473	12,114	5,740	22,122	12,526	10,861	6,344	877,929	437,379
Union of South Africa	277,358	260,212	121,029	106,042	226,288	219,475	101,104	93,718	6,696,344	5,511,156
United Arab Republic (Egypt)	20,562		10,181		9,956	21,480	5,221	10,752	408,786	805,917
Western Africa, n.e.c.[5]	2,128	10,096	1,021	4,740	2,128	10,096	1,021	4,740	76,800	311,506
Total	[3] 913,391	816,799	[3] 443,611	385,955	[3] 843,327	826,740	[3] 414,126	399,160	[3] 33,886,123	32,067,290

Oceania:										
Australia	64	23	32	12	64	23	32	12	2,884	1,029
British Western Pacific Islands					8,829	2,069	4,069	944	373,025	80,798
Total	64	23	32	12	8,893	2,092	4,101	956	375,909	81,827
Grand total [6]	[3] 2,543,841	2,098,438	[3] 1,213,930	985,959	[3] 2,276,970	2,147,192	[3] 1,082,362	1,031,062	[3] 82,307,353	78,144,484

[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] Revised figure.
[4] Effective July 1960; formerly Belgian Congo.
[5] Believed to be Ivory Coast.
[6] In 1961, general imports of ore classified as battery and chemical grades totaled 102,357 short tons averaging 50.8 percent manganese. Of this quantity 31,717 short tons came from Ghana, 30,976 short tons from Morocco, 21,796 short tons from Greece, 6,997 short tons from Republic of the Congo and Ruanda-Urundi, 4,478 short tons from Angola, 3,293 short tons from Ethiopia, and 3,100 short tons from India. Imports for consumption of battery and chemical grades in 1961 totaled 139,024 short tons (averaging 50.2 percent manganese) valued at $7,443,427 or $53.54 per short ton f.o.b. foreign ports. Of this total Greece supplied 57,818 short tons ($3,109,257); Ghana, 33,713 short tons ($2,088,924); Morocco, 30,976 short tons ($1,675,100); Republic of the Congo and Ruanda-Urundi, 5,646 short tons ($212,783); Angola, 4,478 short tons ($155,460); Ethiopia, 3,293 short tons ($108,750); and India, 3,100 short tons ($95,153). Changes in Minerals Yearbook 1960, p. 766, are as follows: receipts of battery and chemical grades totaled 163,036 short tons averaging 51 percent manganese. Of this quantity 48,129 short tons came from Morocco. Imports for consumption of battery and chemical grades in 1960 totaled 133,897 short tons valued at $7,257,402 or $54.22 per short ton f.o.b. foreign ports. Of this total Morocco supplied 48,129 short tons ($2,925,148).

Source: Bureau of the Census.

TABLE 10.—U.S. imports for consumption of ferromanganese, by countries

Country	1960			1961		
	Gross weight (short tons)	Mn content (short tons)	Value	Gross weight (short tons)	Mn content (short tons)	Value
North America:						
Canada	710	615	$296,670	217	166	$36,255
Mexico				2,009	1,513	235,955
Total	710	615	296,670	2,226	1,679	272,210
South America: Chile	573	448	72,967	3,906	2,877	646,884
Europe:						
Belgium-Luxembourg	3,676	2,757	492,265			
France	23,187	18,041	2,771,736	40,859	31,391	5,745,190
Germany, West	804	634	196,247	[1] 21,672	[1] 16,816	[1] 2,572,525
Italy	1,995	1,611	412,745	441	363	97,119
Norway	2,879	2,232	432,949	2,220	1,710	245,000
Spain	1,837	1,422	231,262	1,347	1,058	163,858
Sweden				1,120	844	126,000
United Kingdom	1,121	852	168,080			
Yugoslavia	4,998	3,950	627,785	8,234	6,432	1,005,466
Total	40,497	31,499	5,333,069	75,893	58,614	9,955,158
Asia:						
India	37,105	27,850	6,374,379	96,958	73,058	17,290,849
Japan	30,017	23,328	5,523,179	15,747	12,463	3,104,794
Total	67,122	51,178	11,897,558	112,705	85,521	20,395,643
Africa: Union of South Africa	11,320	8,854	1,408,059	27,206	21,508	3,126,293
Grand total	120,222	92,594	19,008,323	[1] 221,936	[1] 170,199	[1] 34,396,188

[1] Adjusted by Bureau of Mines.

Source: Bureau of the Census.

WORLD REVIEW

NORTH AMERICA

Guatemala.—Minas y Productos de Guatemala, S.A., mined manganese ore of high manganese and low silica content from a surface deposit at high elevation in the Department of Huehuetango. The ore minerals were said to have been petrographically determined as hausmannite, pyrolusite, and other manganese oxides.

Mexico.—Teziutlan Copper Co. and American Brake Shoe Co. joined to form Amsco Mexicana, S.A., to take over the steel foundry at Tlalnepantla, near Mexico City, previously a subsidiary of Teziutlan. Capacity of the foundry was quadrupled to 400 tons per month of castings, of which manganese steel castings for the mining, construction, and heavy industries were an important part in addition to other alloy and carbon steel castings.[4] Cía. Minera Autlan was reported to be exporting manganese ore (concentrate) from its mine near Autlan, Jalisco, via the port of Manzanillo, to the United States and Japan at an annual rate of 100,000 tons, with Mexican consumers taking an additional 25,000 tons. Plans were underway for 22-ton diesel ore trucks to replace the 7-ton flat-bed gasoline trucks currently used

[4] American Metal Market. V. 68, No. 14, Jan. 20, 1961, p. 5.

TABLE 11.—World production of manganese ores, by countries[1 2]

(Short tons)

Country[1]	Mn,[3] percent	1952–56 (average)	1957	1958	1959	1960	1961
North America:							
Cuba	36–50+	[4] 273, 860	[4] 160, 967	[4] 74, 636	[4] 58, 806	[5] 17, 644	[3 4] 46, 000
Mexico	30+	194, 689	[3] 220, 000	[3] 187, 400	[3] 181, 900	[3] 171, 400	[3] 155, 900
Panama	----	----	2, 154	4, 489	----	----	----
United States (shipments)	35+	222, 207	366, 334	327, 309	229, 199	80, 021	46, 088
Total	----	690, 756	749, 455	593, 834	469, 905	269, 065	247, 988
South America:							
Argentina	30–40	9, 061	11, 154	16, 431	21, 358	24, 250	[3] 22, 000
Brazil	38–50	257, 168	1, 011, 939	972, 413	1, 138, 649	1, 101, 387	[3] 1, 100, 000
British Guiana	40–42	----	----	----	----	137, 454	216, 203
Chile	40–50	52, 038	59, 724	42, 061	42, 744	50, 594	38, 580
Peru	40+	6, 355	16, 917	3, 242	1, 262	1, 905	1, 850
Venezuela	38+	[6] 10, 318	32, 930	9, 039	3, 955	----	----
Total	----	334, 940	1, 132, 664	1, 043, 186	1, 207, 968	1, 315, 590	1, 378, 633
Europe:							
Bulgaria	30+	45, 503	89, 600	31, 306	28, 660	30, 900	[3] 30, 900
Greece	35+	18, 355	17, 545	22, 046	38, 580	38, 580	[3] 38, 600
Hungary	30–	112, 529	178, 600	200, 400	170, 100	135, 900	[3] 132, 000
Italy	30–	51, 784	51, 976	48, 588	57, 138	51, 749	52, 302
Portugal	35+	8, 927	6, 035	5, 484	7, 703	8, 197	[3] 7, 700
Rumania	35	219, 930	292, 402	220, 755	216, 910	192, 870	[3] 220, 000
Spain	30+	38, 288	45, 622	40, 267	44, 924	24, 586	[3] 15, 000
U.S.S.R.[7]	----	5, 140, 000	5, 674, 700	5, 915, 000	6, 080, 300	6, 472, 800	[3] 6, 500, 000
Yugoslavia	30+	5, 027	[3] 4, 400	11, 060	8, 900	14, 700	15, 600
Total[1]	----	5, 640, 343	6, 360, 880	6, 494, 906	6, 653, 215	6, 970, 282	[3] 7, 012, 000
Asia:							
Burma	42+	4, 535	506	1, 405	606	324	196
China[3]	----	298, 800	770, 000	935, 000	1, 100, 000	1, 380, 000	1, 100, 000
India	35+	1, 814, 116	1, 852, 701	1, 406, 652	1, 308, 919	1, 302, 930	1, 338, 200
Indonesia	35–49	46, 394	59, 338	48, 909	47, 172	12, 026	14, 330
Iran	30+	5, 777	2, 205	660	2, 425	8, 488	5, 500
Japan	32–40	231, 912	318, 497	326, 269	383, 699	357, 131	326, 695
Korea, Republic of	30–48	3, 857	3, 533	287	496	1, 521	1, 518
Malaya, Federation of	30+	----	----	----	----	3, 222	7, 130
Pakistan	42	----	----	----	32	198	379
Philippines	35–51	14, 959	33, 324	24, 590	38, 365	19, 159	20, 547
Portuguese India	32–50	155, 524	161, 347	86, 078	83, 584	118, 195	[3] 110, 000
Thailand	40+	[6] 450	381	1, 100	452	582	588
Turkey	30–50	73, 210	62, 522	24, 920	39, 341	31, 112	33, 069
Total[3]	----	2, 650, 000	3, 264, 000	2, 856, 000	3, 005, 000	3, 235, 000	2, 958, 000
Africa:							
Angola	38–48	46, 540	23, 518	38, 499	39, 314	25, 728	22, 695
Bechuanaland	38+	----	243	14, 213	20, 507	13, 912	31, 737
Congo, Republic of the (formerly Belgian)	48+	335, 289	404, 572	372, 741	425, 694	412, 154	[3] 344, 185
Ethiopia	51	----	----	----	[3] 1, 500	10, 202	7, 716
Ghana (exports)[9]	48	708, 492	713, 757	574, 124	577, 694	600, 261	431, 580
Ivory Coast	46+	----	----	----	----	68, 343	109, 526
Morocco:							
Northern zone	50	1, 820	732	----	----	----	----
Southern zone	35–50	459, 785	541, 772	452, 041	518, 711	532, 508	629, 512
Rhodesia and Nyasaland, Federation of:							
Northern Rhodesia	30+	18, 084	39, 703	49, 383	57, 986	64, 298	58, 907
Southern Rhodesia	30+	748	1, 785	2, 512	2, 126	1, 676	205
South-West Africa	45+	40, 616	89, 661	103, 049	49, 442	67, 439	50, 295
Sudan[3]	36–44	[6] 7, 700	8, 800	6, 600	440	----	----
Union of South Africa	40+	813, 436	787, 878	934, 097	1, 069, 196	1, 316, 124	1, 562, 718
United Arab Republic (Egypt)[10]	38–58	4, 701	10, 315	48, 730	67, 318	22, 046	2, 272
Total	----	2, 437, 211	2, 622, 736	2, 595, 989	2, 829, 928	3, 134, 691	3, 251, 348

See footnotes at end of table.

TABLE 11.—World production of manganese ore, by countries [1 2]—Continued

(Short tons)

Country [1]	Mn,[3] percent	1952–56 (average)	1957	1958	1959	1960	1961
Oceania:							
Australia	45–58	39,189	86,153	66,845	100,768	68,082	75,810
Fiji	40+	[4] 12,068	38,858	20,503	14,566	13,073	3,808
New Caledonia	45+	4,923	----------	----------	----------	----------	----------
New Hebrides	30+	----------	----------	----------	----------	----------	5,060
New Zealand	48+	260	41	116	114	134	132
Papua	46	17	----------	----------	----------	54	----------
Total	---------	56,457	125,052	87,464	115,448	81,343	84,810
World total (estimate)[1]	---------	11,810,000	14,255,000	13,671,000	14,281,000	15,006,000	14,933,000

[1] In addition to the countries listed, Czechoslovakia and Sweden report production of manganese ore (approximately 13 to 17 percent manganese content), but since the manganese content averages substantially less than 30 percent, the output is not included in this table. Czechoslovakia averages 175,000 short tons annually, and Sweden, approximately 11,000 tons for the last 5 years.
[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] United States imports.
[6] One year only as 1956 was the first year of commercial production.
[7] Grade unstated. Source: The Industry of the U.S.S.R., Central Statistical Administration (Moscow).
[8] Year ending March 20 of year following that stated.
[9] Dry weight.
[10] In addition to high-grade ore shown in the table, Egypt produced the following tonnages of less than 30 percent manganese content: 1952–56 (average), 226,897; 1957, 83,957; 1958, 74,303; 1959, 72,752; 1960, 282,200; and 1961, 304,663.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

through contracts with individual truckowners, who will form a cartage company to drive and maintain the new trucks. Because of heavy grades, a new mine road will be necessary.[5] Cía. Minera Autlan actively explored manganese deposits in the States of Hidalgo and Jalisco.[6]

Panama.—The first shipment of equipment to be used for mining manganese deposits in the Madinga area of the San Blas Gulf arrived in February.[7]

SOUTH AMERICA

Argentina.—A manganiferous metallogenic province constituting 25 manganese districts in Argentina, within an area of 800 square miles, was described. Psilomelane and pyrolusite occur in veins as long as 3,300 feet to provide ore containing 20 to 40 percent manganese.[8] Most Argentine manganese deposits are low grade and contain only 20 to 30 percent manganese. They are widely scattered through the north-western provinces, occurring mostly as thin veins. Minera Alumine, the main producer, found promising deposits in Salta Province and was considering developing them and installing a flotation plant. With continued anticipated growth of the national steel industry, annual manganese ore consumption of 60,000 tons was ex-

[5] U.S. Consulate General, Guadalajara, Mexico. State Department Dispatch 60. Apr. 7, 1961, 2 pp.
[6] U.S. Embassy, Mexico, D.F., Mexico. State Department Dispatch 1307. Apr. 23, 1962, p. 10.
[7] U.S. Embassy, Panama, Panama. State Department Dispatch 528. May 31, 1961, p. 9.
[8] Gamkosian, Alejandro, R. M. Umlandt, and A. C. Jansson. Provincia Manganifera Santiagueno-Cordobesa. Boletin Geominero Santiagueno No. 1, Santiago del Estero, Argentina, 1960, 40 pp.; Econ. Geol., v. 56, No. 6, September–October 1961, p. 1163.

pected within a few years for Argentina, according to projections of Comite de Comercialización de Minerales. New markets have developed in recent years from new ferroalloy plants and from the new steel mill of Sociedad Mixta Siderurgica Argentina (SOMISA) at San Nicolas. Most of the nation's 1960 manganese ore production went to SOMISA for its blast furnace operation, which began in the middle of the year. Production of manganese ore in Argentina was protected by a 150-percent import surcharge, which the ferroalloy producers wanted reduced or removed.[9] The most publicized manganese deposits of Argentina were those of Farallon-Negro in the Agua de Dionisio mining district, Catamarca Province. Since 1948 they have been under serious investigation, which has included underground exploration. The ore contains gold and silver values and will require beneficiation. Yacimientos Mineros Agua de Dionisio (YMAD), the directorship of which is composed of representatives of the University of Tucuman, the Government of Catamarca Province, and the National Government, contracted with Reinstahl Industries Planing of Dusseldorf, West Germany, for a metallurgical study. Expectation was for full production by 1966.[10] Proven reserves of 100,000 tons containing 20 percent manganese have been claimed.[11]

Brazil.—Of the 8-percent mineral production tax, 3 percent went to the Federal Government, payable when shipments were made, and 5 percent to the State and Municipality, payable per month, per year, or when shipments were made. Assessed unit values for computing the tax for 1961 were 6,000 and 3,000 cruzeiros for pyrolusite and psilomelane, respectively, compared with 800 cruzeiros for ferruginous manganese, hematite, or magnetite ore.[12] Several types of ferroalloys, including ferromanganese and spiegeleisen, were among the products of the aluminum reduction plant of Aluminio do Brazil, S.A., at Saramenha near Ouro Preto, Minas Gerais.[13] Exports of manganese ore from Amapa in 1961 totaled 854,000 short tons,[14] of which 800,000 tons went to the United States and the remainder, to Canada, United Kingdom, France, and Japan. A relatively small quantity was shipped to Santos, Brazil.

British Guiana.—Mine output of manganese ore in 1961, the first full year of production, averaged 42 percent manganese.[15]

Chile.—As a result of the mid-1961 agreement between the Chilean and United States Governments to barter U.S. surplus agricultural products for 36,000 short tons of Chilean ferromanganese, the ferromanganese plant of Cia. Manganesos Atacama at Guayacan, near La Serena, resumed production toward the end of the year after having

[9] Bureau of Mines. Mineral Trade Notes. V. 53, No. 6, December 1961, p. 31.
[10] U.S. Embassy, Buenos Aires, Argentina. State Department Dispatch 1240. Apr. 4, 1961, 2 pp.
[11] Tezon, Roberto Vitelmo, and Hector J. de la Iglesia. Deposito de Manganeso, Oro y Plata "Farellon Negro," Provincia Catamarca, Argentina. XX Congreso Geologico Internacional, Symposium Sobre Yacimientos de Manganeso, v. 3, 1956, pp. 417–434.
[12] U.S. Embassy, Rio de Janeiro, Brazil. State Department Dispatch 992. May 5, 1961, 7 pp.
[13] Engineering and Mining Journal. V. 163, No. 1, January 1962, p. 148.
[14] U.S. Consulate, Belem, Brazil. State Department Dispatches 52, 63, 87. Nov. 7, 1961, Jan. 9 and June 4, 1962.
[15] U.S. Consulate, Georgetown, British Guiana. State Department Dispatch 141. Apr. 10, 1962, Encl. 1, p. 1.

been idle since April 1960.[16] The company's Corral Quemado deposit, in Coquimbo Province, is one of the nation's principal deposits, having reserves estimated at 880,000 tons of ore containing 42 percent manganese and 1,500,000 tons containing 23 percent manganese. The ore minerals are pyrolusite, psilomelane, and braunite, occurring in 5 low-dipping mantos that vary in thickness from 4 to 24 inches. Mining was by hand, the ore being sorted at the face and carried in knapsacks or hampers to the surface where it was further cobbed before being trucked to the port of Coquimbo for export. One miner produced about 7 tons of ore a month. Production in September 1961 was at the rate of 1,800 tons a month. Shortage of water discouraged installation of a concentrating mill.[17] Chilean manganese ore was produced mostly in Coquimbo Province by Cia. Manganesos Atacama and Cia. Manganesos Chile.[18] Chilean manganese deposits were described as of four types: (1) Mantos associated with Cretaceous tuffaceous sandstones (Coquimbo deposits); (2) Mantos associated with quartzite layers in mica schists (Cautin-Valdivia deposits); Pliocene or Quaternary lacustrine deposits at high altitude near the Peruvian border; and (4) small vein deposits, apparently of little importance, found at several places in northern Chile.[19] An earlier, more detailed report of Chilean manganese deposits recognized the first two types but mentioned deposits in Jurassic limestone and deposits in recent lavas instead of the last two.[20] Exports of ferromanganese in 1961 were 4,100 short tons, of which the United States took over 90 percent and Peru the remainder; silicomanganese exports were 700 tons, Venezuela importing 500 tons and the United States 200 tons.[21]

EUROPE

France.—Consumption of manganese ore in 1960 was 651,000 short tons, compared with 565,000 tons in 1959. Imports in 1960 totaled 831,000 tons, including 18,000 tons of chemical grade. The principal ore suppliers continued to be Morocco, U.S.S.R., India, and Union of South Africa.[22] Les Metaux Purs Pechiney-Outreau was formed on a 50–50 basis by Pechiney (leading chemical company in France) and Les Acieres de Paris et d'Outreau (leading European ferromanganese producer) to produce electrolytic manganese metal in a 3,000-ton-per-year plant to be built in France near Boulogne-sur-Mer. The new company entered into an agreement with American Potash & Chemical Corp. to exchange technical information.[23]

Italy.—The 52,000 short tons of manganese ore produced in Italy in 1960 averaged 27.35 percent manganese. Manganese ferroalloy production for 1960 was refined ferromanganese (70–80 percent manganese), 5,500 tons; carbon ferromanganese (over 50 percent manga-

[16] U.S. Embassy, Santiago, Chile. State Department Dispatches 276 and 645. Nov. 14, 1961, 1 p., and Apr. 17, 1962, p. 18.
[17] U.S. Embassy, Lima, Peru. State Department Dispatch 224. Oct. 31, 1961, p. 5.
[18] U.S. Embassy, Santiago, Chile. State Department Dispatch 724. May 3, 1961, pp. 11–12.
[19] Ruiz F., Carlos, and George E. Ericksen. Metallogenetic Provinces of Chile. Econ. Geol., v. 57, No. 1, January–February 1962, pp. 91–106.
[20] Riese, Walter A. Los Yacimientos de Manganeso de Chile. XX Congreso Geologico Internacional, Symposium Sobre Yacimientos de Manganeso, v. 3, 1956, pp. 377–416.
[21] U.S. Embassy, Santiago, Chile. State Department Dispatch 651. Apr. 18, 1962, p. 1.
[22] U.S. Embassy, Paris, France. State Department Dispatch 605. Nov. 21, 1961, p. 3.
[23] American Metal Market. V. 68, No. 154, Aug. 11, 1961, p. 14.

nese), 28,000 tons; ferrosilicomanganese, 27,000 tons; manganiferous pig iron (10–12 percent manganese), 7,300 tons; and silico-manganiferous pig iron, 1,700 tons.[24] Principal suppliers of manganese ore in the first half of 1960 were the U.S.S.R. and the Republic of the Congo.[25]

Poland.—Manganese ore imported in 1960 totaled 368,000 short tons, as follows: U.S.S.R., 324,000; Brazil, 22,000; India, 11,000; smaller quantities came from the United Arab Republic, Morocco, China, and the Union of South Africa.

Rumania.—To utilize recently explored reserves of low-grade manganese ores of the Sebes Mountains, plans were made to make ferromanganese and silicomanganese experimentally from this material using a two-stage electric furnace reduction process under study by Rumanian engineers. The ore contains 20 to 26 percent manganese, 9.5 percent iron, 34 to 38 percent silica, and 0.6 to 0.85 percent phosphorus pentoxide and is not amenable to ordinary methods of concentration. The deposit was believed to be large enough so that export possibilities could be considered. Rumania has little metallurgical ore of good quality, but ferromanganese containing 50 to 60 percent manganese, high in phosphorus, has been produced from this kind of ore at the Karl Marx chemical complex at Tirnaveni using standard electric furnace methods.[26]

Spain.—Ferromanganese production in 1960 was 28,000 short tons.[27]

Sweden.—The manganese occurrences of Central Sweden were described as of two general types: Manganiferous skarn- and carbonate-iron ores, and manganese ores of the Langban type which occur near but not in contact with iron ores. The Langban mines were reported exhausted except for recovery of dolomite. The manganese minerals of the Langban-type manganese ores were braunite and hausmannite, accompanied by numerous manganese silicates. The manganese mineral of the central part of the larger ore bodies was braunite; that of outer parts and all of the smaller ore bodies was hausmannite. Manganese content of the skarn ores in the Stollberg mines occurs as carbonates and silicates, and locally has been more than 20 percent.[28]

U.S.S.R.—The Darkveti manganese combine, consisting of new mines and a concentrating plant, was commissioned at Chiatura in early February 1961. This modern plant produced a concentrate containing 50 percent manganese from low-grade ores of 22 to 25 percent manganese content, a lower grade feed than that used previously to obtain 50-percent concentrate at either Chiatura or Nikopol. All ores of Chiatura and Nikopol are processed. Reserves of the two districts were said to constitute 90 percent of total U.S.S.R. reserves, the remainder being less favorably situated in the Urals, Kazakhstan, Western Siberia, and the Khingan Mountains.[29] Extension of the Nikopol deposit along 125 miles of Tertiary shoreline was believed established by a study of manganese deposits at Bol'shoi Tokmak,

[24] U.S. Embassy, Rome, Italy. State Department Dispatch D–941. Apr. 19, 1961, Encl. 1, pp. 1, 4.
[25] U.S. Embassy, Rome, Italy. State Department Dispatch 643. Jan. 20, 1961, p. 11.
[26] Selected Economic Translations on Eastern Europe. No. 605, Aug. 31, 1961, pp. 11–14.
[27] U.S. Embassy, Madrid, Spain. State Department Dispatch 757. June 19, 1961, p. 4.
[28] Magnusson, N. H. Iron and Sulphide Ores of Central Sweden. 21st Internat. Geological Cong., Guide to Excursions Nos. A26 and C21, 1960, 48 pp.
[29] Kowalewski, Jan. Mineral Resources Development in the U.S.S.R. Min. J. (London), v. 257, No. 6570, July 21, 1961, p. 67.

about 25 miles east of Nikopol. The ore at Bol'shoi Tokmak occurs in low-dipping beds at depth of 200 to 450 feet below the surface over an area 55 miles long by about 15 miles wide at the north. It is associated with Oligocene sandstone, shows a gradual transition from sandstone to ore, and has an average manganese content of 23 percent. At the north the ore occurs as oxides, gradually changing to carbonate toward the south. The transition zone has oxide ore in its upper part and carbonate ore in its lower part. The ores of both oxide and carbonate may occur as a continuous bed or as concretions. Initial discovery was of manganese carbonate in cores of water wells in 1939.[30] Soviet exports of manganese ore in 1960 were 1,073,000 short tons, including the following distribution: Poland, 315,000 tons; East Germany, 174,000; United Kingdom, 164,000; France, 128,000; Czechoslovakia, 88,000; West Germany, 87,000; Norway, 39,000; Austria, 21,000; Italy, 20,000; Yugoslavia, 13,000; and Sweden, 9,000. Exports of ferromanganese in 1960 totaled 56,000 tons, much of which went to the Sino-Soviet bloc and to the United Kingdom.[31]

ASIA

India.—In December 1961, Shivrajpore Syndicate Limited, one of the leading manganese ore producers in India, announced a 50-percent reduction in mining operations because stocks at pitheads were large. Inadequate transport facilities, shortages of electric power and explosives, and decreasing demand for export ore continued to be difficulties for the Indian manganese mining industry.[32] A large integrated pilot plant, including an electric-arc furnace for pyrometallurgical investigations, was reported being built at Janshedpur by the National Metallurgical Laboratory for beneficiation studies of low-grade manganese ores.[33] Exports of manganese ore in 1960 totaled 1,354,000 short tons, distributed as follows: United States, 494,000; Japan, 227,000; France, 210,000; United Kingdom, 147,000; Czechoslovakia, 48,000; Belgium, 38,000; Italy, 37,000; West Germany, 34,000; and the remainder divided among Yugoslavia, East Germany, Sweden, Netherlands, Spain, Poland, Norway, Singapore, Philippines, Taiwan, New Zealand, and less than 100 tons each to Indonesia, Pakistan, and Kuwait.[34] Ore production in 1961 included 354,000 short tons that contained less than 35 percent manganese. Ferromanganese production in 1961 was 115,000 short tons,[35] and internal consumption was estimated at approximately 50,000 tons. Expiring mining leases of Central Provinces Manganese Ore Co. (CPMO) were not renewed, and negotiations were underway during much of the year to form a new company (49 percent CPMO; and 51 percent national and state, Maharashtra and Madhya Pradesh, governments) to mine the affected properties under new leases.

[30] Economic Geology. V. 56, No. 1, January–February 1961, p. 221.
[31] Bureau of Mines. Mineral Trade Notes. V. 54, No. 4, Special supp. 61, April 1962, 108 pp.
[32] U.S. Embassy, New Delhi, India. State Department Dispatch 529. Jan. 10, 1962, pp. 8, 9.
[33] Mining Journal (London). V. 257, No. 6586, Nov. 10, 1961, p. 485.
[34] Bureau of Mines. Mineral Trade Notes. V. 53, No. 5, November 1961, pp. 33–35.
[35] U.S. Embassy, New Delhi, India. State Department Dispatch 923. May 3, 1962, 2 pp.

Indonesia.—A Government mining company, P. T. Pertambangan, in which ownership was shared by the Regency of Djogjakarta and the Central Government, began mining early in 1961 in the Kliripan-Kembang area near Djogjakarta. P. T. Mangaan Indonesia, wholly owned by the Central Government, mined manganese ore in the Karangunggal area of West Java.[36]

Japan.—Manganese ore production in 1960 averaged 38 percent manganese, compared with an average grade of 36 percent in 1959.[37] For the first half of the financial year starting April 1, 1961, the Japanese Ministry of Trade announced it would authorize importation of 40,000 tons of ferromanganese in addition to 180,000 tons of manganese ore. Contracts concluded by eight Japanese ferroalloy producers for 9,000 tons of manganese ore from the U.S.S.R.[38] specified minimum 35 percent manganese, maximum 0.25 percent phosphate and not more than 20 percent moisture. Preliminary analyses at the port of embarkation for the shipment due in December 1961 exceeded maximums for both phosphorus and moisture.[39] Yawata Iron and Steel Co., Ltd., was considering an offer involving barter of silicon steel sheets for 40,000 tons of U.S.S.R. manganese ore.[40]

Korea, Republic of.—Exports of manganese ore in 1960 totaled 220 short tons and went to Japan.[41]

Philippines.—Laboratory tests by the Philippine Bureau of Mines demonstrated that floating off the calcite from the low-grade manganese ore of General Base Metals' Guindulman deposit, Anda Peninsula, Bohol, could yield a marketable concentrate.[42] A résumé of the country's manganese resources was published in another report.[43] At the end of 1960, from diamond drilling which apparently was continuing, Acoje Mining Company's newly discovered Sierra Madre manganese ore deposit was estimated to contain 223,000 tons of ore, averaging 44 percent manganese.[44]

Portuguese India.—Combined 1960 exports of manganese ore and ferruginous manganese ore were 171,000 short tons, as follows: West Germany, 120,000 tons; Italy, 12,000 tons; United Kingdom, 10,000 tons; Japan, 9,100 tons; Netherlands, 8,100 tons; Spain, 5,700 tons; France, 5,200 tons; and Belgium, 1,000 tons.[45] Change of sovereignty to India in December 1961 did not affect the status of existing contracts.

Thailand.—A new manganese district, containing iron- and manganese-enriched laterites, was discovered in Lamphun Province in northern Thailand on the remnants of a terrace-like plateau along the edges of the Chiengmai and Li valleys. Several of the deposits

[36] U.S. Embassy, Djakarta, Indonesia. State Department Dispatch 829. Apr. 27, 1961, p. 12.
[37] U.S. Embassy, Tokyo, Japan. State Department Dispatch 1172. Apr. 18, 1961, Encl. 1, p. 3.
[38] American Metal Market. V. 68, No. 104, June 1, 1961, p. 18.
[39] American Metal Market. V. 68, No. 239, Dec. 14, 1961, p. 21.
[40] Bureau of Mines. Mineral Trade Notes. V. 54, No. 1, January 1962, p. 48.
[41] U.S. Embassy, Seoul, Korea. State Department Dispatch 549. May 31, 1961, Encl. 1, p. 4.
[42] Quicho, R. B., C. R. Sison, and E. N. Bautista. Beneficiation of Guindulman Manganese. Philippine Bureau of Mines, Rept. of Inv. 28, February 1961, 14 pp.
[43] Philippine Bureau of Mines. Mineral Resources of the Philippines. Inf. Circ. 19, 1961, pp. 66–87.
[44] U.S. Embassy, Manila, Philippine Islands. State Department Dispatch 728. May 26, 1961, pp. 50–53.
[45] Bureau of Mines. Mineral Trade Notes. V. 53, No. 4, October 1961, pp. 34–37.

were being explored or developed.[46] Exports of manganese ore in 1961 were 130 short tons, compared with 70 tons in 1960.[47] The production of both years was consumed mostly within the country for manufacturing dry-cell batteries.

Turkey.—In Ankara Province, the Cayirli mine, Turkey's principal producer of manganese ore since 1936, produced 70 percent of the national total in 1960. Mining was by open cut, the geology was complex, and shipping grades of ore contained 48 to 49 percent manganese.[48]

AFRICA

Angola.—Manganiferous ore production (20 percent manganese and 30 percent iron) was 1,800 short tons in 1961.[49] Rebellion in northern Angola in 1961 aggravated the labor shortage, a difficulty for Cia. do Manganese de Angola (apparently Angola's only manganese ore producer in 1961) since 1959.

Gabon.—Development of the COMILOG Moanda manganese deposits continued with export shipments expected to begin by mid-1962. The Equatorial Institute of Geological and Mineral Research reported new manganese discoveries near Okandja.[50]

Ghana.—Exports of battery- and chemical-grade manganese ore were 55,000 short tons in 1961 compared with 42,000 tons in 1960. In 1960, 559,000 tons of metallurgical grade ore containing more than 30 percent manganese and 12,000 tons of lower grade ore also were exported.[51]

Morocco.—In 1961, chemical-grade manganese ore production was 126,000 short tons.[52] Exports of chemical-grade ore in 1960 were 85,000 short tons, distributed to United States, 57,000 tons; France, 19,000 tons; and small quantities to Germany, Netherlands, United Kingdom, Czechoslovakia, Denmark, with less than 100 tons each, to Italy, Algeria, and Belgium. Metallurgical-grade ore (192,000 tons) was exported to France, 140,000 tons; Norway, 20,000 tons; United States, 11,000 tons; Yugoslavia, 11,000 tons; Italy, 4,000 tons; Sweden, 2,400 tons; Poland, 2,400 tons; and the remainder to Spain, Germany, Switzerland, Belgium, and Algeria. Exports of manganese sinter (33 and 56 percent manganese) totaled 175,000 tons, of which 90 percent went to France and the remainder, to the United States.[53]

Rhodesia and Nyasaland, Federation of.—Of 47,000 short tons of manganese ore exported in 1961, the United States received 21,000 tons; France, 13,000 tons; and West Germany, 9,000 tons. The Rhodesian Vanadium Corp. Bahati and Mashimba mines and the Nchanga Consolidated Copper Mines, Ltd., Luano mine were closed in 1961. Ore from the almost exhausted Luano deposit had been used by Nchanga

[46] Gardner, Louis S., and Roscoe M. Smith. Geological Survey Research 1961. U.S. Geol. Survey Prof. Paper 424-B, 1961, p. A-55.
[47] U.S. Embassy, Bangkok, Thailand. State Department Dispatch 260, Jan. 26, 1962, Encl. 1, p. 3.
[48] Bureau of Mines. Mineral Trade Notes. V. 54, No. 3, March 1962, pp. 20-22.
[49] U.S. Consulate, Luanda, Angola. State Department Dispatch 243. Apr. 16, 1962, Encl. 2, p. 1.
[50] U.S. Embassy, Libreville, Gabon. State Department Dispatch 136. Mar. 15, 1962, pp. 3-4.
[51] U.S. Embassy, Accra, Ghana. State Department Dispatch 496. Apr. 17, 1962, Encl. 1, p. 1.
[52] U.S. Consulate General, Casablanca, Morocco. State Department Dispatch 124. Feb. 16, 1962, 1 p.
[53] Bureau of Mines. Mineral Trade Notes. V. 54, No. 2, February 1962, pp. 38-39.

as an oxidant in its copper-leaching circuit, but the process was changed to aeration.[54] Paving the 40-mile stretch of road across the Katanga pedicle and improving Rhodesian roads to the east in 1960 and early 1961 greatly facilitated shipping Rhodesian manganese ore.[55]

South-West Africa.—Manganese ore exports in 1961 totaled 63,000 short tons,[56] compared with 64,000 tons in 1960.[57] At the end of August 1961 the Otjisondu manganese mine of South African Minerals Corp., Ltd., closed owing to lack of demand.[58]

Union of South Africa.—Electrolytic Metal Corp. (Pty.) Ltd., which began commercial output of electrolytic manganese metal in March 1960, continued to produce in 1961 at the rate of 2,400 tons per year and planned to double capacity. The company was a joint venture of General Mining and Finance Corp., Ltd.; Anglo-Transvaal Consolidated Investment Co., Ltd.; West Rand Consolidated Mines, Ltd.; A. Johnson & Co. (Swedish); and Technimetals (Pty.) Ltd. Anglo-Transvaal and A. Johnson & Co. had previously supported several years of exploratory pilot plant work. The present plant, on West Rand Consolidated Mines property near Randfontein, began to use local manganese ores in conjunction with the effluent from West Rand's uranium mill [59] because the supply of effluent decreased in relation to demands of the manganese plant. In northern Cape Province extension of the railway north from Sishen to the Hotazel mine of South African Manganese, Ltd., past the Adams and Devon mines of Associated Manganese Mines of South Africa, Ltd., was completed early in 1961. This reduced the truck haul for Associated's important Black Rock mine to 15 miles. In 1960, 100,000 short tons of manganese ore from the Adams and Devon mines was used to produce 48,000 tons of ferromanganese at the Cato Ridge (Natal) plant of Ferroalloys Ltd. In 1961, South African Manganese, Ltd., doubled the capacity of its Hotazel mine to 480,000 tons per year, and at the same time overcame the initial difficulties caused when unexpected high-iron areas were found in the deposit. Early in 1961, because of an announced uranium production stretchout, about 25 small manganese mines in the Transvaal ceased operations, leaving only eight of the larger producers to supply requirements of the uranium mills.[60] These Transvaal ores, occurring in the Dolomite series of the Transvaal system, had been too low in grade to export, but since they contained not less than 35 percent available manganese dioxide, they met specifications for an oxidant in uranium-mill leaching circuits. These ores and those from other manganese deposits in South Africa were de-

[54] Metal Bulletin (London). No. 4576, Mar. 3, 1961, p. 21.
U.S. Consulate General, Johannesburg, Union of South Africa. State Department Dispatch 431. Apr. 26, 1962, pp. 11–12.
[55] U.S. Consulate General, Salisbury, Southern Rhodesia. State Department Dispatch 969. May 5, 1961, pp. 14–15.
[56] U.S. Consulate General, Johannesburg, Union of South Africa. State Department Dispatches 396, 62, 175, 353, 421. June 1, Aug. 15, Nov. 14, 1961, Feb. 20, Apr. 16, 1962, pp. 1, 2.
[57] U.S. Consulate General, Johannesburg, Union of South Africa. State Department Dispatch 378. May 16, 1961, p. 2.
[58] Chemical Trade Journal and Chemical Engineer (London). V. 150, No. 3892, Jan. 5, 1962, p. 47.
[59] U.S. Consulate General, Johannesburg, Union of South Africa. State Department Dispatch 384. May 22, 1961, pp. 2–3.
[60] South African Mining and Engineering Journal (Johannesburg). V. 72, pt. 2, No. 3592, Dec. 8, 1961, pp. 1388–1390.
U.S. Consulate General, Johannesburg, Union of South Africa. State Department Dispatch 7. July 7, 1961, p. 25.

scribed, including the important Postmasburg field and its extension, Kuruman-Black Rock.[61]

United Arab Republic (Egypt).—Exports of manganese ore (largely ferruginous manganese ore containing 21 percent manganese) in 1960 were 230,000 short tons, coming mostly from stockpiles. Orders at the end of 1960 called for 1961 exports totaling 298,000 tons, of which 1,000 tons was to have a manganese dioxide content of 85 to 90 percent, and approximately 20,000 tons was to contain 48 to 50 percent manganese.[62] Reserves of 6 million tons, including all three grades, were established within a 10-mile radius of the deposits under exploitation. The high-grade manganese dioxide ore occurs as small pockets in the lower grade ores.[63]

OCEANIA

Australia.—Provisional figures for 1960 production of manganese ore included 900 short tons of battery grade, averaging 73.7 percent manganese dioxide, and 1,700 tons of other than battery or metallurgical, averaging 66.0 percent manganese dioxide. Metallurgical ore production averaged 48 percent manganese in 1960.[64] For the year ending November 30, 1960, the Newcastle plant of Broken Hill Pty. Co., Ltd., produced 7,200 tons of high-carbon ferromanganese and 1,900 tons of silicomanganese. No other manganese ferroalloys were produced in Australia. Imports of ferromanganese in 1960 totaled 34,000 short tons, of which 31,000 tons came from Union of South Africa and 1,800 tons from Southern Rhodesia. Imports in 1959 were 11,000 tons.[65]

Fiji.—Manganese ore exports for 1961, 1960, and 1959 were 1,100, 2,400, and 23,000 short tons, respectively.[66] The powdery nature of this ore was believed to be a cause of its poor export demand, coupled with increased availability of competitive Australian ore.

TECHNOLOGY

Investigations by the Federal Bureau of Mines at the Rolla (Mo.) Metallurgy Research Center demonstrated that high-damping manganese-copper alloys containing 65 to 80 percent manganese, when aged for optimum mechanical and damping properties, have very satisfactory fatigue resistance. They were found to be comparable to mild steel in this capacity; previously, they were shown to compare favorably in hardness and tensile strength.[67]

Differential thermal analysis studies, using reducing, neutral, and oxidizing atmospheres, were reported for 10 manganese minerals—hausmannite, bixbyite, braunite, pyrolusite, lithiophorite, cryptome-

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[61] Boardman, L. D. Manganese in the Union of South Africa. 7th Commonwealth Min. and Met. Cong. (Johannesburg), 1961, 12 pp.

[62] Bureau of Mines. Mineral Trade Notes. V. 54, No. 4, April 1962, p. 17.
U.S. Embassy, Cairo, United Arab Republic. State Department Dispatch 564. Jan. 20, 1961, p. 16.

[63] Bureau of Mines. Mineral Trade Notes. V. 53, No. 3, September 1961, pp. 50–51.

[64] U.S. Embassy, Canberra, Australia. State Department Dispatch 612. June 14, 1961, p. 2.

[65] Bureau of Mines. Mineral Trade Notes. V. 54, No. 2, February 1962, pp. 17–19.

[66] U.S. Consulate, Suva, Fiji. State Department Dispatch 105. Mar. 15, 1962, Encl. 1, p. 4.
U.S. Consulate, Suva, Fiji. State Department Dispatch 133. Apr. 26, 1962, Encl. 1, p. 1.

[67] Jensen, J. W., A. E. Schwaneke, and D. F. Walsh. Fatigue Properties of Manganese-Copper Damping Alloys. BuMines Rept. of Inv. 5853, 1961, 14 pp.

lane, hollandite, manganite, rhodochrosite, and rhodonite. These data can be used to identify the different minerals and to aid in developing thermal or chemical methods for extracting manganese from low-grade materials. The report included a 132-item bibliography.[68] Using five different sample mixtures, composed in different proportions from three distinctly different manganese dioxides—gamma (electrolytic), rho (Ghana), and pyrolusite (Morocco)—differential thermal analysis was demonstrated to be a valuable complement to X-ray diffraction for identifying, classifying, and evaluating the different manganese dioxide phases that constitute both natural and synthetic ores, and ore mixtures.[69] Apparently, both qualitatively and semi-quantitatively, differential thermal analysis was better than X-ray diffraction for mixtures of different phases. Because the different phases of manganese dioxide are considered to have different depolarizing effects, differential thermal analysis has been found particularly useful in evaluating manganese dioxide for use in dry-cell batteries.

Observations at the Bureau of Mines Boulder City (Nev.) Metallurgy Research Laboratory disclosed the presence in some dry-cell batteries of unidentified bacteria believed to be responsible for short battery life.[70]

A variety of low-grade manganiferous materials from the Cuyuna range of Minnesota, representative of both partly oxidized materials and unoxidized carbonate slate, were evaluated as to their amenability to the high-temperature differential sulfatizing process under development at the Bureau of Mines Minneapolis (Minn.) Metallurgy Research Center. A bench-scale rotary drum furnace was used in making these batch evaluation tests. From the results, it was estimated that approximately 87 percent manganese recovery as a synthetic ore could be expected for 105 million short tons of raw materials that average 7 percent manganese.[71]

From a 6½-ton sample of Cuyuna unoxidized carbonate slate containing, in percent, 6.8 manganese, 25.8 iron, 29.6 silica, 4.0 magnesia, 18.7 carbon dioxide, and 0.15 phosphorus, bench-scale flotation tests at Minneapolis yielded a concentrate averaging 11.1 percent manganese, 27.8 percent iron, and 12.2 percent silica at recoveries of 73 percent of the manganese and 48 percent of the iron. This concentrate represented 45 percent of the feed weight and could be beneficial as an enriched feed for the high-temperature differential sulfatizing process. A calculated analysis for sinter made from the concentrate suggests a product containing 16 percent manganese, 40 percent iron, and 17 to 18 percent silica. This product would be usable as ferruginous manganese ore in producing pig iron.[72]

[68] Dressel, W. M., and H. Kenworthy. Thermal Behavior of Manganese Minerals in Controlled Atmospheres. BuMines Rept. of Inv. 5761, 1961, 35 pp.

[69] Fishburn, H. W., Jr., and W. E. Dill, Jr. A Method for the Semi-Quantitative Analysis and Identification of Mixed Phases of Manganese Dioxide. Power Sources Conf., Atlantic City, N.J., May 10, 1961, 8 pp.

[70] Sutton, Joseph A., and John D. Corrick. Possible Uses for Bacteria in Metallurgical Operations. BuMines Inf. Circ. 8003, 1961, p. 4.

[71] Prasky, Charles, R. L. Marovelli, and F. E. Joyce, Jr. Evaluating Cuyuna Manganese Resources by Sulfatizing. BuMines Rept. of Inv. 5887, 1961, 27 pp.

[72] Wessel, F. W., P. A. Wasson, and D. W. Frommer. Flotation of Unoxidized Manganiferous Material From the Cuyuna Range, Minn. BuMines Rept. of Inv. 5802, 1961, 14 pp.

Continuous-circuit flotation tests were made at the Bureau of Mines Albany (Oreg.) Metallurgy Research Center on composites of low-grade and offgrade oxide and of mixed oxide-carbonate ores purchased by the Government under the domestic manganese purchase program and stockpiled at Butte, Mont. These stockpiled ores averaged 23 to 25 percent manganese. The individual lots had been tested by laboratory batch flotation for amendability to beneficiation to a product meeting National Stockpile Specifications for metallurgical maganese. An oil-emulsion technique was used for the continuous-circuit flotation tests and the concentrate was sintered on a small batch scale. The flotation concentrate from the straight oxide ore recovered 88 percent of the manganese and after sintering contained 48 percent manganese. The flotation concentrate from the mixed oxide-carbonate ore recovered 95 percent of the manganese and gave a sinter containing 41 percent manganese. A blend of the two types of ore, weighted according to the proportions of the two types in the stockpile at the time of testing, when subjected to similar testing, recovered 90 percent of the contained manganese in the flotation concentrate and produced a sinter containing 43 percent manganese.[73]

The scarcity of published material describing operating practice for commercial production of electric-furnace manganese ferroalloys was alleviated with the preparation of two papers for the Electric Furnace Conference (AIME) held at Pittsburgh, Pa., December 6 to 8, 1961. In describing ferromanganese operations, it was concluded that: Slag-to-alloy ratio and manganese content of the slag are the major factors affecting power consumption; raw materials of good quality are needed to minimize penalties due to increasing slag volumes; and thorough knowledge of the limitations of the electric circuits' design characteristics, together with the "art" of the operator, strongly influence successful operation.[74] The production of silicomanganese was described as a complex operation involving both art and science. The early history of manganese and its ferroalloys was traced. First production of silicomanganese was in France in 1905. A study of the physical chemistry of steelmaking in the late 1920's and early 1930's by the Federal Bureau of Mines, in cooperation with Carnegie Institute of Technology and the Metallurgical Advisory Board, was credited with creating interest in the use of silicomanganese in the United States. Latest developments for silicomanganese were the marketing of low-carbon silicomanganese and of ferromanganese-silicon for providing low-carbon manganese additions for silicon sheet, low-alloy structural, low-carbon alloy, and stainless steels.[75]

In discussing the use of silicomanganese as a blocking alloy for control of carbon content in producing steel as compared with separate additions of ferromanganese and ferrosilicon, better internal and surface quality of steels, lower costs through reduced furnace time, better alloy-element recovery, greater ease in producing ongrade heats, and the use of one alloy instead of two, were claimed. Longer and more effective blocks, fewer and less objectionable inclusions, fewer unde-

[73] Sullivan, G. V., W. A. Stickney, and R. C. Bush. Beneficiating Manganese Oxide Ores From the Butte-Philipsburg Federal Stockpile. BuMines Rept. of Inv. 5728, 1961, 19 pp.
[74] McClure, R. N. Manufacture of Standard Ferromanganese in Electric Furnaces. AIME, 1961, 5 pp.
[75] Oxaal, John. Manufacture of Silicomanganese. AIME, 1961, 27 pp.

sirable oxides, and better placing of the silicon and manganese in the bath, also were claimed.[76]

Development was announced of new manganese-aluminum alloys for use as deoxidizing agents in steelmaking. These alloys were made in three standard manganese-aluminum ratios, 60 to 40, 65 to 35, and 80 to 20, by using electrolytic manganese and primary aluminum. Substantial improvements in cleanliness and surface quality of the finished steel were claimed.[77]

Investigation of a new manganese-aluminum magnet alloy was reported. The alloy was very brittle, but swaging in suitable jackets overcame this difficulty.[78]

In discussing the mineralogy of California manganese deposits, it was observed that tephroite, Mn_2SiO_4, was included among the silicates—spessartite, piedmontite, and rhodonite—which are abundant in the deposits of the Sierra belt, thus indicating a high degree of metamorphism. On the other hand, in the Coast Range deposits piedmontite is unknown and these other manganese silicates are very rare.[79]

When manganese ore was irradiated with slow neutrons so that only the manganese component became radioactive, measurement of the radioactivity quickly and accurately determined the manganese content. As a result, automatic control of an ore dressing operation can be effected by varying procedure to agree with manganese content. The method was developed for Chiatura ores by the Department of Radioactive Indicators in Automation, Institute of Physics, Academy of Sciences, Georgian SSR.[80]

Comparison of heat balances for blast-furnace production of pig iron with those for blast-furnace production of ferromanganese showed that the heat requirement for ferromanganese is much greater; also, a greater part of the total heat must be of high temperature, above 2,500° F. Oxygen enrichment of the blast can be used to increase the high-temperature portion of the total heat, the production rate being limited only by the rate of supply of high-temperature heat. The production rate of the ferromanganese furnace was increased 54 percent, and the coke requirement decreased 13 percent, by use of a blast containing 28.8 percent oxygen.[81]

Production in 1961 of 201- and 202-type manganese-nickel stainless steels was a new record of 32,000 short tons, compared with 23,000 tons in 1960, 28,000 tons in 1959, and 30,000 tons in 1958.[82] Extensive use in manufacturing subway cars was reported,[83] and suitability of the 202 grade for manufacturing bulk tanks and other equipment for

[76] Steel. Silicomanganese Helps Produce Cleaner Steels. V. 149, No. 15, Oct. 9, 1961, pp. 126, 129.
[77] American Metal Market. V. 68, No. 124, June 29, 1961, p. 20.
[78] American Metal Market. V. 68, No. 222, Nov. 20, 1961, p. 14.
[79] Hewett, D. F., C. W. Chesterman, and B. W. Troxel. Tephroite in California Manganese Deposits. Econ. Geol., v. 56, No. 1, January–February 1961, pp. 39–58.
[80] Office of Technical Services. Current Review of the Soviet Technical Press. U.S. Dept. of Commerce, BDSA, Mar. 24, 1961, p. 11.
[81] Burr, W. H., and J. H. Bergmark. Thermal Balance for a Ferromangenese Blast Furnace. J. Metals, v. 13, No. 6, June 1961, p. 442.
Stapleton, J. M., R. J. Flanagan, R. L. Stephenson, and D. A. Fletcher. Ferromanganese Production With Oxygen Enrichment. J. Metals, v. 13, No. 1, January 1961, pp. 45–48.
[82] American Metal Market. V. 69, No. 25, Feb. 5, 1962, pp. 5, 21.
[83] Union Carbide Metals Review. V. 4, No. 2, Summer 1961, pp. 7–8.

dairies was indicated by 3½ years' testing at Pennsylvania State University. This grade has a tensile strength of 100,000 psi and a yield strength of 50,000 psi, compared with 90,000 and 35,000 psi, respectively, for type 302 stainless steel, the type usually used for corrosion-resistant dairy service. The 202 grade has been used for automobile trim and for curtain walls of buildings.[84]

[84] American Metal Market. V. 68, No. 88, May 9, 1961, pp. 1, 3.

Mercury

By John E. Shelton [1] and Gertrude N. Greenspoon [2]

DOMESTIC mercury production in 1961 declined 5 percent to 31,700 flasks. All the major producing States recorded lower output. In contrast, increased demand by many principal consumers and the installation of a new chlorine and caustic soda plant caused a 9-percent gain in the use of mercury in the United States. Consumption of 55,800 flasks was the largest since 1955 and only 2 percent below the record peacetime use in that year. Imports for consumption dropped sharply; the total of 12,300 flasks was the lowest quantity since 1941. The average price of $197.61 per flask was also the lowest since 1953.

Mercury continued to be eligible for Government assistance in exploration of deposits through the Office of Minerals Exploration. In late 1961 acquisitions of mercury again could be authorized for barter transactions by the Commodity Credit Corporation.

World output of mercury totaled 240,000 flasks, slightly less than in 1960. Of the leading producing countries, only Yugoslavia reported an increase in output.

TABLE 1.—Salient mercury statistics

	1952-56 (average)	1957	1958	1959	1960	1961
United States:						
Producing mines	81	120	101	71	75	69
Production, flasks [1]	17,712	34,625	38,067	31,256	33,223	31,662
Value, thousands	$4,391	$8,552	$8,720	$7,110	$7,002	$6,257
Imports:						
For consumption, flasks	57,575	42,005	30,196	30,141	19,488	12,313
General, do	58,549	45,449	30,973	30,260	19,515	12,514
Exports, do	673	1,919	320	640	357	285
Reexports, do	981	3,275	934	553	317	180
Stocks Dec. 31, do	23,246	25,388	11,274	13,580	19,761	17,533
Consumption, do	49,788	52,889	52,617	54,895	51,167	55,763
Price: New York, average, per flask	$241.36	$246.98	$229.06	$227.48	$210.76	$197.61
World: Production, flasks	178,000	[2] 240,000	[2] 246,000	[2] 223,000	[2] 242,000	240,000
Price: London, average per flask	$232.32	$232.36	$214.98	$208.61	$197.86	$181.87

[1] Flasks as used in this chapter refers to a 76-pound flask.
[2] Revised figure.

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

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

the Nation's resources for selected mineral commodities. In 1961 two new contracts were made to explore for mercury ores. Financial assistance was obtained for exploration of the Aetna Springs mine, Napa County, Calif. Estimated total cost of the project was $17,640. Pacific Minerals & Chemical Co., Inc., executed a similar contract for $69,720 to explore the Mother lode mine, Crook County, Oreg.

In response to S. Res. 206, 87th Congress, in a resolution adopted September 23, the U.S. Tariff Commission instituted an investigation on mercury for the purpose of updating the Commission's report of November 1958. A public hearing was scheduled for February 20, 1962.

On December 21 mercury was again included as an item 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

Production of primary mercury in the United States declined 5 percent to 31,700 flasks. Output decreased in all principal producing States. The number of producing properties decreased to 69. The quantity of ore treated rose 2 percent, but the mercury recovered declined 4 percent. Mercury recovery was 0.5 pound per ton less than in 1960. The 56-percent increase in output of secondary mercury was due mainly to metal recovered from a mercury boiler withdrawn from service.

California remained the leading mercury-producing State, with output only slightly below 1960. However, its contribution to the total U.S. production rose from 56 to 59 percent. The four principal producers—New Idria, Buena Vista, New Almaden, and Mount Jackson (including Great Eastern)—furnished 87 percent of the total.

Nevada continued to be the second largest mercury-producing State. Output decreased 4 percent from the peak of 1960, but Nevada's share of the total U.S. output was unchanged at 24 percent. The Cordero mine was, as usual, the leading producer in the State and ranked second in the United States. Its production, however, was 2 percent below the peak output in 1960.

Despite a 7-percent decrease in output, Alaska ranked third among principal mercury-producing States for the fifth consecutive year. Production represented 13 percent of the total U.S. output and came mainly from the Red Devil mine, Kuskokwim River region.

Although mercury production in Idaho decreased 30 percent, the State continued to rank fourth and supplied 3 percent of the U.S. total. The Idaho-Almaden mine in Washington County furnished the entire output.

The lowest output in Oregon since 1950 was recorded in 1961. Production fell 73 percent and supplied less than 1 percent of the U.S. total. Output of the principal producer, the Bretz mine in Malheur County, was less than half of the 1960 production.

Arizona supplied the remainder of the 1961 output.

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]
1960:				1961:			
Alaska	3	4,459	$939,779	Alaska	2	4,129	$815,932
California	42	18,764	3,954,700	Arizona	4	148	29,246
Idaho	1	1,538	324,149	California	36	18,688	3,692,936
Nevada	20	7,821	1,648,354	Idaho	1	1,073	212,036
Oregon	5	513	108,120	Nevada	21	7,486	1,479,308
Arizona and Texas	4	128	26,977	Oregon	5	138	27,270
Total	75	33,223	7,002,079	Total	69	31,662	6,256,728

[1] Value calculated at average New York price.

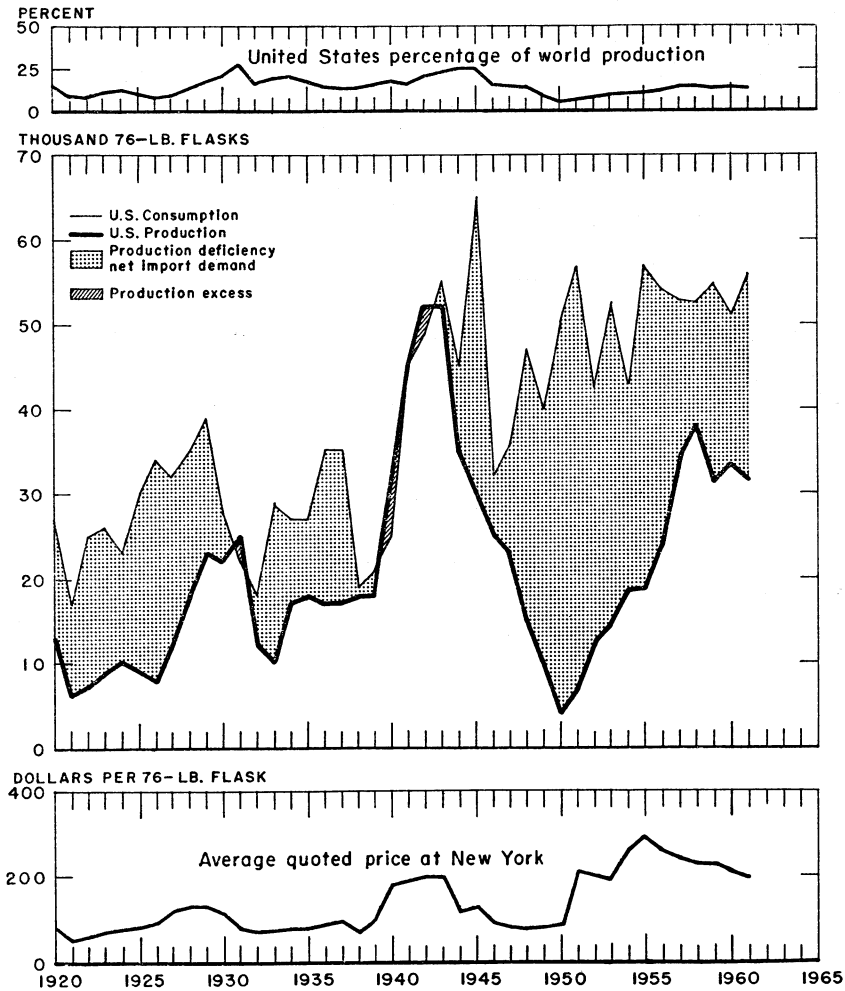


FIGURE 1.—Trends in production, consumption, and price of mercury, 1920–61.

659873—62——57

Of the 69 producing mines in 1961 (75 in 1960), 8 mines, each producing 1,000 flasks or more, supplied 92 percent of the total 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.
	Santa Clara	New Almaden.
	Sonoma	Mount Jackson (including Great Eastern).
	Yolo	Reed.
Idaho	Washington	Idaho-Almaden.
Nevada	Humboldt	Cordero.

In addition to the foregoing mines, the following mercury operations produced 100 flasks or more:

State:	*County*	*Mine*
Arizona	Maricopa	Pine Mountain (Turnbull claims).
California	Lake	Abbott.
	Marin	Edwards.
	Santa Barbara	Gilbraltar.
	Santa Clara	Guadalupe.
	Sonoma	Culver-Baer.
Nevada	Esmeralda	B&B.
	Nye	Horse Canyon.
	Pershing	Freckles (Roman).
Oregon	Malheur	Bretz.

These 18 mines produced 98 percent of the domestic mercury output.

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
1952-56 (average) [2]	182,852	17,463	7.4	1959	275,903	31,109	8.6
1957	309,632	34,058	8.4	1960	258,071	33,106	9.7
1958	328,155	37,209	8.6	1961	262,108	31,633	9.2

[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 rose 56 percent over 1960. In addition to metal reclaimed from dental amalgam, oxide and acetate sludges, and battery scrap, mercury was recovered from a mercury boiler withdrawn from service.

TABLE 4.—Production of secondary mercury in the United States

Year:	*Flasks*
1957	5,800
1958	5,400
1959	4,950
1960	5,350
1961	8,360

CONSUMPTION AND USES

Consumption of mercury in industrial uses in 1961 was 55,763 flasks, 9 percent above 1960; it was the largest since 1955 and was only 2 percent below the peacetime record of that year. The 1961 increase was due partly to the installation of a mercury-cell chlorine and caustic soda plant at Niagara Falls, N.Y., in the last half of the year.

The use of mercury in electrical apparatus rose 11 percent—the largest since 1954. Dental preparations required 21 percent more mercury than in 1960, and pharmaceuticals took 45 percent more. Mercury used in manufacturing mildew-proofing paint rose to 5,100 flasks.

Agricultural uses and industrial instruments required less metal than in 1960; their respective consumption declined 14 percent. Slime-control compounds for paper and pulp manufacture declined 11 percent. The first decrease since 1954 was recorded in the quantity of mercury used to replace losses in manufacturing chlorine and caustic soda; consumption was 3 percent less in 1961.

TABLE 5.—Mercury consumed in the United States by uses

(Flasks)

Use	1952–56 (average)	1957	1958	1959	1960	1961
Agriculture (includes insecticides, fungicides, and bactericides for industrial purposes)	7,560	6,337	6,270	3,202	2,974	2,557
Amalgamation	202	244	248	265	255	278
Catalysts	814	859	816	965	1,018	707
Dental preparations [1]	1,212	1,371	1,741	1,828	1,783	2,154
Electrical apparatus [1]	9,502	9,151	9,335	8,905	9,268	10,255
Electrolytic preparation of chlorine and caustic soda	2,697	4,025	4,547	5,828	6,211	6,056
General laboratory use	992	894	968	1,110	1,302	1,484
Industrial and control instruments [1]	5,777	6,028	6,054	6,164	6,525	5,627
Paint:						
Antifouling	716	568	749	993	1,360	915
Mildew proofing	[2]	[2]	[2]	2,521	2,861	5,146
Paper and pulp manufacture	[2]	[2]	[2]	4,360	3,481	3,094
Pharmaceuticals	1,655	1,751	1,430	1,717	1,729	2,515
Redistilled [1]	8,736	9,703	9,448	9,331	9,678	9,013
Other	9,925	11,958	11,011	7,706	2,722	5,962
Total	49,788	52,889	52,617	54,895	51,167	55,763

[1] A breakdown of the "redistilled" classification showed ranges of 48 to 39 percent for instruments, 12 to 5 percent for dental preparations, 44 to 28 percent for electrical apparatus, and 18 to 8 percent for miscellaneous uses in 1952–60, compared with 38 percent for instruments, 13 percent for dental preparations, 33 percent for electrical apparatus, and 16 percent for miscellaneous uses in 1961.

[2] Data not available.

[3] Included with agriculture.

STOCKS

Stocks of mercury held by consumers and dealers decreased 10 percent in 1961. Withdrawal of metal from inventories for installing a chlorine and caustic soda plant was a factor in the lower stocks.

Stocks held by producers, usually small in relation to total industry inventories, were the lowest since 1959 and furnished only 12 percent of the 1961 total.

In addition to the stocks shown in table 6, 147,000 flasks, of which 16,000 flasks were in the supplemental stockpile, were in Government stockpiles at the end of 1961.

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 1961, 117,000 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, Dec. 31

(Flasks)

Year	Producer	Consumer and dealer	Total
1952-56 (average)	826	22,420	23,246
1957	3,588	21,800	25,388
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

PRICES

The annual price of mercury in the United States averaged 6 percent less in 1961 than in 1960 and was the lowest since 1953. At the beginning of 1961, prices were $209–$212 a flask. Gradual reductions in the price began in February and continued to early August. Prices were $188–$191 a flask from August until about mid-October. After small increases in October and late November, mercury was quoted at $190–$193 a flask and was unchanged at yearend.

Mercury was quoted in London at £69 10s. ($194.60) a flask at the beginning of the year. The price decreased immediately to £69 ($193.20) and remained the same through early April. Thereafter, prices declined gradually until mid-November when the quotation was £59 ($165.20). This price was maintained through December. The annual average price was £65 5s. ($181.87) a flask, 8 percent below the 1960 average.

TABLE 7.—Average monthly prices of mercury at New York and London

(Per flask)

Month	1960		1961	
	New York [1]	London [2]	New York [1]	London [2]
January	$211.00	$200.71	$209.00	$193.99
February	212.21	199.91	208.06	193.19
March	214.00	198.52	206.00	193.03
April	213.33	198.86	205.90	189.57
May	212.00	198.70	203.00	187.20
June	211.27	197.59	200.46	186.36
July	210.30	197.29	194.80	182.57
August	209.00	196.89	188.17	177.14
September	209.00	195.06	188.00	175.06
October	209.00	197.16	188.62	172.44
November	209.00	198.35	189.25	167.21
December	209.00	196.24	190.00	165.77
Average	210.76	197.86	197.61	181.87

[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 [3]

Imports.—Imports of mercury for consumption totaled 12,300 flasks, 37 percent less than in 1960 and lowest since 1941. The

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

TABLE 8.—U.S. imports for consumption [1] of mercury, by countries

Country	1952–56 (average)		1957		1958		1959		1960		1961	
	Flasks	Value (thousands)	Flasks	Value (thousands)	Flasks	Value (thousands)	Flasks	Value (thousands)	Flasks	Value (thousands)	Flasks	Value (thousands)
North America:												
Canada	100	$26	66	$16	50	$7	125	$23	20	$5	24	$4
Mexico	10,383	2,055	5,280	1,023	8,251	1,506	3,516	646	2,419	382	3,010	445
Total	10,483	2,081	5,346	1,039	8,301	1,513	3,641	669	2,439	387	3,034	449
South America:												
Bolivia					9	2	11	2				
Chile	5	1			514	102	813	164	139	26	82	15
Colombia			15	4	80	12			30	6	25	4
Peru	95	23	244	52	345	61	589	112	49	8		
Total	100	24	259	56	948	177	1,413	278	218	40	107	19
Europe:												
Italy	20,403	3,695	8,056	1,869	1,133	221	6,146	1,256	3,420	627	2,073	365
Netherlands	34	7										
Spain	21,241	3,760	25,276	5,677	18,494	3,729	17,111	3,400	12,464	2,278	6,544	1,118
United Kingdom	70	16	2,500	560	[2]	[3]	235	48			[2]	[3]
Yugoslavia	5,212	1,023	568	132	220	46	954	198	900	170	355	62
Total	46,960	8,501	36,400	8,238	19,847	3,996	24,446	4,902	16,784	3,075	8,972	1,545
Asia:												
India	5	[3]										
Japan	5	1										
Philippines					1,100	236	400	81				
Turkey	12	3					100	36			200	35
Total	22	4			1,100	236	500	117			200	35
Africa: Morocco [4]	10	2										
Oceania:												
Australia							126	23				
New Zealand							15	3	47	8		
Total							141	26	47	8		
Grand total	57,575	[5] 10,612	42,005	9,333	30,196	5,922	30,141	5,992	19,488	3,510	12,313	2,048

[1] Data include mercury imported for immediate consumption plus material withdrawn from bonded warehouses.
[2] Less than 1 flask.
[3] Less than $1,000.
[4] French Morocco, before Jan. 1, 1957.
[5] 1954 data known to be not comparable with other years.

Source: Bureau of the Census.

chief suppliers were Spain (53 percent), Mexico (24 percent), and Italy (17 percent). Small quantities were received from Canada, Chile, Colombia, Turkey, United Kingdom, and Yugoslavia. The Canadian metal was scrap mercury received duty free.

Imports of various mercury compounds and preparations totaled 90,700 pounds. Of the total, 54,894 pounds came from Spain, 26,327 pounds from Yugoslavia, 9,478 pounds from United Kingdom, and 1 pound from Israel. In addition, 24 pounds of vermilion reds were imported from Japan.

Exports.—Exports of mercury, usually small, were the lowest since 1951. Of the 285 flasks exported (357 in 1960), 61 flasks (87) went to Canada, 56 (none) to Japan, 28 (32) to Saudi Arabia, 23 (32) to Venezuela, 14 (9) to Philippines, 13 (40) to Colombia, 12 (4) to Brazil, and the remainder in lots of less than 10 flasks each to 22 other countries.

TABLE 9.—U.S. imports [1] of mercury, by countries

Country	1952–56 (average)	1957	1958	1959	1960	1961
North America:						
Canada	100	66	50	125	20	24
Mexico	10,759	5,991	8,350	3,631	2,459	3,192
Total	10,859	6,057	8,400	3,756	2,479	3,216
South America:						
Bolivia			9	11		
Chile	25		1,160	400	139	82
Colombia		15	80	30		115
Peru	95	244	345	599	49	
Total	120	259	1,594	1,040	188	197
Europe:						
Italy	20,776	9,208	1,015	6,175	3,447	2,002
Netherlands	34					
Spain	21,224	25,993	18,644	17,509	12,444	6,544
United Kingdom	113	2,500	[2]	185		[2]
Yugoslavia	5,385	1,432	220	954	910	355
Total	47,532	39,133	19,879	24,823	16,801	8,901
Asia:						
Japan	5					
Philippines			1,100	400		
Turkey	23			100		200
Total	28		1,100	500		200
Africa: Morocco [3]	10					
Oceania:						
Australia				126		
New Zealand				15	47	
Total				141	47	
Grand total	58,549	45,449	30,973	30,260	19,515	12,514

[1] Data are "general" imports; that is, they include mercury imported for immediate consumption plus material entering the country under bond.
[2] Less than 1 flask.
[3] French Morocco, before Jan. 1, 1957.
Source: Bureau of the Census.

Reexports.—Reexports totaled 180 flasks compared with 317 flasks in 1960. Of the total reexported, 166 (268) went to Canada, and 14 (none) to Brazil.

Tariff.—The duty of 25 cents a pound ($19 a flask) on imports of mercury, in effect since 1922, was continued.

TABLE 10.—U.S. exports of mercury

Year	Flasks	Value	Year	Flasks	Value
1952–56 (average)	673	$163,043	1959	640	$92,255
1957	1,919	483,892	1960	357	82,957
1958	320	95,003	1961	285	70,622

Source: Bureau of the Census.

TABLE 11.—U.S. reexports of mercury

Year	Flasks	Value	Year	Flasks	Value
1952–56 (average)	981	$203,055	1959	553	$119,038
1957	3,275	763,303	1960	317	62,015
1958	934	198,501	1961	180	33,067

Source: Bureau of the Census.

WORLD REVIEW

World production of mercury decreased slightly from 242,000 flasks in 1960 to 240,000 flasks in 1961. Output was unchanged in Italy, but it decreased 8 percent in Mexico, 6 percent in Spain, and 5 percent in the United States. Production increased 13 percent in Yugoslavia.

TABLE 12.—World production of mercury by countries [1]

(Flasks) [2]

Country	1952–56 (average)	1957	1958	1959	1960	1961
North America:						
Mexico	16,908	21,068	22,556	16,420	20,114	[3] 18,507
United States	17,712	34,625	38,067	31,256	33,223	31,662
South America:						
Chile	323	678	3,343	2,007	2,876	[3] 2,900
Colombia	[4] 18	99	203	95	89	[3] 100
Peru	112	411	1,983	2,526	3,034	[3] [5] 2,700
Europe:						
Austria	17	6				
Czechoslovakia [6]	725	725	725	725	725	725
Italy	55,510	63,499	58,712	45,833	55,463	55,434
Rumania	367	394	353	387	413	[3] 400
Spain	42,062	54,750	55,382	51,680	53,369	[3] 50,000
U.S.S.R. [3]	14,100	25,000	25,000	25,000	25,000	25,000
Yugoslavia	14,231	12,328	12,270	13,344	14,069	15,954
Asia:						
China [3]	9,500	17,000	17,000	23,000	23,000	26,000
Japan	4,220	4,859	5,720	5,988	5,791	[3] 5,300
Philippines	[4] 1,825	3,363	3,321	3,520	3,086	[3] 3,000
Turkey	436	720	1,486	[5] 1,321	1,339	[3] 1,300
Africa: Tunisia	[4] 94		39	198	166	[3] 80
World total (estimate)	178,000	240,000	246,000	223,000	242,000	240,000

[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 1955–56.
[5] Exports.
[6] Estimate according to the 48th Annual issue of Metal Statistics (Metallgesellschaft), except for 1961.

Compiled by Augusta W. Jann, Division of Foreign Activities.

Italy.—Output in Italy, which led mercury-producing countries in 1960, was unchanged in 1961. Exports fell to 32,700 flasks, the lowest since 1958.

The manufacturing tax on mercury of 32,000 lire ($51.20) a flask of metal and 800 lire ($1.28) per kilogram of mercury in ore instituted by the Italian Government in November 1954 was abolished on December 6, 1961. The tax had been suspended for 3 years beginning February 1, 1959.

TABLE 13.—Italy: Exports of mercury by countries [1]

(Flasks)

Destination	1960	1961	Destination	1960	1961
Australia	322	171	Pakistan	41	1,729
Belgium-Luxembourg	249	249	Poland	2,602	----
Brazil	481	44	Sweden	438	84
Canada	351	----	Switzerland	690	----
Czechoslovakia	400	870	Union of South Africa	1,120	61
Denmark	1,801	200	United Kingdom	10,658	6,504
France	4,453	4,009	United States	3,835	5,587
Germany, West	23,946	10,710	Other countries	215	1,215
India	1,047	980			
Netherlands	183	----	Total	52,887	32,680
Norway	55	267			

[1] This table incorporates some revisions.

Compiled from Customs Returns of Italy by Bertha M. Duggan, Division of Foreign Activities.

Japan.—Production of mercury in Japan in previous reports of this series has included output from imported materials as well as from secondary sources. The data in table 12 have been revised to show production from domestic ore only.

Production from domestic ore falls far short of Japan's requirements. Substantial quantities of imported ore and reclaimed metal are processed. In addition, mercury metal is imported. Consumption by uses for 1957 to 1960 is shown in table 14. Data for January to September 1961 show that 28,400 flasks was consumed in all uses.

TABLE 14.—Japan: Consumption of mercury, by uses

(Flasks)

Use	1957	1958	1959	1960
Agricultural uses	5,090	4,263	2,956	5,091
Catalysts	7,955	8,521	6,914	6,819
Caustic soda	10,834	3,053	7,105	15,112
Explosives	1,157	901	770	549
Industrial and control instruments	2,074	1,732	1,669	1,742
Inorganic chemicals	7,384	5,349	6,371	7,049
Paints	459	380	393	504
Pharmaceuticals	115	95	73	74
Other	63	78	365	369
Total	35,131	24,372	26,616	37,309

Source: State Department Dispatch A–643, Jan. 30, 1962.

Mexico.—Mercury production in Mexico was 8 percent less in 1961. Virtually all of Mexico's output is exported, with Japan the chief country of destination in recent years.

Taxes applicable to mercury in 1961 were as follows:

Production: Ore and concentrate at 4.16 percent of official value of 68.71 pesos per kilogram ($5.4968), equivalent to a tax of 2.8583 pesos per kilogram ($0.228664); metallic mercury at 3.95 percent of 68.71 pesos or 2.7140 pesos per kilogram ($0.217120).

Exports: Ore and concentrate at 25.5 percent of official price of 58.5266 pesos ($4.6821), or 14.9243 pesos per kilogram ($1.1947); metallic mercury at 5.1 percent of official value of 60.3764 pesos ($4.8301), or 3.0792 pesos per kilogram ($0.2463).

TABLE 15.—Mexico: Exports of mercury by countries [1]

(Flasks)

Destination	1959	1960	Destination	1959	1960
Canada	27	239	United States	10,488	5,790
France	450	109	Other countries	399	342
Germany	1,135	347			
Japan	6,062	12,603	Total	20,888	22,642
United Kingdom	2,327	3,212			

[1] This table incorporates some revisions.

Compiled from Customs Returns of Mexico by Bertha M. Duggan and Corra A. Barry, Division of Foreign Activities.

Spain.—Spain ranked second among principal mercury-producing countries. Production averaged 53,000 flasks from 1957–61, compared with 42,000 flasks from 1952–56. More than 90 percent of total output came from the Almaden mine in Ciudad Real Province, and the remainder was supplied by two properties in León and Oviedo Provinces.

Two new Pacific furnace units began operations at the Almaden mine. The addition of modern machinery resulted in metal recovery of more than 95 percent. Treatment capacity was at an annual rate of 110,000 tons of ore.[4]

TABLE 16.—Spain: Exports of mercury, by countries

(Flasks)

Destination	1959	1960	Destination	1959	1960
Australia		268	Korea		333
Austria	1,356	505	Netherlands	997	3,046
Belgium-Luxembourg	300	549	Sweden	1,884	1,001
Brazil	859	753	Switzerland	530	1,511
Canada	851	1,251	United Arab Republic (Egypt)	121	2,279
Czechoslovakia	2,352	1,201	United Kingdom	6,755	8,191
Finland	656	581	United States	14,018	12,322
France	5,130	6,609	Other countries	726	430
Germany	5,119	10,910			
Hungary		500			
India	1,365	378	Total	43,019	52,618

Compiled from Customs Returns of Spain by Bertha M. Duggan and Corra A. Barry, Foreign Statistics, Division of Foreign Activities.

[4] Cefaratti, Anthony J. (commercial attaché). Data on Mercury Requested of the Foreign Service by the U.S. Tariff Commission: State Department Dispatch 536, Madrid, Spain, Feb. 28, 1962, 4 pp.

United Kingdom.—Foreign-trade data for the United Kingdom indicated that consumption of mercury declined 11 percent in 1961. Imports of metal, the largest since 1954, rose 7 percent, but reexports almost doubled the 1960 shipments. The new supply of mercury available for consumption totaled 18,600 flasks.

	1952–56 (average)	1957	1958	1959	1960	1961
Imports	18,500	18,200	19,200	25,700	25,300	27,000
Reexports	4,000	15,300	5,100	5,000	4,300	8,400
Apparent consumption	14,500	2,900	14,100	20,700	21,000	18,600

Imports of mercury by countries are shown in table 17.

TABLE 17.—United Kingdom: Imports of mercury by countries

(Flasks)

Country	1960	1961	Country	1960	1961
Chile	835		U.S.S.R.	700	6,437
China		1,517	United States	32	100
Italy	11,632	6,553	Yugoslavia	501	527
Mexico	2,664	2,953	Other countries	63	21
Netherlands		275			
Spain	7,585	7,202	Total	25,255	27,047
Turkey	1,243	1,462			

Reexports of mercury in flasks were as follows:

Destination:	*1960*	*1961*
Australia	1,023	488
Belgium	186	184
Ceylon	20	170
Denmark	177	273
France	450	1,910
Germany, West	-----	784
Hong Kong	225	18
India	1,089	610
Norway	81	178
Pakistan	84	406
Poland	-----	2,032
Sweden	74	427
Union of South Africa	285	343
Other countries	604	565
Total	4,298	8,388

Yugoslavia.—Production of mercury in Yugoslavia rose 13 percent in 1961 to the highest since the Idria mine was ceded to Yugoslavia at the end of World War II. This mine produced virtually the entire output for the country.

TABLE 18.—Yugoslavia: Exports of mercury by countries [1]

(Flasks)

Destination	1960	1961 [2]	Destination	1960	1961 [2]
Austria	1,015	864	United Kingdom	300	300
Czechoslovakia	----------	300	United States	1,151	1,000
France	305	250	Uruguay	300	----------
Germany, West	400	----------	U.S.S.R.	3,208	----------
Norway	25	80	Other countries	100	2
Poland	----------	900			
Sweden	30	100	Total	6,854	[2] 3,796
Switzerland	20	----------			

[1] This table incorporates some revisions.
[2] January through June, inclusive.

Compiled from Customs Returns of Yugoslavia by Bertha M. Duggan, Division of Foreign Activities.

TECHNOLOGY

Operations at the Red Devil mercury mine in the Kuskokwim Mountain, Alaska, were described.[5] The paper discussed geological setting, mining and milling operations, and mercury recovery practice at one of the major U.S. producers.

The results of research by the Bureau of Mines on leaching mercury ores and concentrates were published.[6] The investigation showed that more than 95 percent of the mercury in flotation concentrates and up to 90 percent of the mercury in ores could be removed by leaching with sodium sulfide. The report also described leaching tests on ores and concentrates for separating arsenic and mercury.

Investigations showed that rare earths could be separated by using mercury electrodes.[7] Separations were made on lanthanon pairs such as praseodymium-neodymium and thulium-ytterbium. The Bureau of Mines studied the purification of cadmium sponge by amalgam electrolysis.

Mercury was used as working fluid in converting nuclear or solar heat into electric power. Some applications of this energy conversion system will be space communications, heating and cooling space vehicles, and electric propulsion.

[5] Lyman, Robert F. The Red Devil Mercury Mine. Min. Eng., v. 13, No. 12, December 1961 pp. 1337-1339.
[6] Town, J. W., R. F. Link, and W. A. Stickney. Caustic Sulfide Leaching of Mercury Products. Bu. Mines Rept. of Inv. 5748, 1961, 35 pp.
[7] Chemical and Engineering News. Electrolysis Yields Pure Rare Earths. V. 39, No. 15, Apr. 10, 1961, pp. 48, 50.

Mica

By Milford L. Skow [1] and Gertrude E. Tucker [2]

DESPITE a substantial decrease in the quantity of sheet mica sold or used by producers in the United States in 1961, the total quantity of domestic sheet and scrap was the second highest on record. Although the Government purchasing program for domestic mica continued, sales of sheet mica larger than punch and circle were the lowest since 1953. However, the average value of this mica was the highest on record. Government inventories absorbed most of this mica, and industry continued to import most of its requirements of sheet mica. Consumption of total sheet mica (block, film, and splittings) declined, although consumption of film increased slightly. Sales of scrap and ground mica increased moderately. Imports declined sharply, but exports were only slightly lower.

TABLE 1.—Salient mica statistics

	1952-56 (average)	1957	1958	1959	1960	1961
United States:						
Domestic, sold or used by producers:						
Sheet mica, thousand pounds	749	690	661	706	[1] 571	480
Value, thousands	$2,316	$2,492	$2,844	$3,419	[1] $3,183	$3,308
Scrap and flake mica, thousand short tons	82	92	93	102	[1] 98	99
Value, thousands	$1,884	$2,109	$2,065	$2,665	[1] $2,698	$2,417
Ground mica [2], thousand short tons	85	96	98	107	[1] 98	103
Value, thousands	$5,229	$6,073	$5,560	$5,646	[1] $5,193	$5,468
Consumption, block and film, thousand pounds	[3] 3,715	3,340	2,856	2,868	2,776	2,536
Value, thousands	[3] $5,212	$4,651	$3,632	$4,449	$3,988	$3,630
Consumption, splittings, thousand pounds	8,992	8,037	5,329	7,223	6,227	5,514
Value, thousands	$6,117	$4,018	$2,720	$3,464	$2,875	$2,266
Imports for consumption, thousand short tons	13	12	10	11	11	7
Exports, do	3	5	5	5	4	4
Consumption, apparent, [4] sheet, thousand pounds	12,382	12,564	11,616	12,675	[1] 9,202	8,430
World: Production, do	285,000	320,000	315,000	350,000	365,000	355,000

[1] Revised figure.
[2] Domestic and some imported scrap mica.
[3] Average for 1954-56.
[4] Sheet mica sold or used plus imports of unmanufactured and manufactured sheet mica minus exports of sheet mica.

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LEGISLATION AND GOVERNMENT PROGRAMS

Purchasing and research programs for mica were continued by various Government agencies under authority delegated by the Office of Civil and Defense Mobilization (OCDM) and the Office of Emergency Planning (OEP), which succeeded OCDM on September 22, 1961.

Defense Materials Service.—Government mica purchases at the three mica-purchasing depots of General Services Administration (GSA) yielded 224,148 pounds of full-trimmed muscovite block mica (over 0.007 inch thick) in 1961. This was 15 percent less than the 263,987 pounds (revised) obtained in 1960 and the lowest amount since 1957. Since its beginning in 1952, mica purchases under this program had been processed into 2,089,640 pounds of full-trimmed block and film, 1,173,562 pounds of punch, 204,318 pounds of other sheet, and 16,720,469 pounds of scrap. Ruby mica constituted 79 percent of the full-trimmed material. The quantity of Stained and better-quality full-trimmed muscovite block obtained from Government purchases of domestic mica in 1961 was 8 percent less than in 1960 and was equivalent to 14 percent of the total 1961 fabrication of muscovite block and film of these qualities, regardless of grade.

TABLE 2.—Yield of full-trimmed muscovite ruby and nonruby block mica from domestic purchases by GSA in 1961, 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	281	365	38	684	706	36	4	746
3	632	984	86	1,702	1,212	133	8	1,353
4	1,680	1,850	234	3,764	2,303	280	25	2,608
5	8,732	13,162	1,486	23,380	6,159	2,090	184	8,433
5½	5,458	6,861	1,075	13,394	3,089	1,025	150	4,264
6	22,920	42,936	6,393	72,249	10,125	8,572	1,075	19,772
Total	39,703	66,158	9,312	115,173	23,594	12,136	1,446	37,176
Franklin, N.H.:								
2 and larger	18	137	86	241	27	33	6	66
3	35	269	205	509	90	84	8	182
4	70	690	428	1,188	185	192	45	422
5	418	3,588	2,305	6,311	839	910	220	1,969
5½	291	2,232	1,969	4,492	336	547	179	1,062
6	1,838	11,250	10,041	23,129	1,169	2,449	811	4,429
Total	2,670	18,166	15,034	35,870	2,646	4,215	1,269	8,130
Custer, S. Dak.:								
2 and larger	17	201	87	305	15	6	2	23
3	31	333	174	538	52	64	14	130
4	53	711	347	1,111	74	93	21	188
5	319	3,179	1,703	5,201	386	487	120	993
5½	204	1,713	992	2,909	185	238	78	501
6	832	7,619	5,040	13,491	638	1,346	425	2,409
Total	1,456	13,756	8,343	23,555	1,350	2,234	660	4,244
Grand total	43,829	98,080	32,689	174,598	27,590	18,585	3,375	49,550

The industry-Government program authorized by OCDM for research on substitutes for strategic natural mica ended at midyear upon completion of the two remaining contracts, those with the Federal Bureau of Mines and General Telephone & Electronics Laboratories, Inc. Although ultimate goals were not reached in this 5-year research program, several promising advances were made. These included a practical method for producing reconstituted synthetic-mica paper and an inorganically bonded synthetic-mica laminate that initial tests indicated had better electrical and thermal properties as a vacuum-tube spacer material than natural mica.

TABLE 3.—Yield of byproducts from domestic purchases of ruby and nonruby mica by GSA in 1961, by depots

(Pounds)

Depot	Ruby			Nonruby		
	Miscellaneous [1]	Punch	Scrap	Miscellaneous [1]	Punch	Scrap
Spruce Pine, N.C.	2,436	11,778	783,789	1,402	2,636	289,198
Franklin, N.H.	2,098	18,483	293,526	505	457	9,598
Custer, S. Dak.	1,346	13,232	223,969	184	771	16,661
Total	5,880	43,493	1,301,284	2,091	3,864	315,457

[1] Includes some full-trimmed thins and block of lower than Heavy Stained qualities.

Commodity Credit Corporation.—Muscovite block and film were received under one new and eight carryover barter contracts for surplus agricultural commodities. Phlogopite splittings were received under two new and three carryover contracts, but muscovite splittings and phlogopite block were not contracted for or received under the barter program.

Office of Minerals Exploration (OME).—One mica exploration contract, with a value of $5,000, was in force at the beginning of the year; it was terminated in February. No additional contracts were executed.

DOMESTIC PRODUCTION

Sheet Mica.—The quantity of sheet mica sold or used by producers declined 16 percent to the lowest total since 1949. Sales of sheet mica larger than punch and circle decreased 11 percent in quantity. However, their value increased 4 percent; it was the third highest on record. Most of this larger sheet mica was sold to the Government at above-market prices under the domestic mica purchasing program. North Carolina continued to be the principal producing State and increased its proportion of the total quantity of sheet mica reported to 81 percent from 75 percent in 1960. New Hampshire, South Dakota, and Maine were other significant producers.

Scrap and Flake Mica.—Demand for scrap and flake mica sold or used by grinders increased slightly to a tonnage surpassed only in 1959. The value, however, decreased 10 percent. North Carolina again was the principal producing State, furnishing 54 percent of the tonnage. Georgia, Alabama, and South Carolina also provided substantial quantities.

TABLE 4.—Mica sold or used by producers in the United States

Year and State	Sheet mica						Scrap and flake mica [3]		Tota	
	Uncut punch and circle mica		Uncut mica larger than punch and circle [1]		Total sheet mica [2]					
	Pounds	Value	Pounds	Value	Pounds	Value	Short tons	Value	Short tons	Value
1952–56 (average)	543, 933	$72, 606	205, 298	$2, 243, 840	749, 231	$2, 316, 446	82, 262	$1, 883, 901	82, 637	$4, 200, 347
1957	425, 737	34, 341	264, 315	2, 458, 121	690, 052	2, 492, 462	92, 438	2, 109, 463	92, 783	4, 601, 925
1958	376, 005	31, 044	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] 240, 862	[4] 3, 161, 401	[5] 571, 108	[5] 3, 183, 029	[4] 97, 912	[4] 2, 697, 510	[4] 98, 196	[4] 5, 880, 539
1961:										
California							950	11, 875	950	11, 875
Colorado							600	9, 600	600	9, 600
Connecticut			159	2, 060	159	2, 060	([6])	([6])	([6])	([6])
Georgia			349	2, 982	349	2, 982	([6])	([6])	([6])	([6])
Maine			7, 373	87, 900	7, 373	87, 900	80	2, 400	84	90, 300
New Hampshire	6, 485	639	56, 252	930, 519	62, 737	931, 158	669	19, 737	700	950, 895
New Mexico							1, 800	52, 200	1, 800	52, 200
North Carolina	247, 959	20, 835	142, 911	2, 216, 244	390, 870	2, 237, 079	53, 615	1, 010, 389	53, 810	3, 247, 468
South Carolina			12	111	12	111	([6])	([6])	([6])	([6])
South Dakota	11, 000	300	7, 086	37, 040	18, 086	37, 340	1, 054	32, 122	1, 063	69, 462
Undistributed [7]			908	9, 730	908	9, 730	40, 276	1, 278, 496	40, 276	1, 293, 379
Total	265, 444	21, 774	215, 050	3, 286, 586	480, 494	3, 308, 360	99, 044	2, 416, 819	99, 283	5, 725, 179

[1] Includes the full-trimmed mica equivalent of hand-cobbed mica, 1952–61.
[2] Includes small quantities of splittings in certain years.
[3] Includes finely divided mica recovered from mica and sericite schist, and mica that is a byproduct of feldspar and kaolin beneficiation.
[4] Revised figure.
[5] Total sheet mica in New Hampshire revised to 72,188 pounds valued at $1,101,458 from 80,065 pounds valued at $904,300. Value of sheet mica revised for the following States: Maine, $302,959 from $274,907; North Carolina, $1,538,924 from $1,411,440.
[6] Included with "Undistributed" to avoid disclosing individual company confidential data.
[7] Figures include Alabama, Arizona, Montana, Pennsylvania, Virginia, Wyoming, and States indicated by foonote 6.

Ground Mica.—Sales of ground mica increased 4 percent in tonnage and 5 percent in value. The total tonnage was 88 percent dry-ground and 12 percent wet-ground mica. Production was reported by 29 grinders in 26 dry-grinding and 9 wet-grinding plants. Carolina-Southern Mining Co., Inc., moved its dry-grinding operation from Kingsport, Tenn., to a new plant at Boonford, N.C. International Minerals & Chemical Corp. abandoned its Greeneville, Tenn., operations, sold its dry-grinding plant at Erwin, Tenn., to Harris Clay Co., Spruce Pine, N.C., and produced dry-ground mica at Spruce Pine in the plant formerly operated by DeWeld Mica Corp. Deneen Mica Co. of Connecticut, Middletown, Conn., and Clute Corp., Pojoaque, N. Mex., were listed as producers of dry-ground mica for the first time.

TABLE 5.—Ground mica sold by producers in the United States, by methods of grinding

Year	Dry-ground		Wet-ground		Total	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1952–56 (average)	71,914	$3,358	13,167	$1,871	85,081	$5,229
1957	83,025	4,015	13,307	2,058	96,332	6,073
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	[1] 86,225	[1] 3,422	12,121	1,771	[1] 98,346	[1] 5,193
1961	90,519	3,747	12,176	1,721	102,695	5,468

[1] Revised figure.

CONSUMPTION AND USES

Sheet Mica.—Consumption of sheet mica (block, film, and splittings) in the United States dropped 11 percent, from 9 to 8 million pounds.

Domestic fabricators used 2.5 million pounds of muscovite block and film mica, almost 9 percent less than in 1960 and the lowest quantity reported since the canvass of block and film mica fabrication was initiated in 1952. The quantity fabricated in 1961 comprised 4 percent Good Stained or better qualities, 48 percent Stained, and 48 percent lower than Stained. Electronic applications, principally tubes, consumed 67 percent of all qualities and 97 percent of the Stained or better qualities. Fabrication of muscovite block and film mica was reported by 21 companies in 9 States. New Jersey had the most plants (five) and reported 10 percent more fabrication despite the overall decline nationally. Almost half the block and film mica fabricated domestically in 1961 came from 13 companies in three States—New Jersey (5), New York (4), and North Carolina (4). At yearend, Sangamo Electric Co. closed its mica fabricating operations at Marion, Ill.

Fabricated mica films were used in mass producing a line of dipped capacitors with high reliability.[3]

The downward trend in consumption of mica splittings continued, with declines of 11 percent in quantity and 21 percent in value. Muscovite splittings from India continued to constitute the bulk of the

[3] Electronic News. Electro Motive's Mica Capacitors for Minuteman. V. 6, No. 262, May 22, 1961, p. 44.

consumption (96 weight-percent); the remainder was principally phlogopite splittings from the Malagasy Republic. Eleven companies fabricated splittings at 12 plants in 9 States. Operations at four plants—two in New York, one in New Hampshire, and one in Massachusetts—required 3.4 million pounds of splittings, 62 percent of the total consumed.

Built-Up Mica.—Splittings were fabricated domestically into various forms of built-up mica principally for use as electrical insulation. For the second consecutive year, segment plate was the form in strongest demand (31 percent of the built-up mica). Next came tape (23 percent) and molding plate (19 percent). Total consumption of built-up mica declined 17 percent in quantity and 15 percent in value. Continental-Diamond Fibre Co. moved its facilities for producing built-up mica from Valparaiso, Ind. to Newark, Del.

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 Coshocton, Ohio, and Samica Corp. (subsidiary of Minnesota Mining & Manufacturing Co.), at Rutland, Vt., continued to be the only producers. Total output was moderately greater than in 1960 and the largest since production began in 1952.

Synthetic Mica.—Commercial production of synthetic mica flake, principally for use in glass-bonded mica ceramic materials, was continued by Electronic Mechanics, Inc., Clifton, N.J., and Synthetic Mica Co., Division of Mycalex Corp. of America, West Caldwell, N.J. Electronic Mechanics, which became Molecular Dielectrics, Inc., late in the year, processed its crude product to recover high-quality crystals of synthetic mica, 1 square inch or larger. 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 in various shapes.

Ground Mica.—Demand for ground mica was up 4 percent; virtually all the increased tonnage was registered for dry-ground mica. Sales of wet-ground mica, used principally in manufacturing paint and rubber, were essentially unchanged. Dry-ground mica was used principally in roofing materials, paint, joint cement, and well-drilling compounds. Paint, joint cement, and well-drilling compounds took greater proportions of the total ground mica than in 1960.

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 1961

(Pounds)

Variety, form, and quality	Electronic uses				Nonelectronic uses			Grand total
	Capacitors	Tubes	Other	Total	Gageglass and diaphragms	Other	Total	
Muscovite:								
Block:								
Good Stained or better	650	20,710	4,581	25,941	5,851	90	5,941	31,882
Stained	6,320	1,155,411	9,562	1,171,293	1,299	37,360	38,659	1,209,952
Lower than Stained [1]	251	417,040	24,184	441,475	376	776,188	776,564	1,218,039
Total	7,221	1,593,161	38,327	1,638,709	7,526	813,638	821,164	2,459,873
Film:								
First quality	4,820			4,820				4,820
Second quality	53,699			53,699		90	90	53,789
Other quality	2,375			2,375				2,375
Total	60,894			60,894		90	90	60,984
Block and film:								
Good Stained or better [2]	59,169	20,710	4,581	84,460	5,851	180	6,031	90,491
Stained [3]	8,695	1,155,411	9,562	1,173,668	1,299	37,360	38,659	1,212,327
Lower than Stained	251	417,040	24,184	441,475	376	776,188	776,564	1,218,039
Total	68,115	1,593,161	38,327	1,699,603	7,526	813,728	821,254	2,520,857
Phlogopite: Block (all qualities)			104	104		14,782	14,782	14,886

[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 1961, 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	4,620	3,555	2,133	10,357	581	21,246
Stained	8,618	32,891	98,457	953,272	89,523	1,182,761
Lower than Stained	90,362	111,238	82,230	355,017	386,222	1,025,069
Total	103,600	147,684	182,820	1,318,646	476,326	2,229,076
Nonruby:						
Good Stained or better	1,616	514		8,506		10,636
Stained	1,361	3,962	1,760	20,108		27,191
Lower than Stained	15,184	24,380	11,450	2,539	139,417	192,970
Total	18,161	28,856	13,210	31,153	139,417	230,797
Film:						
Ruby:						
First quality	1,055	925	875	465		3,320
Second quality	21,992	17,048	9,914	4,110		53,064
Other quality					2,375	2,375
Total	23,047	17,973	10,789	4,575	2,375	58,759
Nonruby:						
First			1,000	500		1,500
Second	35	165	525			725
Other						
Total	35	165	1,525	500		2,225

[1] Figures for block mica include "all smaller than No. 6" grade and "punch" mica.

TABLE 8.—Consumption and stocks of mica splittings in the United States, by sources

(Thousand pounds and thousand dollars)

	Canadian		Indian		Malagasy [1]		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Consumption:								
1952–56 (average)	[2] 82	[2] $42	8,232	$5,567	[3] 678	[3] $508	8,992	$6,117
1957	[4]	[4]	7,531	3,617	[4] 506	[4] 401	8,037	4,018
1958	[4]	[4]	4,982	2,437	[4] 347	[4] 283	5,329	2,720
1959	[4]	[4]	6,726	3,098	[4] 497	[4] 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
Stocks Dec. 31:								
1952–56 (average)	[5] 21	[5] 9	6,276	4,961	[6] 401	[6] 328	6,698	5,298
1957	[4]	[4]	4,942	2,594	[4] 325	[4] 267	5,267	2,861
1958	[4]	[4]	3,392	1,801	[4] 316	[4] 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	273	167	2,819	1,379

[1] Formerly Madagascan.
[2] Average for 1952–54.
[3] Includes Canadian, 1955.
[4] Canadian included with Malagasy.
[5] Average for 1952–53.
[6] Includes Canadian, 1954–56.

TABLE 9.—Built-up mica [1] sold or used in the United States, by products

(Thousand pounds and thousand dollars)

Product	1960		1961	
	Quantity	Value	Quantity	Value
Molding plate	1,015	$2,325	737	$2,089
Segment plate	1,210	2,886	1,177	2,521
Heater plate	510	1,478	[2]	[2]
Flexible (cold)	541	1,894	489	1,578
Tape	1,117	5,260	892	4,522
Other	177	747	517	1,677
Total	4,570	14,590	3,812	12,387

[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	1960		1961	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Roofing	[1] 35,647	[1] $980	32,696	$917
Wallpaper	569	85	675	97
Rubber	10,020	785	6,987	655
Paint	[1] 20,464	[1] 1,799	22,559	1,765
Plastics	488	58	486	57
Welding rods	[2]	[2]	1,029	61
Joint cement	13,189	837	17,994	1,225
Well drilling	10,775	299	13,981	412
Other uses [3]	[1] 7,194	[1] 350	6,288	279
Total	[1] 98,346	[1] 5,193	102,695	5,468

[1] Revised figure.
[2] Included with "Other uses."
[3] Includes mica used for molded electric insulation, house insulation, Christmas-tree snow, annealing, welding rods (1960), and other purposes.

STOCKS

Government inventories of sheet mica accumulated under the stockpiling program contained 60.5 million pounds of strategic and 9.5 million pounds of nonstrategic block, film, and splittings. Quantities of all strategic categories except phlogopite block exceeded maximum objectives.

TABLE 11.—Government inventories of sheet mica, December 31, 1961

Category	Inventory, thousand pounds				Percent of maximum objective
	National (strategic) stockpile	Defense Production Act	Commodity Credit Corporation and supplemental stockpiles	Total	
Muscovite block:					
Stained A or better, meeting stockpile specifications	6,655	2,666	764	10,085	121.5
Stained A or better, below stockpile specifications	347	3,623	135	4,105	(1)
Stained B or lower	4,642	----	----	4,642	(1)
Total	11,644	6,289	899	18,832	(1)
Muscovite film:					
First and Second quality, meeting stockpile specifications	1,195	103	63	1,361	104.7
First and Second quality, below stockpile specifications	24	----	----	24	(1)
Third quality	513	----	----	513	(1)
Total	1,732	103	63	1,898	(1)
Muscovite splittings	40,030	----	4,826	44,856	211.6
Phlogopite block:					
Meeting stockpile specifications	16.6	----	----	16.6	97.8
Below stockpile specifications	206.5	----	----	206.5	(1)
Total	223.1	----	----	223.1	(1)
Phlogopite splittings	3,074	----	1,154	4,228	248.7

[1] No established objective.

PRICES AND SPECIFICATIONS

Purchases of domestically produced full-trimmed and half-trimmed mica by the Government continued throughout 1961 at prices established in May 1956. Government prices for hand-cobbed mica had not changed since 1954; however, 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 1960 and ranged from 7 to 12 cents a pound for the smallest size (punch) to $4 to $8 a pound for 6- by 8-inch sheets. Stained or electric mica was quoted 10 to 20 percent lower.

The price of North Carolina scrap mica was listed throughout the year at $20 to $30 a short ton, depending on quality. Quoted prices for dry- and wet-ground mica held steady, unchanged since March 1956.

A second duplicate master set of visual standards for muscovite block mica was selected, framed, and presented to the Government of India by the American Society for Testing Materials.

TABLE 12.—Prices for domestically produced muscovite mica purchased by the Government in 1961, by grade and quality

Form, variety, and grade	Price per pound					Price per short ton
	Full-trimmed			Half-trimmed		
	Good Stained or better	Stained	Heavy Stained	Stained	Heavy Stained	
Block and film mica:						
Ruby:						
No. 3 and larger	$70.00	$31.90	$14.80	$12.00	$8.00	
No. 4 and No. 5	40.00	18.25	6.85	5.00	4.00	
No. 5½ and No. 6	17.70	7.55	4.00	3.00	2.00	
Nonruby:						
No. 3 and larger	70.00	25.55	11.85	9.60	6.40	
No. 4 and No. 5	40.00	14.60	5.45	4.00	3.20	
No. 5½ and No. 6	17.70	6.55	4.00	2.40	1.60	
Hand-cobbed mica:						
Ruby						$600
Nonruby						540

TABLE 13.—Price of dry- and wet-ground mica in the United States in 1961 [1]

(Cents per pound)

Mica	Value	Mica	Value
Dry-ground:		Wet-ground [2]—Continued	
Paint, 100-mesh	4	Paint or lacquer, 325-mesh, less than carlots [3]	9
Plastic, 100-mesh	4	Rubber	8
Roofing, 20- to 80-mesh	3	Rubber, less than carlots [3]	8¾
Wet-ground: [2]		Wallpaper	8¾
Biotite	6½	Wallpaper, less than carlots [3]	9
Biotite, less than carlots [3]	7¼	White, 5-10 microns	8¼
Paint or lacquer, 325-mesh	8¼	White, 5-10 microns, 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.

FOREIGN TRADE [4]

Imports.—Total quantity of mica imported for consumption was 34 percent lower than in 1960, as all major categories registered decreases. Most of the reduction in tonnage (85 percent) resulted from the decline in imports of scrap mica. The total value of mica imports declined only 4 percent, largely because the quantity of imported manufactured mica, which had a high unit value, was virtually unchanged from 1960; it accounted for 76 percent of the total value.

Exports.—Total exports of mica and mica products were 5 percent lower than in 1960. Ground-mica exports, which continued to constitute most of the total, were essentially unchanged, but exports of other manufactured mica declined 22 percent. Exports of unmanufactured mica were the smallest since 1954 but had the highest value since 1943.

Table 14.—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)
1952–56 (average)	2,123,209	[1] $3,616	6,357	[1] $88	5,194	[1] $8,631	12,613	[1] $12,335	3,282	$1,392
1957	1,841,840	[1] 3,359	5,187	57	5,766	[1] 8,031	11,874	[1] 11,447	5,355	1,550
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	1,238
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	3,823	6,116	7,273	7,998	3,799	1,227

[1] Data known to be not comparable with other years.

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 mica, by kinds and countries

Year and country	Unmanufactured									
	Waste and scrap, valued not more than 5 cents per pound				Untrimmed phlogopite mica from which no rectangular piece exceeding 1 by 2 inches in size may be cut		Other			
	Phlogopite		Other				Valued not above 15 cents per pound, n.e.s.		Valued above 15 cents per pound	
	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value
1952–56 (average)	594,022	$6,203	12,119,095	[1] $82,228	81,581	$15,272	193,170	$15,702	1,848,458	[1] $3,584,927
1957			10,373,171	56,888			220,460	16,424	1,621,380	[1] 3,342,465
1958			8,128,613	48,169			10,317	1,182	2,170,739	5,090,800
1959			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:										
North America: Canada	30,000	224	35,110	664						
South America:										
Argentina							66,139	3,825	27,525	34,786
Brazil			248,018	6,188			[2] 2,480	[2] 260	[2] 529,855	[2] 928,577
Europe: United Kingdom									752	3,551
Asia:										
India			5,668,320	33,201			(3)	(3)	[2] 185,761	[2] 718,960
Japan									1,400	3,973
Africa:										
Angola									3,959	10,557
British East Africa									10,609	81,943
Malagasy Republic	66,138	988							10,057	20,120
Mozambique									2,923	918
Rhodesia, Federation of and Nyasaland									1,200	1,515
Union of South Africa									4,538	26,054
Oceania: Australia									5,450	6,173
Total	96,138	1,212	5,951,448	40,053			[2] 68,619	[2] 4,085	[2] 784,029	[2] 1,837,127

Year and country	Manufactured—films and splittings							
	Not cut or stamped to dimensions				Cut or stamped to dimensions		Total films and splittings	
	Not above 1/10,000 of an inch in thickness		Over 1/10,000 of an inch in thickness					
	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value
1952-56 (average)	7,700,581	[1] $3,486,427	2,284,812	$3,701,277	54,732	[1] $975,869	10,040,125	[1] $8,163,573
1957	9,303,287	[1] 3,871,615	1,936,041	[1] 2,569,468	71,652	[1] 1,050,799	11,310,980	[1] 7,491,882
1958	7,628,263	4,551,191	2,268,139	3,135,871	40,884	646,800	9,937,286	8,333,862
1959	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:								
North America:								
Canada			535	919			535	919
Jamaica			1,228	5,563	2,063	7,684	3,291	13,247
Mexico			360	1,603	128,871	203,482	129,231	205,085
South America:								
Argentina			2,645	2,695			2,645	2,695
Brazil	50,339	49,145	667,376	730,076	2,160	10,226	719,875	789,447
Europe:								
France					35	1,328	35	1,328
Germany, West	3,857	1,750			66	689	3,923	2,439
United Kingdom	41,757	10,438			11,288	253,814	53,045	264,252
Asia:								
India	4,658,144	1,722,118	654,854	949,564	19,602	220,495	5,332,600	2,892,177
Japan	7,250	3,124	1,400	2,008	18,222	439,954	26,872	445,086
Africa:								
Angola	200	405					200	405
British East Africa	1,355	1,092	3,856	4,216			5,211	5,308
Malagasy Republic	1,062,705	800,701	91,567	70,720			1,154,272	871,421
Union of South Africa	25,300	32,478					25,300	32,478
Total	5,850,907	2,621,251	1,423,821	1,767,364	182,307	1,137,672	7,457,035	5,526,287

See footnotes at end of table.

TABLE 15.—U.S. imports for consumption of mica, by kinds and countries—Continued

Year and country	Manufactured-cut or stamped to dimensions, shape, or form		Manufactured—other					
			Mica plates and built-up mica		All mica manufactures of which mica is the component material of chief value		Ground or pulverized	
	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value
1952–56 (average)	44,717	[1] $69,741	47,474	$209,912	41,910	[1] $174,741	213,700	$12,590
1957	31,904	[1] 44,099	37,866	[1] 85,933	103,924	[1] 406,952	46,000	3,760
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								
North America:								
Canada					7	273	23,000	1,380
Jamaica					5,138	5,882		
Mexico	793	1,617			7,333	27,498		
South America: Brazil					45,604	177,681		
Europe:								
Belgium-Luxembourg			57,235	48,251				
France					390	13,715		
Germany, West			5	22				
Netherlands					869	22,191		
Spain					27	1,161		
Switzerland			19	255				
United Kingdom			200	441	28,191	237,850		
Asia:								
India					17,485	45,208		
Japan			150	997	733	5,811		
Total	793	1,617	57,609	49,966	105,777	537,270	23,000	1,380

[1] Data known to be not comparable with other years.
[2] Adjusted by the Bureau of Mines.

Source: Bureau of the Census.

TABLE 16.—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
1952–56 (average)	390,126	$55,044	5,900,359	$327,094	274,795	$1,009,870
1957	911,006	46,391	9,256,170	520,557	541,432	983,446
1958	1,030,540	90,565	8,198,367	430,820	254,198	695,626
1959	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:						
North America:						
Bahamas					216	416
British Honduras			35,000	2,667		
Canada	50,502	15,322	2,552,110	125,328	116,651	405,832
Canal Zone					58	791
Costa Rica					47	266
Dominican Republic					182	520
Guatemala			58,292	3,094		
Jamaica	9,455	8,137	28,000	980	932	2,143
Mexico	46,155	24,436	287,009	14,956	11,961	59,165
Netherlands Antilles					129	513
Panama			16,200	1,601	174	528
Trinidad and Tobago			79,641	5,016		
South America:						
Argentina					3,741	12,717
Bolivia	12,000	1,110				
Brazil					1,560	3,573
Chile	397	998			4,250	18,934
Colombia	234	590	131,000	7,183	2,849	7,670
Ecuador			74,400	4,372		
Peru	275	630	220,004	10,965	5,091	7,456
Uruguay					470	3,828
Venezuela	517	1,300	503,083	26,981	3,002	10,923
Europe:						
Belgium-Luxembourg			430,945	24,443	313	2,940
Denmark					645	3,851
France	6,670	3,608	456,800	34,662	7,690	17,752
Germany, West	7,130	11,789	877,859	51,785	3,110	18,139
Iceland			20,000	1,350		
Italy	110,473	4,146	500,000	28,557	3,533	13,356
Netherlands	17,879	25,549	22,196	1,778	1,180	4,256
Portugal			18,400	1,218	253	960
Spain			22,000	1,650	216	918
Sweden					7,446	34,216
Switzerland	10,000	10,000	39,800	3,084	456	968
United Kingdom	14,677	16,672	49,519	4,335	1,911	9,575
Asia:						
Arabia Peninsula States, n.e.c.			25,000	2,191		
Hong Kong	4,000	380			240	302
India	1,007	2,530	21,000	1,577	308	1,478
Indonesia			4,600	366	34	410
Iran			24,500	2,155		
Israel			42,480	3,398		
Japan	13,683	11,333	132,000	6,402	1,205	3,215
Korea					618	975
Kuwait			12,000	696		
Lebanon			7,486	554		
Pakistan					79	216
Philippines	20,000	1,800	66,781	5,810	1,214	2,451
Saudi Arabia					201	510
Taiwan					328	2,141
Viet-Nam					440	1,805
Africa:						
Congo, Republic of the, and Ruanda-Urundi					332	1,636
Somali Republic			50,000	1,368		
Union of South Africa	9,157	1,400	106,145	5,729	4,980	19,636
United Arab Republic (Egypt Region)			49,200	4,306	379	2,375
Oceania:						
Australia			81,350	2,874	1,896	9,882
New Zealand			30,050	2,132		
Total	334,211	141,730	7,074,850	395,563	190,320	689,238

Source: Bureau of the Census.

WORLD REVIEW

World production of mica was 3 percent less than in 1960. Decreased production of marketable scrap mica by India and the Union of South Africa contributed most to the change, but this decline was counteracted somewhat by increased production of scrap mica in the United States.

Angola.—Exports of sheet mica continued to decline in 1959 and 1960; exports of scrap mica increased sharply in 1959.

Data on exports for 1961 were not available; however, it was known that both production and exports were reduced drastically as a result of internal unrest.

Australia.—State subsidies to Australian mica producers were discontinued at the start of 1961, making continuance of the country's mica mining industry highly improbable. Australia was consuming about US$224,000 worth of Good Stained and better mica in grades 3, 4, and 5.[5]

Canada.—Establishment of grinding facilities in western Canada reversed the declining trend in the Canadian mica industry. Georgian Minerals Industries, Ltd., Calgary, British Columbia, was producing dry-ground mica from a muscovite schist near Cedarside in east central British Columbia.[6] The schist was mined by strip methods,[7] pulverized in a high-speed hammermill, and screened into six size ranges. A small quantity of quartz and garnet was removed from each fraction by air separation.[8]

India.—Based on activity during the first 6 months, exports of mica in 1961 were expected to drop about 20 percent from 1960. The decreased demand for Indian mica, particularly by buyers in the United States and the United Kingdom, resulted in the closing of a large mica factory and a number of small ones.[9]

The only micanite plant in India was established in conjunction with the Second Five-Year Plan for developing electrical industries, principally the Bhopal heavy electrical machinery plant. The Bhopal project, originally scheduled to begin operating by March 1961, was not expected to begin production before the end of 1962, and it was not expected to reach full production before March 1966. Thus, Indian production of micanite for the next 2 or 3 years was expected to be negligible because the price of the product was reportedly too high to compete in the world market.[10]

A fund of 1.85 million rupees (US$388,500) for research on uses of scrap mica was made available by the Indian Government to the Central Glass and Ceramic Research Institute in Calcutta. The Institute previously had conducted studies on the use of ground mica in the rubber and paint industries.[11]

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[5] Rhodesian Mining and Engineering. New Mineral Export Markets Found in Australia and Japan. V. 26, January 1961, p. 27.
[6] Department of Mines and Technical Surveys, Ottawa. A Preliminary Survey of the Canadian Mineral Industry in 1961. Miner. Inf. Bull. MR 56, February 1962, p. 41.
[7] Canadian Mining Journal (Gardenvale, Quebec). Georgian Minerals First Mica Shipment. V. 82, March 1961, pp. 118–119.
[8] Mining Journal (London). Canada's New Mica Industry. V. 256, Feb. 24, 1961, p. 223.
[9] Mining Journal (London). Indian Mica Industry in Doldrums. V. 256, May 5, 1961, p. 514.
[10] Bureau of Mines. Mineral Trade Notes. V. 53, No. 5, November 1961, p. 37.
[11] Work cited in footnote 10.

TABLE 17.—World production of mica by countries [1] [2]

(Thousand pounds)

Country [1]	1952–56 (average)	1957	1958	1959	1960	1961
North America:						
Canada (shipments):						
Block	134	108	90	49	176	2,061
Splittings	4	15				
Ground	1,005	910	1,380	591	791	
Scrap	750	247	35	174	734	
United States (Sold or used by producers):						
Sheet	749	690	661	706	571	480
Scrap	164,524	184,876	186,694	203,082	195,824	198,088
South America:						
Argentina:						
Sheet	1,140	212	[3] 192	[3] 403	[3] 397	[3] [4] 265
Scrap	29	2				
Brazil	3,792	3,265	2,829	2,553	4,440	[4] 4,400
Europe:						
Austria [5]			134	216	317	194
Norway, including scrap	2,831	4,630	4,519	12,059	5,732	6,114
Spain	22	24	20	11	(6)	
Sweden:						
Block	7					
Ground	364	474	421	220	441	[4] 440
Yugoslavia	[7] 18	37	4	4	4	9
Asia:						
Ceylon	7					
India (exports):						
Block	4,314	4,411	5,243	6,305	5,216	4,592
Splittings	13,371	16,645	14,264	15,988	17,469	18,208
Scrap	21,195	27,915	24,001	29,242	42,829	35,355
Taiwan, including scrap	31	11	(6)	(6)		
Africa:						
Angola:						
Sheet	44	46	46	20	26	4
Scrap and splittings	463	844	716	384	721	46
Kenya	2		15	22	2	(6)
Malagasy Republic (phlogopite):						
Block	88	139	234	269	256	223
Splittings	1,329	1,984	2,154	1,922	1,973	2,002
Morocco:						
Sheet	2					
Scrap	11					
Mozambique, including scrap	13	66	4	7	2	2
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia, Sheet	13	1	2	1	(6)	
Southern Rhodesia:						
Block	161	71	108	106	90	64
Scrap	333					
South-West Africa				234		
Sudan:						
Block		13	225	882		
Scrap			154			
Tanganyika (exports):						
Sheet	172	148	108	117	179	196
Ground	7					
Scrap	214		24	190		
Union of South Africa:						
Sheet	7	2	2	(6)	2	2
Scrap	5,423	4,226	4,255	3,752	7,284	5,441
Oceania: Australia:						
Block	64	37	31	33	9	
Scrap	20	40	84	187	653	185
Damourite	1,042	1,455	1,080	1,100	1,252	1,138
World total (estimate) [1] [2]	285,000	320,000	315,000	350,000	365,000	355,000

[1] Mica is also produced in China, Rumania, and U.S.S.R., but production data are not available; estimates for these countries are included in the total.

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

[3] Exports.

[4] Estimate.

[5] Including reclaimed from dumps.

[6] Less than 500 pounds.

[7] One year only, as 1956 was first year of commercial production.

Compiled by Liela S. Price, Division of Foreign Activities.

TABLE 18.—Angola: Exports of mica

	1959		1960	
	Quantity	Value	Quantity	Value
Sheet mica.....pounds..	20,020	US$45,000	17,471	US$46,000
Scrap mica.....short tons..	1,243	42,000	658	13,000

Source: U.S. Consulate, Luanda, Angola. State Department Dispatch 249, Apr. 11, 1961, p. 2; State Department Dispatch 243, Apr. 16, 1962, p. 1.

Japan.—Requirements for block mica were reported to be about 900,000 pounds per year. Most of this amount had been coming from India, and interest was expressed in Rhodesia as an alternate source of supply.[12]

Malagasy Republic.—Exports of mica totaled 1,358 tons valued at US$1.65 million, compared with 1,095 tons valued at US$1.17 million in 1960. The United States share in 1961 was 542 tons valued at US$852,000.[13]

The state of the mica industry was summarized briefly,[14] and the history of mica production and trade, a description of deposits, and the economics of the industry were reported in detail.[15]

Rhodesia and Nyasaland, Federation of.—No mica production was reported from the Aries mine, which produced sheet mica in 1960. The mine is located in a pegmatite 4.5 miles north of Lundazi on the Nyasaland border. Total production in the Federation dropped in 1961. Mica exports totaled 65,044 pounds of sheet valued at US$42,524 and 57,334 pounds of scrap valued at US$1,235.[16]

A comprehensive report was published on the geology of the main mica mining areas in Southern Rhodesia and included information on mica production from individual mines.[17]

Tanganyika.—In Eastern Province, two well-established African mica mining cooperative societies were the most important producers; they sold their output to licensed dealers in Morogoro. Many more claims were established in 1961, and a continued increase in production was expected. There was renewed interest in the Pare Mountains, where two cooperative societies were being formed. The Anglo American Vulcanized Fibre Co. obtained a mining lease on 44 square miles in the Tungwa area of the Southern Highlands Province and exported considerable low-quality mica to its factory in the United Kingdom.[18]

[12] Work cited in footnote 5, p. 31.
[13] U.S. Embassy, Tananarive, Malagasy Republic. State Department Dispatch 167. Apr. 18, 1962, encl. 2, p. 1; encl. 6, p. 1.
[14] Murdock, T. G. Possibilities of Mineral Development in the Malagasy Republic. U.S. Operations to the Malagasy Republic, Miner. Rept. 13, Oct. 10, 1961, p. 4.
[15] ——— The Phlogopite Mica Resources and Industry of the Malagasy Republic. U.S. Operations Mission to the Malagasy Republic, Miner. Rept. 14, Oct. 20, 1961, 19 pp.
[16] U.S. Consulate, Johannesburg, Union of South Africa. State Department Dispatch 431. Apr. 26, 1962, p. 12, encl. 3, p. 1.
[17] Wiles, J. W. The Geology of the Miami Mica Field (Urungwe District). Southern Rhodesia Geol. Survey Bull. 51, 1961, 235 pp.
[18] South African Mining & Engineering Journal (Johannesburg). Tanganyika Mining Industry in 1961. V. 73, Mar. 30, 1962, pp. 672–675.

Exports of sheet mica for 1958–61 were as follows:

Year:	*Thousand pounds*	*Value (thousands)*
1958	107.6	US$142.8
1959	116.4	145.6
1960	181.4	218.4
1961	194.8	246.4

Source: U.S. Embassy, Dar es Salaam, British East Africa. State Department Dispatch 137. Mar. 7, 1962, encl. 2, p. 5.

Union of South Africa.—Exports of scrap mica have continued near the same level since 1958; the largest portion went to the United Kingdom.

TABLE 19.—Union of South Africa: Production, local sales, and exports of mica

	Sheet, pounds	Scrap, short tons	Ground, short tons
Production:			
1959	492	1,881	----------
1960	1,724	3,356	----------
1961	1,341	2,720	948
Local sales:			
1959	427	985	----------
1960	1,638	465	----------
1961	735	509	382
Exports:			
1959	----------	904	34
1960	----------	981	425
1961	497	894	566

Source: U.S. Consulate, Johannesburg, Union of South Africa. State Department Dispatch 390. Mar. 14, 1962, p. 3. Bureau of Mines. Mineral Trade Notes. V. 53, December 1961, p. 34.

Values of mica exports in 1961 were US$718 for sheet, $27,300 for scrap, and $68,400 for ground.

The South African Mica Process Co. (Pty.), Ltd., opened a US$168,000 plant to grind mica by a fluid-energy process. Scrap mica for the operation was being mined in northern Transvaal. Exports were expected to take about 90 percent of the plant's 3,300-ton-per-month capacity; Australia, the United Kingdom, and the United States were to be the major markets.[19]

U.S.S.R.—Neither known reserves nor existing capacity for producing mica was considered adequate for supplying mica consumption, which was expected to double or triple during the Seven Year Plan period. Mapped muscovite deposits were nearing exhaustion, and phlogopite reserves were considered insufficient. For a number of years, imports of mica into the U.S.S.R. from India had been large.[20]

TECHNOLOGY

Natural Mica.—The geology, exploration methods, and reserves of the Kings Mountain, N.C., pegmatites, from which mica is recovered as a byproduct, were discussed in detail.[21]

[19] E&M Metal and Mineral Markets. South African Mica Plant. V. 32, Aug. 3, 1961, p. 10. Chemical Trade Journal and Chemical Engineer (London). Micro Mica Powders. V. 149, Oct. 6, 1961, p. 761. Bureau of Mines, Mineral Trade Notes. V. 53, December 1961, p. 35.

[20] Kowalewski, Jan. Mineral Resources Development in U.S.S.R.—II, Nonmetallic Minerals. Min. J. (London), v. 257, July 28, 1961, p. 94.

[21] Kesler, T. L. Exploration of the Kings Mountain Pegmatites. Min. Eng., v. 13, September 1961, pp. 1062–1068.

The location, geology, and quality of mica deposits in the Sudan were described.[22]

Attempts to grow large single crystals of muscovite by hydrothermal methods resulted in conversion of the muscovite used as seed and nutrient material to kalsilite and an iron-rich mica.[23] The reactions of muscovite with quartz were examined as a function of temperature at pressures up to 20,000 atmospheres.[24]

Various dielectric properties were determined and reported for Indian clear ruby and green micas at temperatures up to 400° C.[25] Phlogopite sheet mica was heated between 300° and 950° C with a simultaneously applied voltage of 200 to 1,000 volts per mil to improve its dielectric properties.[26] A study was made of the dielectric properties of phlogopite mica as a function of pressure at various temperatures and frequencies. The changes in dielectric properties were explained on the basis of swelling of the mica crystal, which was accompanied by formation of lens-shaped spaces filled with water vapor.[27] Dislocations lying in the cleavage plane were observed in thin fragments of muscovite mica by examination with an electron microscope.[28] Surface forces in mica crystals were discussed in one of a collection of articles on surface phenomena.[29] Fission products in irradiated muscovite, biotite, and synthetic fluorphlogopite were found to be related to the ease of thermal decomposition of the mica.[30]

An instrument was devised to measure rapidly the apparent optic angle of mica to an accuracy of 5 minutes of arc; samples up to 2 inches in diameter could be measured.[31]

Studies were continued on relations between mineralogical compositions of clay materials, their thermal reactions, and ceramic properties of the fired products. Mica was found to be particularly important because of its role in forming a glassy component.[32]

Sheet mica was used as the substrate for determining shear strength of boundary lubricants,[33] as a window in high-temperature vacuum apparatus,[34] and as an aid in studying interference figures.[35]

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[22] Kabesh, M. L. Mica Deposits of Northern Sudan. Republic of the Sudan Geol. Survey Bull. 7, 1960, 55 pp.

[23] Kopp, O.C., L. A. Harris, and G. W. Clark. The Hydrothermal Conversion of Muscovite to Kalsilite and an Iron-Rich Mica. Am. Miner., v. 46, May–June 1961, pp. 719–727.

[24] Segnit, R. E., and G. C. Kennedy. Reactions and Melting Relations in the System Muscovite—Quartz at High Pressures. Am. J. Sci., v. 259, April 1961, pp. 280–287.

[25] Mandal, S. S., and R. N. Dhar. Electrical Properties of Green and Ruby Mica at Elevated Temperatures. Central Glass & Ceram. Res. Inst. Bull. (Calcutta), v. 7, October–December 1960, pp. 161–170.

[26] Endicott, H. S., and G. E. Ledges. Method of Producing a Dielectric Material. U.S. Pat. 2,977,193, Mar. 28, 1961.

[27] Afanas'yev, N. V., and M. S. Metsik. (The Nature of Dielectric Loss in Crystals of Phlogopite Mica.) Izvestiya vysshikh uchebnykh zavedeniy, Fizika, No. 6, 1961, pp. 132–140.

[28] Silk, E. C. H., and R. S. Barnes. The Observation of Dislocations in Mica. Acta Metallurgica, v. 9, June 1961, pp. 558–562.

[29] Metsik, M. S. (Role of Surface Forces in Mica Crystals.) Issledovaniya v oblasti poverkhnostnykh sil; sbornik dokladov na konferentsii po poverkhnostnym silam, aprel. 1960 g, Izdvo AN SSSR, Moscow, 1961, pp. 66–75.

[30] Bonfiglioli, Guido, Andrea Ferro, and Adriana Mojoni. Electron Microscope Investigation on the Nature of Tracks of Fission Products in Mica. J. Appl. Phys., v. 32, December 1961, pp. 2499–2503.

[31] Ruthberg, Stanley. Telescope for Measurement of Optic Angle of Mica. NBS J. Res., v. 65C, April–June 1961, pp. 125–128.

[32] Brindley, G. W., D. M. Maroney, and S. Udagawa. High-Temperature Reactions of Clay Mineral Mixtures and Their Ceramic Properties; Shrinkage and Porosity in Relation to Initial Mineralogy. J. Am. Ceram. Soc., v. 44, January 1961, pp. 42–47.

[33] Bailey, A. I. Friction and Adhesion of Clean and Contaminated Mica Surfaces. J. Appl. Phys., v. 32, August 1961, pp. 1407–1412.

[34] Lindsay, W. B. Improved Demountable High-Temperature Mica Vacuum Window. Rev. Sci. Instr., v. 32, June 1961, pp. 748–749.

[35] Craig, D. B. The Benford Plate. Am. Miner., v. 46, May–June 1961, pp. 757–758.

Data on properties of mica and mica products were reported.[36]

The process used by a plant in Connecticut to recover byproduct mica by flotation was described.[37]

A study of the differential thermal analysis of various particle sizes of dry-ground ruby and green mica demonstrated that the temperature of the endothermic peak indicating dehydroxylation was constant for all particle sizes. However, an exothermic peak appeared at a lower temperature and grew in area with decreasing particle size.[38]

A machine for recovering mica from an aqueous slurry consisted essentially of a reciprocating sluice trough with transverse riffles, adjustable inclination, and selectively altered compound motion.[39] The combined action of a revolving drum with a helical conveyor attached to its innner surface and a flow of water countercurrent to the movement of material by the conveyor was used to separate clay and other fine material from mica flakes.[40] A method of recovering mica flakes from a silt deposit utilized an inclined flat screen, a pair of trommel screens, and a series of hydrocones.[41] In a proposed process for eliminating clay slimes from ground mica, the feed material was passed through a sizing stage wherein the undersize material, preferably minus 40-mesh, advanced to the next stage and the oversize material returned to the grinding step. One of various specified water-soluble selective differential flocculating reagents was added to a slurry of the undersize particles in water to flocculate the mica and disperse the clay slimes. The dispersed slimes were removed as the overflow from a thickener, and the flocculated mica was collected as the underflow.[42]

Ground mica was autoclaved in the presence of water and lime to produce a voluminous, reactive filler material.[43]

The deterioration of gas-turbine engines through deposits and corrosion was reduced or prevented by the addition of ground mica to the fuel.[44] More uniform air injection rates were obtained in an in situ combustion process by partially plugging the more permeable layers of the carbonaceous stratum with a composition which included fine mica as an essential ingredient.[45]

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[36] Materials in Design Engineering. Materials Selector Issue; Other Nonmetallics. V. 54, Mid–October 1961, p. 282.

[37] The Glass Industry. Feldspar by Flotation. V. 42, December 1961, pp. 694–695.

[38] Bishui, B. M., R. N. Dhar, and S. S. Mandal. Studies on Indian Mica: Effect of Dry Grinding on DTA. Central Glass & Ceram. Res. Inst. Bull. (Calcutta), v. 8, January–March 1961, pp. 15–22.

[39] Gobatti, E. F. Concentrator. U.S. Pat. 2,989,184, June 20, 1961.

[40] Neisler, C. E., Jr. Method and Apparatus for Separating Fine Material from Coarse Material. U.S. Pat. 2,981,414, Apr. 25, 1961.

[41] Clawson, F. J., and W. O. McClintock. Method of Treating Ores. U.S. Pat. 3,008,574, Nov. 14, 1961.

[42] Lancaster, H. A., and W. A. Faust (assigned to Kings Mountain Mica Co.). Process for Eliminating Clay Slimes from Mica. U.S. Pat. 3,009,570, Nov. 21, 1961.

[43] Schrauf, Robert, and Artus Frez (assigned to Deutsche Gold- und Silber-Scheideanstall vormals Roessler). Process for the Production of Light Voluminous Silicates. U.S. Pat. 2,981,599, Apr. 25, 1961.

[44] Mackenzie, K. J., E. L. Howe, and R. T. Roles (assigned to The British Petroleum Co. Ltd.). Operation of Gas Turbine Engines and Fuel Compositions for Use in Said Engines. U.S. Pat. 2,993,336, July 25, 1961.

[45] Hurley, J. R., and H. Purre (assigned to Phillips Petroleum Co.). Inverse In Situ Combustion Process. U.S. Pat. 3,010,512, Nov. 28, 1961.

Ground mica was used as an additive to a cigarette-tobacco mixture to reduce the burning temperature [46] and as an ingredient in compositions for joint cement [47] and water-repellant coatings for masonry.[48]

Wet- and dry-ground mica, aluminum paste, and stainless steel flakes were tested alone and in various combinations as platy extenders in alkyd paints having otherwise nonplaty pigmentation. Wet-ground mica was especially beneficial to gloss and color retention and vapor-sealing properties of the paint film.[49] Extension of the studies to alkyd paints containing only platy pigments showed that the properties of the paint films were influenced by the shape, size, and manner of distribution of the platy pigments.[50]

Ground mica, in combination with cristobalite and other substances, was added to a solution of thermosetting silicone resin in an organic solvent to produce an insulating coating able to withstand 1,000° F.[51] A method of applying an insulating coating to various articles used a mixture of ground mica and epoxy resin as the coating composition.[52]

Synthetic Mica.—The Bureau of Mines continued research on synthetic mica at the Norris Metallurgy Research Laboratory, Norris, Tenn. Principal studies were concerned with the growth of large single crystals, the synthesis of mica from cheap and abundant raw materials, the production and evaluation of various synthetic micas, and the preparation of machinable dielectrics by devitrification of synthetic mica glasses.

In the final 6 months of the U.S. industry-Government program to develop substitutes for strategic natural mica, the search continued for a suitable sheet material that could be obtained from synthetic mica. Efforts were directed principally toward inorganic bonding of sheets reconstituted from fluorphlogopite flakes and toward improving the properties of films formed from water-swelling micas.

Synthetic-mica research under a 3-year contract with the U.S. Air Materiel Command was concluded by Synthetic Mica Co., Division of Mycalex Corp. of America. The objective of the program was to develop a commercially feasible technique for producing large-area, single crystals of fluorphlogopite mica. Methods tried were not successful in producing commercially usable crystals in significant quantities.

A method was proposed for using seed crystals to induce the growth of large, usable synthetic fluormica crystals from melts in crucibles.[53] Synthetic fluormica crystals also were produced by precipitation from

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[46] Markes, M. M. Cigarette Filler Composition. U.S. Pat. 2,999,775, Sept. 12, 1961.

[47] Ptasienski, M. P., and J. W. Gill (assigned to United States Gypsum Co.). Dry Cement Composition Comprising Cellulosic Thickener Gelled Starch, Polyvinyl Alcohol and Polyvinyl Acetate. U.S. Pat. 3,003,979, Oct. 10, 1961.

[48] Liberthson, Leo. Water-Repellent Masonry Coating Composition Containing Filler Coated with an Organopolysiloxane and Masonry Coated Therewith. U.S. Pat. 3,006,875, Oct. 31, 1961.

[49] Wet-Ground Mica Association, Inc. Comparative Studies on Different Platy Pigments in Alkyd Paints: Pt. I, Using Platy Pigments in Connection with Other Pigments. Tech. Bull. 44, January 1961, 7 pp.

[50] ——— Comparative Studies on Different Platy Pigments: Pt. II, Using Platy Pigments in Connection with Other Pigments. Tech. Bull. 45, June 1961, 11 pp.

[51] Anderson, E. P. (assigned to Engelhard Industries, Inc.). Composite Material and Method for the Production Thereof. U.S. Pat. 2,984,590, May 16, 1961.

[52] Matter, R. C., and J. R. Sims (assigned to General Motors Corp.). Electrical Apparatus and Method of Making Same. U.S. Pat. 2,997,776, Aug. 29, 1961.

[53] Daimon, Nobutoshi. Method of Producing Synthetic Mica. U.S. Pat. 3,009,785, Nov. 21, 1961.

molten lead borate.[54] A process was devised for producing fluormica bodies by solid-state reaction of the compacted ingredients.[55]

The disposal of fission products in a solid having long-term weatherproof properties was effected by incorporating the radioactive material in fluorphlogopite mica by solid-state reaction with the mica batch.[56]

Soviet scientists continued research on synthetic mica. Production of fairly large sheets on a laboratory scale was reported at the Institute for Rare Metals, Irkutsk, Siberia. Progress also was reported on "novomycalex," mica ceramics, and foamed mica.[57]

Built-Up and Reconstituted Products From Natural and Synthetic Mica.—Phlogopite mica bonded with silicone resin was used as layer insulation in power transformers built to operate as high as 1,100° F.[58] A machine was devised to classify mica splittings to uniform thickness, split oversize material, and form a layer of thin splittings ready for bonding.[59]

A process was described for preparing a sheet material from mica flakes and various organic polymers.[60]

Mica paper and various articles made therefrom were bonded with an acid aluminum phosphate solution.[61] Reconstituted mica also was used as transformer insulation [62] and to form rigid tubing for various electrical insulating applications.[63] Phosphoric acid dissolved in methyl alcohol was the bonding agent for producing readily punchable and shapable insulation from reconstituted synthetic mica.[64]

Details were reported of research on reconstituting synthetic mica by electrophoresis and recrystallizing of the deposited flakes.[65] In a proposed method for bonding reconstituted synthetic mica by crystallization, the sheets were hot-pressed after addition of a small quantity of an inorganic salt as volatile at the temperature employed.[66] Water-swelling synthetic mica was used in preparing extremely thin platelets of synthetic mica and in forming flexible sheets therefrom.[67]

Techniques similar to those used in molding plastics were adopted for fabricating close-tolerance insulators from glass-bonded mica.[68]

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[54] Moore, R. E. Method of Making Synthetic Mica. U.S. Pat. 3,011,868, Dec. 5, 1961.
[55] Beaver, W. W. Process of Producing Synthetic Mica. U.S. Pat. 2,987,777, June 13, 1961.
[56] Evans, E. J. Process of Containing and Fixing Fission Products. U.S. Pat. 3,000,072, Sept. 19, 1961.
[57] Mukhortov, V. (Synthetic Mica Substitutes (U.S.S.R.).) Ekonomicheskaya Gazeta, June 2, 1961, p. 4.
[58] Materials in Design Engineering. New Developments in Electrical Insulation Materials. V. 53, March 1961, pp. 107–110.
[59] Badger, R. A. Flake Mica Separating and Film Forming Machine. U.S. Pat. 2,989,-111, June 20, 1961.
[60] Holmes, R. J. (assigned to General Aniline & Film Corp.). Inorganic Papers and Methods of Making Same. U.S. Pat. 3,005.745, Oct. 24, 1961.
[61] Thompson, J. S. (assigned to Oxalloy Co.). Solution and Method for Treating Mica Products and Articles Produced Therefrom. U.S. Pat. 2,979,108, Apr. 11, 1961.
[62] Technical Survey. Electrical, Electronic Developments. V. 17, Mar. 25, 1961, p. 204.
[63] Electronic News. Set Thin Wall Rigid Mica Paper Tubing. V. 6, July 24, 1961, p. 33.
[64] McCarthy, J. P., and R. Greer, Jr (assigned to Synthetic Mica Corp.). Method of Manufacturing Inorganically Bonded Micaceous Sheet. U.S. Pat. 2.996,106, Aug. 15, 1961.
[65] McNeill, W., J. E. Chrostowski, and T. J. Mackus. The Electrophoretic Deposition and Recrystallization of Syntheic Fluorphlogopite Mica. J. Electrochem. Soc., v. 108, August 1961, pp. 763–767.
[66] Hatch, R. A., and H. R. Shell (assigned to the U.S. Department of the Interior). Recrystallizing a Reconstituted Fluorine-Mica Sheet. U.S. Pat. 3,008,802, Nov. 14, 1961.
[67] Hatch, R. A. (assigned to Minnesota Mining and Manufacturing Co.). Synthetic Mica Flakes and Structures. U.S. Pat. 3,001,571, Sept. 26, 1961.
[68] Ceramic Age. Transfer and Compression Molding of Glass-Bonded Mica. V. 77, March 1961, pp. 28–31.

A method of producing glass-bonded mica with a firmly bonded metal surface was announced.[69] A glass-bonded synthetic mica suitable for high-service temperatures, complex configurations, and applications requiring high reliability was described and compared with earlier types of glass-bonded mica.[70] A ceramic embedding compound with good mechanical and electrical properties consisted of synthetic mica bonded with a silicic acid gel. After curing at 325° F, the material was usable from minus 70° to plus 2,000° F.[71]

[69] Electronic News. Glass-Bond Mica Plating Technique. V. 6, Oct. 9, 1961, p. 69.
[70] Materials in Design Engineering. Moldable Ceramoplastic 1,200° F is Vacuum-Tight. V. 53, March 1961, pp. 14–15.
[71] Fabian, R. J. Electrical Insulations for 930° F Plus. Materials in Design Eng., v. 54, October 1961, pp. 100–107.

Molybdenum

By Horace T. Reno [1] and Mary J. Burke [2]

DOMESTIC exports of molybdenum ore and concentrate totaled over 35 million pounds of contained molybdenum in 1961, exceeding the record established in 1960 by 18 percent However, domestic production of molybdenum was slightly less than in 1960.

The Federal Bureau of Mines expanded its molybdenum research program and sucessfully completed a project to produce molybdenum by reducing the oxide with magnesium.

The prices quoted for molybdenite concentrate and primary products increased for the first time since 1958.

TABLE 1.—Salient molybdenum statistics

(Thousand pounds of contained molybdenum and thousand dollars)

	1952–56 (average)	1957	1958	1959	1960	1961
United States:						
Concentrate:						
Production	55,683	60,753	41,069	50,956	68,237	66,563
Shipments	56,479	57,143	42,328	51,603	69,941	66,753
Value [1]	$57,619	$67,605	$50,371	$64,655	$87,406	$87,925
Consumption	34,014	38,954	31,298	37,448	44,784	42,261
Imports for consumption	68	27	1			
Stocks, Dec. 31: Mine and plant	5,830	7,093	5,643	4,074	3,481	2,815
Primary products:						
Production	33,195	37,698	30,915	36,294	43,427	41,050
Shipments	33,908	36,865	31,359	41,658	45,777	47,106
Consumption	[2] 33,497	30,016	24,231	32,350	31,837	32,621
Stocks, Dec. 31: Producer	3,333	5,789	8,081	5,958	8,157	5,074
World: Production	67,200	76,200	57,700	70,300	89,500	87,900

[1] Largely estimated by Bureau of Mines.
[2] 1956 only.

DOMESTIC PRODUCTION

Domestic production of molybdenum in concentrate decreased slightly from the record high established in 1960. Molybdenite concentrate was produced at the Climax Molybdenum Co. Climax mine in Colorado and was recovered as a byproduct from copper mining in Arizona, Nevada, New Mexico, and Utah. Molybdenum oxide was recovered from tungsten ores in California. Mine shipments of contained molybdenum were 5 percent less than the record established in 1960.

[1] Assistant chief, Branch of Ferrous Metals.
[2] Statistical assistant.

Molybdenum Mines.—According to the annual report to stockholders, the Climax mine operated 24 hours per day 7 days per week throughout the year. The mine produced 12,274,000 tons of ore, an average of 34,000 tons per day, setting a new record. However, Climax mined lower grade ore and, consequently, recovered about 1.5 million pounds less molybdenum in 1961 than in 1960. The company announced that it was undertaking a $20 million expansion program to increase output.[3] Development work on the Ceresco Ridge ore body was continued to the point where full-scale preparation for production was justified. The ore there is to be mined by a system of loading and haulage drifts on the same elevation as the Phillipson level, but from a separate adit. Present plans are to produce 5,000 tons a day from this area beginning in 1965.

In its 1961 annual report Climax conservatively estimated its total reserves at 462 million tons, including 19 million tons in the Ceresco Ridge deposit.

The Molybdenum Corporation of America, in a progress report to the stockholders on October 26, 1961, stated that since June 30, 1960, it had drilled 16,000 feet in 29 diamond drill holes and had completed 5,500 feet of tunneling at the Questa property in New Mexico. Thirteen of the drill holes and about 30 percent of the tunnels were in an enriched zone in the northeast ore body. The company also acquired additional contiguous property by location to expand its land holdings in the area to approximately 10 by 2 miles.

Byproduct Sources.—Molybdenum obtained as a byproduct was 28 percent of the total quantity produced in the United States in 1961. As in 1960, most of the byproduct producers shipped molybdenite concentrate rather than converting it to the oxide before shipment.

CONSUMPTION AND USES

Domestic consumption of molybdenum contained in concentrate was 6 percent less than in 1960 but was again at a comparatively high rate, owing mainly to shipments of molybdic oxide for export. By far the largest part of the concentrate was converted to molybdic oxide. This oxide which was used either for direct addition to steel or to produce virtually all other primary molybdenum products.

End-use molybdenum consumption was essentially the same as in 1960 except for a 28-percent increase of molybdenum in stainless steel and a 37-percent decrease of molybdenum powder to make wire, rod, sheet, and other shapes. The increased use in stainless steel may have been more apparent than real, inasmuch as concerns reporting end-use consumption statistics to the Bureau of Mines classified a large part of the molybdenum used in steel as used in "other alloys." The "other alloy" classification could have included, in 1960, a substantial quantity of alloys of the stainless steel type, which in 1961 were classified properly in the stainless category. Nevertheless, the use of molybdenum in engineering steel and steel alloys did increase in 1961 compared with 1960, apparently because of wider applications, emphasizing the newly developed alloys.

[3] Mining Record. Climax Molybdenum Launches $20 Million Expansion Program in Colorado Rockies. V. 72, No. 9, Mar. 2, 1961, p. 3.

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	
	1960	1961	1960	1961	1960	1961
Received from other producers	4,436	2,750	31	34	24	177
Gross production during year	40,337	38,382	2,692	1,751	2,216	1,085
Used to make other products listed here	9,457	6,578	90	187	2,044	841
Net production	30,880	31,804	2,602	1,564	172	244
Shipments:						
Domestic consumers	27,406	27,151	2,465	1,585	247	370
Export	6,586	8,314				2
Total	33,992	35,465	2,465	1,585	247	372
Producer stocks, Dec. 31	3,660	2,746	456	469	129	179

	Product—Continued					
	Sodium molybdate		Other [2]		Total	
	1960	1961	1960	1961	1960	1961
Received from other producers	45	12	3	5	4,539	2,978
Gross production during year	476	446	9,304	6,994	55,025	48,658
Used to make other products listed here		2	7		11,598	7,608
Net production	476	444	9,297	6,994	43,427	41,050
Shipments:						
Domestic consumers	492	453	8,151	8,800	38,761	38,359
Export	2	1	428	430	7,016	8,747
Total	494	454	8,579	9,230	45,777	47,106
Producer stocks, Dec. 31	114	115	3,798	1,565	8,157	5,074

[1] Includes molybdic oxide briquets, molybdic acid, and molybdenum trioxide.
[2] Includes ferromolybdenum, calcium molybdate, phosphomolybdic acid, molybdenum disulfide, and pellets.

The decline in end-use consumption of molybdenum powder, on which the reported statistics are considered reliable within 5 percentage points, indicates less use of molybdenum as a refractory in aerospace equipment designed to operate in an oxidizing environment at temperatures above 2,500° F., compared with the other refractory metals.

Among the newly developed molybdenum-bearing alloys, type 433 corrision-resistant stainless steel (molybdenum and copper additions to standard type 430 stainless) developed by Allegheny Ludlum Steel Corp.[4] and rhenium-molybdenum alloys, produced commercially by Chase Brass & Copper Co., Inc., received the most publicity. Type 433 stainless was developed for use in the automotive and appliance industries. The rhenium-molybdenum alloys were developed for use in electronic and electrical equipment and in space satellites and guided missiles. They will partly replace pure rhenium in many components.

[4] American Metal Market. New Ludlum Stainless, Moly, Copper Among Ingredients. V. 68, No. 37, Feb. 24, 1961, p. 4.

TABLE 3.—Consumption of molybdenum products by end uses in 1961

(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	1,160	553				27	1,740
Hot-work tool	241	83				2	326
Other tool	176	88				2	266
Stainless	2,755	2,020				19	4,794
Other alloy [4]	14,804	1,547				57	16,408
Steel mill rolls	856	97					953
Gray and malleable castings	334	2,233	1			10	2,578
Welding rods		245					245
High-temperature alloys	372	203	5			818	1,398
Molybdenum powder:							
Wire, rod and sheet			858			1	859
Other			617				617
Chemicals:							
Inorganic pigments	446			7	13		466
Organic pigments	153			4	201	7	365
Catalysts	330			38	2		370
Miscellaneous [5]	68	547	19	20	3	579	1,236
Total	21,695	7,616	1,500	69	219	1,522	32,621
Stocks at consumer plants Dec. 31	2,770	1,089	54	12	27	282	4,234

[1] Includes technical and purified oxides.
[2] Includes molybdenum silicide and calcium molybdate.
[3] Includes thermite molybdenum and molybdenum pellets, purified molybdenum disulfide, and molybdenite concentrate.
[4] Includes quantities 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.

Research scientists determined that the rust inhibitor characteristics of calcium and zinc molybdates equal or exceed those of red lead, zinc chromate, and similar materials.[5] Sodium molybdate was used as a corrosion inhibitor in antifreeze solutions in industrial and automotive applications. Molybdenum disulfide gained further acceptance as a lubricant, as research on bonded and cured dry-film processes developed bonded, dry-film, molybdenum disulfide lubricants that could be used up to 900° F. Engineers also developed molybdenum disulfide-filled thrust washers and retainer rings for self-lubricating bearings suitable for service at high temperatures.[6]

It was demonstrated experimentally that a composite of molybdenum fiber skeleton impregnated with silver could be used to form a seal that would retain hot-air pulsating pressures from 0 to 5,000 psi at 1,200° F.[7]

Scientists of Electron Technology, Inc., described a glass-to-metal seal of "chromallized" molybdenum, which they had found to be well suited for use in vacuum tubes.[8]

[5] Foundry. Rust Preventives. V. 89, No. 7, July 1961, p. 104.
[6] Iron Age. Maintenance Costs Tumble. V. 187, No. 9, Mar. 2, 1961, p. 15.
Materials in Design Engineering. TFE Retainer Rings Make 575 F Bearing Self-Lubricating. V. 53, No. 5, May 1961, p. 137.
[7] Chemical Engineering. Material Resists Elevated Temperature Cycling, Without Leakage. V. 68, No. 8, Apr. 17, 1961, pp. 142, 144.
[8] Koch, S. J. Glass-To-Metal Seals Take Hold. Iron Age, V. 188, No. 9, Aug. 31, 1961, pp. 88–89.

STOCKS

The national (strategic) stockpile contained 84,305,000 pounds of molybdenum on December 31, 1961, 16,954,000 pounds of which had been upgraded from the sulfide to molybdic oxide. The industrial inventory of molybdenum in concentrate and compounds totaled 12,123,000 pounds, 22 percent less than at yearend 1960. Stocks at mines decreased 19 percent, and stocks at producer plants decreased 38 percent, but those at consumer plants increased 6 percent compared with 1960.

PRICES

E&MJ Metal and Mineral Markets quoted prices per pound of contained molybdenum, f.o.b. point of shipment, for molybdenite concentrate and primary products were as follows: Concentrate, 95 percent MoS_2, $1.25; molybdic trioxide (MoO_3), in bags $1.46, and in cans $1.47, unchanged from 1960 to June 1, 1961. From June 1, 1961, to yearend, the quoted prices were: concentrate, 95 percent MoS_2, $1.40; molybdic trioxide 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 $3.55, unchanged during the year; and ferromolybdenum per pound of contained molybdenum, 5,000 pounds or more, f.o.b. New York (58 to 64 percent Mo), powdered; packed $1.82, other sizes packed $1.76 to June 1, and then $1.95 and $1.89, respectively, to the end of the year.

FOREIGN TRADE [9]

Imports.—There were no imports of molybdenum ore and concentrate for consumption in the United States. Imports of molybdenum products for consumption included ferromolybdenum, molydenum metal and powder, calcium molybdate, and other compounds and alloys of molybdenum containing 10,906 pounds of molybdenum valued at $36,514; molybdenum ingots, shot, bars, or scrap molybdenum or molybdenum carbide with a gross weight of 2,636 pounds valued at $1,120; and molybdenum sheets, wire, and other forms of molybdenum not elsewhere provided for, with a gross weight of 18,376 pounds, valued at $199,241.

Exports.—U.S. exports of molybdenum ore and concentrate reached a new peak, 18 percent more than in the preceding year. West Germany again was the principal recipient, receiving 23 percent of the total, a 12-percent increase compared with 1960. The United Kingdom received 22 percent of the total, 16 percent more than in 1960; exports to the Netherlands almost doubled, and exports to Canada increased 77 percent.

Among the countries of the European Iron and Steel Community, Italy was the only one that received less molybdenum from the United States in 1961 than in 1960; exports to that country were down 16 percent. Apparently the increase in exports of molybdenum again

[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.

was due principally to expanded use of molybdenum in the ferroalloy industry in Western Europe and in Japan. The exports to Canada may have been only for processing or possibly for reexport to other countries.

Ferromolybdenum valued at $501,476 was exported to 16 countries; molybdenum wire exports were valued at $375,821; and exports of molybdenum powder were valued at $39,788. Other molybdenum products exported included molybdenum metal and alloys in crude form and scrap valued at $433,136 and molybdenum and molybdenum alloys in semifabricated forms valued at $134,972.

TABLE 4.—Molybdenum reported by producers as shipments for export from the United States

(Thousand pounds of contained molybdenum)

Product	1960	1961
Molybdenite concentrate	23,341	24,165
Molybdic oxide	6,586	8,314
All other primary products	430	433

TABLE 5.—U.S. exports of molybdenum products

(Pounds, gross weight)

Product	1960	1961
Ferromolybdenum [1]	424,819	358,523
Metal and alloys in crude form and scrap	295,004	440,849
Wire	9,639	12,488
Powder	9,620	11,816
Semifabricated forms (mainly rods, sheets, and tubes)	4,940	7,362

[1] Ferromolybdenum contains about 60–65 percent molybdenum.

Source: Bureau of the Census.

Tariff.—There were no changes in the import duties on molybdenum ores and concentrates 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 molybdenum ores and concentrates, 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	1960		1961	
	Molybdenum content (pounds)	Value	Molybdenum content (pounds)	Value
North America:				
Canada	915,473	$909,978	1,617,911	$1,763,866
Mexico	3,268	3,638	5,404	7,726
Total	918,741	913,616	1,623,315	1,771,592
South America:				
Argentina	400	698	274	388
Brazil	1,986	2,512	1,651	2,526
Chile	3,000	4,410	14,448	20,704
Total	5,386	7,620	16,373	23,618
Europe:				
Austria	1,985,863	2,961,352	1,577,872	2,458,195
Belgium-Luxembourg	29,200	45,163	357	438
France	4,907,280	6,291,624	6,408,257	8,679,994
Germany, West	7,205,098	9,169,392	8,073,153	10,633,828
Italy	1,729,162	2,223,635	1,442,231	1,942,176
Netherlands	296,373	446,539	590,937	816,990
Spain			3,588	5,387
Sweden	1,785,497	2,244,095	2,290,865	2,963,614
United Kingdom	6,630,386	8,476,785	7,683,030	10,365,238
Total	24,568,859	31,858,585	28,070,290	37,865,860
Asia:				
Hong Kong			490	780
Japan	4,716,978	7,020,365	5,922,628	9,057,572
Philippines	3,600	5,524	3,022	3,965
Total	4,720,578	7,025,889	5,926,140	9,062,317
Africa: Union of South Africa			879	1,268
Australia: Oceania	30,932	41,681	24,004	33,802
Grand total	30,244,496	39,847,391	35,661,001	48,758,457

Source: Bureau of the Census.

WORLD REVIEW

No official statistics were available on molybdenum production in the U.S.S.R. and other Communist-bloc nations, but estimates for those countries are included in the world total. Free-world production was 2.4 million pounds less than in 1960, owing principally to less output in the United States and Chile.

TABLE 7.—World production of molybdenum in ores and concentrates by countries [1] [2]

(Thousand pounds)

Country [1]	1952–56 (average)	1957	1958	1959	1960	1961
Australia	(3)	2	4	(3)		
Austria	11					
Canada	525	785	888	747	767	765
Chile	3,047	2,998	2,972	3,785	4,440	3,699
China [4]	(5)	(5)	2,200	3,300	3,300	3,300
Japan	401	600	692	842	840	827
Korea, Republic of	22	31	68	49	97	71
Mexico	49	29	57	57	132	[4] 7
Norway	335	397	483	498	542	[4] 550
Peru	4		2			
Philippines				123	150	[4] 220
Portugal	[6] 8	18				
Union of South Africa		13	9			
U.S.S.R. [4]	(5)	9,300	9,300	9,900	11,000	11,900
United States	55,683	60,753	41,069	50,956	68,237	66,563
Yugoslavia	13	4	4	[4] 4		
World total (estimate) [1]	67,200	76,200	57,700	70,300	89,500	87,900

[1] Molybdenum is also produced in North Korea, Rumania, and Spain, but production is negligible.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Less than 500 pounds.
[4] Estimate.
[5] Data not available; estimate by author of chapter included in total.
[6] Average annual production 1953–56.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

NORTH AMERICA

Canada: *British Columbia.*—Reportedly the first commercial shipment of molybdenite was made from British Columbia when 10,000 pounds of 90-percent molybdenite concentrate valued at $9,500 was sent to Sweden from the Keremeos Mines, Ltd., copper-molybdenum property at Olla.[10] Friday Mines, Ltd., acquired a purchase option on the Keremeos property and on four adjoining Crown-granted claims of Hedley Monarch Mines, Ltd., and diamond-drilled to investigate the continuity of the mineralization. The mineralization on the Keremeos property was in a well-defined vein.[11] Noranda Exploration, Ltd., a wholly owned subsidiary of Noranda Mines, Ltd., explored the Boss Mountain molybdenum property, 50 miles east of Williams Lake, with diamond drillholes from the surface. The Noranda surface exploration, with that done previously on the property by American Metal Climax, Inc., indicated the presence of a million tons of material, containing 0.95 percent molybdenum to a depth of 500 feet. The company undertook underground exploration to confirm this estimate.[12]

New Brunswick.—Molybdenite associated with tin and tungsten minerals was reported to occur in steeply dipping lenses within a silicified area on Mount Pleasant, 37 miles south of Fredericton.[13]

[10] Mining Journal (London). V. 256, No. 6549, Feb. 24, 1961, p. 221.
[11] Canadian Mining and Metallurgical Bulletin. V. 54, No. 587, March 1961, p. 287.
[12] Northern Miner (Toronto). Noranda to Open Molybdenite Zone. V. 47, No. 34, Nov. 16, 1961, p. 9.
[13] Black, P. T. Tin, Tungsten, Molybdenum Mineralization, Mount Pleasant Area, New Brunswick. Canadian Min. J. V. 82, No. 4, Apr. 1961, pp. 94–96.

Quebec.—The Molybdenite Corporation of Canada, Ltd., was again the only molybdenum producer in Canada, other than copper producers who recovered byproduct molybdenite. The corporation altered the milling plant at its La Corne mine and installed sufficient equipment to increase its capacity to 1,000 tons per day.[14] Preissac Molybdenite Mines, Ltd., owned 48 percent by Molybdenite Corporation of Canada, Ltd., completed a three-compartment vertical shaft to the 615-foot level at its property in Preissac Township in northwestern Quebec and started exploring on the 450- and 575-foot levels. Three vein structures ranging from 3 to 14 feet in width were intersected on both levels.[15] Anglo American Molybdenite Mining Corp. also completed a vertical exploration shaft in Preissac Township at its molybdenum-bismuth property about 15 miles north of the town of Cadillac.[16] The corporation continued exploration underground, crosscutting from the 150-foot level and diamond drilling from the shaft station on the 300-foot level.

Gaspe Copper Mines, Ltd., began constructing a pilot plant for treating copper concentrate to determine if molybdenum could be recovered as a byproduct from its copper deposit on Gaspe Peninsula in eastern Quebec.[17]

SOUTH AMERICA

Chile.—Molybdenum production in Chile was virtually suspended from August 10 to September 11 when a strike at the Andes Copper Mining Co. El Salvador mine resulted in sympathy strikes at the Chile Exploration Co. Chuquicamata mine, and the Braden Copper Co. El Teniente mine. The molybdenum recovery plant at Chuquicamata was shut down in April and May. Nevertheless, the 1961 total output was 16 percent more than in 1960. Braden Copper Co. was again by far the largest molybdenum producer in 1961. However, not all the molybdenum produced in Chile was a byproduct of copper mining because Compania Minera Indiana, a Chilean firm, opened a small molybdenum mine near La Calera in 1960. Minera Indiana's first sale was made in the last quarter of 1960 when molybdenum-bearing concentrate valued at $4,800 was shipped to France.[18]

Chile exported 3,496 short tons of molybdenum concentrate containing an estimated 2,300 tons of molybdenum in 1961. Approximately 40 percent was destined for West Germany, 31 percent for the United Kingdom, 15 percent for the Netherlands, 9 percent for Sweden, and the remaining 5 percent for France.

An export tax on molybdenum concentrate equivalent to 50 percent of the annual average price at London and New York Metals Exchanges was proposed to the Congress of Chile by a Conservative member.[19] Inasmuch as molybdenum concentrate is not refined in

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[14] Northern Miner (Toronto). Molybdenite Corp., Expanding to Meet Increased Demand. V. 47, No. 16, July 13, 1961, sec. 1, pp. 1 (625), 9 (633).
[15] Northern Miner (Toronto). Production Decision by This Fall Is Aim of Preissac Molybdenite. V. 47, No. 15, July 6, 1961, sec. 1. pp. 1 (605), 11 (615).
[16] Northern Miner (Toronto). Complete Shaft, Talk Major Funds for Anglo American Molybdenite. V. 47, No. 14, June 29, 1961, sec. 1, pp. 1 (585), 2 (586).
[17] Canadian Mining Journal (Gardenvale, Quebec). Gaspe Copper Builds Molybdenum Pilot Plant. V. 82, No. 10, Oct. 1961, p. 124.
[18] U.S. Embassy, Santiago, Chile. State Department Dispatch 724. May 3, 1961, p. 11.
[19] U.S. Embassy, Santiago, Chile. State Department Dispatch 292. Nov. 17, 1961, p. 1.

Chile, the tax apparently was proposed as a means of forcing the larger copper companies to install molybdenum sulfide processing equipment at their plants.

ASIA

China.—A review of the molybdenum resources of China indicated that development of newly discovered deposits could exert a strong influence on world molybdenum markets, although China's output in recent years was estimated at only 1,000 to 2,000 tons of concentrate annually. A large part of the output was sent to the U.S.S.R., East Germany, and Poland.[20] The significant new molybdenum resources are in three large deposits in the middle and eastern sections of Ch'in Ling, between Lan-T'ien (approx. 34°10′ N., 109°15′ E.) in Shensi and I-yand (approx. 34°10′ N., 112°30′ E.) in Honan.

TECHNOLOGY

The Federal Bureau of Mines expanded its molybdenum research program, principally on projects designed to produce and evaluate high-purity metal. A project to produce molybdenum by reducing molybdenum oxides with magnesium was completed successfully.

In other projects, attempts to reduce molybdenum chloride with magnesium and with hydrogen and molybdenum oxides with hydrogen were not promising. A report describing preliminary studies on electrowinning molybdenum was published.[21] In these studies a tertiary system electrolyte containing sodium pyrophosphate, sodium tetraborate, and sodium chloride gave excellent results. Continuing the work, however, it was found that sodium tetraborate and a eutectic mixture of sodium chloride and sodium flouride was even better, but the optimum composition was not established for publication in 1961. Bureau researchers in similar studies determined that direct reduction of molybdenum sulfide by fused-salt electrolysis is impractical. They continued investigating the radical $(MoCl_6)^{-3}$ in molten alkali chlorides as an electrolyte for producing pure molybdenum.

Bureau metallurgists stopped an investigation of processes for recovering byproduct molybdenum from uranium plant solutions after finding it to be technically feasible to recover the molybdenum, but unattractive economically.

An X-ray fluorescence method of analyzing tungsten and molybdenum metals and electrolytes, developed to service research studies on selective deposition of the metals from a fused-salt bath, was described by Bureau of Mines chemists.[22]

A Canadian metallurgist described a process for obtaining high-purity molybdenite concentrate (99.8 percent MoS_2) suitable for use as a lubricant from technical grade MoS_2 concentrate.[23] In this proc-

[20] Bureau of Mines. Mineral Trades Notes. V. 52, No. 4, Apr. 1961, pp. 33–35.
[21] Heinen, H. J., and J. B. Zadra. Electrowinning Molybdenum: Preliminary Studies. BuMines Rept. of Inv. 5795, 1961, 8 pp.
[22] Stever, K. R., J. L. Johnson, and H. H. Heady. X-Ray Flourescence Analysis of Tungsten-Molybdenum Metals and Electrolytes. Advances in X-Ray Analysis, V. 4, 1961. pp. 474–487.
[23] Borbash, E. Production of Pure Molybdenum Disulphide. Canadian Min. J., Aug. 1961. V. 82, No. 8, pp. 66–69.

ess the high-purity molybdenite was obtained by regrinding, then refloating the technical-grade concentrate and leaching the product with hydrochloric acid, volatilizing the contained silica with hydrofluoric acid, and washing the residue. It was reported that molybdenite recovery was 6 percent more than that achieved with a conventional, screening-milling screening method and that the greater processing cost could be offset through increased value of the better quality product.

On the basis of cost estimates made from laboratory indices and the cost data for producing natural molybdenite at the Skopin (U.S.S.R.) plant, Soviet metalurgists reported that artificial molybdenite can be produced for approximately half the cost of the natural mineral.[24] They obtained the artificial mineral by reacting molybdenum trioxide and calcium molybdate with sulfur in a salt melt. Their work demonstrated for the first time the existence of allotropic modifications of molybdenum disulfide. The artificial crystal lattice parameter, *a*, equaled the corresponding parameter of natural molybdenite, but the *c* parameter was one and a half times greater. Laboratory tests showed the lubricating properties of the artificial molybdenite differed little from those of the natural crystal.

Research and development of a process to obtain molybdenum by direct thermal dissocation of molybdenite, which extended over approximately 7 years, was described by metallurgists working in the Climax Molybdenum Co. Michigan Research Laboratory.[25] Molybdenum powder in up to 100-pound batches was obtained in the dissociation process in vacuo at 1,600° to 1,700° C. (2,910° to 3,090° F.). The powder was lower in oxygen than commercially available molybdenum powder, and analyses of ingots arc-cast from the two powders indicated that the degree of impurity was similar.

Molybdenum alloy and process technology changes since 1956 were reviewed.[26] The review showed large gains in technology and indicated that the alloy development was far ahead of processing.

Among the newly devolped molybdenum alloys, rhenium-molybdenum and technetium-molybdenum received the most attention in 1961. Rhenium-molybdenum alloys were made commercially for use in coils in compact electromagnets having high field strengths. According to a report given by Bell Laboratory scientists, technetium-molybdenum becomes superconductive and remains ductile at less coldness than any other known material.[27]

A method of coating molybdenum and other refractory metals in a dynamic fluidized bed of powdered silica [28] was developed by scientists at the Aerospace Division of the Boeing Co.[29] They reported that this method retained all the advantages of the "pack cementation" method, that special tooling and retorts are not used, that processing time is

[24] Zelikman, A. N., and O. E. Krein. Preparation of Molybdenum Disulfide Suitable for Use as a Lubricant. J. Applied Chem. of the USSR. V. 23, No. 1, Jan. 1960, pp. 46–51.
[25] Scholz, W. G., D. V. Doane, and G. A. Timmons. Molybdenum by Direct Thermal Dissociation of Molybdenum Disulfide, AIME, Trans. V. 221, No. 2, Apr. 1961, pp. 356–364.
[26] Nelson, R. C. Molybdenum Alloy and Process Technology. J. Metals. V. 13, No. 3, Mar. 1961, pp. 223–225.
[27] American Metal Market. Superconductive Ductile Alloy Found. V. 68, No. 81, Apr. 28, 1961, pp. 1, 14.
[28] Missiles and Rockets. Refractory Coating by Fluidized Bed. V. 9, No. 17, Oct. 23, 1961, p. 28.
[29] Changed May 2, 1961, from Boeing Airplane Co.

shorter, and that the tendency for the parts being coated to warp is reduced. The "pack cementation" method of coating refractory metals was the most widely used, but other techniques investigated showed genuine merit for producing coating systems.[30] Scientists at the National Research Corp., described a method of coating molybdenum with an aluminum silicon alloy having a melting point above 3,600° F.[31] They reported that with this process the coat can be applied by semiskilled labor using standard metallurgical procedures. The size of the body to be coated presented no limits, and the coating could be applied with facility to all surfaces and shapes. Furthermore, they reported that the aluminum-silicon alloy would deform sufficiently to permit hot-working of the base without destroying the integrity of the cover.

[30] Krier, C. A. Coatings for the Protection of Refractory Metals From Oxidation. Defense Metals Information Center, Battelle Memorial Institute, DMIC Report 162, Nov. 24, 1961, 226 pp.

[31] Clough, P. J., and P. L. Raymond. Oxidation Resistant Coatings for Molybdenum and Other Refractory Bodies. Am. Ceram. Soc. Bull. V. 40, No. 5, May 15, 1961, pp. 314–315.

Nickel

By Joseph H. Bilbrey, Jr.,[1] and Ethel R. Long[2]

THE DOMESTIC price of nickel, which was raised 7¼ cents to 81¼ cents per pound in June 1961, had remained unchanged for 4½ years.

The United States used 118,500 tons of nickel in 1961, 10 percent more than in 1960, and approximately 45 percent of the free world consumption.

Hanna Mining Co. acquired from the U.S. Government the ferronickel plant operated by its subsidiary, Hanna Nickel Smelting Co., at Riddle, Oreg. The output of this plant equaled 9 percent of domestic consumption. Except for a small quantity of nickel produced as a byproduct of copper refining, Hanna was the only domestic nickel producer at yearend. National Lead Co. closed its mining and refining facilities at Fredericktown, Mo., in May.

The seizure of U.S. nickel plants in Cuba in 1960 resulted in the loss of about 16 percent of nickel imports; this deficit was made up by increased imports from Canada.

The International Nickel Company of Canada, Ltd., began producing nickel at its new facility at Thompson, Manitoba, and exceeded its production goal of 37,500 tons a year from this plant. As in 1960, industry increased its research and development in exploration, mining, processing, use, and marketing of nickel.

TABLE 1.—Salient nickel statistics

(Short tons)

	1952-56 (average)	1957	1958	1959	1960	1961
United States:						
Mine production	[1] 3,455	12,900	13,490	13,374	14,079	13,133
Plant production:						
Primary [2]	2,517	10,070	11,740	11,606	14,303	11,176
Secondary	10,167	12,037	7,411	9,438	9,431	10,688
Imports for consumption	129,000	140,000	90,000	112,000	103,000	127,000
Exports	20,296	13,415	14,032	13,073	54,109	55,493
Consumption	107,898	122,466	79,017	112,661	108,159	118,515
Stocks Dec. 31: Consumer [3]	10,061	25,282	13,339	14,125	11,369	18,298
Price, cents per pound	64½-74	74	74	74	74	74-81¼
World: Production	242,000	315,000	247,000	314,000	[4] 359,000	396,000

[1] Average annual production 1953-56.
[2] Comprises metal from domestic ore and nickel recovered as a byproduct of copper refining.
[3] Does not include scrap.
[4] Revised figure.

[1] Commodity specialist, assisted technically by Isaac E. Weber, Division of Minerals.
[2] Statistical clerk, Division of Minerals.

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DOMESTIC PRODUCTION

Primary Nickel.—Domestic mine output of nickel contained in ore was 13,133 short tons, 7 percent less than in 1960. In June, Hanna Mining Co. acquired from the U.S. Government the ferronickel plant operated by its subsidiary, Hanna Nickel Smelting Co., at Riddle, Oreg. Hanna processed 830,775 dry short tons of ore, averaging 1.46 percent nickel, from its Riddle deposit, to produce 20,241 tons of ferronickel containing 10,325 tons of nickel. Output of nickel was 7 percent less than in 1960, but the average nickel content of the ferronickel increased from 46 to 51 percent. A substantial part of the production was sold to industry for use in the manufacture of stainless steel and other alloy steels, and some was sold to the U.S. Government.

National Lead Co. closed its mining and refining facilities at Fredericktown, Mo., in May, and the plant and equipment were to be liquidated. The refinery of Freeport Nickel Co. at Port Nickel, La., did not operate because suitable concentrate was not available.

Refineries at Carteret and Perth Amboy, N.J., Laurel Hill, N.Y., and Tacoma, Wash., recovered 625 tons of nickel in the form of nickel sulfate as a byproduct of copper refining. Shipments from refiners contained 641 tons of nickel. Refined nickel salts (mainly sulfate), containing 2,518 tons of nickel, were produced in the United States. Total refined salts production was 3,143 tons (nickel content), and shipments of salts to consumers contained 3,210 tons of nickel.

A new metallurgical research center was to be built by International Nickel Co., Inc., on a 150-acre site in Sterling Forest, Orange County, N.Y. Long-term fundamental research to develop new and improved nickel alloys was planned.[3]

TABLE 2.—Nickel produced in the United States

(Short tons, nickel content)

	1952–56 (average)	1957	1958	1959	1960	1961
Primary:						
Byproduct of copper refining	587	502	502	493	623	625
Domestic ore	[1] 2,415	9,568	11,238	11,113	[2] 11,907	10,551
Secondary	10,167	12,037	7,411	9,438	9,431	10,688

[1] Average annual production 1953–56.
[2] Revised figure. In addition, 1,773 tons of primary nickel was produced from imported Cuban concentrate.

Secondary Nickel.—Recovery of nickel from nonferrous scrap in the United States in 1961 was 10,700 short tons, an increase of 14 percent from the 9,400 tons recovered in 1960.

Recovery of nickel from ferrous nickel-base scrap is not included in the secondary nickel tables. Ferrous nickel-base alloys consist of those in which the metal of highest percentage is nickel, but which contain so much iron, chromium, cobalt, or other constituents of ferrous alloys that they must be classed as ferrous alloys, although they

[3] The International Nickel Company of Canada, Ltd., Ann. Rept. 1961, pp. 11–13.

are also nickel-base. Examples are inconel and nichrome. Both nonferrous and ferrous nickel-base alloys may be used as alloying ingredients in ferrous alloys, but ferrous nickel-base alloys cannot be used to make nonferrous alloys.

Consumption of nonferrous nickel-base scrap decreased 11 percent to 13,600 tons compared with 15,300 tons in 1960, due mainly to the use of less unalloyed nickel and nickel residues.

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	1960	1961	Form of recovery	1960	1961
New scrap:			As metal	1,274	1,210
Nickel-base	3,015	3,108	In nickel-base alloys	1,955	1,824
Copper-base	1,396	1,564	In copper-base alloys	2,458	2,640
Aluminum-base	342	510	In aluminum-base alloys	481	863
Total	4,753	5,182	In ferrous and high temperature alloys [1]	1,130	2,059
Old scrap:					
Nickel-base	4,151	4,734	In chemical compounds	2,133	2,092
Copper-base	402	433			
Aluminum-base	125	339	Grand total	9,431	10,688
Total	4,678	5,506			
Grand total	9,431	10,688			

[1] Includes only nonferrous nickel scrap added to ferrous and high-temperature alloys.

CONSUMPTION AND USES

The United States remained the world's largest user of nickel. Nickel consumption in 1961 was 118,515 short tons, 10 percent more than in 1960. The largest single use of nickel was in stainless steels, 29 percent of the total and 14 percent greater than in 1960. Other steels consumed 15 percent, and nonferrous alloys, 24 percent. These quantities were 19 and 8 percent higher, respectively, than in 1960. Nickel used in high-temperature and electrical-resistance alloys increased 12 percent. Nickel was used in about the same quantities for anodes, catalysts, ceramics, and magnets.

STOCKS

In addition to the consumer stocks reported in table 7, the total quantity of nickel in all Government stockpiles as of December 31, 1961, was given as 438,702,000 pounds. Of this amount, 115,702,000 pounds, 35.8 percent more than the maximum stockpile objective, was declared surplus. The total quantity included 334,538,000 pounds in the national (strategic) stockpile, and 104,164,000 pounds of nickel in Defense Production Act (DPA) inventory, 21.2 million pounds less than at the end of 1960. The DPA inventory was reduced by sales of electrolytic nickel and Nicaro nickel oxide and withdrawals under contract settlements; it was increased by receipts of ferronickel from Hanna Nickel Smelting Co. and electrolytic nickel from Falconbridge Nickel Mines Ltd.

TABLE 4.—Stocks and consumption of new and old nickel scrap in the United States in 1961

(Short tons, gross weight)

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	216	979	655	290	945	250
Monel metal	411	1,327	366	1,049	1,415	323
Nickel silver [1]	905	3,103	293	2,955	3,248	760
Miscellaneous nickel alloys	20	4,841	6	4,846	4,852	9
Nickel residues	63	141	5	146	151	53
Total	710	7,288	1,032	6,331	7,363	635
Foundries and plants of other manufacturers:						
Unalloyed nickel	501	2,755	1,375	1,615	2,990	266
Monel metal	126	602	118	519	637	91
Nickel silver [1]	2,620	7,535	7,309	22	7,331	2,824
Miscellaneous nickel alloys	40	370	-------	365	365	45
Nickel residues	590	2,152	1,833	402	2,235	507
Total	1,257	5,879	3,326	2,901	6,227	909
Grand total:						
Unalloyed nickel	717	3,734	2,030	1,905	3,935	516
Monel metal	537	1,929	484	1,568	2,052	414
Nickel silver [1]	3,525	10,638	7,602	2,977	10,579	3,584
Miscellaneous nickel alloys	60	5,211	6	5,211	5,217	54
Nickel residues	653	2,293	1,838	548	2,386	560
Total	1,967	13,167	4,358	9,232	13,590	1,544

[1] Excluded from totals because it is copper-base scrap, although containing considerable nickel.

TABLE 5.—Nickel (exclusive of scrap) consumed in the United States, by forms

(Short tons)

Form	1952–56 (average)	1957	1958	1959	1960	1961
Metal	79,156	94,765	61,768	87,751	87,399	101,394
Oxide powder and oxide sinter	18,238	17,049	13,007	20,710	19,392	15,883
Matte	9,008	9,047	3,309	2,899	17	16
Salts [1]	1,496	1,605	933	1,301	1,351	1,222
Total	107,898	122,466	79,017	112,661	108,159	118,515

[1] Figures do not cover all consumers.

PRICES

Effective June 30, the domestic price of electrolytic nickel was raised 7¼ cents to 81¼ cents (U.S.) per pound, duty included, f.o.b. Port Colborne, Ontario; nickel oxide sinter was increased to 77½ cents per pound, nickel content, packaged f.o.b. U.S. port of entry. The mounting cost of production was given as the reason for the first increase in prices in 4½ years. The General Services Administration announced similar prices for nickel products to be sold from the national stockpile. Nickel sulfate was quoted at 30 cents per pound, in bags, carlots, delivered.

TABLE 6.—Nickel (exclusive of scrap) consumed in the United States, by uses

(Short tons)

Use	1952–56 (average)	1957	1958	1959	1960	1961
Ferrous:						
Stainless steels	25,884	26,986	23,039	32,249	30,086	34,213
Other steels	17,393	15,882	14,510	18,342	15,331	18,238
Cast irons	4,644	5,534	3,851	4,857	4,605	4,649
Nonferrous [1]	32,758	33,449	18,048	25,606	26,567	28,789
High-temperature and electrical-resistance alloys	8,576	9,837	7,435	10,518	10,095	11,294
Electroplating:						
Anodes [2]	12,690	23,354	7,693	14,644	15,847	15,737
Solutions [3]	1,042	1,131	734	883	970	770
Catalysts	1,553	2,113	1,165	1,712	1,545	1,519
Ceramics	319	358	354	373	365	366
Magnets	778	902	636	1,028	778	773
Other	2,261	2,920	1,552	2,449	1,970	2,167
Total	107,898	122,466	79,017	112,661	108,159	118,515

[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	1952–56 (average)	1957	1958	1959	1960	1961
Metal	7,310	21,082	10,608	9,567	9,009	12,199
Oxide powder and oxide sinter	1,874	3,037	2,464	4,334	2,143	5,856
Matte	401	787	3	24	7	5
Salts	476	376	264	200	210	238
Total	10,061	25,282	13,339	14,125	11,369	18,298

FOREIGN TRADE [4]

Imports.—The United States imported 127,000 tons of nickel in metal, oxide, slurry, and scrap—23 percent more than 1960. Canada provided 89 percent of the imports, and Norway slightly less than 11 percent; the latter originated in Canada. Thus, increased Canadian imports made up for the cessation of imports of Cuban nickel, which formerly amounted to about 16 percent of total imports.

Exports.—Nickel-bearing materials exported in 1961, a total of 55,493 tons, consisted mainly of nickel and nickel-alloy metals in scrap. Shipments to West Germany were 28 percent of the total; to Japan, 22 percent; to Sweden, 21 percent; and to Canada and the United Kingdom, 8 percent each. Export controls on nickel scrap to certain destinations remained unchanged.

Tariff.—The duty of 1¼ cents a 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	1952–56 (average)	1957	1958	1959	1960	1961
Ore and matte	13,016	13,177	4,574	4,071	184	[1]
Metal (pigs, ingots, shot, cathodes, etc.)[2]	95 491	99,787	62,793	82,888	79,662	115,985
Oxide powder and oxide sinter	[3] 30,874	[3] 37,080	29,622	[4] 30,062	[4] 24,584	14,613
Slurry [5]	([6])	211	260	839	4,477	258
Refinery residues [7]	687		211			
Scrap [2]	680	410	271	619	135	278
Total: Gross weight	140,748	150,665	97,731	118,479	109,042	131,134
Nickel content (estimated)	129,000	140,000	90,000	112,000	103,000	127,000

[1] Less than 1 ton.
[2] Separation of metal from scrap on basis of unpublished tabulations.
[3] Figures for 1956 include, but for 1957 exclude, 1,524 tons received from Cuba in December 1956 but not included in figures of Bureau of the Census until 1957.
[4] Adjusted by Bureau of Mines.
[5] Nickel-containing material in powders, slurry, or any form, derived from ore by chemical, physical, or any other means, and requiring futher processing to recover nickel or other metals.
[6] Not provided for in import schedule before July 1, 1956.
[7] 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			
	1960	1961	1960		1961	
	Gross weight	Gross weight	Gross weight	Nickel content	Gross weight	Nickel content
North America:						
Canada	66,216	101,710	7,396	5,548	14,613	10,967
Cuba			[1] 17,188	[1] 15,390		
Total	66,216	101,710	[1] 24,584	[1] 20,938	14,613	10,967
Europe:						
France	3	([2])				
Germany, West	33	8				
Netherlands		4				
Norway	13,092	13,889				
Sweden		58				
United Kingdom	318	316				
Total	13,446	14,275				
Grand total	79,662	115,985	[1] 24,584	[1] 20,938	14,613	10,967

Country	Slurry and other [3]				Ore and matte			
	1960		1961		1960		1961	
	Gross weight	Nickel content	Gross weight	Nickel content	Gross weight	Nickel content	Gross weight	Nickel content
North America:								
Canada	1,246	324	258	66	184	139	([2])	([2])
Cuba	[1] 3,231	[1] 1,555						
Total	[1] 4,477	[1] 1,879	258	66	184	139	([2])	([2])

[1] Adjusted by Bureau of Mines.
[2] Less than 1 ton.
[3] 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	1959		1960		1961	
	Short tons	Value	Short tons	Value	Short tons	Value
Ore, concentrate, and matte	----------	----------	1	$4,326	1,766	$495,254
Nickel and nickel-alloy metals in ingots, bars, rods, sheets, plates, strips, and other crude forms	5,707	$9,678,331	9,835	16,839,376	7,152	13,702,988
Nickel and nickel-alloy metal scrap	6,111	2,289,042	42,633	[1] 10,289,345	44,479	11,265,674
Nickel and nickel-alloy semifabricated forms, not elsewhere classified	519	2,313,625	644	2,321,654	1,037	3,980,160
Nickel-chrome electric-resistance wire except insulated	139	597,559	235	969,261	254	1,079,325
Nickel catalysts	597	1,161,911	761	1,240,236	805	1,455,809
Total	13,073	16,040,468	54,109	[1] 31,664,198	55,493	31,979,210

[1] Revised figure.

Source: Bureau of the Census.

WORLD REVIEW

Estimated world production of nickel reached a new record of 396,000 tons, 10 percent higher than in 1960. The estimated free world output was 301,000 tons. Of this total, Canada produced 79 percent; New Caledonia, 16 percent; and the United States, 4 percent.

NORTH AMERICA

Canada.—Canada produced 236,555 tons of nickel, a new high and 10 percent more than in 1960. The International Nickel Company of Canada, Ltd., (Inco), delivered 186,230 tons of nickel in refinery, rolling-mill and foundry products, and salts and chemicals to consumers, an increase of 6 percent over 1960. Included in these deliveries was 24,120 tons of nickel which was sold at the same price at which it was acquired from the U.S. Government or its suppliers.

Ore production from the Sudbury district and the Thompson mine, Manitoba, amounted to 17,489,000 short tons, 4 percent more than in 1960. In 1961, Inco began operating the Clarabelle open-pit mine, north of Copper Cliff, and the smaller Ellen mine, in Denison Township, in order to replace tonnage from exhausted mines. Though seven mines were thus operating in the Sudbury district, no increase in production capacity resulted. All mining at the Frood-Stobie mine was under ground. The "undercut-and-fill" mining method, using hydraulic sandfill, was introduced into the Creighton and Levack mines to improve working conditions and to provide more efficient mining. The company's proven ore reserves on December 31, 1961, were 297,419,000 tons containing 8,937,300 tons of nickel-plus-copper.

The new plant for fluid-bed roasting of nickel sulfide at the Copper Cliff smelter, Ontario, became operative. The new nickel production facility at Thompson, Manitoba, was officially dedicated on March 25. A new research station, at Port Colborne, Ontario, for the study of new methods for the extraction of nickel from all types of ores was opened by Inco in 1961. Of the $7.4 million spent by Inco on exploration, more than one-half was expended in Manitoba, where an explora-

TABLE 11.—World production of nickel by countries [1]

(Short tons)

Country	1952–56 (average)	1957	1958	1959	1960	1961
North America:						
Canada [2]	159,795	187,958	139,559	186,555	214,506	236,555
Cuba:						
Content of oxide	13,703	22,245	19,782	19,658	[3] 12,547	[4] 8,000
Estimated content of slurry—U.S. imports				200	1,600	
United States:						
Byproduct of copper refining	587	502	502	493	623	625
Recovered nickel in domestic ore refined	[5] 2,415	9,568	11,238	11,113	11,907	10,551
Total	176,500	220,273	171,081	218,019	241,183	255,731
South America:						
Brazil (content of ferronickel)	[4] 48	90	80	85	150	[4] 150
Venezuela (content of ore)	[6] 7	35	42	29	14	
Total	55	125	122	114	164	[4] 150
Europe:						
Albania (content of nickeliferous ore) [4]			1,000	1,800	[7] 2,700	2,800
Finland:						
Content of nickel sulfate	152	89	125	92	126	[4] 110
Content of concentrates				324	2,369	[4] 2,400
Germany, East (content of ore) [4]	[6] 110	110	110	110	110	110
Greece (content of nickeliferous ore)	[8] 386	565	265			
Poland (content of ore) [4]	[9] 1,068	1,400	1,488	1,405	1,382	1,400
U.S.S.R. (content of ore) [4]	45,400	55,000	58,000	60,000	64,000	83,000
Total [4]	47,100	57,200	61,000	63,700	70,700	89,800
Asia: Burma (content of speiss)	80	74	367	159	81	[4] 110
Africa:						
Morocco (content of cobalt ore)	161	94	204	266	280	284
Rhodesia and Nyasaland, Federation of: Southern Rhodesia (content of ore)	13	73	4		24	64
Union of South Africa (content of matte and refined nickel)	2,334	4,562	[4] 2,200	[4] 2,900	[4] 3,200	[4] 2,900
Total	2,508	4,729	2,408	3,166	3,504	3,248
Oceania: New Caledonia (recoverable) [10]	15,814	32,359	12,345	28,810	43,325	46,700
World total (estimate)	242,000	315,000	247,000	314,000	359,000	396,000

[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 1953–56.
[6] Average annual production 1955–56.
[7] Planned production.
[8] One year only, as 1956 was first year of commercial production.
[9] Average annual production 1954–56.
[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: 1952–56 (average), 21,070 tons; 1957, 47,700 tons; 1958, 15,600 tons; 1959, 36,200 tons; 1960, 59,000 tons; and 1961, estimated 60,000 tons.

Compiled by Augusta W. Jann, Division of Foreign Activities.

tion shaft was completed on the Pipe Lake property south of Thompson and an exploration level established at the 1500-foot horizon. About $1.9 million was spent on exploration in the Sudbury district. The work included underground exploration at the producing mines at Crean Hill and in Falconbridge Township. Exploration programs and property examinations were carried out in northern Ontario, Quebec, Saskatchewan, and the Northwest Territories; in Greece; Guatemala; Morocco; Southern Rhodesia; South Africa; the South

Pacific Islands; and the United States.[5] Falconbridge Nickel Mines Ltd., had another record year, and delivered 32,773 tons of nickel, a slight increase over 1960. It produced about 35,500 tons of nickel at its refinery in Norway. Ore receipts from the Norduna Emtwo mine totaled 100,000 tons; ore milled was 2,443,000 tons, and ore reserves at yearend totaled 46,247,000 tons averaging 1.45 percent nickel. Shaft sinking at the Strathcona mine progressed to a depth of 2,196 feet.

The installation of equipment for pyrrhotite separation and treatment was completed by Falconbridge. The La Motte Township nickel property in Quebec, owned jointly by Marchant Mining Co., Ltd., and Falconbridge through Marbridge Mines Ltd., was expected to be ready for production in early 1962. The ore will be processed by Canadian Malartic Gold Mines Ltd., a nearby mill, and Falconbridge will smelt the concentrate.[6]

Sheritt Gordon Mines Ltd., mined and milled 1,219,000 tons of ore from its Lynn Lake, Manitoba, property, an increase of 6 percent over 1960. In the fourth quarter, 25 percent of the ore hoisted came from the Farley shaft, production from which began in the third quarter. The refinery at Fort Saskatchewan, Alberta, produced 11,003 tons of nickel from Lynn Lake ore and purchased concentrate, 5 percent less than in 1960. The refinery also produced 2,237 tons of nickel on a toll basis. The ore reserve at the end of 1961 was calculated at 14 million tons, with an average grade of 0.92 percent nickel. The results of extensive underground exploration at the mine at Lynn Lake were disappointing. Sherritt Gordon Mines Ltd., purchased 3,500 tons of nickel-cobalt calcine, containing about 19 percent nickel and 13 percent cobalt, from the U.S. Government. This purchase was to provide the first feed for the new acid leaching circuit, construction of which was started in the third quarter of 1961.[7]

North Rankin Nickel Mines Ltd., produced an estimated 1,900 tons of nickel in the Northwest Territories. The concentrate was shipped to the Sherritt Gordon refinery.

Giant Nickel Mines Ltd., in British Columbia, became a wholly owned subsidiary of Giant Mascot Mines Ltd. on March 1. A contract was signed on that date with Sumitomo Metal Mining Co., continuing shipments of nickel concentrate to Japan for an additional 3 years. Daily mill production was increased at the end of 1961 from 900 to 1,200 tons a day. Shipments of concentrate from the Pride of Emory mine and mill were expected to somewhat exceed the 2,148 tons of combined nickel shipped to Japan in 1960.[8]

Nickel Mining and Smelting Corp. expected to bring its Gordon Lake nickel property, 55 miles northwest of Kenora, Ontario, into production in September 1962 at the rate of 700 tons a day. Faraday Uranium Mines Ltd. was providing the finances. The nickel-copper concentrate was to be trucked 70 miles by road to Lac du Bonnet and shipped by rail to Sudbury for processing by Inco under a 5-year

[5] The International Nickel Company of Canada, Ltd., Ann. Rept. 1961, pp. 7–16.
[6] Falconbridge Nickel Mines Ltd., 33d Ann. Rept, 1961, pp. 7–11.
[7] Sherritt Gordon Mines Ltd., Ann. Rept. 1961, pp. 3–6.
[8] Northern Miner (Toronto). Giant Mascot Reviews Position. V. 47, Aug. 24, 1961, p. 18.
Merret, J. E. Pride of Emory (Giant Mines Ltd.). Minister of Mines and Petrol. Res., Province of British Columbia, Ann. Rept. 1960, pp. 87, 88.

contract. Mine reserves at Gordon Lake were estimated at 825,000 tons, grading 1.75 percent nickel and 0.72 percent copper.[9]

In April, Chibougamau Mining and Smelting Co., Inc., entered into an agreement with Canadian Nickel Co., an exploration subsidiary of Inco, to develop 180 copper-nickel claims in the Frotet Lake district of northwestern Quebec, some 60 miles north of Chibougamau.[10]

Dumont Nickel Corp. began deep drilling on its Marrias Township nickel property in northwestern Quebec, where previous shallow drilling indicated a large tonnage of low-grade nickel-cobalt mineralization. Surface work was carried out in the Laurentian area of Quebec, 30 miles from Ottawa, Ontario.[11]

Raglan Nickel Mines Ltd., estimated its indicated reserves at 3 million tons, grading 1.60 percent nickel and 0.78 percent copper, at its Cape Smith-Wakeham Bay area, Ungava, New Quebec. Drilling in 1961 totaled 17,000 feet, with 35,000 feet to be drilled in 1962.[12]

Porcupine Prime Mines Ltd. was testing ore possibilities at depth, inside the Sudbury nickel basin in Blezard and Rayside Townships, by diamond drilling to a depth of 4,000 and possibly 6,000 feet.[13] It was reported that surface work at the Trout Bay base metal property, 26 miles west of the Cochenour Willans Gold mine at Red Lake in northwestern Ontario, revealed widespread nickel-copper values, some of them of ore grade.[14] A new nickel-copper discovery was made by Bicroft Uranium Mines Ltd., in Limerick Township, 14 miles south of Bancroft, Ontario, where the Bicroft Uranium mine is located. A potential of 2,200 tons per vertical foot was indicated, based on 12 drill holes in an area with an average width of 35 feet.[15]

Fatima Mining Co. drilled 18 holes on its nickel property south of Timmins, northern Ontario. Nickel mineralization was encountered in several new locations, and four areas were recommended for further drilling.[16]

Cuba.—Cuba reportedly shipped nickel oxide from the formerly U.S. Government-owned Nicaro plant to Soviet Bloc countries.

SOUTH AMERICA

Brazil.—The State of Goiás requested Brazilian Federal assistance to mine nickel ore in the municipality of Niquelandia, and to install a metallurgical plant to produce nickel.[17]

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[9] Northern Miner (Toronto). Faraday Putting Nickel Mining Into Production. V. 47, Aug. 17, 1961, pp. 1, 5.
Northern Miner (Toronto). Nickel M. & S. Makes Excellent Progress at Gordon Lake. V. 47, Oct. 26, 1961, pp. 1, 11.
[10] Northern Miner (Toronto). Chiboug. Mining Canadian Nickel Co. Combining Efforts. V. 47, June 29, 1961, pp. 1, 12.
[11] Northern Miner (Toronto). Dumont Nickel Drilling. V. 47, Nov. 2, 1961, pp. 13–20.
[12] Mining Journal (London). V. 257, No. 6578, Sept. 15, 1961, p. 261.
[13] Precambrian Mining in Canada (Winnipeg). Porcupine Prime Drilling Deep Test In Nickel Basin. V. 34, June 1961, p. 50.
[14] Northern Miner (Toronto). Cochenour Output Still Rising as Ore Picture Broadens. V. 47, Aug. 10, 1961, pp. 1–5.
[15] Northern Miner (Toronto). Bicroft Strikes Nickel-Copper in Drill Program Near Coe Hill. V. 47, Nov. 16, 1961, pp. 1–11.
[16] Northern Miner (Toronto). Fatima Negotiates Additional Funds for New Drilling. V. 47, Dec. 14, 1961, p. 3.
[17] U.S. Consulate General, Sao Paulo, Brazil, State Department Dispatch 148, Nov. 17, 1961, p. 4.

Venezuela.—The Ministry of Mines estimated that the nickel deposits in the Loma de Hierro area, State of Aragua, contained some 30 million tons of ore, grading 1.5 percent nickel.[18]

EUROPE

Finland.—Outokumpu Oy, the Finnish Government copper-mining corporation, was estimated to have produced 2,400 tons of nickel and 110 tons of nickel sulfate in 1961.

Greece.—Agreement was reached between Société le Nickel and Greek Chemical and Fertiliser Co. for the joint development of the iron and nickel deposits of Larymna.[19]

Norway.—Falconbridge Nikkelverk, A/S, of Kristiansand S., a subsidiary of Falconbridge Nickel Mines, Ltd., Canada, increased its annual production of nickel to 35,500 tons.

ASIA

Japan.—Japan produced 6,750 tons of pure nickel and 18,670 tons of nickel in ferronickel. Demand for ferronickel declined appreciably towards yearend, with a consequent cutback in production. The Ministry of International Trade and Industry set at 530 tons the duty-free import of nickel for the fiscal year ending March 30, 1962.[20] Inco will supply most of the imports through Inco Nickel Import Co.[21] A provisional committee of the projected Sulawesi Nickel Development Corp. was set up to provide financial assistance and to work with the Indonesian Government to develop nickel mines in the Celebes.[22]

Philippines.—Acoje Mining Co. made its first shipment, 45 tons, of nickel-platinum concentrate to Japan. The concentrate contained 21 to 23 percent nickel.[23] A preliminary estimate of the nickel-iron deposits of Dinagat Island showed a potential reserve of approximately 1,600 million short tons of laterite containing 41.44 percent iron and 0.71 percent nickel.[24]

OCEANIA

New Caledonia.—Nickel ore production was 2,546,000 tons containing 60,000 tons of recoverable nickel. Société le Nickel, at its new installation at Pointe Doniambo, produced 17,020 tons of nickel matte and 53,364 tons of ferronickel, with nickel contents of 13,194 tons and 14,733 tons, respectively. The total nickel produced was 27,927 tons, 16 percent more than that of 1960. Ore exported was 1,107,000 tons, up 3 percent from 1960. Société le Nickel exported 27,988 tons of

[18] Mining Journal (London). Venezuelan Mineral Deposits. V. 257, No. 6593, Dec. 29, 1961, p. 685.
[19] Chemical Trade Journal (London). Nickel Industry for Greece. V. 149, No. 3881, Oct. 20, 1961, p. 873.
[20] Japan Metal Bull., Sept. 16, 1961.
[21] Japan Metal Bull., Aug. 24, 1961.
[22] Japan Metal Bull., Sept. 16, 1961.
[23] Mining Journal (London). Philippine Nickel for Japan. V. 257, No. 6587, Nov. 17, 1961, p. 523.
[24] Bureau of Mines, Republic of the Philippines. Substantial Potential Reserves Disclosed in Dinagat Island Iron-Nickel Deposits. Mineral News Service, No. 42, Nov. 1961, p. 5.

nickel, 11 percent more than in 1960. Exports were 13,199 tons of nickel contained in matte and 14,789 tons in ferronickel.

TECHNOLOGY

The Federal Bureau of Mines research program included investigation of the nickeliferous laterite deposits of northwestern California, sulfatization of nickeliferous laterite and other methods for recovering and separating nickel and cobalt from lateritic ores, and production of high-purity nickel. Work was done on recovering nickel from high-temperature scrap and on the refining of nickel and cobalt in a fused-salt bath. Published reports included a study of methods for recovering metal components from alloy scrap;[25] flotation studies on copper-nickel sulfide ores from deposits near Rockport, Maine;[26] an electron diffraction study of garnierite;[27] preparation of high-purity nickel;[28] mining and milling methods and costs at the Madison mine of National Lead Co., Fredericktown, Mo., where sulfides of copper, nickel, and cobalt occur in commercial quantities with lead sulfide;[29] and salt roasting and leaching of sulfide ore concentrates containing cobalt, nickel, copper, lead, and iron.[30] The Defense Metals Information Center, Battelle Memorial Institute, Columbus, Ohio, published a report on strengthening mechanisms, heat treatment, and evolutionary history of nickel-base superalloys.[31] On April 4, Inco sponsored a research seminar for representatives of Government agencies in Washington, D.C. Some of the papers presented dealt with improved high-temperature-service stainless steels, nickel-base alloys for use up to 1,500° F in the steam and gas turbine industries, nickel-base alloys for use at about 1,850° F for cast turbine blades, columbium-bearing 70–30 cupro-nickel alloys, physical and mechanical properties of electroformed nickel at room and elevated temperatures, research on nickel in aluminum alloys, and nickel-cobalt-molybdenum steels.[32]

The production of nickel and cobalt at the new Thompson, Manitoba, plant of the International Nickel Company of Canada, Ltd., was described.[33]

The structure of the Thompson Moak Lake nickel belt, a major nickel region, was discussed.[34] A paper described ore recovery by the

[25] Kenworthy, H., V. A. Nieberlein, and A. G. Starliper. Experimental Extraction of Strategic Components From S–816 Alloy Scrap. BuMines Rept. of Inv. 5786, 1961, 27 pp.
[26] Shelton, J. E. Flotation Studies on Copper-Nickel Sulfide Ores From Deposits Near Rockport, Maine. BuMines Rept. of Inv. 5793, 1961, 17 pp.
[27] Huggins, C. W. Electron Diffraction Study of Garnierite. BuMines Rept. of Inv. 5837, 1961, 10 pp.
[28] Kershner, K. K., F. W. Hoertel, and J. C. Stahl. Preparation of High-Purity Nickel. BuMines Rept. of Inv. 5840, 1961, 15 pp.
[29] Kline, H. D., W. A. Calhoun, and B. M. Reynolds. Mining and Milling Methods and Costs, Madison Mine; National Lead Co., St. Louis Smelting and Refining Division, Madison County, Mo. BuMines Inf. Circ. 8028, 1961, 26 pp.
[30] Kershner, K. K., and F. W. Hoertel. Recovering Cobalt and Nickel From Complex Sulfide Ores of Southeastern Missori. BuMines Rept. of Inv. 5740, 1961, 16 pp.
[31] Lund, C. H. Physical Metallurgy of Nickel-Base Superalloys. DMIC Rept. 153, May 5, 1961 (OTS PB 171422), 39 pp.
[32] Research Seminar on Improved Materials for Critical Applications. The International Nickel Company, Inc., April 4, 1961.
[33] Northern Miner (Toronto). The Thompson Mine of the International Nickel Company of Canada, Ltd. Magazine Supp., Aug. 17, 1961, pp. 39–94.
[34] Wilson, H. D. B., and W. C. Brisbin. Regional Structure of the Thompson Moak Lake Nickel Belt. Canadian Mining and Met. Bull., v. 54, November 1961, pp. 815–822.

undercut-and-fill method at the Frood-Stobie Mine of the International Nickel Company of Canada, Ltd., at Sudbury, Ontario. The method was to be applied at the Creighton and Levack mines.[35]

The First International Congress on Metallic Corrosion was held in London in April. A number of the papers presented dealt with various aspects of the corrosion of nickel, nickel-base, and nickel-bearing alloys.[36]

The papers, with discussions, presented at the International Symposium on the Extractive Metallurgy of Copper, Nickel, and Cobalt in New York in February 1960, under the auspices of American Institute of Mining, Metallurgical, and Petroleum Engineers, were published in a book.[37]

Inco announced a new cast alloy, IN–100, for use up to 1,900° F; its nominal composition is 10 percent chromium, 15 percent cobalt, 3 percent molybdenum, 1 percent vanadium, 5.5 percent aluminum, 5 percent titanium, 0.18 percent carbon, 0.015 percent boron, 0.05 percent zirconium, and the balance nickel. It has a minimum rupture life of 23 hours at 1,800° F and 29,000 psi stress, with 4 percent minimum elongation.[38] New 18-percent nickel-cobalt-molybdenum maraging alloy steels with unmatched toughness at high-strength levels and good machining properties were reported by Inco. One of these, the 250 steel, has a composition range of 17–19 percent nickel, 7–9 percent cobalt, 4.6–5.1 percent molybdenum, and 0.3–0.5 percent titanium. It has a yield strength of 250,000 psi while maintaining a nil ductility temperature below minus 80° F; a notched tensile strength of about 400,000 psi; a high resistance to stress corrosion cracking, good formability, and ready weldability. Variation of the base composition produces changes in the strength levels of the alloys. Vacuum-melted steels had better improved properties than air-melted steels.[39]

A new class of alloys, the "Nitinol" series, based on the ductile intermetallic compound titanium-nickel (TiNi) and associated phases, was investigated by the U.S. Naval Ordnance Laboratory. The alloys are nonmagnetic and corrosion-resistant, and can be hardened to 62 Rockwell C hardness.[40] Special Metals, Inc., formerly the metals division of Kelsey-Hayes Co., developed a new vacuum-melted wrought-nickel-base superalloy, Udimet 520, with the following composition: Carbon, 0.04–0.05 percent; chromium, 18–20 percent; cobalt, 11–13 percent; Molybdenum, 5.5–6.5 percent; tungsten, 0.9–1.2 percent; titanium, 2.9–3.2 percent; aluminum, 1.9–2.2 per cent; boron, 0.001–0.010 percent; and the balance nickel. It is recommended for use in jet-engine turbine blades and wheels, for temperatures up to 1,800° F.[41]

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[35] Pigott, J. A., and R. J. Hall. Undercut-and-Fill Mining at the Frood-Stobie Mine of the International Nickel Company of Canada, Ltd. Canadian Min. and Met. Bull. v. 54, June 1961, pp. 420–424.

[36] Nickel Bulletin, First International Congress on Metallic Corrosion. V. 34, May 1961, pp. 130–137.

[37] Queneau, P. (ed.), Extractive Metallurgy of Copper, Nickel, and Cobalt. (Annotated Bibliography by Robb, K. G.): Interscience Publishers, Inc., New York and London, 1961, 647 pp.

[38] Bieber, C. G., and T. E. Kihlgren. A New Cast Alloy for Use at 1900° F: Metal Progress, v. 79, April 1961, pp. 97–99.

[39] Decker, R. F. Nickel-Cobalt-Molybdenum Steels. Research Seminar on Improved Materials for Critical Applications, Apr. 4, 1961, pp. 14–1—14–7.

[40] Buehler, W. J., and R. C. Wiley. The Properties of TiNi and Associated Phases. NOLTR 61–75, U.S. Naval Ordnance Laboratory, White Oak, Md., August 1961, 91 pp.

[41] Roberts, D. A. Review of Recent Developments in the Technology of Nickel-Base and Cobalt-Base Alloys. DMIC memo 122, Aug. 4, 1961, p. 2.

Factors to be considered in the selection of iron-base, nickel-base, and cobalt-base superalloys for high-temperature applications were discussed.[42]

The Alloy Casting Institute published a resume of past research on the properties of a HK-type heat-resistant casting alloy, with a specification of 0.20–0.60 percent carbon, a 2-percent maximum of manganese, a 2-percent maximum of silicon, 24–28 percent chromium, and 18–22 percent nickel. The resume was prompted by the interest taken in construction of process equipment involving pressure vessels that operate in the 1,600° to 2,000° F range.[43] Sherritt Gordon Mines Ltd., produced blanks made from pure strip rolled from nickel powder for the Royal Canadian Mint. It also made nickel composite powders, such as nickel-coated carbide, for flame and plasma-spraying, and high-purity close-screened nickel powders for use in battery and fuel-cell plates.[44]

Beryllium-nickel-alloy strip or narrow width sheet was to be made available by The Beryllium Corp., Reading, Pa. The new alloy has a tensile strength up to 260,000 psi and Rockwell hardness to C53. It may be used for heat-resistant springs, diaphragms, and other highly stressed parts where hardness, corrosion, and oxidation resistance are required.[45] Nickel-cadmium cells with a higher energy-weight ratio than conventional cells were produced by a new method, which lends itself to continuous processing, using active and conductive materials dispersed in a microporous plastic structure. The active materials in conventional nickel-cadmium cells are contained in the pores of sintered nickel plaques or in nickel or nickel-plated steel tubes or pockets.[46]

Sixteen major power companies joined in a research program with producers of condenser tubes to compare newly developed copper-nickel alloys with older type condenser tubes as used in the power industry, and to determine the usefulness of the new alloys under differing operating conditions and types of cooling water. The Development and Research Division of Inco was to coordinate the program.[47]

Univertical Corp., Detroit, Mich., developed a new anode which offered a number of advantages over the conventional anode. It was made up of 2-inch-diameter nickel balls nested in a perforated container of commercially pure titanium.[48]

The American Society for Testing and Materials (ASTM) published in its 1961 Book of ASTM Standards, B 374–61T, Tentative

[42] Simmons, Ward F. What Alloy Shall I Use for High-Temperature Applications (Above 1,200° F)? Metal Prog., v. 80, October 1961, pp. 84–91.
[43] Mangone, R. J., and A. M. Hall. Properties of Type HK Cast Alloys. Alloy Casting Bull., October 1961, p. 10.
[44] Sheritt Gordon Mines Ltd., Ann. Rept. 1961, p. 6.
[45] American Metal Market. Berylco Says Beryllium-Nickel Now Available in Strip Form. V. 68, Nov. 3, 1961, p. 14.
[46] Duddy, J. C., and A. J. Salkind. High Energy: Weight Ratio, Nickel Cadmium Cells. Electrochem. Soc., v. 108, August 1961, pp. 717–719.
[47] American Metal Market. Copper Tube Firms, Utilities Embark on Joint Research. V. 68, Oct. 6, 1961, pp. 1–8.
[48] Iron Age. Nickel-Ball Anodes Aid Plating. V. 188, July 13, 1961, p. 97.

Definitions of Terms Relating to Electroplating, and B 375–61T, Tentative Specifications for Electrodeposited Castings of Multi-Layer Nickel Plus Chromium on Steel.

Patents were issued on the recovery of nickel from ores,[49] separation of nickel from cobalt,[50] various alloys,[51] nickel catalysts,[52] bright nickel

[49] Matson, R. F. (assigned to Freeport Sulphur Co.). Recovery of Nickel and Cobalt From Mixtures of the Same With Iron Sulfide, as Impurity. U.S. Pat. 2,971,835, Feb. 14, 1961.
Takakuwa, T. Method of Processing Lateritic Nickeliferous Ores. U.S. Pat. 2,978,317, Apr. 4, 1961.
Greene, A. E. Nickel Recovery From Ore. U.S. Pat. 2,994,601, Aug. 1, 1961.
Uemura, M. (assigned to Tohoku Denki Seitetsu Kabushiki Kaisha). Method of Recovering Nickel and Iron From Laterite Ores by Preferential Reduction. U.S. Pat. 2,995,455, Aug. 8, 1961.
Illis, A., and P. E. Queneau (assigned to The International Nickel Co., Inc.). Processing Nickel-Containing Lateritic Ores. U.S. Pat. 2,998,311, Aug. 29, 1961.
Queneau, P. E. (assigned to The International Nickel Co., Inc.). Treatment of Nickel-Containing Silicate Ores. U.S. Pat. 3,004,846, Oct. 17, 1961.
[50] Peters, K. Extraction Techniques for the Separation and Purification of Metals. U.S. Pat. 2,967,088, Jan. 3, 1961.
Hall, J. D. Separation of Nickel and Cobalt. U.S. Pat. 2,971,836, Feb. 14, 1961.
Howling, H. L., and E. S. Shanley (assigned to Arthur D. Little, Inc.). Nickel-Cobalt Separation. U.S. Pat. 2,977,221, Mar. 28, 1961.
Hampton, T. C., and R. A. Mock (assigned to The Dow Chemical Co.). Hydrometallurgical Separation of Nickel, Copper, and Cobalt in Ammoniacal Solutions. U.S. Pat. 2,993,782, July 25, 1961.
[51] Clark, C. A. (assigned to The International Nickel Co., Inc.). Temperature Compensating Iron-Nickel-Copper Alloys. U.S. Pat. 2,968,548, Jan. 17, 1961.
Eash, J. T. (assigned to The International Nickel Co., Inc.). Gall Resistant Nickel-Copper Alloy. U.S. Pat. 2,968,550, Jan. 17, 1961.
Freche, J. C. (assigned to the U.S. Administrator of National Aeronautics and Space Administration). High Temperature Nickel-Base Alloy. U.S. Pats. 2,971,837, 2,971,838, Feb. 14, 1961.
Eash, J. T. (assigned to The International Nickel Co., Inc.). Gall Resistant Nickel Alloy. U.S. Pat. 2,974,038, Mar. 7, 1961.
Wilson, J. E., and E. L. Dunn (assigned to General Electric Co.). Nickel Base Alloy. U.S. Pat. 2,975,051, Mar. 14, 1961.
Bieber, C. G. (assigned to The International Nickel Co., Inc.). Heat-Resisting Nickel Base Alloys. U.S. Pat. 2,977,222, Mar. 28, 1961.
Brown, J. T. (assigned to Westinghouse Electric Corp.). Stabilized and Precipitation-Hardened Nickel-Base Alloys. U.S. Pat. 2,977,223, Mar. 28, 1961.
Brown, J. T., C. P. Mueller, L. L. France, and A. W. Cochardt (assigned to Westinghouse Electric Corp.). Cobalt-Nickel Base Alloy. U.S. Pat. 2,981,620, Apr. 25, 1961
Thielmann, R. H. (assigned to Sierra Metals Corp.). High Temperature Nickel-Iron Base Alloy. U.S. Pat. 2,981,621, Apr. 25, 1961.
Hoppin, G. S., III (assigned to General Electric Co.). Copper Base Brazing Alloy and Mixtures. U.S. Pat. 2,988,447, June 13, 1961.
Post, C. B., and W. S. Eberly (assigned to The Carpenter Steel Co.). High Initial Permeability Magnetic Alloy. U.S. Pat. 2,990,277, June 27, 1961.
Perkins, R. A., and C. R. Bishop (assigned to Union Carbide Corp.). Iron-Nickel-Silicon Alloys. U.S. Pat. 2,992,917, July 18, 1961.
Faulkner, W. H. (assigned to Union Carbide Corp.). Nickel Base Alloy for Service at High Temperatures. U.S. Pat. 3,005,704, Oct. 24, 1961.
Cochardt, A. W. (assigned to Westinghouse Electric Corp.). High Temperature Alloys. U.S. Pat. 3,005,705, Oct. 24, 1961.
Boyd, W. K., and M. E. Langston (assigned to Battelle Memorial Institute), and T. E. Johnson (assigned to Stainless Foundry and Engineering, Inc.). Nickel-Base Alloys. U.S. Pat. 3,008,822, Nov. 14, 1961.
[52] Beuther, H., R. A. Flinn, and J. B. McKinley (assigned to Gulf Research and Development Co.). Hydrogenation of Aromatics with a Tungsten and Nickel Sulfide, Supported on Alumina, Catalyst Composite. U.S. Pat. 2,967,204, Jan. 3, 1961.
Nahin, P. G. (assigned to Union Oil Company of California). Hydrocarbon Conversion Catalysts. U.S. Pat. 2,968,634, Jan. 17, 1961.
Nowlin, G., and H. D. Lyons (assigned to Phillips Petroleum Co.). Process and Catalyst for Polymerization of Olefins. U.S. Pat. 2,969,408, Jan. 24, 1961.
Raney, M. (assigned to Raney Catalyst Co., Inc.). Process of Producing Nickel Catalysts. U.S. Pat. 2,977,327, Mar. 28, 1961.
Zeiss, H. H., and M. Tsutsui (assigned to Monsanto Chemical Co.). Di-Valent Nickel Acetylene Reactions. U.S. Pat. 2,980,741, Apr. 18, 1961.
Yeo, A. A., and R. Turner (assigned to The British Petroleum Co. Ltd.). Catalysts and Catalytic Hydrocarbon Conversion Processes. U.S. Pat. 2,982,720, May 2, 1961.
Holm, V. C. F., G. C. Bailey, and A. Clark (assigned to Phillips Petroleum Co.). Supported Nickel Oxide Catalyst and Process of Making Same. U.S. Pat. 2,985,598, May 23, 1961.
Pruett, R. L. (assigned to Union Carbide Corp.). Process for Producing Nickel and Cobalt Hydrogenation Catalysts. U.S. Pat. 2,999,075, Sept. 5, 1961.

coatings,[53] an insoluble nickel core anode for use in sulfate-type nickel plating solutions,[54] the production of nickel oxide,[55] and nickel sulfate produced from nickel oxide.[56]

[53] Foulke, D. G., O. Kardos, and H. Koretzky (assigned to Hanson-Van Winkle-Munning Co.). Electrodeposition of Nickel. U.S. Pats. 3,002,902, 3,002,903, 3,002.904, Oct. 3, 1961.
[54] Knapp, B. B., and W. A. Wesley (assigned to The International Nickel Co., Inc.). Insoluble Anodes. U.S. Pat. 3,007,856, Nov. 7, 1961.
[55] Llewelyn, D. M., and D. H. West (assigned to The International Nickel Co., Inc.). Production of Nickel Oxide. U.S. Pat. 2,989,373, June 20, 1961.
[56] Horrigan, R. V. (assigned to National Lead Co.). Production of Nickel Sulfate from High-Temperature Calcined Green Nickel Oxide. U.S. Pat. 3,002,814, Oct. 3, 1961.

Nitrogen Compounds

By Richard W. Lewis [1] and Betty Ann Brett [2]

DOMESTIC production capacity of anhydrous ammonia increased about 2 percent during the year 1961 and was estimated at 5.6 million short tons at yearend. Nitrogen (gaseous and liquid) capacity of air-separation plants was also markedly increased. Coking plants supplied approximately 179,000 tons of NH_3 content as byproducts.

TABLE 1.—Salient nitrogen-compounds statistics [1]

(Thousand short tons)

	1952-56 (average)	1957	1958	1959	1960	1961
United States:						
Production of ammonia, NH_3 content	2,800	3,791	3,945	4,591	4,878	5,256
Imports for consumption of nitrogen compounds, gross weight	1,789	1,480	1,374	1,509	1,233	1,451
Exports of nitrogen compounds, gross weight	507	1,218	704	747	623	446
Consumption of nitrogen compounds, nitrogen equivalent, for years ended June 30	2,442	3,015	3,263	3,759	3,968	4,090
World: Production of nitrogen compounds, nitrogen equivalent, for years ended June 30	7,772	10,221	11,397	12,438	13,572	14,708

[1] This table incorporates some revisions.

DOMESTIC PRODUCTION

Production of anhydrous ammonia for 1961 exceeded that of the preceding year by 376,554 short tons, an increase of 8 percent.

Construction was started by American Cyanamid Co. on a 40-percent production expansion for its anhydrous ammonia facility at Fortier, La., with the completion date set for late 1962.

American Oil Co. planned to construct a large anhydrous ammonia plant at Texas City, Tex., as soon as engineering studies could be completed. Capacity of the plant was not announced.

American Humates Inc., Dallas, Tex., leased over 4,000 acres of Federal coal-bearing land north of Glenrock, Wyo., to produce fertilizer from the high-nitrogen coal. Plans called for construction of a

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.

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75-ton-per-day fertilizer plant in which 200 to 300 tons of coal would be processed daily into concentrated humus grains.

Ground was broken for a new $25 million nitrogen-products facility on April 25 at Cherokee, Ala. The project was financed by a bond issue floated by the town of Cherokee, but the facility will be leased to Armour Agricultural Chemical Co. when completed in 1962. The installation was planned to include six plants having daily capacities for 360 tons of ammonia, 50 tons of urea, 250 tons of nitrogen solutions, 300 tons of nitric acid, 250 tons of ammonium nitrate, and 500 tons of ammonium phosphate.

TABLE 2.—Major nitrogen compounds produced in the United States[1]

(Short tons, NH_3 content)

Compound	1952–56 (average)	1957	1958	1959	1960	1961[2]
Anhydrous ammonia: Synthetic plants[3]	2,741,268	3,732,562	3,878,778	4,519,705	4,817,704	5,194,258
Aqua ammonia:						
Synthetic plants[3]	39,444	40,683	50,933	56,177	45,126	[4] 48,000
Coking plants	19,462	17,341	14,902	14,710	14,884	13,363
Total	58,906	58,024	65,835	70,887	60,010	61,363
Ammonium sulfate:						
Synthetic plants[3]	237,433	268,963	281,467	282,106	221,684	241,642
Coking plants	228,866	234,497	165,228	160,028	162,971	153,143
Total	466,299	503,460	446,695	442,134	384,655	394,785
Ammonium nitrate[3 5]	779,983	1,099,053	1,097,064	1,214,410	1,326,728	1,377,081
Ammonium chloride[3]	9,557	7,464	7,078	8,133	8,870	(6)
Diammonium phosphate: Coking plants	[7] 6,067	9,689	10,581	12,093	11,878	12,294

[1] This table incorporates some revisions.
[2] Preliminary figures.
[3] Data from Bureau of the Census Current Industrial Reports.
[4] Estimate by Bureau of Mines.
[5] Nitrate nitrogen—also calculated to NH_3.
[6] Data not available.
[7] Production for 1956 only.

Construction began on a new ammonia plant for California Chemical Co. at Fort Madison, La. Three other units were planned to complete a $22 million plant food operation—a nitric acid plant, an ammonium nitrate plant, and a mixed-fertilizer plant.

Farm cooperatives were quite active during 1961 with new construction and expansion plans. Coastal Chemical Corp. awarded contracts for a $4.5 million expansion of its anhydrous ammonia plant near Pascagoula, Miss., to double its capacity. Three midwestern farm cooperatives planned to form a new corporation with Central Farmers Fertilizer Co. of Chicago to build and operate a $20 million ammonia plant in either Illinois or Indiana. Two Iowa cooperatives, Calmus Cooperative Elevator Co. and Clinton County Consumers Cooperative Association, jointly purchased an anhydrous ammonia plant at Grand Mound, La. Cooperative Farm Chemicals Association (CFCA) contracted the designing, erecting, and equipping of a 120-ton-per-day nitric acid plant at Lawrence, Kans. CFCA also started continuous operation of a new urea plant at Lawrence using Chemical Construction Corp.'s new "low cost" process. Consumers Cooperative started construction on an $8 million, 20-ton-per-day anhydrous ammonia plant at Hastings, Nebr. Landmark Farm Bureau

Cooperative planned a $20 million project near Terre Haute, Ind., to produce anhydrous ammonia, ammonium nitrate, nitrogen solutions, and urea products. Farmers Chemicals Association, Inc. (FCA) leased Volunteer Ordnance Works, Chattanooga, Tenn., and negotiated for a lease on Alabama Ordnance Works, Childersburg, Ala. FCA was formed by four cooperatives: Southern States Cooperative, Richmond, Va.; Cotton Producers Association, Atlanta, Ga.; Tennessee Farmers Cooperative, La Vergne, Tenn.; and Farmers Cooperative Exchange, Raleigh, N.C. The group planned to spend $9 million to convert part of the plants to the production of nitrogenous fertilizers.

Escambia Chemical Corp. made good progress with construction of a new urea solutions plant at Pace, Fla. The plant, with a rated capacity of 20,000 tons of urea per year, was scheduled for production early in 1962.

At Memphis, Tenn., a new 60,000-ton-per-year ammonia plant of the Nitrogen Products Division, W. R. Grace & Co., was brought on stream. The overall ammonia capacity of the Memphis facility was increased to 160,000 tons annually by the new addition. In April, W. R. Grace & Co. announced plans for a 60,000-ton-per-year ammonia plant at Big Spring, Tex., adjoining the Cosden Petroleum Corp. oil refinery. Cosden, 53-percent owned by W. R. Grace, was to operate the new plant.

Swift & Co. and Skelly Oil Co. jointly formed Hawkeye Chemical Corp. to build and operate a 300-ton-per-day ammonia plant near Clinton, Iowa. Nitric acid, ammonium nitrate, nitrate solutions, and urea were to be the principal products.

Hercules Powder Co. began construction on two new units at its ammonia plant at Louisiana, Mo.; one to produce 50,000 tons per year of ammonium nitrate solution, and the other, about 40,000 tons per year of ammoniated nitrate. Additional units were planned to process ammonia to urea, urea solutions, urea-ammonium nitrate solutions, and prilled ammonium nitrate.

Monsanto Chemical Co. completed a 15,000-ton-capacity anhydrous ammonia storage terminal and started construction on a new 200-ton-per-day ammonia plant near Muscatine, Iowa.

A contract was awarded by Pure Oil Co. for the construction of a 30-ton-per-day ammonia facility at Worland, Wyo.

A new 300-ton-per-day ammonia plant of Solar Nitrogen Chemicals, Inc., near Joplin, Mo., went into production.

Southern Nitrogen Co., Inc., expanded urea capacity at its Savannah, Ga., plant from 10,000 to 17,000 tons per year and planned to increase anhydrous ammonia production from 100,000 to 150,000 tons per year. The company also increased its nitric acid and ammonium nitrate production at the Savannah facilities.

A $7 million nitrate of potash plant was under construction at Vicksburg, Miss., by Southwest Potash Corp., a division of American Metal Climax, Inc.

Tenneco Chemical Co., formed by Tennessee Gas Transmission Co. of Houston, Tex., planned to build and operate a $100 million petrochemical complex on the Houston Ship Channel. Anhydrous ammonia was to be produced, in addition to other chemicals.

A new ammonia plant was constructed at East Tampa, Fla., by Tennessee Corp.

Texaco, Inc., installed new facilities to increase the anhydrous ammonia capacity of its plant at Lockport, Ill., to 220 tons per day.

A number of air-separation plants were planned or constructed during 1961. Air Reduction Sales Co., a division of Air Reduction Co., Inc., brought two units on stream for production of liquid nitrogen, one at Baton Rouge, La., and the other at Tampa, Fla. The company also had a $6.5 million plant under construction at Claymont, Del., and units were planned for Huron, Ohio, and Beaumont, Tex. Air Products and Chemicals, Inc., began operating plants at Cleveland, Ohio, Sparrows Point, Md., and Granite City, Ill. Air Products also acquired the facilities of Southern Oxygen Co. and Delta Oxygen Co. who were producers of oxygen and nitrogen. Air Reduction Pacific Co. planned to double its Richmond, Calif., oxygen and nitrogen capacity. A $6.5 million air-separation plant was planned for Pasadena, Tex., by Hydrocarbon Research, Inc., to supply Tenneco Chemical Co. with 730 tons per day of oxygen and nitrogen. National Cylinder Gas Division of Chemetron Corp., completed an air-separation plant at Dallas, Tex., and began construction of an onsite plant at Sharon Steel Corp.'s Roemer Works, Farrell, Pa., to supply oxygen, nitrogen, and argon. Houston Chemical Corp. installed a high-purity-nitrogen unit at Beaumont, Tex. General Dynamics Corp.'s Liquid Carbonic Division constructed a liquid oxygen-nitrogen plant at Tewksbury, Mass. Superior Air Products Co. began operating a new type of automatic plant for producing high-purity nitrogen at Newark, N.J. Linde Co., a division of Union Carbide Corp., formally opened its 140-ton-per-day liquid oxygen and nitrogen plant at Marshall Space Flight Center, Huntsville, Ala. Also, a similar plant by Linde went on stream at Neosho, Mo., near Fort Crowder.

CONSUMPTION AND USES

Nearly 4.1 million short tons of contained nitrogen was consumed in the year ending June 30, 1961, an increase of 3 percent above 1959–60. Agriculture accounted for about 73 percent of consumption. The principal nitrogen fertilizer materials in order of importance in 1960–61 were ammonium nitrate, nitrogen solutions, anhydrous ammonia, ammonium sulfate, and aqua ammonia.

Demand increased greatly for nitrogen gas, and consumption by industry was 36 percent above 1960, totaling approximately 25 billion cubic feet.

PRICES

The prices for sodium nitrate, ammonium sulfate, and cynamide remained steady during the year, but prices for most other major nitrogen compounds were unstable. Urea price quotations changed several times during the year, dropping to a low of $87.25 per ton. Anhydrous ammonia was quoted at $84 per ton from August 21 to October 9, but recovered for the remainder of the year. It was reported that actual selling prices for both urea and anhydrous ammonia were under the posted prices part of the year.

TABLE 3.—Price quotations for major nitrogen compounds in 1961

(Per short ton)

Compound	Jan. 2	Dec. 25	Effective date of change
Sodium nitrate, imported, crude, carlots, port warehouse, bulk	$44.00	$44.00	
Sodium nitrate, domestic, crude, carlots, works, bulk	44.00	44.00	
Ammonium sulfate, granular, bulk, f.o.b. works, base	32.00	32.00	
Cyanamide, fertilizer-mixing-grade, 21 percent N, granular, bags, Niagara Falls, Ontario	57.00	57.00	
Ammonium nitrate, fertilizer-grade, 33.5 percent N:			
Canadian, carlots, shipping point freight equalized, bags	70.00	[1] 67.00	Oct. 9.
Domestic, f.o.b. works, bags	67.00	[1] 67.00	Oct. 9.
Anhydrous ammonia, fertilizer, tanks, works, freight equalized east of Rockies	92.00	[2] 92.00	Oct. 9.
Ammonium nitrate, domestic with dolomite, 20.5 percent N, bags, carlots, Hopewell, Va	48.00	44.00	Aug. 21.
Urea:			
Industrial, 46 percent N, bags, carlots, ton lots, f.o.b. plant	98.00	100.00	Feb. 6.
Agricultural, 45 percent N, bags, carlots, f.o.b. plant	100.00	[3] 91.25	Oct. 9.

[1] Quoted at $64 per ton from Aug. 21 to Oct. 9.
[2] Quoted at $84 per ton from Aug. 21 to Oct. 9.
[3] Quoted at $98 per ton on Feb. 6, $90 per ton on Feb. 27, $92.50 per ton on Mar. 13, and $87.25 per ton from Aug. 21 to Oct. 9.

Source: Oil, Paint and Drug Reporter.

FOREIGN TRADE [3]

Gross weight of nitrogen compounds imported for consumption increased 18 percent over 1960. Most of the compounds showed higher shipments.

Exports for the year were down 28 percent from the 1960 tonnage. Shipments of all compounds were lower except those of urea and sodium nitrate, which showed small increases.

WORLD REVIEW

NORTH AMERICA

Canada.—The first shipment of urea fertilizer was made from the Consolidated Mining & Smelting Co. plant at Calgary, Alberta.[4] Sherritt Gordon Mines, Ltd., started construction of a 35,000-ton-per-year urea plant at Fort Saskatchewan, Alberta.[5]

El Salvador.—Articles of incorporation of the El Salvador affiliate of Fertica de Panama were signed in San Salvador. The company planned to construct a $5 million plant at Acajutla to produce ammonium phosphate and ammonium sulfate.[6]

Mexico.—Fertilizantes del Istmo S.A. began operating a 150-ton-per-day nitric acid plant and a 200-ton-per-day ammonium nitrate plant in August 1961. These were the first of a total of six units of a nitrogen fertilizer complex costing $11.5 million to go into oper-

[3] Figures on imports and exports compiled by Mae B. Price and Elsie B. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.
[4] Chemical Week. Market Newsletter. V. 88, No. 8, Feb. 25, 1961, p. 84.
[5] Oil, Paint and Drug Reporter. Urea Plant's Goal 35,000 Tons a Year. V. 180, No. 3, July 17, 1961, pp. 3, 62.
[6] Sulphur Institute News. More News of the Industry, Fertilizer. V. 1, No. 10, November 1961, p. 2.

TABLE 4.—U.S. imports for consumption and exports of major nitrogen compounds

(Short tons)

	1960	1961
Imports:		
Industrial chemicals: Ammonium nitrate	----------	106
Fertilizer materials:		
Ammonium nitrate containing over 32 percent nitrogen	[1] 172,366	156,593
Ammonium nitrate mixtures containing 32 percent and less nitrogen, including ammonium nitrate-calcium carbonate mixtures, except solutions	[1] 73,193	92,630
Ammonium phosphates	119,937	112,993
Ammonium sulfate	211,351	242,866
Calcium cyanamide	44,100	41,987
Calcium nitrate	62,023	73,737
Nitrogen solutions	50,174	63,626
Nitrogenous materials, n.e.s.:		
Organic	2,303	1,851
Other synthetic	41,475	47,280
Potassium nitrate, crude	[1 2] 635	1,962
Potassium-sodium nitrate mixtures, crude	[1 2] 18,632	13,801
Sodium nitrate	355,112	494,345
Urea, n.e.s.	[1] 82,054	107,018
Total	[1] 1,233,355	1,450,795
Exports:		
Industrial chemicals:		
Ammonium nitrate	2,449	1,554
Anhydrous ammonia and chemical-grade aqua (ammonium content)	14,692	9,513
Fertilizer materials:		
Ammonium nitrate	36,942	28,324
Ammonium phosphates and other nitrogenous phosphatic-type fertilizer materials	107,371	77,506
Ammonium sulfate	237,309	144,450
Anhydrous ammonia and aqua (ammonia content)	93,968	92,904
Nitrogenous chemical materials, n.e.c.	63,219	18,145
Sodium nitrate	1,040	1,217
Urea	66,380	72,317
Total	623,370	445,930

[1] Revised figure.
[2] Adjusted by Bureau of Mines.

Source: Bureau of the Census.

TABLE 5.—World production and consumption of nitrogen, years ended June 30

(Thousand short tons)

Year	Production [1]	Consumption [1]	
		In agriculture	In industry
1956-57	10,221	8,502	1,595
1957-58	11,397	9,295	1,793
1958-59	12,438	10,322	1,965
1959-60 [2]	13,572	11,383	2,265
1960-61	14,708	12,136	2,339

[1] Estimate.
[2] Revised figure.

Source: British Sulphate of Ammonia Federation, Ltd.

TABLE 6.—World production and consumption of fertilizer nitrogen compounds, years ended June 30, by principal countries

(Thousand short tons of contained nitrogen)

Country	Production			Consumption		
	1957–58	1958–59	1959–60 [1]	1957–58	1958–59	1959–60 [1]
Australia	28	28	24	40	38	29
Austria	173	170	179	44	47	50
Belgium	286	325	336	98	107	109
Brazil	1	3	12	36	49	49
Canada	243	246	264	63	69	
Ceylon				22	27	34
Chile	284	223	163	32	5	53
Denmark				109	115	135
Egypt	36	38	42	173	195	116
Finland	24	31	34	45	47	58
France	562	594	632	539	530	556
Germany:						
East	337	353	363	247	249	
West	1,155	1,158	1,159	625	637	688
Greece				69	78	77
India	89	89		197	198	
Indonesia				26	31	
Israel	14	15	17	16	17	
Italy	451	585	650	296	329	398
Japan	973	1,087	1,028	693	751	655
Korea, Republic of				158	189	184
Mexico	14			152	154	
Netherlands	419	431	448	230	230	234
Norway	241	251	270	50	50	54
Peru	19	40	50	35	61	49
Philippines	9	15		17	22	
Portugal	15	33	46	58	73	75
Spain	55	66	89	205	302	259
Sweden	41	37	47	94	98	113
Switzerland	13	15	21	13	15	17
Taiwan	25	33	43	124	108	122
Union of South Africa	18	23	23	33	40	48
U.S.S.R.	694	788	816	671	756	782
United Kingdom	382	392	441	347	381	463
United States	2,360	2,698	2,871	2,284	2,672	2,792
Yugoslavia	6	7	5	64	84	86
World total [2]	9,447	10,351	10,825	8,664	9,678	10,163

[1] Preliminary figures.
[2] Includes quantities for minor producing and consuming countries not listed above.

Source: Converted and rounded from United Nations Food and Agriculture Organization.

ation.[7] A urea plant was planned for Salamanca, northwest of Mexico City, by Fertilizantes del Bajio, with technical aid from Lummus Co., of New York.[8]

Netherlands Antilles.—It was announced by the Government Information Service of Aruba that Standard Oil Company of New Jersey would build an ammonia plant and that the Aruba Chemical Industries, N.V., would start construction of plants to produce fertilizer, urea, and nitric and sulfuric acids.[9]

Trinidad.—Trinidad's first nitrogen fertilizer plant, located at Point Lisas, Claxton Bay, went into full operation.[10]

[7] Chemical Week. Mexico: Now Fertilizer Exporter. V. 89, No. 22, Dec. 2, 1961, p. 35.
[8] Chemical Trade Journal and Chemical Engineer. Urea Plant for Salamanca. V. 148, No. 3852, Mar. 31, 1961, p. 708.
[9] Foreign Trade (Ottawa). Commodity Notes. V. 115, No. 5, Mar. 11, 1961, p. 21.
[10] Chemical Trade Journal and Chemical Engineer. Fertilisers in Trinidad. V. 148, No. 3856, Apr. 28, 1961, p. 932.

SOUTH AMERICA

Argentina.—Dirección General de Fabricaciones Militares started construction of a plant at Rio Tercero to produce ammonia and nitric acid.[11] Borden Chemical Co. began operating a urea and resin plant at Pilar. The plant was said to be capable of producing 6.6 million pounds of urea annually.[12]

Chile.—Only two small independent nitrate producers were operating in 1961. The largest, Compañia Salitrera Iqueque, S.A., began the year with two plants, at Chile and Alemania, but closed the Chile plant in April. The second company, Compañia Salitrera Perfetti, operated a plant near Taltal. The closing of this plant was prevented only by a large loan from the Chilean Government's Development Corporation (CORFO).[13]

TABLE 7.—Chile: Exports of nitrate in 1961, by countries[1]

(Thousand short tons)

Destination	Quantity	Destination	Quantity
Argentina	23	Mexico	9
Australia and New Zealand	18	Middle East	16
Belgium	27	Netherlands	50
Brazil	73	Peru	7
Denmark	18	Portugal	9
France	87	Spain	109
Germany, West	11	Sweden	41
Greece	3	United Kingdom[2]	25
India	24	United States	585
Ireland	5	Other countries[3]	7
Italy	26		
Japan	20	Total	1,193

[1] Includes 78,500 tons, potassium nitrate.
[2] Includes 9,000 tons in transit.
[3] Includes Bolivia, Costa Rica, Colombia, Equador, El Salvador, Guatemala, Nicaragua, Panama, Uruguay, and Venezuela.

Colombia.—Amoniaco del Caribe, S.A., an affiliate of International Petroleum (Colombia) Ltda., started construction of a 325-ton-per-day ammonia plant and a 167-ton-per-day nitric acid plant.[14] Construction of a nitrogenous fertilizer plant near Cartagena was begun in April 1961 with completion scheduled for late 1962. A newly established company, Abonos Colombianos, S.A. (ABOCOL), was to operate the plant.[15]

Ecuador.—The Government of Ecuador recommended a plant for the manufacture of ammonium sulfate with an adjoining sulfuric acid plant as the first step in providing the country with a fertilizer industry.[16]

Peru.—A contract was awarded a German engineering group to construct a nitrogenous fertilizer plant at Cuzco with a daily capacity of about 190 tons of ammonium nitrate.[17]

[11] Chemical Trade Journal and Chemical Engineer. Notes From Abroad. V. 149, No. 3879, Oct. 6, 1961, p. 756.
[12] Chemical & Engineering News. Industry & Business Concentrates. V. 39, No. 35, Aug. 28, 1961, p. 17.
[13] U.S. Embassy, Santiago, Chile. State Department Dispatch 166. Sept. 14, 1961, p. 3.
[14] Chemical Age. Ammonia Fertiliser Complexes Planned in Colombia. V. 86, No. 2190, July 1, 1961, p. 23.
[15] Bureau of Mines. Mineral Trade Notes. V. 53, No. 5, November 1961, p. 39.
[16] Chemical Age. Fertiliser Industry for Ecuador. V. 86, No. 2211, Nov. 25, 1961, p. 857.
[17] Chemical Trade Journal and Chemical Engineer. Fertilisers in Peru. V. 149, No. 3883, Nov. 3, 1961, p. 970.

EUROPE

Belgium.—A Belgian royal decree, effective on October 1, 1961, revised specifications for what may be lawfully sold as ammonium nitrate. The minimum acceptable nitrogen content (ammoniacal nitrogen and nitric nitrogen) was increased from 15.5 percent to 22 percent.[18]

Denmark.—Plans were completed for Denmark's first nitrogen fixation plant, to be built at Grenaa, Jutland.[19]

France.—Société Belge de l'Azote et des Produits Chimiques du Marly (S.B.A.), Liége, Belgium, was awarded a contract for designing a 150-ton-per-day ammonium nitrate plant for Ammonia, S.A.[20] A new nitrogen fertilizer plant by Société Chimique de la Grande Paroisse was announced, and preparatory work on the site, between Donges and Montoir, was completed.[21]

Hungary.—A 350,000-ton-per-year nitrogenous fertilizer plant was under construction at Tiszapalkonya.[22]

Ireland.—The Ministry of Industry & Commerce announced plans for constructing a nitrogenous fertilizer plant at Arklow.[23]

Netherlands.—A new ammonium nitrate plant was under construction, commissioned by N. V. Maatschappij tot Exploitatie Van Kooksovengassen. The capacity of the plant was stated to be 285 tons per day.[24]

Norway.—Norsk Hydro-Elektrisk Kvaelstofaktieselskab completed the first stage of an ammonia plant expansion program at Glomfjord, increasing production to over 70,000 tons per year.[25] Norway's state-owned concern, Norsk Koksverk, planned construction of a 50,000-ton-per-year ammonia plant in connection with the coke plant being built in Nord-Rana.[26]

Poland.—Polimex, a state-held trade organization, contracted with the British firm, Constructors John Brown Ltd., to design and build three oxygen and nitrogen plants for ammonia production at Tarnow. The total capacity of these plants, which were to come on stream over the next 5 years, was to be 1,000 tons per day.[27] The British Davy-Ashmore engineering group subsidiary, Power-Gas Corp. Ltd., received a contract for constructing a 500-ton-per-day urea plant, the first of five according to Poland's present 5-year plan.[28]

Rumania.—A 6-year plan was established (1961–66) to increase annual nitrogen production for fertilizers to about 800,000 tons by 1965.

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[18] Commercial Fertilizer. The International Scene, Belgium. V. 103, No. 2, August 1961, p. 46.
[19] Chemical Trade Journal and Chemical Engineer. Nitrogen Production in Denmark. V. 149, No. 3884, Nov. 10, 1961, p. 1040.
[20] Commercial Fertilizer. Around the Map, France. V. 103, No. 3, Sepetmber 1961, p. 35.
[21] Chemical Trade Journal and Chemical Engineer. New Nitrogen Fertiliser Plant for France. V. 149, No. 3878, Sept. 29, 1961, p. 709.
[22] Chemical Age. Mammoth Nitrogen Fertiliser Plant Will Boost Hungarian Output. V. 85, No. 2167, January 1961, p. 150.
[23] Foreign Commerce Weekly. World Trade Leads. V. 66, No. 13, Sept. 25, 1961, p. 26.
[24] Chemical Age. Overseas News, Holland. V. 86, No. 2208, Nov. 4, 1961, p. 721.
[25] Chemical Age. Overseas News, Norsk Hydro Complete First Stage of Ammonia Expansion. V. 85, No. 2174, Mar. 11, 1961, p. 411.
[26] Commercial Fertilizer. Around the Map, Norway. V. 103, No. 1, July 1961, p. 62.
[27] Chemical Engineering. C.P.I. News Briefs—International. V. 68, No. 19, Sept. 18, 1961, pp. 226, 228.
[28] Fertiliser and Feeding Stuffs Journal. Research Digest, Urea Plant for Poland. V. 54, No. 13, June 28, 1961, p. 572.

Existing plants were being expanded, and new plants were under construction.[29]

Spain.—Three nitrogen-producing plants were under construction: Empresa Nacional de Siderurgica at Avilés, Refineria de Petroles de Escombreres S.A. (REPESA) at Cartagena, and Abonos Sevilla at Seville. The total annual capacity in nitrogen equivalent of these plants was stated to be 210,000 tons.[30]

U.S.S.R.—Techmashimport, the Soviet trading organization, contracted Société Études et Recherches Industrielles (ERI), Brussels, to supply a new ammonia plant using the process of Société Belge de l'Azote et des Produits Chimiques du Marly (SBA), Liége, Belgium. Two other plants by ERI and SBA were nearing completion.[31]

United Kingdom.—Construction began on a new ammonia plant for Nitrogen Fertilisers Ltd. at Flixborough, Lincolnshire.[32]

Yugoslavia.—A nitrogen fertilizer plant was built at Lukovac (central Bosnia) for Korsara Boris Kidric. The production rate given was 120,000 tons per year.[33]

ASIA

India.—In February 1961, India was reported to have an established combined-plant capacity for nitrogenous fertilizer of 277,325 short tons of contained nitrogen. Four plants, totaling 253,000 tons capacity, were under construction at Rourkela, Orissa; Neyveli, Madras; Trombay, Maharashtra; and Ennore, Madras. In addition, five plants were approved and eight proposed that when completed would give India a productive capacity of over 1 million tons of contained nitrogen per year.[34]

Indonesia.—Morrison-Knudsen International Constructors, Inc., Boise, Idaho, was awarded a contract to design and construct a 100,000-ton-per-year urea plant at Palembang, Sumatra.[35]

Iraq.—The first fertilizer plant for Iraq was under construction near Basrah on the Persian Gulf. U.S.S.R. equipment was used, and the planned annual output in 1965 included 116,000 tons of ammonium sulfate and 56,000 tons of ammonium nitrate.[36]

Malaya.—Plans for a new urea plant at Port Dickson were nearing completion.[37]

Pakistan.—East Pakistan's new urea plant at Fenchuganj was dedicated. When in full production, it was expected to produce 117,000 tons of urea annually.[38]

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[29] Nitrogen. Expansion of Nitrogen Production in Roumania. No. 11, May 1961, p. 34.
[30] Nitrogen. Spain's Nitrogen Industry. No. 12, July 1961, p. 6.
[31] Chemistry & Industry (London). Ammonia Plant Contract. No. 36, Sept. 9, 1961, p. 1444.
[32] Chemical Age. Chemico Start Work on New Ammonia Plant at Flixborough. V. 85. No. 2183, May 13, 1961, p. 763.
[33] Chemical Age. Italian-Built Plant in Yugoslavia. V. 86, No. 2208, Nov. 4, 1961, p. 721.
[34] Bureau of Mines. Mineral Trade Notes. V. 52, No. 6, June 1961, pp. 27–31.
[35] Chemical Age. U.S. Contract for Indonesian Urea Plant. V. 85, No. 2178, Apr. 8, 1961, p. 585.
[36] Chemical Trade Journal and Chemical Engineer. Notes From Abroad. V. 149, No. 3874. Sept. 1, 1961, p. 480.
[37] Oil, Paint and Drug Reporter. Urea Project Progresses. V. 180, No. 12, Sept. 18, 1961, p. 54.
[38] Commercial Fertilizer. Around the Map, Pakistan. V. 102, No. 2, February 1961, p. 25.

Philippines.—A large copper plant using a new process which would produce 100,000 tons of byproduct ammonium sulfate fertilizer per year was proposed.[39]

Taiwan.—An agreement was signed by Chinese Petroleum Corp. of Taiwan, Socony Mobil Oil Co., and Allied Chemical Corp., whereby US$22.5 million was to be made available for the construction of a new 100,000-ton-per-year urea plant and new ammonia-producing equipment for the Nankang plant.[40] Taiwan imported 330,000 tons of ammonium sulfate from Japan during the year ending June 30, 1961.[41]

United Arab Republic (Syria Region).—It was reported that the U.S.S.R. will build a US$28 million ammonium nitrate plant at Homs. The first unit, capable of producing 60,000 tons per year, was planned for completion in 1965.[42]

Viet-Nam.—South Viet-Nam planned its first chemical center at An-Hoa, 360 miles northeast of Saigon; the center would produce approximately 55,000 tons of urea and 8,000 tons of calcium cyanamide annually.[43] Another urea plant was in the planning stages for central Viet-Nam; it initially would produce 33,000 tons annually, but later would be increased to 80,000 tons.[44]

AFRICA

Rhodesia and Nyasaland, Federation of.—The Federal Ministry of Commerce and Industry completed a survey and published a report on the production potential for nitrogenous fertilizer and explosives. U.S. firms were invited to submit proposals to the Ministry for the establishment of a nitrogenous fertilizer factory at Salisbury.[45] Kamativi Mines Ltd. in southern Rhodesia began using ammonium nitrate-diesel fuel mixtures for blasting in both underground and open-pit operations.[46]

Tunisia.—A feasibility study, completed by W. R. Grace & Co. for the Société Tunisienne de Banque, recommended the construction near Sfax of a nitrogenous fertilizer plant which would have an annual capacity of 79,000 tons of ammonium nitrate and 14,000 tons of anhydrous ammonia.[47]

Union of South Africa.—The African Explosives and Chemical Industries, Ltd., urea plant at Modderfontein began production. It was stated that over U.S. $8 million a year in foreign exchange will be saved by the plant.[48]

United Arab Republic (Egypt).—The second stage of the nitrogen fertilizer plant facilities at Aswan, Egypt, was put into operation, in-

[39] Mine and Quarry Engineering. Copper Plant in the Philippines. V. 27, No. 6, June 1961, p. 281.
[40] Commercial Fertilizer. Around the Map, Taiwan. V. 103, No. 2, August 1961, p. 30.
[41] Agricultural Chemicals. International Market Report, Formosa. V. 16, No. 7, July 1961, p. 11.
[42] Commercial Fertilizer. Around the Map, Syria. V. 103, No. 4, October 1961, p. 46.
[43] Chemical Week. International, Foreign Roundup. V. 88, No. 16, Apr. 22, 1961, p. 117.
[44] Chemical Trade Journal and Chemical Engineer. Fertilisers in Viet-Nam. V. 148, No. 3854, Apr. 14, 1961, p. 807.
[45] Commercial Fertilizer. International Scene, Rhodesia. V. 103, No. 2, August 1961, p. 47.
[46] Mining Journal (London). Opencast Blasting at Kamativi, S. Rhodesia. V. 256, No. 6557, Apr. 21, 1961, pp. 441, 443.
[47] Bureau of Mines. Mineral Trade Notes. V. 52, No. 5, May 1961, pp. 24, 25.
[48] Commercial Fertilizer. Around the Map, Africa. V. 102, No. 2, February 1961, p. 61.

creasing the daily production of ammonium nitrate-limestone from 1,200 to 1,600 tons.[49]

OCEANIA

Australia.—The Australian Minister of Trade imposed a temporary duty on imported nitrogenous fertilizers. Products containing nitrogen imported for use other than as fertilizers were exempt.[50] It was reported that Imperial Chemical Industries of Australia and New Zealand Ltd., expect to build a large plant at Botany to produce ammonia, ammonium nitrate, nitric acid, urea, and methanol. Production from the first unit was planned for 1963.[51]

TECHNOLOGY

A new low-cost process for producing high-purity nitrogen at pressures suitable for direct use, developed by Petrocarbon Developments, Ltd., London, and used in England in 1960, was reported used for the first time in the United States.[52] E. I. du Pont de Nemours & Co., Inc., and Engelhard Industries, Inc., developed a method for recovering pure nitrogen from waste gases of the Du Pont nitric acid plant at Gibbstown, N.J. It was claimed that the method was successful as an air-pollution control and economical in that enough valuable chemicals were recovered to offset operational costs.[53]

Research and Development Division, Engelhard Industries, Inc., reported on a method for removing carbon monoxide from ammonia synthesis gas.[54]

Dutch State Mines described a new approach to making urea with a low-biuret content. Prills were blanketed in a vessel with ammonia under pressure, which caused the biuret to revert to urea.[55]

A way to select the most economical method to fractionate ammonia-water vapors was reported by United States Steel Corp.[56]

A Japanese plant disclosed it would switch its recycle urea plant to a new type, total carbamate recycle. It was reported that studies showed plant capacities can be increased 50 percent for an added capital investment equal to 25 percent to the original investment for the conversion.[57]

The flowsheet of the Cooperative Farm Chemicals Association urea plant at Lawrence, Kans., was fully described.[58]

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[49] Oil, Paint and Drug Reporter. Fertilizer Plant Progresses. V. 180, No. 9, Aug. 28, 1961, p. 66.
[50] Chemical Age. Overseas News, Australian Levy on Imported Nitrogen Fertilizers. V. 85, No. 2185, May 27, 1961, p. 857.
[51] Chemical Age. Project News, Ammonia Complex for I.C.I. Australia. V. 86, No. 2192, July 15, 1961, p. 89.
[52] Chemical Engineering. Chementator. V. 68, No. 18, Sept. 4, 1961, p. 60.
[53] Chemical Engineering. Process Wrings Pure Nitrogen From Nitric Fumes. V. 68, No. 21, Oct. 16, 1961, pp. 102, 104.
[54] Anderson, Holger C., and William J. Green. Removing Carbon Monoxide From Ammonia Synthesis Gas. Ind. and Eng. Chem., v. 53, No. 8, August 1961, pp. 645, 646.
[55] Chemical Engineering. Ammonia Blanket Gives Low-Biuret Urea Prills. V. 68, No. 22, Oct. 30, 1961, p. 60.
[56] Fields, M. C. Recovering Ammonia From Ammonia-Water Vapors. Ind. and Eng. Chem., v. 53, No. 2, February 1961, pp. 131–136.
[57] Chemical Week. Technology Newsletter. V. 89, No. 1, July 8, 1961, pp. 57, 58.
[58] Chopey, N. P. Fresh Ideas Improve Urea Process. Chem. Eng., v. 68, No. 14, July 10, 1961, pp. 116–118.

A Swedish process giving good nitroform yields with low acid loss was reported. Success of the process was attributed to a special two-stage distillation method.[59]

A new nitric acid process developed by Hercules Powder Co. was reported. Ammonia is oxidized to produce 60 percent nitric acid which is then concentrated to 99.99 percent by extractive distillation.[60]

An economical process to recover about 65 percent of the ammonia from pulping effluent was reported.[61]

A fluid-bed process that was claimed to be a superior method for ammoniating superphosphate was developed in Czechoslovakia. The superphosphate is fluidized by a current of air and ammonia. The ammonia absorption rate in the fluid layer was said to be much higher than in conventional units. Also, initial and operating costs were stated to be lower.[62]

An automatic instrument for determining nitrogen by the Kjeldahl wet-digestion method was marketed by Technicon Controls, Inc. The company claimed that 1 man operating 2 automatic digesters can make at least 320 analyses per 8-hour shift.[63]

Ammonium nitrate-fuel oil (AN–FO) explosives were tested in underground blasting in Canada, and the results were reported.[64]

Stanrock Uranium Mines Ltd. used AN–FO underground on a production scale at its Quirk Lake, Ontario, mine. This was reportedly the first underground use of AN–FO in Canada and appreciable reductions in cost of blasting supplies and loading time were said to result. A significant step forward was made by using an insensitive blasting agent in place of a high explosive. Under operational conditions, no significant difference was detected between the gases produced by AN–FO and by fume class 1 explosives.[65]

Armour Industrial Chemical Co. and The Dow Chemical Co. developed a process for producing oxygen-free hydrogen. Ammonia is dissociated by conventional high-temperature cracking in the presence of a catalyst, and the nitrogen is removed from the combined gas in a battery of three absorption units containing activated charcoal. The only impurity in the final product is a small amount of nitrogen. With a leaktight system there is no possibility of oxygen contamination, and the process precludes contamination from CO or CO_2.[66]

Spacecraft to use liquid nitrogen engines were reported in the designing stages at The Martin Co.[67]

The use of liquid nitrogen to cool refrigerated rail cars, truck trailers, and delivery trucks was spearheaded by Linde Co., a division of

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[59] Chemical & Engineering News. Special Distillation Recovers Nitroform. V. 39, No. 25, June 19, 1961, pp. 69, 70.
[60] Chemical Week. Technology Newsletter. V. 88, No. 9, Mar. 4, 1961, p. 51.
[61] Chemical Week. Ammonia Recovery: Bonus for Pulpers. V. 88, No. 20, May 20, 1961, pp. 55, 56.
[62] Commercial Fertilizer. "Fluid Bed" Ammoniating Process. V. 103, No. 4, October 1961, p. 44.
[63] Chemical & Engineering News. Kjeldahl Analysis Made Automatic. V. 39, No. 28, July 10, 1961, p. 53.
[64] Northern Miner. Underground Use of Ammonium Nitrate Seen Revolutionary Cost-Cutting Step. V. 47, No. 25, Sept. 14, 1961, p. 23.
[65] Hunkin, G. G., R. Drozd, and L. A. Gibbons. The Application of Ammonium Nitrate Fuel Oil Explosives in Underground Mining at Stanrock. Canadian Min. and Met. Bull., v. 54, No. 593, September 1961, pp. 667–672.
[66] Chemical Trade Journal and Chemical Engineer. Hydrogen From Ammonia. V. 148, No. 3851, Mar. 24, 1961, p. 640.
[67] Missiles and Rockets. Martin Reveals Nuclear ASP Concept. V. 9, No. 10, Sept. 4, 1961, p. 14.

Union Carbide Corp. It was predicted that in-transit refrigeration would become the largest liquid nitrogen market within a few years.[68]

An interesting but limited new use for ammonium nitrate was reported. It was applied to ski runs to prolong the skiing season.[69]

[68] Chemical & Engineering News. Liquid Nitrogen Moves Into Refrigeration. V. 39, No. 34, Aug. 21, 1961, p. 24.
[69] Commercial Fertilizer. Of This and That. V. 103, No. 4, October 1961, p. 72.

Perlite

By John W. Hartwell [1] and Victoria R. Schreck [2]

PRODUCTION of crude perlite in the United States in 1961 was 3 percent less than in 1960. Output of expanded perlite also was about 3 percent less.

DOMESTIC PRODUCTION

Crude Perlite.—Crude perlite was produced by 15 companies from 16 mines, compared with 12 companies and 14 mines in 1960.

The quantity of crude ore used in producer's plants was 16 percent greater than in 1960, and the quantity of crude sold to expanders was 8 percent less.

The State of New Mexico continued to lead in producing crude perlite; 302,100 short tons were mined, 81 percent of the U.S. total. Other producing States, in order of output, were Nevada, California, Arizona, Colorado, Idaho, and Utah.

Expanded Perlite.—Perlite was expanded in 30 States by 68 companies at 102 plants, compared with 29 States, 60 companies, and 87 plants in 1960. Idaho was added to the list of States expanding perlite in 1961. The greatest number of expanders was in California, 14; followed by Pennsylvania, 7; Texas, 6; Illinois, New Mexico, and New York, 5 each; and Colorado, Nevada, and New Jersey, 4 each.

Erection of a crushing and screening plant at a perlite deposit in central Lake County, Oreg., was planned.

A new company began mining perlite from a deposit near Lovelock, Nev., and planned to build an expanding plant at Stockton, Calif.

Oneida Perlite Corp. began mining perlite at deposits 25 miles northwest of Malad, Oneida County, Idaho. The ore was processed in a new plant near the mine. The expanded product was marketed chiefly in the Rocky Mountain States as a building-plaster aggregate.

Great Lakes Carbon Corp. closed its perlite plant at Socorro, N. Mex., because sales were not enough to maintain a profitable operation. The plant had been operating since 1947. Great Lakes continued its perlite operations at No Agua, N. Mex., and Antonito, Colo. The Antonito perlite plant began processing in 1961. Final processing and grading were almost completely automated. The annual capacity of the plant was 24,000 tons of filter aid products and was so designed that additional capacity could be added when needed.

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.

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
1952–56 (average)	270	167	$1,408	69	$399	236	207	207	$10,648
1957	422	194	1,730	107	832	301	249	245	12,511
1958	372	197	1,624	95	840	292	241	239	12,373
1959	443	221	1,846	104	891	325	276	273	14,187
1960	385	214	1,847	98	818	312	248	244	13,046
1961	374	196	1,665	114	998	310	240	235	12,605

TABLE 2.—Expanded perlite produced and sold by producers in the United States

(Thousand short tons and thousand dollars)

State	1960				1961			
	Quantity produced	Sold			Quantity produced	Sold		
		Quantity	Value			Quantity	Value	
			Total	Average per ton			Total	Average per ton
California	24	24	$1,395	$59.13	22	22	$1,374	$63.77
Florida	9	9	599	69.23	7	7	452	61.00
Kansas	1	1	43	76.70	1	1	53	73.10
Michigan	5	5	287	54.70	4	4	237	56.09
New Jersey	9	9	547	61.80	10	10	626	62.08
New York	18	18	886	48.11	14	14	662	44.34
Pennsylvania	17	17	1,092	62.65	16	16	1,037	66.02
Texas	23	23	1,343	57.50	24	24	1,424	58.68
Other Eastern States [1]	86	84	4,721	56.46	79	77	4,408	57.07
Other Western States [2]	56	54	2,133	39.42	63	60	2,332	39.01
Total	248	244	13,046	53.46	240	235	12,605	53.59

[1] Includes Illinois, Indiana, Maryland, Massachusetts, New Hampshire, North Carolina, Ohio, Tennessee, Virginia, and Wisconsin.
[2] Includes Arizona, Colorado, Idaho (1961), Iowa, Louisiana, Minnesota, Missouri, Nebraska, Nevada, New Mexico, Oregon, and Utah.

The new Johns-Manville Perlite Corp. mill at No Agua, N. Mex., began operating in December 1960 at a capacity of 150,000 tons annually, and was reported to be the world's largest processing plant. The deposit, covering an area of 2,000 acres, and ore reserves were enough to last for more than 100 years at the 1961 rate of production. The milled perlite was trucked to a Johns-Manville blending and loading plant in Antonito, Colo.

CONSUMPTION AND USES

The following end-use percentages for expanded perlite were reported by producers: Building-plaster aggregates, 50; filter aids, 21;

concrete aggregate, 16; insulation (loose fill), insulation (other), soil conditioning, and filler, 2 each; oil well cement and wallboard, 1 each; and miscellaneous uses, 4.

PRICES

The average value of crushed, cleaned, and sized perlite, sold to expanders, was $8.49 per short ton, f.o.b. producers' plants, compared with $8.64 in 1960. The average value of crude perlite expanded by prime producers was $8.75, compared with $8.31 in 1960. A weighted average price of these two categories of crude perlite was $8.59 in 1961, less than 1 percent more than in 1960.

The average price of all expanded perlite sold in 1961 was $53.59 per ton, about the same as in 1960.

FOREIGN TRADE

Crude perlite may be imported duty-free under paragraph 1719 of the Tariff Act of 1930. Expanded perlite has had a duty at 15 percent ad valorem since Jan. 1, 1948.

WORLD REVIEW

In 1961 the United States produced, expanded, and used more perlite than any other country.

Bulgaria.—Deposits of perlite have been reported in many areas of Bulgaria. Expanding plants with annual capacities of nearly 75,000 cubic feet were to be built at Kurdyali, Rousse, Varna, Bourgas, and Sofia during 1961.[3]

Canada.—Perlite ore occurs in British Columbia but has not been developed commercially. All the crude perlite used during 1960 was imported from the United States. About 104,000 cubic yards of expanded perlite valued at Can$832,000 was produced from the imported crude material. The quantity expanded was 18 percent less and its value was 17 percent less than in 1959. Seven companies processed perlite at eight plants in Alberta, British Columbia, Manitoba, Ontario, and Quebec.

Prices for expanded perlite were quoted at 25 to 35 cents a cubic foot in bags of 3 to 4 cubic feet.

In 1960, 86 percent of the expanded perlite was used as an aggregate in plaster, compared with 81 percent in 1959 and 91 percent in 1958; 5 percent was used as an aggregate in insulating concrete, compared with 13 percent in 1959 and 3 percent in 1958; and 9 percent was used in acoustic tile and plaster, insulation, stucco, horticulture, and for a few miscellaneous purposes, compared with 6 percent in both 1959 and 1958.[4]

U.S.S.R.—Deposits estimated to contain 21 million cubic yards of perlite were found in Buryat, A.S.S.R., near the southern tip of Lake Baikal. Expanding plants were built, and commercial production was started. The capacity and output of the plants were not revealed.[5]

[3] Mining Journal (London). Mining Miscellany. V. 256, No. 6547, Feb. 10, 1961, p. 157.
[4] Wilson, H. S. Lightweight Aggregates 1960 (Preliminary). Canadian Min. Ind. Dept., Min. and Tech. Surveys, Ottawa, Rev. No. 29, 1960, pp. 1–5.
[5] Mining Journal (London). Mining Miscellany. V. 258, No. 6595, Jan. 12, 1962, p. 40.

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TECHNOLOGY

A paper was presented containing information on the history, geology, mining, milling, processing, uses, and outlook for perlite.[6]

Perlite from Arizona, California, Colorado, Nevada, New Mexico, and Utah was discussed in an article that contained information on history, definitions, specifications, geology, petrology, mining, milling, expansion, uses, substitutes, research, development, reserves, production, consumption, prices, and a bibliography.[7]

Yearly production, the quantity used as a filter aid, and the cost of perlite were estimated in an article which described the growth of the filter aid industry. A short history of the leading perlite producers was included.[8]

Some grades of perlite were said to be described as better filter aids than diatomite. Perlite formed filter cakes with densities 20 to 30 percent lower than comparable diatomite grades. When other requirements of the filtration could be met satisfactorily, the lower density of perlite cake was advantageous.[9]

Fifteen brands of high-temperature block insulation, including some made of perlite, were evaluated for petrographic composition, bulk density, permeability, modulus of rupture, resistance to water disintegration, hot compressive strength, refractoriness, and thermal conductivity.[10]

Expanded perlite powder was considered as an insulator for cryogenic applications.[11]

The relation of the properties of various aggregates, including perlite, in plaster were discussed; methods of testing expanded perlite were proposed; data on the strength and dimensional changes in perlite plaster were described.[12]

The Perlite Institute, New York, N.Y., issued information on the use of perlite in insulating concrete. Detailed instructions on transit and job mixing were included.[13] Another release by the same organization contained data on perlite as a lightweight plaster aggregate. Detailed specifications for perlite applications in plaster and in fireproofing were given.[14]

A method of and an apparatus for expanding perlite or exfoliating vermiculite was patented.[15]

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[6] Barnes, Richard E. The Perlite Industry. Paper pres. at AIME, St. Louis, Mo. (Preprint No. 61H83), Feb. 26–Mar. 2, 1961, 11 pp.

[7] Sharps, Thomas I. Perlite in Colorado and Other Western States. Colorado Sch. Mines, Miner. Ind. Bull., v. 4. No. 6, November 1961, pp. 1–16.

[8] Chemical Week. In the Bag: Filter-Aid Growth. V. 89, No. 6, Aug. 12, 1961, pp. 33–35.

[9] Jackson, Thomas M., Jr. Filter Aids Speed Up "Difficult" Filtrations. Chem. Eng., v. 68, No. 6, Mar. 20, 1961, pp. 141–146.

[10] Eusner, G. R., and J. T. Shapland. Block Insulation for Stoves and Bustle Pipes. Am. Ceram. Soc. Bull., v. 40, No. 7, July 1961, pp 439–444.

[11] Materials in Design Engineering. The Role of Materials in Cryogenics. V. 54, No. 1, July 1961, p. 14. La Fave, I. V., and I. L. Wisemiller (assigned to Chicago Bridge & Iron Co.). Insulated Cyrogenic Storage Tank. U.S. Pat. 2,999,366, Sept. 12, 1961.

[12] Russell, J. J., F. A. Blakey, and R. D. Hill. Mechanical Properties and Dimensional Changes of Some Perlite Plasters. Commonwealth Sci. and Ind. Res. Organization, Division of Building Res., Melbourne, Australia, Tech. Paper No. 9, 1960, 32 pp.

[13] Perlite Institute, Inc. Perlite Concrete. Sec. 1C, Perlite Design Manual, 1961.

[14] Perlite Institute, Inc. Perlite Lightweight Plaster Aggregate Catalog. A.I.A. File Nos. 21–A–5 and 21–C–1, 1961.

[15] Robinson, D. W. (assigned to Zonolite Co.). Method of and Apparatus For Heat Processing Particulate Solids. U.S. Pat. 3,010,911. Nov. 28, 1961.

A patent was granted for a filter aid composition made of expanded perlite particles of less than 200-mesh and a nonswelling montmorillonite clay.[16]

A filtering composition used in producing evaporator plates for air-conditioning units was developed.[17]

A method of making a ready-mixed gypsum plaster containing expanded perlite or exfoliated vermiculite and a wetting-antifoaming agent was patented.[18]

Another patent on an improved plaster mix for acoustical or heat-insulating purposes using perlite was granted.[19]

A plastic insulating composition consisted of expanded perlite or exfoliated vermiculite, asbestos fiber, and other materials.[20]

Two types of refractory materials consisting of expanded perlite and a ceramic bond were developed in Hungary. One type was reported to withstand temperatures up to 900° C. and the other to 1,350° C. Both have heat insulating properties reported to be superior to other Hungarian and foreign refractories.[21]

Perlite ore admixed with a white refractory metal oxide was heated in the range of 1,500° to 2,100° F. to expand the particles. The patented product was said to have improved light-reflecting properties.[22]

A process for making thermal insulating shapes with about 48 percent 100-mesh expanded perlite particles, 10 percent chrysotile, 12 percent swelling bentonite, 15 percent plastic magnesia, and 15 percent calcined diatomite was patented.[23]

Two patents were granted on compositions for refractories. One was for a lightweight castable refractory using 6 to 12 percent expanded perlite[24] and the other for a basic refractory in insulating shapes, containing 15 to 25 percent expanded perlite.[25]

A patent was issued for a water-repellent aggregate made by mixing hot bituminous particles with a lightweight aggregate such as expanded perlite.[26]

A lightweight and water-impervious blasting plug was patented. It consisted of a shaped mixture of cement, mortar, and a lightweight aggregate such as expanded perlite.[27]

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[16] McCollum, Louis S., and Sol Gindoff (assigned to International Minerals & Chemical Corp.). Filter Aid. U.S. Pat. 2,967,149, Jan. 3, 1961.

[17] Breiner, R. C., and R. G. Quinn (assigned to Johns-Manville Corp.). Humidifier Plates. U.S. Pat. 3,007,841, Nov. 7, 1961.

[18] Hampton, A. L. (assigned to U.S. Gypsum Co.). Plaster Composition. U.S. Pat. 2,980,548, Apr. 18, 1961.

[19] Sucetti, G. Dry Plaster Mix Comprising Aggregate, Clay, Cellulose Derivative and Amine Aldehyde Resin. U.S. Pat. 2,993,016 July 18, 1961.

[20] Sucetti, G. Insulating Composition Containing Sodium Carboxymethylcellulose, Aluminum Acetate and Polyvinyl Acetate. U.S. Pat. 2,993,017, July 18, 1961.

[21] Mining Journal (London). New Refractory Material. V. 257, No. 6592, Dec. 22, 1961, p. 657.

[22] Houston, H. H. (assigned to International Minerals & Chemical Corp.). Improving the Light Reflectance of Expanded Perlite Material. U.S. Pat. 2,977,240, Mar. 28, 1961.

[23] Heilman, R. H., R. W. Ortmiller and A. P. Mueller (assigned to The Philip Carey Mfg. Co.). Insulation Material and Method of Making Same. U.S. Pat. 2,971,878, Feb. 14, 1961.

[24] Charles, G. W., and A. R. Lesar (assigned to A. P. Green Fire Brick Co.). Lightweight Refractory Castable and Method of Manufacture. U.S. Pat. 3,010,835, Nov. 28, 1961.

[25] Miller, E. D., Jr. (assigned to Harbison-Walker Refractories Co.). Basic Refractory Insulating Shapes. U.S. Pat. 3,008,842, Nov. 14, 1961.

[26] Goff, D. C., and G. E. Ziegler (assigned to Zonolite Co.). Water Repellent Aggregate. U.S. Pat. 3,010,840, Nov. 28, 1961.

[27] Edney, R. E., and R. McGee (said McGee assigned to said Edney). Blasting Plug. U.S. Pat. 2,995,087, Aug. 8, 1961.

Expanded perlite fines were used to improve the weight-suspending ability of a water-in-oil emulsion well fluid.[28]

Foreign patents not formerly issued in the United States were granted on a method of making an improved filter aid with expanded perlite;[29] a process for making a thermal insulating powder of low sensitivity to pressure changes from a mixture of 85 percent expanded perlite and the remainder of sand or silica aerogel;[30] a fire-resistant acoustic ceiling panel made of gypsum plaster, expanded perlite or vermiculite, and mineral wool;[31] and a process of manufacturing an insulating material of expanded perlite, sodium silicate, and calcium chloride.[32]

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[28] Van Dyke, O. W., and W. A. Reddie (assigned to Magnet Cove Barium Corp.). Water-In-Oil-Emulsion Well Fluid and Materials for Preparing Same. U.S. Pat. 3,006,845. Oct. 31, 1961.

[29] Kenny, J. W., Jr., and A. R. Bollaert (assigned to Great Lakes Carbon Corp.). Canadian Pat. 619,785, May 9, 1961.

[30] Matsch, L. C. (assigned to Union Carbide Corp.). Canadian Pat. 614,213, Feb. 7, 1961.

[31] Harris, J. Australian Pat. 232,806, Feb. 17, 1961.

[32] Spivak-Slonitskii, O. V., M. A. Al'tshuler, and A. G. Sviridov. Soviet Pat. 129,528, June 15, 1960.

Phosphate Rock

By Richard W. Lewis [1] and Gertrude E. Tucker [2]



MARKETABLE phosphate-rock production in the United States in 1961 increased for the fourth consecutive year and was 6 percent above 1960. Marketable rock sold or used by producers did not keep pace with production and increased only 4 percent. A world production record was also set, which was an increase of 7 percent over 1960, the previous record year. U.S. imports were 4 percent higher. Exports as reported by domestic phosphate-rock producers declined 2 percent.

TABLE 1.—Salient phosphate rock statistics

(Thousand long tons and thousand dollars)

	1952-56 (average)	1957	1958	1959	1960	1961
United States:						
Mine production	[1] 44,398	45,460	46,459	49,249	54,338	60,535
P_2O_5 content	[1] 5,395	5,315	5,805	6,048	6,552	8,017
Marketable production	13,280	13,976	14,879	15,869	17,516	18,559
P_2O_5 content	4,213	4,356	4,668	4,939	5,443	5,804
Value	$81,812	$87,689	$93,693	$98,758	$117,041	$130,535
Average per ton	$6.16	$6.27	$6.30	$6.22	$6.68	$7.03
Sold or used by producers	12,836	14,597	14,757	16,065	17,202	17,842
P_2O_5 content	4,070	4,564	4,616	5,014	5,352	5,551
Value	$79,673	$91,718	$92,842	$99,657	$115,363	$125,593
Average per ton	$6.21	$6.28	$6.29	$6.20	$6.71	$7.04
Imports for consumption [3]	112	110	108	140	129	134
Value	$2,658	$3,090	$2,944	$3,421	$3,754	$3,629
Average per ton	$23.73	$28.21	$27.21	$24.45	$29.04	$27.08
Exports [3]	2,122	3,010	2,694	3,048	3,994	3,918
P_2O_5 content	698	977	887	956	1,290	1,261
Value	$13,404	$20,070	$18,060	$20,466	$26,632	$26,924
Average per ton	$6.32	$6.67	$6.70	$6.71	$6.67	$6.87
Consumption, apparent [4]	10,826	11,697	12,171	13,157	13,337	14,058
World: Production	29,390	32,640	35,290	37,890	40,870	43,770

[1] Average annual production, 1953-56.
[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.

DOMESTIC PRODUCTION

Although the total U.S. production of phosphate rock was a record high in 1961, the Western States producers reported a decrease of 22 percent from the output of marketable rock in the preceding year. Florida and Tennessee producers were responsible for the U.S. production record by increasing their production 12 and 15 percent,

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

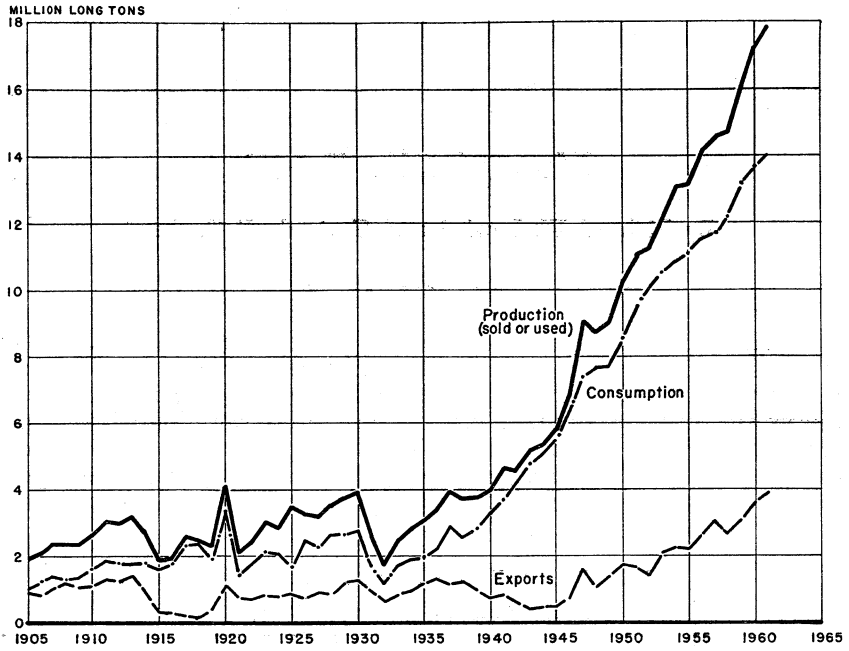


FIGURE 1.—Production (sold or used), apparent consumption, and exports of phosphate rock, 1905–61.

respectively. Florida furnished 74 percent of the total domestic output of marketable phosphate rock; the Western States contributed 14 percent; Tennessee, 12 percent.

The phosphate industry continued active in expanding its facilities in Florida. American Cyanamid Co. expanded its Brewster operations, raising its capacity for producing phosphoric acid to 400,000 tons per year. Armour Agricultural Chemical Co. installed two new dust collectors in its phosphate mill near Bartow, was constructing a new phosphate processing plant at Fort Meade to be completed early in 1962, ordered a 35-cubic-yard dragline excavator for mining rock to feed the Fort Meade plant, and purchased 880 acres of Polk County phosphate land, about 3 miles west of Fort Meade. W. R. Grace & Co., Davison Chemical Division, installed a new dragline excavator at the Bonny Lake operations. Another 35-cubic-yard dragline was being installed by International Minerals & Chemical Corp. (IMC) at the Achan mine, 4 miles south of Mulberry. IMC also added a 100,000-ton-per-year diammonium phosphate unit to its Bonnie phosphate-chemicals plant and was constructing a new plant to calcine rock at Noralyn, 4 miles south of Bartow. A new phosphoric acid plant at Bartow was put into operation by Swift & Co. U.S. Phosphoric Products Division, Tennessee Corp., planned a 50-percent increase in capacity of its Tampa facilities for superphosphates, phosphoric acid, and diammonium phosphate. Expansion of facilities for producing calcined phosphate rock at the Nichols plant, of Virginia-

Carolina Chemical Corp., was completed, which increased its annual capacity for calcining rock by 400,000 tons.

In Tennessee, Hooker Chemical Corp. purchased the former Tennessee Valley Authority (TVA) plant at Godwin from International Minerals & Chemical Corp. Hooker also bought some undeveloped phosphate reserves in the State and leased mineral rights in the Ashwood, Darks, Mill, Shady Grove, and Centerville areas.

Construction was started on a $3 million, 25,000-kilowatt rotating electric furnace for producing elemental phosphorus at Muscle Shoals, Ala., by TVA. Annual production of the furnace was stated to be 16,000 tons of elemental phosphorus, twice the capacity of any furnace operated by TVA. However, the overall capacity of the plant would remain the same, as the new unit was to replace several smaller furnaces.

TABLE 2.—Mine production of phosphate-rock ore in the United States, by States

(Thousand long tons)

Year	Florida		Tennessee [1]		Western States [2]		Total United States	
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content
1953–56 (average)	39,736	4,310	2,635	538	2,027	547	44,398	5,395
1957	40,584	4,173	2,752	587	2,124	555	45,460	5,315
1958	41,084	4,556	3,003	625	2,372	624	46,459	5,805
1959	43,365	4,679	2,709	556	3,175	813	49,249	6,048
1960	48,007	5,023	2,931	636	3,400	893	54,338	6,552
1961	54,403	6,543	3,321	734	2,811	740	60,535	8,017

[1] Includes brown rock, white rock in 1953–58, and blue rock in 1954–58.
[2] Includes Idaho, Montana, Utah, and Wyoming.

The Western States producers also were expanding their facilities. The Bunker Hill Co. started producing phosphoric acid at its new plant at Kellogg, Idaho. The plant had been completed over 7 months before, but owing to a labor strike had not been operated. Construction work continued on a new assay laboratory and sintering plant. Collier Carbon & Chemical Corp. leased about 30,000 acres of submerged lands, rich in phosphates, off the coast of southern California. Duval Sulphur & Potash Co. and Kern County Land Co. began a joint prospecting and evaluation program of phosphate reserves at Sublette Ridge, near Border, Wyo. International Minerals & Chemical Corp. entered into an agreement with Husky Oil Co. for the purpose of developing a phosphate-rock deposit at Soda Springs, Idaho, which was stated to be the largest known supply of surface-minable phosphate ore in the United States. Consolidated Mining & Smelting Co. of Canada, Ltd. was considering the possibility of building a $4 million plant in western Montana to process phosphate rock. San Francisco Chemical Co. had plans for building five more plants on its Vernal, Utah, property. J. R. Simplot Co. purchased The Anaconda Company ammonium phosphate plant at Anaconda, Mont., and moved it to Pocatello, Idaho, where it was put back into operation. Stauffer Chemical Co. announced that its Victor Chemical Division planned to construct an elemental phosphorus plant at Vernal, Utah.

Other phosphate industry news included the following: General Chemical Division, Allied Chemical Corp., began production of phosphoric acid in new facilities at East St. Louis, Ill. National Phosphate Corp. started expanding its plant in Marseilles, Ill., which when completed in 1962 will triple its phosphoric acid capacity. Northwest Cooperative Mills, Inc., planned a 100,000-ton-per-year ammonium phosphate plant at Pine Bend, Minn., for operation in the summer of 1962. Monsanto Chemical Co. completed a new phosphoric acid plant at Addyston, Ohio, and started producing a 105-percent product. Monsanto also announced plans for the construction of a new plant in Augusta, Ga., to produce phosphoric acid and tripolyphosphate.

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
1952–56 (average)	9,908	3,304	1,550	406	1,822	503	13,280	4,213
1957	10,191	3,352	1,812	469	1,973	535	13,976	4,356
1958	10,851	3,593	1,903	495	2,125	580	14,879	4,668
1959	11,564	3,794	1,755	458	2,550	687	15,869	4,939
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

[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

Apparent consumption in 1961 was again higher than in the preceding year, increasing 5 percent.

Producers reported that 5,551,000 long tons (P_2O_5 content) of phosphate rock was sold or used in 1961, of which 58 percent was used for agriculture, 19 percent for industrial uses, and 23 percent for export.

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
1952–56 (average)	12,836	$79,673	10,826
1957	14,597	91,718	11,697
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

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
1952–56 (average)	86	30	$693	$8.06	75	15	$460	$6.13
1957	80	28	682	8.59	56	12	401	7.15
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
	Land pebble				Total			
	Rock	P_2O_5 content	Value		Rock	P_2O_5 content	Value	
			Total	Average per ton			Total	Average per ton
1952–56 (average)	9,393	3,139	$57,240	$6.09	9,554	3,184	$58,393	$6.11
1957	10,508	3,467	66,863	6.36	10,644	3,507	67,946	6.38
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

[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		Year	Rock	P_2O_5 content	Value	
			Total	Average per ton				Total	Average per ton
1952–56 (average)	1,627	427	$12,102	$7.44	1959	1,775	462	$13,266	$7.47
1957	1,778	459	11,857	6.67	1960	1,927	502	15,319	7.95
1958	1,923	501	13,160	6.84	1961	2,291	592	19,099	8.34

[1] Includes small quantity of Tennessee blue rock in 1954–58 and white rock in 1952–58.

TABLE 7.—Western States phosphate rock sold or used by producers

(Thousand long tons and thousand dollars)

Year	Idaho [1]				Montana [2]				Total			
	Rock	P_2O_5 content	Value		Rock	P_2O_5 content	Value		Rock	P_2O_5 content	Value	
			Total	Average per ton			Total	Average per ton			Total	Average per ton
1952–56 (average)	980	259	$4,430	$4.52	[3] 675	[3] 200	[3] $4,748	$7.03	1,655	459	$9,178	$5.55
1957	1,418	374	6,589	4.65	[3] 757	[3] 224	[3] 5,326	7.04	2,175	598	11,915	5.48
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

[1] Idaho includes Utah in 1952.
[2] Montana includes Utah in 1953–55 and 1961, and Wyoming in 1952–61.
[3] Wyoming data published previously in Phosphate Rock chapters included as follows: 1952–56 (average): 28,000 long tons of rock, 9,000 tons of P_2O_5, valued at $184,000, for 1952 data only; 1957: 182,000 long tons of rock, 58,000 tons of P_2O_5, valued at $1,197,000.

TABLE 8.—Phosphate rock sold or used by producers in the United States, by grades and States

(Thousand long tons)

Year and grade—B.P.L. [1] content (percent)	Florida		Tennessee		Western States		Total United States	
	Quantity	Percent of total	Quantity	Percent of total	Quantity	Percent of total	Quantity	Percent of total
1960:								
Below 60	305	2	1,561	81	1,761	58	3,260	19
60 to 66			293	15			660	4
68 basis, 66 minimum	2,929	24	(2)	(2)	(2)	(2)	3,726	22
70 minimum	1,302	11	[2] 73	[2] 4	[2] 1,263	[2] 42	[3] 1,841	[3] 10
72 minimum	2,209	18			(2)	(2)	2,209	13
75 basis, 74 minimum	3,920	32					3,920	23
77 basis, 76 minimum	1,586	13					1,586	9
Total	12,251	100	1,927	100	3,024	100	17,202	100
1961:								
Below 60	83	1	2,034	89	1,561	56	3,678	21
60 to 66	125	1			733	27	378	2
68 basis, 66 minimum	2,767	22	257	11			3,430	19
70 minimum	2,073	16			[2] 478	[2] 17	[4] 2,625	[4] 15
72 minimum	1,831	14			(2)	(2)	1,831	10
75 basis, 74 minimum	4,484	35			(2)	(2)	4,484	25
77 basis, 76 minimum	1,416	11					1,416	8
Total	12,779	100	2,291	100	2,772	100	17,842	100

[1] Bone phosphate of lime, $Ca_3(PO_4)_2$.
[2] Figures combined to avoid disclosing individual company confidential data.
[3] Includes 72 grade rock in Western States.
[4] Includes 72 and 75/74 grade rock in Western States.

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_2O_5 content	Rock	P_2O_5 content
1960:								
Domestic:								
Agricultural:								
Ordinary superphosphate	4,000	1,350	(1)	(1)	(1)	(1)	4,270	1,436
Triple superphosphate [2]	3,538	1,160	114	36	817	258	4,199	1,368
Direct application to soil	528	163	64	19	(3)	(3)	592	182
Stock and poultry feed	285	90	-------	------	(3)	(3)	285	90
Other [4]	34	11	6	1	6	2	46	14
Total	8,385	2.774	184	56	823	260	9,392	3,090
Industrial:								
Elemental phosphorus, ferrophosphorus, phosphoric acid	387	116	1,733	443	1,684	409	3,804	968
Other [5]	-------	-------	10	3	2	1	12	4
Total	387	116	1,743	446	1,686	410	3,816	972
Exports [6]	3,479	1,129	-------	------	515	161	3,994	1,290
Grand total	12,251	4,019	1,927	502	3,024	831	17,202	5,352
1961:								
Domestic:								
Agricultural:								
Ordinary superphosphate	4,316	1,454	(1)	(1)	(1)	(1)	4,462	1,501
Triple superphosphate [2]	3,924	1,296	72	23	644	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]	(7)	(7)	1	(8)	20	6	21	6
Total	9,006	2,990	148	46	664	207	9,818	3,243
Industrial:								
Elemental phosphorus, ferrophosphorus, phosphoric acid	377	114	2,135	544	1,586	387	4,098	1,045
Other [5]	-------	-------	8	2	-------	------	8	2
Total	377	114	2,143	546	1,586	387	4,106	1,047
Exports [6]	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

[1] Included with triple superphosphate.
[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] Includes phosphate rock used in pig iron blast furnaces, parting compounds, research, defluorinated phosphate rock, refractories, and other applications.
[6] As reported to the Bureau of Mines by domestic producers.
[7] Included with stock and poultry feed.
[8] Less than 1,000 tons.

STOCKS

Producer's stocks at the end of 1961 were 19 percent higher than at yearend 1960.

TABLE 10.—Producer stocks of phosphate rock, December 31 [1]

(Thousand long tons)

Source	1960		1961	
	Rock	P_2O_5 content	Rock	P_2O_5 content
Florida	2,484	820	3,494	1,149
Tennessee [2]	258	74	202	57
Western States	[3] 991	[3] 263	754	204
Total	3,733	1,157	4,450	1,410

[1] As reported to the Bureau of Mines by domestic producers.
[2] Includes a quantity of washer-grade ore (matrix).
[3] Includes inventory adjustments.

PRICES

Prices for Florida land-pebble phosphate rock remained firm through August, as quoted by Oil, Paint and Drug Reporter. The September 6, 1961, issue quoted a 23-cent-per-ton increase on all grades. The price was based on fuel oil at $2.52 per barrel and labor at $1.72 per hour. Prices were then steady to the end of the year.

Tennessee and Western States phosphate-rock prices were not quoted in the trade journals.

TABLE 11.—Prices of Florida land pebble, unground, washed, and dried phosphate rock, in bulk, carlots, at mine, in 1961

(Per short ton)

Grade (percent B.P.L.)	January 2	December 25
66/68	$4.989–5.398	$5.22–5.629
68/70	5.849–5.858	6.08–6.089
70/72	6.429–6.438	6.66–6.669
74/75	7.329–7.338	7.56–7.569
76/77	8.219–8.228	8.45–8.459

Source: Oil, Paint and Drug Reporter.

FOREIGN TRADE [3]

Imports.—The quantity of crude phosphates imported was nearly 4 percent greater in 1961 than in the preceding year, but the value was $125,500 less. All fertilizer import items increased in tonnage except ammoniated superphosphate and ammonium phosphates, which declined slightly. However, ammonium phosphate remained the highest valued single item. Guano shipments increased to nearly $1 million, ranking third in value of fertilizer imports.

TABLE 12.—U.S. imports for consumption of phosphate rock and phosphatic fertilizers

Fertilizer	1960		1961	
	Long tons	Value	Long tons	Value
Phosphates, crude, not elsewhere specified	129,290	$3,754,425	134,004	$3,628,897
Superphosphates (acid phosphate):				
Normal (standard)	1,112	27,431	1,151	24,797
Concentrated (treble)	915	55,258	1,946	135,522
Ammoniated	237	17,182	140	10,188
Total superphosphates	2,264	99,871	3,237	170,507
Ammonium phosphates, used as fertilizer	107,087	7,464,663	100,887	7,471,148
Bone dust, or animal carbon and bone ash, fit only for fertilizer	8,225	533,280	9,673	786,542
Guano	[1] 1,797	[1] 163,067	9,362	977,754
Slag, basic, ground, or unground			46	1,281
Dicalcium phosphate (precipitated bone phosphate) all grades	5,164	282,665	10,149	516,673

[1] Revised figure.

Source: Bureau of the Census.

Exports.—Total phosphate-rock exports were lower than in 1960 in both quantity and value by 3 and 2 percent, respectively, according to data from Bureau of the Census. Exports to Japan were 120,700 tons less than in 1960. Japan, however, remained the leading customer, taking 32 percent of the total. Foreign demand for superphosphates was greater, and about 13 percent more was exported than in 1960. Three countries were chiefly responsible for the increase—Mexico, Indonesia, and the Republic of Korea.

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

TABLE 13.—U.S. exports of phosphate rock, by grades and countries

Grade and destination	1960		1961	
	Long tons	Value	Long tons	Value
Florida phosphate rock:				
North America:				
Bahamas	27	$864		
Canada	294,730	2,725,248	378,216	$3,532,409
Costa Rica	187	2,079	295	3,147
Cuba	28,302	270,968		
El Salvador	179	4,638	171	2,121
Haiti			28	290
Mexico	70,897	475,646	62,998	465,764
South America:				
Argentina	2,034	20,280		
Brazil	41,552	415,336	44,332	495,219
Chile	1,929	38,145	1,922	28,362
Colombia	1,303	14,530	3,124	38,190
Peru	13,453	121,068	11,991	112,638
Uruguay	17,257	177,085	12,890	147,688
Venezuela	89	2,066	627	8,999
Europe:				
Belgium-Luxembourg			3,029	31,798
Czechoslovakia	16,505	148,549		
Denmark	29,139	262,265	52,638	477,099
France			11,106	111,279
Finland	7,639	69,540	26,169	246,547
Germany:				
East	9,221	63,154		
West	[1] 396,020	[1] 3,212,641	298,248	2,468,450
Greece	22,437	197,944	20,871	187,839
Ireland	15,806	142,261		
Italy	548,934	4,475,267	682,722	5,683,487
Netherlands	192,390	1,676,188	160,479	1,496,525
Norway	8,685	77,837	7,838	74,458
Spain	125,598	1,161,976	30,072	270,548
Sweden	62,870	588,151	43,649	450,834
Switzerland	2,004	21,649	3,968	41,092
United Kingdom	274,024	2,321,403	266,206	2,289,819
Asia:				
India	28,485	284,867	1,005	6,241
Israel			39	872
Japan	1,437,102	10,906,517	1,316,373	10,638,961
Korea, Republic of	15,182	269,441		
Pakistan			62	526
Philippines	6,480	65,987	34,508	304,443
Taiwan			36,874	344,551
Viet-Nam	11,735	209,532	743	13,137
Africa: Union of South Africa	20,887	187,977	877	6,225
Total	[1] 3,703,082	[1] 30,611,099	3,514,070	29,979,558
Other phosphate rock: [2]				
North America:				
British Honduras			29	400
Canada	542,527	6,887,836	583,915	6,656,144
El Salvador	89	1,532		
Mexico	34	915	51	754
South America:				
Brazil	3,002	30,079		
Chile	986	15,630		
Uruguay			11,058	114,517
Venezuela	1,250	37,500	5,876	62,092
Europe:				
Italy			208	12,227
United Kingdom			249	2,802
Asia:				
Taiwan			5,717	53,670
Viet-Nam			1,559	27,490
Total	547,888	6,973,492	608,662	6,930,096
Grand total	[1] 4,250,970	[1] 37,584,591	4,122,732	36,909,654

[1] Revised figure.
[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	1960		1961	
	Long tons	Value	Long tons	Value
North America:				
Bahamas	220	$8,577	397	$16,211
Canada	169,621	6,037,060	167,316	5,347,166
Costa Rica	1,785	99,414	1,817	108,753
Cuba	43,693	1,618,822		
Dominican Republic	3,748	257,371	4,730	329,193
El Salvador	400	28,275	835	41,009
Guatemala	54	2,585	357	22,357
Jamaica	20	1,276	93	6,529
Mexico	15,357	996,567	35,805	2,382,159
Nicaragua	5	236	45	1,275
Panama	167	11,300	277	17,988
Trinidad and Tabago	150	10,088		
Other	24	1,753	96	6,708
South America:				
Argentina	310	18,765	1,477	43,587
Brazil	54,803	3,044,132	58,205	2,965,214
Chile	36,499	2,369,044	46,797	2,902,751
Colombia	4,168	279,102	1,525	102,160
Ecuador	250	17,286	329	22,425
Peru	2,640	64,890	53	5,655
Venezuela	9,595	612,979	7,620	485,488
Other	99	6,786	29	938
Europe:				
Denmark			40	1,000
Germany, West	206	11,088	344	18,662
Ireland	1,792	98,327		
Netherlands	15,103	793,846	12,587	644,926
Sweden	10	624		
United Kingdom			8	684
Asia:				
Hong Kong	5,303	375,366		
India			1,476	96,960
Indonesia	27	1,953	37,822	2,125,982
Korea, Republic of	36,525	2,116,353	88,586	5,966,056
Pakistan	11,351	792,000	24	1,454
Philippines	2,953	201,536	491	31,000
Viet-Nam	36	3,182		
Other	5	462	16	1,200
Africa: Libya	7	585		
Oceania: Trust Territory of the Pacific Islands	5	502		
Total	416,931	19,882,132	469,197	23,695,490

Source: Bureau of the Census.

WORLD REVIEW

NORTH AMERICA

Canada.—Cyanamid of Canada, Ltd., planned new facilities to produce diammonium phosphate and granular triple superphosphate at Welland, Ontario.[4] Electric Reduction Co. of Canada, Ltd. (ERCO), brought a new 70,000-ton-per-year phosphate plant into production. ERCO, subsidiary of Albright & Wilson Ltd., United Kingdom, expected to market at least 25,000 tons (P_2O_5 content) in North Central United States. It was stated that up to 500,000 tons of Florida phosphate rock would be imported annually by the new plant. Products were reported to be normal and triple superphosphates, phosphoric acid, liquid phosphates for fertilizers, and dicalcium phosphate for animal feed.[5]

[4] Commercial Fertilizer. Around the Map: Canada. V. 103, No. 5, November 1961, p. 53.
[5] Chemical & Engineering News. Ontario Gets Superphosphate Plant. V. 39, No. 43, Oct. 23, 1961, p. 38.

TABLE 15.—World production of phosphate rock by countries [1] [2]

(Thousand long tons)

Country [1]	1952–56 (average)	1957	1958	1959	1960	1961
North America:						
United States	13,280	13,976	14,879	15,869	17,516	18,559
Netherlands Antilles (exports)	107	105	85	97	113	144
Total	13,387	14,081	14,964	15,966	17,629	18,703
South America:						
Brazil:						
Apatite	39	124	111	131	200	[3] 200
Phosphate rock		200	524	860	666	[3] 69
Chile:						
Apatite	52	32	18	20	17	17
Guano	40	34	31	21	[3] 21	17
Peru (guano)	282	281	164	107	144	156
Venezuela	[4] 30	146				
Total	443	817	848	1,139	1,048	[3] 1,080
Europe:						
Belgium	34	16	18	13	8	14
France	99	92	102	76	[3] 75	[3] 75
Spain	20	[5]		[5]	3	[3] 3
Sweden (apatite)	6					
U.S.S.R.:						
Apatite [3]	3,090	3,940	3,940	3,940	4,230	4,530
Sedimentary rock	1,335	1,720	1,970	1,970	2,260	3,050
Total [1]	4,830	6,000	6,280	6,250	6,820	7,920
Asia:						
China [3]	140	200	300	500	600	600
Christmas Island (Indian Ocean) (exports)	342	336	374	494	503	694
India (apatite)	4	9	15	14	14	20
Indonesia	1	4	2	10	7	9
Israel	59	150	206	201	221	222
Jordan	100	258	289	332	356	365
Korea, North	[6]	[6]	[6]	[6]	[6]	[3] 50
Philippines (guano)	3	4	8	[5]	10	[5]
Sarawak (guano)	1	[5]	[5]	1	[3] 1	[5]
Viet-Nam, North:						
Apatite	[6]	55	133	256	482	568
Phosphate rock	[6]	22	32	50	50	[3] 50
Total [1] [3]	715	1,070	1,390	1,890	2,285	2,580
Africa:						
Algeria	680	603	552	563	554	419
Malagasy Republic (Madagascar)	2	3	5	7	5	[3] 5
Morocco: Souther zone	4,720	5,480	6,236	7,050	7,354	7,824
Rhodesia and Nyasaland, Federation of: Southern Rhodesia				2	3	[5]
Senegal:						
Aluminum phosphate	67	88	103	94	104	[3] 100
Calcium phosphate	16				106	[3] 100
Seychelles Islands (guano)	7	6	17	6	7	[3] 7
South-West Africa (guano)	1	3		1		1
Togo						278
Tunisia	1,985	2,035	2,243	2,150	2,063	1,950
Uganda	4	3	2	3	4	[5]
Union of South Africa	111	166	213	228	263	292
United Arab Republic (Egypt)	552	576	549	668	558	[3] 560
Total	8,145	8,963	9,920	10,772	11,021	11,536
Oceania:						
Angaur Island (exports)	91					
Australia	6	11	7	5	2	[3] 2
Makatea Island (French Oceania)	241	304	320	362	398	363
Nauru Island (exports)	1,243	1,105	1,234	1,192	1,351	1,282
Ocean Island (exports)	285	292	324	314	320	301
Total	1,866	1,712	1,885	1,873	2,071	1,948
World total (estimate) [1] [2]	29,390	32,640	35,290	37,890	40,870	43,770

[1] Poland produces phosphate rock, but data of output are not available; estimates have 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. A negligible amount is produced in Jamaica, Japan Mozambique, Somalia Republic, and Tanganyika.

[3] Estimate.

[4] One year only as 1956 was first year of commercial production.

[5] Less than 500 tons.

[6] Data not available; estimate by senior author of chapter included in the total.

Compiled by Liela S. Price, Division of Foreign Activities.

Mexico.—Guanos y Fertilizantes de México, S.A., completed a new 50,000-ton-per-year triple superphosphate plant in the Minatitlan and Coatzacoalcos area of Veracruz.[6]

Netherlands Antilles.—Aruba Chemical Industries, N.V., a new company, was established and plans were made to build and operate a group of six plants including one for producing phosphoric acid.[7]

SOUTH AMERICA

Argentina.—Albright & Wilson Ltd., United Kingdom, and Villa Aufricht of Buenos Aires were reported to have entered into an agreement to establish a phosphoric acid plant in Argentina and were expected to begin producing early in 1962.[8]

Brazil.—Plans were made by Cia. de Superfosfatos e Productos Qúimicos to build a plant in Capuavo, San Paulo, with capacity to produce 40,000 tons of superphosphates, 50,000 tons of sulfuric acid, and 12,000 tons of phosphoric acid annually.[9] Fosforita Olmida, S.A., planned to increase annual mining capacity from the existing 250,000 tons to 350,000 tons by 1965. Also included in the proposed expansion were new plants to produce triple superphosphate, sulfuric acid, and phosphoric acid.[10] A dicalcium phosphate plant was part of the planning of Carbocloro-Industrias Qúimicas Ltda. at Cubatao. Construction was started on an electrolytic caustic-chlorine plant, and production of hydrochloric acid and dicalcium phosphate was expected to begin in 1963.[11]

Colombia.—Plans for a 100,000-ton-per-year triple superphosphate plant were initiated by Instituto de Fomento Industrial. Tenders for a study of the project were invited from firms in Italy, West Germany, and the United States.[12]

Peru.—One of the largest phosphate-rock deposits in the world, found in the Sechura Desert, was extensively explored by Minerales Industriales del Peru, S.A. The company began drilling in 1959, and more than 15,000 feet of 2-inch core had been obtained by May 1961. The areas drilled indicated a quantity of ore containing the equivalent of 561 million tons of phosphate rock upgraded to 31 percent P_2O_5. The concessions held by the company covered 1,852,500 acres in the western Sechura Desert in the Department of Piura, extending from latitude 5°10′ S. to latitude 6°34′ S. and longitude 80°15′ W. to longitude 81°2′ W.[13]

EUROPE

Austria.—At Carinthia, Bleiberger Bergwerk-Union began operating a new superphosphate plant of 30,000-ton-per-year capacity.[14]

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[6] Bureau of Mines. Mineral Trade Notes. V. 54, No. 2, February 1962, p. 43.
[7] Chemical Engineering. CPI News Briefs: Netherlands West Indies. V. 68, No. 9, May 1, 1961, p. 124.
[8] Commerical Fertilizer. Around the Map: Argentina. V. 103, No. 5, November 1961, p. 53.
[9] Commercial Fertilizer. Around the Map: Brazil. V. 102, No. 6, June 1961, pp. 30, 32.
[10] Bureau of Mines. Mineral Trade Notes. V. 52, No. 4, April 1961, p. 40.
[11] Chemical Engineering. CPI News Briefs-International. V. 68, No. 19, Sept. 18, 1961, p. 228.
[12] Mining Journal (London). Superphosphate Plant for Colombia. V. 257, No. 6588, Nov. 24, 1961, p. 546.
[13] Bureau of Mines. Mineral Trade Notes. V. 54, No. 2, February 1962, pp. 44–48.
[14] Chemical Age (London). Overseas News: Austrian Superphosphates Plant on Stream. V. 86, No. 2210, Nov. 18, 1961, p. 819.

France.—The Office Nationale Industriel de l'Azote and Cie. Royale Asturienne des Mines, of Belgium, formed a joint company, Sté Astunoria, to produce phosphoric acid at Tonnay-Charente. First production was expected early in 1963. [15]

Germany, West.—A new phosphoric acid plant with a 60-ton P_2O_5 daily capacity was under construction at Castrop-Rauxel for Gewerkschaft Victor Chemische Werke.[16]

Greece.—A new superphosphate plant of an annual capacity of 55,000 tons P_2O_5 content was planned for Kavalla in northern Greece.[17]

Ireland.—Albatross-Windmill Fertiliser Co., Ltd., planned to construct a new superphosphate plant adjacent to its existing plant at New Ross, County Wexford. Production of 100,000 tons of superphosphate annually was expected by 1962.[18]

Netherlands.—Albatros Superphosphate Works announced plans to construct a 100,000-ton-per-year superphosphate plant at Pernis. The plant was scheduled for completion in 1962.[19]

U.S.S.R.—A 3-year trade agreement was concluded with West Germany, which would supply a number of chemical plants, one of which was to be for manufacturing phosphorus during 1961–63.[20]

United Kingdom.—Construction of two phosphoric acid plants was started; one at Belfast for Richardson's Chemical Manure Co., Ltd., and the other for Scottish Agricultural Industries Ltd. in connection with a project underway to convert the Sandilands, Aberdeen, works from superphosphates to ammonium phosphate.[21]

Yugoslavia.—A new copper smelter at Bor began operating enabling the newly erected sulfuric acid plant at Bor and the superphosphate plant at Prahovo to start production. The annual capacity of the Prahovo plant was stated as 570,000 tons.[22]

ASIA

Cambodia.—The Superior Council of the Ministry of Plans voted to form a company to finance the construction and operation of a phosphate plant at Tuk Meas. The proposed plant, with an annual capacity of 12,000 tons of phosphate, will be supplied with phosphate rock from deposits in Kampot Province which Cambodians started mining early in 1961.[23]

India.—An ammonium phosphate factory was under construction at Ennore, about 8 miles north of Madras, and was scheduled for production by the middle of 1962.[24] The Fertilizers & Chemicals, Travancore, Ltd., invited bids for building a 100-ton-per-day phosphoric acid plant and a 300-ton-per-day ammonium phosphate plant.[25]

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[15] Chemical Trade Journal and Chemical Engineer (London). New Phosphoric Acid Plant for France. V. 149, No. 3882, Oct. 27, 1961, p. 924.
[16] Sulfur Institute News. Phosphoric Acid. V. 1, No. 10, November 1961, p. 3.
[17] Commercial Fertilizer. Around the Map: Greece. V. 103, No. 5, November 1961, p. 53.
[18] Bureau of Mines. Mineral Trade Notes. V. 52, No. 6, June 1961, p. 33.
[19] Bureau of Mines. Mineral Trade Notes. V. 54, No. 2, February 1962, p. 43.
[20] Chemical Trade Journal and Chemical Engineer (London). Notes From Abroad. V. 148, No. 3851, Mar. 24, 1961, p. 660.
[21] Chemical Age (London). W. J. Fraser Handle Two U.S. Phosphoric Acid Plants. V. 86, No. 2214, Dec. 16, 1961, p. 959.
[22] Chemical Trade Journal and Chemical Engineer (London). Jugoslavia's New Plants. V. 149, No. 3872, Aug. 18, 1961, p. 363.
[23] Bureau of Mines. Mineral Trade Notes. V. 53, No. 1, July 1961, p. 32.
[24] Chemical Trade Journal and Chemical Engineer (London). Notes From Abroad. V. 148, No. 3856, Apr. 28, 1961, p. 941.
[25] Commercial Fertilizer. The International Scene: India. V. 103, No. 2, August 1961, p. 46.

Fertilizers were placed high on the priority list in India's third 5-Year Plan which started in April 1961. The government set an annual production goal of 400,000 tons of phosphatic (P_2O_5 content) fertilizers for 1965–66. About 15 plants were expected to go into production by 1962, all operated by privately owned companies. These plants would bring the total number of plants producing single superphosphate in India to 31. Rallis Chemicals, Ltd., was reported to be building a superphosphate plant at Magarwara near Kanpur.[26]

Indonesia.—Construction of a superphosphate plant was scheduled to begin in mid-1961 financed by Soviet credit amounting to the equivalent of U.S. $117.5 million.[27]

Israel.—A U.S. $22.5 million plant expansion including four new units was planned by Negev Phosphates Co., Ltd., in Oran.[28] The government of Israel granted prospecting rights to Israel-American Phosphates Co. of the United States in half the deposit areas at Ein-Yahav and Meishar and the entire deposit at Hor Hahar. Under the agreement, if the operations proved successful, a plant would be built within 4 years to treat at least 500,000 tons of ore annually. Construction of a calcining facility with an annual capacity of 200,000 tons (37 to 38 percent P_2O_5) was started with a completion date set for 1963.[29]

Japan.—Ube Soda Industries Co. planned construction that would double its capacity for producing potassium-ammonium phosphate chloride to 10,000 tons a month. Phosphoric acid production capacity was also to be increased from 23 to 75 tons per day. The construction of a sodium tripolyphosphate plant with a 600-ton-a-month capacity was started and scheduled for completion in September 1961, at which time construction was to start on a second plant of the same capacity.[30]

Turkey.—Gubre Fabrikalari TAO began operating a 100,000-ton-per-year superphosphate facility at Yasimoa, near Izmit.[31]

Viet-Nam.—North Viet-Nam began opening the large phosphate-rock (apatite) deposits near Lao Kay on the northwest boundary with China. These deposits were estimated to contain more than 1 billion tons of ore that would provide China with sorely needed phosphatic fertilizer.[32] Rumania granted a large credit to north Viet-Nam to help increase Vietnamese production of apatite. The credit was to be met by apatite deliveries of 630,000 tons in 1965 and 1 million tons in 1970. Rumania was to deliver equipment and provide the technical assistance necessary to expand production at the Lao Kay mine.[33]

AFRICA

Algeria.—A $25 million phosphate works was under construction at Djebel Onk, one of the world's major phosphate-rock deposits. The total reserve was estimated at 500 million tons, one-fifth of which is available by open-pit mining. Société d'Exploitation du Gisement

[26] Chemical & Engineering News. India Sets Fertilizer Goals for 1965–66. V. 39, No. 25, June 19, 1961, p. 88.
[27] Bureau of Mines. Mineral Trade Notes. V. 52, No. 3, March 1961, p. 27.
[28] Foreign Commerce Weekly. World Trade Leads: Planned Construction Reports. V. 66, No. 13, Sept. 25, 1961, p. 26.
[29] Bureau of Mines. Mineral Trade Notes. V. 53, No. 4, October 1961, p. 43.
[30] Chemical Age (London). Overseas News: Ube Soda to Increase Fertiliser Capacity. V. 85, No. 2182, May 6, 1961, p. 735.
[31] Sulphur Institute News. News of the Industry: Fertilizer. V. 1, No. 10, November 1961, p. 1.
[32] Commercial Fertilizer. The International Scene: Vietnam. V. 103, No. 1, July 1961, p. 58.
[33] Mining Journal (London). Mining Miscellany. V. 256, No. 6549, Feb. 24, 1961, p. 221.

de Phosphate de Chaux du Djebel Onk was to mine the ore. The major shareholder of the company, Compagnie des Phosphates de Constantine, was reported to have a 40-percent interest and the French Government a 34-percent interest. The remaining shares were held by various Algerian development groups. The company expected to be in full production by 1964 with an annual output of 800,000 tons of marketable phosphate rock. Plans were made to roast the raw ore at Djebel Onk and to ship the product to a washer and drying plant at Bône on the Mediterranean, 210 miles north. The treatment plants were expected to cost $8 million and an electric railroad from Djebel Onk to Tebessa, an additional $9 million.[34] Union Phosphatière Africaine, a new phosphate marketing agency, was organized to represent the phosphate-rock producers in Algeria, Tunisia, Senegal, and Togo.[35]

Malagasy Republic.—A hand-mining phosphate-rock operation was reported active on Juan de Nova Island, 109 miles northwest of Maintirano and 261 miles from Majunga. The marketable rock analyzed 29.1 percent phosphoric acid, 44 percent lime, and 8.5 percent water. No estimate of reserves was available.[36]

Morocco.—L'Office Chérifien des Phosphates (OCP), a government-owned agency, announced that it would invest approximately U.S. $50 million over a 4-year period to develop the phosphate industry and to provide social services for the employees. OCP stated that with the installation of a new plant, 3 million tons of enriched phosphate was expected to be produced annually by 1964.[37] Dorr-Oliver Inc. of Stamford, Conn., was engaged by OCP to study the feasibility of a new drying process for phosphate rock including the use of nuclear power as a source of heat.[38]

Rhodesia and Nyasaland, Federation of.—It was reported that African Explosive & Chemical Industries (Rhodesia) Ltd. had requested the Ministry of Commerce and Industry to impose protective import duties on all phosphatic fertilizers. A decision by the Ministry was not reported.[39]

Spanish Sahara.—Instituto Nacional de Industria began organizing for industrial exploitation of its phosphate-rock deposits. Roasting and upgrading the ore were expected to be studied by foreign consulting firms.[40]

Tanganyika.—New Consolidated Goldfields Ltd., began mining a phosphate-rock deposit 70 miles southeast of Arusha. It was indicated that the deposit contained a reserve of 10 million tons of ore with 1 million tons easily accessible. The rock averaged 30 percent P_2O_5, and the company planned to market about 50,000 tons annually in East Africa.[41]

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[34] Foreign Trade (Ottawa). Commodity Notes: Phosphate. V. 115, No. 7, Apr. 8, 1961, p. 33.
[35] Chemical Trade Journal and Chemical Engineer (London). African Phosphate Rock. V. 149, No. 3890, Dec. 22, 1961, p. 1376.
[36] Murdock, Thomas G. Possibilities of Minerals Development in the Malagasy Republic. U.S. Operations Mission to the Malagasy Republic, Mineral Report No. 13, Oct. 10, 1961, p. 25.
[37] Mining Journal (London). Morocco's Phosphate Industry Expands. V. 257, No. 6586, Nov. 10, 1961, p. 477.
[38] Mining Congress Journal. News and Views—Eastern: Morocco Looking at Phosphate Rock Drying Process Utilizing Nuclear Fuel. V. 47, No. 8, August 1961, p. 94.
[39] Fertilizer and Feeding Stuffs Journal (London). Phosphate Duty in Rhodesia. V. 55, No. 12, Dec. 13, 1961, p. 535.
[40] Foreign Commerce Weekly. World Trade Leads: Planned Construction Projects. V. 66, No. 11, Sept. 11, 1961, p. 20.
[41] Mining World and Engineering Record (London). Bush Telegraph Digest. V. 177, No. 4546, January 1961, p. 21.

TABLE 16.—Selected African countries: Exports of phosphate rock in 1961, by countries

(Long tons)

Destination	Algeria	Morocco	Senegal	Togo	Tunisia	Total
North America:						
Canada		98				98
United States				10,060		10,060
South America:						
Brazil		6,593			8,021	14,614
Chile					9,399	9,399
Cuba		50,497				50,497
Peru					1,968	1,968
Uruguay			5,432		16,043	21,475
Europe:						
Austria		122,633				122,633
Belgium		796,742	2,040			798,782
Bulgaria					74,279	74,279
Czechoslovakia		51,322			67,587	118,909
Denmark		207,246		6,116	24,866	238,228
Finland		86,962	6,053			93,015
France	108,506	1,078,347	107,340	17,414	472,312	1,783,919
Germany:						
East		56,789				56,789
West	7,569	657,475	93,398	3,395	63,295	825,132
Greece		59,835			85,353	145,188
Hungary		1,612				1,612
Ireland	4,645	212,094				216,739
Italy	33,278	341,936	3,937		301,889	681,040
Netherlands		370,978	27,209		95,024	493,211
Norway		83,619				83,619
Poland		302,017			127,027	429,044
Portugal		278,314				278,314
Spain	202,728	709,816		2,362	4,577	919,483
Sweden		247,833	8,348		31,626	287,807
Switzerland		25,933			1,870	27,803
United Kingdom	2,382	805,941	8,235		47,921	864,479
Yugoslavia		8,630			69,288	77,918
Asia:						
China		274,065				274,065
India		24,382			52,947	77,329
Indonesia	9,700					9,700
Japan		158,645	72,669	16,653	55,018	302,985
Formosa (Taiwan)		39,074				39,074
Turkey					21,921	21,921
Viet-Nam	5,629					5,629
Africa:						
Canary Islands		15,132				15,132
Rhodesia and Nyasaland, Federation of		72,049				72,049
Union of South Africa		299,223			58,519	357,742
Total	374,437	7,445,832	334,661	56,000	1,690,750	9,901,680

Compiled from Customs Returns by Corra A. Barry, Division of Foreign Activities.

Togo, Republic of.—The first shipment of phosphate by Compagnie Togolaise des Mines de Bénin was reported on September 2, 1961, when 5,000 tons was loaded for shipment to Japan. A 10,220-ton shipment followed, destined for Baltimore, Md. The 750,000-ton-per-year processing plant was reported ready for full operation. The company, 80 percent owned by six French companies and 20 percent by the government of Togo, expected to have an annual export trade of 600,000 tons.[42]

Tunisia.—Compagnie des Phosphates et du Chemin de Fer de Gafsa (Sfax-Gafsa) was reorganized with the Tunisian government acquiring a 50-percent interest. The company requested a U.S. $25 million loan from the Development Loan Fund to purchase and install equipment for upgrading its phosphate ore.[43] Construction was begun

[42] Bureau of Mines. Mineral Trade Notes. V. 53, No. 6, December 1961, pp. 35, 36.
[43] Bureau of Mines. Mineral Trade Notes. V. 53, No. 3, September 1961, p. 36.

on a wet-process phosphoric acid plant and a triple superphosphate plant in Sfax for N.P.K.-Engrais S.A.T., subsidiary of the Swedish A B Förenade Superfosfatfabriker.[44]

Uganda.—Construction was started on a superphosphate plant with an annual output of 25,000 tons for Tororo Industrial Chemicals & Fertilizers Co., Ltd., which was an associated company of Uganda Development Corp., Ltd. Full production was expected in September 1962.[45]

Union of South Africa.—A new superphosphate plant was planned by African Explosives & Chemical Industries, Ltd. The plant was to use phosphate rock from Phalaborwa and sulfuric acid from pyrites of Witwatersrand gold mines.[46] Windmill Fertilizer Co. planned to build a fertilizer facility in Sasolburg, South Africa.[47]

United Arab Republic (Egypt).—The Société Financière et Industrielle d'Egypte awarded a contract for increasing the capacity of the superphosphate facility at Kafr-ez Zaiyat to Bradley Pulverizer Co., London.[48]

TABLE 17.—United Arab Republic (Egypt): Exports of phosphate rock by countries [1]

(Long tons)

Destination	1959	1960
Ceylon	70,708	57,746
Czechoslovakia	36,821	4,444
Germany, West	[2] 6,998	----
Greece	7,779	----
India	63,396	91,649
Italy	----	4,941
Japan	[2] 139,637	89,531
Spain	102,563	28,616
Yugoslavia	2,736	19,910
Other countries	11,005	65
Total	441,643	296,902

[1] This table incorporates some revisions.
[2] From import detail of Customs Returns of the respective country.

Source: Compiled from Customs Returns of United Arab Republic (Egypt) by Corra A. Barry, Division of Foreign Activities.

TECHNOLOGY

Negev Phosphates Co., Ltd., of Israel developed a new process for enriching phosphate ores. The process was claimed to produce a uniform product containing 38 percent P_2O_5.[49]

Because the availability of cheap byproduct hydrochloric acid was increased, the fertilizer industry became aware of its possible use in processing phosphate rock. A use for byproduct hydrochloric acid to upgrade calcareous phosphate rock was reported. Many deposits of phosphate ore, of marine sedimentary origin and containing con-

[44] Chemical Trade Journal and Chemical Engineer (London). Notes From Abroad: German-Built Fertiliser Plant for Tunisia. V. 149, No. 3881, Oct. 20, 1961, p. 873.
[45] Mining Journal (London). East African Apatite for Fertilizer Venture. V. 256, No. 6562, May 26, 1961, p. 597.
[46] Chemical Trade Journal and Chemical Engineer (London). Notes From Abroad: S. African Fertiliser Industry Expansion. V. 149, No. 3882, Oct. 1961, p. 925.
[47] Oil, Paint and Drug Reporter. Fertilizer Plant in So. Africa. V. 180, No. 11, Sept. 11, 1961, p.3.
[48] Fertiliser and Feeding Stuffs Journal (London). Superphosphate in Egypt. V. 55, No. 12, Dec. 13, 1961, p. 542.
[49] Chemical Age (London). Overseas News: New Israel Process for Enriching Phosphate Ores. V. 85, No. 2165, Jan. 7, 1961 p. 16.

siderable quantities of calcite, were stated as particularly suited for processing by the method.[50]

A new method for producing wet-process phosphoric acid was developed by Nissan Chemical Industries, Ltd., of Tokyo. Yields up to 97 percent of the phosphate value in phosphate rock were claimed, compared with a conventional yield of 94 percent. A high-quality gypsum suitable for wallboard was said to be a byproduct of the process. The quality of the gypsum was stated to be dependent upon close temperature and chemical control during crystallization.[51]

A process was developed and used experimentally in Taiwan to produce an unusually pure phosphoric acid of 65 percent P_2O_5. This technique, a modified wet process using solvent extraction of the acid with 1-butanol, required five steps, including recovering and recycling the solvent. Some disadvantages were that the phosphate rock must be finely ground, two separate mixing operations are required, and extraction and distillation require heat and solvent makeup. Other problems such as thermal and material balances, economics, and solvent stability were not studied.[52]

Tennessee Valley Authority (TVA) reported on a pilot-plant study of concentrating wet-process phosphoric acid to the 70-percent P_2O_5 range. Important advantages with only a small increase in cost were claimed: Solid impurities in the acid were sequestered, storage and shipping costs were less, and solid and liquid fertilizers of higher analysis were produced.[53]

Three Czechoslovakian chemists developed a fluid-bed process for ammoniating superphosphate. The ammonia absorption rate in the fluid layer was said to be much higher than in conventional methods. Both initial and operating costs were reported to be lower.[54]

The trend of technological developments toward higher analysis plant foods continued. TVA described its ammonium polyphosphate (containing about 16 percent nitrogen and 61 percent phosphorus pentoxide) as the most concentrated fertilizer on the market. Preliminary estimates from pilot plant operations at Muscle Shoals, Ala., indicated production costs per unit of plant nutrient were roughly comparable to those of diammonium phosphate.[55]

A process for manufacturing granular potassium metaphosphate, analyzing about 57 percent P_2O_5 and 37 percent K_2O, was developed by Scottish Agricultural Industries, Ltd. This process reacts phosphoric acid with potassium chloride at temperatures as low as 450° C. The hydrogen chloride formed is kept separate from the combustion gases and recovered as a useful product.[56]

The possibilities of various metal ammonium phosphates as fertilizers were studied. It was reported that since these compounds are only slightly soluble in water and soil solutions, their possible use as

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[50] Chemical Age (London). Cheap By-Product HCl Helps Expand Fertiliser Interests. V. 86, No. 2206, Oct. 21, 1961, p. 630.
[51] Chemical Week. Processes: Semihydrate Phosphoric. V. 88, No. 16, Apr. 22, 1961, pp. 85, 87.
[52] Chemical Age (London). Purer, Stronger Phosphoric Acid From New Five-Step Process. V. 85, No. 2168, Jan. 28, 1961, p. 179.
[53] Scott, W. C., G. G. Patterson, and H. W. Elder. Wet-Process Phosphoric Acid: Pilot-Plant Production. Ind. and Eng. Chem., v. 53, No. 9, September 1961, pp. 713–716.
[54] Oil, Paint and Drug Reporter. Superphosphate Process Developed by Czech Trio. V. 180, No. 7, Aug. 14, 1961., p. 7
[55] Chemical Engineering. Ammoniated Phosphates Highlight Fertilizer Shift. V. 68, No. 10, May 15, 1961, pp. 68, 70.
[56] Farm Chemicals. Producing Granular Potassium Metaphosphate at Scottish Agricultural Industries. V. 124, No. 6, June 1961, pp. 22, 24.

non-burning and long-lasting sources of nitrogen, phosphorus, and various metals was suggested.[57]

The use of diammonium phosphate and ammonium sulfate for repressing and retarding forest fires was tested by the U.S. Forest Service. Diammonium phosphate was reported to be as effective as the borates and bentonite clays ordinarily used and would also serve as a fertilizer after being rain-washed into the soil. The phosphate was estimated to be 30 percent cheaper to use than borates.[58]

Phosphate ester surfactants assumed more importance in 1961 according to General Aniline & Film Corp. The company marketed eight of the anionic surfactants and planned to release six more in 1962.[59]

Albright & Wilson, Ltd., developed a new copper plating electrolyte based on pyrophosphate. The performance of the new bath (Pyrobrite) was confirmed in industrial practice under a wide variety of operating conditions from decorative uses to electroforming.[60]

A nonaqueous phosphating process was developed by the Paint Division of Imperial Chemical Industries, Ltd. (ICI), which dispensed with heating and rinsing the tank. It was stated that a sealed phosphate coating was produced with no sludge formed in the processing tank. The phosphate coating enhances paint adhesion and resistance to rust creep in the same manner as conventionally produced zinc or iron phosphate coatings.[61]

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[57] Agricultural Chemicals. Metal Ammonium Phosphates As Non-Burning Fertilizers. V. 16, No. 10, October 1961, pp. 26, 80, 81.
[58] Chemical Engineering. Phosphate Fertilizer Helps Fireproof the Forests. V. 68, No. 22, Oct. 30, 1961, p. 60.
[59] Chemical & Engineering News. Phosphate Esters Edge Into Surfactants. V. 39, No. 52, Dec. 25, 1961, pp. 40, 41.
[60] Chemical Trade Journal and Chemical Engineer (London). Copper Plating. V. 148, No. 3846, Feb. 17, 1961, p. 348.
[61] Metal Industry (London). Industrial News: New Phosphating Process. V. 99, No. 12, Sept. 22, 961, p. 234.

Platinum-Group Metals

By J. P. Ryan [1] and Kathleen M. McBreen [2]

INDUSTRIAL demand for platinum-group metals continued at a high level and prices remained stable in 1961. Domestic consumption of platinum-group metals increased moderately, and net imports were up sharply. Imports included platinum and palladium acquired under the Government's barter program. Domestic mine production and output of new platinum-group metals recovered by domestic refiners increased substantially. Refinery output of secondary metal of the platinum group also increased in 1961.

TABLE 1.—Salient platinum-group metals statistics

(Troy ounces)

	1952-56 (average)	1957	1958	1959	1960	1961
United States:						
Mine production [1]	25,857	18,531	14,359	15,485	23,609	43,248
Value	$1,997,351	$1,428,642	$740,583	$913,736	$1,485,439	$2,256,432
Refinery production:						
New metal	57,928	47,228	48,195	49,321	51,243	79,453
Secondary metal	71,952	87,521	81,514	135,996	76,857	85,971
Imports for consumption	747,433	682,013	670,431	1,010,333	680,646	884,463
Exports (except manufactures)	29,795	40,354	47,368	31,405	65,149	61,845
Stocks Dec. 31: Refiner, importer, dealer	439,425	507,189	493,426	495,851	515,750	555,445
Consumption	655,838	744,025	689,693	896,403	775,214	823,226
World: Production	950,000	1,320,000	890,000	[2] 1,060,000	[2] 1,250,000	1,190,000

[1] From crude platinum placers and byproduct platinum-group metals recovered largely from domestic gold and copper ores.
[2] Revised figure.

World production of platinum-group metals, estimated at 1.2 million ounces, was slightly less than in 1960. Output in Canada and the Union of South Africa declined, but output of platinum-group metals in the U.S.S.R. was estimated to be appreciably higher than that given for 1960. Although their refinery production of platinum-group metals was somewhat lower than last year, the two leading producers of platinum-group metals in the free world, The International Nickel Company of Canada, Ltd. (Inco), and Rustenburg Platinum Mines, Ltd., Union of South Africa, reported increased sales in 1961.

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.

Production of platinum-group metals as a byproduct of nickel ores began at the Thompson mine (Inco) in northern Manitoba, thus establishing an important new Canadian source of these metals.

LEGISLATION AND GOVERNMENT PROGRAMS

The regulations established under the Defense Materials System by Business and Defense Services Administration of the U.S. Department of Commerce, governing the flow of raw materials to defense agencies, continued to apply to platinum-group metals. Purchase orders for materials needed in national defense work continued to have priority rating over unrated commercial business orders.

All platinum-group metals through the semifabricated stage required a validated license for export to Soviet-bloc countries.

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 (OME); however, no projects were active in 1961. Platinum and palladium were removed from the list of materials eligible for barter by the Commodity Credit Corporation (CCC) of the Department of Agriculture as authorizations for these commodities were fully utilized.

DOMESTIC PRODUCTION

Mine output of platinum-group metals recovered from platinum placers in Alaska, as byproducts from gold placers in California, and as byproducts of refining copper and gold, increased 83 percent to 43,200 ounces. Most of the increase in output represented byproduct metal recovered from a backlog of unrefined materials. The leading domestic producers of platinum metals were Goodnews Bay Mining Co., the only company producing platinum as a primary product in the United States; American Metal Climax, Inc.; American Smelting and Refining Company; International Smelting and Refining Company; and Yuba Consolidated Industries, Inc.

Total new platinum-group metals recovered by refiners from both domestic and foreign crude materials was 79,500 ounces, a 55-percent increase over the 1960 output. Substantial gains in production of both platinum and palladium were noted, but output of the four minor metals, iridium, osium, rhodium, and ruthenium, declined. Slightly more than half the total new metals recovered came from domestic sources.

Secondary platinum-group metals recovered by refiners, chiefly from scrap, outmoded jewelry, sweeps, sludges, and other industrial residues, aggregated 86,000 ounces, 12 percent more than the quantity so recovered in 1960. Platinum recovery, comprising about 60 percent of the total, was up one-third; recovery of palladium, comprising most of the remainder, declined moderately. In addition, refiners delivered nearly 700,000 ounces of platinum-group metals refined on toll compared with 763,000 ounces of such metals in 1960. This metal delivered on toll was received from industry in the form of depleted catalysts, wornout extrusion dies, spinnerets, laboratory ware, and other used equipment for reworking or re-refining.

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
1952–56 (average)	47,744	5,642	2,618	895	526	503	57,928
1957	37,109	4,031	2,693	1,349	1,056	990	47,228
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:							
From domestic sources:							
Crude platinum, Gold and copper refining	10,232	8,274	810	118	769	163	20,366
From foreign crude platinum	24,899	1,362	1,865	885	1,688	178	30,877
Total	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

TABLE 3.—Secondary platinum-group metals recovered in the United States

(Troy ounces)

Year	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1952–56 (average)	36,665	30,224	1,173	356	1,641	1,893	71,952
1957	49,022	31,294	1,406	398	3,014	2,387	87,521
1958	36,426	38,883	1,223	335	2,639	2,008	81,514
1959	58,945	68,279	1,188	361	5,631	1,592	135,996
1960	38,861	35,465	914	279	953	385	76,857
1961	51,218	32,451	193	6	1,836	267	85,971

Domestic ores and secondary materials furnished about 16 percent of domestic requirements of platinum-group metals in 1961.

CONSUMPTION AND USES

The quantity of platinum-group metals sold to domestic consumers increased 6 percent in 1961 to 823,000 ounces. This was about 8 percent less than the record high established in 1959. Gains in the quantity of metals absorbed by the electrical and chemical industries and for dental and medical uses more than offset declines in the consumption of these metals for other industrial uses. U.S. industries absorbed about 70 percent of the world production of platinum-group metals in 1961.

Platinum sales dropped 13 percent from 1960, owing chiefly to the falloff in demand from the electrical and glass industries. As in 1960, the chemical, petroleum, and glass industries absorbed about half the total platinum sold, and the electrical and electronic industries used nearly one-third of the total. Jewelry and decorative uses took 11 percent of the total platinum sold, and dental, medical, and miscellaneous uses, 7 percent.

Sales of palladium increased 23 percent, chiefly because of the sharp rise in demand from electrical and electronic equipment manufacturers, who took over two-thirds of the total palladium sold. Demand for palladium for dental uses also was up, but demand from the petroleum industry and for jewelry and decorative uses declined.

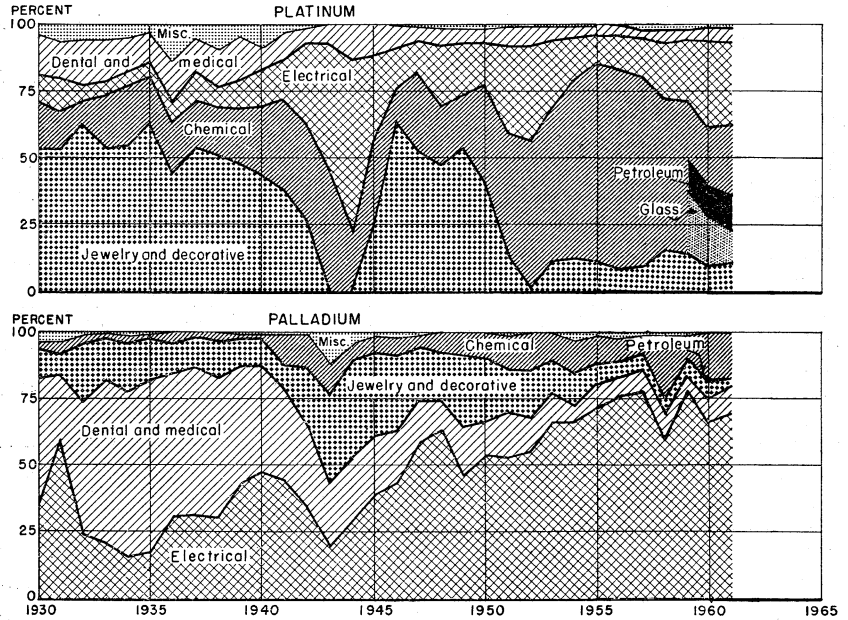


FIGURE 1.—Sales of platinum and palladium to various consuming industries in the United States, 1930–61, as percent of total.

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
1960:								
Chemical	71,253	73,854	810	550	7,705	1,496	155,668	20
Petroleum	35,645	5,300	2	--------	33	--------	40,980	5
Glass	59,390	6	49	--------	8,273	--------	67,718	9
Electrical	106,903	271,560	1,802	31	4,163	970	385,429	50
Dental and medical	15,898	38,617	234	2	83	575	55,409	7
Jewelry and decorative	32,666	23,336	3,165	1	4,175	753	64,096	8
Miscellaneous	2,828	1,552	106	204	183	1,041	5,914	1
Total	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

Sales of minor platinum-group metals—iridium, osmium, rhodium, and ruthenium—dropped 12 percent to 32,100 ounces. Nearly 40 percent of the quantity of metals sold went to the chemical and glass industries, 28 percent for jewelry and decorative uses, 18 percent for electrical uses, and 5 percent for dental and medical uses. Rhodium comprised about 60 percent of the total sales.

The platinum-group metals are noted for their high resistance to corrosive chemicals, resistance to oxidation and the formation of surface films, and stability at high temperatures. These properties, combined with superior catalytic activity and good electrical conductivity, form the basis of most of the industrial uses. In the electrical industry, platinum-group metals, particularly palladium, were used chiefly for make-and-break contacts where freedom from tarnish ensures low and constant contact resistance. A wide range of alloys and electroplated metals were used for specialized electrical applications where resistance to spark erosion and mechanical wear are essential. The electrical industry was the largest consumer. In the chemical industry, the second largest consumer, platinum-group metals and alloys were used for a wide variety of corrosion resistant equipment such as crucibles, autoclaves, and other reaction vessels. Platinum and palladium catalysts were used in many chemical processes including gas purification, production of nitric acid, and hydrogen peroxide. Substantial quantities of platinum-group metals continued to be used as catalysts in petroleum refining particularly in the production of high-octane gasoline by various reforming processes involving cracking, isomerization, hydrogenation and dehydrogenation, and sulfur removal. The pharmaceutical industry also used large quantities of platinum-metal catalysts in many complex reactions for producing a variety of drugs.

Although no significant new developments in the use pattern of the platinum-group metals were noted during the year, there was evidence that platinum-group metals were being used to an increasing extent in some of the more recently developed applications. Tests indicated that thin coatings of platinum and related elements can provide protection against oxidation and corrosion at high temperatures to such refractory metals as tungsten, molybdenum, and tantalum. Full-scale tests by E. I. Du Pont de Nemours & Co. Inc., demonstrated that higher output and significant improvements in product quality can be achieved by using platinum-plated titanium electrodes for electrolytic production of chlorine. Extensive tests by the National Cylinder Gas Division of Chemetron Corp. proved the commercial feasibility of the production of ultrapure hydrogen by palladium-alloy diffusion. Ultrapure hydrogen is desired in the production of high-purity metals and semiconductor materials. These newly-developed applications are expected to lead to greater use of platinum metals in the chemical and other industries and in such aerospace applications as protective coatings for nose cones of missiles and fuel nozzles for jet engines.

Substantial quantities of platinum alloys continued to be used for such established applications as high-temperature thermocouples, resistance thermometers, and limit fuses. Large quantities of platinum alloys also were used for bushings and headers for forming glass fiber and equipment for melting optical glass. Other important uses

of platinum-group metals and alloys include spinnerets for extruding synthetic fiber, electric heating elements in furnaces operating at high temperatures under oxidizing conditions, dental devices, and many types of jewelry and decorative products.

Rhodium, the most abundant of the minor platinum-group metals was used principally for alloying with platinum, and rhodium electroplate was widely used in jewelry, in printed electrical circuitry, electrical sliding contacts, and to impart a lustrous, nontarnishing surface to precision apparatus, scientific instruments, and reflectors.

Iridium, osmium, and ruthenium were used mostly as alloying elements to improve the properties of the more abundant platinum and palladium by increasing their hardness, tensile strength, and resistance to heat and corrosion. A greater use of iridium as a source material in isotope radiography and the use of ruthenium and osmium as hydrogenation catalysts were noted.

STOCKS

Domestic refiners and dealers reported that total working stocks of platinum-group metals on hand, in process, or in transit, aggregated 555,400 ounces at yearend, about 8 percent more than at the end of 1960. Platinum-group metals held in Government stockpiles at yearend aggregated 1,544,000 ounces.

TABLE 5.—Government inventory of platinum-group metals, December 31, 1961

(Thousand troy ounces)

Metal	National (strategic) stockpile	DPA [1] inventory	CCC and supplemental stockpile	Total
Iridium	14			14
Palladium	90	8	648	746
Platinum	717		50	767
Rhodium	2			2
Ruthenium			15	15
Total	823	8	713	1,544

[1] Defense Production Act.

Approximately 50,000 ounces of platinum and 100,000 ounces of palladium were acquired for the supplemental stockpile under barter contracts in 1961. About 1,675 ounces of rhodium, 27 ounces of osmium, and 51 ounces of ruthenium were sold from the supplementary stockpile.

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
1957	306,988	154,005	13,272	4,420	18,998	9,506	507,189
1958	295,274	151,572	10,548	4,241	20,883	10,908	493,426
1959	290,691	158,706	11,127	4,218	20,720	10,389	495,851
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

PRICES

Sustained demand at a relatively high level coupled with adequate supply brought continued price stability to the market for platinum-group metals. Official prices per troy ounce quoted by E & MJ Metal and Mineral Markets remained virtually unchanged, as follows: Platinum, $80–$85; palladium, $24–$26; osmium, $60–$70; rhodium, $137–$140; iridium, $70–$75; and ruthenium, $55–$60. Sales of platinum metals of Soviet origin were reported to have been made at prices slightly below official quotations.

Reflecting lack of speculative interest and continued price stability, trading in platinum futures on the New York Mercantile Exchange was very quiet; no contracts were made during the year. Trading in platinum on the London market also was generally quiet with little change in price except for slight activity in August when the Berlin crisis brought some increase in demand. The London equivalent price range was about US$77–$79 an ounce, somewhat below the corresponding price at New York. Similarly, there was little trading in palladium except during the Berlin crisis, and prices on the London market remained relatively stable with the equivalent price range approximately US$21–$23 an ounce, also slightly below the quoted price at New York.

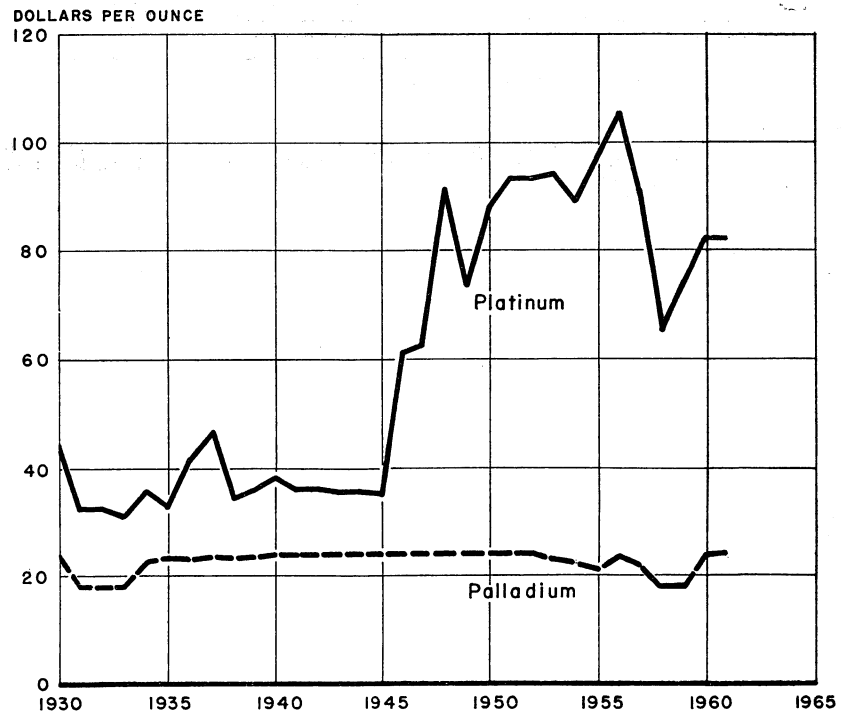


FIGURE 2.—Average price per ounce of platinum and palladium, 1930–61.

FOREIGN TRADE [3]

Imports.—Foreign countries continued to supply more than 80 percent of domestic industrial requirements for platinum-group metals. Imports of these metals increased 30 percent to 884,000 ounces valued at $36.8 million; they included platinum and palladium acquired for the supplemental stockpile under the CCC program to barter surplus agricultural commodities for minerals and metals.

Imports of platinum, refined and unrefined together, were slightly higher. Palladium imports rose 55 percent, and the quantity of iridium, osmium, and ruthenium imports also increased in 1961. Rhodium imports dropped sharply compared with 1960.

Most of the gain in imports resulted from a sharp rise in the quantity of metals received from the U.S.S.R., the United Kingdom, and the Netherlands, which accounted for 70 percent of the total. Imports from these countries more than offset a sharp drop in the quantity of metals imported from Canada and Switzerland.

TABLE 7.—U.S. imports for consumption of platinum-group metals

Year	Troy ounces	Value (thousands)	Year	Troy ounces	Value (thousands)
1952–56 (average)	747,433	[1] $41,237	1959	1,010,333	$36,912
1957	682,013	[1] 35,783	1960	680,646	34,131
1958	670,431	24,972	1961	884,463	36,840

[1] 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 8.—U.S. imports for consumption of platinum-group metals (unmanufactured), by countries [1]

(Troy ounces)

Year and country	Unrefined material [2]				Refined metals						
	Ores and concentrates of platinum metals	Platinum grain and nuggets (including crude, dust, and residues)	Platinum sponge and scrap	Osmiridium	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1960:											
North America:											
Canada	27	11			71,218	111,446	1,406		9,731	40	193,879
Mexico			41								41
Total	27	11	41		71,218	111,446	1,406		9,731	40	193,920
South America: Colombia	374	28,855	1,929		785						31,943
Europe:											
Czechoslovakia					3,239	3,700					6,939
France					1,248	1,618					2,866
Germany, West					5,576	1,011	14				6,601
Netherlands					11,618	5,483					17,101
Norway		190			3,395	1,830					5,415
Switzerland					6,821	111,962			2,090		120,873
U.S.S.R.					34,837	66,114			10,154		111,105
United Kingdom		1,282			99,570	64,672	2,833	277	9,747	3,957	182,338
Total		1,472			166,304	256,390	2,847	277	21,991	3,957	453,238
Asia:											
Japan			1,089								1,089
Lebanon						420					420
Total			1,089			420					1,509
Oceania: Australia			36								36
Grand total:											
Troy ounces	401	30,338	3,095		238,307	368,256	4,253	277	31,722	3,997	680,646
Value	$30,095	$2,200,830	$212,477		$18,917,141	$8,188,861	$283,055	$16,525	$4,126,336	$155,575	$34,130,895

See footnotes at end of table.

TABLE 8.—U.S. imports for consumption of platinum-group metals (unmanufactured), by countries [1]—Continued

(Troy ounces)

Year and country	Unrefined material [2]				Refined metals						
	Ores and concentrates of platinum metals	Platinum grain and nuggets (including crude, dust, and residues)	Platinum sponge and scrap	Osmiridium	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
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	28,227	2,965		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	29,997	11,550	2,601	236,859	571,693	4,366	466	17,394	8,969	884,463
Value	$39,124	$2,180,687	$688,750	$65,757	$18,164,919	$12,672,492	$286,356	$26,107	$2,327,883	$388,415	$36,840,490

[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.

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	
1952–56 (average)	[2] 13,297	[2] $1,143,225	[2] 16,498	[2] $499,103	[2] $1,634,098
1957	17,199	1,328,551	23,155	373,728	1,960,062
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.					
North America:					
Canada	1,164	103,168	3,236	82,699	2,081,827
Cuba	299	29,131	40	958	2,476
Guatemala			12	300	
Haiti					672
Mexico	393	41,328	1,667	43,095	124,019
Panama	6	562			
Total	1,862	174,189	4,955	127,052	2,208,994
South America:					
Brazil	100	7,566			
Chile			12	288	2,718
Colombia	10	850	185	5,250	8,671
Venezuela	4	864	84	2,164	3,955
Other	35	6,079			4,485
Total	149	15,359	281	7,702	19,829
Europe:					
Belgium-Luxembourg	10	800	70	14,640	20,075
France	4,305	355,104	387	36,633	96,386
Germany, West	9,906	796,381	1,524	74,883	6,046
Switzerland	11,951	656,476	7,580	190,376	513,604
United Kingdom	19,135	1,075,066	69	4,141	57,936
Other	645	15,673			22,243
Total	45,952	2,899,500	9,630	320,673	716,290
Asia:					
India	158	13,616			
Japan	1,301	103,349	781	48,175	20,019
Philippines			5	312	5,478
Other	37	4,768			3,904
Total	1,496	121,733	786	48,487	29,401
Africa	38	757			1,502
Oceania					2,420
Grand total	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

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	
1961—Continued					
Europe:					
Belgium-Luxembourg	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

[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 output of platinum-group metals, estimated at 1.2 million ounces, was 5 percent less than in 1960. Lower output was reported in the two leading platinum-metal producing countries of the free world, Canada and the Union of South Africa. These two countries furnished about two-thirds of the total world production; most of the remainder came from the U.S.S.R.

Increased demand for platinum catalysts in the petroleum-refining industries of Europe and the Middle East was a significant factor in platinum sales outside the United States. New installations were made in these areas for the production of high-octane fuel.

Canada.—Production of platinum-group metals declined 12 percent in 1961 to 404,900 ounces valued at Can$23.8 million. Slightly less than half the total output was platinum and most of the remainder was palladium. Virtually all of the metal was recovered as a by-product of smelting and refining nickel-copper ores. In prior years, Canadian production of platinum metals came almost entirely from the Sudbury district of Ontario, but in March 1961 production of platinum-bearing nickel ore began at the Thompson mine in northern Manitoba, thus establishing a second Canadian source of platinum-group metals.

TABLE 10.—World production of platinum-group metals [1]

(Troy ounces)

Country	1952–56 (average)	1957	1958	1959	1960	1961
North America:						
Canada:						
Platinum: Placer and from refining nickel-copper matte	147,214	199,565	146,092	150,382	221,832	404,883
Other platinum-group metals: From refining nickel-copper matte	178,096	216,582	154,366	177,713	238,489	
United States: Placer platinum and from domestic gold and copper refining	25,857	18,531	14,359	15,485	23,609	43,248
Total	351,167	434,678	314,817	343,580	483,930	448,131
South America: Colombia: Placer platinum (U.S. imports)	35,739	24,267	19,619	31,498	28,855	28,227
Europe: U.S.S.R.: Placer platinum and from refining nickel-copper ores [2]	210,000	250,000	250,000	300,000	330,000	350,000
Asia:						
Japan:						
Palladium from refineries	169	233	240	341	1,396	2,151
Platinum from refineries	786	354	442	472	563	1,550
Iridium from refineries	[3] 5	3,215	643			
Philippines:						
Platinum from refining nickel-platinum concentrates						174
Palladium from refining nickel-platinum concentrates						215
Total	960	3,802	1,325	813	1,959	4,090
Africa:						
Congo, Republic of the (formerly Belgian): Palladium from refineries [4]	67	325	161			
Ethiopia: Placer platinum	201	248	180	68	189	180
Union of South Africa:						
Platinum-group metals from platinum ores	347,269	603,704	[2] 300,000	[2] 375,000	[2] 400,000	[2] 350,000
Osmiridium from gold ores	6,618	5,361	[5] 4,873	5,352	[5] 6,334	[2] 7,000
Total	354,155	609,638	305,214	380,420	406,523	357,180
Oceania:						
Australia:						
Placer platinum	10	17	22		[2] 2	
Placer osmiridium	35	66	42	3		
New Guinea	6	14	28	18	4	[2] 4
Total	51	97	92	21	6	[2] 4
World total (estimate) [1]	950,000	1,320,000	890,000	1,060,000	1,250,000	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, 1955–56.
[4] Includes platinum.
[5] Sales.

Compiled by Augusta W. Jann, Division of Foreign Activities.

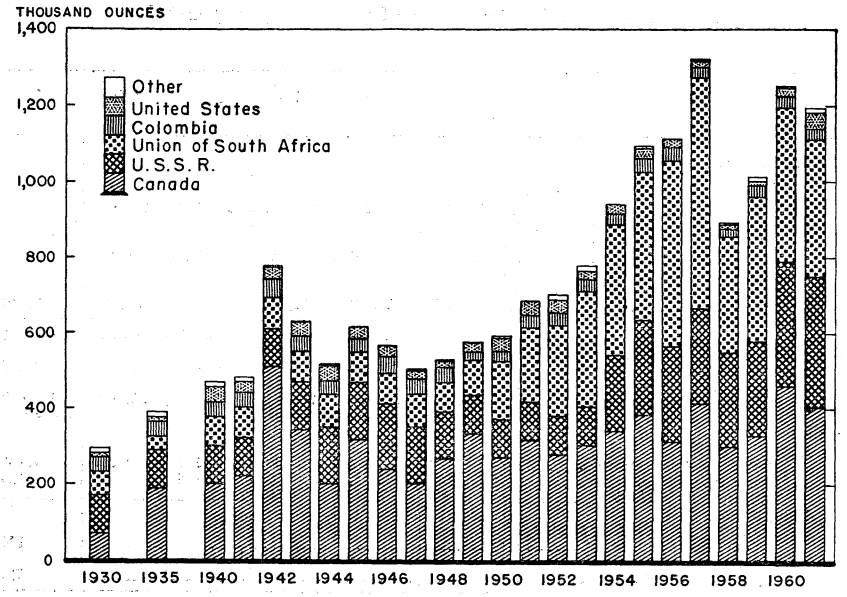


FIGURE 3.—World production of platinum-group metals, 1930, 1935, 1940–61.

The International Nickel Company of Canada, Ltd., the largest producer, operated seven mines, including two which commenced production during the year. The company reported a new high in ore production, increased deliveries of platinum metals, and an increase in its ore reserve. As part of a general program for improving the efficiency of methods of refining platinum metals, the company rebuilt and reequipped the smelting section of its platinum refinery at Acton, England.

Falconbridge Nickel Mines, Ltd., the other Canadian producer of platinum metals, operated five mines in the Sudbury district, two of which were virtually depleted at yearend. One new mine, the Stratcona, was under development. Pre-production development continued at two new platinum-bearing nickel-copper ore deposits, the Marbridge Mines, Ltd., property in Quebec and the Nickel Mining & Smelting Corp., property in western Ontario. A new copper-platinum deposit discovered near Belleterre, Quebec, was reported to contain from 0.05 to 0.07 ounce a ton platinum.

Colombia.—Output of platinum-group metals in Colombia was only slightly lower than in 1960. The leading producer, South American Gold & Platinum Co., reported a 16-percent drop in output of platinum as the grade of gravel declined. Six dredges were operated throughout the year and handled 21.6 million cubic yards, about 1 million cubic yards more than in 1960. The company also reported a gravel reserve of 64.2 million cubic yards averaging US$0.174 a cubic yard combined gold and platinum, compared with 64.4 million cubic yards averaging US$0.200 a cubic yard in 1960.[4]

[4] South American Gold & Platinum Co., Forty-fifth Annual Report 1961, p. 17.

Union of South Africa.—Output of platinum-group metals in South Africa was estimated to have decreased about 12 percent, as Rustenburg Platinum Mines, the leading producer, reduced ore production. The company did not disclose production figures, but the following statement from the company's Annual Report for fiscal year 1961 indicates a falloff in output of platinum metals:

> As stocks began to build up to the required levels during the year ended 31st August 1961, the scale of operations was gradually reduced, and after the close of the financial year, further reductions were effected and production at the company's mines is now in the course of being stabilized at a level considered appropriate to normal market requirements.

The Rustenburg company also reported a small gain in the total quantity of platinum-group metals sold, as increased sales of byproduct metals more than offset a slight decline in platinum sales. The company also reported reserve stocks of platinum-group metals as of August 31 valued at US$10.4 million, about 10 percent more than at the corresponding date of 1960.

TECHNOLOGY

The geological setting of the world's largest platinum ore deposits, their development, methods of extracting and treating the ores, and general operating conditions at the mines were described.[5]

A process for plating platinum-group metals by chemical displacement without an external electric current was developed by International Nickel Co. (Mond), Ltd., London, Eng., The procedure is particularly applicable to plating palladium and rhodium on printed circuits since it eliminates the need for electrical connections to isolated parts of the printed pattern. Details of the plating techniques and some specific applications were described.[6]

A new composite material was developed to prevent undesirable transfer of glass constituents through platinum in such applications as crucibles, laboratory ware, and glass-handling apparatus.[7] The new material provides substantially longer life and improved strength under high temperatures and corrosive operating conditions. It consists of three layers of material—two outside layers, composed of wrought platinum or platinum alloy, and a layer of powdered metal, bonded between these outer layers. The ingot resulting from the metallurgical bonding of the three layers can be worked as a standard platinum-alloy bar.

A composite metal wire, developed for application in thermocouple elements, gave superior performance with increased life under conditions where the thermocouple may be subjected to abnormal stresses. The new wire was recommended for use in steel-bath quick-immersion pyrometry, route creep testing, laboratory thermal analysis, and in applications where the thermocouple may be subjected to vibration

[5] Beath, C. B., C. A. Cousins, and R. J. Westwood. The Exploration of the Platiniferous Ores of the Bushveld Igneous Complex with Particular Reference to the Rustenburg Platinum Mines. Paper pres. at the 7th Commonwealth Min. and Met. Cong., April 1961, 23 pp.

[6] Johnson, R. W. Immersion Plating of Platinum Group Metals. J. Electrochem. Soc., v. 108, No. 7, July 1961, pp. 632–635.

[7] Hill, J. S. Trilay—A Noble Metal Composite Material. Engelhard Industries, Inc., Tech. Bull., v. 11, No. 2, September 1961, pp. 45–47.

or shock. The composition, methods of production, and physical properties of the wire were described.[8]

An article describing the properties, production, technology, and uses of rhodium was published.[9]

Adaptations of solions, which consist basically of platinum electrodes in a solution of elementary iodine in an aqueous potassium iodide solution, for use as simple electrochemical diodes, pressure- and movement-measuring devices, integrators, and amplifiers were described.[10] Principal applications of the solion will probably be in control engineering.

Oxides of the pure platinum metals, formed in air and oxygen at various temperatures, were discussed and compared. Also the nature of the oxidation of platinum and palladium alloys and the relationship of the form of oxidation to the type of alloying constituent and temperature were determined.[11]

The chemical, physical, and mechanical properties of platinum-group metals were discussed, and several applications of the metals in the chemical industry were described in a trade journal.[12]

Testing several electrolytic solutions of ruthenium salts and nitrosyl derivatives for electrodeposition of ruthenium disclosed that the most useful electrolyte for continuous operation was prepared from ruthenium-nitrosyl-sulphamate with 5 g Ru/1 as the optimum concentration. A current density of 8 amp/dm^2 at 70° C produced bright deposits up to 0.0002 inch thick.[13]

The electrochemical properties of titanium and platinum-coated titanium anodes and methods of applying platinum to titanium were discussed.[14] Uses of platinum-titanium anodes included fuel cells, cathodic protection systems, electrodialysis cells, and caustic-chlorine cells.

Based on a 15-month operating test, E. I. du Pont de Nemours & Co., Inc., disclosed that platinized-titanium anodes employed in place of the usual graphite anodes in chlorine cells resulted in lower cost, increased production, and improved product quality. A 25-percent increase in output was reported, based solely on direct substitution of platinized titanium for platinum.[15]

Atlantic Refining Co. announced the development of an improved process of repurifying spent platinum catalyst used in oil refining. The process, called Met-X, uses tiny beads of special resin in water to separate metal contaminants from the platinum. The metal is scoured

[8] Hill, J. S. The Use of Fibro Platinum in Thermocouple Elements. Engelhard Industries, Inc., Tech. Bull., v. 11, No. 3, December 1961, pp. 85–87.
[9] Sanderson, L. Rhodium. Can. Min. J., v. 82, No. 11, November 1961, pp. 65–67.
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from the resins in an acid bath. The company reports substantial savings in the cost of catalysts by the use of the Met-X process.[16]

Development of a halide-free platinum reforming catalyst was announced by Houdry Process Corp. The new catalyst containing about 0.5 percent platinum was being used in reforming units in Japan and was reported to be producing high yields of motor gasoline of the required high octane number without adding halogen compounds previously considered a necessary component of the catalyst system. The new catalyst contains the same amount of platinum as other reforming catalysts and is readily regenerated in place.[17]

A precision resistance temperature detector for high pressure applications with a response time of less than 1 second was developed by Engelhard Industries, Inc.[18] The major application of the high-speed detector is expected to be in nuclear reactors, where sudden temperature increases may indicate trouble developing and split-second automatic shutdown is imperative. The unit senses changes in temperature by the resultant change in the electrical resistance of a platinum or nickel wire element and is designed for operating pressures up to 2,500 psi and temperatures at 600° F.

More than 200 patents were issued in the United States and the United Kingdom involving the use of platinum metals in various industrial processes and products. The bulk of the patents covered the preparation, use, and recovery of platinum metals as catalysts in petroleum refining and chemical and petrochemical processes and in the manufacture of pharmaceuticals.[19] In addition, several patents were issued for applications of platinum metals in electrical and electronic equipment, for alloys used in structural materials, and for metal joining.

Several miscellaneous articles of general interest on platinum-group metals were issued during the year.[20]

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[16] Wall Street Journal. Atlantic Refining Says New Process to Purify Catalysts Will Cut Cost. V. 158, No. 105, Nov. 29, 1961, p. 22.

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[20] Allen, C. C. The Platinum Metals. Min. Res. Div., Dept. of Mines and Tech. Surv., Ottawa, Canada, 1961, 68 pp.

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Potash

By Richard W. Lewis [1] and Gertrude E. Tucker [2]

PRODUCTION of marketable potassium salts in the United States continued to increase and was 157,000 short tons above the preceding record year of 1960. Sales for 1961 were down 4 percent, however, total value of sales exceeded that of 1960 owing to price increases.

TABLE 1.—Salient potash statistics

(Thousand short tons and thousand dollars)

	1952–56 (average)	1957	1958	1959	1960	1961
United States:						
Production of potassium salts (marketable)—quantity	3,330	3,840	3,640	4,033	4,472	4,629
Approximate equivalent K_2O—do	1,953	2,266	2,147	2,383	2,638	2,732
Value [1]	$73,573	$84,612	$75,000	$80,393	[2] $89,676	$104,464
Sales of potassium salts by producers—quantity	3,194	3,625	3,954	4,191	4,412	4,226
Approximate equivalent K_2O—do	1,871	2,137	2,336	2,476	2,602	2,487
Value at plant	$70,604	$79,628	$81,577	$83,903	[2] $88,417	$95,388
Average per ton	$22.11	$21.97	$20.64	$20.02	[2] $20.04	$22.57
Imports for consumption of potash materials—quantity	300	339	366	432	[2] 415	465
Approximate equivalent K_2O—do	160	182	199	234	226	262
Value	$10,968	$11,823	$12,874	$15,737	[2] $15,370	$17,327
Exports of potash materials—quantity	187	467	507	572	833	807
Approximate equivalent K_2O—do	106	234	254	337	491	475
Value	$7,675	$17,506	$18,276	$18,496	$25,926	$32,668
Apparent consumption of potassium salts [3]—quantity	3,307	3,497	3,813	4,051	[2] 3,994	3,884
Approximate equivalent K_2O—do	1,925	2,085	2,281	2,373	2,337	2,274
World: Production (marketable):						
Approximate equivalent K_2O—do	7,300	8,700	8,800	9,400	10,000	10,500

[1] Derived from reported value of "Sold or used."
[2] Revised figure.
[3] Measured by sold or used plus imports minus exports.

LEGISLATIVE AND GOVERNMENT PROGRAMS

The U.S. Department of the Interior declared a 10-year withdrawal from oil and gas leasing of approximately 5,000 acres of public lands in southeastern Utah. The area, 8 miles northwest of Moab, was reported to contain rich potash deposits.[3]

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.
[3] Federal Register. Withdrawing Public Lands From Oil and Gas Leasing for Preservation and Development of Potash Deposits Belonging to the United States. V. 26, May 18, 1961, p. 4333.

DOMESTIC PRODUCTION

Marketable production of potassium salts in the United States for 1961 was 4 percent greater than in 1960. Output of crude potassium salts in the Carlsbad, N. Mex., area reached a new high, 4 percent over the preceding year. The calculated average grade of the crude salts mined was 18.74 percent K_2O equivalent, compared with 18.85 percent in 1960.

The principal producing States were New Mexico, California, and Utah; New Mexico furnished 92 percent of the domestic output. Maryland and Michigan again contributed only relatively small quantities.

Approximately 15,000 short tons of manure salts, containing 3,250 tons K_2O equivalent was produced in New Mexico and Utah.

No new companies began producing in 1961, but Texas Gulf Sulphur Co. appeared to be on schedule with the development work on its property near Moab, Utah.

A 25-percent expansion of capacity was under way at the American Potash & Chemical Corp., Trona, Calif., plant. The project was scheduled for completion in 1962 at an estimated cost of $12–$15 million.

Bonneville Ltd., Wendover, Utah, planned additional expansion of potassium chloride production capacity, which had been raised 25 percent in 1960. Japan was an important export market, and the company shipped an initial 5,250 tons of muriate from the Port of Stockton.

Continental Oil Co. and San Jacinto Petroleum Corp. began joint exploration on approximately 38,000 acres of potash permits in Utah and planned large-scale commercial production if the ore body is confirmed.

TABLE 2.—Production and sales of potassium salts in New Mexico

(Thousand short tons and thousand dollars)

Year	Crude salts [1]		Marketable potassium salts					
	Mine production		Production			Sales		
	Gross weight	K_2O equivalent	Gross weight	K_2O equivalent	Value [2]	Gross weight	K_2O equivalent	Value
1952-56 (average)	9,965	2,000	3,016	1,770	$66,213	2,891	1,694	$63,474
1957	12,893	2,430	3,528	2,080	77,197	3,353	1,977	73,243
1958	12,224	2,309	3,355	1,978	69,106	3,650	2,157	75,343
1959	13,932	2,588	3,707	2,189	74,117	3,821	2,258	76,725
1960	15,071	2,841	4,138	2,440	[3] 82,645	4,092	2,412	[3] 81,653
1961	15,653	2,934	4,281	2,523	96,380	3,882	2,281	87,415

[1] Sylvite and langbeinite.
[2] Derived from reported value of "Sold or used."
[3] Revised figure.

Duval Sulphur & Potash Co. started mining potash at its new Wills-Weaver mine, 13 miles north of its Saunders mine and refinery in the Carlsbad basin. New screening and granulating facilities, near completion in December, would allow the company to supply granular potash in addition to coarse and standard grades. No increase in capacity was announced.

International Minerals & Chemical Corp. expected to complete a $1.8 million expansion and improvement program at its Carlsbad potash operation.

Kerr-McGee Oil Industries, Inc., joined National Farmers Union Service Corp. in forming Kermac Potash Co. to mine and mill extensive potash reserves near Carlsbad, N. Mex. A large-scale pilot-plant program was launched at the Kerr-McGee metallurgical research facilities at Golden, Colo., to obtain data to aid in formulating construction plans for a 1,500-ton-per-day plant. The reserve under lease by the company was estimated at 80 million tons of ore, averaging 18.43 percent K_2O.[4]

Leprechaun Mining and Chemical Co., Inc., conducted exploratory drilling in a dry lakebed near Silver Peak, Nev. Estimates of the potash reserves were given as more than 10 million tons.[5] The commercial production of lithium, cesium, and rubidium as byproducts was a possibility.

Potash Company of America embarked upon a $3.5 million modernization program at its Carlsbad, N. Mex., facilities. The project included a new flotation system and modern equipment for handling the potash ore and waste materials. It was reported that, when the project is completed in mid-1962, the life of the company reserves will be extended to at least 16 years. Before modernization, the reserves had been calculated at 10 years.

Southwest Potash Corp. completed construction of a $7 million potassium nitrate fertilizer plant at Vicksburg, Miss., and began test and break-in operations.

Texas Gulf Sulphur Co. showed progress in its $30 million potash project at Moab, Utah. By the end of 1961, the 22-foot-diameter shaft was nearing the 700-foot level; foundations were laid for a warehouse to store 125,000 tons of refined potash; access roads were under construction; the Denver & Rio Grande Western Railroad had begun construction of a 36-mile-long branch line from Crescent Junction to the plant site; and Utah Power & Light Co. had brought electric power lines to the project. Metallurgical tests were conducted at the Colorado School of Mines Research Foundation on the ore recovered from test-well drill cores, and the final flowsheet was prepared by Texas Gulf engineers. First production was scheduled for the end of 1962.

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[4] Skillings' Mining Review. New Company to Mine Potash. V. 50, No. 48, Dec. 2, 1961, p. 20.

[5] California Mining Journal. Clayton Valley Potash Deposit to Bring a Modern Goldfield Boom. V. 30, No. 12, August 1961, p. 24.

CONSUMPTION AND USES

The apparent consumption of potassium salts in the United States continued to decline and was about 63,000 short tons (K_2O equivalent) less than in 1960, approximating the 1958 level. This drop in consumption was due in part to adverse weather conditions in some States. The large reduction in corn acreage and the price increase also contributed.

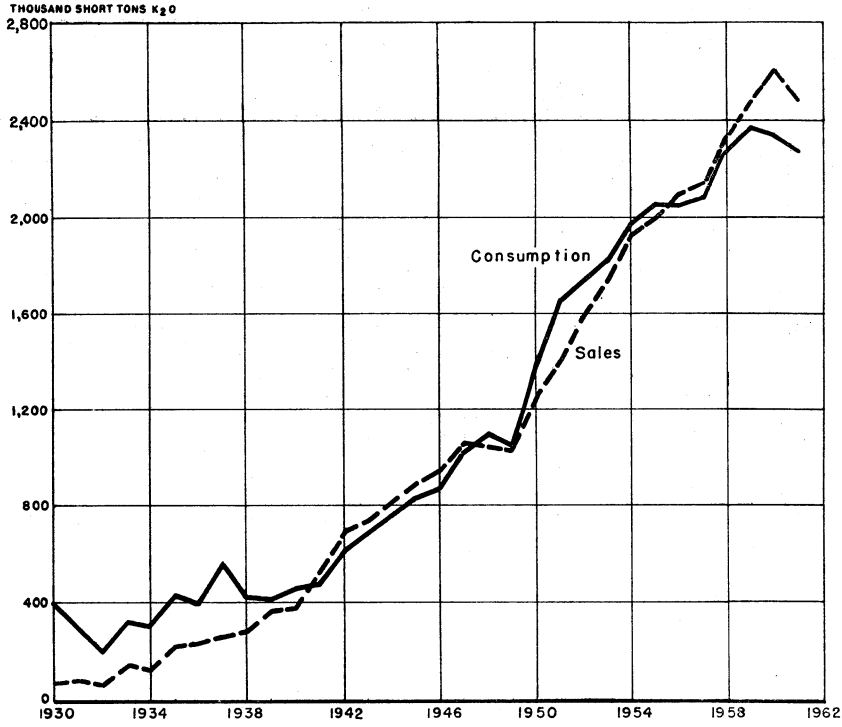


FIGURE 1.—Comparison of apparent domestic consumption of potash (K_2O) and sales of domestic producers of potash in the United States, 1930–61.

Illinois continued to be the leading State for deliveries of agricultural potash, with 200,011 short tons (K_2O equivalent); Georgia, Indiana, Ohio, and Florida followed in order. Virginia ranked sixth with a 20-percent increase over 1960. Deliveries, however, do not necessarily correspond to consumption since much of the potash delivered is used in mixed fertilizers and resold outside the receiving State.

The consumption of high-purity potassium chloride for chemical use increased nearly 7 percent.

TABLE 3.—Deliveries of potash salts in 1961, by States of destination

(Short tons of K_2O)

State	Agricultural potash	Chemical potash	State	Agricultural potash	Chemical potash
Alabama	76,401	19,896	Nevada	----	1,472
Arizona	1,227	122	New Hampshire	36	20
Arkansas	42,573	125	New Jersey	31,265	1,894
California	19,945	7,909	New Mexico	1,424	20
Colorado	1,075	12	New York	35,737	65,026
Connecticut	2,984	126	North Carolina	102,919	299
Delaware	7,277	468	North Dakota	3,298	----
District of Columbia	464	----	Ohio	148,248	4,686
Florida	140,707	1,126	Oklahoma	6,225	508
Georgia	158,230	730	Oregon	5,016	256
Idaho	1,116	----	Pennsylvania	35,535	2,579
Illinois	200,011	3,198	Rhode Island	1,455	588
Indiana	157,283	2,468	South Carolina	56,096	----
Iowa	65,561	221	South Dakota	264	----
Kansas	2,337	588	Tennessee	88,127	----
Kentucky	43,820	7,179	Texas	66,537	6,599
Louisiana	21,896	458	Utah	80	98
Maine	12,216	101	Vermont	3,577	----
Maryland	72,462	974	Virginia	130,515	506
Massachusetts	17,509	126	Washington	9,279	448
Michigan	69,256	685	West Virginia	1,107	11,929
Minnesota	65,402	----	Wisconsin	72,808	109
Mississippi	45,203	48	Wyoming	24	----
Missouri	50,667	1,477			
Montana	25	(1)	Total	2,078,790	145,074
Nebraska	3,571	----			

[1] Less than 1 ton.

Source: American Potash Institute.

STOCKS

Producer-held stocks of potash (K_2O) increased 79 percent, almost equaling the record of 1957. Yearend stocks in the potash industry include material sold for delivery in the spring planting season that begins in February.

TABLE 4.—Stocks of potassium salts in the United States

(Thousand short tons)

Year	Number of producers	Stocks, Dec. 31	
		Potassium salts	Equivalent potash (K_2O)
1952–56 (average)	10	508	300
1957	11	939	560
1958	11	625	372
1959	11	464	277
1960	11	521	311
1961	11	924	556

PRICES

The 1961–62 bulk prices of domestic potash were 2 to 3 cents per unit higher than in the preceding fertilizer year.

Price lists were published by producers in April 1961 for shipments during the months indicated against contracts made before July 1, 1961. An additional 2 cents per unit was charged on contracts made after June 30, 1961.

All producers charged $5 per short ton extra for muriate shipped in 100-pound bags and reserved the right to adjust prices to meet competition from other producers.

TABLE 5.—Bulk prices for New Mexico potash [1]

(Cents per unit K_2O)

Product	1961			1962	
	July–Aug.	Sept.–Oct.	Nov.–Dec.	Jan.	Feb.–June
Standard muriate, 60 percent K_2O minimum	35	36	37	37	40
Coarse muriate, 60 percent K_2O minimum	36.5	37.5	38.5	38.5	41.5
Granular muriate, 60 percent K_2O minimum	38	39	40	40	43
Sulfate of potash, 50 percent K_2O minimum	65.5	70.5	70.5	73.5	73.5
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 6.—Bulk prices for California potash [1]

(Cents per unit K_2O)

Product	1961			1962	
	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	76	76–81	81	84	84

[1] Quoted by American Potash & Chemical Corp., carlots, f.o.b., Trona, Calif.

FOREIGN TRADE [6]

Imports.—Imports of potassium material used chiefly for fertilizer were 13 percent higher than in 1960; muriate shipments from West Germany and France increased 35 and 26 percent, respectively. Also, Italy shipped 17,758 short tons of potassium sulfate to the U.S. market. Imports from the U.S.S.R. decreased 31 percent; Spanish muriate was 27 percent less.

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

TABLE 7.—U.S. imports for consumption of potash materials

Material	Approximate equivalent as potash (K_2O) (percent)	1960				1961			
		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	301,781	181,068	80.0	$8,578,896	347,023	208,361	79.5	$10,582,032
Potassium nitrate, crude	40	[2][3] 635	[2] 254	.1	[2][3] 77,024	1,962	785	.3	142,285
Potassium-sodium nitrate mixtures, crude	14	[2][3] 18,632	[2] 2,608	1.2	[2][3] 793,864	13,801	1,932	.8	583,679
Potassium sulfate, crude[1]	50	74,575	37,288	16.5	2,771,839	93,540	46,723	17.8	3,641,471
Other potash fertilizer materials	6	[2] 9,866	[2] 592	.3	[2] 385,614	46	3	.0	2,150
Total fertilizer		[2] 405,489	[2] 221,810	98.1	[2] 12,607,237	456,372	257,804	98.4	14,951,617
Used chiefly in chemical industries:									
Bicarbonate	46	34	16		5,942	233	107		28,683
Bitartrate:									
Argols	20	198	40		34,076	261	52		34,479
Cream of tartar	25	1,438	360		771,476	880	220		453,108
Carbonate	61	600	366		82,797	178	109		24,466
Caustic	80	666	533		136,660	958	766		176,239
Chlorate and perchlorate	36	464	167		108,945	439	158		101,994
Chromate and dichromate	40	2	[4]	1.9	648	5	2	1.6	1,801
Cyanide	70	887	621		448,587	763	534		417,870
Ferricyanide	42	336	141		202,358	319	134		183,314
Ferrocyanide	44	646	284		251,522	481	212		183,045
Nitrate	46	2,433	1,119		308,668	2,475	1,139		325,111
Permanganate	29	42	12		16,947	20	6		9,686
Rochelle salts	22	185	41		82,557	194	43		83,464
All other	50	1,383	692		311,215	1,479	740		352,128
Total chemical		9,314	4,392	1.9	2,762,398	8,685	4,222	1.6	2,375,388
Grand total		[2] 414,803	[2] 226,202	100.0	[2] 15,369,635	465,057	262,026	100.0	17,327,005

[1] Quantities furnished by American Potash Institute, Inc.; values adjusted by Bureau of Mines.
[2] Revised figure.
[3] Adjusted by Bureau of Mines.
[4] Less than 1 ton.

Source: Bureau of the Census.

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TABLE 8.—U.S. imports for consumption of potash materials, by countries

(Short tons)

Year and country	Bitartrate		Caustic (hydroxide)	Chlorate and perchlorate	Cyanide	Muriate (chloride)[2]	Potassium nitrate crude	Potassium sodium nitrate mixtures, crude	Potassium nitrate (saltpeter), refined	Potassium sulfate, crude[2]	All other[3]	Total	
	Argols or wine lees [1](20)	Cream of tartar [1](25)	[1](80)	[1](36)	[1](70)	[1](60)	[1](40)	[1](14)	[1](46)	[1](50)		Quantity	Value
1960:													
Chile[4]								18,420			5,311	23,731	$994,973
France	82		15	13	219	124,395	96			47,147	4,394	176,361	5,956,124
Germany:													
East									388		88	476	91,087
West		43	428	38	474	98,777	[5] 539	[5] 210	1,798	27,428	[5] 1,176	[5] 130,911	[5] 4,522,490
Italy		538							240		169	947	378,336
Netherlands		5	48						7		1,117	1,177	388,583
Spain		231				59,350					1	59,582	1,751,739
Sweden			175	288								463	135,419
U.S.S.R.						19,259						19,259	481,016
United Kingdom		621			105						673	1,399	501,630
Other countries	116			125	89			2			165	497	168,238
Total	198	1,438	666	464	887	301,781	[5] 635	[5] 18,632	2,433	74,575	[5] 13,094	[5] 414,803	[5] 15,369,635
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						665	1,181	388,588
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	2,955	465,057	17,327,005

[1] Figures in parentheses indicate, in percent, approximate equivalent as potash (K_2O).
[2] Quantities furnished by American Potash Institute, Inc.; values adjusted by Bureau of Mines.
[3] Approximate equivalent as potash (K_2O): 1960-61, 38 percent.
[4] Potassium sodium nitrate mixtures, crude, include 2,400 tons ($97,560) credited by the Bureau of the Census to potassium nitrate, crude.
[5] Revised figure.

Source: Bureau of the Census.

Exports.—Total potash exports amounted to 19 percent of sales but shipments were down nearly 3 percent from 1960. Exports of fertilizer potash to North American, European, and Asian countries decreased 14, 59, and 4 percent, respectively. Deliveries to Oceania, however, increased 66 percent.

TABLE 9.—U.S. exports of potash materials, by countries

Destination	Fertilizer				Chemical			
	1960		1961		1960		1961	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
North America:								
Canada	104,283	$3,148,901	107,058	$4,256,709	8,925	$1,270,454	6,448	$1,148,384
Costa Rica	4	214	524	23,055	13	4,781	20	3,022
Cuba	28,558	895,610	-------	-------	60	19,585	-------	-------
Dominican Republic	4,866	169,785	4,869	172,132	4	1,106	1	292
El Salvador	95	5,580	-------	-------	2	1,530	2	2,651
Mexico	13,453	366,252	17,305	452,438	583	142,620	907	168,431
Other	100	6,327	408	17,868	21	22,687	46	9,843
Total	151,359	4,592,669	130,164	4,922,202	9,608	1,462,763	7,424	1,332,623
South America:								
Argentina	282	8,597	1,225	40,290	155	40,224	300	93,613
Brazil	47,442	1,401,807	42,996	1,482,976	195	52,582	256	63,988
Chile	551	25,986	4,222	127,704	61	21,782	27	11,539
Colombia	1,128	36,076	550	24,150	151	37,655	143	34,983
Ecuador	-------	-------	600	31,760	30	8,509	68	12,810
Peru	165	9,100	-------	-------	6	4,726	42	11,359
Uruguay	-------	-------	-------	-------	8	3,961	46	10,521
Venezuela	275	9,580	-------	-------	94	27,742	319	79,457
Other	-------	-------	67	3,185	14	13,734	73	14,008
Total	49,843	1,491,146	49,660	1,710,065	714	210,915	1,274	332,278
Europe:								
Belgium-Luxembourg	4,500	117,350	-------	-------	29	16,707	40	16,680
Germany, West	-------	-------	-------	-------	77	32,723	327	138,608
Ireland	15,355	415,747	-------	-------	-------	-------	2	1,080
Italy	24,808	617,333	16,240	495,705	1,261	93,241	227	39,173
Netherlands	-------	-------	624	26,222	113	58,481	32	13,373
Sweden	2,204	66,307	-------	-------	639	44,875	523	53,707
United Kingdom	5,085	138,859	4,475	123,054	664	196,171	82	13,246
Other	-------	-------	-------	-------	72	39,911	497	242,976
Total	51,952	1,355,596	21,339	644,981	2,855	482,109	1,730	518,843
Asia:								
India	-------	-------	-------	-------	7	4,927	158	35,730
Japan	486,869	13,857,907	409,082	16,574,044	20	11,615	106	26,220
Korea, Republic of	1,911	86,456	18,998	690,086	1,222	54,726	1	920
Pakistan	-------	-------	11,593	475,860	1	1,347	13	2,818
Philippines	4,683	145,235	7,467	236,047	43	18,925	68	20,508
Taiwan	10,578	320,697	25,388	907,258	1	318	11,034	301,137
Viet-Nam	-------	-------	9,194	402,498	5	1,293	30	8,341
Other	10	1,172	-------	-------	50	23,901	267	49,682
Total	504,051	14,411,467	481,722	19,285,793	1,349	117,052	11,677	445,356
Africa:								
Union of South Africa	12,879	366,395	18,602	621,515	1,519	47,590	59	11,760
Other	72	3,141	5	224	1,004	27,691	66	34,522
Total	12,951	369,536	18,607	621,739	2,523	75,281	125	46,282
Oceania:								
Australia	2,465	73,706	29,489	939,346	323	69,575	7,492	316,204
New Zealand	42,900	1,214,280	45,833	1,548,175	(1)	300	18	3,719
Other	-------	-------	13	494	-------	-------	-------	-------
Total	45,365	1,287,986	75,335	2,488,015	323	69,875	7,510	319,923
Grand total	815,521	23,508,400	776,827	29,672,795	17,372	2,417,995	29,740	2,995,305

[1] Less than 1 ton.

Source: Bureau of the Census.

WORLD REVIEW

Canada.—Interest continued high in the rich potash area of Saskatchewan with both speculation and activity taking place. By the end of 1961, 14 firms were holding about 1.6 million acres under permit. The great difficulties encountered by three companies while sinking shafts through the Blairmore formation, containing water and sand under high pressure, caused others to be reluctant to start operating.

Continental Potash Corp. made good progress in reclaiming and repairing its 1,800-foot shaft, which had filled to within 360 feet of the surface with water and sand in the summer of 1960. Plans were made for cement grouting upon completion of the repair work, after which the shaft would be extended about 1,400 feet to the top of the potash deposit.[7]

TABLE 10.—World production of potash (marketable, unless otherwise stated) by countries [1 2]

(Short tons, K_2O equivalent)

Country [1]	1952–56 (average)	1957	1958	1959	1960	1961
North America:						
Canada				46,500		
United States	1,952,803	2,266,481	2,147,671	2,383,259	2,638,574	2,732,602
Crude (including brines) [3]	2,183,446	2,615,808	2,478,725	2,781,960	3,039,309	3,143,569
South America: Chile (nitrate)	10,335	8,339	9,811	15,482	[4] 16,500	[4] 14,000
Europe:						
France	1,197,033	1,545,323	1,628,146	1,611,466	1,692,046	[4] 1,850,000
Crude [3]	1,360,874	1,736,894	1,835,033	1,828,804	1,909,791	2,098,798
Germany:						
East [4]	1,520,000	1,653,000	1,700,000	1,764,000	1,764,000	1,764,000
Crude [3 4]	1,754,000	1,900,000	1,960,000	2,028,000	2,028,000	2,028,000
West	1,676,380	1,862,904	1,886,052	2,026,046	2,179,836	2,252,901
Crude [3]	1,995,556	2,190,290	2,225,564	2,363,353	2,553,161	2,645,544
Italy	[5]	[5]	9,022	11,575	51,162	[4] 154,300
Spain	230,310	251,460	262,672	269,790	291,356	[4] 298,000
U.S.S.R. [4]	669,000	1,040,000	1,100,000	1,160,000	1,212,500	1,300,000
Asia:						
Israel	11,128	50,000	67,100	72,000	108,000	[4] 132,300
Japan:						
Alunite [4]	370	500	500	210	190	130
Carbonate [4]		1,175	1,380	2,120	2,570	2,540
Africa: Eritrea	265		450			
World total (marketable) (estimate) [1]	7,300,000	8,700,000	8,800,000	9,400,000	10,000,000	10,500,000

[1] Potash may be produced in Poland; data on production are not available, and 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 the detail.
[3] To avoid duplication of figures, data on crude potash are not included in the total.
[4] Estimate.
[5] Data not available, estimate included in total.

Compiled by Helen L. Hunt, Division of Foreign Activities.

International Minerals & Chemical Corp. (Canada), Ltd. (IMC), on March 25, 1961, completed the cast-iron-ring lining of its shaft through the Blairmore formation. The shaft is about 14 miles east of Esterhazy, Saskatchewan.[8] Plans were announced by IMC officials

[7] Northern Miner (Toronto). Continental Potash Makes New Plans for Shaft Sinking. V. 47, No. 38, Dec. 14, 1961, pp. 1, 11.
[8] Bureau of Mines. Mineral Trade Notes. V. 53, No. 1, July 1961, pp. 32–33.

to expand the refinery capacity to more than 1 million tons per year. The processing facilities completed in 1961 would handle 420,000 tons of product annually.[9]

Also active in shaft work was Potash Company of America, which first produced potash in Canada in 1959 from its property near Saskatoon, Saskatchewan. The mine closed in the fall of the same year because of water problems in the shaft. Grouting of the entire shaft was started and by the end of 1961 was complete in the two lower zones.[10]

Northwest Company, Ltd., was issued permits to carry out potash exploration on approximately 200,000 acres in the Findlater and Regina Beach-Lundsen areas of Saskatchewan.[11]

Standard Chemical Ltd., a jointly owned subsidiary of Armour & Co. and Pittsburgh Plate Glass Co., embarked upon a $1 million exploratory program to determine whether a "solution mining" technique would be successful in exploiting a 5,000-foot deep potash deposit at Belle Plaine, Saskatchewan.[12]

Tombill Mines, Ltd., completed 11 test holes which indicated an estimated 600 million tons of ore, which averaged 25 percent K_2O. In October the company began drilling to find the most favorable shaft site. Material from the drill cores was used for flowsheet studies.[13]

United States Borax & Chemical Corp. and Homestake Mining Co. entered into a joint venture to complete studies to determine the possibilities for large-scale potash production in Saskatchewan, where U.S. Borax had been exploring land held under permits since 1957.[14]

Ethiopia.—Ralph M. Parsons Co. of Los Angeles, Calif., was awarded a concession for exploiting potash at Dallol on September 23, 1961. Development of the Dallol potash deposits was planned to take place during the next few years and would include housing facilities, maintenance shops, powerplants, mining operations, a processing plant, a new deep-water port on the Red Sea, and a 68-mile road or railroad from plant to port.[15]

Germany, East.—According to the East German news agency, ADN, considerable reserves of mineral including 2 billion tons of potash salts, were discovered and proved in East Germany.[16]

India.—Included in India's plans for increased use of fertilizer was an annual consumption of 200,000 tons of potash by 1966, all of which would be imported.[17]

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[9] Precambrian-Mining in Canada (Winnipeg). International Minerals Starts $10 Million Program. V. 34, No. 9, September 1961, p. 55.
[10] Mining Congress Journal, v. 47, No. 12, December 1961, p. 84.
[11] Mining Engineering. Calgary Firm in Potash Exploration. V. 13, No. 9, September 1961, p. 1023.
[12] Commercial Fertilizer. Standard Chemical Ltd. V. 103, No. 3, September 1961, p. 33.
[13] Northern Miner (Toronto). Tombill Hopeful Lining Up Markets Potash Tonnage. V. 47, No. 31, Oct. 26, 1961, p. 3.
[14] Commercial Fertilizer. Around the Map, Canada. V. 103, No. 3, September 1961, p. 33.
[15] Bureau of Mines. Mineral Trade Notes. V. 53, No. 6, December 1961, p. 39.
[16] Mining Journal (London). Mining Miscellany. V. 257, No. 6573, Apr. 11, 1961, p. 143.
[17] Oil, Paint and Drug Reporter. Potash Consumption in India Seen Rising Sevenfold by 1965 to 200,000 Tons of Imports. V. 179, No. 22, May 29, 1961, pp. 7, 58.

TABLE 11.—France: Exports of potash materials[1] by countries

(Short tons)

Destination	1959	1960	Destination	1959	1960
North America:			Europe—Continued		
Canada	25,219	21,783	Switzerland	61,271	73,902
Cuba	5,557	12,603	United Kingdom	242,814	245,832
Martinique	8,077	10,975	Asia:		
United States	147,812	158,783	Ceylon	37,238	33,655
South America:			India	14,465	9,277
Brazil	19,988	46,519	Japan	201,148	224,636
Chile	5,191	2,205	Taiwan	10,947	11,023
Colombia	----------	6,090	Africa:		
Venezuela	----------	6,654	Algeria	21,434	18,798
Europe:			Morocco: Southern Zone	3,127	7,077
Austria	32,771	39,759	Rhodesia and Nyasaland, Federation of	7,740	11,678
Belgium-Luxembourg	173,767	149,346	Tunisia	8,314	3,858
Denmark	26,107	35,612	Union of South Africa	20,029	19,518
Finland	9,066	10,830	Oceania:		
Germany, West	----------	18,767	Australia	20,508	23,486
Greece	4,593	6,366	New Zealand	24,999	25,574
Ireland	48,977	38,928	Other countries	94,853	53,648
Italy	61,783	61,762			
Netherlands	148,661	141,149	Total	1,524,728	1,597,668
Norway	13,627	16,465			
Sweden	24,645	51,110			

[1] Figures include salts, carbonate, chloride and nitrate of potash.

Compiled from Customs Returns of France by Bertha M. Duggan, Division of Foreign Activities.

TABLE 12.—West Germany: Exports of potash materials[1] by countries[2]

(Short tons)

Destination	1960	1961	Destination	1960	1961
North America:			Europe—Continued		
Canada	30,137	34,311	United Kingdom	278,047	252,141
Cuba	6,634	----------	Asia:		
Puerto Rico	26,863	11,839	Ceylon	8,238	16,306
United States	115,628	192,263	India	12,138	12,663
South America:			Indonesia	9,522	6,981
Brazil	37,004	43,104	Japan	142,448	239,637
Chile	2,132	9,183	Korea, Republic of	10,472	----------
Venezuela	5,887	3,034	Malaya, Federation of	10,719	11,738
Europe:			Pakistan	----------	16,547
Austria	53,985	62,341	Philippines	5,529	14,247
Belgium-Luxembourg	159,148	155,788	Taiwan	23,512	22,849
Denmark	259,725	246,086	Africa:		
Finland	65,279	10,208	Rhodesia and Nyasaland, Federation of	19,457	9,205
France	3,095	26,979	Union of South Africa	22,045	26,640
Greece	6,241	8,288	Oceania:		
Ireland	24,643	15,426	Australia	20,799	20,706
Italy	45,846	35,966	New Zealand	21,670	59,667
Netherlands	212,627	149,525	Other countries	29,680	52,246
Norway	5,713	11,483			
Rumania	----------	8,270	Total	1,756,583	1,848,066
Sweden	47,300	27,786			
Switzerland	34,420	34,613			

[1] Data include crude salts, chloride, sulfate, magnesium sulfate, and beet ash.
[2] This table incorporates some revisions.

Compiled from Customs Returns of West Germany by Bertha M Duggan, Division of Foreign Activities

Israel.—Dead Sea Works, Ltd., at Sodom at the south end of the Dead Sea began the first stage of its $70 million expansion program in January 1961, by awarding a contract to a Dutch firm for the detailed planning of additional evaporating pans. Completing the new pans will increase production capacity from 150,000 to about 1 million short tons annually.[18]

[18] Bureau of Mines. Mineral Trade Notes. V. 52, No. 5, May 1961, p. 27.

Jordan.—Arab Potash Co., Ltd., awarded a contract to Western Knapp Engineering Co. for consultant engineering services in constructing a 250,000-ton-per-year potash plant on the shore of the Dead Sea, where the company has a 100-year concession on 17,300 acres.[19]

Poland.—Development of a potassium salt industry in the area of Klodawa was planned as part of the current Polish 5-Year Plan according to Przeglad Techniczny. During the 5-Year Plan, the first shaft for potassium salt would be constructed, and production capacity would be 25,000 tons of potassium salts. After developing two additional mines, the annual capacity would be 300,000 tons.[20]

Spain.—Sylvinite deposits of about 60 million tons containing 21 percent potassium were reported discovered near Pamplona.[21]

TABLE 13.—Spain: Exports of potash materials by countries

(Short tons)

Destination	1960	1961	Destination	1960	1961
North America:			Europe—Continued		
Canada	5,952		Netherlands	22,267	19,147
United States	59,508	34,021	Norway	59,471	57,176
Europe:			Portugal	14,225	17,240
Belgium-Luxembourg	5,732	32,300	United Kingdom	75,383	50,371
Denmark	46,196	12,762	Asia: Japan	46,725	78,868
France	10,086		Other countries	1,240	
Germany	11,023				
Italy	51,613	21,065	Total	409,421	322,950

Compiled from Customs Returns of Spain by Bertha M. Duggan, Division of Foreign Activities.

TECHNOLOGY

A paper on the geology of the Paradox basin of southwest Utah and southwest Colorado, which includes important potash deposits under development was published.[22]

A $300,000 Goodman Potash Borer was installed and under study in the Carlsbad, N. Mex., potash mine of International Minerals & Chemical Corp. The machine was designed to eliminate drilling, undercutting, blasting, and loading operations in the normal mining procedure. It has two 6-foot revolving heads that bores two slightly overlapping holes in the ore. As the machine advances it leaves arched sides and a smooth back for greater strength in mine tunnels.[23]

A report on the mining methods used at the Montecatini Co. new and unique San Cataldo potash mine in Sicily was published.[24]

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[19] Bureau of Mines. Mineral Trade Notes. V. 53, No. 6, December 1961, p. 39.
[20] Debski, Stefan. (Under the Klodawa Sky). Przeglad Techniczny (Warsaw), No. 37, Sept. 13, 1961, p. 7.
[21] Mining Journal (London). Mining Miscellany. V. 256, No. 6561, May 19, 1961, p. 579.
[22] Hite, Robert J. Potash-Bearing Evaporite Cycles in the Salt Anticlines of the Paradox Basin, Colorado and Utah. Geol. Survey Prof. Paper 424–D, 1961, pp. D–135–D–137.
[23] Mining Record. IMC's $2 Million Expansion Program at Carlsbad Operation Set for Completion. V. 72, No. 43, Oct. 26, 1961, p. 8.
[24] Mining World. Montecatini Mines Steeply Dipping Potash Beds by Sub-level Stoping. V. 23, No. 8, July 1961, pp. 22–24.

A research paper was published containing data concerning the selective removal of potassium from mixed salt solutions, using clinoptilolite by cation exchange techniques. The process may have future commercial value for the extraction and recovery of potash from mixed salt solutions.[25]

Tests conducted by the U.S. Naval Research Laboratories were reported to indicate potassium bicarbonate to be twice as efficient as sodium bicarbonate for dry-powder fire extinguishers. The Navy adopted the new powder for use in conjunction with mechanical foam extinguishers especially for dealing with aircraft crash fires.[26]

A new fast and cheap colorimetric semiquantitative method for analyzing water-soluble potassium in the presence of large amounts of sodium was reported.[27]

Several patents of interest were reported. A process was described for the separation of potassium and magnesium from material comprised essentially of carnallite with sodium chloride as an impurity.[28] A method for beneficiating a slime-bearing potash-containing material was reported which induces previously treated particles to accept differential electric charges and then subjects the charged particles to an electrostatic field to recover a concentrate.[29] A process was described for beneficiating sylvinite ore containing up to 12 percent by weight carnallite.[30] Another beneficiating process for the recovery of sylvite from potash ores by certain flotation techniques was reported.[31]

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[25] Economic Geology. Scientific Communications, The Use of Clinoptilolite to Remove Potassium Selectively From Aqueous Solutions of Mixed Salts. V. 56, No. 6, September–October 1961, pp. 1133–1136.

[26] Chemical Trade Journal and Chemical Engineer (London). Fire Fighting Agents. V. 149, No. 3891, December 1961, p. 1419.

[27] Mining World. Potash Assaying. V. 23, No. 9, August 1961, p. 33.

[28] Rubin, Maurice (assigned to Société d'Études Chimiques pour l'Industrie et l'Agriculture, Paris, France), (Separation of Potassium and/or Magnesium Ions From Double Salts Containing Potassium and Magnesium.) French Pat. 2,977,186, Mar. 10, 1958.

[29] Adams, Albert, and William B. Dancy (assigned to International Minerals & Chemical Corp., New York, N.Y.), Beneficiation of Potash Ores. U.S. Pat. 2,984,348, Aug. 14, 1959.

[30] Clark, Howard P., and Albert Adams (assigned to International Minerals & Chemical Corp., New York, N.Y.). Potash Ore Treatment. U.S. Pat. 2,968,525, June 9, 1958.

[31] Samsel, Gene L. (assigned to International Minerals & Chemical Corp., New York, N.Y.). Method for Beneficiating Potash Materials. U.S. Pat. 2,997,171. June 2. 1958.

Pumice

By John W. Hartwell [1] and Victoria R. Schreck [2]

PUMICE and pumiceous materials sold or used by United States producers in 1961 increased 11 percent in quantity and 22 percent in value over 1960.

DOMESTIC PRODUCTION

Pumice production was reported from 114 mines by 105 operators in 15 States.

Total output was almost 2.5 million tons valued at $6.8 million. Arizona, with 10 mines and 30 percent of the production, was the leading State, followed by California, with 25 percent from 38 mines; New Mexico, with 14 percent from 17 mines; and Hawaii, with 13 percent from 19 mines.

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
1952–56 (average)	792	$2,478	[1] 729	[1] $874	1,521	$3,352
1957	1,055	3,091	772	1,537	1,827	4,628
1958	925	3,091	1,048	2,196	1,973	5,287
1959	784	3,267	1,492	2,596	2,276	5,863
1960	[2] 601	2,767	[2] 1,609	2,802	[2] 2,210	5,569
1961	936	4,203	1,527	2,596	2,463	6,799

[1] Four-year average (1953–56). Volcanic cinder not reported separately before 1953.
[2] Revised figure.

TABLE 2.—Pumice sold or used by producers in the United States

(Thousand short tons and thousand dollars)

State	1960		1961	
	Quantity	Value	Quantity	Value
Arizona	703	$1,164	745	$1,893
California	427	1,895	610	2,202
Colorado	32	70	44	60
Hawaii	361	676	324	626
Idaho	56	88	60	95
New Mexico	365	827	339	879
Utah	60	134	60	95
Wyoming	33	30	20	20
Other States [1]	173	685	261	929
Total	2,210	5,569	2,463	6,799

[1] Includes Kansas, Nebraska, Nevada, Oklahoma, Oregon, Texas, and Washington.

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.

CONSUMPTION AND USES

Consumption and use of natural pumiceous material other than pumice or pumicite decreased about 5 percent. The largest uses of domestic pumice was for admixtures and aggregates (43 percent) and railroad ballast (25 percent).

TABLE 3.—Pumice sold or used by producers in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1960		1961	
	Quantity	Value	Quantity	Value
Abrasive: Cleaning and scouring compounds	11	$678	13	$221
Concrete admixture and concrete aggregate	929	2,704	1,047	3,518
Railroad ballast	824	858	603	563
Road construction [1]	271	538	558	1,083
Other uses [2]	[3] 175	[3] 791	242	1,414
Total	2,210	5,569	2,463	6,799

[1] Includes surfacing, ice control, and maintenance.
[2] Includes abrasive uses (miscellaneous), absorbents, acoustic plaster, brick manufacture, filtration, insecticides, insulation, soil conditioners, and miscellaneous uses.
[3] Revised figure.

PRICES

Nominal price quotations covering domestic and imported prepared pumice were carried regularly in trade publications. The Oil, Paint and Drug Reporter quoted the following average prices per pound, bagged, in ton lots: Domestic, coarse to fine, $0.03625; imported, Italian, silk-screened, coarse, $0.0650, 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. These quoted prices had not changed since 1952.

The values per ton for pumice in various-use categories were: Cleaning and scouring compounds and other abrasive uses, $19.95; concrete admixtures and aggregate, $3.36; insulation, $9.39; railroad ballast, $0.93; road construction, $1.94; and other and unclassified uses, $3.69.

FOREIGN TRADE [3]

Imports.—Pumice stone for use in the manufacture of concrete masonry products, such as building block, brick, and tile, was a new category in which pumice imports were classified by the U.S. Department of Commerce, Bureau of the Census, effective October 28, 1959. Under this classification, imports from Greece and Italy were 24,652 short tons in 1961, compared with 47,104 tons in 1960. Imported crude pumice, valued at less than $15 per ton, had an average value of $8.95 per short ton in 1961, compared with $8.40 in 1960; imported crude pumice valued at more than $15 per ton averaged $17.66,

[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.

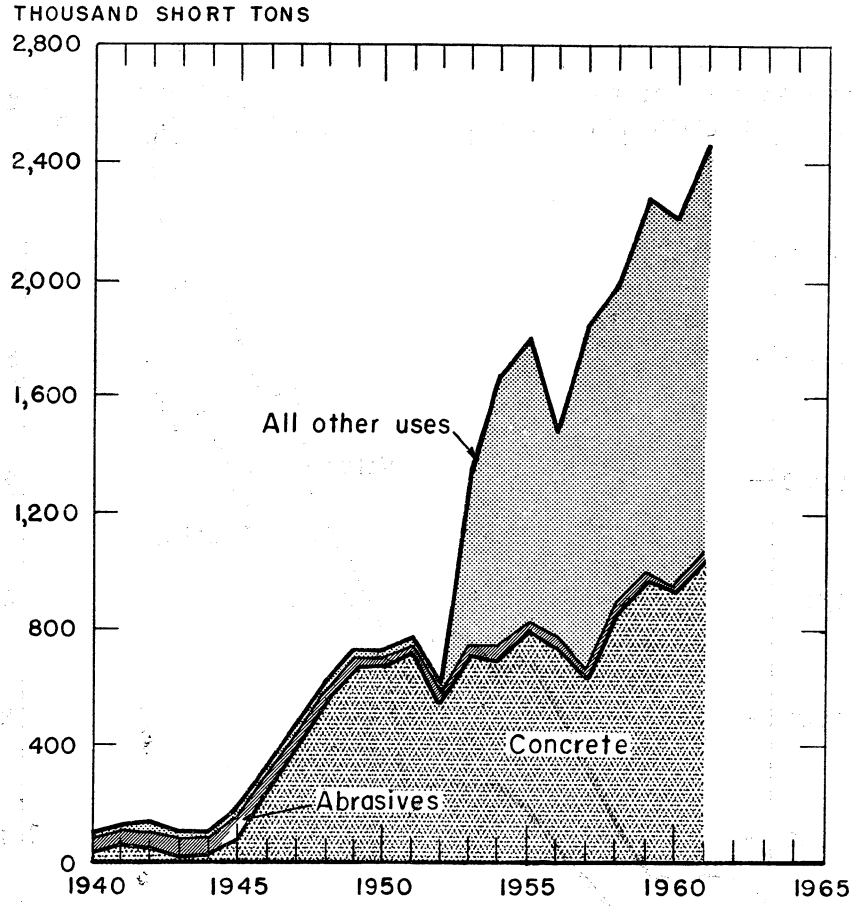


FIGURE 1.—Trends in pumice by uses, 1940–61.

compared with $15.38 in 1960; and wholly or partly manufactured pumice averaged $28.48, compared with $26.29 in 1960.

Exports.—Pumice exports were grouped with other mineral commodities and were not available separately.

Tariff.—Duty per pound on imported pumice was the same as in 1960: Crude valued at $15 a ton and under, 0.045 cent; crude valued over $15 a ton, 0.12 cent; and wholly or partially manufactured, 0.45 cent.

WORLD REVIEW

West Germany, which produced nearly 6 million tons, was the leading producing country, followed by Italy and the United States.

Iceland.—Pumice from a deposit near Hafnarfjordur was being tested by a West German firm to determine if large-scale extraction and export of pumice would be profitable.[4]

[4] U.S. Embassy, Reykjavik, Iceland. State Department Dispatch 141. Feb. 6, 1962, p. 16.

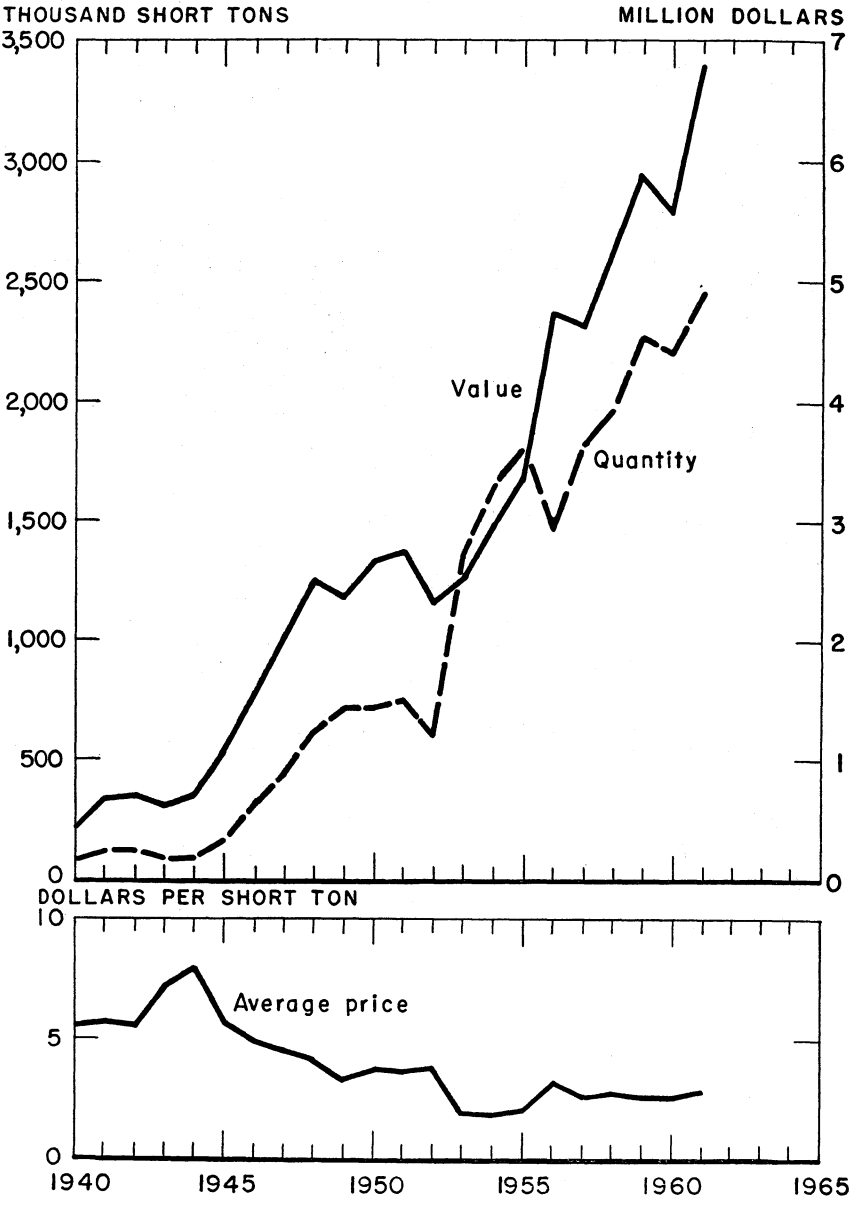


FIGURE 2.—Total value, quantity, and price per ton of pumice, 1940–61.

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.	
	1960		1961		1960		1961		1960		1961		1960	1961
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Value	
Austria														$1,159
Canada													$600	
France													243	
Germany, West													32,027	17,466
Greece														
Italy	6,556	$58,113	6,907	$68,830	3,916	$102,951	4,063	$115,704	47,077	$203,172	11,278	$56,490		
Japan									27	357	13,374	27,824	572	
Netherlands													994	
Norway														137
United Kingdom													180	
													1,353	695
Total	6,556	58,113	6,907	68,830	3,916	102,951	4,063	115,704	47,104	203,529	24,652	84,314	35,969	19,457

[1] Imported to be used in the manufacture of concrete masonry products.

Source: Bureau of the Census.

West Indies.—The Antillian Aggregate Corporation, Curacao, Netherlands Antilles, was granted a 10-year option to exploit a pumice deposit at St. Eustatius in the Windward Islands.

The pumice deposit was estimated to contain 400 to 500 million tons. Plans were made to mine 300,000 tons a year, and after beneficiation, it was intended to export material to Florida and Puerto Rico for use chiefly as a lightweight aggregate and admixture for concrete.[5]

TABLE 5.—World production of pumice by countries [1,2]

(Short tons)

Country [1]	1952-56 (average)	1957	1958	1959	1960	1961
Argentina [3]	[4] 32,656	20,278	22,307	19,842	[5] 20,000	[5] 20,000
Austria: Trass	43,787	38,875	29,784	34,885	38,581	40,846
Canary Islands	899	----------	----------	1,836	1,614	[5] 1,650
Cape Verde Islands: Pozzolan	----------	----------	----------	10,033	4,043	[5] 4,400
France:						
Pumice	11,939	8,781	7,051	2,064	5,071	[5] 5,000
Pozzolan	295,472	468,228	396,975	482,683	518,086	[5] 520,000
Germany, West (marketable)	2,796,854	3,261,735	3,255,121	4,039,966	4,742,138	5,897,359
Greece:						
Pumice	46,617	61,242	49,614	71,650	[5] 82,000	[5] 88,000
Santorin earth	52,587	87,634	94,428	93,696	[5] 110,000	[5] 198,000
Iceland	[6] 15,102	15,102	[5] 11,000	[5] 10,000	[5] 9,000	[5] 9,000
Italy:						
Pumice	169,583	221,990	145,413	258,254	345,390	[5] 3,970,000
Pumicite	33,187	37,302	137,899	146,717	124,671	
Pozzolan	1,726,582	2,897,620	2,992,880	3,055,978	3,494,273	
Japan	(7)	(7)	120,000	(7)	(7)	(7)
Kenya	[8] 1,831	2,319	821	2,515	2,711	779
New Zealand	8,027	16,991	25,851	31,803	49,204	[5] 50,000
United Arab Republic (Egypt)	392	1,836	1,185	2,756	3,307	4,335
United States (sold or used by producers):						
Pumice and pumicite	792,641	1,054,594	925,026	783,873	601,315	936,039
Volcanic cinder	[9] 729,019	772,384	1,047,930	1,492,247	1,609,050	1,526,546
World total (estimate) [1,2]	6,810,000	9,100,000	9,300,000	10,700,000	11,900,000	13,400,000

[1] Pumice is also produced in 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, 1955-56.
[5] Estimate.
[6] Average annual production, 1954-56.
[7] Data not available; estimate included in total.
[8] One year only, as 1956 was first year of commercial production.
[9] Average annual production, 1953-56. Volcanic cinder was not reported before 1953.

Compiled by Helen L. Hunt, Division of Foreign Activities.

TECHNOLOGY

Volcanic cinder deposits 20 miles east of Baker and 8 miles south of Valley Wells Station, San Bernardino County, Calif., were described. Processed cinder from the deposits was used as a lightweight concrete aggregate in Las Vegas, Nev. It sold for $2 to $6.50 per ton f.o.b. mine.[6]

Pumicite beds in southeastern California, deposited during the Pleistocene age as volcanic ash, were described.[7]

[5] U.S. Embassy, Curacao, Netherlands Antilles. State Department Dispatch 120. Nov. 21, 1961, pp. 1-3.
[6] Evans, James R. Volcanic Cinders Near Baker. Miner. Inf. Service, California Division of Mines, v. 14, No. 9, September 1961, pp. 10-11.
[7] Blanc, Robert P., and George B. Cleveland. Pleistocene Lakes of Southeastern California—II. Miner. Inf. Service, California Division of Mines, v. 14, No. 5, May 1961, pp. 5-6.

The Geological Survey of Fiji reported on two large deposits of pumice, their potential for development, and possible industrial uses for the material. The report summarized the work done by the Survey and listed some of the more recent literature concerning pumice. Tests were made and results given on the suitability of the pumice for lightweight concrete. Use of the pumice for construction, road-making, agriculture, and other applications was discussed. Advantages of pumice products were given. It was suggested that the pumice could be quarried for local use and possibly for export.[8]

Pumice mined at Keshegy Hill in the Matra Mountains of northern Hungary for hundreds of years was described. It is composed of a porous glassy groundmass containing embedded porphyritic and microlitic crystals. The rock is light gray, has a silky luster, and a specific gravity of 1.9.[9]

Data on the uses of various types of volcanic glasses, including scoria, pumice, pumicite, tuffs, trass, and volcanic ash, in lime silicate plants were given. The processing requirements involved in their use also were described.[10]

A method of producing a low-cost structural clay block, using pumice and other lightweight aggregates, was patented.[11] A material, consisting of water and oil emulsion and finely divided pumice filler or other inorganic material, was developed for coating concrete blocks.[12] Another coating material, with water-repellent composition containing pumice or other fillers, also was patented.[13]

Canadian patents on uses of pumice were issued for a method of producing abrasive pellets for use in tumble polishing materials,[14] and for a method of producing lightweight building units.[15]

[8] Rickard, M. J. The Possibility of a Pumice Products Industry in Fiji. Geol. Survey Department, Suva, Fiji, G.S. Rept. No. 70, July 1961, 24 pp.
[9] Otvos, Ervin G., Jr. Pumice and Perlite in a Rhyolite Complex in Hungary. Econ. Geol., v. 56, No. 6, September–October 1961, pp. 1112–1122.
[10] Bauer, Wolf G. The Lime-Silicate Plant, Part IV—Utilization of the Glassy Silicates. Pit and Quarry, v. 53, No. 9, March 1961, pp. 122, 125, 127, 129–131.
[11] Burnett, W. H. Building Units and Methods of Producing the Same. U.S. Pat. 2,970,061–1, Jan. 31, 1961.
[12] Heijmer, G. B. Coating Compounds. U.S. Pat. 3,002,853, Oct. 3, 1961.
[13] Liberthson, L., and H. Lipkind (assigned to Sonneborn Chemical & Refining Corp. of Canada, New York, N.Y.). Water-Repellent Masonry Coating Composition Containing Filler Coated With an Organopolysiloxane and Masonry Coated Therewith. U.S. Pat. 3,006,875, Oct. 31, 1961.
[14] Smith-Gorman, R. J. (assigned to Rolls-Royce Ltd.). Canadian Pat. 612,269. Jan. 10, 1961.
[15] Conrnu, F. L. Canadian Pat. 614,759. Feb. 21- 1961.

Quartz Crystal (Electronic Grade)

By James D. Cooper [1] and Gertrude E. Tucker [2]

CONSUMPTION of electronic-grade quartz crystal in the United States decreased 6 percent from 1960; however, total production of finished crystal units was 13 percent greater. The increase was attributed to more efficient cutting methods, production of more miniaturized units, and increased use of manufactured quartz crystal, which contains more usable material than the natural crystal.

TABLE 1.—Salient electronic- and optical-grade quartz crystal statistics

	1952–56 (average)	1957	1958	1959	1960	1961
Imports of electronic- and optical-grade quartz crystal (estimated) [1]—thousand pounds	802	432	274	[2] 367	[2] 676	854
Value—thousands	$1,844	$652	$341	[2] $638	[2] $504	$762
Consumption of raw electronic-grade quartz crystal [3]—thousand pounds	272	182	158	210	230	216
Production, piezoelectric units, number, thousands	5,401	[4] 5,787	[4] 5,510	[4] 6,820	[4] 8,712	[4] 9,822

[1] Imports for 1953–61 are Brazilian pebble valued at 35 cents or more per pound.
[2] Excludes quartz crystal imported from Brazil and accepted under Government agricultural barter contracts.
[3] For 1954 and subsequent years, data include some reworked scrap quartz crystal.
[4] Includes finished crystal units produced from reprocessed blanks, from raw quartz previously reported as consumption, and from imported blanks.

DOMESTIC PRODUCTION

There was no reported production of natural electronic-grade quartz crystal in the United States in 1961. At the end of the year three companies were producing manufactured quartz crystal in commercial quantity. Sawyer Research Products, Inc., Eastlake, Ohio, marketed over 6,500 pounds of manufactured quartz crystal, mostly to cutters in the United States. Western Electric Co., North Andover, Mass., produced manufactured crystal for use by Western Electric and affiliated companies. The third company, Transcom Electronics, Inc., Middletown, R.I., started commercial production in December, but reported no sales for the year.

Total production capacity for manufactured quartz crystal was estimated to be about 41,000 pounds per year as of December 1961.

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

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CONSUMPTION

Consumption of raw quartz crystal for producing piezoelectric units was 216,000 pounds, 14,000 pounds or 6 percent less than was used in 1960. Consumption in 1961 of 7,100 pounds of domestically produced manufactured quartz crystal was more than double the 1960 consumption. About 9,365,000 finished crystal units were produced from raw quartz crystal consumed in 1961, and an additional 457,000 units were obtained from blanks carried over from prior years and from imported blanks. The yield per pound of raw quartz crystal consumed was 43.4 finished crystal units compared with 36.5 units in 1960. The yield from manufactured quartz crystal was reported to be from 2 to 10 times the yield from natural quartz.

A total of 42 quartz-crystal cutters, representing 40 companies in 17 States, reported to the Bureau of Mines in 1961. Thirty-nine of the consumers produced piezoelectric units, and three produced semi-finished blanks only. About 90 percent of the raw quartz crystal used was reported by 30 consumers in 8 States. Pennsylvania, with 35 percent of the consumption, was the leading State, followed by Illinois, Missouri, Kansas, and Massachusetts.

In 1961, piezoelectric units were reported by 52 producers (50 companies) in 22 States. Of the 52 producers, 13 did not consume raw quartz crystal but manufactured finished crystal units from partly processed blanks. Almost 90 percent of the total production was reported for 26 plants in 10 States. Pennsylvania, Kansas, Missouri, Illinois, and Massachusetts produced the largest individual quantities of finished crystal units. Oscillator plates comprised 89 percent of the total production of piezoelectric units. The remaining 11 percent consisted of filter plates, telephone resonator plates, transducer crystals, and miscellaneous items.

STOCKS

Domestic consumers, importers, and dealers reported stocks of imported and manufactured quartz crystal totaling 395,000 pounds at the end of 1961.

Government stocks of electronic-grade quartz crystal as of December 31, 1961, totaled 5,044,000 pounds, of which 4,812,000 pounds was in the national (strategic) stockpile, and 232,000 pounds in the Commodity Credit Corporation and supplemental stockpiles. Excess Government stocks amounted to 4,394,000 pounds, 676 percent above the maximum stockpile objective of 650,000 pounds.

PRICES

Prices for natural electronic-grade quartz crystal sold to domestic consumers remained unchanged from the preceding year except for the smaller sizes, for which prices were somewhat lower. Approximate prices for the various weight classes were as follows:

Weight class (grams):	*Price per pound*
100–200	$2.00 to $3.50
201–300	4.00 to 12.50
301–500	8.00 to 14.00
501–700	12.00 to 20.00
701–1,000	18.00 to 24.00
1,001–2,000	24.00 to 35.00

Prices for manufactured quartz crystal sold by Sawyer Research Products, Inc., ranged from $27.50 to $35 per pound, depending on quantity commitments, unchanged from the preceding year.

Prices for lasca, used for manufacturing clear fused quartz and as the feed material for manufactured quartz crystal, were about $0.50 per pound for first quality material; small lots sold for as much as $1 per pound. Second quality lasca was priced at about $0.25 per pound.

FOREIGN TRADE[3]

Imports of electronic- and optical-grade quartz crystal valued at more than 35 cents per pound were 26 percent higher than in 1960, exclusive of material obtained by barter of agricultural products (1960). Total declared value was up 51 percent. Brazil, the major supplier, furnished 849,700 pounds, which was over 99 percent of the total. The remaining 4,500 pounds came from Japan and Peru.

Imports of quartz crystal valued at less than 35 cents per pound totaled 319,385 pounds, valued at $36,562, a decrease of 28 percent in quantity and 37 percent in value from 1960. This material, known as lasca, was used principally for manufacturing fused quartz and as the feed material in producing manufactured quartz crystal.

Exports of raw quartz crystal were up sharply. The value of exports was $518,384 compared with $353,869 in 1960, an increase of 46 percent. Principal countries of destination were Japan, Canada, United Kingdom, and West Germany. Data on the quantity of quartz crystal exported are not available. Reexports were valued at $75,350, compared with $26,634 in 1960. Canada, United Kingdom, and Japan were the principal countries of destination.

WORLD REVIEW

Brazil.—Exports of electronic- and fusing-grade quartz crystal in 1961 totaled 4,640,680 pounds, valued at approximately US $1,315,000,[4] an increase of 29 percent in quantity and 27 percent in value over 1960. No breakdown was available by grade, but a substantial quantity of the material consisted of lasca, which is used primarily for manufacturing fused quartz and as the feed material in producing manufactured quartz crystal.

Malagasy Republic.—Exports of electronic-grade quartz crystal in 1961 totaled 10,360 pounds valued at US$45,456. Production of electronic-grade quartz crystal in 1960 was 5,071 pounds valued at US$28,493. Production data for 1961 were not available.

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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] U.S. Embassy, Rio de Janeiro, Brazil, State Department Dispatch 850, Apr. 30, 1961, encl. 1, p. 6.

Exports of ornamental quartz crystal in 1961 totaled 26,450 pounds, valued at US$25,562; and exports of fusing-grade quartz crystal were 4,850 pounds, valued at US$835.[5]

Peru.—A small quantity of electronic-grade quartz crystal was imported from Peru in 1961; however, no data on production from that country were available.

TECHNOLOGY

Studies were made of various possible methods for improving the quality of manufactured quartz crystal. Variables which appeared to have promise were temperature differential, composition of solution, type of feed, type of tank lining, and tank baffles.[6]

Electronic quartz crystal resonators, which can operate at temperatures up to 550° C. and in gamma-ray environments, were made by electrolyzing the raw quartz with 500 volts per centimeter at 500° C. for approximately 24 hours. This treatment makes it practicable to cut the crystals at higher orientation angles.[7]

Experimental ultraminiature crystals one-tenth inch in diameter and smaller were produced, which operate in the 10 to 100 megacycle range and exceed requirements for Q-factor of 10,000.[8]

A new process for making fused quartz from domestic raw material was announced. Previously only imported quartz crystal (lasca) was available in sufficient quantity to meet requirements for high-quality fused quartz.[9] The new product is reportedly much lower in alumina, lithium, and boron than that made from imported quartz crystal.

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[5] U.S. Embassy, Tananarive, Republic of Malagasy, State Department Dispatch 163, Apr. 10, 1962, p. 3.

[6] Hale, D. R., and E. A. Carlson. Study of Methods for Improving Quality of Synthetic Quartz. Clevite Corp., Cleveland, Ohio, Quart. Rept. No. 2, Jan. 16–Apr. 15, 1961, 23 pp.; U.S. Govt. Res. Rept., Off. Tech. Services, U.S. Dept. Commerce, v. 36, No. 2, July 20, 1961, p. 117; Quart. Rept. No. 3, Apr. 16–July 15, 1961, 16 pp.; U.S. Govt. Res. Rept., Off. Tech. Services, U.S. Dept. Commerce, v. 36, No. 10, Nov. 20, 1961, pp. 33–34.

[7] Chemical & Engineering News. Electrolysis Aids Quartz Resonators. V. 39, No. 49, Dec. 4, 1961, p. 49. Chemical Week. Quartz for Hot Jobs. V. 89, No. 23, Dec. 9, 1961, p. 99.

[8] Deininger, J. G., and R. E. Bennet. Ultraminiature Quartz Crystal Units. Union Thermoelectric Corp., Chicago, Ill., Quart. Progress Rept. No. 3, Dec. 15, 1960–Mar. 14, 1961, 23 pp.; U.S. Govt. Res. Rept., Off. Tech. Services, U.S. Dept. Commerce, v. 36, No. 1, July 5, 1961, p. 32.

Stringe, Jack W. Ultraminiature Quartz Crystal Units. Union Thermoelectric Corp., Chicago, Ill., Quart. Progress Rept. No. 4, Mar. 15–June 14, 1961, 16 pp.; U.S. Govt. Res. Rept., Off. Tech. Services, U.S. Dept. Commerce, v. 36, No. 8, Oct. 20, 1961, p. 27.

[9] Wall Street Journal. GE Says It Developed Purer Fused Quartz From Material in U.S. Oct. 25, 1961, p. 7.

Rare-Earth Minerals and Metals

By John G. Parker [1] and Ethel M. Tucker [2]

DOMESTIC mine shipments of rare-earth minerals in 1961 totaled about two and one half times those for the preceding year. Monazite concentrate purchased by processing companies from the Union of South Africa, Australia, and Malaya supplemented the domestic raw materials.

The Office of Minerals Exploration (OME) contributed financial aid up to 50 percent of the allowable costs of exploration for monazite and other rare-earth minerals.

DOMESTIC PRODUCTION

Concentrate.—In 1961 bastnaesite concentrate was produced by Molybdenum Corporation of America at its mine and processing facilities at Mountain Pass, Calif. Large shipments of monazite concentrate from beach sand were made by Titanium Alloy Manufacturing Division, National Lead Co., Duval County, Fla.

Metals and Compounds.—Rare-earth concentrates were processed, and separated metals and compounds were produced and refined by American Potash & Chemical Corp., West Chicago, Ill.; American Scandium Corp., Cincinnati, Ohio; W. R. Grace and 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, Pittsburgh, Pa.; Research Chemicals Division, Nuclear Corporation of America, Phoenix, Ariz.; and Vitro Chemical Co., Chattanooga, Tenn.

Cerium metal, misch metal, ferrocerium, and other rare-earth-bearing alloys were produced by American Metallurgical Products Co., Pittsburgh, Pa.; Castalloy, Inc., Natick, Mass.; The Dow Chemical Co., Midland, Mich.; Mallinckrodt Chemical Works, St. Louis, Mo.; Ronson Metals Corp., Newark, N.J.; and Union Carbide Metals Co., New York, N.Y.

Kleber Laboratories, Inc., a new company, produced high-purity rare-earth compounds and metals. Research Chemicals Division of Nuclear Corporation of America moved to the Phoenix, Ariz., plant formerly occupied by U.S. Semiconductor Products, Inc., whose assets it had acquired. Ronson Metals Corp. expanded and modernized its plant to allow a 30-percent increase in misch-metal production

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.

capacity and actively pursued research and development on rare-earth metal and alloy products in a new electronics and metallurgical laboratory. Dresser Products, Inc., Great Barrington, Mass., fabricated rare-earth compounds, cermets, metals, and alloys into finished shapes and forms from high-purity materials supplied by Michigan Chemical Corp. The latter concern also arranged a cooperative agreement with Haveg Industries, Inc., Wilmington, Del., to develop and manufacture lightweight shielding as protection against fast and thermal neutrons and against gamma radiation. Davison Chemical was to produce and sell rare-earth oxide polishing materials to the glass industry under the terms of a long-term contract signed with Molybdenum Corporation of America, which would supply the rare-earth concentrates. In a similar marketing venture, United States Borax & Chemical Corp. was to sell rare-earth products manufactured by Vitro Chemical Co. to the glass and ceramic industries.

CONSUMPTION AND USES

Apparent consumption of rare-earth elements again increased about 20 percent over that of 1960, to approximately 2,150 short tons of rare-earth oxides.

Commercial grade rare-earth compounds were available from the large processors of rare-earth concentrates. High-purity materials could be purchased from these concerns and from smaller refining companies.

The biggest potential uses for rare-earth materials seemed to lie in extended application in glass polishing and in steel alloying. Cerium dioxide was used at ophthalmic plants because it has long life, is easily removed from unpolished lens edges, is freely dispersed on polishing pads, and can be recirculated in the process.[3] A new low-priced high-speed cerium oxide polish gave promise of increasing the use of such material in the plate glass industry.[4]

Cerium added to steel and cast iron as misch metal or as rare-earth exides was said to improve fluidity, reduce grain growth usually occurring at high temperatures in high-chromium steels, and suppress deleterious elements and promote graphite in nodulization, thereby creating ductility in cast iron.[5]

Some nuclear reactors used rare-earth elements with extremely high thermal neutron cross sections and relative radiation damage immunity as absorbers in control rods. Costs of such materials were discussed as a function of metallurgical composition and reactor endurance.[6]

Large quantities of rare-earth oxides and fluorides continued to be consumed in the manufacture of arc-light carbons. Garnet and other crystals, doped with rare-earth materials as activators, were used in laser and other microwave applications.

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[3] Glass Industry. Grinding and Polishing Lenses for Eyeglasses. V. 42, No. 12, December 1961, pp. 683–685, 711.
[4] American Metal Market, v. 68, No. 173, Sept. 8, 1961, p. 14.
[5] London & Scandinavian Metallurgical Co., Ltd. Cerium. Ch. in Constituent Elements in Steel and Cast Iron. Sheffield, England. 1961, pp. 16–17.
[6] Anderson, W. K., C. J. Beck, and J. S. Theilacker. Control Rod Economics. Nuclear Sci. and Eng., v. 9, January 1961, pp. 1–15; Nuclear Sci. Abs., v. 15, No. 8, Apr. 30, 1961, pp. 1330–1331.

STOCKS

Monazite concentrate stocks, which had reached their lowest point in several years, were replenished in 1961 by the importation of a substantial quantity of the material. Stocks of intermediate material, such as rare-earth sodium sulfate, appeared adequate for several years at the 1961 rate of consumption. As of December 31, 1961, Government inventories of rare earths and undisclosed materials, including national (strategic) and supplemental stockpiles, totaled 14,473 short tons.

PRICES

Since the end of 1955, monazite prices quoted nominally by E&MJ Metal and Mineral Market had remained essentially the same. 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; and sand, 55-percent grade, 10 to 15 cents, 66-percent grade, 18 cents, and 68-percent grade, 20 cents. Large-scale transactions for purchase of imported and domestic monazite were concluded at prices well below those quoted. The price for domestic bastnaesite was not available.

Prices for misch metal, depending upon variety and quantity, were cut 10 cents per pound by a major producer early in the year. Quoted prices on small lots of 99.9-percent-pure rare-earth metals, published periodically in American Metal Market, had remained unchanged for several years. Lunex Co., Research Chemicals, Kleber Laboratories, and Semi-Elements, Inc., Saxonburg, Pa., quoted prices on pound lots of high-purity rare-earth metals, and stated that prices on larger quantities were available upon request. Davison Chemical, Kleber Laboratories, and Semi-Elements, Inc., quoted prices on purified rare-earth oxides and salts.

FOREIGN TRADE [7]

Imports.—A total of 66 pounds of cerium metal valued at $937 was imported (2 pounds from the United Kingdom and 64 pounds from West Germany). Cerium alloy, including ferrocerium, came from Austria, France, Japan, the United Kingdom, and West Germany, and totaled 22,955 pounds, valued at $63,210. Austria supplied about 70 percent of the total. Monazite concentrate and other thorium ores, imported from Australia, Canada, Federation of Malaya, and the Union of South Africa, totaled 2,902 short tons, valued at $415,381. The Union of South Africa supplied 72 percent of this quantity.

Exports.—Of the 6,563 pounds of cerium ores, metal, and alloys exported, 63 percent went to the United Kingdom, 23 percent to Canada, and about 14 percent to France, Mexico, and West Germany. These exports were valued at $29,839. Ferrocerium (lighter flints) exported in 1961 totaled 20,338 pounds and was valued at $89,362; nearly half was sent to the United Kingdom.

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[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.

WORLD REVIEW

Argentina.—Discovery of over 30 million tons of mineral-bearing sands containing approximately 4 percent monazite was reported in Cordoba Province.[8]

Australia.—Preliminary statistics for 1961 revealed that Australia produced 1,998 short tons of monazite concentrate.[9] This was obtained chiefly as a byproduct from ilmenite operations in Western Australia; the remainder came from rutile mining along the east coast. Exports of monazite concentrate for the first half of 1961 totaled 1,674 tons and went mainly to the United States, France, the United Kingdom, and Japan.[10]

Brazil.—Monazite production was estimated at 926 short tons of 60-percent concentrate according to reports from the Ministry of Finance.[11]

Ceylon.—Mineral production statistics released by the government of Ceylon showed that 239 short tons of monazite were produced during 1961.[12]

India.—British interests of the Trivandrum Titanium Works were requested, by the Kerala Government, to study the possibility of establishing plants in the ilmenite and monazite production centers.[13] The developmental history of the beach sand industry in South India was presented.[14]

Ivory Coast.—The Development and Resources Corporation recommended a 3-year (1961 to 1963) mineral exploration program, including search for rare-earth elements.[15]

Japan.—Improved techniques for separating rare-earth elements enabled Japan to increase production of cerium fluoride and cerium and other rare-earth oxides. Fluorides were used almost exclusively in the manufacture of arc carbons; the oxides were used principally in polishing compounds. Misch metal was produced for use in lighter flints and as an additive to steel.[16]

Pure cerium oxide was produced using the ethylenediaminetetraacetic acid-copper method in new ion-exchange equipment. By purifying 2.2 kg of cerium oxide of 79-percent purity, 1.37 kg of pure cerium oxide was obtained.[17]

Korea, Republic of.—The Ministry of Commerce and Industry reported production of 28 short tons of monazite in 1961.[18]

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[8] Engineering and Mining Journal, v. 163, No. 1, January 1962, p. 112.
[9] U.S. Embassy, Canberra, Australia. State Department Dispatch 543, May 2, 1962, p. 3.
[10] Bureau of Mineral Resources, Geology and Geophysics. The Australian Mineral Industry. Part 1—Quarterly Review. V. 14, No. 2, December 1961, p. 41.
[11] U.S. Embassy, Rio de Janeiro, Brazil. State Department Dispatch 850, Apr. 30, 1962, p. 4.
[12] U.S. Embassy, Colombo, Ceylon. State Department Disptach 584, Apr. 17, 1962, p. 1.
[13] Mining Journal (London), v. 257, No. 6588, Nov. 24, 1961, p. 547.
[14] Viswanathan, P. The Beach Sands Industry in South India: A Fifty-Year Review. Science and Culture, v. 27, January 1961, pp. 16–21.
[15] Bureau of Mines. Mineral Trade Notes. V. 53, No. 4, October 1961, pp. 62–64.
[16] Japan Association of Metals for Atomic Energy. Current Situation of Newer Metals in Japan in 1961. Tokyo, Japan, pp. 17–20.
[17] Nishigori, Kenjiro, Toyoji Ishiyama, and Tadashi Kuroda. (Study of Industrial Ion Exchange Separation of Rare Earth Elements by EDTA Copper Method. 3. Manufacture of Ion Exchange Equipment.) Denki Shikensho Iho, Mar. 25, 1961, pp. 327–336; Nuclear Sci. Abs., v. 15, No. 21, Nov. 15, 1961, p. 3572.
[18] U.S. Embassy, Seoul, Korea. State Department Dispatch 413, Apr. 27, 1962, p. 2.

Malagasy Republic.—Exports of monazite in 1961 were 481 short tons valued at US$111,183. In addition, slightly over 1 ton of bastnaesite valued at approximately US$400 was exported.[19]

Malaya, Federation of.—Exports of monazite reached 780 short tons, priced at approximately US$78 a ton.[20]

Mozambique.—A small quantity of monazite was produced.[21]

Nigeria.—The Federal Ministry of Mines and Power reported that 8 short tons of monazite was produced during 1961. The output was valued at £527 (US$1,486).[22]

TECHNOLOGY

Results of rare-earth metals research were reported by the U.S. Atomic Energy Commission (AEC). Magnetic properties and internal structures of certain rare-earth isotopes were studied at the Lawrence Radiation Laboratory by orienting nuclei in fixed positions at temperatures near absolute zero and measuring unidirectionally emitted gamma rays. Studies of rare-earth alloys verified the coexistence of superconductivity and ferromagnetism at cryogenic temperatures. At the Argonne National Laboratory, solubilities of the rare-earth metals in liquid cadmium were measured. These showed that new and significant regularities in solid intermetallic compounds, existing in equilibrium with saturated solutions, would aid in developing lower cost pyrometallurgical processes. Phase equilibrium investigations on molten systems containing rare-earth fluorides at Oak Ridge National Laboratory showed regularities of their properties which are correlatable with cation size. These studies and known isostructural relationships permitted predictions about binary systems not yet studied.[23]

At the Second Rare-Earth Conference at Glenwood Springs, Colo., results of research on chemical, mechanical, metallurgical, and physical properties of rare-earth metals, alloys, and compounds were presented. Materials such as rare-earth hydrides, chalcogenides, oxides, borides, and borates, techniques using liquid-liquid extraction, and distillation and fabrication of rare-earth metals were discussed.

An industry-sponsored research project on utilization of individual rare-earth elements of the light subgroup was started at Pennsylvania State University.[24]

A new mineral discovered in Kazakstan, U.S.S.R., was named gagarinite, in honor of the first man to orbit the earth. Found in albitized granite, gagarinite contains yttrium and rare-earth elements.[25]

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[19] U.S. Embassy, Tananarive, Malagasy Republic. State Department Dispatch 163, Apr. 10, 1962, pp. 2–3.
[20] U.S. Embassy, Kuala Lumpur, Federation of Malaya. State Department Dispatch 321, Mar. 16, 1962, 1 p.
[21] U.S. Consulate General, Lourenço Marques, Mozambique. State Department Dispatch 278, Apr. 17, 1962, p. 1.
[22] U.S. Embassy, Lagos, Nigeria. State Department Dispatch 288, Mar. 22, 1962, p. 1.
[23] U.S. Atomic Energy Commission. Atomic Energy Research 1961. Spec. rept., December 1961, pp. 147, 155, 156, 158, 181.
[24] American Metal Market, v. 68, No. 202, Oct. 20, 1961, p. 14.
[25] Stepanov, A. V., and E. A. Severov. (Gagarinite—A New Rare-Earth Mineral.) Doklady Akad. Nauk S.S.S.R., v. 141, No. 4, 1961, pp. 954–957.
Chemical Abstracts, v. 56, No. 12, June 11, 1962, col. 13835d.

The Bureau of Mines continued research on rare-earth elements. Thirteen reports were published giving results of thermochemical and solubility investigations; phase equilibria and inversion studies; extractive, separatory, and analytical techniques; reduction, electrowinning, and electrorefining of rare-earth metals; and the effect of rare-earth additives in steel.[26]

In the separation of rare-earth elements from Indian monazite, ceria of over 99 percent purity was continuously separated from mixed rare-earth chlorides.[27]

Chlorination of unground Egyptian monazite sand concentrate at 900° C in a horizontal tube furnace indicated that optimum recovery of rare-earth elements and thorium was obtained from a moderate concentrate of about 90 percent purity.[28]

An exclusive foaming process used on a semiindustrial scale was said to facilitate recovery of rare-earth metals, among others, from solutions. No solids are involved, and selective foaming agents probably are available for many desired solutes.[29] Russian scientists reported on the separation of rare-earth metals by selective precipitation of their insoluble compounds from fused ammonium nitrate.[30] Separation of actinides from rare-earth elements was facilitated by a rapid liquid-liquid extraction procedure.[31] A solution of triiso-octylamine-xylene was used to remove the actinides from a hydrochloric acid-lithium chloride solution. Water immiscible extractants were used to remove rare-earth elements from water-swollen ion-exchange resins.[32]

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[26] Broadhead, Kenneth G., and Howard H. Heady. Radiochemical Precipitation Studies of Rare-Earth Oxalates. BuMines Rept. of Inv. 5783, 1961, 8 pp.
Campbell, T. T., F. E. Block, R. E. Mussler, and G. B. Robidart. Preparation and Metallic Reduction of Rare-Earth Halides and Oxides. BuMines Rept. of Inv. 5880, 1961, 29 pp.
Copeland, M. I., C. E. Armantrout, and H. Kato. Zirconium-Gadolinium Equilibrium Diagram. BuMines Rept. of Inv. 5850, 1961, 13 pp.
Croeni, J. G., S. C. Rhoads, C. E. Armantrout, and H. Kato. Titanium-Gadolinium Phase Diagram. BuMines Rept. of Inv. 5796, 1961, 14 pp.
Gruzensky, William G. Extraction and Separation of Yttrium and Rare-Earth Elements Found in Euxenite. BuMines Rept. of Inv. 5910, 1961, 22 pp.
King, E. G., and A. U. Christensen. High-Temperature Heat Contents and Entropies of Cerium Dioxide and Columbium Dioxide. BuMines Rept. of Inv. 5789, 1961, 6 pp.
King, E. G., W. W. Weller, and L. B. Pankratz. Thermodynamic Data for Lanthanum Sesquioxide. BuMines Rept. of Inv. 5857, 1961, 6 pp.
Leary, R. J., E. M. Ostrowski, and N. Derick. Producing and Ladle-Treating Medium-Carbon Alloy Steels with Rare-Earth Metals and Oxides. BuMines Rept. of Inv. 5895, 1961, 50 pp.
Lindstrom, R. E., J. O. Winget, and J. S. Berber. Effect of Temperature in Ion-Exchange Separation of Rare-Earth Elements and Recovery of EDTA from Effluent Solutions. BuMines Rept. of Inv. 5879, 1961, 16 pp.
Montgomery, R. L., and J. M. Stuve. Thermochemistry of Erbium. BuMines Rept. of Inv. 5892, 1961, 10 pp.
Morrice, E., B. Porter, E. A. Brown, C. Wyche, and R. G. Knickerbocker. Electrowinning Cerium-Group and Yttrium-Group Metals. BuMines Rept. of Inv. 5868, 1961, 39 pp.
Porter, Bernard, and E. A. Brown. Determination of Oxide Solubility in Molten Fluorides. BuMines Rept. of Inv. 5878, 1961, 8 pp.
Stecura, Stephan, and William J. Campbell. Thermal Expansion and Phase Inversion of Rare-Earth Oxides. BuMines Rept. of Inv. 5847, 1961, 47 pp.

[27] Gupta, J., S. K. Kundra, and B. R. L. Row. Separation of Rare Earths Obtained From Indian Monazite. I. Separation of Ceria and Preparation of Lanthanum and Didymium Concentrates. J. Sci. and Ind. Res., v. 20D, No. 4, April 1961, pp. 148–152.

[28] Hilal, O. M., and F. A. El Gohary. Chlorination of Monazite. Ind. and Eng. Chem., v. 53, No. 12, December 1961, pp. 997–998.

[29] Oil, Paint and Drug Reporter. Metals Separated from Foam. V. 179, No. 14, Apr. 3, 1961, pp. 5, 52.

[30] Val'tsev, V. K., S. M. Artamonova, N. R. Didora, and L. Kh. Kravchenko. (Precepitation of Elements from Fused Salts. Report 1. Precipitation of Some Elements from Fused Ammonium Nitrate). Izvest. Sibirsk. Otdel. Akad. Nauk S.S.S.R., No. 4, 1961, pp. 38–42; abstract resulting from the SOV/STEP program under the sponsorship of the U.S. Air Force, available from Off. Tech. Services, U.S. Dept. Commerce.

[31] Moore, Fletcher L. New Technique for the Separation of Trivalent Actinide Elements from Lanthanide Elements. Anal. Chem., v. 33, No. 6, May 1961, pp. 748–751.

[32] Small, H. Gel-Liquid Extraction—II. The Separation of Metallic Species Using Ion Exchange Resins in Conjunction with Water-Immiscible Organic Extractants. J. Inorg. and Nuclear Chem., v. 19, Nos. 1–2, September 1961, pp. 160–169.

Samarium, europium, and yetterbium were removed from concentrates by a continuous sodium-amalgam process.[33] Electrochemical deposition was investigated as a rapid and highly specific method for separating rare-earth elements.[34] Highly concentrated solutions may be processed and current varied to control electrolysis rates, but current efficiency is low and power consumption is high.

A gravimetric method which forms no complexes with the trivalent rare-earth elements was used to analyze for, and to separate quadrivalent cerium from, typical rare-earth elements such as lanthanum and gadolinium.[35]

Russian scientists reported the use of a new reagent, salicylfluorone [9-(o-hydroxy-phenyl) 2, 3, 7-trihydroxyfluorone] which is supposedly much higher in selectivity than Arsenazo I in the photometric determination of rare-earth elements.[36]

Combined neutron activation, ion-exchange chromatography, and photometric methods were used by Japanese researchers in the separation and quantitative determination of individual rare-earth elements from minerals containing light and heavy subgroup rare-earth elements.[37] Japanese scientists also used neutron activation analysis to determine elements such as europium, lanthanum, and samarium in granite and basalt.[38]

Lanthanum was used as an internal standard in the optical spectrographic determination of samarium and other rare-earth elements.[39] A rapid and economical method was developed for the analysis of gadolinium and samarium oxides added as neutron absorbers to high-alumina ceramic.[40] Mass spectrometric studies indicated that vapor compositions and volatilities of different rare-earth oxides in high vacuum vary considerably, the gaseous monoxide stability tending to decrease with increase in atomic number.[41]

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[33] Mining Magazine, v. 104, No. 6, June 1961, p. 323.

[34] Chemical & Engineering News. Electrolysis Yields Pure Rare Earths. V. 39, No. 15, Apr. 10. 1961, pp. 48, 50.

Onstott, E. I. Separation of the Lanthanons at Amalgam Cathodes. Measurement of the Separability of Praseodymium and Neodymium in Aqueous Lithium Citrate Electrolytes. Anal. Chem., v. 33, No. 11, October 1961, pp. 1470–1473.

[35] Bhat, A. N., and B. D. Jain. Gravimetric Determination of Cerium IV and Its Separation From Rare Earths Using 3-Acetyl-4-Hydroxycoumarin. J. Less-Common Metals, v. 3, No. 3, June 1961, pp. 259–261.

[36] Zaikovskii, F. V., and G. F. Sadova. (Photometric Determination of Rare Earths With Salicylfluorone.) Zhur. analiticheskoi Khim., v. 16, No. 1, January–February 1961, pp. 29–31; abstract resulting from the SOV/STEP program under the sponsorship of the U.S. Air Force, available from Off. Tech. Services, U.S. Dept. of Commerce.

[37] Fujii, Isao. (Determination of the Individual Rare Earth Elements in the Rare Earth Minerals by Neutron Activation Method. Determination of the Individual Rare Earth Elements in Monazite and Allanite.) J. Atomic Energy Soc. of Japan, v. 3, March 1961, pp. 9–18; Nuclear Sci. Abs., v. 15, No. 9, May 15, 1961, p. 1392.

——— (Determination of the Individual Rare Earth Elements in the Rare Earth Minerals by Neutron Activation Method. II. Determination of the Individual Rare Earth Elements in Gadolinite, Xenotime, Fergusonite, Euxenite, and Yttrialite.) J. Atomic Energy Soc. of Japan, v. 3, March 1961, pp. 186–189; Nuclear Sci. Abs., v. 15, No. 14, July 31, 1961, p. 2329.

[38] Hamaguchi, Hiroshi, and others. Values for Trace Elements in G–1 and W–1 With Neutron Activation Analysis. Geochim. et Cosmochim. Acta, v. 23, Nos. 3 and 4 (Geochemical Notes), May 1961, pp. 296–299.

[39] Pittwell, L. R. Determination of Samarium and Other Rare Earths. Analyst (Cambridge, England, v. 86, No. 1019, February 1961 (Notes), pp. 137–140.

[40] Borror, Kenneth P., and E. A. Fisher. X-Ray Methods for Oxide Analysis. Ceram. Age, v. 77, No. 4, April 1961, pp. 40–42.

[41] Shchukarev, S. A., and G. A. Semenov. (Mass-Spectroscopic Study of Vapor Composition Over Oxides of Rare-Earth Elements). Doklady Akad. Nauk S.S.S.R., v. 141, No. 3, Nov. 21, 1961, pp. 652–654; Current Review of Soviet Technical Press, Jan. 26, 1962, (623) p. 4.

Rare-earth hexaborides were synthesized and their electrical properties studied at room temperature.[42] The stability of the structures of cubic dodecaborides such as HoB_{12} and ErB_{12} were found to depend upon the effective size of the metal atom.[43]

Research performed at the National Bureau of Standards indicated that for most of the rare-earth borates the only stable phase is of the vaterite type.[44] It was stated that rare-earth borates have melting points greater than 1,400° C and that ceramics made from them show resistance to attack by boric acid at elevated temperatures.[45] Most of the trivalent rare-earth oxides were included in binary systems investigations which defined specific regions of stability for the different structure types and summarized the structure types found in all possible binary mixtures of the oxide studied.[46]

Phase equilibria studies showed that a eutectic appeared in the europia-india system at 1,730° C at about the composition of 73 mole-percent india.[47] The melting points of europia and india were determined as 2,240° C ±10° C and 1,910° C ±10° C, respectively. The brown, higher oxide of terbium—Tb_4O_7—was shown to be due probably to the slow oxidation of a lower oxide when the latter is cooled in air or oxygen.[48]

Good atmospheric stability and high reflectance in the infrared were shown by erbium and ytterbium deposited as optical film surfaces by vacuum evaporation techniques on quartz and glass substrates.[49] Rare-earth intermetallic compounds were investigated to determine their melting points and oxidation resistance at elevated temperatures in the search for special refractory coatings.[50]

Crucibles made from cerium dioxide were said not to react with metals such as molten aluminum, zinc, lead, and tin up to 1,000° C over periods of 1 day or more.[51]

Thermal expansion coefficients of rare-earth metals, yttrium, and scandium were described by empirical equations derived from X-ray data.[52] High-temperature X-ray techniques were used to determine

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[42] Sclar, Nathan. Unijunction Devices Made From Rare Earth Semiconductors. Nuclear Corporation of America, quarter. rept. No. 2, April–June 1961 (contract DA 36-039-sc-87392, proj. 3A99021-001), June 30, 1961, 26 pp.; AD 265 421.

[43] LaPlaca, S., I. Binder, and B. Post. Binary Dodecaborides. J. Inorg. and Nuclear Chem., v. 18, March 1961, pp. 113–117.

[44] Levin, Ernest M., Robert S. Roth, and Jerry B. Martin. Polymorphism of ABO_3 Type Rare Earth Borates. Am. Mineral, v. 46, Nos. 9 and 10, September–October 1961, pp. 1030–1055.

[45] Chemical & Engineering News, v. 39, No. 7, Feb. 13, 1961, p. 39.

Felten, E. J. Preparation and Properties of Some Rare Earth Borates. J. Inorg. and Nuclear Chem., v. 19, September 1961, pp. 61–64.

[46] Schneider, S. J., R. S. Roth, and J. L. Waring. Solid State Reactions Involving Oxides of Trivalent Cations. J. Res. Nat. Bur. Standards. A. Physics and Chemistry, v. 65A, No. 4, July–August 1961, pp. 345–374.

[47] Schneider, S. J. Phase Equilibria Systems Involving the Rare Earth Oxides. Part III. The Eu_2O_3-In_2O_3 System. J. Res. Nat. Bur. Standards. A. Physics and Chemistry, v. 65A, No. 5, September–October 1961, pp. 429–434.

[48] Bainziger, N. C., H. A. Eick, H. S. Schuldt, and L. Eyring. Terbium Oxides. III. X-Ray Diffraction Studies of Several Stable Phases. J. Am. Chem. Soc., v. 83, No. 10, June 2, 1961, pp. 2219–2223.

[49] Wilburn, David K. Some Optical Properties of Several Evaporated Rare Earth Metals. U.S. Army Ordnance Tank-Automotive Command, Rept. RR-36, Mar. 1, 1961, 23 p.; AD 261 131.

[50] Nuclear Corporation of America, Research Chemicals Division. Rare Earth Intermetallics. Rept. No. 1, November–December 1960 (contract NOw 61-0257-c); December 1960, 20 pp.; AD 252 345.

[51] Samsonov, G. V., G. A. Yasinskaya, and E. P. Laptova. Ogneupory, No. 1, 1961, pp. 41–42; Current Review of Soviet Technical Press, Apr. 14, 1961, p. 2.

[52] Spedding, F. H., J. J. Hanak, and A. H. Daane. High Temperature Allotropy and Thermal Expansion of the Rare-Earth Metals. J. Less Common Metals, v. 3, No. 2, April 1961, pp. 110–124.

that the crystal structures of lanthanum, cerium, praseodymium, neodymium, yttrium, and possibly gadolinium are body-centered cubic at temperatures near their respective melting points. Electrical resistance measurements gave evidence for possible high-temperature crystalline transformations in gadolinium, terbium, dysprosium, holmium, and lutetium. Constitutional diagrams were determined for the systems gadolinium-iron, gadolinium-nickel, and gadolinium-cobalt.[53] Of 23 intermetallic compounds found in the three systems, the most stable were $GdFe_4$, GdNi, $GdNi_5$, and $GdCo_4$, melting at over 1,800°, 1,300°, 1,500°, and over 1,600° C, respectively.

It was reported that Russian technologists had developed and exhibited a nonpyrophoric alloy containing 40 to 50 percent cerium and lesser quantities of lanthanum and other rare-earth elements, magnesium, and iron designed to promote nodulization in cast iron.[54]

Neodymium or gadolinium in calcium tungstate and bivalent samarium in calcium fluoride were said to act as good light amplifier materials in optical masers.[55]

Direct-current resistivity measurements were made on sintered barium titanate to which very small quantities of rare-earth oxides had been added singly.[56] A very large increase in resistivity occurred near the tetragonal-cubic transition temperature of 120° C.

Samarium sulfide and cerium sulfide were found to have excellent high-temperature stability and good thermo-electric efficiencies up to 2,000° F, although not as good as lower temperature materials. When used in series with other thermoelectric materials, these rare-earth compounds permit higher operating temperatures in thermoelectric generators.[57]

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[53] Novy, F. V., R. C. Vickery, and E. V. Kleber. The Gadolinium-Iron System. AIME Met. Soc. Trans., v. 221, No. 3, June 1961, pp. 580–585.
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———. The Gadolinium-Cobalt System. AIME Met. Soc. Trans., v. 221, No. 3, June 1961, pp. 588–590.

[54] Klubnichkin, K. F. (Application of Rare Elements.) Tsvetnye Metally, No. 1, 1961, pp. 60–66; abstract resulting from the SOV/STEP program under the sponsorship of the U.S. Air Force, available from Off. Tech. Services, U.S. Dept. Commerce.

[55] Americal Metal Market, v. 68, No. 198, Oct. 16, 1961, p. 8.
Scovil, H. E. D. Solid-State Maser Research. Bell Telephone Laboratories, Inc., Quarterly Prog. Rept. No. 4, Mar. 20–June 20, 1961 (contract DA 36-039-sc-85357); AD 261 145, 44 pp.
Electronic News, v. 6, No. 253, Mar. 23, 1961, pp. 1, 8.

[56] Tenney, V. J., and R. L. Cook. Investigation of Rare-Earth Doped Barium Titanate. Am. Ceram. Soc. J., v. 44, No. 4, Apr. 1, 1961, pp. 187–193.

[57] Ceramic Age. Thermoelectricity at Westinghouse. V. 77, No. 9, September 1961, pp. 49–55.

Salt

By Robert T. MacMillan [1] and Victoria R. Schreck [2]

TOTAL output of salt in the United States in 1961 exceeded the record production of 1960 by 200,000 tons. Increased production of evaporated salt was responsible for the new record, as the output of both brine and rock salt was slightly below 1960.

LEGISLATION AND GOVERNMENT PROGRAMS

A Federal grand jury indicted four major salt companies on charges of price fixing. The indictment, returned in Federal court at St. Paul, Minn., charged the firms with conspiracy to submit identical bids on contracts to supply rock salt to various State and municipal governments. The Department of Justice instituted a civil antitrust suit against the same defendants, charging violation of section 1 of the Sherman Act and enjoined them from (1) conspiring to restrain the sale of rock salt, (2) adhering to zone pricing formulas, and (3) exchanging price and market information.[3]

The Federal Trade Commission dropped its suit against a western salt producer after the firm agreed to sell two smaller firms which it had acquired allegedly in violation of laws relating to monopoly.

TABLE 1.—Salient salt statistics [1]

(Thousand short tons and thousand dollars)

	1952–56 (average)	1957	1958	1959	1960	1961
United States:						
Sold or used by producers	21,585	23,844	21,910	25,160	[2] 25,481	25,707
Value [3]	$102,900	$148,886	$141,486	$155,839	[2] $161,214	$160,223
Imports for consumption	172	651	611	1,025	1,057	1,050
Value	$982	$3,523	$3,368	$5,438	$4,484	$3,755
Exports	346	391	363	424	[2] 420	642
Value	$2,872	$2,591	$2,273	$2,660	$2,548	$3,876
Consumption, apparent	21,411	24,104	22,158	25,761	[2] 26,118	26,115
World: Production	68,200	79,300	83,000	88,000	93,900	96,400

[1] Includes Puerto Rico.
[2] Revised figure.
[3] Values are f.o.b. mine or refinery and do not include cost of cooperage or containers.

DOMESTIC PRODUCTION

Louisiana and Texas continued as the leading salt-producing States in 1961; each having about 18 percent of the national production. New York, with 16 percent, ranked third. Michigan, Ohio, Califor-

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.
[3] Oil, Paint, and Drug Reporter. Rock Salt Defendants Hit by Civil Antitrust Actions. V. 180, No. 3, July 17, 1961, pp. 4–5.

nia, and Kansas, with 15, 14, 6, and 5 percent, respectively, completed the list of States in which salt production was over 1 million tons. These seven States supplied 92 percent of the total U.S. output. The remaining 8 percent was produced in 10 other States.

Salt was produced at 95 plants by 57 companies. Four companies, operating 22 plants, produced 48 percent of the total production, and 6 other companies, with 18 plants, provided 37 percent. The remaining plants supplied 15 percent of the output.

Over 1 million tons of salt was produced at each of 6 plants; 9 plants reported production ranging between 500,000 and 1 million tons; and 35 plants produced 100,000 to 500,000 tons each. Of the remaining plants, 24 produced less than 10,000 tons each.

TABLE 2.—Salt sold or used by producers in the United States [1]

(Thousand short tons and thousand dollars)

State	1960		1961	
	Quantity	Value	Quantity	Value
California	1,443	(2)	1,601	(2)
Kansas [3]	[4] 933	[4] $11,873	913	$11,409
Louisiana	4,792	21,959	4,722	23,357
Michigan	4,088	33,759	3,885	31,284
New Mexico	39	331	33	284
New York	4,008	30,763	4,149	30,761
Ohio	3,108	24,149	3,465	25,037
Oklahoma	3	16	3	19
Texas	4,756	18,222	4,695	17,682
Utah	231	3,092	249	3,187
West Virginia	920	3,673	899	3,510
Other States [5]	[4] 1,160	[4] 13,377	1,093	13,693
Total	[4] 25,481	[4] 161,214	25,707	160,223

[1] Includes Puerto Rico.
[2] Included with "Other States" to avoid disclosing individual company confidential data.
[3] Brine, quantity, and value, included with "Other States."
[4] Revised figure.
[5] Includes States indicated by footnote 2, and Alabama, Colorado, Hawaii (1961 only), Kansas (brine only), Nevada, North Dakota, and Virginia.

TABLE 3.—Salt sold or used by producers in the United States,[1] by methods of recovery

(Thousand short tons and thousand dollars)

Method of recovery	1960		1961	
	Quantity	Value	Quantity	Value
Evaporated:				
Bulk:				
Open pans or grainers	317	$8,578	315	$8,465
Vacuum pans	2,109	45,510	2,183	45,398
Solar	[2] 1,348	[2] 8,129	1,532	8,738
Pressed blocks	330	7,575	357	7,866
Total	[2] 4,104	[2] 69,792	4,387	70,467
Rock:				
Bulk	6,406	43,457	6,376	41,289
Pressed blocks	60	1,526	63	1,661
Total	6,466	44,983	6,439	42,950
Salt in brine (sold or used as such)	14,911	46,439	14,881	46,806
Grand total	25,481	161,214	25,707	160,223

[1] Includes Puerto Rico.
[2] Revised figure.

TABLE 4.—Evaporated salt sold or used by producers in the United States[1]

(Thousand short tons and thousand dollars)

State	1960		1961	
	Quantity	Value	Quantity	Value
Kansas	401	$9,358	411	$9,180
Louisiana	191	4,737	196	4,430
Michigan	830	17,085	875	17,420
Oklahoma	1	14	1	14
Texas	103	2,987	101	2,761
Other States[2]	[3] 2,578	[3] 35,611	2,803	36,662
Total	[3] 4,104	[3] 69,792	4,387	70,46

[1] Includes Puerto Rico.
[2] Includes California, Hawaii (1961 only), Nevada, New Mexico, New York, North Dakota, Ohio, Utah, and West Virginia.
[3] Revised figure.

TABLE 5.—Rock salt sold by producers in the United States

(Thousand short tons and thousand dollars)

Year	Quantity	Value	Year	Quantity	Value
1952-56 (average)	4,958	$28,847	1959	6,160	$41,119
1957	5,341	36,389	1960	6,466	44,983
1958	5,407	37,125	1961	6,439	42,950

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
1952-56 (average)	282	$4,687	60	$947	342	$5,634
1957	289	6,064	55	1,327	344	7,391
1958	280	6,413	53	1,372	333	7,785
1959	288	6,763	55	1,406	343	8,169
1960	330	7,575	60	1,526	390	9,101
1961	357	7,866	63	1,661	420	9,527

Some weakening in the price structure of rock salt was said to be caused by a slight temporary above normal capacity in the industry. However, new uses and increased demands for salt were relieving the condition. Several new salt-producing facilities were in various stages of completion. The new mine of International Salt Co., at Cleveland, Ohio, was nearing completion, and shaft-sinking operations for new salt mines were underway at two locations in Louisiana, one at Belle Island, by Cargill, Inc., and the other at Cote Blanch Island, a joint venture of Monsanto Chemical Co., and Carey Salt Co.[4] A third salt well was started by Dakota Salt and Chemical Co., at Williston, N. Dak.

[4] Chemical Week. U.S. and Canadian Rock Salt Relief: How Soon? V. 90, No. 3, Jan. 20, 1962, pp. 75–76, 78.

CONSUMPTION AND USES

Nearly 10 million tons, or 39 percent, of the total salt output was used in making chlorine and its coproduct, caustic soda. This was an increase of 800,000 tons from 1960. Tonnage used in manufacturing sodium carbonate (soda ash), the second largest consumer of salt, continued to decline, reflecting the increasing use of natural sodium compounds for producing soda ash. Manufacture of chemicals, including chlorine and caustic and soda ash, required over 17 million tons or about two-thirds of the total salt production.

The third largest use of salt, taking 9 percent of the total output, was for highway snow and ice removal and for road stabilization. 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	1960				1961			
	Evaporated	Rock	Brine	Total	Evaporated	Rock	Brine	Total
Chlorine	(1)	(1)	7,546	9,146	(1)	(1)	8,357	9,971
Soda ash	-------	(1)	(1)	6,534	-------	(1)	(1)	5,740
Soap (including detergents)	30	6	-------	36	29	7	-------	36
All other chemicals	191	481	636	1,308	209	524	617	1,350
Textile and dyeing	70	125	-------	195	79	120	-------	199
Meatpackers, tanners, and casing manufacturers	351	421	-------	772	346	426	-------	772
Fishing	22	7	-------	29	23	8	-------	31
Dairy	57	3	-------	60	82	9	-------	91
Canning	175	44	-------	219	193	52	-------	245
Baking	116	7	-------	123	(1)	(1)	-------	109
Flour processors (including cereal)	56	7	-------	63	43	6	-------	49
Other food processing	75	8	-------	83	87	10	-------	97
Ice manufacturers and cold-storage companies	25	31	-------	56	30	30	-------	60
Feed dealers	579	367	-------	946	610	365	-------	975
Feed mixers	203	91	-------	294	243	90	-------	333
Metals	41	73	-------	114	66	62	-------	128
Ceramics (including glass)	3	9	-------	12	(1)	7	(1)	14
Rubber	(1)	(1)	(1)	130	(1)	(1)	84	118
Oil	37	66	43	146	38	66	33	137
Paper and pulp	9	91	37	137	(1)	88	(1)	131
Water-softner manufacturers and service companies	172	209	15	396	198	(1)	(1)	423
Grocery stores	588	207	-------	795	566	221	-------	787
Railroads	12	41	-------	53	9	33	-------	42
Bus and transit companies	(1)	(1)	-------	34	(1)	(1)	-------	51
States, counties, and other political subdivisions (except Federal)	144	2,220	-------	2,364	(1)	2,127	(1)	2,266
U.S. Government	16	21	-------	37	24	36	-------	60
Miscellaneous	[2] 845	538	16	[2] 1,399	996	480	16	1,492
Undistributed [3]	287	1,393	6,618	-------	516	1,672	5,774	-------
Total	[2] 4,104	6,466	14,911	[2] 25,481	4,387	6,439	14,881	25,707

[1] Included with "Undistributed" to avoid disclosing individual company confidential data.
[2] Revised figure.
[3] 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	1960		1961	
	Evaporated	Rock	Evaporated	Rock
Alabama	30	229	26	216
Alaska	3		3	
Arizona	16	2	12	9
Arkansas	12	57	14	56
California	675	67	699	64
Colorado	77	27	81	27
Connecticut	13	57	13	53
Delaware	7	6	7	7
District of Columbia	6	5	5	9
Florida	20	64	21	69
Georgia	44	73	41	70
Hawaii	4		4	
Idaho	26	3	28	2
Illinois	209	475	240	434
Indiana	130	191	135	166
Iowa	126	147	135	152
Kansas	61	190	60	173
Kentucky	36	176	38	180
Louisiana	31	143	28	178
Maine	10	141	9	145
Maryland	44	114	43	137
Massachusetts	43	189	75	215
Michigan	176	309	159	188
Minnesota	121	96	116	100
Mississippi	21	68	17	72
Missouri	73	183	84	172
Montana	25	2	23	2
Nebraska	67	79	72	78
Nevada	10	163	25	159
New Hampshire	5	140	5	183
New Jersey	122	258	131	287
New Mexico	14	61	13	42
New York	213	1,131	208	1,130
North Carolina	80	115	82	116
North Dakota	21	4	60	5
Ohio	236	506	233	393
Oklahoma	27	42	31	45
Oregon	25		24	
Pennsylvania	155	253	160	312
Rhode Island	10	18	9	21
South Carolina	22	20	23	20
South Dakota	27	16	26	18
Tennessee	84	91	81	91
Texas	83	215	85	222
Utah	59	[2]	55	[2]
Vermont	6	57	6	57
Virginia	68	82	73	93
Washington	129		124	
West Virginia	25	37	22	53
Wisconsin	133	139	139	165
Wyoming	15	1	14	1
Other [3]	[4] 429	24	570	52
Total	[4] 4,104	6,466	4,387	6,439

[1] Includes Puerto Rico.
[2] Included with "Other" to avoid disclosing individual company confidential data.
[3] Includes shipments to Territories, oversea areas administered by the United States, exports, and some shipments to unspecified destinations.
[4] Revised figure.

PRICES

Prices quoted for salt in 1961 by Oil, Paint and Drug Reporter continued at the level where they have remained since 1958. Quoted prices and value data were as follows:

Rocksalt, 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
Dry salt, average value	per ton	10.47
Salt in brine, average value	per ton contained salt	3.15

FOREIGN TRADE [5]

Imports.—The increase of the past 2 years in the tonnage of salt imported for consumption was halted in 1961, as total imports dropped slightly. However, they remained above 1 million tons. Imports from Mexico increased 19 percent, making Mexico the leading foreign supplier of salt to the United States, with 37 percent of the total imports; Canadian imports, 15 percent below the 1960 level, were 36 percent. The Bahamas supplied 18 percent, and the remaining imports came from other Caribbean islands and Spain. Total imports were approximately 4 percent of U.S. production.

Exports.—Dry salt exports increased more than 50 percent above the 1960 level, establishing a new record. Most of the increase went to Japan and Canada. Exports were 2 percent of U.S. production.

TABLE 9.—Salt shipped to the Commonwealth of Puerto Rico and oversea areas administered by the United States

Territory	1960		1961	
	Short tons	Value	Short tons	Value
American Samoa	144	$4,915	99	$3,321
Guam	55	6,398	85	8,607
Puerto Rico	14,029	1,020,453	9,852	764,037
Virgin Islands	83	10,270	127	17,332
Wake Island			1	155

Source: Bureau of the Census.

TABLE 10.—U.S. imports for consumption of salt, by countries

Country	1960		1961	
	Short tons	Value	Short tons	Value
North America:				
Bahamas	194,520	$759,526	190,738	$736,771
Canada	451,315	2,998,321	381,894	2,166,879
Dominican Republic	63,743	259,731	64,763	288,049
Jamaica	16,194	44,027	6,810	18,240
Leeward and Windward Islands	5,152	13,800		
Mexico	326,097	404,732	386,828	483,742
Total	1,057,021	4,480,137	1,031,033	3,693,681
Europe:				
Germany, West	2	1,866		
Italy	5	1,443		
Spain			19,051	60,963
United Kingdom	(1)	268		
Total	7	3,577	19,051	60,963
Grand total	1,057,028	4,483,714	1,050,084	3,754,644

[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
1952–56 (average)	7,870	[1] $109,382	163,930	[1] $872,800
1957	34,501	[1] 426,596	616,344	3,096,098
1958	43,864	558,902	567,179	2,809,557
1959	37,726	531,151	986,903	4,906,490
1960	17,693	267,634	1,039,335	4,216,080
1961	9,259	144,210	1,040,825	3,610,434

[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	1960		1961	
	Short tons	Value	Short tons	Value
Buffalo	35,520	$235,801	4,651	$49,340
Chicago	47,733	300,955	16,576	77,742
Connecticut			33,521	150,171
Duluth and Superior	42,025	268,505	48,564	263,633
Georgia	129,414	501,430	133,219	510,996
Maine and New Hampshire	1,200	29,030	9,606	55,963
Maryland			11,226	40,092
Massachusetts	29,821	97,499	37,461	133,312
Michigan	284,611	1,843,322	176,810	985,774
New York	63,793	260,971	54,657	251,513
Ohio	8,037	50,690	79,296	462,011
Oregon	77,442	96,806	116,544	145,787
Philadelphia	2	1,866		
Puerto Rico	8,711	43,556	6,100	30,500
Rochester	418	2,872		
San Diego	25	299	13	130
Vermont	606	4,323	256	1,721
Virginia	47,925	176,311	43,025	161,495
Washington	248,653	308,286	270,272	337,825
Wisconsin	31,092	261,192	8,287	96,639
Total	1,057,028	4,483,714	1,050,084	3,754,644

Source: Bureau of the Census.

Tariff.—The duty on bulk salt into the United States, unchanged since June 30, 1958, was $0.017 per 100 pounds. Duty on packaged salt was unchanged at $0.035 per 100 pounds. Duty on salt in brine, an unenumerated article in paragraph 1558 of the Tariff Act of 1930, was 10 percent ad valorem.

Representatives of several large salt-producing firms testified at hearings of the U.S. Tariff Commission and the Committee for Reciprocity Information. The salt-producing firms were against further reduction of tariffs on salt because cheaper foreign salt threatened the U.S. market for domestically produced salt.[6]

[6] Chemical & Engineering News. Salt Producers Oppose Tariff Cut. V. 39, No. 3, Jan. 16, 1961, p. 29.

TABLE 13.—U.S. exports of salt, by countries

Destination	1960		1961	
	Short tons	Value	Short tons	Value
North America:				
Bermuda	20	$2,392	137	$2,430
Canada	[1] 50,038	567,122	95,848	770,163
Central America:				
British Honduras	10	320	19	410
Canal Zone	108	1,844		
Costa Rica	266	8,493	1,115	13,945
El Salvador	46	3,215	94	2,134
Guatemala	208	11,412	530	9,781
Honduras	249	10,612	309	8,700
Nicaragua	489	12,824	565	13,924
Panama	54	3,336	438	9,092
Mexico	4,678	173,130	3,426	111,079
West Indies:				
Bahamas	114	13,144	1,280	17,334
Cuba	1,979	53,652	600	23,180
Dominican Republic	64	4,616	180	2,479
Haiti	52	3,814	54	2,822
Netherlands Antilles	373	26,570	428	25,708
Other West Indies	64	5,731	184	4,173
Total	[1] 58,812	902,227	105,207	1,017,354
South America:				
Chile			302	2,807
Ecuador	251	6,134	180	4,882
Peru	49	4,788	248	5,086
Venezuela	369	12,240	1,890	16,946
Other South America	20	2,886	350	3,680
Total	689	26,048	2,970	33,401
Europe:				
Italy	3	2,536	1,027	9,476
Netherlands	1	726	1,383	13,860
Spain			648	6,600
United Kingdom	213	12,623	1,849	17,376
Other Europe	26	16,436	988	11,948
Total	243	32,321	5,895	59,260
Asia:				
Hong Kong	[2]	524	490	3,920
Japan	359,919	1,525,814	516,498	2,647,168
Lebanon	27	3,482	234	3,748
Philippines	112	10,080	643	10,466
Saudi Arabia	165	16,447	816	36,861
Other Asia	55	5,531	667	14,241
Total	360,278	1,561,878	519,348	2,716,404
Africa:				
Angola	[2]	1,170	585	2,340
Congo, Republic of the, and Ruanda-Urundi	45	2,880	1,593	6,370
Ghana	50	1,000	750	3,000
Nigeria	23	1,215	350	1,800
Union of South Africa			2,156	10,448
Other Africa	12	2,618	16	1,550
Total	130	8,883	5,450	25,508
Oceania:				
Australia			2,307	9,227
New Zealand			514	2,244
Other Oceania	170	16,443	275	12,609
Total	170	16,443	3,096	24,080
Grand total	[1] 420,322	2,547,800	641,966	3,876,007

[1] Revised figure.
[2] Less than 1 ton.

Source: Bureau of the Census.

WORLD REVIEW

World production of salt continued to increase, totaling more than 96 million tons in 1961. About 27 percent of the world output was produced in the United States.

Brazil.—Floods destroyed 350,000 tons of salt in Brazil in 1961. This was about one-half the Nation's stocks. Imports were necessary to make up the loss.[7]

Canada.—A new salt refinery and processing plant was under construction at Pugwash, Nova Scotia, where rock salt had been mined for several years. The marine terminal for loading and unloading salt in oceangoing freighters was completed.[8]

Plans for expanding production at the Goderich, Ontario, rock salt mine were reported. A new 1,800-foot shaft was expected to increase the mine capacity 50 percent and to improve ventilation and mine safety.[9]

El Salvador.—The Government of El Salvador prohibited the importation or manufacture of uniodized salt. The Law for Iodization of Salt was published February 27, 1961, and it provided that the minimum iodine content of salt be set by the Ministry of Health. Local manufacturers were allowed a 1-year grace period in which to comply. The new law was intended to overcome iodine deficiency in the diet, a cause of goiter prevalent in many parts of the nation.[10]

Poland.—Salt mines and reserves were described in an article on chemical raw materials of Poland. Deposits at Wieliczka and Bochnia had been exploited for several centuries, and reserves were nearly exhausted. Reserves were estimated at about 25 percent of total salt resources, and they represented that part of the total which could be mined profitably. Large reserves of salt were being mined in central Poland, at Inowroclaw, Wapo, and Klodawa, and additional discoveries were considered probable in the Permian formation.[11]

South-West Africa.—Southwest Africa Salt Co. (Pty.) Ltd. of Swakopmund announced a merger with a group which represented the most important salt sources of South-West Africa. The group planned to build two vacuum salt refineries to supply local needs and some salt for export.[12]

United Arab Republic (Syria Region).—Discovery of a high-grade rock salt deposit was reported at Harmoushieh, northwest of Deir ez-Zor. The salt was said to contain 99.4-percent sodium chloride and only 0.6-percent gypsum.[13]

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[7] Chemical Week. Salt (Brazil). V. 88, No. 17, Apr. 29, 1961, p. 26.
[8] Northern Miner (Toronto). New Salt Refinery. V. 47, No. 23, Aug. 31, 1961, p. 7.
[9] Northern Miner (Toronto). Order 1,800-Foot Shaft for Rock Salt Mine. V. 47, No. 27, Sept. 28, 1961, p. 19, sec. 2.
[10] Foreign Commerce Weekly. Salvador Bans Manufacture, Import of Uniodized Salt. V. 64, No. 15, Apr. 10, 1961, p. 12.
[11] Ciesla, E. Chemical Raw Materials. Chemik (Warsaw), v. 14, No. 1/157, January 1961, pp. 11–15. JPRS 8711.
[12] Bureau of Mines. Mineral Trade Notes. V. 53, No. 1, July 1961, pp. 36, 37.
[13] Bureau of Mines. Mineral Trade Notes. V. 53, No. 6, December 1961, p. 41.

TABLE 14.—World production of salt, by countries[1 2]

(Thousand short tons)

Country[1]	1952–56 (average)	1957	1958	1959	1960	1961
North America:						
Canada	1,150	1,772	2,361	3,317	3,311	3,242
Costa Rica	4	49	[3] 33	14	[3] 14	[3] 14
Guatemala	15	18	18	18	17	25
Honduras	[3] 11	13	[3] 11	[3] 11	[3] 11	[3] 11
Mexico	228	333	400	573	[3] 573	[3] 661
Nicaragua	13	10	11	12	12	13
Panama	8	9	7	9	8	9
Salvador	43	55	[3] 55	[3] 55	[3] 55	[3] 55
United States (including Puerto Rico):						
Rock salt	4,953	5,342	5,407	6,160	6,466	6,439
Other salt	16,631	18,512	16,504	19,003	19,015	19,268
West Indies:						
British:						
Bahamas	123	192	112	233	231	[3] 231
Leeward Islands (exports)	4	1	[3] 1			
Turks and Caicos Islands	12	18	22	23	28	33
Cuba	64	75	75	[3] 66	[3] 66	(4)
Dominican Republic:						
Rock salt	22	47	49	71	73	[3] 73
Other salt	14	18	18	22	22	[3] 22
Haiti	36	[3] 11	[3] 11	11	[3] 11	[3] 11
Netherlands Antilles	3	1	[3] 1	[3] 1	(5)	(5)
Total	23,334	26,476	25,096	29,599	29,913	[3] 30,150
South America:						
Argentina:						
Rock salt	2	2	(5)	(5)	(5)	(5)
Other salt	471	359	632	639	[3] 639	[3] 639
Brazil	793	880	1,053	941	1,017	[3] 1,017
Chile	52	37	[3] 44	[3] 44	[3] 44	50
Colombia:						
Rock salt	188	228	243	235	259	294
Other salt	43	106	78	63	75	77
Ecuador	36	26	21	24	31	[3] 31
Peru	96	126	116	116	117	100
Venezuela	82	95	97	86	87	[3] 79
Total[1 3]	1,780	1,880	2,300	2,165	2,290	2,300
Europe:						
Austria:						
Rock salt	1	1	1	1	2	3
Other salt	409	568	567	443	530	474
Bulgaria	80	82	123	98	98	[3] 98
Czechoslovakia	171	177	179	177	185	[3] 185
France:						
Rock salt and salt from springs	2,755	3,265	3,059	2,971	3,429	[3] 4,189
Other salt	672	639	925	869	800	
Germany:						
East	[3] 1,653	1,935	1,960	1,858	1,968	[3] 1,968
West (marketable):						
Rock salt	3,154	3,598	3,556	3,659	4,001	4,783
Brine salt	343	357	370	363	374	376
Greece	94	99	106	108	107	128
Italy:						
Rock salt and brine salt	1,034	1,190	1,135	1,412	1,743	1,780
Other salt	908	817	1,053	780	1,123	[3] 1,102
Malta	2	1	2	2	1	2
Netherlands	572	791	876	1,087	1,208	1,228
Poland:						
Rock salt	1,190	417	432	560	574	670
Other salt		1,017	1,344	1,455	1,571	1,591
Portgual	240	345	343	236	[3] 236	[3] 236
Rumania	640	934	807	926	1,152	[3] 1,152
Spain:						
Rock salt	456	565	617	616	592	[3] 1,532
Other salt	880	926	983	873	941	
Switzerland	127	144	138	151	164	[3] 164
U.S.S.R.[3]	7,000	7,200	7,200	7,200	8,300	9,000
United Kingdom:						
Rock salt	67	99	130	160	168	320
Other salt	4,919	5,484	5,397	5,956	6,371	6,033
Yugoslavia	152	163	190	150	166	[3] 182
Total[1 3]	27,900	31,200	31,900	32,500	36,200	37,600

See footnotes at end of table.

TABLE 14.—World production of salt, by countries—Continued

(Thousand short tons)

Country [1]	1952–56 (average)	1957	1958	1959	1960	1961
Asia:						
Aden	302	222	174	196	143	128
Afghanistan:						
Rock salt	} 26	{ 35	29	29	29	17
Other salt	}	{ 28	[3] 37	[3] 44	[3] 55	73
Burma	88	128	123	123	163	138
Cambodia	51	33	71	55	41	[3] 44
Ceylon	67	89	20	34	60	39
China [3]	6,225	8,820	11,500	12,600	14,200	15,400
Cyprus	2	7	6	6	----	2
India:						
Rock salt	6	4	6	4	4	4
Other salt	3,303	4,041	4,661	3,499	3,782	3,821
Indonesia	193	383	303	347	218	[3] 713
Iran [6]	272	331	82	88	143	[3] 143
Iraq [6]	24	24	29	41	[3] 41	[3] 41
Israel	24	35	37	37	41	23
Japan	554	917	1,166	1,285	977	913
Jordan	10	11	12	18	13	21
Korea, Republic of	249	407	481	430	440	134
Lebanon	[3] 13	13	13	14	[3] 6	11
Pakistan:						
Rock salt	161	174	198	176	203	222
Other salt	241	333	197	141	272	207
Philippines	56	122	154	193	105	103
Portuguese India	15	11	6	4	8	[3] 8
Ryukyu Islands	4	3	4	4	1	1
Taiwan	368	427	489	474	499	476
Thailand	[3] 298	290	471	386	369	276
Turkey:						
Rock salt	32	10	41	39	34	33
Other salt	410	494	498	503	456	262
United Arab Republic (Syria Region)	20	37	[3] 44	36	36	[3] 36
Viet-Nam, South	107	88	68	172	116	[3] 110
Yemen	[7] 72	[3] 110	----	110	110	132
Total [1 3]	13,190	17,630	21,400	21,600	23,100	24,000
Africa:						
Algeria	99	132	150	147	[3] 158	[3] 158
Angola	68	57	76	76	64	[3] 58
Canary Islands	20	17	17	14	13	[3] 13
Cape Verde Islands	21	22	9	22	26	26
Chad, Republic of	6	[3] 6	----	[3] 3	[3] 7	[3] 7
Congo, Republic of the (formerly Belgian)	1	(5)	(5)	1	1	1
Ethiopia (including Eritrea)	202	194	183	155	173	[3] 184
French Somaliland	46	2	----	----	----	----
Ghana	[3] 24	[3] 24	[3] 24	[3] 24	12	18
Kenya	23	25	21	22	24	25
Libya	15	19	14	17	14	11
Mauritius	3	4	4	4	4	4
Morocco	62	72	67	37	33	[3] 33
Mozambique	13	20	24	21	44	44
Senegal, Republic of (including Mauritania)	64	72	78	78	55	[3] 55
Somali Republic	4	4	4	4	[3] 8	2
South-West Africa:						
Rock salt	7	7	7	6	4	4
Other salt	53	66	89	50	76	56
Sudan	60	60	60	60	60	[3] 60
Tanganyika	25	29	40	41	39	36
Tunisia	153	165	187	101	183	150
Uganda	8	11	11	10	6	8
Union of South Africa	162	161	241	261	279	229
United Arab Republic (Egypt)	498	459	444	422	575	570
Total [1 3]	1,638	1,629	1,751	1,577	1,859	1,753

See footnotes at end of table.

TABLE 14.—World production of salt, by countries—Continued

(Thousand short tons)

Country [1]	1952–56 (average)	1957	1958	1959	1960	1961
Oceania:						
Australia	390	478	481	510	524	[3] 525
New Zealand	4	9	23	23	19	[3] 20
Total	394	487	504	533	543	[3] 545
World total (estimate) [1] [2]	68,200	79,300	83,000	88,000	93,900	96,400

[1] Salt is produced in Albania, Bolivia, Malagasy, Nigeria, and North Korea, 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 included in total.
[5] Less than 500 tons.
[6] Year ended Mar. 31 of year following that stated.
[7] Average annual production 1953–56.

Compiled by Helen L. Hunt, Division of Foreign Activities.

TECHNOLOGY

A comprehensive description of salt mining operations at Detroit, Mich., Cleveland and Fairport Harbor, Ohio, and Goderich and Ojibway, Ontario, was published.[14]

These mines tap the extensive salt formations of the Eastern basin, which extends beneath parts of New York, Pennsylvania, Virginia, West Virginia, Ohio, Michigan, and Ontario. More than 43 percent of the U.S. salt was produced in this area. High-quality salt, low-cost water transportation, and nearby markets contributed to the high salt production in the area.

Mine shafts were concrete-lined, and the main shafts were 16 feet in diameter. The room-and-pillar method of mining was used; rooms ranged from 30 to 60 feet wide and 17 to 40 feet high. The size of pillars was adjusted so that not more than 70 percent of the salt was mined; in deeper mines the extraction was less. The mine openings were completed within the salt bed; about 1 foot of salt was left on the floor, and 4 to 6 feet formed the roof. This practice helped to seal out water and gas which may be in the surrounding formations. The plastic property of rock salt under pressure helped to support the roof. Temperatures in the mines ranged from 55° to 75° F., and working conditions were judged to be excellent.

The salt was drilled and blasted after cutting a 6-inch slot 10 feet deep at the base of the face. A mixture of ammonium nitrate and fuel oil was the blasting agent at the Fairport Harbor and Detroit mines;[15] 40-percent-strength dynamite was used in the other three mines.

The broken salt was mechanically loaded and hauled in rubber-tired vehicles to the primary crusher, located under ground. Finish crushing and screening operations were usually above ground, where the various grades were stored ready for market.

Virtually the only waste material produced by the mining and screening operation was an excess of "FC" grade consisting of extra

[14] Bleimeister, W. C. Rock Salt Mining Operations in Michigan, Ohio, and Ontario. Min. Eng., v. 13, No. 5, May 1961, pp. 467–471.
[15] Ryon, J. L., Jr. Underground Use of Ammonium Nitrate-Fuel Oil Explosives. Min. Eng., v. 13, No. 4, April 1961, pp. 377–380.

fine material, as much as 15 percent of the total salt mined. This fraction was utilized at the Fairport mine by passing the preheated material between heavily spring-loaded rollers. Emerging from the rolls as a solid ribbon, the salt was broken up and screened to produce the desired sizes. Undersize material was returned to the rolls.

The use of pneumatically placed ammonium nitrate-fuel oil mixtures for blasting in several large salt mines was described.[16] After 2 years' experience at the Detroit mine and somewhat less than 2 years' use at the Avery Island and Retsof mines, the use of ammonium nitrate-fuel oil mixtures was declared advantageous compared to dynamite. The required amount of fuel oil was added to plastic bags of ammonium nitrate prills, and the bags were allowed to stand 24 to 48 hours. No mechanical agitation was required. Fuel oil added was about 6 percent of the weight of ammonium nitrate. After placing a blasting cap at the back of the hole, the blasting mixture was blown pneumatically into the hole. No measurable static electrical charges were produced by this operation. To avoid loosening the top layer of salt forming the roof, it was found necessary to cushion the effect of the blast in the top row of holes by loading these holes with the blasting mixture contained in long, narrow plastic tubes. The air surrounding the tubes cushioned the blast so that the top layer of salt remained intact.

The history, geology, and mining methods used in a Louisiana salt dome were described.[17] The salt was mined by the room-and-pillar method in much the same manner as in the Eastern basin salt mines. The chief difference was that in the Eastern basin the beds extend laterally for many miles but are usually only a few yards thick, whereas salt domes may be many thousands of feet thick but extend beneath only a few square miles of surface area. Mines in salt domes have great vertical development; some rooms are 110 feet high. Salt may be extracted from several different levels in the dome.

Ductility of single-crystal specimens of sodium chloride was affected by the microcracks on the surface of the crystal. Removal of surface microcracks by dissolution followed by proper drying improved the bending characteristics of the specimens. The effects of various gaseous atmospheres, including nitrogen, argon, air, oxygen, and ozone, on the crystals were observed. Embrittlement of the crystals resulted from exposure to oxygen and ozone atmospheres. A surface film of sodium chlorate was associated with the increase in brittleness.[18]

The theory of aerosol spraying with a solution of sodium chloride in water to control dusts in mines was described. Dust particles less then 10 microns in diameter are potentially harmful because they are not removed by the filtering action of the nose and on entering the lungs may cause tissue damage and silicotic diseases. Spraying the mine air with a fine aerosol mist of sodium chloride solution caused the fine dust particles to be attracted to the aerosol droplets, producing an agglomerated particle greater than 10 microns in size, which are not likely to enter the fine pores of the lungs.[19]

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[16] Work cited in footnote 15.

[17] Hughes, J. H., Jr. Salt Mining on Historic Jefferson Island. Explosives Eng., v. 39, No. 6, November–December 1961, pp. 179–182.

[18] Class, W. H., E. S. Machlin, and G. T. Murray. Embrittlement of NaCl by Surface Compound Formation. Trans. Met. Soc. AIME, v. 221, No. 4, August 1961, pp. 769–775.

[19] Bandyopadhyay, S. Aerosol Spraying in Mines Combats Dusts. Canadian Min. J (Gardendale, Quebec, Canada), v. 81, No. 12, December 1960, pp. 66–70.

Increased use of rock salt on highways for snow and ice control focused attention on the corrosion of vehicles caused by the salt and the effectiveness of chemical rust inhibitors, such as sodium hexametaphosphate, which may be mixed with the salt. Opposing views were expressed by officials in various cities regarding the effectiveness and economic justification of blending rust inhibitors with highway salt. Some felt that the additional cost of the inhibitors was not justified unless surrounding communities also cooperated; others continued to recommend using inhibitors.

In a simulated road test it was found that mixing sodium hexametaphosphate inhibitor with deicing salt reduced corrosion of vehicles 55.7 percent. Other findings were that the corrosion was proportional to time rather than mileage traveled, that the corrosion rate was greatest when vehicles were stored in heated garages, and that dry mixing of fine inhibitors with coarse salt particles lead to segregation of the inhibitor.[20]

A new crystal form of salt was developed for certain specialty uses. Highly pure salt crystals suspended in brine were induced to grow at the corners, forming three-dimensional starlike crystals having fast solubility, good storing qualities without caking, and good blending ability. Small quantities of sodium ferrocyanide in aqueous solution introduced into the saturated brine suspension were absorbed on the faces of the crystals, restricting crystal growth to the corners. The new form of salt was expected to find use as a bulking agent in textile dyeing, in industrial detergents and soap manufacturing, and in explosives.[21]

As part of a program to explore the peaceful uses of nuclear energy, the U.S. Atomic Energy Commission triggered a nuclear device in a cavern created in a salt dome near Carlsbad, N. Mex. The blast, at a depth of 1,200 feet, had been designed to be completely contained in the salt formation; however, some venting of radioactive gases occurred. About 70 percent of the objectives of the experiment were successfully completed. No harmful effects from the vented gases were reported.[22]

Two patents were issued on methods of preventing the caking of salt. In the first method, alkali metal ferrocyanides or like compounds were coated with a molten waxy material.[23] After the wax cooled and solidified, the coated particles were mixed with the salt, reducing its tendency to cake. In the second patent the addition of a small quantity of nitrilotriacetamide to solid granular salt was said to substantially reduce the caking tendency of the salt.[24]

Another patent described an improved apparatus and method for reviving old brine fields to recover additional salt by solution mining.[25]

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[20] Chemical Week. Inhibited Salt: Blowing Up a Storm. V. 89, No. 18, Oct. 28, 1961, pp. 45–46, 48–49.

[21] Chemical & Engineering News. Dendritic Salt Goes Into Production. V. 39, No. 18, May 1, 1961, p. 48.

[22] Chemical & Engineering News. Project Gnome May Meet Scientific Goals. V. 39, No. 51, Dec. 18, 1961, pp. 23–25.

[23] Ladenburg, K., and R. S. Ploss (assigned to International Salt Co., Inc.). Reduction of Caking Tendency of Salt. U.S. Pat. 3,009,775, Nov. 21, 1961.

[24] Scott, T. R., N. G. Bromby, and C. Alday (assigned to Imperial Chemical Industries, Ltd.). Prevention of Caking of Common Salt. U.S. Pat. 2,990,246, June 27, 1961.

[25] Jacoby, C. H. (assigned to International Salt Co., Inc.). Method of Reviving an Old Brine Field. U.S. Pat. 3,012,764, Dec. 12, 1961.

Sand and Gravel

By Perry G. Cotter [1] and Jewel B. Mallory [2]

PRODUCTION of sand and gravel for construction in the United States reached a new high in 1961, exceeding by 3 percent, in both quantity and value, the former record year of 1959. The rise in output of construction sand and gravel was directly related to the volume of general construction. New construction put-in-place was 3 percent higher than in 1960 and starts for new housing were up 5 percent. Total outlays for public construction were $17 billion, the highest ever recorded. Authorizations for military construction provided for 3,000 housing units under the Capehart program and arranged for conclusion of this program in October 1962.

Output of industrial sands decreased slightly both in tonnage and value.

LEGISLATION AND GOVERNMENT PROGRAMS

The Federal-Aid Highway Act of 1961 amended certain laws relating to the program and increased revenue taxes on some items such as motor fuel, tires, and use taxes on special types of vehicles.

As of June 30, the National System of Interstate and Defense Highways had 10,825 miles of road completed and open to traffic; 4,900 miles were under construction. On 10,000 miles, engineering and acquisition of right-of-way were under progress, and 15,300 miles remained without action.[3]

DOMESTIC PRODUCTION

Output of sand and gravel was 752 million short tons valued at $751 million, increases of 6 percent and 4 percent, respectively, from 1960.

Commercial Production.—Commercial operations provided 72 percent of total production of sand and gravel. The average price reported for commercially produced material was $1.11 per ton, slightly lower than that reported for the previous year.

Completely integrated portable processing plants, which included crushing, screening, and washing units, were used to a greater extent by both large and small producers.

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[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.
[3] American Highways. National System of Interstate and Defense Highways, Status of Improvement as of June 30, 1961. V. 40, No. 4, October 1961, p. 6.

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	1960		1961	
	Quantity	Value	Quantity	Value
Construction:				
Building:				
Sand	[1] 122,845	[1] $127,972	125,290	$132,000
Gravel	[1] 108,149	[1] 136,152	111,378	146,188
Paving:				
Sand	[1] 99,391	[1] 91,742	108,788	95,866
Gravel	[1] 289,559	[1] 258,860	311,714	271,704
Fill:				
Sand	[1] 20,382	[1] 10,951	26,924	12,824
Gravel	[1] 29,433	[1] 15,673	30,119	15,094
Railroad ballast:				
Sand	622	468	517	354
Gravel	4,650	3,810	3,232	2,570
Other:				
Sand	4,086	3,384	3,770	3,512
Gravel	[1] 6,425	[1] 7,367	6,875	7,202
Total	[1] 685,542	[1] 656,379	728,607	687,314
Industrial sand:				
Unground:				
Glass	[1] 6,449	[1] 21,642	6,682	21,943
Molding	6,063	16,001	5,815	15,808
Grinding and polishing	1,023	2,030	1,094	2,388
Blast sand	679	3,303	635	2,814
Fire or furnace	559	1,214	622	1,285
Engine	890	1,683	754	1,477
Ferrosilicon	63	173	47	126
Filtration	269	624	210	547
Oil (hydrafrac)	153	939	258	1,677
Other	[1] 1,203	[1] 3,472	1,011	2,864
Total	[1] 17,351	[1] 51,081	17,128	50,929
Ground[2]	[1] 979	[1] 8,001	919	8,064
Total	[1] 18,330	[1] 59,082	18,047	58,993
Miscellaneous gravel	5,920	4,971	5,130	4,994
Grand total	[1] 709,792	[1] 720,432	751,784	751,301
Commercial:				
Sand	[1] 234,139	[1] 271,265	240,346	275,099
Gravel	[1] 288,756	[1] 318,145	299,209	324,185
Government-and-contractor:[3]				
Sand	[1] 31,517	[1] 22,334	42,990	28,450
Gravel	[1] 155,380	[1] 108,688	169,239	123,567

[1] Revised figure.
[2] See table 11 for use breakdown.
[3] Approximate figures for operations by States, counties, municipalities, and other Government agencies under lease.

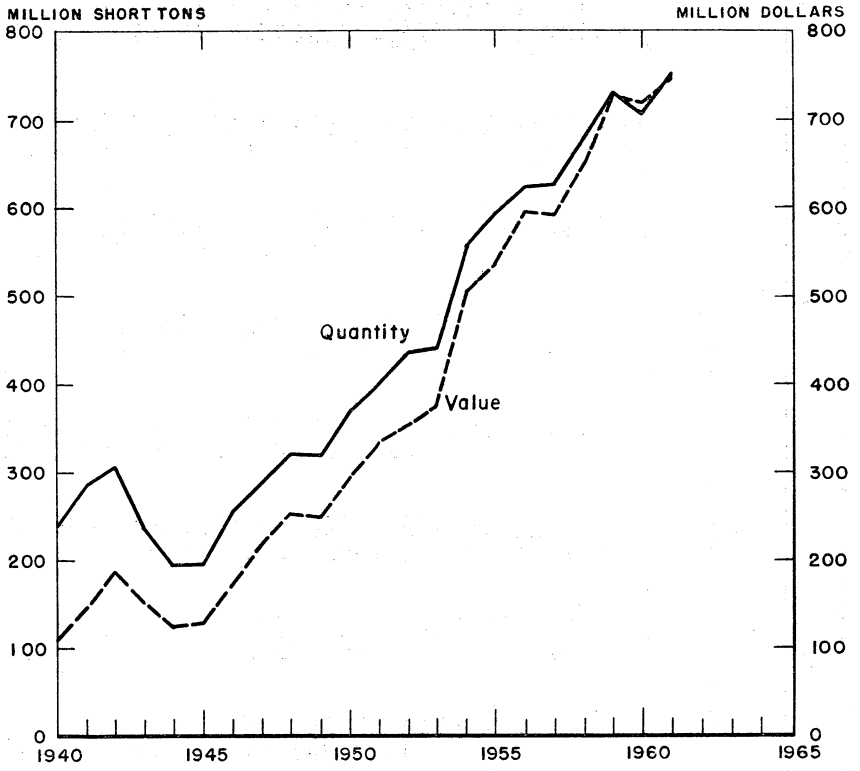


FIGURE 1.—Production and value of sand and gravel in the United States, 1940–61.

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
1952–56 (average)	193, 611	$195, 452	336, 630	$277, 524	530, 241	$472, 976
1957	236, 020	244, 640	396, 235	355, 110	632, 255	599, 750
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 [2]	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

[1] Includes possessions and other areas administered by the United States (1952–56).
[2] Revised figures

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	1960						1961					
	Commercial		Government-and-contractor		Total		Commercial		Government-and-contractor		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	4,305	$4,692	54	$67	4,359	$4,759	4,919	$5,621	881	$831	5,800	$6,452
Alaska	987	1,695	5,026	3,788	6,013	5,483	629	1,177	4,612	3,008	5,241	4,185
Arizona	6,371	6,975	8,119	7,260	14,490	14,235	10,283	9,699	11,670	15,007	21,953	24,706
Arkansas	5,935	6,732	2,257	3,530	8,192	10,262	5,933	6,892	3,456	2,182	9,389	9,074
California	73,033	93,310	14,646	14,193	87,679	107,503	86,046	107,153	24,135	16,958	110,181	124,111
Colorado	10,293	10,888	8,760	5,994	19,053	16,882	9,383	9,720	8,977	7,226	18,360	16,946
Connecticut	5,115	5,244	1,460	716	6,575	5,960	5,669	5,732	1,830	901	7,499	6,633
Delaware	1,084	907	----------	----------	1,084	907	961	970	----------	----------	961	970
Florida	6,757	5,559	----------	----------	6,757	5,559	5,944	5,072	586	505	6,530	5,577
Georgia	3,338	3,047	----------	----------	3,338	3,047	3,150	3,049	----------	----------	3,150	3,049
Hawaii	473	1,299	17	25	490	1,324	336	667	80	91	416	758
Idaho	2,486	2,617	4,602	3,977	7,088	6,594	2,198	2,417	5,107	4,376	7,305	6,793
Illinois	31,202	35,150	1,936	1,105	33,138	36,255	30,516	34,578	837	520	31,353	35,098
Indiana	20,202	18,102	550	275	20,752	18,377	19,109	16,660	468	238	19,577	16,898
Iowa	12,164	12,005	2,528	1,511	14,692	13,516	10,154	9,665	3,237	1,986	13,391	11,651
Kansas	8,178	6,148	1,532	660	9,710	6,808	8,975	6,722	2,391	1,059	11,366	7,781
Kentucky	4,912	5,528	201	235	5,113	5,763	5,349	5,287	233	253	5,582	5,540
Louisiana	13,935	18,990	384	116	14,319	19,106	11,783	14,729	259	104	12,042	14,833
Maine	1,968	1,181	7,865	2,711	9,833	3,892	2,275	1,513	6,646	2,283	8,921	3,796
Maryland	9,638	13,110	438	111	10,076	13,221	12,230	16,833	174	61	12,404	16,894
Massachusetts	10,900	11,328	3,889	1,685	14,789	13,013	12,614	12,603	5,447	2,355	18,061	14,958
Michigan	34,026	32,171	12,884	7,133	46,910	39,304	39,667	36,348	14,936	11,442	54,603	47,790
Minnesota	18,786	18,002	11,516	6,609	30,302	24,611	19,109	17,644	11,581	6,499	30,690	24,143
Mississippi	6,068	5,522	113	46	6,181	5,568	5,536	5,314	384	589	5,920	5,903
Missouri	9,631	11,194	576	407	10,207	11,601	8,744	10,266	627	422	9,371	10,688
Montana	1,806	2,209	10,783	9,448	12,589	11,657	2,122	2,269	12,580	11,237	14,702	13,506
Nebraska	10,114	8,174	762	572	10,876	8,746	9,099	7,476	995	774	10,094	8,250
Nevada	2,035	2,881	2,050	2,343	4,085	5,224	2,635	3,356	4,460	4,087	7,095	7,443
New Hampshire	2,017	1,816	4,604	1,871	6,621	3,687	1,924	1,588	5,777	2,039	7,701	3,627
New Jersey	11,538	19,493	56	18	11,594	19,511	12,246	20,890	11	5	12,257	20,895
New Mexico	5,356	5,348	2,063	2,111	7,419	7,459	4,111	4,913	8,412	5,136	12,523	10,049
New York	24,816	30,276	5,871	4,876	30,687	35,152	25,329	29,112	2,714	1,359	28,043	30,471
North Carolina	5,999	5,932	2,802	1,521	8,801	7,453	6,314	6,391	3,465	2,076	9,779	8,467
North Dakota	3,292	2,518	5,356	4,386	8,648	6,904	1,719	1,654	7,676	5,853	9,395	7,507
Ohio	35,090	43,209	[1] 2,853	[1] 1,770	[1] 37,943	[1] 44,979	32,536	40,177	1,152	1,095	33,688	41,272
Oklahoma	4,823	6,544	1,601	924	6,424	7,468	4,029	4,515	1,281	998	5,310	5,513
Oregon	7,402	8,083	10,271	8,087	17,673	16,170	6,477	7,583	5,822	6,097	12,299	13,680
Pennsylvania	12,927	21,102	84	102	13,011	21,204	12,594	19,766	----------	----------	12,594	19,766

Rhode Island	1,516	1,343	19	12	1,535	1,355	1,686	1,628	40	38	1,726	1,666
South Carolina	2,991	3,031	38	17	3,029	3,048	2,867	3,050	37	17	2,904	3,067
South Dakota	3,299	2,527	10,249	6,832	13,548	9,359	4,126	3,040	7,198	4,296	11,324	7,336
Tennessee	5,479	7,020	814	635	6,293	7,655	5,576	7,507	656	539	6,232	8,046
Texas	26,918	29,857	2,926	897	29,844	30,754	23,272	27,975	4,126	2,716	27,398	30,691
Utah	4,895	4,136	1,953	2,046	6,848	6,182	7,920	4,798	6,140	3,650	14,060	8,448
Vermont	901	946	908	272	1,809	1,218	920	1,001	1,312	566	2,232	1,567
Virginia	7,450	11,320	216	112	7,666	11,432	9,568	14,516	271	181	9,839	14,697
Washington	[1] 11,045	[1] 10,301	14,549	9,158	[1] 25,594	[1] 19,459	11,526	10,007	7,468	6,138	18,994	16,145
West Virginia	4,413	9,711	93	91	4,506	9,802	4,882	10,152	----------	----------	4,882	10,152
Wisconsin	22,874	18,582	12,807	7,066	35,681	25,648	22,496	17,465	17,482	10,992	39,978	28,457
Wyoming	2,112	1,655	3,816	3,701	5,928	5,356	2,069	2,124	4,600	3,232	6,669	5,356
Total	[1] 522,895	[1] 589,410	[1] 186,897	[1] 131,022	[1] 709,792	[1] 720,432	539,555	599,284	212,229	152,017	751,784	751,301
Guam	----------	----------	1	1	1	1	----------	----------	38	49	38	49
Johnston Island	----------	----------	1	4	1	4	----------	----------	1	1	1	1
Panama Canal Zone	65	68	----------	----------	65	68	75	73	----------	----------	75	73
Puerto Rico	8,996	8,669	----------	----------	8,996	8,669	6,682	9,072	4,688	1,313	11,370	10,385

[1] Revised figure.

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TABLE 4.—Sand and gravel sold or used by producers in the United States in 1961, 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	1,606,009	$1,388,243	5,591	$5,537	531,850	$459,634	74,099	$28,496
Alaska	98,369	309,823	6,166	19,780			411,675	449,156
Arizona	1,884,600	2,556,500	908,500	1,808,600	772,500	636,600	898,400	656,600
Arkansas	1,349,703	1,459,061			959,032	905,650	1,977,785	786,696
California	20,446,508	25,149,497	41,903	93,876	9,169,744	10,004,362	6,956,821	7,365,204
Colorado	1,644,400	1,827,400	25,000	39,800	446,900	319,100	122,400	104,300
Connecticut	1,754,735	1,659,192			974,987	883,193	45,000	13,500
Delaware	81,207	89,995			178,636	196,986		
Florida	4,760,011	3,741,718	300	219	309,091	271,246	312,593	325,046
Georgia	2,085,549	1,514,082			485,458	367,731		
Hawaii	309,952	596,071	550	950	5,071	9,992	14,620	38,600
Idaho	341,094	556,974	105	157	95,308	116,095	226,281	211,571
Illinois	4,367,330	4,279,002			6,910,358	6,488,741	113,831	55,544
Indiana	4,062,693	3,273,622			2,809,961	2,251,533		
Iowa	2,560,489	2,178,279	693	381	1,378,976	1,159,558	49,047	26,870
Kansas	3,223,990	2,364,270	1,305	522	3,465,946	2,695,420	1,339,895	599,132
Kentucky	2,054,777	2,034,156			1,148,959	958,521		
Louisiana	2,133,711	1,997,010			1,905,190	1,904,983		
Maine	303,071	249,739	23,014	8,055	132,328	94,067	618,234	230,039
Maryland	3,049,420	3,898,145			2,433,094	3,546,161	(1)	(1)
Massachusetts	2,902,295	2,850,051	515	515	1,820,941	1,805,699	152,687	93,748
Michigan	4,427,062	3,428,149			5,233,825	4,694,120	1,567,130	882,020
Minnesota	3,595,937	3,010,609			3,021,148	1,996,369	3,791,585	1,985,587
Mississippi	710,263	589,794			999,104	889,631	(1)	(1)
Missouri	3,061,804	2,736,948			1,040,330	916,179	25,011	25,011
Montana	336,080	459,713	21,207	44,423	100,264	85,694	29,141	52,342
Nebraska	2,005,100	1,746,900	200	300	850,800	715,800	227,300	109,600
Nevada	364,267	611,489	1,257	4,525	151,404	169,832	76,839	69,542
New Hampshire	301,017	242,437	4,850	1,940	209,086	145,543	950,788	380,626
New Jersey	3,961,173	4,874,606			2,160,062	1,792,566		
New Mexico	796,000	927,100	26,100	23,800	152,700	211,300	167,600	182,800
New York	8,756,819	10,215,034	108	164	5,087,285	5,524,987	70,525	51,175
North Carolina	2,080,843	1,501,197			1,086,675	841,716	2,370,494	1,216,360
North Dakota	296,500	348,300	18,000	9,000	61,300	58,900	391,200	299,100

Ohio	5,772,678	6,426,799			6,198,033	6,363,469	467,694	467,694
Oklahoma	1,689,647	1,352,180	351,428	431,428	884,674	731,733	418,014	248,691
Oregon	802,229	936,705	116,910	89,360	395,045	433,737	24,475	22,110
Pennsylvania	3,820,455	5,102,350			1,852,766	2,657,086		
Rhode Island	412,871	370,511			214,558	148,731	12,498	7,432
South Carolina	968,385	469,377			456,869	155,732	22,719	12,537
South Dakota	502,000	582,800	125,000	87,500	254,900	220,100	594,100	494,000
Tennessee	1,748,123	2,605,059			559,586	661,142	2,693	3,338
Texas	6,506,337	6,478,309	51,922	45,944	3,058,461	2,822,525	719,512	393,880
Utah	842,800	854,500	205,600	193,800	273,400	243,000	15,000	9,200
Vermont	70,393	66,879			184,422	137,695	353,728	145,031
Virginia	1,516,508	2,112,447			2,067,742	3,097,175	95,982	40,739
Washington	1,747,559	1,939,514	359,687	368,093	610,665	497,312	566,609	486,148
West Virginia	1,362,004	1,671,464			586,402	846,515		
Wisconsin	3,378,100	2,852,209			2,814,327	2,053,758	5,401,323	2,761,789
Wyoming	115,800	183,100	25,300	52,400	43,700	57,800	379,200	92,700
Undistributed [1]							189,356	196,939
Total	122,968,667	128,669,309	2,321,211	3,331,069	76,543,863	74,245,419	32,243,884	21,620,893
Guam			38,472	49,085				
Johnston Island			540	1,200				
Panama Canal Zone	37,602	36,637			37,602	36,637		
Puerto Rico	1,808,327	2,727,807	8,000	13,000	1,548,595	1,529,324	96,405	115,885

[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 1961, 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	36,314	$22,657	13,573	$6,349					682	$321
Alaska							9,000	$27,000	23,642	53,158
Arizona	8,400	7,900	253,300	285,400	55,500	$21,100	(1)	(1)		
Arkansas			(1)	(1)			(1)	(1)		
California	52,197	37,939	3,624,800	2,018,077	539,211	519,653	492,848	533,370	1,565	1,685
Colorado			12,200	4,800	8,400	3,900	28,200	29,500	4,900	4,900
Connecticut			556,288	284,659			118,415	106,701		
Delaware			24,515	17,143			1,800	1,800		
Florida			301,448	136,562	239,480	130,134	40,106	28,876	10,000	8,500
Georgia	119	71	(1)	(1)			30,000	18,000		
Hawaii					4,370	3,000				
Idaho			29,646	12,516						
Illinois	21,733	16,992	862,459	527,696			100,953	94,001		
Indiana			1,191,444	388,472			75,985	49,443	1,100	385
Iowa	(1)	(1)	474,607	240,881	12,000	9,000	48,773	83,041	3,586	2,402
Kansas	109,671	50,886	682,272	377,511	688	275	21,748	16,583		
Kentucky			236,082	161,477						
Louisiana	(1)	(1)	174,254	90,904						
Maine			133,691	48,290			70,248	35,495	3,105	642
Maryland			24,250	16,641			329,743	508,805		
Massachusetts			706,570	225,099	2,563,187	952,381	298,782	215,754	17,800	12,541
Michigan			2,360,694	855,327	1,028,027	407,961	43,377	30,316	39,621	18,944
Minnesota	17,542	11,446	388,039	220,846	100,744	31,882	85,480	49,670		
Mississippi			13,105	10,041					352	141
Missouri	(1)	(1)	304,931	248,661			1,522	2,128		
Montana			(1)	(1)			(1)	(1)		
Nebraska	500	300	251,000	118,700	70,000	14,000	(1)	(1)		
Nevada			20,661	20,494	8,550	14,250	167	424		
New Hampshire			228,550	46,655	587,205	218,932	24,233	10,670		
New Jersey			203,412	111,798			36,921	41,901		
New Mexico			34,500	55,100			95,200	135,800		
New York	(1)	(1)	596,964	233,225	477,342	259,952	663,502	635,829	228,677	87,668
North Carolina	(1)	(1)	42,823	27,310	342,000	212,040	(1)	(1)		
North Dakota	(1)	(1)	26,100	16,400			(1)	(1)		
Ohio			778,180	648,842	31,586	31,146	119,685	109,853		
Oklahoma	11,000	5,500	391,792	202,890			2,047	819	8,566	7,244

Oregon			189,073	135,531			(1)	(1)	68	135
Pennsylvania			79,813	58,706			(1)	(1)		
Rhode Island			(1)	(1)			64,993	64,141		
South Carolina			(1)	(1)					14,437	4,937
South Dakota	(1)	(1)	13,000	6,800			5,800	5,800		
Tennessee			(1)	(1)			(1)	(1)		
Texas			317,010	162,805			55,767	65,020		
Utah			20,600	10,500	1,436,900	240,200	20,300	19,600		
Vermont			(1)	(1)			41,775	31,686	23,288	11,543
Virginia	(1)	(1)	282,650	147,742			(1)	(1)	18,191	7,276
Washington			1,746,172	706,305	4,200	1,680	7,060	9,888	1,910	1,469
West Virginia			(1)	(1)						
Wisconsin	101,950	80,990	874,042	451,433	480,991	184,326	(1)	(1)	33,847	17,443
Wyoming	16,600	8,300	2,500	4,400			9,500	4,800		
Undistributed [1]	140,946	111,133	376,958	224,950			390,295	303,643		
Total	516,972	354,114	18,933,968	9,567,938	7,990,381	3,255,812	3,334,225	3,270,357	435,337	241,334
Guam					284	284				
Johnston Island										
Panama Canal Zone										
Puerto Rico			501,431	219,796	4,505,930	1,050,390				

[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 1961, by States, uses, and classes of operations—Continued
(Commercial unless otherwise indicated)

State	Sand, industrial							
	Glass		Molding		Grinding and polishing [2]		Fire or furnace	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Alabama			85,626	$200,230				
Alaska								
Arizona					(1)	(1)		
Arkansas	202,586	$561,163	43,116	119,431	(1)	(1)		
California	(1)	(1)	(1)	(1)	226,043	$838,351	2,690	$13,947
Colorado					(1)	(1)		
Connecticut			2,062	1,138				
Delaware								
Florida	90,899	178,973	(1)	(1)	(1)	(1)		
Georgia	(1)	(1)	83,631	131,529	(1)	(1)		
Hawaii								
Idaho	(1)	(1)	(1)	(1)	847	8,639		
Illinois	1,338,447	3,171,705	626,447	2,300,021	(1)	(1)	14,077	42,911
Indiana	(1)	(1)	(1)	(1)			134,002	237,307
Iowa			(1)	(1)	(1)	(1)		
Kansas					(1)	(1)		
Kentucky	14,000	42,000	6,000	17,500				
Louisiana					(1)	(1)		
Maine			(1)	(1)				
Maryland	(1)	(1)			(1)	(1)		
Massachusetts			(1)	(1)	(1)	(1)		
Michigan	(1)	(1)	1,693,079	2,497,998	292,871	328,980		
Minnesota	(1)	(1)	59,525	197,150	(1)	(1)		
Mississippi			(1)	(1)	157	237		
Missouri	385,977	1,017,395	(1)	(1)	177,667	517,877		
Montana								
Nebraska								
Nevada	(1)	(1)	(1)	(1)			(1)	(1)
New Hampshire								
New Jersey	(1)	(1)	1,291,648	4,147,244	138,311	620,255	16,849	37,819
New Mexico								
New York			174,399	683,337				
North Carolina								
North Dakota								
Ohio	(1)	(1)	340,906	1,269,318	(1)	(1)	161,543	397,968
Oklahoma	(1)	(1)	(1)	(1)	8,201	24,370	2,000	1,400
Oregon			694	3,470				
Pennsylvania	(1)	(1)	147,772	427,479	(1)	(1)	226,666	469,668
Rhode Island			(1)	(1)				
South Carolina	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)

South Dakota			(1)	(1)	(1)	(1)		
Tennessee	(1)	(1)	208,727	608,823	(1)	(1)		
Texas	(1)	(1)	24,102	53,614	79,431	494,983	1,480	2,768
Utah			3,300	9,700	100	200	20,000	24,000
Vermont								
Virginia	(1)	(1)	(1)	(1)				
Washington	(1)	(1)	(1)	(1)	(1)	(1)		
West Virginia	(1)	(1)	(1)	(1)	(1)	(1)	31,032	35,687
Wisconsin			105,565	265,619	18,583	43,453		
Wyoming								
Undistributed [1]	4,650,087	16,971,642	919,613	2,874,474	787,449	2,323,977	11,460	21,381
Total	6,681,996	21,942,878	5,815,212	15,808,075	1,729,660	5,201,322	621,799	1,284,856
Guam								
Johnston Island								
Panama Canal Zone								
Puerto Rico								

[1] Figures withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[2] Includes 635,510 tons of blast sand valued at $2,813,635.

TABLE 4.—Sand and gravel sold or used by producers in the United States in 1961, by States, uses, and classes of operations—Continued
(Commercial unless otherwise indicated)

State	Sand, industrial—Continued											
	Engine		Ferrosilicon		Filtration		Oil (hydrafrac)		Other		Ground sand	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Alabama					20,000	$13,000						
Alaska									15,333	$33,222		
Arizona	(1)	(1)					20,100	$204,100				
Arkansas	(1)	(1)			(1)	(1)			(1)	(1)	8,667	$165,000
California	(1)	(1)			(1)	(1)	(1)	(1)	35,276	170,703	(1)	(1)
Colorado	(1)	(1)			5,200	53,900			800	1,200	13,400	15,100
Connecticut					(1)	(1)						
Delaware	28,418	$21,323										
Florida					(1)	(1)			(1)	(1)		
Georgia					13,865	31,615			43,398	52,427	(1)	(1)
Hawaii	(1)	(1)							(1)	(1)		
Idaho	(1)	(1)			10	102						
Illinois	(1)	(1)			(1)	(1)	(1)	(1)	(1)	(1)	216,087	1,981,805
Indiana	69,016	105,320			(1)	(1)			(1)	(1)		
Iowa	(1)	(1)			(1)	(1)			(1)	(1)		
Kansas	23,492	44,598			(1)	(1)						
Kentucky	(1)	(1)							(1)	(1)		
Louisiana	5,000	3,250			(1)	(1)			(1)	(1)		
Maine	2,206	2,757							(1)	(1)		
Maryland	(1)	(1)							(1)	(1)		
Massachusetts											(1)	(1)
Michigan	45,653	58,730							(1)	(1)	(1)	(1)
Minnesota	(1)	(1)					(1)	(1)	(1)	(1)	(1)	(1)
Mississippi	56	37										
Missouri	(1)	(1)	(1)	(1)					(1)	(1)	(1)	(1)
Montana												
Nebraska											(1)	(1)
Nevada									40,420	94,848		
New Hampshire	(1)	(1)			(1)	(1)						
New Jersey	26,767	79,650			27,916	94,998			132,411	558,736	(1)	(1)
New Mexico												
New York	(1)	(1)			9,510	11,735			30,000	24,000		
North Carolina									4,089	2,044		
North Dakota												
Ohio	(1)	(1)	(1)	(1)	12,507	42,767			(1)	(1)	(1)	(1)
Oklahoma	(1)	(1)	(1)	(1)	(1)	(1)			(1)	(1)	(1)	(1)
Oregon	(1)	(1)										
Pennsylvania	65,063	171,729	(1)	(1)					172,847	404,580	(1)	(1)
Rhode Island												

South Carolina	22,752	56,703			9,130	24,530			41,955	56,630		
South Dakota							2,500	21,300				
Tennessee	1,037	1,555										
Texas	21,466	20,404			(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Utah	1,200	2,900										
Vermont	(1)	(1)										
Virginia	35,940	46,731			(1)	(1)			(1)	(1)	189	758
Washington											1,034	12,711
West Virginia	98,353	275,600	(1)	(1)					(1)	(1)	(1)	(1)
Wisconsin	(1)	(1)			7,000	17,500			(1)	(1)	(1)	(1)
Wyoming							41,662	128,847				
Undistributed [1]	307,424	585,586	47,327	$125,755	104,657	256,488	194,250	1,322,848	494,147	1,465,152	679,715	5,888,575
Total	753,843	1,476,873	47,327	125,755	209,795	546,635	258,512	1,677,095	1,010,676	2,863,542	919,092	8,063,949
Guam												
Johnston Island												
Panama Canal Zone												
Puerto Rico											98,057	104,155

[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 1961, 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	1,803,641	$2,470,210			649,970	$858,455	800,996	$796,624
Alaska	70,037	235,811	68,761	$21,812	58,856	89,739	2,042,312	1,443,231
Arizona	1,668,600	2,129,300	3,394,400	6,776,200	3,407,700	2,658,700	6,406,500	5,737,900
Arkansas	1,214,241	1,727,500			1,716,766	1,604,385	1,407,434	1,363,805
California	23,832,497	32,075,650	54,245	97,491	23,437,276	28,026,698	15,921,748	8,405,261
Colorado	2,886,000	3,698,800	88,200	90,200	4,041,000	3,392,900	8,419,800	6,841,500
Connecticut	1,155,090	1,654,840			726,092	800,157	1,784,550	887,475
Delaware	57,120	114,363			579,283	521,072		
Florida	150,482	188,800			162,352	323,954	24,360	40,630
Georgia	(1)	(1)			(1)	(1)		
Hawaii	12,287	49,148					60,039	46,102
Idaho	480,331	572,722	205	342	1,092,022	1,012,957	4,685,067	4,088,735
Illinois	3,120,845	3,006,860	6,683	4,411	11,361,315	10,169,018	707,200	455,633
Indiana	3,336,086	3,684,871	34,966	19,231	4,873,869	4,779,880	322,723	185,096
Iowa	1,520,929	2,299,934			3,842,503	3,034,341	3,156,604	1,941,405
Kansas	155,190	128,898	42,722	16,433	1,191,956	932,456	993,032	437,687
Kentucky	753,077	944,492			1,044,676	1,064,860	233,279	252,940
Louisiana	3,466,430	4,527,097	156,923	62,769	3,783,072	5,833,233	101,880	40,752
Maine	338,329	390,008			1,037,748	546,396	6,001,098	2,043,841
Maryland	2,079,794	3,819,542			2,275,944	3,199,586	(1)	(1)
Massachusetts	2,973,410	3,941,914			2,133,955	2,209,048	2,302,795	1,152,982
Michigan	4,342,782	5,179,474	38,187	21,003	20,220,029	17,193,729	11,795,445	9,935,741
Minnesota	2,805,164	4,171,397	63,411	34,876	8,030,714	6,746,744	7,273,008	4,330,528
Mississippi	990,770	975,930			2,675,414	2,670,465	(1)	(1)
Missouri	1,957,163	2,429,898			1,405,200	1,078,236	602,053	396,953
Montana	526,815	656,081	51,953	100,510	928,710	878,210	12,453,199	11,015,245
Nebraska	2,144,500	1,809,500	26,100	25,300	3,617,400	2,902,600	615,500	569,000
Nevada	472,797	785,552	1,809	6,512	1,180,536	838,198	4,350,947	3,971,010
New Hampshire	209,016	362,622	66,858	26,743	586,816	674,351	2,785,141	1,114,236
New Jersey	2,133,131	3,553,576			993,760	1,249,431	11,268	5,064
New Mexico	791,600	1,033,200	22,600	63,200	1,919,100	2,170,300	3,066,100	3,894,500
New York	4,096,425	5,851,844			3,737,011	4,473,402	1,003,326	368,451
North Carolina	1,304,530	1,959,837			1,346,693	1,371,649	752,296	647,258
North Dakota	322,000	639,900	111,400	72,900	670,700	450,000	7,144,500	5,464,000

Ohio	5,265,360	6,597,498	1,600	2,226	10,678,912	13,038,494	648,665	593,226
Oklahoma	79,254	101,650			(1)	(1)	499,154	308,817
Oregon	1,831,876	2,246,261	9,180	16,695	2,721,031	3,382,439	5,670,743	5,968,004
Pennsylvania	3,175,350	4,169,641			1,941,437	2,747,338		
Rhode Island	(1)	(1)			231,518	304,500	27,321	30,484
South Carolina	926,283	1,641,744						
South Dakota	108,800	159,500			2,961,100	1,813,200	6,479,500	3,714,200
Tennessee	1,258,570	1,625,844			1,352,660	1,135,332	628,939	516,086
Texas	7,630,803	10,477,928	373,325	531,036	4,721,766	6,066,046	2,981,787	1,745,561
Utah	1,296,100	1,321,800	640,100	648,500	5,347,100	2,245,200	2,311,700	1,998,500
Vermont	102,181	172,164			446,008	559,807	933,911	408,205
Virginia	1,868,146	2,935,594			2,693,790	4,760,018	145,385	115,612
Washington	2,502,649	2,562,068	1,146,910	582,918	3,545,825	3,373,772	5,291,256	4,620,149
West Virginia	1,290,461	1,428,268			423,870	643,111		
Wisconsin	3,570,032	3,184,000			9,400,646	6,836,468	11,311,008	7,912,646
Wyoming	337,900	453,100	79,900	150,800	1,398,800	1,330,600	4,050,600	2,896,400
Undistributed [1]	482,269	669,479			549,569	557,455	367,725	453,068
Total	104,897,143	136,816,110	6,480,438	9,372,108	163,142,470	162,548,930	148,571,894	109,154,543
Guam								
Johnston Island								
Panama Canal Zone								
Puerto Rico	1,299,000	2,348,396	5,000	19,000	965,600	1,783,835	19,400	27,310

[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 1961, by States, uses, and classes of operations—Continued
(Commercial unless otherwise indicated)

State	Gravel, construction—Continued										Gravel, miscellaneous	
	Railroad ballast		Fill				Other					
			Commercial		Government-and-contractor		Commercial		Government-and-contractor			
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Alabama	54,250	$51,787	(1)	(1)							(1)	(1)
Alaska	62,806	59,679	146,266	$166,695	2,058,828	$1,021,156	150,000	$225,000			18,459	$29,666
Arizona	(1)	(1)	1,793,500	595,900			(1)	(1)	6,400	$5,900	88,800	176,800
Arkansas	49,760	44,784	56,938	27,852	71,000	32,000	(1)	(1)			10,600	12,875
California	221,783	243,492	2,467,183	2,144,135	476,839	332,186	1,014,902	1,263,297	142,488	142,544	232,634	299,909
Colorado	1,800	5,400	138,300	85,800	308,600	141,300	56,700	125,800			93,200	112,400
Connecticut			236,262	141,519			(1)	(1)			89,546	135,840
Delaware											10,350	7,315
Florida												
Georgia			(1)	(1)			(1)	(1)				
Hawaii			4,482	4,482	520	2,000						
Idaho	79,935	36,961	50,870	31,239	195,522	75,182	(1)	(1)			(1)	(1)
Illinois	111,089	70,753	658,404	395,829	9,295	4,145	123,340	146,442			274,761	188,777
Indiana	138,756	121,866	1,898,042	958,301	109,518	33,185	57,336	56,192			96,256	116,061
Iowa	(1)	(1)	110,530	64,264			14,052	78,381	15,340	6,136	(1)	(1)
Kansas			25,398	16,340	13,499	5,400	29,915	40,627			23,529	24,918
Kentucky			(1)	(1)								
Louisiana	22,446	18,937	276,237	336,844								
Maine	46,173	40,845	119,962	55,828	340	110	1,073	546			88,871	45,635
Maryland			859,299	714,673			589,107	329,303			454,864	340,793
Massachusetts	(1)	(1)	918,817	503,792	409,503	143,326	452,111	230,438			(1)	(1)
Michigan	111,733	119,056	307,417	217,318	304,687	105,461	(1)	(1)	162,627	70,939	41,861	43,872
Minnesota	370,530	329,088	396,828	195,297	346,194	114,603	119,647	91,719	5,741	1,435	48,639	34,241
Mississippi	(1)	(1)	18,380	9,125							47,520	33,000
Missouri	70,032	51,067	39,505	26,692	47	39	1,880	1,880			18,124	8,725
Montana	114,084	85,191	82,636	70,177	9,450	9,922	6,332	5,327	14,900	14,900	3,258	4,520
Nebraska			11,600	8,100			83,200	58,100	55,600	55,600	126,200	108,100
Nevada	(1)	(1)	255,933	258,894	114	57	(1)	(1)	20,070	21,642		
New Hampshire	2,126	830	302,868	73,950	1,382,300	296,305	(1)	(1)			(1)	(1)
New Jersey			188,606	86,688			57,914	103,943			21,711	34,958
New Mexico	45,600	24,900	91,600	167,000	5,130,000	972,000	4,200	7,500			180,300	180,300
New York	(1)	(1)	1,201,323	611,716	874,979	571,196	567,051	400,197	59,355	20,774	362,577	371,368
North Carolina	(1)	(1)	1,838	1,838							(1)	(1)
North Dakota	154,100	69,800	163,000	61,200	9,000	7,400	(1)	(1)	2,200	1,100	(1)	(1)
Ohio	53,096	38,590	715,617	587,912			1,515,995	2,330,221	2,210	457	439,714	380,332
Oklahoma					3,660	1,830	405	220			10,000	5,000

Oregon	(1)	(1)	279,744	194,098			37,466	52,158	165	287	166,306	145,476
Pennsylvania	(1)	(1)	93,294	63,316			(1)	(1)			59,109	42,095
Rhode Island			215,875	141,196			32,252	26,122			160,931	108,795
South Carolina	(1)	(1)					33,486	53,578				
South Dakota	62,200	59,200	97,300	48,700			19,900	22,400			88,700	73,500
Tennessee	(1)	(1)	(1)	(1)	25,000	20,000					(1)	(1)
Texas	(1)	(1)	126,266	105,283			190,406	111,576			137,629	115,174
Utah	(1)	(1)	64,600	41,900	1,510,800	537,300	10,800	12,500	19,500	22,500	(1)	(1)
Vermont			34,937	13,737	1,500	900	(1)	(1)			(1)	(1)
Virginia			(1)	(1)			(1)	(1)	12,000	18,000		
Washington	193,201	108,617	996,879	497,869			113,342	111,345	97,123	77,072	40,322	27,694
West Virginia	4,738	6,396	1,746	2,297							150	225
Wisconsin	415,509	290,573	608,036	345,990	248,791	110,608	160,943	133,084	6,000	4,500	785,312	668,044
Wyoming	121,600	60,800	(1)	(1)	9,600	9,600	(1)	(1)	55,100	29,600	12,400	11,000
Undistributed [1]	725,102	631,375	553,092	472,740			754,222	691,017			897,204	1,106,469
Total	3,232,449	2,569,987	16,609,410	10,546,526	13,509,586	4,547,211	6,197,977	6,708,913	676,819	493,386	5,129,837	4,993,877
Guam												
Johnston Island												
Panama Canal Zone												
Puerto Rico			210,017	128,780	8,000	16,000	251,400	229,620	45,000	71,710		

[1] Figures withheld to avoid disclosing individual company confidential data; included with "Undistributed."

Government-and-Contractor Production.—The volume of sand and gravel classified as produced by Government-and-contractor was 28 percent of the total output, an increase of 2 percent from 1960. The value was $152 million, an average of $0.72 per ton. This output went into government-financed construction projects, including Federal, State, and local programs for new highway construction, schools, hospitals, and road maintenance. States reported 60 percent of Government-and-contractor production in 1961; counties, 22 percent; Federal agencies, 15 percent; and municipalities, 3 percent. Most production was by contract; the remainder was by regular maintenance crews.

The entire production of a private producer must be on a contract to a government agency to be classed under the Government-and-contractor category. If any part of the production is sold commercially, the entire output is designated as commercial.

Degree of Preparation.—Because of availability some noncommercial sand and gravel was sold without processing for road fill, base course, and subgrade in highway construction for as little as 36 cents a ton.

Indicative of more exacting specifications, washed, screened, or otherwise processed material comprised 90 percent of commercial sand and gravel production and sold for an average of $1.17 per ton. Sixty-nine percent of Government-and-contractor production, with an average value of $0.85 per ton, was prepared.

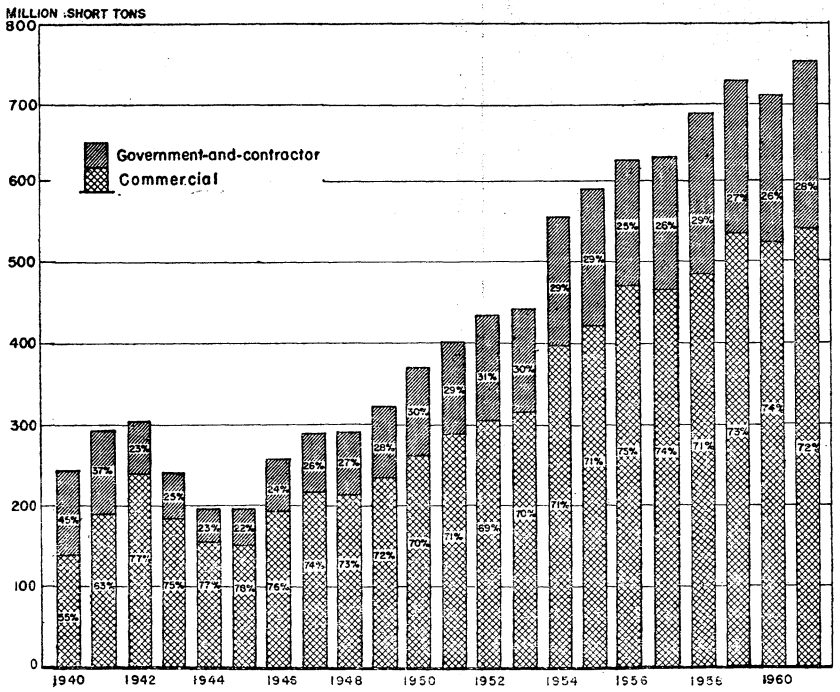


FIGURE 2.—Sand and gravel sold or used in the United States, 1940–61.

TABLE 5.—Sand and gravel sold or used by Government-and-contractor producers in the United States,[1] by uses

(Thousand short tons and thousand dollars)

Year	Sand								Gravel								Total Government-and-contractor sand and gravel	
	Building		Paving		Fill		Other		Building		Paving		Fill		Other			
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1952–56 (average)	1,508	$1,534	17,635	$8,333	(2)	(2)	(2)	(2)	8,810	$5,379	122,448	$64,835	(2)	(2)	(2)	(2)	150,401	$80,081
1957	2,324	1,903	24,159	12,280	(2)	(2)	(2)	(2)	7,857	5,860	130,908	83,734	(2)	(2)	(2)	(2)	165,248	103,777
1958	1,584	1,807	28,496	15,151	(2)	(2)	(2)	(2)	3,814	4,116	161,310	106,432	(2)	(2)	(2)	(2)	195,204	127,506
1959	1,353	1,419	34,097	19,654	1,927	$899	254	$102	10,387	6,882	144,525	100,308	2,719	$789	20	$14	195,282	130,067
1960	[3] 962	[3] 1,374	[3] 26,042	[3] 18,500	3,785	2,122	728	338	[3] 7,320	[3] 6,417	[3] 130,323	[3] 93,859	[3] 17,106	[3] 7,890	[3] 631	[3] 522	[3] 186,897	[1] 131,022
1961	2,321	3,331	32,243	21,621	7,991	3,256	435	242	6,480	9,372	148,572	109,155	13,510	4,547	677	493	212,229	152,017

[1] Includes possessions and other areas administered by the United States (1952-56).
[2] Data not available.
[3] Revised figure.

Size of Plants.—A total of 2,044 plants, producing between 50,000 and 500,000 tons per year, supplied 59 percent of production; 193 operators of large plants (500,000 to more than 1 million tons) furnished 33 percent of production. Ten more plants than in 1960 produced 1 million tons or more.

Production Trends.—A survey conducted by the Colorado Sand and Gravel Producers Association indicated that the supply of good, low-cost gravel in the Denver area would be exhausted in 12½ years at the 1961 rate of consumption. More than 50 percent of the land area with good gravel deposits had been built over.

The Elmhurst-Chicago Co. installed what may be the last sand and gravel plant in the Chicago area. The deposit is in the path of many suburban developments and near a network of express highways. The plant was designed to be completely portable.[4]

A well-illustrated publication of the National Sand and Gravel Association Committee on Public Relations showed methods used and results of land rehabilitation programs carried out by 10 sand and gravel producers.[5]

Methods of Transportation.—Trucks moved 89 percent of the total output of sand and gravel. Rail shipments, which were 20 percent in 1951, declined to a new low of 8 percent in 1961. Water transporta-

[4] Rock Products. It's the End of an Era in Chicago. V. 64, No. 12, December 1961, pp. 90–94.
[5] National Sand and Gravel Association. Case Histories: Rehabilitation of Worked-Out Sand and Gravel Deposits. May 1, 1961, 32 pp.

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	1952–56 (average)		1957		1958	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction and maintenance crews	47,291	$18,662	49,646	$24,076	49,770	$26,314
Contractors	103,110	61,419	115,602	79,701	145,434	101,192
Total	150,401	80,081	165,248	103,777	195,204	127,506
States	86,431	46,859	97,813	60,120	123,555	78,676
Counties	40,898	17,503	44,303	23,234	49,329	29,639
Municipalities	3,124	1,541	3,092	2,547	2,970	1,959
Federal agencies	19,948	14,178	20,040	17,876	19,350	17,232
Total	150,401	80,081	165,248	103,777	195,204	127,506

	1959		1960		1961	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction and maintenance crews	49,800	$28,643	[2] 52,035	[2] $31,212	54,030	$33,194
Contractors	145,482	101,424	[2] 134,862	[2] 99,810	158,199	118,823
Total	195,282	130,067	[2] 186,897	[2] 131,022	212,229	152,017
States	111,696	74,947	[2] 110,157	[2] 78,227	127,004	94,111
Counties	56,293	34,975	[2] 48,563	[2] 31,654	46,932	30,334
Municipalities	3,282	1,972	2,897	1,755	6,357	3,335
Federal agencies	24,011	18,173	25,280	19,386	31,936	24,237
Total	195,282	130,067	[2] 186,897	[2] 131,022	212,229	152,017

[1] Includes possessions and other areas administered by the United States (1952–56).
[2] Revised figure.

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)

	1960 [1]		1961	
	Quantity	Value	Quantity	Value
Commercial operations:				
Prepared	472,875	$558,759	483,344	$567,909
Unprepared	50,020	30,651	56,211	31,375
Total	522,895	589,410	539,555	599,284
Government-and-contractor operations: [2]				
Prepared	127,557	102,939	146,244	124,189
Unprepared	59,340	28,083	65,985	27,828
Total	186,897	131,022	212,229	152,017
Grand total	709,792	720,432	751,784	751,301

[1] Revised figures.
[2] Includes operations by or for States, counties, municipalities, and Federal Government agencies as follows—1960: 1,614 operations; 1961: 1,775.

TABLE 8.—Number and production of domestic commercial sand and gravel plants by size of operation

Annual production (short tons)	1960				1961			
	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	[2] 1,672	[2] 35.5	[2] 16,984	3.2	1,631	35.1	16,946	3.2
25,000 to 50,000	[2] 794	16.9	[2] 28,848	5.5	778	16.7	28,193	5.2
50,000 to 100,000	[2] 834	17.7	[2] 59,952	11.5	825	17.8	58,470	10.8
100,000 to 200,000	[2] 673	14.3	[2] 93,763	17.9	692	14.9	97,287	18.0
200,000 to 300,000	309	6.6	74,870	14.3	301	6.5	72,886	13.5
300,000 to 400,000	145	3.1	50,085	9.6	129	2.8	44,204	8.2
400,000 to 500,000	92	[2] 2.0	41,005	7.9	97	2.1	43,302	8.0
500,000 to 600,000	64	1.4	34,895	6.7	54	1.2	29,313	5.4
600,000 to 700,000	29	.6	18,652	3.6	34	.7	21,944	4.1
700,000 to 800,000	22	.5	16,420	3.1	21	.5	15,810	2.9
800,000 to 900,000	15	.3	12,702	2.4	16	.3	13,876	2.6
900,000 to 1,000,000	12	.2	11,392	2.2	15	.3	14,301	2.7
1,000,000 and over	43	.9	63,327	12.1	53	1.1	83,023	15.4
Total	[2] 4,704	100.0	[2] 522,895	100.0	4,646	100.0	539,555	100.0

[1] Includes a few companies operating more than 1 plant but not submitting separate returns for individual plants.
[2] Revised figure.

tion was a major factor in the movement of sand and gravel along the Mississippi River and its tributaries and around the Great Lakes, although it accounted for only 3 percent of the U.S. total. Off-the-road trucks increased in size, but use of oversized trucks on most highways was restricted by weight regulations.

Reasons for declining use of rail transportation for moving sand and gravel were discussed from the viewpoint of a producer.[6]

Because of a local shortage of fill material, 3 million cubic yards of bank-run sand and gravel was hauled by rail 70 miles from pit to roadbed on the Massachusetts Interstate Highway Project.[7]

TABLE 9.—Sand and gravel sold or used in the United States, by classes of operation and methods of transportation

	1960		1961	
	Thousand short tons	Percent of total	Thousand short tons	Percent of total
Commercial:				
Truck	[1] 436,091	62	460,131	61
Rail	61,962	9	56,184	8
Waterway	23,457	3	22,227	3
Unspecified	1,385	(2)	1,013	(2)
Total commercial	[1] 522,895	74	539,555	72
Government-and-contractor: Truck [3]	[1] 186,897	26	212,229	28
Grand total	[1] 709,792	100	751,784	100

[1] Revised figure.
[2] Less than 0.5 percent.
[3] Entire output of Government-and-contractor operations assumed to be moved by truck.

[6] Brady, Charles E. Sand, Gravel Transport by Rail . . . Soon to be Only a Memory? Pit and Quarry, v. 53, No. 12, June 1961, pp. 124–125.
[7] Construction Methods and Equipment. Trains Move Earth 70 Miles for Highway Fill in River. V. 43, No. 10, October 1961, pp. 86–88.

Conveyors.—Multiple units of conveyor belts were used to move material through the various stages of processing. In many plants conveyor belt installations were controlled automatically.

Employment and Productivity.—Average output per man per hour was 7.4 tons, the same as in 1960. In 1951 average production was 5.0 tons per man hour.

TABLE 10.—Employment in the commercial sand and gravel industry and average output per man in the United States in 1961, by States[1]

State	Employment					Production		
		Time employed					Average per man (short tons)	
	Average number of men	Average number of days	Total man shifts	Man-hours		Short tons		
				Average man per day	Total		Per shift	Per hour
Alabama	507	252	127,697	8.6	1,095,906	4,918,576	38.5	4.5
Alaska	51	87	4,421	8.7	38.432	629,126	142.3	16.4
Arizona	830	252	209,323	7.7	1,610,360	10,283,300	49.1	6.4
Arkansas	607	250	151,763	8.6	1,308,828	5,932,849	39.1	4.5
California	4,658	229	1,067,154	8.1	8,660,789	86,045,789	80.6	9.9
Colorado	581	192	111,832	8.6	956,780	9,382,700	83.9	9.8
Connecticut	364	230	83,743	8.2	688,974	5,669,257	67.7	8.2
Delaware	70	195	13,638	8.4	114,011	961,329	70.5	8.4
Florida	348	266	92,704	8.7	810,968	5,943,735	64.1	7.3
Georgia	352	271	95,542	8.0	761,759	3,149,846	33.0	4.1
Hawaii	43	99	4,265	8.0	34,126	335,628	78.7	9.8
Idaho	227	140	31,795	8.1	257,758	2,197,676	69.1	8.5
Illinois	1,889	224	422,209	8.4	3,531 008	30,515,731	72.3	8.6
Indiana	1,040	244	253,494	8.6	2,186,482	19,108,945	75.4	8.7
Iowa	870	209	181,665	9.2	1,674.755	10,154,160	55.9	6.1
Kansas	624	223	139,381	9.0	1,248,223	8,974,428	64.4	7.2
Kentucky	434	284	123,454	8.9	1,099,371	5,349,214	43.3	4.9
Louisiana	1,081	270	291,565	8.8	2,551.385	11.782,912	40.4	4.6
Maine	253	164	41,572	8.5	352,637	2,274,771	54.7	6.5
Maryland	867	254	219,972	8.7	1,904,118	12,230,110	55.6	6.4
Massachusetts	885	197	174,087	8.1	1,416.951	12,614,169	72.5	8.9
Michigan	1,915	227	434,660	8.8	3,803,947	39,667,614	91.3	10.4
Minnesota	1,970	145	286,040	9.0	2,571,179	19,109,468	66.8	7.4
Mississippi	351	253	88,648	8.7	768.370	5,536,088	62.5	7.2
Missouri	677	224	151,410	8.8	1,338.360	8,743,930	57.8	6.5
Montana	245	166	40,554	8.0	325,725	2,121,943	52.3	6.5
Nebraska	749	212	159,114	9.2	1,457.008	9,099.100	57.2	6.2
Nevada	203	154	31,230	8.0	249,766	2,635,424	84.4	10.6
New Hampshire	118	207	24,464	8.7	213,358	1,924,124	78.7	9.0
New Jersey	1,049	246	258,211	8.3	2,153,388	12,246,210	47.4	5.7
New Mexico	305	185	56,275	8.1	456,526	4,110,800	73.0	9.0
New York	1,811	211	382,677	8.4	3,227,800	25,328,927	66.2	7.8
North Carolina	573	219	125,299	8.8	1,097,682	6,314,235	50.4	5.8
North Dakota	178	160	28,557	8.5	241,819	1,719,100	60.2	7.1
Ohio	2,392	224	535,167	8.2	4,409.778	32,536,018	60.8	7.4
Oklahoma	298	249	74,337	8.7	644,250	4,029,263	54.2	6.3
Oregon	705	216	152,629	7.6	1,165,343	6,477,032	42.4	5.6
Pennsylvania	1,392	211	294,197	8.4	2.475,592	12,594,123	42.8	5.1
Rhode Island	132	208	27,391	8.0	220,227	1,686,281	61.6	7.7
South Carolina	231	244	56,256	8.1	456,277	2,866,760	51.0	6.3
South Dakota	371	164	60,707	9.1	551,761	4,125,700	68.0	7.5
Tennessee	563	258	145,140	8.3	1,208,724	5,575,682	38.4	4.6
Texas	1,847	247	456,282	9.5	4,331.913	23,271,668	51.0	5.4
Utah	300	237	71,172	8.0	572,557	7,919,900	111.3	13.8
Vermont	119	197	23,410	8.5	198,454	919,839	39.3	4.6
Virginia	654	254	166,354	8.7	1,439,960	9,567,940	57.5	6.6
Washington	804	178	143,128	8.2	1,180.066	11,526.436	80.5	9.8
West Virginia	529	204	107,946	8.8	947,462	4,881,590	45.2	5.2
Wisconsin	1,512	196	295,871	9.0	2,653,653	22.496,147	76.0	8.5
Wyoming	196	176	34,572	8.0	276,875	2,069,300	59.9	7.5
Total	38,770	221	8,552,974	8.5	72,941,441	539,554,893	63.1	7.4

[1] Excludes operations by or for States, counties, municipalities, and Federal Government agencies. All employment data are preliminary.

CONSUMPTION AND USES

Construction Uses, Including Ballast.—Increased consumption of sand and gravel was attributed to increased expenditures for public highways and private nonresidential construction. Total new construction put-in-place advanced to a new peak of $57.4 billion, a 3-percent increase over 1960.[8] Demand for thicker highway base courses to support the weight and volume of modern traffic increased use of sand and gravel for road fill.

Industrial Sands.—Consumption of industrial sand, including ground sand, decreased 283,000 tons. Minor increases were reported for grinding and polishing sands, furnace sand, and glass sand. Production of oil sand increased 69 percent.

PRICES

Average value of total sand and gravel output at producer plants, both commercial and Government-and-contractor operations, was $1.00 per short ton, compared with $1.01 per ton in 1960. Average value for commercially produced sand and gravel was $1.11; that for Government-and-contractor was $0.72. The price of construction sand in December 1961 (average price in 20 large cities) was $2.32 per ton, compared with $2.36 per ton reported for the same period in 1960.[9]

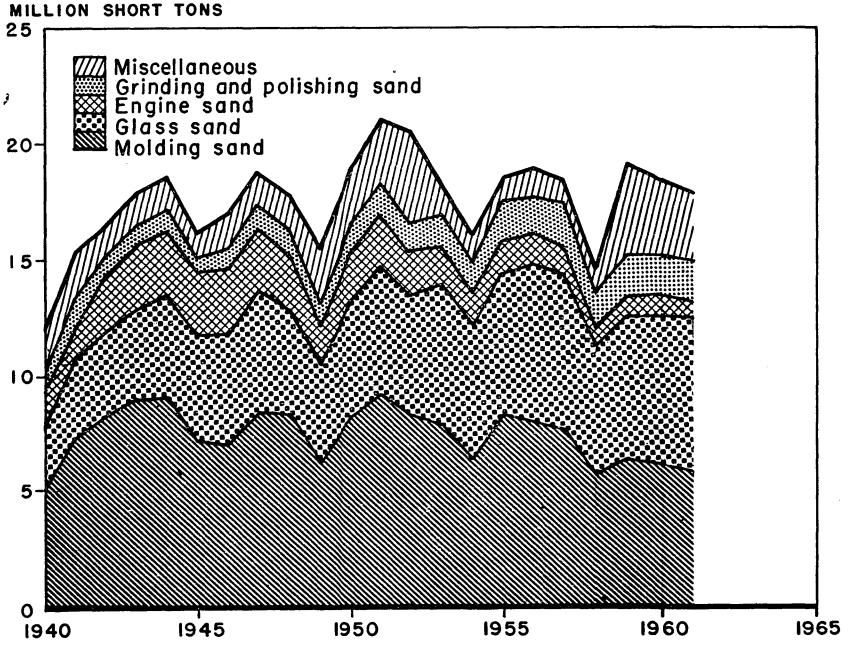


FIGURE 3.—Production of industrial sands in the United States, 1940–61.

[8] Construction Review. Construction in 1961. V. 8, No. 3, March 1962, pp. 5, 9.
[9] Engineering News-Record. V. 168, No. 2, Jan. 4, 1962, p. 62.

TABLE 11.—Ground sand sold or used by producers in the United States,[1] by uses

Use	1960		1961	
	Short tons	Value	Short tons	Value
Abrasives	162,391	$1,540,180	159,238	$1,561,176
Chemicals	13,178	139,324	15,111	147,034
Enamel	9,653	107,986	15,874	166,025
Filler	123,275	752,074	68,729	500,512
Foundry uses	[2] 237,239	[2] 1,365,106	162,782	1,045,838
Glass	47,422	409,240	47,807	412,193
Pottery, porcelain, and tile	184,673	1,773,220	208,443	1,965,591
Unspecified	201,668	1,914,343	241,108	2,265,580
Total	[2] 979,499	[2] 8,001,473	919,092	8,063,949

[1] Arkansas, California, Colorado, Georgia, Illinois, Louisiana (1960 only), Massachusetts, Michigan, Minnesota, Missouri, Nebraska (1961 only), New Jersey, Ohio, Oklahoma, Pennsylvania, Texas, Virginia, Washington, and West Virginia.
[2] Revised figure.

FOREIGN TRADE [10]

Tonnage of ordinary sand and gravel entering foreign trade is small in comparison with the total annual production and is confined chiefly to the Mexican and Canadian borders. High-purity sand for manufacturing glass and silicon carbide, and for foundry uses was exported to Canada.

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
1952-56 (average)	4,137	[2] $159,378	306,940	[3] $362,365	39,121	[3] $5,132	350,198	[3] $526,875
1957	683	[2] 621,065	290,280	[3] 437,114	14,877	[3] 21,951	305,840	[3] 1,080,130
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

[1] Classification reads: "Sands containing 95 percent or more silica and not more than 0.6 percent oxide of iron and suitable for manufacturing glass."
[2] Consists mainly of synthetically prepared silica from West Germany for specialized uses and is not comparable in value to ordinary glass sand.
[3] Data known to be not comparable with other years.

Source: Bureau of the Census.

WORLD REVIEW

Belgium.—Provisional production estimates for 1961 were 3,700,000 short tons of dredged gravel, 1,311,000 tons of glass sand, and 2,990,000 tons of construction sand.[11]

[10] 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.
[11] U.S. Embassy, Brussels, Belgium. State Department Dispatch 942, Apr. 19, 1962, p. 2.

Canada.—Quartz and silica sand production in 1960 amounted to 2,235,795 short tons, valued at Can$3,322,824. Exports of quartzite, mostly to the United States for production of ferrosilicon, dropped from 147,412 tons in 1959 to 13,057 tons in 1960.[12]

Japan.—Production of high-grade sand in 1961 was 1,317,000 short tons compared with 1,210,000 tons in 1960.[13]

Norway.—Production of quartz increased to an estimated 385,809 short tons in 1960; 27,558 tons more than in 1959. The increased output was due to demand for ferrosilicon.[14]

Peru.—According to preliminary figures, production of sand and gravel totaled 860,000 short tons in 1960, compared with 849,000 tons in 1959.[15]

Philippines.—Silica sand production of 97,405 short tons in 1960 was 2.5 times the amount produced in 1959. The increase in production was caused partly by demand for silica by Republic Glass Corp. which began producing sheet glass in 1960. Average price for this sand was U.S. $27.50 per ton.[16]

Puerto Rico.—Del Rio Sand and Gravel Corp. opened a plant to produce 115 cubic yards of gravel, sand, and thin gravel per hour. Deposits from the Loiza River were to be utilized. Daily aggregate capacity was expected to be about 2,450 cubic yards.[17]

Sweden.—Exports of quartz sand in 1960 were 37,596 short tons valued at U.S.$121,041. Other forms of quartz or quartzite reported were 92,973 tons valued at U.S.$373,834 and 13,929 tons of crude block quartz valued at U.S.$79,533.[18]

TECHNOLOGY

General.—Panel discussions, conducted during the 1961 Annual Convention of the National Sand and Gravel Association, dealt with the problems of exploring and prospecting, operating in winter, removing trash, jigs, heavy-medium separating, and screening.[19]

Mixtures for grouting foundations which could be used without unfavorably affecting pumping were discussed. Fine material used in these mixtures included naturally rounded sands from Mississippi, limestone sand from Tennessee, and a sand manufactured from trap rock. Among other conclusions it was determined that a rise in the percentage of minus 100-mesh material permitted an increase in the quantity of sand pumpable and manufactured sands could be pumped profitably.[20]

The first portion of a three-part bulletin on occurrences of sand and gravel deposits in California covered location, extent, geology, and status of economic development of deposits in 17 counties in Northern

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[12] Collings, R. K. Silica, Review 51. Canadian Miner. Ind.—1960 (Preliminary), 9 pp.
[13] U.S. Embassy, Tokyo, Japan. State Department Dispatch 820, Apr. 14, 1962, p. 6.
[14] Bureau of Mines. Mineral Trade Notes. V. 53, No. 4, October 1961, p. 56.
[15] U.S. Embassy, Lima, Peru. State Department Dispatch 659, May 12, 1961, p. 1.
[16] U.S. Embassy, Manila, Philippines. State Department Dispatch 728, May 26, 1961, p. 75.
[17] The San Juan Star. San Juan, Puerto Rico, May 29, 1961.
[18] U.S. Embassy, Stockholm, Sweden. State Department Dispatch 407, Nov. 13, 1961, p. 1.
[19] National Sand and Gravel Association. Operating Problems in Sand and Gravel Production. NSGA Circ. No. 8, April 1961, 38 pp.
[20] Polatty, J. M. Symposium on Grouting; Investigation of Sand-Cement Grouts. Proc. Am. Soc. Civ. Eng., 1961, No. 87 (SM2), pp. 83–93.

California. Data on individual deposits, including results of laboratory tests, were reported, and a list of producers was included. [21]

Use of precoated gravel for surface dressing bituminous paving was particularly effective in overcoming difficulties caused by stripping or loose chipping.[22]

Possible lines of research were suggested to determine effects of impurities such as shale and soft particles upon performance of aggregates in concrete. [23]

The 1960 revision of the original British Standard for sampling and testing mineral aggregates, sands, and fillers specified methods for sampling, classifying, and testing these materials. It also classified stone according to petrological characteristics and included a glossary of rock names. Tests covered methods for determining particle size and shape, absolute and apparent specific gravities, bulk density, absorption, and physical properties such as resistance to impact, abrasion, and polishing. [24]

Plant Equipment.—An Ohio River sand and gravel producer increased output 200 to 300 percent by installing a new dredge with a hydraulic cutter head. Design of the cutter head allowed the dredge to dig into islands previously bypassed by bucket dredges. The beneficiation plant removed trash and fines and was sufficiently flexible to produce 11 sizes of gravel to meet Ohio specifications and 14 sizes for West Virginia specifications. [25]

A floating dredge with a jib-mounted grab bucket was developed to mine sand and gravel at a depth of 100 feet from the Darent River in Kent, England. [26]

Processing Equipment.—Rubber-lined wet cyclones were used to extract clay, silt, and other finely divided solids from waste wash water at a California sand plant. The clarified water was then pumped to settling ponds for reuse in the washing circuit. [27]

A patent was issued for a vibrating feeder, which combined scalping and feeding in one operation to insure against large stones or particles hanging and clogging the mechanism. [28]

An improved nonreticulating wire screen for vibratory screening of sand and gravel was described. Wires were individually tensioned and feed of material was along, not across, the wires. [29]

A Midwestern producer of sand and gravel removed cohesive clay balls with a double roll crusher whose rolls were rubber coated. The rubber was hard enough to break down the clay without crushing sand or fine gravel. [30]

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[21] Goldman, Harold B. Sand and Gravel in California: Part A—Northern California. California Div. of Mines, Bull. 180–A, 1961, 38 pp.

[22] Jarvis, H. W. Surface Dressing with High-Viscosity Tar and Pre-Tarred Flint Gravel. Cement, Lime, and Gravel, v. 36, No. 9, September 1961, pp. 266–267.

[23] Jordan, J. P. R. Problems Associated with Research on Aggregates. Chem. and Ind. (London), No. 9, Sept. 30, 1961, pp. 1542–1546.

[24] British Standards Institution (London). British Standards 812. 1960, 84 pp.

[25] Wakley, James T. How One Dredge Doubled Our Aggregate Production. Pit and Quarry, v. 54, No. 2, August 1961, pp. 98–102.

[26] Mine and Quarry Engineering. Winning Sand and Gravel by Floating Grab. V. 27, No. 11, November 1961, pp. 484–491.

[27] Utley, Harry F. Wet Cyclones Minimize Water Requirements at New Kaiser Sand Plant. Pit and Quarry, v. 53, No. 10, April 1961, pp. 152–154.

[28] Behnke, G. W., and R. G. Westcott (assigned to Simplicity Engineering Co., Durand, Mich.). Grizzly Feeders. U.S. Pat. 2,974,795, Mar. 14, 1961.

[29] Ball, B. V. (assigned to H. Brazier Ltd., Hertford, England). Metal Openwork Screens. U.S. Pat. 2,983,381, May 9, 1961.

[30] Rock Products. Hints and Helps—Clay Crusher. V. 64, No. 6, June 1961, p. 83.

Use of a jig for beneficiation enabled a California producer to remove heavy sandstone and shale from a deposit and thus meet stringent State specifications for road aggregate. About 23 percent of the total feed was rejects which were marketed for fill. [31]

Processes and equipment used for cleaning both coarse and fine aggregates were described in detail. [32]

A combined operating facility consisting of four units was built by a California producer to process river sand for sand blasting, clay, roofing rock, and foundry sands.[33]

Heavy-Medium Plants.—Installing a heavy-medium plant enabled a California producer of river aggregate to remove shale and soft sandstone and thus produce a premium product for Vandenberg Air Force Base. Soft porous rock in the float fraction was found to be marketable for walks and driveways.[34]

Calculations necessary to determine economic feasibility of installing heavy-medium beneficiation plants for sand and gravel were explained and illustrated by charts and flow sheets.[35]

At the Glen Canyon Dam project on the Colorado River 1,400 tph of aggregate was required to furnish processed material at the rate of 850 tph. Five untreated sizes of aggregate were produced, and three sizes were prepared by heavy-medium separation. The reject material, amounting to nearly 40 percent, consisted chiefly of soft sandstone unsuitable for concrete aggregate.[36]

Portable Plants.—A completely portable screening and washing plant was constructed by a Denver operator to mine at sites having a limited life. The plant usually operated in one deposit for 3 or 4 months. Disassembly, moving, and reassembly took less than 1 week.[37]

Vertical Sand Drains.—The Newark Bay Pier Development project in New Jersey used 40,000 lineal feet of sand drains on the 700-acre site. An ocean-going self-loading and unloading dredge supplied sand both for fill and drains.[38]

The Capital Beltway Interchange in Northern Virginia required 187,000 lineal feet of sand drains. Depth of muck in the sand drain area ranged from 15 feet to 30 feet. Sand for the drains was pumped from a borrow pit, and backfill overload material was pumped 1½ miles from the Potomac River.

Patents.—A patent was granted for a process of preparing a nonclogging filter sand for spinneret assemblies. The method used commercial sand and removed binder material by successive treatments with 10 to 30 percent hydrochloric acid and 10 percent caustic solution to leave single sand grains of substantially uniform size.[39]

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[31] Bergstrom, John H. Pennies Save Dollars for Mission Rock. Rock Products, v. 64, No. 6, June 1961, pp. 96–99.
[32] Hudson, L. W. Methods of Cleaning Aggregate by Washing. Cement, Lime and Gravel, v. 36, No. 7, July 1961, pp. 204–215.
[33] Oliver, Robert K. A New and Unique Concept of Modern Mineral Manufacturing. Mines Mag., v. 51, No. 8, August 1961, pp. 14–16, 24.
[34] Bergstrom, John H. HMS Meets Space-Age Challenge. Rock Products, v. 64, No. 9, September 1961, pp. 82–85.
[35] Ruff, H. J. Dense Media Separation as Applied to Aggregate Preparation. Quarry Mgr. J., v. 45, No. 6, June 1961, pp. 228–234.
[36] Hewitt-Robins News of Industry. Hewitt-Robins Helps Build Glen Canyon Dam. V. 7, No. 1, Spring 1961, pp. 3–5.
[37] Bergstrom, John H. All-In-One Washing Plant Hits the Road. Rock Products, v. 64, No. 6, June 1961, pp. 128–130.
[38] Construction Methods and Equipment. Contractors Turn Swamp into $150 Million Marine Terminal. V. 43, No. 10, October 1961, pp. 93–97.
[39] Behnke, Wallace P., and Arthur J. Herrman (assigned to E. I. duPont de Nemours & Co., Inc.). Process for the Purification of Sand. U.S. Pat. 2,984,546, May 16, 1961.

A method for improving soil resistance of regenerated cellulose was patented. It comprised mixing an aqueous suspension of silica with a hydrolizable, acidic, multivalent, metal salt from the group consisting of zinc, magnesium, aluminum, and ferric and cupric salts; passing the cellulose through the bath; and drying the cellulose to retain the silica particles.[40]

A process for preparing a hydrocarbon conversion catalyst from silica and hafnium oxide was described.[41]

A patent was granted for a method of making a self-bonding coated-silica-sand product for use in metal casting.[42]

The usable range of colloidal silicas was extended by substituting alumina for silica on the surface of silica spheres. These silicas were used as binders for inorganic fibers, ceramic products, paper, and for increasing the coefficient of friction of floor polishes.[43]

A 40-inch deep bed of silica gel was used at the U.S. Air Force Arnold Engineering Center in Tennessee to dry air for its supersonic tunnel. Over 1 million pounds of the desiccant was required for two beds.[44]

Glass.—An alumino-silicate optical glass was developed that retained its strength at temperatures as high as 220° C.[45]

Low-density hollow glass spheres were combined with various plastics to make articles for electronic parts and for high-frequency radio transmitters. Using these spheres made the articles more rigid and less flammable.[46]

Plastic-reinforced fiber glass tapes were used to replace steel wire in winding armature coils. Using these fiber glass tapes cut down time required to build and repair large armatures and eliminated problems of conduction and hysteresis loss. The tapes had extremely high tensile strength.[47]

Foundry Sands.—A pneumatic system was used at the Electric Boat Division of General Dynamics Corp., Groton, Conn., to unload molding sand from boxcars. The blower, operated by one man, emptied a carload of sand in 7 to 9 hours. Formerly this operation required 32 to 55 manhours.[48]

An air-conveying system, which used both suction and pressure for conveying foundry sand, was described. It was stated that this system could deliver sand anywhere in a foundry to which a pipe could be run, that the system was dustproof and waterproof, and that there was no spillage of sand.[49]

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[40] Schappel, Joseph W. (assigned to American Viscose Corp.). Production of Soil-Resistant Material. U.S. Pat. 2,999,774. Sept. 12, 1961.
[41] Plank, Charles J., and Edward J. Rosinski (assigned to Socony Mobile Oil Co., Inc.). Manufacture of a Silica-Hafnia Catalyst for Conversion of Hydrocarbons. U.S. Pat. 2,996,448, Aug. 14, 1961.
[42] Bean, Xariffa L. (assigned to Morris Bean & Co., Yellow Springs, Ohio). Coated Sand and Method of Making. U.S. Pat. 2,991,267, July 4, 1961.
[43] Chemical and Engineering News. Aluminum Stabilizes Colloidal Silica. V. 39, No. 40, Oct. 2, 1961, p. 69.
[44] Chemical and Engineering News. News Focus. V. 39, No. 43, Oct. 23, 1961, p. 131.
[45] Chemical Trade Journal and Chemical Engineer (London). Alumino-Silicate Glass. V. 148, No. 3853, Apr. 7, 1961, p. 776.
[46] Chemistry. Glass Makes Plastics Lighter. V. 34, No. 8, April 1961, pp. 2–21.
[47] The Glass Industry. Armature Banding: Fiber Glass vs. Steel. V. 43, No. 1, January 1962, p. 3.
[48] Foundry. Pneumatic Sand Unloader. V. 89, No. 7, July 1961, pp. 128–129.
[49] Zimnawoda, H. W. Sand Handling by Air Conveyor. Foundry, v. 89, No. 4, April 1961, pp. 76–80.

Performance of molding sands (green, dry, and at high temperatures) was found to be closely related to the intergranular bond, physical properties, and surface area of the aggregate, particle size and packing, and number and size of voids.[50]

Fundamental factors in sand control for foundries were discussed. Relationships between screen analysis, clay content, metal-pouring rates, water content, permeability, and combustible material were illustrated.[51]

Methods were developed, using a neutron probe and detectors, by which the moisture content in foundry sand could be determined with an accuracy of ±0.05 percent at the 3-percent level.[52]

A somewhat similar nuclear gaging system for controlling moisture was developed for the Danville, Ill., plant of the Central Foundry Division of General Motors Corp.[53]

A process for producing a resin-impregnated shell-molding sand that was free-flowing and nondusting was patented.[54]

A survey indicated how much Canadian foundries had effected better control of sand properties by changing from natural to synthetic molding sand.[55]

Procedures required for conversion from natural foundry sand to synthetic sand were itemized by a Connecticut foundry. Synthetic sand used at this plant consisted of AFS 150 (Amer. Foundrymen's Society grain fineness number) clay-free, washed, and dried sand, 6.5-percent Mississippi bentonite, 0.5-percent wood flour, and 3.5- to 4.2-percent water. At a 2-percent conversion rate the changeover required 145 working days.[56]

Special Silicas.—Improved light bulbs were produced by a method in which silicon tetrachloride and hot steam were reacted to form a uniform and stable film of silicon dioxide upon the inner surface of the bulbs.[57]

After 8 years of research, General Electric Co. produced an ultrapure grade of fused quartz from domestic silica sands. Until this discovery silicon dioxide of the required quality was imported from Brazil and Malagasy.[58]

A method was patented for preparing a silica pigment that could be dispersed in a rubbery composition.[59]

A dry-grinding system was used at an industrial sand plant in England to produce feldspar-free sand for manufacturing sodium silicate;

[50] Lawrence, Willis G. Factors Influencing Molding Sand Properties. Foundry, v. 89, No. 10, October 1961, pp. 61–67.
[51] Schumacher, Joseph S. Be Your Own Sand Detective. Foundry, v. 89, No. 10, October 1961, pp. 76–81.
[52] Burley, H. A., A. D. Block, and M. J. Diamond. Measuring Moisture Content of Foundry Sand. Metal Ind. (London), v. 99, No. 7, Aug. 18, 1961, pp. 122–124.
[53] Steel. Nuclear Water Witching Upgrades Foundry Sand. V. 148, No. 13, Mar. 27, 1961, pp. 164–165.
[54] Bluestein, Julius M. (assigned to Ford Motor Co., Dearborn, Mich.). Process for Forming a Novalak Resin and Sand with an A-Stage Resin and Sand to Obtain a Shell Molding Sand. U.S. Pat. 2,999,833, Sept. 12, 1961.
[55] Murton, A. E. Canadian Nonferrous and Iron Foundry Practice Survey. Modern Castings, v. 37, No. 4, April 1960, pp. 198–208.
[56] Herrault, Andre, and Harry Heron. Converting From Natural Sand to Synthetic Sand. Foundry, v. 89, No. 9, September 1960, pp. 68–70.
[57] Technical Survey. Electrical, Electronic Developments. V. 17, No. 3, Jan. 21, 1961, p. 44.
[58] Chemical Engineering. New Chemicals, Ultra-pure Quartz. V. 68, No. 25, Dec. 11. 1961, pp. 92–94.
[59] Allen, Edward M. (assigned to Pittsburgh Plate Glass Co.). Process for Preparing Silica Pigment. U.S. Pat. 3,010,791, Nov. 8, 1961.

a glass sand 100 percent minus 16 British Standard Sieve mesh analyzing less than 0.03 percent; Fe_2O_3 and a silica flour for scouring powder.[60]

A two-stage sand processing plant was set up to prepare oil-well fracturing sands from deposits at Voca, Tex.[61]

The method of preparing activated silica for use as a coagulant aid in water treatment was described. This type of silica acts as a nucleus for starting coagulation action and so promotes rapid formation and aggregation of the resultant flocculate, which entraps suspended and colloidal impurities in the water.[62]

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[60] Mine and Quarry Engineering (London). Sand Preparation at Moneystone Quarry. V. 27, No. 7, July 1961, pp. 296–305.
[61] Pit and Quarry. Silica Sand Plant Built to Supply Texas Oil Wells. V. 53, No. 12, June 1961, p. 85.
[62] Aitken, Ian M. E. Sodium Silicate in Water Treatment. Chem. Trade J. and Chem. Eng. (London), v. 149, No. 3877, Sept. 22, 1961, pp. 627–628.

Silicon

By H. Austin Tucker,[1] Gertrude C. Schwab,[2] and Hilda V. Heidrich [2]

THE OUTPUT of domestic polycrystal high-purity silicon declined in 1961 for the first time since 1956 because of decreased demand and technological improvements. Unit values of polycrystal silicon continued the downward trend begun early in 1960. Single-crystal production also decreased, but the unit value increased because producers upgraded the product by slicing more rods into wafers and by epitaxially depositing doped coatings on part of the wafers. The term "epitaxially depositing" means to deposit axially upon a single-crystal substrate a layer of the same material that extends the substrate's single-crystal structure.

Metallurgical silicon and silicon alloy production and shipments declined in 1961, largely because of drastic declines in consumption of silvery pig iron. However, other alloys of silicon, and metallurgical silicon showed gains in 1961 for both output and shipments.

In 1961, for the first time, the Bureau of Mines collected data on metallurgical silicon from prime producers and publishes it together with high-purity silicon data in this separate Minerals Yearbook chapter. High-purity silicon data in 1960 appeared in the "Silicon (High-Purity)" chapter and before 1960, in the "Minor Metals" chapter. Metallurgical silicon and silicon alloy data may be found in the "Ferroalloy" chapter before 1961.

DOMESTIC PRODUCTION

HIGH-PURITY SILICON

In 1961, high-purity silicon producers made 27,568 kilograms of polycrystal silicon and 7,429 kilograms of single-crystal silicon, 20 and 15 percent less, respectively, than in 1960. Significantly, production of the highest grade of polycrystal silicon, 50 to over 100 ohm-centimeters (ohm cm), increased 58 percent over that in 1960. Production of the 25- to 49-ohm cm grade decreased 77 percent. These changes reflect a trend toward the use of the best grade of silicon. The drastic changes in production and shipments of both polycrystal and single-crystal high-purity silicon are graphically shown in figure 1.

Dow Corning Corp. completed expansion plans with a new production plant at Hemlock, Mich. Merck & Co., Inc., increased its facility at Danville, Pa., for producing single-crystal slices and epitaxial wafers.

[1] Commodity specialist, Division of Minerals.
[2] Statistical assistant, Division of Minerals.

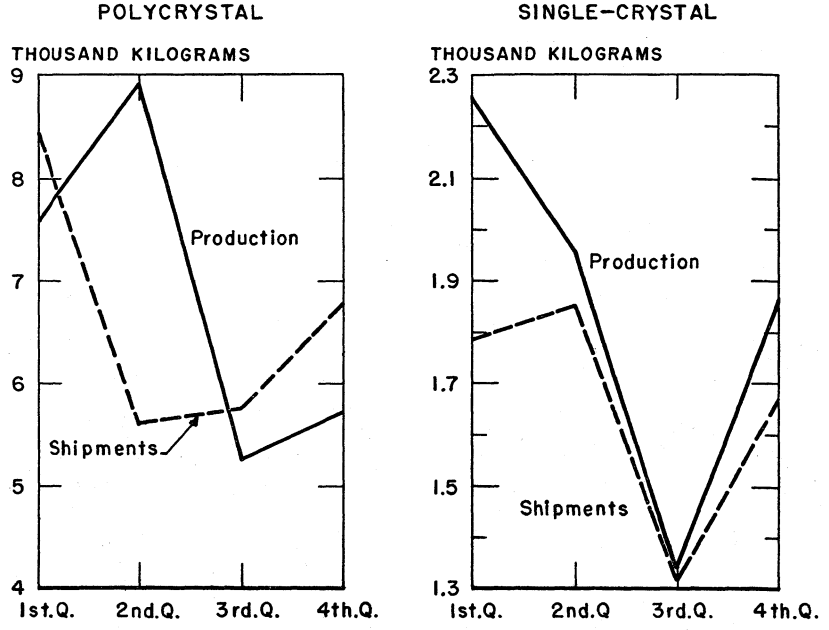


FIGURE 1.—Quarterly changes in production and shipments of high-purity silicon in the United States in 1961.

Producers of high-purity silicon in 1961 and their plant locations 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.
International Metalloids, Inc	Toa Alta, Puerto Rico.
Kemet Co. (division of Union Carbide Corp.)	Cleveland, Ohio.
Mallinckrodt Chemical Works	St. Louis, Mo.
Merck & Co., Inc	Danville, Pa.
Monsanto Chemical Co	St. Charles, Mo.
Sylvania Electric Products, Inc	Towanda, Pa.
Texas Instruments, Inc	Dallas, Tex.
Trancoa Chemical Corp	Reading, Mass.

METALLURGICAL SILICON AND SILICON ALLOYS

In 1961, metallurgical silicon was produced by 6 firms in 10 plants as follows:

Company:	*Plant location*
Keokuk Electro-Metals Co., division of Vanadium Corp. of America.	Wenatchee, Wash.
National Metallurgical Corp., subsidiary of Apex Smelting.	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.

TABLE 1.—Production, shipments, value, and stocks of high-purity silicon in the United States [1]

Type and grade (resistivity, ohm cm)	Stocks as of Dec. 31, 1959 (kilograms)	1960			Stocks as of Dec. 31, 1960 [2] (kilograms)	1961			Stocks as of Dec. 31, 1961 (kilograms)
		Production (kilograms)	Shipments			Production (kilograms)	Shipments		
			Quantity (kilograms)	Value (thousands)			Quantity (kilograms)	Value (thousands)	
POLYCRYSTAL SILICON									
Negative and positive:									
50 to over 100	2,302	11,001	10,196	$4,514	4,170	17,411	14,185	$3,417	4,824
25 to 49	1,294	13,026	11,350	3,851	2,709	2,952	3,611	681	1,109
5 to 24	1,451	4,690	4,267	1,216	1,386	[3]	2,832	433	[3]
Solar and other	607	5,550	5,397	1,317	834	[3]	5,496	830	[3]
Total	5,654	34,267	31,210	10,898	9,099	27,568	26,124	5,361	8,237
SINGLE-CRYSTAL SILICON									
Negative:									
Rods	[4]	[4]	[4]	[4]	1,669	[5] 4,587	[5] 4,015	[5] $5,031	2,222
Slices	[4]	[4]	[4]	[4]	83	[6] 1,204	[6] 1,195	[6] 2,875	31
Total	[4]	[4]	[4]	[4]	1,752	5,791	5,210	7,906	2,253
Positive:									
Rods	[4]	[4]	[4]	[4]	462	[3]	[3]	[3]	[3]
Slices	[4]	[4]	[4]	[4]	32	[3]	[3]	[3]	[3]
Total	[4]	[4]	[4]	[4]	494	1,638	1,404	2,454	651
Grand total	547	8,706	6,838	$12,027	2,246	7,429	6,614	10,360	2,904

[1] Includes Puerto Rico.
[2] Revised figures.
[3] Figure withheld to avoid disclosing individual company confidential data.
[4] See 1960 Minerals Yearbook for detailed classification using another gradation.
[5] Includes infrared shapes.
[6] Includes epitaxial wafers.

Ferrosilicon was produced by most of these firms and by the remainder of the ferroalloy industry. A more complete list of silvery pig iron and ferrosilicon producers is given in the "Ferroalloys" chapter of the 1959 Minerals Yearbook. Table 2 shows the net production of silicon metal and its iron alloys. Net production was the gross production less the quantity of alloy used to make other alloys within the reporting plant.

CONSUMPTION AND USES

HIGH-PURITY SILICON

Shipments of polycrystal silicon were 16 percent less than in 1960, and the total value of $5.4 million was only half that in 1960. Single-crystal shipments were down only 3 percent in quantity from those in 1960, although total value decreased 14 percent. Again in 1961, as in each preceding year, the electronic industry made more electronic devices from silicon. In 1961, industry fabricated 14 million transistors and 107 million diodes and rectifiers, compared with 8.8 million

TABLE 2.—Net production, shipments, and stocks of silvery pig iron, ferrosilicon, and silicon metal in 1961

(Short tons, gross weight)

Alloy and percent of silicon contained	Net production	Shipments	Stocks as of Dec. 31, 1961
Silvery pig iron:			
Blast furnace: 5–13	70,264	103,631	41,079
Electric furnace: 14–20	104,187	111,307	23,482
Ferrosilicon:			
21–55	182,022	205,071	27,847
56–70	31,624	34,258	8,746
71–80	75,857	81,032	9,811
81–89	7,010	8,357	1,916
90–95	4,288	6,244	1,398
Silicon metal: 96–99	41,967	45,114	3,191
Ferrosilicon briquets: 40–50	27,111	26,693	----------
Miscellaneous silicon alloys	5,976	8,120	6,385
Total	550,306	629,827	123,855

transistors and 80 million diodes and rectifiers in 1960. No data were available in either year on the number of solar cells and infrared optical shapes made. Prices of these devices in 1961 declined to almost half those in 1960, and therefore, total values of sales were less, with transistors totaling $92 million compared with $100 million in 1960, and diodes and rectifiers, $98 million compared with $126 million in 1960.[3]

METALLURGICAL SILICON

Table 3 itemizes the consumption of silicon metal and its alloys with iron. Most of the silicon metal was consumed in aluminum-base alloys (22,712 short tons), and most of the quantity reported under "Miscellaneous uses" (5,854 short tons) was consumed in the manufacture of silicone products. The automobile industry used about 1 million pounds of aluminum a day; most of this was alloyed with silicon for engine castings. Seven kinds of compact cars had aluminum engines in 1961, and the millionth aluminum engine was produced late in November. Some aluminum alloy was hauled in a molten state 285 miles from Ravenswood, W. Va., to Defiance, Ohio, where it was cast into engine blocks and other auto parts.

The most significant use change in 1961 was the decreased consumption of silvery pig iron, especially of the lower grade made in blast furnaces. This change was attributed to more stringent purity requirements in more heats of steel and to a lower price per pound of contained silicon in other ferrosilicons.

STOCKS

Stocks of polycrystal silicon at producers' plants at yearend were 9 percent less than those on hand at the beginning of the year; however, single-crystal stock increased 29 percent during the same period.

[3] Electronic Industries Association, Marketing Data Department. Factory Sales of Germanium and Silicon Semiconductor Diodes and Rectifiers. December 1960, pp. 5–8; December 1961, pp. 9–16.
Electronic Industries Association, Marketing Data Department. Factory Sales of Transistors. December 1960, pp. 3, 4; December 1961, pp. 8, 9.

TABLE 3.—Consumption by major end uses and stocks of silicon alloys in the United States in 1961

(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	----------	1,163	1,022	----------	784	86,569
14–20	----------	4,890	12,755	----------	64	73,245
Ferrosilicon:						
21–55 [4]	5,763	45,741	73,246	491	663	41,151
56–70	237	11,979	16,965	----------	----------	573
71–80	8,521	15,959	4,853	568	86	7,886
81–89	66	643	1,707	1	52	2,987
90–95	14	3,681	143	----------	28	261
Silicon metal: 96–99	26	44	24	1	----------	235
Ferrosilicon briquets: 40–50	6	323	298	----------	15	22,658
Miscellaneous silicon alloys [8]	245	4,972	7,390	55	105	3,336
Total	14,878	89,395	118,403	1,116	1,797	238,901

Alloy and percent of silicon contained	Aluminum-base alloys	High temperature alloys	Other nonferrous alloys [2]	Miscellaneous uses	Total consumption	Stocks as of Dec. 31, 1961
Silvery pig iron:						
5–13	1	----------	----------	1	89,540	8,728
14–20	----------	----------	24	[3] 6,688	97,666	13,492
Ferrosilicon:						
21–55 [4]	35	178	1,736	[5] 9,304	178,308	23,836
56–70	----------	----------	----------	[5] 4,661	34,415	2,712
71–80	----------	39	19	[6] 3,609	41,540	5,688
81–89	----------	----------	37	10	5,503	813
90–95	2,429	402	38	53	7,049	743
Silicon metal: 96–99	22,712	171	492	[7] 5,854	29,559	2,900
Ferrosilicon briquets: 40–50	----------	----------	----------	17	23,317	3,585
Miscellaneous silicon alloys [8]	172	44	24	2,114	18,457	2,285
Total	25,349	834	2,370	32,311	525,354	64,782

[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.

Demand fell off at midyear, and some plants stopped producing polycrystal silicon during the third quarter to reduce inventories. Part of the polycrystal silicon inventory was converted to single-crystal silicon, but remained unsold in a weak market.

During the year metallurgical silicon and ferrosilicon producer stocks declined 41 percent; the greatest decline was in blast-furnace silvery pig iron. Consumer stocks decreased 12 percent during the same period.

PRICES

Prices of polycrystal high-purity silicon declined steadily during 1961, from an average price of $280 per kilogram at the beginning of the year to $155 at yearend. The average value of single-crystal silicon was $1,600 per kilogram at the beginning of the year, $1,440

at midyear, and $1,630 at yearend. No change occurred in producers' pricelists for single-crystal silicon during 1961.

TABLE 4.—Representative prices of polycrystal, high-purity silicon

Grade (resistivity minimum, ohm cm)	Boron content (parts per billion)	September 1960 (per gram)	September 1961 (per gram)
Solar	----------	$0.18	$0.100
25	0.9	.23	.165
50	.8	.34	.187
100	.7	.35	.210
150	.6	----------	.230
200	.5	----------	.250

Some producers lowered the price of silicon metal during 1961 from $0.2150 to $0.1775 per pound for the grade with a maximum of 0.35 percent iron and 0.07 percent calcium. The price of 50 percent ferrosilicon decreased $0.011 per pound of contained silicon to $0.135 in February and increased to $0.145 about November 1.[4]

FOREIGN TRADE[5]

Foreign trade in high-purity silicon was reportedly large in 1961, and the United States was predominantly an exporting country. However, figures were not available on this trade.

The quantities of silicon metal and ferrosilicon imported were relatively small compared with those in domestic trade. Exports of ferrosilicon, small in 1959 and 1960, increased sharply in 1961. No data were available on silicon metal exports.

WORLD REVIEW

EUROPE

Belgium.—The new high-purity silicon plant of the Olen Chemical Products Division of Société Générale Métallurgique de Hoboken at Olen was completed.

Germany, West.—Early in 1961 trade agreements were made with the U.S.S.R. for imports through 1963, including 7,150 short tons of ferrosilicon in 1961, 9,350 tons in 1962, and 9,350 tons in 1963.

Norway.—Norwegian ferrosilicon output for 1961 was estimated to be 196,000 short tons, compared with 190,500 tons in 1960. Almost all the ferrosilicon produced was exported, mostly to the United Kingdom, West Germany, and Belgium.[6]

Switzerland.—Lonza Elektrizitätswerke und Chemische Fabriken A.G. announced plans to begin producing high-purity silicon.[7]

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[4] American Metal Market, Vanadium Lifts Price of 50% Ferrosilicon. V. 68, No. 210, Nov. 1, 1961, pp. 1, 14.

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

[6] Mining Journal (London). Mining Miscellany. V. 257, No. 6592, Dec. 22, 1961, p. 658.

[7] Mining Journal (London). Mining Miscellany. V. 257, No. 6574, Aug. 18, 1961, p. 167.

TABLE 5.—U.S. imports for consumption of ferrosilicon, by grades and countries, and silicon metal, by countries

	1959			1960			1961		
	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	10,027	1,533	$553,754	12,685	1,940	$687,012	12,580	1,931	$616,024
Germany, West	1,753	270	279,598	1,336	200	246,790	580	87	109,403
Total	11,780	1,803	833,352	14,021	2,140	933,802	13,160	2,018	725,427
30 percent and less than 60 percent silicon:									
Canada	2,011	966	270,014	413	200	56,911	514	248	67,788
Germany, West				1	1	281			
Total	2,011	966	270,014	414	201	57,192	514	248	67,788
60 percent and less than 80 percent silicon:									
Canada	986	693	209,296	257	178	55,239	35	24	6,438
France	220	169	30,000						
Japan	28	22	4,830	185	140	33,676			
Norway	2,223	1,721	333,362	2,819	2,177	424,955			
Union of South Africa	27	19	4,103	54	41	8,937	21	17	3,630
Yugoslavia				66	52	9,541			
Total	3,484	2,624	581,591	3,381	2,588	532,348	56	41	10,068
80 percent and less than 90 percent silicon: Japan	28	24	5,989	53	43	9,398			
90 percent or more silicon: Japan	[1] 183	167	43,939						
Grand total	[1] 17,486	5,584	1,734,885	17,869	4,972	1,532,740	13,730	2,307	803,283
Silicon metal:									
Canada				4	4	889			
France	1,067	1,055	269,011	269	266	72,342	31	30	8,206
Italy	1,196	1,179	316,147	28	27	7,475			
Japan	873	856	217,908						
Sweden	6	5	1,679						
Total	3,142	3,095	804,745	301	297	80,706	31	30	8,206

[1] Adjusted by Bureau of Mines.

Source: Bureau of the Census.

TABLE 6.—U.S. exports of ferrosilicon

Year	Short tons	Value	Year	Short tons	Value
1952–56 (average)	2,964	$576,679	1959	10,558	$980,658
1957	2,649	502,401	1960	5,501	867,140
1958	2,177	391,621	1961	34,764	6,104,913

Source: Bureau of the Census.

Yugoslavia.—Silicon metal production was reported to have been started in Serbia by Prva Iskra. Annual capacity was estimated to be 280 short tons.[8]

ASIA

Japan.—Six Japanese firms were reported to be making high-purity silicon at an estimated annual rate of 5,000 kilograms of polycrystal

[8] Mining Journal (London). Metals and Minerals. V. 255, No. 6539, Dec. 16, 1960, p. 690.

silicon and 2,000 kilograms of single-crystal silicon in 1961.[9] The six companies are Nitchitsu Electronics Chemical Co., Ltd., wholly owned subsidiary of Shin Nippon Chisso Hiryo, K. K.; Komatsui Electronic Metal Co., Ltd.; Nippon Electronic Metal Co., Ltd.; Shinetsu Chemical Co., Ltd.; Tokai (Toyo) Electrode Co., Ltd.; and Osaka Titanium Co., Ltd. In another report, Shin Nippon Chisso Hiryo, K. K. (SNC), named an exclusive U.S. distributor for its line of pure-silicon products.[10] SNC exported about 20 kilograms in 1961 and was the only Japanese producer to export high-purity silicon.[11]

The Japan Electronic Industry Development Association appointed a special committee to study technical standards for high-purity silicon materials for semiconductor uses.

Consumption of high-purity silicon was steadily increasing. Silicon transistors had been made in increasing numbers since early 1960, but the total production for 1960 was little more than 100,000 units, compared with 140 million germanium transistors.[12] The slow rise of silicon for transistor use in Japan was attributed to high unit cost of high-purity silicon. Japanese consumers saw no distinctive advantage for silicon over lower priced germanium. About 70 to 80 percent of the single-crystal silicon used in 1961 was imported, and it sold for $0.55 per gram, compared with $0.15 per gram for germanium.

The Japan Ferro-Alloy Producers' Association reported production of 7,850 short tons of metallurgical silicon in Japan for the fiscal year ending March 31, 1961.[13]

TECHNOLOGY

Technological improvements in making, slicing, and fabricating high-purity silicon in 1961 resulted in more efficient use of material. The most important technological development was the use of a diamond-wheel saw that was gripped on its outer periphery and sliced rods with its inner periphery. The rigidity provided by this technique made possible the use of wheels 0.008 inch instead of 0.016 inch thick. Thus, in one mechanical development the sawdust waste was halved, increasing the quantity of available silicon by about 25 percent.

Silicon producers made a purer polycrystal product by improving the distillation technology of their raw materials and made single-crystal rods more uniform in respect to physical size, doping gradients, crystal perfection, axis orientation, and lifetime. These improvements lessened the quantity of devices rejected by electronic fabricators and maintained the price of single-crystal silicon because the fabricators' more stringent specifications involved more labor and rejection losses by the silicon producer.

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[9] Electronic News, Japan Bureau. Japan Group Plans Silicon Standards. V. 6, No. 264, June 5, 1961, p. 42.
[10] Electronic News. U.N. Alloy Steel Corp. To Stock Japanese Silicon. V. 7, No. 298, Jan. 15, 1962, p. 48.
[11] Yoshimura, Toshio. Ton of Pure Silicon Slated for Export by Japan Firm. Electronic News, v. 7, No. 309, Mar. 27, 1962, p. 88.
[12] Yoshimura, Toshio. '61 Si Transistor Output in Japan Seen Up Slightly. Electronic News, v. 6, No. 261, May 15, 1961, p. 44.
[13] American Metal Market. Ferroalloy Output in Japan Shows Rise for Year. V. 68, No. 85, May 4, 1961, p. 19.

The mesa-type transistor and epitaxial growth were described in the "Silicon (High-Purity)" chapter of volume 1 of the 1960 Minerals Yearbook. In 1961, the planar-type transistor was developed by using epitaxially grown layers of pure silicon on a silicon substrate. The planar transistor tended to displace the mesa type because of its higher performance characteristics and ease of manufacture. Its high performance depends largely on the intimate contact of the three essential parts of the transistor, which are sealed against electrical leakage at nonworking junctions with an oxidized surface. The planar transistor has combined the switching speeds formerly obtained with germanium and the durability of silicon, promising a brighter future for silicon transistors.

One manufacturer automated a furnace for producing mesa and planar epitaxial silicon transistors. The console of the furnace was programmed from previously tabulated data so that the operator's only functions were to load the furnace with wafers of silicon, press the starting button, and remove the wafers after the furnace had completed a cycle. The console automatically purged the furnace of air, heated the furnace to the correct temperature, and controlled the rate of gas flow, the mixture of the doping impurity, and the cooling of the furnace. This procedure repeated itself automatically three times, and each time doping compounds and the epitaxial layer thickness were varied to develop the essential characteristics of the transistor being made.[14]

Again as in previous years, electronic device makers used less silicon per unit by developing miniature and multipurpose components. One manufacturer marketed a pancake transistor 0.06 inch thick by 0.230 inch in diameter that would be advantageous in printed-circuit-board, sandwich-type equipment. Another firm introduced a microminiature diode for use in computers that was hermetically sealed in a glass package 0.04 inch in diameter by 0.06 inch long.

The tunnel diode, which was introduced with much publicity and hope for success in 1959 but which failed to be rapidly adopted in 1960 because of early breakdowns and lack of circuitry designed to use it, was developed further in 1961.

No outstanding technical development occurred in 1961 in metallurgical silicon. However, with reduced steel production during the first half of the year, silicon smelters concentrated on mechanizing and making automatic as much equipment as possible to reduce labor costs. Savings were made with mechanical stokers. One operator with a mechanical stoker can service two furnaces, dispensing with the labor of several men. Improvements were made in moving, weighing, and mixing raw materials and in charging furnaces by installing more automatic weighing devices, conveyor belts, skipways, tramways, hoppers, and chutes.

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[14] Arthur, Earl. Epitaxial Growth Furnace Automated at Motorola Unit. Electronic News, v. 7, No. 308, Mar. 26, 1962, p. 118.

Silver

By J. P. Ryan [1] and Kathleen M. McBreen [2]

UNITED STATES mine production of silver increased 13 percent to 34.8 million ounces in 1961, thus reversing the steady decline in output since 1957. Relatively stable operating conditions at major mines was the chief factor contributing to the production gain. Shutdowns due to labor strikes had reduced production in 1959 and 1960. Consumption of silver, both in the arts and industry, and in coinage, rose 9 percent to 161 million ounces, the third successive annual increase.

A Presidential order on November 28 suspending sales of silver to domestic consumers was the principal feature affecting world silver markets in 1961. This action brought a sharp advance in price and ended a 3-year period of price stability.

Imports of silver, including lend-lease returns, declined sharply for the fourth successive year but exports rose substantially, as somewhat higher foreign prices attracted metal from domestic sources.

Sales to domestic industries and withdrawals for coinage, offset in part by lend-lease returns and purchase of newly mined domestic metal, again brought a sharp drop in the Treasury stock of free-silver which reached a low of 22 million ounces near the end of November when Treasury sales were discontinued. Lend-lease returns and transfers from monetary reserves brought the nonmonetary (free) silver stock to 28.5 million ounces at yearend.

World silver production was 231.8 million ounces, about 8 million ounces less than in 1960.

Consumption of silver in free-world countries increased 8 percent to 352.4 million ounces, exceeding production by 158 million ounces. U.S. consumption was 46 percent of the total free-world consumption.

LEGISLATION AND GOVERNMENT PROGRAMS

On November 28 the President, pursuant to recommendations of the Secretary of the Treasury, issued a directive suspending Treasury sales of silver. The President also recommended that legislation be enacted to repeal the Silver Purchase Acts and the relevant part of the Internal Revenue code to permit the development of a free futures market in silver. The recommended legislation also would provide

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.

TABLE 1.—Salient silver statistics

	1952-56 (average)	1957	1958	1959	1960	1961
United States:						
Mine production thousand troy ounces	37,977	38,165	34,111	31,194	30,766	34,794
Value thousands	$34,371	$34,541	$30,872	$28,232	$27,845	$32,167
Ore (dry and siliceous) produced:						
Gold ore thousand short tons	2,255	2,359	2,411	2,289	2,267	2,060
Gold-silver ore do	146	116	107	137	347	248
Silver ore do	599	712	639	597	641	565
Percentage derived from—					5	
Dry and siliceous ores	32	32	41	45	37	39
Base-metal ores	68	68	59	55	63	61
Imports, general [1] thousand troy ounces	99,055	206,119	165,966	69,088	60,657	50,256
Exports [1] do	3,025	10,299	2,733	9,180	26,593	39,828
Stocks Dec. 31: Treasury million troy ounces	1,942	2,014	2,106	2,060	1,992	1,863
Consumption:						
Industry and the arts thousand troy ounces	97,980	95,400	85,500	101,000	102,000	105,500
Coinage do	38,520	52,000	38,200	41,400	46,000	55,900
Price: Treasury per troy ounce	[2] $0.905+	[2] $0.905+	[2] $0.905+	[2] $0.905+	[2] $0.905+	[3] $0.924+
World:						
Production thousand troy ounces	220,700	[4] 231,100	[4] 239,000	[4] 221,900	[4] 240,200	231,800
Consumption [5]—industry and the arts thousand troy ounces	175,980	212,600	190,500	214,900	226,100	238,100
Coinage do	79,540	84,200	79,500	86,400	99,300	114,300

[1] Excludes coinage.
[2] Treasury buying price for newly mined silver.
[3] Average New York price.
[4] Revised figure.
[5] Free world only.

for the gradual release of silver now required for backing $1 and $2 silver certificates currently in circulation and authorize the Federal Reserve banks to include these denominations in the range of notes they are permitted to issue.

The exchange of letters between the President and the Secretary of the Treasury pertinent to contemplated and actual policy changes with respect to silver are given below.

November 27, 1961.

DEAR MR. PRESIDENT: The Treasury has, as you requested, been studying for some time the uses of silver in our monetary system. Informal conferences have also been held with other departments in your Administration, with the Federal Reserve, and with leading representatives of both silver producing and consuming interests. It now seems appropriate to recommend several changes in our silver procedures, largely because of the change that has taken place in the world position of silver.

The industrial uses of silver have been expanding greatly and the industrial consumption of silver is steadily increasing; it continues to be used extensively in the arts; it is needed in our coinage. All together, the industrial, artistic, and coinage uses of silver are currently consuming more than 150 million ounces of silver per year in the United States. The total world-wide consumption is estimated at more than 300 million. Production, however, falls far short of these totals. World-wide it is currently estimated at 235 million ounces annually, of which only about 35 million is produced in the United States. The indicated gap between world production and world consumption, apart from changes in inventories, is thus now running at about 65 million ounces.

This gap, and it is a growing one, has for some time been filled by sales from the stocks of "free silver" held by the United States Treasury. These stocks were accumulated in earlier years when total demand was much lower and purchases by the United States Treasury, at the minimum price established by the Congress for monetary purposes, absorbed virtually all new domestic production. The Treasury's supply of free silver reached its peak in April 1959, at 222 million ounces. Since that time, purchases have steadily decreased and

sales have increased and the Treasury's stock of free silver has declined. By the end of 1959 it was 174 million ounces; by the end of 1960 it had fallen to 123 million ounces; as of today, following unusually rapid sales in recent weeks, it has fallen to about 22 million fine ounces.

It is clear that under present procedures this stock would soon be entirely exhausted and that the Treasury would thereafter have no further silver available for public sale. It also seems clear on the basis of these developments that there is no remaining need for Government support of the silver price at 90.5 cents, as provided under current legislation. In the absence of further Government sales of free silver, the private market is quite obviously prepared to absorb all domestic production at or above the price of 90.5 cents.

The Government still has, however, nearly 1.7 billion ounces in a bullion reserve held against the issuance of a part of our paper currency. Roughly one quarter of the total is held against $5 and $10 silver certificates, although existing legislation also permits issuance of $5 and $10 notes by the Federal Reserve, and these latter notes represent well over 90 percent of the outstanding currency of these denominations. The other three quarters of the silver bullion reserve is used to support $1 and $2 silver certificates; under existing law, only silver certificates are authorized for currency of these denominations.

In view of the large and growing aggregate demand for silver, it does not seem to me to be either wise or feasible to continue to impound a substantial holding of silver bullion in these currency reserves. I propose that we now begin an actual, though gradual withdrawal of silver bullion from the currency reserves, permitting substitution of Federal Reserve notes for the silver certificates withdrawn, and using the bullion thereby released to meet our continually heavy coinage requirements. At the same time, under the authority of existing law, I propose to suspend further sales of silver to the market. I further recommend that appropriate legislation be requested promptly to remove the Treasury from an active role in the markets for the purchase and sale of silver, and to permit trading in silver as a primary commodity. Meanwhile, the Treasury's remaining stocks of free silver should be conserved for possible use in contributing to orderly market conditions pending enactment of the necessary legislation.

If you should desire to implement this general policy, the first step would be a Presidential directive to the Secretary of the Treasury to suspend further sales from the remaining stock of free silver. Uses of this remaining stock for subsidiary coinage should be terminated, and to meet coinage needs I would propose to retire from circulation a sufficient amount of $5 and $10 silver certificates to release the silver required for this purpose. These retired certificates would be replaced by Federal Reserve notes.

Paralleling this action it would be desirable to recommend to Congress, when it reconvenes, the immediate repeal to the Silver Purchase Act of 1934, as well as the Acts relating to silver of July 6, 1939, and July 31, 1946. Since the existing tax on transfers of interest in silver bullion is necessary only to support this legislation, it would also be desirable to propose simultaneously to Congress that the relevant part of the Internal Revenue Code be repealed so as to permit the development of a free futures market in silver.

Finally, I suggest that you consider recommending to Congress the enactment of legislation authorizing the Federal Reserve System to issue Federal Reserve notes in denominations of less than $5, thus providing an orderly, long-term means for replacing or supplementing the supply of silver certificates and thereby freeing the supplies of silver that will be needed to cover future coinage requirements.

Faithfully yours,

(S) DOUGLAS DILLON.

THE PRESIDENT,
The White House.

NOVEMBER 28, 1961.

DEAR MR. SECRETARY: On the basis of your recommendations and the studies conducted by the Treasury and other Departments, I have reached the decision that silver metal should gradually be withdrawn from our monetary reserves.

Simultaneously with the publication of this letter, you are directed to suspend further sales of free silver, and to suspend use of free silver held by the Treasury for coinage. In this way, the remaining stock and any subsequently acquired can be used, at your discretion, to contribute to the maintenance of an

orderly market in silver and for such other special purposes as you may determine. In order to meet coinage needs, the amount of silver required for this purpose should be obtained by retirement from circulation of a sufficient number of five-dollar and ten-dollar silver certificates.

Pursuant to this general determination, I intend to recommend to Congress, when it reconvenes, that it repeal the acts relating to silver of June 19, 1934, July 6, 1939, and July 31, 1946. The existing tax on transfers of interest in silver bullion has been necessary only to provide reinforcement for this legislation. I will therefore simultaneously propose that the relevant portion of the Internal Revenue Code also be repealed.

These actions will permit the establishment of a broad market for trading in silver on a current and forward basis comparable to the markets in which other commodities are traded. Our new policy will in effect provide for the eventual demonetization of silver except for its use in subsidiary coinage.

Although the potential supply of silver now embodied in the outstanding five-dollar and ten-dollar certificates will be sufficient to cover coinage requirements for a number of years, I believe this is an appropriate time to provide for the gradual release of the silver now required as backing for one-dollar and two-dollar silver certificates. I shall therefore also recommend that legislation be enacted to accomplish this purpose and authorize the Federal Reserve Banks to include these denominations in the range of notes they are permitted to issue.

Sincerely,

(S) JOHN F. KENNEDY.

Hon. DOUGLAS DILLON,
Secretary of the Treasury,
Washington, D.C.

Bills (S. 2420, H.R. 390) to repeal the Silver Purchase Acts were introduced in the 87th Congress and referred to the respective Committees on Banking and Currency of the Senate and House of Representatives, but no further action was taken. These bills included a provision for the continued sale of silver in excess of the Treasury's requirements and an amendment to the Federal Reserve Act permitting the issuance of Federal Reserve notes in $1 and $2 denominations.

DOMESTIC PRODUCTION

Reversing a 4-year decline, mine output of recoverable silver in the United States rose 13 percent to 34.8 million ounces. The production gain was attributed principally to relatively stable operations prevailing at major silver-producing mines in Idaho during most of the year, following settlement of labor strikes late in 1960. Strikes were the chief cause of reducing silver production in the preceding 2 years. The United States retained second place among the silver-producing countries of the world, and was exceeded in output only by Mexico.

A sharp gain in silver output in Idaho coupled with moderate gains in Arizona and Colorado greately exceeded production declines in other silver-producing States. In Idaho, The Bunker Hill Co. and American Smelting and Refining Company resumed full-scale mining operations following settlement of a 9-month strike. A strike settlement at the Eagle mine and reopening of the Camp Bird mine late in 1960 were factors contributing to Colorado's increased silver output.

The gain in silver production in Arizona reflected increased output of silver-bearing copper ores. Lower recovery of byproduct silver at The Anaconda Company Butte mines, and the shutdown of the Jack Waite mine were factors in the decline in silver output in Montana. The sharp drop in Nevada's silver output was attributed chiefly to the

shutdown of the Argentum Mining Co. and United States Milling & Minerals Corp. operations, and decreased production at the Consolidated Eureka and Bristol Silver mines. A strike in August at the Utah Copper mine reduced output of silver-bearing copper ore and was the chief factor in the drop in Utah's silver production.

Idaho, the leading silver-producing State, contributed over half the total domestic output. The four leading silver-producing States, Idaho, Arizona, Utah, and Montana supplied nearly 90 percent of the total output.

About 60 percent of the domestic output was recovered as a by-product of ores mined chiefly for copper, lead, zinc, and gold. Virtually all the remainder came from ores in which silver was the principal product. Of the 25 leading silver-producing mines, only 4 in Idaho depended chiefly on the value of silver in the ore. Seven mines, producing over 1 million ounces each, supplied 56 percent of the total domestic output; the 25 leading mines (table 4) furnished 86 percent. Domestic mines supplied about one-third of the total silver used in the Nation's arts and industries.

Approximately 3,600 persons were employed in the silver and gold-silver mining industry at 300 separate lode mining operations, compared with 3,700 persons and 500 mines in 1960.

Ore production and classification, methods of recovery, and metal yields, embracing all ores that yielded silver in the United States in 1961, are given in tables 6 to 9.

The classification of ores, originally adopted in 1905 on the basis of smelter terminology, smelter settlement contracts, and metal recovery, has been used continuously in succeeding years, except for modification necessitated by the improvement in metallurgy and the lowering of the grade of complex ores treated. Details of the current basis of ore classification are given as follows:

Copper ores include smelting ores that contain 2.5 percent or more recoverable copper and ores and tailings concentrated or leached chiefly for their copper content. Ores leached in place or ores for which the tonnage cannot be calculated are excluded; slags smelted for their copper content are included.

Lead ores are those that contain 5 percent or more recoverable lead, irrespective of the precious metal content, and ores, tailings, or slags that are treated chiefly for their lead content.

Zinc-concentrating ores and tailings include those, from which a marketable zinc concentrate is made, irrespective of precious metal content. Virtually no zinc ore is now smelted directly except for cold slags, which when fumed are classified as smelting ore and may contain as little as 5 percent recoverable zinc.

The mixed ores are combinations of those enumerated above; they will be designated by the names of their constituent base metals in alphabetical order, irrespective of the predominance of value.

Gold, gold-silver, and silver ores with the base-metal content too small to be classified in accordance with the foregoing are dry ores, irrespective of the ratio of concentration. The dry ores are thus ores, chiefly siliceous, valuable for their silver and gold content, and in some instances for their fluxing properties, regardless of method of treatment. Dry gold ores are defined as those in which the gold value equals or exceeds three-fourths of the combined gold and silver values; dry silver ores are those in which the silver value equals or exceeds three-fourths of the combined gold and silver values. The gold and silver values in dry gold-silver ores equal or exceed one-fourth of the combined gold and silver values. Tailings and slags follow the same scheme of classification as ores.

The classifications are not to be modified by considerations of payments of metals by smelters or customs mills, or by method of treatment by the smelters.

TABLE 2.—Silver produced in the United States according to mine and mint returns

(Troy ounces of recoverable metal)

	1952–56 (average)	1957	1958	1959	1960	1961
Mine	37,976,731	38,164,915	34,111,027	31,194,006	30,766,327	34,794,456
Mint	37,673,922	38,720,200	36,800,000	23,000,000	36,800,000	34,900,000

TABLE 3.—Mine production of silver in the United States in 1961, by months

Month	Troy ounces	Month	Troy ounces
January	3,052,843	August	2,876,750
February	2,899,031	September	2,742,175
March	3,189,490	October	2,562,269
April	2,475,219	November	2,722,193
May	3,151,367	December	3,080,150
June	3,180,728		
July	2,862,241	Total	34,794,456

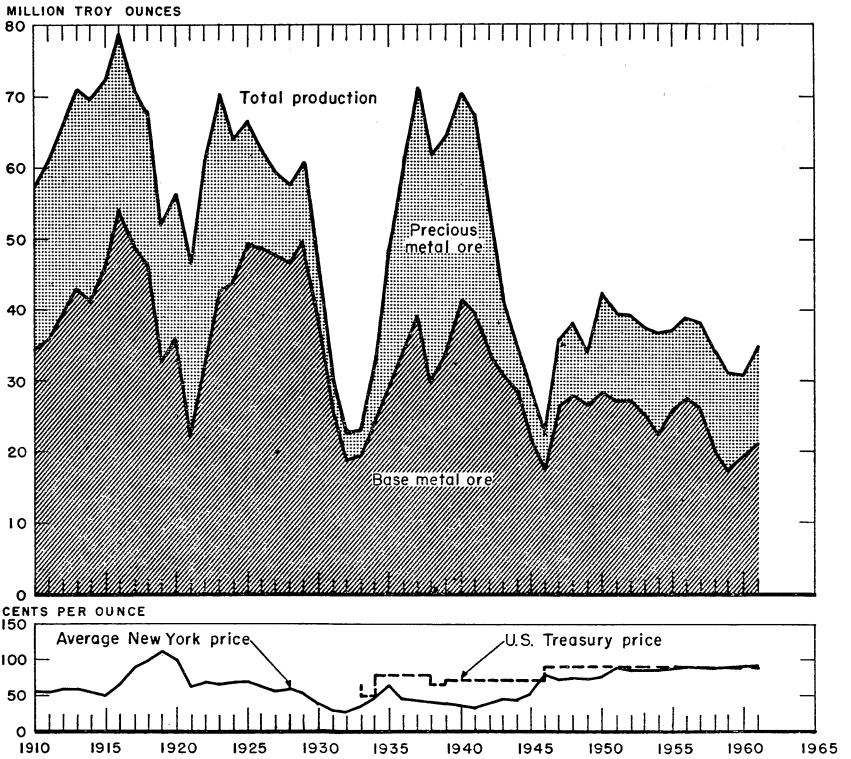


FIGURE 1.—Silver Production in the United States and Price Per Ounce, 1910–61.

TABLE 4.—Twenty-five leading silver-producing mines in the United States in 1961, 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	Bunker Hill	Coeur d'Alene	Idaho	The Bunker Hill Co	Lead-zinc, lead ores.
6	Butte Hill Mines	Summit Valley (Butte)	Montana	The Anaconda Company	Copper ore.
7	United States & Lark	West Mountain (Bingham)	Utah	United States Smelting, Refining, and Mining Co.	Lead-zinc, gold-silver ores.
8	Silver Summit	Coeur d'Alene	Idaho	Hecla Mining Co	Silver ore.
9	Copper Queen-Lavender Pit	Warren	Arizona	Phelps Dodge Corp	Copper ore.
10	Crescent	Coeur d'Alene	Idaho	The Bunker Hill Co	Silver ore.
11	Berkeley Pit	Summit Valley (Butte)	Montana	The Anaconda Company	Copper ore.
12	Morenci	Copper Mountain	Arizona	Phelps Dodge Corp	Copper, gold-silver ores.
13	Idarado	Upper San Miguel-Eureka (Red Mountain).	Colorado	Idarado Mining Co	Copper-lead-zinc ore.
14	Eagle	Red Cliff (Battle Mountain)	do	The New Jersey Zinc Co	Copper, lead-zinc ores.
15	Kelley	Summit Valley (Butte)	Montana	The Anaconda Company	Copper ore.
16	Magma	Pioneer	Arizona	Magma Copper Co	Copper, gold-silver ores.
17	United Park City Mines	Unitah-Blue Ledge	Utah	United Park City Mines Co	Lead-zinc, silver ores.
18	Iron King	Big Bug	Arizona	Shattuck Denn Mining Corp	Lead-zinc ore.
19	Knob Hill & Gold Dollar	Republic	Washington	Knob Hill Mines, Inc	Gold ore.
20	New Cornelia	Ajo	Arizona	Phelps Dodge Corp	Copper, gold-silver ores.
21	Star	Coeur d'Alene	Idaho	The Bunker Hill Co	Lead-zinc ore.
22	Emperius	Creede	Colorado	Emperius Mining Co	Do.
23	San Manuel	Pioneer	Arizona	San Manuel Copper Corp	Copper ore.
24	Algonquin	Flint Creek	Montana	Trout Mining Co	Zinc ore.
25	Mission Unit	Pima	Arizona	American Smelting and Refining Company	Copper ore.

TABLE 5.—Mine production of recoverable silver in the United States, by States

(Troy ounces)

State	1952-56 (average)	1957	1958	1959	1960	1961
Alaska	32,825	28,862	23,507	21,358	25,934	18,485
Arizona	4,632,987	5,279,323	4,684,580	3,898,336	4,774,992	5,120,007
California	867,585	522,288	188,260	172,810	179,780	93,351
Colorado	2,697,561	2,787,892	2,055,517	1,340,732	1,659,037	1,965,021
Idaho	14,546,739	15,067,420	15,952,796	16,636,486	13,646,508	17,576,322
Illinois	2,387					
Kentucky	6	56	99	75		2,065
Michigan	171,598	430,000				
Missouri	358,783	183,427	250,917	339,760	15,594	11,793
Montana	6,294,396	5,558,228	3,630,530	3,420,376	3,606,991	3,490,350
Nevada	807,515	958,477	932,728	611,135	707,291	388,426
New Mexico	287,560	309,385	158,758	158,925	303,903	282,755
New York	51,838	63,880	66,738	51,588	49,324	40,507
North Carolina	274	12,347	15,157	16,319	212,368	169,742
Oregon	10,598	15,924	2,728	242	284	2,022
Pennsylvania	9,250	(1)	(1)	(1)	(1)	(1)
South Dakota	142,472	134,737	152,995	124,425	108,119	127,427
Tennessee	63,752	54,407	44,592	59,739	64,560	83,417
Texas	979					
Utah	6,584,353	6,198,464	5,277,693	3,734,297	4,782,960	4,797,583
Vermont	44,814	36,794	5,101			
Virginia	1,333	1,745	2,023	866		
Washington	367,074	[1] 521,133	[1] 666,278	[1] 606,537	[1] 628,678	[1] 625,176
Wyoming	52	126	30		4	7
Total	37,976,731	38,164,915	34,111,027	31,194,006	30,766,327	34,794,456

[1] Pennsylvania and Washington combined.

CONSUMPTION AND USES

Consumption of silver in the arts and industries of the United States rose 3 percent to 105.5 million ounces according to the U.S. Bureau of the Mint. The 1961 gain was the third successive annual increase in silver consumption. Treasury silver supplied nearly 60 percent of total domestic requirements; imports furnished most of the remainder. Total U.S. consumption of silver, including coinage, rose 9 percent to 161 million ounces.

The quantity of silver absorbed in such established products as sterling silverware, and brazing alloys for electrical appliances and automotive equipment, declined slightly, but this decline was probably offset by increases in the quantity of silver used in photographic, electronic and metal-bonding applications in specialized industrial and national defense products. Although no detailed breakdown by end uses is available, it is estimated that the manufacture of sterling and plated silverware accounted for about one-third of the total silver used; photographic supplies, solders and brazing alloys, and electrical and electronic components, comprising the major industrial uses, absorbed most of the remainder.

Increased quantities of silver were absorbed in manufacturing silver compounds for light-sensitive paper for amateur, professional, and industrial photographic film. Improved silver brazing alloys continued to be developed to withstand high temperature and provide a bonded joint resistant to corrosion, shock, and vibration such as are encountered by jet aircraft, rockets, and other air and space vehicles.

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 1961 [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	452	0.876					152	12.586
Arizona	30,450	.165	119,595	0.192	29,525	0.571	71,970,777	.061
California	24,650	.090			13	94.769	19,449	2.248
Colorado	56,418	.083	2,000	.959	373	31.062	15,764	25.206
Idaho	2,406	.879			409,037	29.822	20,866	1.070
Montana	10,531	4.558	10,592	6.045	35,144	5.319	12,533,042	.214
Nevada	36,944	.080			11,598	8.546	12,008,578	.020
New Mexico	17	2.059	48,235	1.519	2,445	.345	7,405,692	.011
South Dakota	1,780,746	.064	19	670.737	8	8.875		
Utah	4	.250	66,881	.195	72,201	2.312	27,856,459	.087
Undistributed [2]	116,890	4.891	412	4.061	4,165	.406	1,749,063	.063
Total	2,059,508	.365	247,734	.765	564,509	22.468	133,579,842	.078

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	41	33.854					645	5.732
Arizona	1,258	5.065	15,059	0.043	417,371	[3] 1.634	72,584,035	.071
California	1,720	2.467	14	12.714	55	[4] 663.055	45,901	1.918
Colorado	2,273	10.501	18	7.500	861,394	1.771	938,240	2.094
Idaho	165,561	15.365	50,847	.775	847,938	3.267	1,496,655	11.744
Montana	12,747	4.757	189,971	2.359	361	9.155	[5] 12,792,388	.273
Nevada	9,301	4.661	283	.110	376	3.261	12,067,080	.032
New Mexico	7,588	.093	288,270	.282	24,968	1.821	7,777,215	.036
South Dakota							1,780,773	.072
Utah	1,233	13.240	69,865	.334	487,180	[3] 4.411	28,553,823	.168
Undistributed [2]	7	25.286			[6] 1,867,452	.124	[7] 3,737,989	.245
Total	201,729	13.389	614,327	.965	4,507,095	1.652	141,774,744	.245

[1] Missouri excluded.
[2] Includes Kentucky, New York, North Carolina, Oregon, Tennessee, Washington, and Wyoming.
[3] Includes silver recovered from uranium ore.
[4] Includes silver recovered from tungsten ore.
[5] Includes manganese ore and silver therefrom.
[6] Includes fluorspar and tungsten ore and silver therefrom.
[7] Excludes magnetite-pyrite-chalcopyrite ore and silver therefrom in Pennsylvania.

TABLE 7.—Mine and refinery production of silver in the United States in 1961, 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	14,788	396	1,913	1,388			18,485	18,500
Arizona	3	44,791	4,386,317	6,372	654	[2] 681,873	5,120,007	5,075,000
California	5,293	3,447	43,721	4,244	178	[3] 36,468	93,351	105,500
Colorado	270	18,165	397,342	23,868	135	1,525,241	1,965,021	2,061,600
Idaho	166	12,200,307	22,317	2,543,899	39,430	2,770,203	17,576,322	17,517,600
Illinois								27,100
Kentucky						[4] 2,065	2,065	
Michigan								87,700
Missouri				[5] 11,793			11,793	1,880
Montana	11	298,966	2,679,279	60,639	448,150	[6] 3,305	3,490,350	3,557,000
Nevada	524	102,072	241,222	43,351	31	1,226	388,426	385,500
New Mexico	1	74,146	81,260	703	81,167	45,478	282,755	292,800
New York						40,507	40,507	40,500
North Carolina		49	25,311			[3] 144,382	169,742	175,800
Oregon	104	1,722	41	87		68	2,022	1,530
Pennsylvania [7]								7,380
South Dakota		127,427					127,427	117,600
Tennessee			83,417				83,417	92,000
Utah		179,936	2,428,969	16,325	23,310	[2] 2,149,043	4,797,583	4,700,000
Washington [8]	1	573,276	8,080	90		43,729	625,176	635,000
Wyoming		7					7	10
Total	21,161	13,624,707	10,399,186	2,712,759	593,055	7,443,588	34,794,456	34,900,000
Percent	0.1	39.1	29.9	7.8	1.7	21.4	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 some silver recovered from lead-copper ore.
[6] Includes silver recovered from manganese ore.
[7] Included with Washington.
[8] Includes silver recovered from magnetite-pyrite-chalcopyrite ores in Pennsylvania.

TABLE 8.—Silver produced in the United States from ore and old tailings in 1961, 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	645	447	212				198	3,485
Arizona	72,584,035	71,769,153	120	9,521	2,309,623	4,537,905	814,882	572,458
California	45,901	45,306	1,317	30	7,124	80,531	595	6,180
Colorado	938,240	921,227	1,403	2,717	131,596	1,534,179	17,013	426,452
Idaho	1,496,655	1,460,376	341		222,439	17,513,374	36,279	62,441
Montana	12,792,388	12,679,618	17		387,645	3,158,205	112,770	332,117
Nevada	12,067,080	11,987,533	598	65,275	259,117	175,590	79,547	145,439
New Mexico	7,777,215	7,639,330			328,714	206,494	137,885	76,260
South Dakota	1,780,773	1,780,746	86,516	28,096			27	12,815
Utah	28,553,823	28,324,908	1		817,578	4,424,200	228,915	373,382
Undistributed [2]	[3] 3,737,989	[3] 3,696,907	2	109,317	[3] 137,816	765,016	41,082	48,496
Total	141,774,744	140,305,551	90,527	214,956	4,601,652	32,396,494	1,469,193	2,059,525

[1] Missouri excluded.
[2] Includes Kentucky, New York, North Carolina, Oregon, Pennsylvania, Tennessee, Washington and Wyoming.
[3] Excludes magnetite-pyrite-chalcopyrite ore and concentrates therefrom in Pennsylvania.

TABLE 9.—Silver produced at amalgamation and cyanidation mills in the United States and percentage of silver recoverable from all sources [1]

Year	Bullion and precipitates recoverable (troy ounces)		Silver from all sources (percent)			
	Amalgamation	Cyanidation	Amalgamation	Cyanidation	Smelting [2]	Placers
1952–56 (average)	92,091	286,441	0.2	0.7	99.0	0.1
1957	95,809	250,232	.2	.7	99.0	.1
1958	90,207	324,705	.3	.9	98.6	.2
1959	92,663	557,034	.3	1.8	97.7	.2
1960	86,353	533,286	.3	1.7	97.9	.1
1961	90,527	214,956	.2	.6	99.1	.1

[1] Missouri excluded.
[2] Both 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
1952–56 (average)	121,018	23,038	97,980	1959	142,984	41,984	101,000
1957	133,742	38,342	95,400	1960	151,007	49,007	102,000
1958	121,500	36,000	85,500	1961	155,812	50,312	105,500

[1] Includes secondary materials to monetary use, jewelry, plate, scrap film and other forms of scrap.

Source: U.S. Bureau of the Mint.

Large quantities of silver continued to be used for electrical contacts where low contact resistance is required as in household electrical appliances, in high-voltage switch equipment, and in large motors and generators. Increased quantities of silver were used for electrical conductors and decorative finishes in the ceramic industry, and in the manufacture of silver-zinc and silver-cadmium batteries for applications requiring high power output with minimum size and weight. Other uses of silver that continued to absorb substantial quantities of silver include catalysts in the production of synthetic organic chemicals; bearings in aircraft and diesel engines; dental alloys and amalgams; backing for mirrors; coatings for wire and thermos bottles; pharmaceutical products; and medical, scientific, and chemical equipment.

The quantity of silver absorbed in U.S. subsidiary coinage increased 22 percent to 56 million ounces, nearly one-half the total silver used in free-world coinage. As in 1960, the 1961 gain was attributed principally to increased demand for silver coins resulting from the expanded use of merchandise-vending and other coin-operated machines.

Applications of silver and silver alloys as materials of construction in chemical plant equipment were reviewed, and the economic feasibility of extending the uses in manufacturing chemicals and processing foods were discussed and evaluated.[3]

[3] Stevenson, J. A. Materials of Construction for Chemical Plant—Silver. Chem. & Process Eng., v. 42, No. 7. July 1961, pp. 323–326.

STOCKS

Treasury stocks of silver bullion and coin declined in 1961 for the third successive year, dropping 129.5 million ounces to 1,863 million ounces at yearend. Silver coinage in circulation, continuing its annual growth, increased 93.9 million ounces to 1,486 million ounces. The Treasury acquired 183,000 ounces of newly mined domestic silver in addition to silver from lend-lease returns, withdrawn coins, and other sources. Acquisitions totaled 14.8 million ounces. Withdrawals from Treasury silver stocks included 61.9 million ounces sold to industrial consumers and Government agencies and 55.9 million ounces for subsidiary coinage. The stock of free-silver bullion was reduced 95 million ounces during the year to 28.5 million ounces on December 31, 1960, the lowest level since 1955. After sales of silver were stopped on November 28 the Treasury began withdrawing $5 and $10 silver certificates from circulation and replacing them with Federal Reserve notes, thereby releasing silver from its monetary reserve to meet coinage requirements. During November and December about $14.8 million of silver certificates were retired, equivalent to about 11.5 million ounces of silver which was transferred to the free-silver stock.

The ratio of silver to the total value of gold and silver in the U.S. monetary stocks at yearend was 20.3 percent compared with 19.8 at the end of 1960.

TABLE 11.—U.S. monetary silver

(Million troy ounces)

	1957	1958	1959	1960	1961
In Treasury:					
Securing silver certificates:					
Silver bullion	1,711.5	1,736.3	1,741.3	1,741.8	1,730.5
Silver dollars	169.4	156.8	141.1	124.9	101.0
Subsidiary coin	5.9	10.9	2.4	2.0	2.7
Free silver bullion	127.4	202.2	175.1	123.5	28.5
Total	2,014.2	2,106.2	2,059.9	1,992.2	1,862.7
Coinage in circulation:					
Silver dollars	208.3	220.8	236.3	[1] 252.5	276.0
Subsidiary coin	1,014.6	1,046.2	1,094.7	[1] 1,140.0	1,210.4
Total	1,222.9	1,267.0	1,331.0	[1] 1,392.5	1,486.4
Grand total	3,237.1	3,373.2	3,390.9	[1] 3,384.7	3,349.1

[1] Revised figure.

Source: Compiled from Treasury Bulletin.

PRICES

The prices at which the U.S. Treasury bought and sold silver, established under the Act of July 31, 1946, continued unchanged at 90.5+ and 91.0 cents a fine troy ounce, respectively. Although only a relatively small quantity of silver was offered to the Treasury by domestic producers, Treasury sales of silver increased substantially and the availability of Treasury silver to domestic industries at the official price was the principal factor stabilizing the world price of silver in

the first 11 months of 1961. The Presidential Order on November 28 stopping sales of Treasury silver ended a 3-year period of relative price stability in world markets.

During the first 11 months of 1961 the New York price remained unchanged at 91⅜ cents a troy ounce, 0.999 fine based on the cost of Treasury silver delivered in New York. This was the price paid by Handy & Harman for silver in unrefined materials and was one-fourth cent below the price for refined bar silver offered for nearby delivery.

In the remainder of 1961 following the Presidential Order world prices fluctuated considerably as markets were adjusting to the new conditions. Withdrawal of Treasury silver from the New York market was shortly followed by a sharp rise in price to 100¾ cents an ounce. Subsequent increases brought the price to a new high of 104¾ cents on December 15, where it remained unchanged to the end of the year. Based on the 1961 average New York quotation of 92.449 cents an ounce, the price ratio of gold to silver was 37.8 to 1.

Spot prices in the London silver market were higher than in the New York market during most of the year, ranging from a low of 79⅜d. in January to a high of 88¾d. on December 19, equivalent to 92.6 cents and 103.5 cents, respectively. The closing price quotation for cash delivery at yearend was 88d. equivalent to 102.6 cents. Forward transactions on the London market increased in volume, reflecting greater speculative and consumer interest. The premium for forward silver (2-month delivery) over the cash price ranged from ⅛d. to ⅞d. (⅛+ to 1 cent). The volume of forward silver purchases in the London silver market during 1961 was estimated at 50 million ounces.[4]

As a large part of the London market silver supply which came from China was not eligible for purchase by U.S. citizens, non-Chinese silver brought a premium of slightly over ½ cent an ounce.

FOREIGN TRADE [5]

Imports.—Imports of silver, both refined and unrefined, aggregated 50.2 million ounces valued at $45 million, 10.5 million ounces less than 1960. Imports included 1.4 million ounces of lend-lease returns from Saudi Arabia. Canada, Peru, and Mexico supplied about 90 percent of the total imports.

Exports.—Exports of silver from the United States increased 50 percent to 39.8 million ounces valued at $36.9 million. The sharp rise in exports again reflected the higher prices available in foreign markets during most of the year. Nearly 70 percent of the total exports went to western European countries and Canada.

LEND-LEASE SILVER

Of the original 410.8 million ounces of silver supplied to foreign countries under lend-lease agreements, all but 15 million ounces had been repaid. Pakistan reduced its outstanding lend-lease obligation

[4] S. Montagu & Co., Ltd. Annual Bullion Review, 1961. February 1962, p. 20.
[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. Dept. of Commerce, Bureau of the Census.

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by returning 4.6 million ounces of silver to the United States. The remaining 4.6 million of Pakistan's obligation was scheduled for repayment in 1962. Saudi Arabia repaid 10.9 million ounces of its 21.3 million ounce obligation—1.4 million ounces in silver and 9.5 million ounces in dollars.

WORLD REVIEW

World silver output was estimated at 231.8 million ounces, about 8 million ounces less than in 1960. Increased output in Peru, and Japan failed to offset substantial production declines in Canada, Mexico, and Australia. Changes in the silver output of other countries were small. Mexico, Peru, Canada, and the United States, the principal free-world silver-producing countries, contributed about 60 percent of world output.

TABLE 12.—U.S. imports of silver in 1961, by countries

(Thousand troy ounces and thousand dollars)

Country	Ore and base bullion		Refined bullion		United States coin value	Foreign coin value
	Quantity	Value	Quantity	Value		
North America:						
Canada	12,069	$10,828	11,693	$10,784	$297	$11
El Salvador					67	
Guatemala	142	128				
Honduras	2,526	2,315				
Mexico	5,135	4,567	2,918	2,411		21
Nicaragua	240	213				
Total	20,112	18,051	14,611	13,195	364	32
South America:						
Argentina	8	7				
Bolivia	977	880				
Chile	2,102	1,895				
Colombia	42	36				
Ecuador	62	52				
Peru	7,153	6,438	1	1		
Total	10,344	9,308	1	1		
Europe:						
Austria						1
France						(1)
Germany, West	1	1				(1)
Portugal	53	48				
Switzerland					1	1
United Kingdom	91	81	1,084	976	27	2
Total	145	130	1,084	976	28	4
Asia:						
Philippines	602	541	1	1		
Saudi Arabia	1,371	975				
Total	1,973	1,516	1	1		
Africa:						
Mozambique	51	46				
Rhodesia and Nyasaland, Federation of	239	218				
Union of South Africa	447	413				
Total	737	677				
Oceania: Australia	1,248	1,150				
Grand total	34,559	30,832	15,697	14,173	392	36

[1] Less than $1,000.

Source: Bureau of the Census.

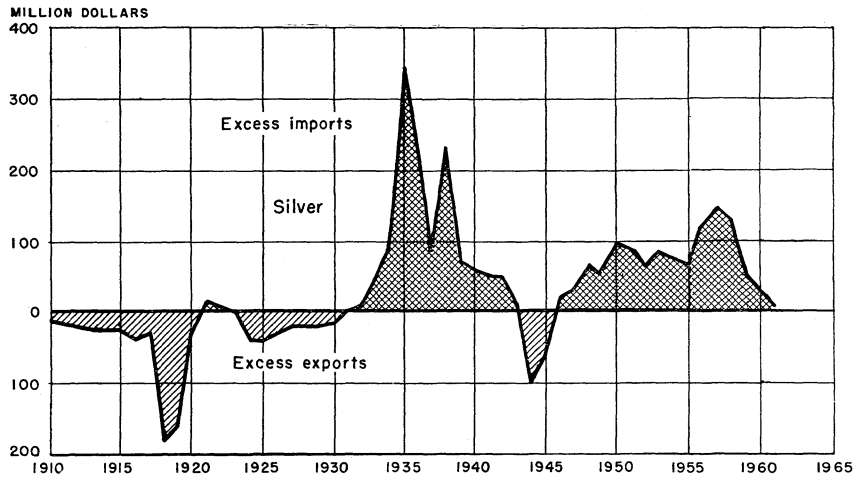


FIGURE 2.—Net Imports or Exports of Silver, 1910–61.

TABLE 13.—U.S. exports of silver in 1961, by countries

(Thousand troy ounces and thousand dollars)

Destination	Ore and base bullion		Refined bullion		United States coin value	Foreign coin value
	Quantity	Value	Quantity	Value		
North America:						
Bahamas					$2	
Canada			11,955	$10,867	2	$851
Guatemala					5	
Mexico	(1)	(2)	3	3		
Netherlands Antilles					10	
Total	(1)	(2)	11,958	10,870	19	851
South America:						
Brazil			181	170		
Chile			(1)	(2)		
Colombia			31	28		
Venezuela			5	5		
Total			217	203		
Europe:						
Belgium-Luxembourg	351	$321				
France			4,327	3,984		
Germany, West			11,106	10,521		
Ireland					19	
Italy			2,482	2,292		
Netherlands	3	2				
Switzerland					1	
United Kingdom	300	274	5,607	5,151		
Total	654	597	23,522	21,948	20	
Asia:						
Israel			2	2	5	
Japan			3,475	3,338		
Total			3,477	3,340	5	
Africa: Liberia						1
Grand total	654	597	39,174	36,361	44	852

[1] Less than 1,000 troy ounces.
[2] Less than $1,000.

Source: Bureau of the Census.

Consumption of silver in free-world countries was estimated at 352.4 million ounces, 8 percent more than in 1960.[6] Industrial uses increased 5 percent to 238.1 million ounces and coinage requirements, aggregating 114.3 million ounces, were up 15 percent. The gain in coinage consumption resulted from large increases in the quantities used by France and the United States. The quantities of silver used for Canadian and Japanese coinage were substantially lower than in 1960.

Free-world silver consumption continued to exceed production by a substantial margin, and in 1961 the excess rose to a record high of nearly 158 million ounces. As in several preceding years the production deficit was balanced by withdrawals from world stocks, chiefly those of the U.S. Treasury.

TABLE 14.—World production of silver, by countries[1 2 3]

(Troy ounces)

Country	1952–56 (average)	1957	1958	1959	1960	1961
North America:						
Canada	28,211,112	28,823,298	31,163,470	31,923,969	34,016,829	31,168,283
Central America and West Indies:						
Cuba (U.S. imports)	194,254	252,728	325,278	215,000	121,415	----------
Guatemala	398,052	528,436	320,621	[4] 88,000	[5] 663,121	[5] 515,905
Honduras	3,320,730	2,260,433	2,762,932	3,167,376	2,947,021	3,544,702
Nicaragua	247,214	230,081	304,277	298,413	326,673	417,253
Salvador	269,162	172,306	197,629	199,080	76,809	----------
Mexico	45,831,880	47,149,513	47,592,358	44,075,291	44,526,463	40,342,397
United States [6]	37,673,982	38,720,200	36,800,000	23,000,000	36,800,000	34,900,000
Total	116,146,400	118,137,000	119,466,600	102,967,100	119,478,300	110,888,500
South America:						
Argentina	1,316,916	1,350,331	1,543,200	1,549,600	1,671,838	1,430,675
Bolivia (exports)	6,326,451	5,375,089	6,051,284	4,504,126	4,887,138	3,900,174
Brazil	168,425	348,160	185,317	225,152	252,930	260,415
Chile	1,617,118	1,555,903	1,504,365	1,767,230	1,434,277	[4] 1,300,000
Colombia	115,170	106,494	105,162	102,678	134,333	127,549
Ecuador	56,277	61,327	84,522	162,608	126,419	39,448
Peru	20,872,622	24,845,257	25,918,353	27,225,216	30,755,496	33,581,997
Total	30,473,000	33,640,000	35,390,000	35,540,000	39,260,000	40,640,000
Europe:						
Austria	3,794	1,286	----------	64,300	64,300	64,300
Czechoslovakia [7]	1,608,000	1,608,000	1,608,000	1,608,000	1,608,000	1,608,000
Finland	233,672	373,592	560,709	522,739	390,374	456,155
France	622,715	703,587	770,267	944,750	929,381	[4] 950,000
Germany:						
East [7]	4,500,000	4,800,000	4,800,000	4,800,000	4,800,000	4,800,000
West	2,187,350	2,139,407	2,112,304	1,897,730	1,842,559	1,879,790
Greece	77,470	93,462	99,410	150,273	106,100	[4] 144,700
Hungary [7]	64,300	64,300	64,300	64,300	64,300	64,300
Italy	892,048	956,420	1,334,256	1,060,749	943,946	973,139
Norway	104,168	64,301	----------	----------	----------	----------
Poland [7]	115,800	128,600	128,600	128,600	128,600	128,600
Portugal	61,787	62,308	45,783	54,141	52,920	[4] 55,000
Rumania [7]	643,000	643,000	643,000	643,000	643,000	643,000
Spain	1,243,153	1,345,734	1,774,850	2,206,698	1,739,677	[4] 1,800,000
Sweden	2,188,694	2,512,163	2,944,301	3,098,070	2,659,448	2,825,246
U.S.S.R. [4]	24,800,000	25,000,000	25,000,000	25,000,000	25,000,000	25,000,000
United Kingdom	28,746	27,337	20,553	13,655	7,097	[4] 7,000
Yugoslavia	2,839,612	2,589,742	3,751,702	2,827,336	3,025,160	3,454,083
Total [4]	42,200,000	43,100,000	45,700,000	45,100,000	44,000,000	44,900,000

See footnotes at end of table.

[6] Handy & Harman, The Silver Market in 1961, p. 26.

TABLE 14.—World production of silver, by countries[1 2 3]—Continued

(Troy ounces)

Country	1952–56 (average)	1957	1958	1959	1960	1961
Asia:						
Burma	1,028,744	1,526,810	1,961,472	2,041,395	1,984,263	1,743,302
China [7]	400,000	500,000	600,000	800,000	800,000	800,000
India	90,405	125,838	109,828	124,777	132,718	179,144
Japan	5,896,960	6,543,673	6,552,032	6,650,928	6,912,602	7,946,570
Korea:						
North [7]	100,000	300,000	400,000	500,000	500,000	500,000
Republic of	77,972	277,346	247,788	241,898	329,649	460,341
Philippines	567,239	479,216	497,987	504,085	1,133,343	812,793
Saudi Arabia	65,250					
Taiwan	40,904	82,965	52,380	60,974	52,579	77,303
Total [4]	8,300,000	9,800,000	10,400,000	10,900,000	11,800,000	12,500,000
Africa:						
Algeria (recoverable) [8]	193,890	235,000	225,000	400,000	300,000	300,000
Bechuanaland	288	35	44	42	24	39
Congo, Republic of the (formerly Belgian)	4,421,479	3,044,868	3,793,788	4,768,180	3,962,836	3,470,000
Ghana (exports)	41,031	25,390	45,762	16,839	14,160	7,027
Kenya	19,371	23,051	44,146	46,420	35,797	37,962
Morocco	2,082,317	2,411,250	2,411,000	1,234,303	1,097,273	907,905
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia [9]	453,598	569,949	558,535	935,678	698,127	744,084
Southern Rhodesia	80,257	74,179	264,630	328,947	392,026	106,801
South-West Africa (recoverable)	1,110,283	1,789,323	1,719,990	1,966,955	1,004,921	1,833,437
Tanganyika (exports)	310,804	521,465	737,802	536,407	614,279	64,144
Tunisia	78,563	113,556	135,194	43,339	34,401	69,767
Uganda (exports)	55	21	36	54	109	64
Union of South Africa	1,332,923	1,767,472	1,795,384	2,020,780	2,226,204	2,288,279
Total	10,125,000	10,580,000	11,730,000	12,300,000	10,380,000	9,830,000
Oceania:						
Australia	13,359,496	15,739,400	16,270,181	15,076,363	15,198,923	[4] 13,000,000
Fiji	21,537	24,946	25,375	23,652	31,319	37,712
New Guinea	51,510	38,014	24,952	36,796	33,037	30,700
New Zealand	37,767	1,279	2,339	4,873	1,353	804
Total	13,470,300	15,804,000	16,323,000	15,142,000	15,265,000	13,069,000
World total (estimate)	220,700,000	231,100,000	239,000,000	221,900,000	240,200,000	231,800,000

[1] In addition to the countries listed, 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 48th annual issue of Metal Statistics (Metallgesellschaft) Germany.
[4] Estimate.
[5] Recoverable.
[6] Refinery production.
[7] Estimate, according to 48th annual issue of Metallgesellschaft (Germany) except 1961 which is an extension of the 1960 estimate.
[8] Estimated recoverable silver content of lead and zinc concentrates, according to 1960 annual issue of Minerais et Metaux (France) except 1961 which is an extension of the 1960 estimate.
[9] Partially recovered from refinery sludges and blister copper.

Compiled by Augusta W. Jann, Division of Foreign Activities.

Australia.—Silver production in Australia dropped 14 percent to 13 million ounces, reflecting curtailed output of lead concentrates from which most of the country's silver was recovered as a coproduct.

Mount Isa Mines, Ltd., Queensland, treated 813,000 tons of silver-lead-zinc ore assaying 6.2 ounces of silver a ton and reported an ore reserve of 25.6 million tons assaying 5.6 ounces a ton, virtually the same as in 1960. New Broken Hill Consolidated Ltd., reported increased output of lead-zinc ore and a reserve of 4.4 million tons assaying 2.7 ounces of silver a ton. Broken Hill, Mount Isa, Rosebery, and Cap-

tains Flat, the principal silver mining areas, furnished 90 percent of the total mine output of silver.

Canada.—After rising for 5 successive years, Canada's silver output dropped to 31.2 million ounces in 1961. This was 2.8 million ounces below the record high of 1960. As a result, Canada dropped to fourth place among world silver producers.

Most of the decline in silver production was in Ontario, but lower silver output also was recorded in the Yukon Territory, Saskatchewan, Quebec, and Newfoundland. Output in British Columbia and Manitoba continued to increase.

Two provinces, British Columbia and Ontario, together with the Yukon Territory continued to produce more than three-fourths of the total output. Two companies, United Keno Hill Mines, Ltd., and Consolidated Mining & Smelting Co. of Canada, Ltd., contributed about half of Canada's total silver production. About 82 percent of the total silver was recovered as a coproduct or byproduct of base metal ores, and most of the remainder continued to come from silver and silver-cobalt ores.

Exports of silver and silver in ores and concentrates, most of which went to the United States, aggregated 23.6 million ounces, compared with 21.7 million ounces in 1960. Imports of silver tripled those in 1960, totalling about 12 million ounces. This sharp increase in imports resulted chiefly from the return of refined silver from shipments of concentrates sent to the United States for treatment. An increase in concentrate shipments to the United States followed the closing in March 1961 of the Deloro, Ontario, refinery which had treated concentrates from the Cobalt and Gowganda areas for many years.

Consumption of silver for industrial uses in Canada was estimated at 4.2 million ounces, which was about the same as in 1960. Coinage consumption also was about 4.2 million ounces compared with 7.5 million ounces in 1960.

Trading in silver futures on the Canadian Stock Exchange in Montreal began early in the year.

Japan.—Industrial consumption of silver in Japan was about 21.5 million ounces, virtually the same as in 1960. Coinage consumption dropped sharply to 1.4 million ounces compared with 4.6 million ounces in 1960. Production of silver was estimated at 7.9 million ounces, which was about 1 million ounces more than in 1960. Imports aggregated approximately 4.4 million ounces, of which 3.5 million ounces came from the United States.

Of the original 64 million ounces of wartime confiscated silver about 4.5 million ounces was scheduled to be returned to private companies, and nearly 2 million ounces have been returned so far. The remaining 60.5 million ounces was transferred to the Japanese Government, and part of this stock was used for coinage. Remaining Government stocks were estimated at 47 million ounces.[7]

Mexico.—Production of silver in Mexico, the leading silver-producing country, was 40.3 million ounces, 4.2 million ounces less than in 1960. Approximately three-fourths of Mexico's silver output was recovered as a coproduct or byproduct of lead, zinc, and copper.

[7] Page 20 of work cited in footnote 6.

The remaining one-fourth came chiefly from silver ores in the States of Hidalgo, Guanajuato, Guerrero, and Durango.

Industrial consumption of silver was estimated at 3.4 million ounces, and about 2.5 million ounces was absorbed in domestic coinage, almost equal to the quantity so used in 1960.

Exports of silver bullion aggregated 33.5 million ounces, nearly half of which went to West Germany. The United Kingdom and Switzerland each received about 1.3 million ounces, and 8 million ounces was shipped to the United States. The remainder went to other European, and Central and South American countries.

Demonetized coin withdrawn from circulation totaled 2.8 million ounces, compared with 3.0 million in 1960. About 80 million ounces of silver demonetized coin was estimated to be held by the public. [8]

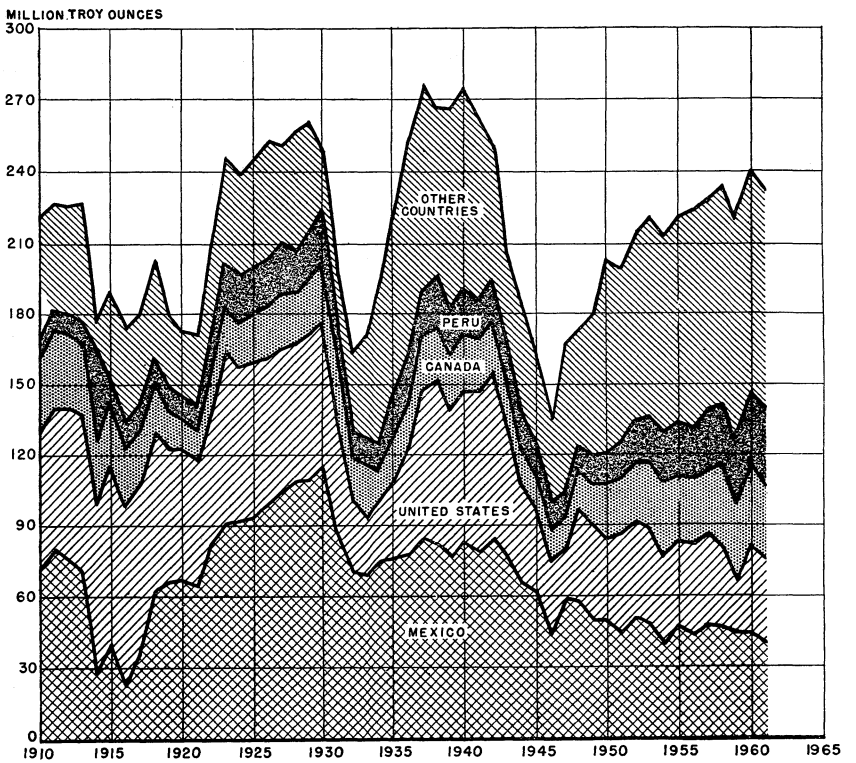


FIGURE 3.—World Production of Silver, 1910–61.

Peru.—Peru rose to third place among the leading silver-producing countries as silver production increased for the 13th successive year. Output was up 2.8 million ounces from 1960 to 33.6 million ounces, a new production record. Exports of silver totaled 33.4 million ounces, valued at $27.4 million, about 28 percent greater than in 1960. Cerro de Pasco Corp., the leading producer, produced 16.7

[8] Page 19 of work cited in footnote 6.

million ounces, about half of the total output. Approximately 40 percent of Cerro's output came from its own mines; the remainder came from custom ore purchases. The straight silver mines, Castrovirreyna Metal Mines Co., San Juan de Lucanas S.A., Cia. Minera Caylloma, and Cia. Explotadora Millotengo produced 6.2 million ounces, about 18 percent of Peru's total production.

United Kingdom.—Consumption of silver in the arts and industries of the United Kingdom was estimated at 20 million ounces compared with 18.5 million ounces in 1960. Imports of silver totaled 65.8 million ounces, which more than double those in 1960. About 70 percent of the imports, 46.4 million ounces came from China, 13.4 million ounces from Western Hemisphere countries, and the remainder from several other countries.[9]

Exports from the United Kingdom (including re-exports) totaled 26.8 million ounces compared with 8.6 million ounces in 1960. The major part of the exported silver went to other European countries chiefly Italy, Switzerland, France, and Austria, in order of magnitude.

About 5 million ounces of silver was refined from silver coin withdrawn from circulation in the United Kingdom, 1 million of which was released for sale in the London Market; the remainder was retained by the Royal Mint to meet the demand for foreign coinage. An additional 2.7 million ounces of silver in coin was received from Uruguay and 1 million ounces from Iraq. Total stocks held by speculators in London at yearend were estimated at 30 million ounces. An additional estimated 10 million ounces was held in inventories to meet future requirements.

TECHNOLOGY

A composite of silver impregnated with sapphire whiskers developed by the space vehicle department of General Electric Co. was reported to be five times stronger than the metal itself. The composite, containing 12.5 percent whiskers, withstands a tension of 118,000 psi, and the added strength permits the metal to perform at temperatures far above its normal operating range.[10]

Powder Weld Inc., reported the development of a new method of applying a silver coating to aluminum bus bars and switch gear parts for the electrical industry. In the process, a silver powder is applied with a carrier gas, and melted and bonded with a small torch. The method forms an anodic bond of silver with the aluminum and is reported to be much more economical than the standard electroplating process.

Silver impregnated molybdenum and stainless steel gaskets and seals developed by Armour Research Foundation withstood pulsating pressures of 5,000 psi at temperatures up to 1,200° F. The sealing composite combines the resiliency of the fiber metal skeleton with the

[9] Pages 21, 23 and 27 of work cited in footnote 4.
[10] Chemical & Engineering News. Research & Technology. V. 39, No. 33, Aug. 14, 1961. p. 51.

softness and conformability of the filler metal to provide an effective corrosion resistant seal.[11]

Two electrolytic processes for treating silver, one using catophoretic deposition of an oxide layer, the other electrolytic chromating, were reported to be effective in eliminating tarnishing problems in applications such as electrical contacts and surfaces for soldering.[12]

A method of silver plating by chemical reduction was patented.[13] The method comprises essentially an alkali metal cyanide and a dissolved hypophosphite reducing agent in conjunction with dissolved silver ions and a compound containing undissolved silver ions in contact with the plating solution.

A patent [14] was issued for an electroplating cell for recovering silver from spent photographic solutions using a cylindrical cathode surrounding a cylindrical anode.

Another patented device for reclaiming silver from photographic baths used circumferentially spaced electrodes and a removable circulating pump mounted on the electrode unit.[15]

Continuous photocurrent measurements on silver halide cells to distinguish between photoconductive or photocatalytic and photogalvanic effects were described, and the results reported in a trade journal.[16]

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[11] Materials in Design Engineering. Fiber Metal Seals Take 5,000 Psi, 1200° F. V. 53, No. 4, April 1961, p. 17.

[12] Steel. Ends Silver Tarnishing. V. 148, No. 14, Apr. 3, 1961, p. 81.

[13] Brookshire, R. R. (assigned to Hughes Aircraft Co.). Methods of Silver Plating by Chemical Reduction. U.S. Pat. 2,976,180, Mar. 21, 1961.

[14] Cedrone, N. J. (assigned to Hispeed Equipment Inc.). Electrolytic Cell for Recovery of Silver From Spent Photographic Fixing Baths. U.S. Pat. 3,003,942, Oct. 10, 1961.

[15] James, C. E., and P. Fedelchak. Device for Reclaiming Silver From Photographic Hypo Baths. U.S. Pat. 2,997,438, Aug. 22, 1961.

[16] Zaromb, S., M. E. Lasser, and F. Kalhammer. Cyclic Photogalvanic Silver Halide Cells. J. Electrochem. Soc., v. 108, No. 1, January 1961, pp. 42–47.

Slag—Iron-Blast Furnace

By Perry G. Cotter[1]

PRODUCTION of pig iron continued high, but output of processed iron-blast furnace slag declined 11 percent in 1961. The decline does not reflect a lessened demand for processed slag but rather a shortage of material available to processors. In some areas of the United States, slag banks built up in past years were exhausted, and processors had to rely on the daily production of slag from furnaces. In other areas, operators used the slag from their furnaces for fill and other purposes instead of selling it to processors. The short supplies of slag for processing caused some slag companies to make available sand and gravel to their customers.

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	Quantity	Value	Quantity	Value [1]	Quantity	Value
1952–56 (average)	23,585	$33,203	1,185	$749	3,559	$1,413	2,547	$6,559
1957	25,414	40,203	2,167	1,408	4,318	1,615	2,942	8,435
1958	20,499	34,027	1,411	1,170	3,536	1,373	2,985	8,638
1959	21,816	36,774	1,039	957	2,702	1,396	2,812	8,037
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

[1] Excludes value of slag used for manufacturing hydraulic cement.

Source: National Slag Association.

DOMESTIC PRODUCTION

Output of processed iron-blast-furnace slag totaled nearly 26 million short tons in 1961, compared with 29 million tons in 1960.

The 40 reporting slag processing companies operated 64 air-cooled; 16 granulated; and 22 expanded-slag plants.

Slag processing was reported from 16 states. Pennsylvania, Ohio, and Alabama led, with Pennsylvania the top producer in both volume and sales value.

[1] Commodity specialist, Division of Minerals.

Recovery of Iron.—In 1961, 372,017 tons of iron slag (about 60 percent iron) was recovered during processing of slag and returned for remelting, a 19-percent decrease from 1960.

Employment.—A total of 3,554,000 man-hours was worked by 1,854 plant and yard employees in producing commercial slag, compared with 4,090,952 man-hours by 2,010 plant and yard employees in 1960. Output at slag operations was 7.23 tons of processed slag per man-hour, up 3 percent from 1960; in 1941, 4.8 short tons was produced per man-hour. Injury experience of 49 competing plants in the 1960 National Slag Association Safety Competition was the best in the 12-year history. Top safety honors were awarded to the Lackawanna No. 2 plant of Buffalo Slag Co., Inc., at Lackawanna, N.Y., for the best safety record in the large-plant group and to the Middletown, Ohio, plant of American Materials Corp. in the small-plant group. For the first time in 10 years no fatalities were recorded.

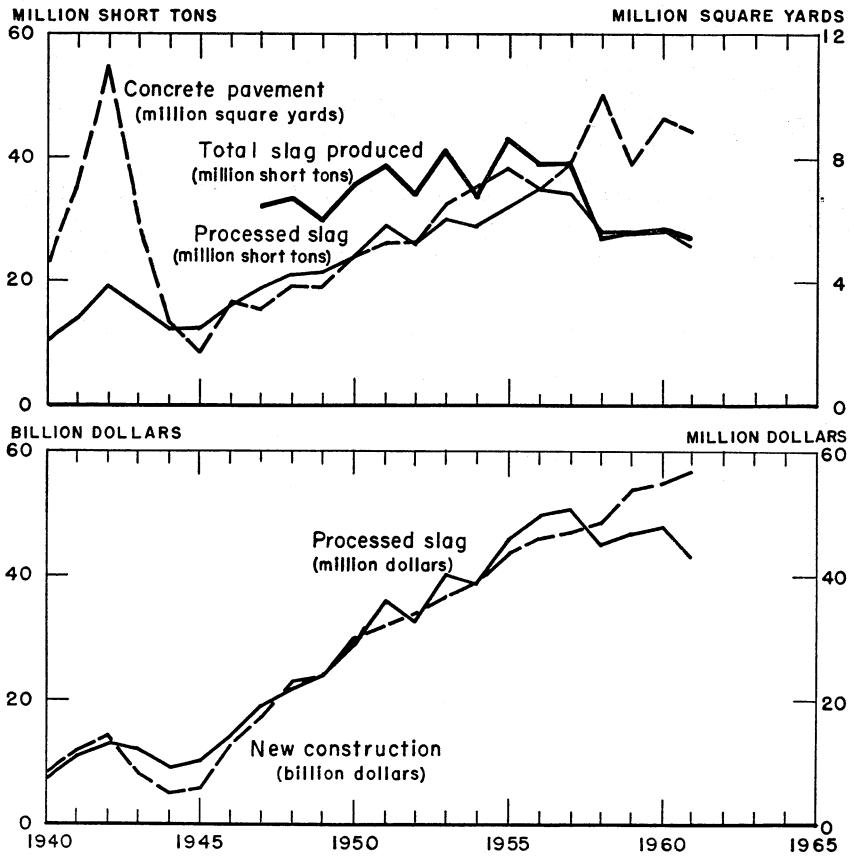


FIGURE 1.—Production of iron-blast-furnace slag compared with yards of concrete pavement (contract awards), monthly average, and value of new construction compared with value of processed slag, 1940–61.

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
1960:				
Alabama	2,503	$4,301	3,162	$5,202
Ohio	5,425	10,016	6,426	12,431
Pennsylvania	5,036	9,266	7,804	11,651
Other States [1]	8,944	14,088	11,406	18,698
Total	21,908	37,671	28,798	47,982
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

[1] California, Colorado, Illinois, Indiana, Kentucky, Maryland, Michigan, Minnesota, New Jersey, New York, Tennessee, Texas, and West Virginia.

Source: National Slag Association.

Methods of Transportation.—Shipments of processed slag by rail and truck, as in other years, accounted for most of the tonnage. Shipments by water decreased 22 percent.

CONSUMPTION AND USES

Screened air-cooled slag constituted 75 percent of the total output of processed slag. Production of other types was as follows: Unscreened air-cooled, 6 percent; granulated, 10 percent; and expanded, 9 percent.

Screened Air-Cooled Slag.—Consumption decreased by approximately 2.7 million tons, chiefly because of diminished use in highway and airport construction, in bituminous pavement, and as railroad ballast. Slight increases were noted in the tonnages used for mineral wool and roofing.

TABLE 3.—Shipments of iron-blast-furnace slag in the United States, by methods of transportation

Method of transportation	1960		1961	
	Thousand short tons	Percent of total	Thousand short tons	Percent of total
Rail	8,379	29	7,458	29
Truck	19,492	68	17,360	68
Waterway	738	2	578	2
Total shipments	28,609	99	25,396	99
Interplant handling [1]	189	1	285	1
Total processed	28,798	100	25,681	100

[1] Confined mainly to granulated slag used in manufacturing cement.

Source: National Slag Association.

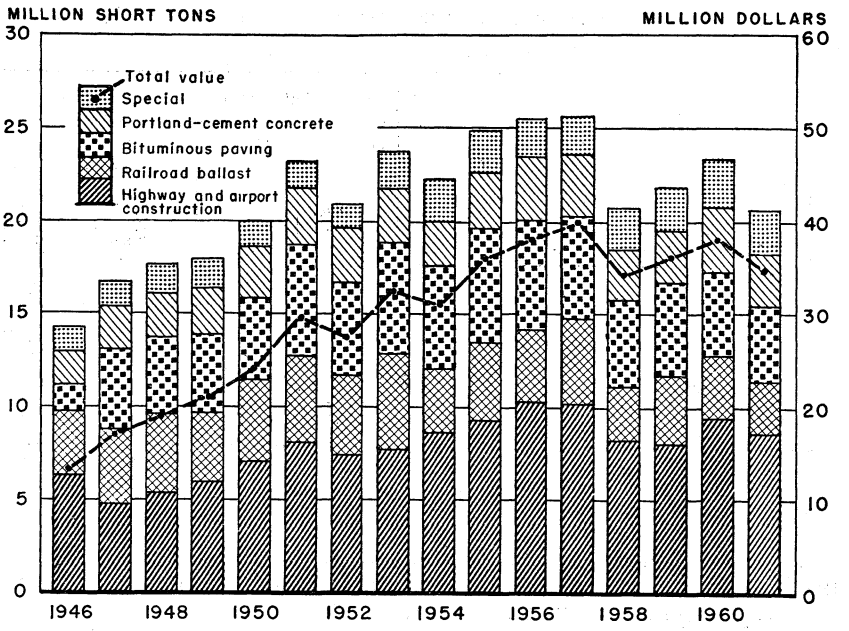


FIGURE 2.—Consumption and value of air-cooled, iron-blast-furnace slag sold or used in the United States, 1946–61.

TABLE 4.—Air-cooled iron-blast-furnace slag sold or used by processors in the United States, by uses

(Thousand short tons and thousand dollars)

Year and use	Screened		Unscreened	
	Quantity	Value	Quantity	Value
1960:				
Aggregate in—				
Portland-cement concrete construction	3,388	$6,123		
Bituminous construction (all types)	4,538	8,311		
Highway and airport construction [1]	8,684	15,312	676	$615
Manufacture of concrete block	504	838		
Railroad ballast	3,355	4,228	9	6
Mineral wool	451	739		
Roofing (cover material and granules)	371	1,147		
Sewage trickling filter medium	19	39		
Agricultural slag, liming	28	53		
Other uses	570	881	552	428
Total	21,908	37,671	1,237	1,049
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

[1] Other than in portland-cement concrete and bituminous construction.

Source: National Slag Association.

TABLE 5.—Granulated and expanded iron-blast-furnace slag sold or used by processors in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1960				1961			
	Granulated		Expanded		Granulated		Expanded	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Highway construction (base and subgrade)	630	$707	--	--	543	$758	--	--
Fill (road, etc.)	436	342	--	--	184	179	--	--
Agricultural slag, liming	57	92	--	--	45	64	--	--
Manufacture of hydraulic cement	1,518	(1)	--	--	1,545	(1)	--	--
Aggregate for concrete-block manufacture	176	157	2,568	$7,589	123	154	2,225	$6,646
Aggregate in lightweight concrete	--	--	22	60	--	--	18	49
Other uses	210	191	36	124	223	212	32	111
Total	3,027	[2] 1,489	2,626	7,773	2,663	[2] 1,367	2,275	6,806

[1] Data not available.
[2] Excludes manufacture of hydraulic cement, value not available.

Source: National Slag Association.

Unscreened Air-Cooled Slag.—Fifty-three percent of the unscreened air-cooled slag was used in highway and airport construction, a 17-percent increase from 1960.

Granulated Slag.—The principal use for granulated slag was in manufacturing portland blast-furnace slag cement. This use accounted for 58 percent of the total production of 2,633,000 short tons. Twenty-seven percent was used in highway construction as base, subgrade, and fill. Production decreased 12 percent from 1960.

Expanded Slag.—Production of expanded slag for lightweight concrete block and for aggregate in lightweight structural concrete was 2.2 million tons, slightly lower than in 1960.

PRICES

The average unit value of processed slag ranged from $0.66 to $2.99 per short ton, according to type. Slight increases in price were noted for slag used for bituminous paving, highway and airport construction, manufacture of concrete block, railroad ballast, mineral wool, and sewage trickling medium.

The small quantity of granulated slag used in highway construction for base and subgrading increased 25 percent in unit value over 1960.

TECHNOLOGY

A Westphalian steel plant used a specially designed truck to move ladles of molten slag from blast furnaces to slag pit. The cab was heat-shielded, and the truck had heat-resistant tires. Ladles containing 33 to 38 tons were moved at 20 miles per hour. It was claimed that the trucking system was more economical to operate than a railroad transportation system with its high capital and operating

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					
	1960	1961	1960	1961	1960	1961	1960	1961
Aggregate in—								
Portland-cement concrete construction	$1.81	$1.81					[1] $2.73	[1] $2.72
Bituminous construction (all types)	1.83	1.88		$0.89				
Highway and airport construction [2]	1.76	1.80	$0.91	.87	[3] $1.12	[3] $1.40		
Manufacture of concrete block	1.66	1.68			.89	1.25	2.96	2.99
Railroad ballast	1.26	1.27	.67					
Mineral wool	1.64	1.73		.67				
Roofing (cover material)	3.09	3.09						
Sewage trickling filter medium	2.05	2.60						
Agricultural slag, liming	1.89	1.27			1.61	1.42		
Fill (road, etc.)					.78	.97		
Other uses	1.55	1.71	.78	.41	.91	.95	3.44	3.47

[1] Lightweight concrete. [2] Other than in portland-cement and bituminous construction.
[3] Base and subgrade material.

Source: National Slag Association.

costs, and because trucks were not tied to a fixed timetable. Savings were also made because of reduced personnel requirements.[2]

An hydraulic conveying system for moving granulated slag from pit to storage reservoir was described. Economics of this system as compared with other systems were reported. Descriptions of armored high-pressure centrifugal pumps, rubber-lined conveying pipes, and methods of maintenance were given. Cast-basalt liners were used in slurry tanks. Equipment was illustrated.[3]

Slag sand and slag dust were used to make a refractory brick for lining metallurgical furnaces. Components used experimentally were 20 to 80 per cent wastes (slag sand or dusts from granulating) and 25 to 75 percent vitreous slag.[4]

An insulating material that was heat-resisting and sound-deadening was produced by granulating, crushing, and screening a porous mass of blast-furnace slag.[5]

In producing crystalline building brick, 5 to 10 percent of pumice, basaltic tuff, or diabase tuff was added to molten blast-furnace slag, and the mixture slowly cooled to form either brick or material which could be crushed for aggregate.[6]

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[2] Engineer. V. 211, No. 5484, Mar. 13, 1961, p. 356.
[3] Altpeter, W. Erfahrungen mit der Hydraulischen Forderung von Hochofenschlackensand und anderen Festoffen in Hüttenwerken (Experience With the Hydraulic Transfer of Blast-Furnace-Slag and Other Furnace-Sinters in a Metallurgical Plant). Stahl u. Eisen, v. 81, No. 15, July 20, 1961, pp. 1006–1014.
[4] Kessler, H. (assigned to Hüttenwerk Rheinhausen, A. G.). Verfahren zur Herstellung von Hüttenstein (Method for Manufacturing Metallurgical Brick). German Pat. 1,066,941, Oct. 8, 1959.
[5] Vilpert, E., and Y. M. Thiebaud. Fabrication d'un laitier spécial ultra-léger de haut fourneau utilisable comme matériau isolant et pour les constructions légères (Manufacture of a Very Light Insulating Material From Blast Furnace Slag, Usable for Light Construction). French Pat. 1,235,403, May 30, 1960.
[6] Wolf, E. (assigned to Bauersteinwerk der Stadt Kassel). Verfahren zur Herstellung von Krystallinen Steinen aus Schlackinschmelzen (Method for Making Crystalline Bricks From Molten Slag). German Pat. 1,065,315, Sept. 10, 1959.

A mixture of water-granulated blast-furnace slag and minus 140-mesh silica was agitated and heated to 1,800° to 2,300° F whereby the bloated slag was coated with silica. The mixture was then heated to 1,900° to 2,000° F. The bloated slag composition resulting from this process weighed 25 pcf.[7]

Concrete structural units that have high fire and radiation resistance were made of a mixture of 80 percent blast-furnace slag, 20 percent portland cement, and a minor quantity of calcium chloride. The concrete formed contained a larger amount of calcium trisilicate than regular slag cements and was heat resistant up to 1,200° C. The addition of approximately 1 percent boron carbide made the structures substantially impermeable to radiation caused by nuclear blast.[8]

A product resembling natural, vesiculated, basaltic rock was produced by a method in which molten blast-furnace slag was mixed with 5 to 15 percent of ground rock or granulated mineral additive such as a basic or ultrabasic rock. The mixture was stirred, cooled slowly, and crushed. Adding the basic constituent converted a normally dry slag to a wet melt, which solidified in porous and crystalline form.[9]

A French patent described a method for producing high-strength hydraulic cement by grinding together flue ash, blast-furnace slag, gypsum, and sodium hydroxide and adding crystal nuclei.[10]

A British patent described a method by which granulation of foamed blast-furnace slag was eliminated. The foamed hot slag was carried to a seasoning station while the stream was surrounded by a water film. By this method the inner structure of the slag was maintained in a plastic foamed condition.[11]

The new plant of Margram Slag Co. at Port Talbot, Wales, was designed to produce three types of material: Air-cooled slag for ballast, concrete aggregate, and roadstone; granulated slag for cement; and foamed slag for building construction. Three-stage crushing was used to give best particle shape for roadstone. The plant was designed to supply large hourly demands for roadstone and also allow steady production of a number of sizes of aggregate. The coating plant was automatically controlled by a system which regulated such variables as binder type and quality, flux and filler requirements, and heating and mixing times.[12]

A cement that resisted the corrosive action of sulfate water was produced by mixing a portion of clinker with equal parts granulated blast-furnace slag and quick-setting cement. The process required controlled particle sizes of both slag and cement.[13]

In a process for granulating slag, molten blast-furnace slag was fed at a high speed tangentially into an upright funnel provided with a venturi-like outlet. The melt separated into small droplets, the size

[7] Parsons, J. R. (assigned to Chicago Fire Brick Co.). Lightweight Aggregate. U.S. Pat. 2,977,239, Mar. 28, 1961.
[8] Stocker, R. Concrete Structure. U.S. Pat. 3,002,843, Oct. 3, 1961.
[9] Schlosser & Co., G.m.b.H. Improvements Relating to the Manufacture of Crystalline and Porous Slag Bricks or Blocks. British Pat. 881,219, Nov. 1, 1961.
[10] Duriez, M. J. J., and R. E. A. Lezy. Nouveaux Ciments Quaternaires (New Quartenary Cements). French Pat. 1,210,920, Oct. 5, 1959.
[11] Chocola, J. Improvements in Methods of and Apparatus for Producing Foamed Slag and Like Materials. British Pat. 881,048, Nov. 1, 1961.
[12] Mine and Quarry Engineering (London). Margram Slag Processing Plant. V. 27, No. 4, April 1961, pp. 162–168.
[13] Société Ciments de la Porte de France. Procédé de fabrication d'un liant à prise rapide résistant aux agents agressifs (Process for Making a Quick-Setting, Easily-Worked Acid-Resistant Cementitious Material). French Pat. 1,209,787, Sept. 21, 1959.

of which could be regulated, and dropped into a water filled container.[14]

To remove undissolved water from light liquid petroleum products, a carrier of 1-inch- to 20-mesh-blast-furnace slag was coated with sodium silicate. The resulting material was charged as a bed to the contacting tower, and the petroleum product was filtered through it at 80° to 105° F.[15]

Blast-furnace slag grit was used in British Admiralty tests to determine effectiveness of grit blasting on ships' hulls. Some abrasive particles were embedded, but use of a pretreatment primer before painting reduced paint breakdown.[16]

Various spectrographic methods of slag analysis were reviewed, and results of tests for accuracy and reproducibility of these methods were reported. Solution spectrography was considered to give more rapid and reliable results than either fusion methods or dry powder methods.[17]

A method was described by which the determination of calcium, aluminum, and magnesium in slags, sinters, and raw materials was made in 2 hours. A combination of ion exchange and complexometric methods was used. Methods of sample solution, preparation of reagents, and analytical procedures were given. Tables compared results with those obtained by standard methods.[18]

Grain strength tests on 11 grades of granulated slag of different origins and compositions were made using the Los Angeles test and the modified method of A. Hummel. A comparison was made of the exactness of information gained by each of these methods. The interrelation between strength and total porosity was described. Equipment used was illustrated.[19]

Laboratory studies by the U.S. Bureau of Public Roads on strength, durability, and other properties of air-entrained concretes prepared with portland blast-furnace slag cement were completed. It was concluded that slag-cement concrete had lower early strength but higher ultimate strength than comparable portland-cement concrete. Slag-concrete had greater durability under laboratory freezing and thawing tests. It was also determined that slag-cement with sufficiently high slag content might be suitable for use with highly alkali-reactive aggregate.[20]

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[14] Hüttenwerk, Salzgitter, A. G., Drutte 1, Germany. Improvements Relating to Processes and Apparatus for Granulating Metal and Slag Melts. British Pat. 873,394, July 26, 1961.

[15] Hunn, O. D. (assigned to Sinclair Refining Co., New York, N.Y.). Process for Dehazing Petroleum Hydrocarbons With Soluble Sodium Silicate. U.S. Pat. 2,973,279, Feb. 28, 1961.

[16] Rowlands, J. C. Paint Performance on Grit Blasted Ships' Hulls. J. Iron and Steel Inst., v. 199, pt. 4, pp. 329–333.

[17] Argyle, A. Spectrographic Analysis of Slags—The Present Position. Brit. Cast Iron Res. Assoc. J., v. 9, No. 3, May 1961, pp. 364–376.

[18] Lewis, L. L., M. J. Nardozzi, and L. M. Melnick. Rapid Determination of Aluminum, Calcium, and Magnesium in Raw Materials, Sinters, and Slags. Anal. Chem., v. 33, No. 10, September 1961, pp. 1351–1355.

[19] Kayser, W. Untersuchung zur Ermittlung der Stoffeigenshaften von Hüttenbims (Investigation of the Properties of Foamed-Slag). Stahl u. Eisen, v. 81, No. 19, September 1961, pp. 1288–1292.

[20] Grieb, W. E., and G. Werner. Final Report of Tests of Concrete Containing Portland Blast-Furnace Slag Cement. Public Roads, v. 31, No. 9, August 1961, pp. 183–193.

Sodium and Sodium Compounds

By Robert T. MacMillan [1] and Victoria R. Schreck [2]

OUTPUT of sodium carbonate decreased less than 1 percent in 1961, compared with 1960, but sodium sulfate increased nearly 7 percent. Natural sources of these commodities continued to play an increasingly important role in the total production.

LEGISLATION AND GOVERNMENT PROGRAMS

The Federal Bureau of Land Management proclaimed new rules governing the issuance of sodium prospecting permits. Under the new rules not more than 5,120 acres may be leased for sodium prospecting in any one State by a single individual, association, or corporation; except that 15,360 acres may be leased where it can be proved necessary for economic mining. The annual rental of 25 cents per acre placed sodium leases on the same basis as potassium. Each prospector was required to post a $1,000 bond.

On June 30, 1961, 986 sodium permits were in effect on 2 million acres of land administered by the Bureau of Land Management. Most of the permits were issued in California, Nevada, and Wyoming. Complete text of the amendments was published in the supplement to the Code of Federal Regulations.[3]

DOMESTIC PRODUCTION

Total output of soda ash (sodium carbonate) in 1961 was slightly below the 1960 output and considerably below the record high production of 1959. Soda ash from natural sources continued to hold about 15 percent of the total market although the upward trend in natural ash for several years was halted by a very slight production decrease in 1961.

There were several indications, however, that the slowing in natural soda ash production would be temporary. Expansion of the trona mine and plant of FMC Corp.[4] near Green River, Wyo., was in progress, and in the same formation but several miles away, the new

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.
[3] Code of Federal Regulations, Cumulative Pocket Supplement. Title 43, pt. 195, Jan. 1, 1962, pp. 165–171.
[4] Name changed May 23, 1961, from Food Machinery & Chemical Corp.

mine and refinery of Stauffer Chemical Co. was nearing completion.[5] Other chemical firms were reported to be interested in the Wyoming trona deposits.

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
1952-56 (average)	4,785	507	$12,878
1957	4,659	653	17,792
1958	4,324	629	17,032
1959	4,904	735	19,078
1960	4,558	809	20,865
1961	[4] 4,516	806	20,444

[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
1952-56 (average)	712	164	236	271	$4,453
1957	709	128	280	331	6,542
1958	640	106	255	347	6,716
1959	734	99	308	403	7,689
1960	738	72	303	450	8,706
1961	[3] 815	[3] 64	[3] 301	466	9,296

[1] Bureau of the Census.
[2] Includes glauber salt converted to 100-percent Na_2SO_4 basis.
[3] Preliminary figure.

To satisfy a growing preference among consumers for dense soda ash a leading producer of manufactured soda ash was reported to be doubling its production of the dense variety. Made from light ash, the denser product weighed about 66 pounds per cubic foot and was nearly twice as heavy as the light ash. Fewer storage, handling, and dusting problems were encountered with the dense ash. These advantages were worth the slightly higher price of the dense compared with the light ash.[6]

[5] Chemical & Engineering News. More Natural Soda Ash on the Way. V. 39, No. 43, Oct. 23, 1961, pp. 44, 46.
[6] Oil, Paint and Drug Reporter. Dense Ash Capacity Being Hiked by Solvay. V. 180, No. 22, Nov. 27. 1961, p. 3.

Natural sodium carbonate was produced from brines of Searles Lake and Owens Lake in California and from a large bedded deposit of trona in southwestern Wyoming. In California, Searles Lake brines were used to produce sodium carbonate and other chemicals by American Potash & Chemical Corp. at Trona and by Stauffer Chemical Co., West End Division, at Westend; Owens Lake was the source of sodium carbonate produced near Bartlett, Calif., by Pittsburgh Plate Glass Co., Chemical Division, formerly Columbia Southern Chemical Corp.

In Wyoming, Intermountain Chemical Co., a subsidiary of FMC Corp., mined trona at a depth of 1,500 feet from a 9- to 11-foot bedded deposit near Rock Springs (Sweetwater County). Most of the mine output was converted in the refinery to high-grade commercial soda ash.

Annual growth rate for the chlor-alkali industry as a whole was estimated at 4.5 percent for the period 1960–65. Soda ash growth was pegged at a modest 1.5 percent, caustic soda at 4.5 percent, and chlorine at 5 percent. Growth achieved by chlorine during the 1950's was 9.4 percent.[7]

Total output of sodium sulfate, including both the natural and by-product varieties, increased 7 percent in 1961, compared with the preceding year. The production increase from natural sources was only 4 percent, the smallest gain from this source in several years. Natural sources of sodium sulfate supplied nearly 41 percent of the total output.

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 State Borax & Chemical Corp. produced sodium sulfate as a coproduct in making boric acid from borax. In Wyoming, William E. Pratt and the Sweetwater Chemical Co. produced sodium sulfate from semi-dry lakebeds.

In Texas, Ozark-Mahoning Mining Co. produced sodium sulfate from subterranean brines at Monahans and Brownfield. A 50 percent expansion of the Brownfield plant was completed in 1961, boosting the output to 115,000 tons. Output of the Monahans plant was about 40,000 tons.[8]

Additional sodium sulfate capacity also was being installed by Stauffer Chemical Co., West End Division, at Westend, Calif. The expansion was said to raise the sodium sulfate output of the plant to 200,000 tons per year.[9]

Figures on the production of metallic sodium for 1961 were withheld to avoid disclosing individual company confidential data. Three companies were reported to be in production: E. I. du Pont de Nemours & Co., Inc., with plants at Niagara Falls, N.Y., and Memphis, Tenn.; Ethyl Corp., with plants at Baton Rouge, La., and Houston, Tex.; and National Distillers & Chemical Co., at Ashtabula, Ohio.

[7] Chemical & Engineering News. Chlor-Alkali Growth Pegged at 4.5%. V. 3, No. 22, May 29, 1961, p. 25.
[8] Chemical Week. Salt Cake. V. 89, No. 22, Dec. 2, 1961, p. 30.
[9] Mining World. What's Going on in Mining—California. V. 23, No. 1, January 1961, p. 47.

CONSUMPTION AND USES

The largest use of sodium carbonate continued to be in the manufacture of glass which consumed an estimated 40 percent of the total production. Glass containers consumed the greatest quantity of soda ash; plate glass—particularly automobile glass—was also an important consumer. Manufacture of chemicals consumed about one-third of the soda ash output. Sodium tripolyphosphates, sodium silicates, sodium bicarbonate, and lime-soda caustic were the chief chemical outlets for soda ash. The abundance of caustic soda from the increasing number of electrolytic chlor-alkali plants continued to lessen the demand for caustic from lime-soda caustic plants. However, increasing demand for soda ash from the phosphate and silicate industries tended to offset the declining lime-soda caustic industry.

Other uses of soda ash were in pulp and paper manufacture, water treatment, nonferrous metal production, cleaners, soap, textiles, and dyes. Increasing use of liquid detergents resulted in greater use of potassium compounds for this purpose at the expense of sodium compounds.[10]

The chief use of sodium sulfate continued to be in the kraft paper industry where sodium sulfate is added to pulpwood digesters to aid in dissolving lignin and releasing cellulose fibers. An estimated 70 percent of the total sodium sulfate output was consumed by this industry. Other uses of this chemical were in manufacturing glass, ceramic glazes, detergents, stock feeds, dyes, textiles, medicines, and miscellaneous chemicals.

Metallic sodium was used chiefly in producing tetraethyl lead (TEL) and tetramethyl lead (TML), two compounds added to motor fuels to increase their antiknock rating. Formerly, TEL was used almost exclusively to improve the antiknock characteristics of motor fuels; however, TML began to be used in substantial quantities in 1960 and indications were that it would provide strong competition for TEL. Several blends of the two agents together with scavenging agents were available.

The supply-demand outlook for TEL and TML was clouded by technological changes brought about by the increasing use of jet aircraft, which use no antiknock fuel additives, and smaller automobiles, which require less of the additives. Nevertheless several new TML plants were planned or under construction.[11]

Metallic sodium also was used in metal descaling, in ore reduction, and in making sodium peroxide, hydride, amide, cyanide, borohydride, and other chemicals.

[10] Oil, Paint and Drug Reporter. Heavy Chemicals. V. 179, No. 17, Apr. 24, 1961, p. 35.
[11] Chemical & Engineering News. New Producers Invade Faltering TEL Market. V. 39, No. 21, May 22, 1961, pp. 25–26.

PRICES

Prices quoted for sodium carbonate, sodium sulfate, and sodium by Oil, Paint and Drug Reporter were mostly unchanged from 1960. Prices for these commodities in 1961 were as follows:

Commodity:		Price
Sodium carbonate (soda ash 58 percent Na_2O):		
Light, paper bags, carlots	per hundredweight	$1.85
Light, bulk	do	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
N.F.VII, drums	per pound	.22½
Metallic sodium:		
Bricks, lots of 18,000 pounds and over, works	do	.21
Fused, lots of 18,000 pounds and over, works	do	.19½
Bulk, tank, works	do	.17

[1] Delivered east of Mississippi River.

FOREIGN TRADE [12]

Imports of sodium sulfate continued the upward trend of the last 5 years with a 17-percent gain in 1961 and were about 15 percent of the combined imports and production; Belgium and Luxembourg supplied 47 percent of total imports and Canada, 43 percent. The remaining tonnage was supplied by the Netherlands, West Germany, and the United Kingdom.

Exports of sodium sulfate were slightly greater in 1961 but were only 3 percent of the domestic production. Sodium carbonate exports decreased about 15 percent compared with 1960, and were only 3 percent of domestic output.

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
1952-56 (average)	88	$1,640	5	$134	93	$1,774
1957	73	1,450	2	61	75	1,511
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

[1] Includes glauber salt, as follows: 1958, 12 tons, at $830; 1959, 227 tons, at $4,839; 1960, 7 tons, at $479; 1961, none.

Source: Bureau of the Census.

[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. Dept. of Commerce, 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
1952-56 (average)	166	$5,706	27	$863
1957	174	6,282	24	859
1958	104	4,279	20	786
1959	153	5,644	22	805
1960	155	5,143	31	940
1961	132	4,045	32	992

Source: Bureau of the Census.

WORLD REVIEW

Continued industrial growth throughout the world was reflected in the number of new plants opened in 1961 for producing basic sodium compounds. Sodium carbonate, sodium sulfate, and caustic soda and chlorine were produced in several countries that had previously depended entirely on imports for such basic chemicals. In other countries, existing plants were expanded or additional plants were built.

Because of demand for chlorine for plastics, bleaches, insecticides, bactericides, and many other uses most of the new plants were of the chlorine-caustic soda type instead of the ammonia-soda design. However, several new facilities for producing sodium sulfate and soda ash were reported.

A partial list of new or expanded sodium compounds plants in various countries is as follows:

Country	Area	Plant type	Firm	Development stage
Brazil	Cubatao, near Sao Paulo.	Caustic-chlorine	Diamond Alkali International Corp.	Under construction.
Canada	Trail, British Columbia.	do	Consolidated Mining & Smelting Corp.	Do.
Do	New Brunswick	do	Canadian Industries, Ltd.	Planned.
Do	Bishopric, Saskatchewan.	Sodium sulfate	Saskatchewan Minerals.	Rehabilitated.
Germany, West	Uerdingen	Caustic-chlorine	Farbenfabriken Bayer A. G.	Expanded.
India	Shahpura	Heavy soda ash	Sahu Chemicals & Fertilizers.	Inaugurated.
Korea, South		Caustic soda, soda ash.	Toyo Chemical Industries.	Planned.
Peru		Caustic-chlorine	W. R. Grace & Co.	Opened.
Philippines	Iligan City, Mindanao.	Hydrochloric acid, caustic soda.	Mabuhay Rubber Corp.	Under construction.
United Arab Republic	Al Maks, Alexandria.	Caustic-chlorine	Misr Chemical Industries Co.	Opened.

TECHNOLOGY

Plant-scale tests on substituting platinized titanium for graphite anodes in the electrolysis of brine to produce caustic soda and chlorine showed significant savings in the consumption of anodes, dia-

phragms, and power. Increases in the quality and quantity of the chlorine output per cell made possible by the new anodes were even more important to chlorine-caustic producers. Weighed against these advantages were the high capital investment in the new electrodes and the need for completely redesigning the cells in order to take full advantage of the new electrodes.[13]

Chlorine-caustic electrolytic cells are used almost exclusively in electrolyzing salt brine to produce nearly 5 million tons of caustic soda and an equivalent tonnage of chlorine each year. The cells are of two types, diaphragm and mercury. Both have graphite anodes that erode slowly during the operation of the cell. The disintegration products tend to clog the cell diaphragms and contaminate the chlorine. Power requirements are increased as the graphite anodes wear away enlarging the space between the electrodes.

Platinized titanium anodes function satisfactorily in both types of cells and, as they do not erode, the power requirements remain relatively constant.

Titanium was used as the backup metal because it resists chlorine corrosion by forming a tough oxide film. To overcome the electrical resistance of this film a thin platinum coating (10 to 250 microinches thick) is applied to the surface of the titanium. Erosion of this coating is so slight that no more than 0.5 gram is lost per ton of chlorine output. Platinized titanium anodes lasted 25 percent longer than graphite, offered less resistance to the removal of chlorine, and eliminated the need for electrode gap readjustment mechanisms.

Although producers exhibited much interest in the platinized titanium anodes, further tests were needed for their full evaluation.[14]

The demand for new sources of power needed for defense and rapidly developing space technology encouraged experimental work to produce a practical fuel cell. The high position of sodium on the electromotive series of the elements gives it an advantage over most other elements, including hydrogen, when used to power fuel cells. In small-scale tests the chemical reactivity of sodium was controlled by introducing the sodium into the cell as a dilute mercury amalgam. Open-circuit voltage of a sodium-oxygen cell was 2 volts—nearly twice the voltage produced by a hydrogen-oxygen cell. The weight, including fuel, of a sodium-oxygen fuel cell was reported to be 2 to 3 pounds per kilowatt-hour (kwhr); current densities up to 400 amperes per square foot at 1.5 volts were attained. Chief disadvantage of the system was the high cost of the sodium fuel. For commercial application the cost of power generated by the system was estimated at $0.20 per kwhr.[15]

Reacting sodium amalgam with chlorine or bromine as the oxidizing agent in a fuel cell produced higher voltages than the sodium-oxygen cell. An experimental 1-watt cell using sodium amalgam and chlorine produced 3.3 volts on open circuit.[16]

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[13] Chemical Week. Platinum Anode Wins Chlorine Test. V. 88, No. 12, Mar. 25, 1961, pp. 153–154, 158, 160.

[14] Chemical Engineering. Chlorine Makers View Metal Anode With Interest But Stress the Need for More Evaluation. V. 69, No. 2, Jan. 22, 1962, pp. 68–69.

[15] Chemical Engineering. For Economical Fuel-Cell Power Find a Cheap Source of Sodium. V. 68, No. 1, Jan. 9, 1961, p. 38.

[16] Chemical Engineering. Sodium-Chlorine System Boosts Limit on Fuel Cell Voltage, Power Output. V. 68, No. 12, June 12, 1961, p. 104.

Successful operation of a sodium-graphite nuclear reactor experiment was described.[17] Metallic sodium melts at 207.5° F and boils at about 1,600° F. This large temperature span, in which sodium is liquid, makes it a desirable fluid for removing heat at high temperatures from reactor cores without the necessity of pressurizing the vessel. Core operation near 1,000° F was successful without pressurizing in a sodium-cooled reactor.

Graphite is the moderator in this type of reactor designated SRE. Intermittent operation since 1957 demonstrated that high quality superheated steam for power generation may be produced in a system powered by a sodium-cooled graphite-moderated reactor. Methods of core maintenance of the reactor and of handling high-purity sodium were developed that made possible the design of similar reactors which may be capable of competing successfully with conventional powerplants.

A patent was issued for producing dense soda ash from crude trona by a cyclic process.[18] Calcining sodium sesquicarbonate crystals normally produces light soda ash while the more desirable dense ash is produced by calcining sodium carbonate monohydrate. A method was described by which the monohydrate may be crystallized by reacting light ash, produced in one part of the process, with recirculating mother liquor used to dissolve crude trona.

An improvement was patented in processing sodium tripolyphosphate from crude trona.[19] Treating sodium carbonate produced from trona with chlorine or bromine at temperatures between 150° and 400° C was found to increase the reflectance and foaming characteristics of sodium tripolyphosphate subsequently produced from the treated sodium carbonate.

Alkali sulfates—particularly those of sodium and potassium—were found to be the cause of unsightly white efflorescent deposits, often found on exposed brick surfaces. Portland cement used in the mortar and grout between the bricks was the source of the sulfates. Controlling brick efflorescence in test walls was accomplished by introducing a compound into the mortar or grout which precipitated or immobilized the sulfate ion.[20]

Practical means for recovering sodium hydroxide and sulfuric acid from waste sodium sulfate solutions were claimed by an engineer at the University of Budapest. The process, an electrolytic one, was designed to use waste sodium sulfate solutions of viscose plants. A stream of 40-percent sulfuric acid strong enough to be used in viscose preparation was produced by the process. The cell contained a mercury cathode, and the sodium-mercury amalgam produced by the electrolysis constantly flowed to a decomposition chamber, where the sodium was reacted with water producing 60-percent sodium hydroxide and hydrogen gas.[21] Oxygen also was a byproduct of the process.

[17] Durand, R. E. Sodium Reactor Operating Experience. Chem. Eng. Prog., v. 57, No. 3, March 1961, pp. 54–59.
[18] Caldwell, N. A., and W. C. Bauer (assigned to FMC Corp., New York, N.Y.). Trona Process. U.S. Pat. 2,970,037, Jan. 31, 1961.
[19] Osborne, Roy T. (assigned to FMC Corp., New York, N.Y.). Deactivation of Color Forming and Foam Stabilizing Bodies in Sodium Carbonate Produced From Trona. U.S. Pat. 2,989,369, June 20, 1961.
[20] Brick and Clay Record. Solution Near on Efflorescence Research. V. 138, No. 4, April 1961, p. 61.
[21] Chemical Engineering. Two-Stage Process Recovers Sulfuric Acid From Na_2SO_4. V. 68, No. 11, May 29, 1961, pp. 48, 50.

Stone

By Perry G. Cotter [1] and Nan C. Jensen [2]

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ALTHOUGH the value of new construction put-in-place in 1961 was 3 percent greater than in 1960, production of stone decreased. This apparent statistical inconsistency may have been due to the increased use of certain prefabricated construction units and to the use of various stone substitutes. Output of dimension stone increased 3 percent in volume and 2 percent in value.

Starts for new housing increased 5 percent in value, but part of this rise was directly related to higher land prices.

TABLE 1.—Salient stone statistics in the United States [1]

(Thousand short tons and thousand dollars)

	1952–56 (average)	1957	1958	1959	1960	1961
Sold or used by producers:						
Dimension stone	2,397	2,456	2,522	2,442	2,257	2,315
Value	$73,630	$83,688	$80,254	$87,571	$86,009	$88,093
Crushed stone	404,205	530,967	533,401	581,721	[2] 614,527	613,073
Value	$555,345	$741,714	$746,431	$824,411	[2] $866,546	$862,467
Total stone	406,602	533,423	535,923	584,163	[2] 616,784	615,388
Value	$628,975	$825,402	$826,685	$911,982	[2] $952,555	$950,560
Imports for consumption (value) [3]	$5,575	$8,792	$8,312	$11,064	$11,344	$12,268
Exports (value)	$4,665	$6,013	$6,756	$7,292	[2] $6,166	$6,648

[1] Includes slate. 1952–56 includes Territories of the United States, possessions, and other areas administered by the United States.
[2] Revised figure.
[3] Includes whiting.

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[2] Supervisory statistical assistant, Division of Minerals.

The Calcite Quarry, Michigan Limestone Division, U.S. Steel Corp., at Rogers City, Mich., won top honors in the 37th National Safety Competition sponsored by the Federal Bureau of Mines. This quarry operated 922,297 man-hours without a disabling injury.

TABLE 2.—Stone sold or used by producers in the United States, by States

(Thousand short tons and thousand dollars)

State	1960		1961	
	Quantity	Value	Quantity	Value
Alabama	13,503	$19,970	[1] 13,651	[1] $19,909
Alaska	275	852	[2]	[2]
Arizona	4,249	5,107	3,582	4,626
Arkansas	10,939	13,555	12,029	12,402
California	33,075	49,842	33,850	50,327
Colorado	2,442	4,651	2,451	5,301
Connecticut	5,057	8,313	5,206	8,616
Delaware	[2]	[2]	[2]	[2]
Florida	[1] 27,629	[1] 37,419	[1] 28,855	[1] 36,305
Georgia	14,297	37,033	[1] 15,854	[1] 38,077
Hawaii	3,535	6,443	4,429	7,656
Idaho	1,318	2,141	1,873	3,111
Illinois	41,721	55,593	36,361	47,939
Indiana	18,956	34,920	18,001	33,062
Iowa	23,185	30,321	22,018	28,916
Kansas	[1] 11,814	[1] 15,031	[1] 12,328	[1] 16,411
Kentucky	[1] 15,810	[1] 21,493	17,085	23,309
Louisiana	[1] 4,691	[1] 8,882	[1] 4,641	[1] 7,656
Maine	1,012	3,851	998	4,694
Maryland	7,944	16,962	10,671	21,203
Massachusetts	5,247	12,782	5,210	13,399
Michigan	31,256	32,274	28,731	30,103
Minnesota	4,234	10,034	3,957	9,975
Mississippi	807	808	913	1,044
Missouri	27,180	37,878	25,631	36,577
Montana	1,183	1,576	1,512	1,849
Nebraska	3,336	5,651	3,622	6,324
Nevada	579	1,350	677	1,576
New Hampshire	104	594	117	684
New Jersey	10,202	22,814	11,315	24,539
New Mexico	1,277	1,692	1,853	2,206
New York	29,802	46,955	26,951	43,734
North Carolina	14,721	23,296	15,921	25,262
North Dakota	28	44	40	40
Ohio	[1] 35,856	[1] 59,479	33,652	55,701
Oklahoma	[1] 14,054	[1] 16,098	14,981	16,561
Oregon	[3] 16,913	[3] 19,721	17,272	20,939
Pennsylvania	42,136	74,168	41,834	71,344
Rhode Island	1,810	4,372	[2]	[2]
South Carolina	[1] 5,994	[1] 8,178	[1] 5,511	[1] 7,461
South Dakota	3,149	7,909	2,806	6,642
Tennessee	20,074	29,942	23,940	35,906
Texas	39,029	45,088	38,316	45,874
Utah	1,837	3,087	1,808	3,219
Vermont	2,114	17,444	2,731	18,715
Virginia	[3] 19,358	[3] 33,019	22,934	39,206
Washington	13,897	15,796	11,464	14,758
West Virginia	[1] 8,001	[1] 14,001	7,628	13,244
Wisconsin	16,486	22,302	13,418	19,686
Wyoming	1,401	2,302	2,594	3,315
Undistributed	3,267	9,522	4,166	11,157
Total	[3] 616,784	[3] 952,555	615,388	950,560
American Samoa	523	261	362	286
Guam	962	2,194	292	591
Johnston Island	2	5	1	2
Midway Island			11	34
Panama Canal Zone	203	306	163	271
Puerto Rico	4,219	7,661	5,049	7,284
Virgin Islands	15	51	20	75
Wake Island	36	49	24	62

[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] Figure withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[3] Revised figure.

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
1952–56 (average)	24,987	$57,785	32,914	$52,334	654	$15,008	300,251	$411,106	[1] 15,780	[1] $22,106
1957	41,636	75,985	43,798	72,869	1,423	23,707	383,022	532,863	19,098	27,563
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	[2] 42,748	[2] 89,654	57,884	87,699	1,644	31,060	451,253	623,437	18,934	33,706
1961	44,058	93,873	63,257	96,140	1,592	30,960	438,253	608,139	20,973	33,009

Year	Calcareous marl		Sandstone		Slate		Other stone [3]		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1952–56 (average)	([4])	([4])	11,196	$34,722	721	$12,577	20,099	$23,337	406,602	$628,975
1957	1,916	$1,804	16,294	49,102	632	11,029	25,604	30,480	533,423	825,402
1958	1,803	1,660	24,973	53,677	638	11,459	20,178	25,848	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	[2] 21,493	[2] 27,642	[2] 616,784	[2] 952,555
1961	1,099	987	23,386	49,114	496	9,334	22,274	29,004	615,388	950,560

[1] Average for 1954–56 only. Data not available, 1952–53.
[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] Calcareous marl for agricultural use not included in stone; marl used in making cement, 1954–56, included with limestone.

LEGISLATION AND GOVERNMENT PROGRAMS

Apportionment of $3.3 billion was authorized for Federal aid to States for continuing the National Highway Program during fiscal year 1963. The new appropriation included $2.4 billion for the Interstate System.[3]

The Bureau of Public Roads reported that nearly 11,000 miles of the National System of Interstate and Defense Highways was completed and open to traffic as of June 30, 1961, and 4,849 miles was under construction. Engineering work and right-of-way clearance was underway on 10,000 miles of the System.[4] The remaining mileage, on which no work was in progress, amounted to 15,300 miles. Under the Federal-Aid Primary and Secondary Highway System Program, 119,361 miles of intrastate highways was completed as of June 30, 1961.[5]

The new Federal Highway Act of 1961 provided for the appropriation of $25.3 billion for interstate roads during the next 9 years.[6]

[3] American Highways. Final Apportionment of Federal Aid Highway Funds Authorized for the Fiscal Year 1963. V. 40, No. 4, October 1961, p. 33.
[4] American Highways. National System of Interstate and Defense Highways, Status of Improvement as of June 30, 1961. V. 40, No. 4, October 1961, p. 6.
[5] American Highways. Federal-Aid Primary and Secondary Highway Systems, Active and Completed Projects Financed with Primary, Secondary, and Urban Funds. V. 40, No. 4, October 1961, p. 9.
[6] American Road Builder. Principal Provisions of the New Highway Act. V. 38, No. 7, July 1961, p. 6.

DIMENSION STONE

Production of dimension stone was 2,315,000 short tons valued at $88 million, an increase of 3 percent in tonnage and 2 percent in value as compared with 1960. Of the 597 plants operating in 44 States, the 164 plants in Georgia, Indiana, Ohio, Pennsylvania, and Vermont accounted for over half the tonnage and value of dimension stone.

The term dimension stone identifies the various natural stones prepared by sawing, cutting, polishing, and rubbing, in accordance with a particular shape or dimension, usually for a specific order. Although some quarries maintained small stocks of rough blocks, production and use were clearly coordinated. The value of dimension stone used for memorials and buildings was directly related to the amount of work expended in processing it, although some stones, because of rarity or beauty, commanded higher prices.

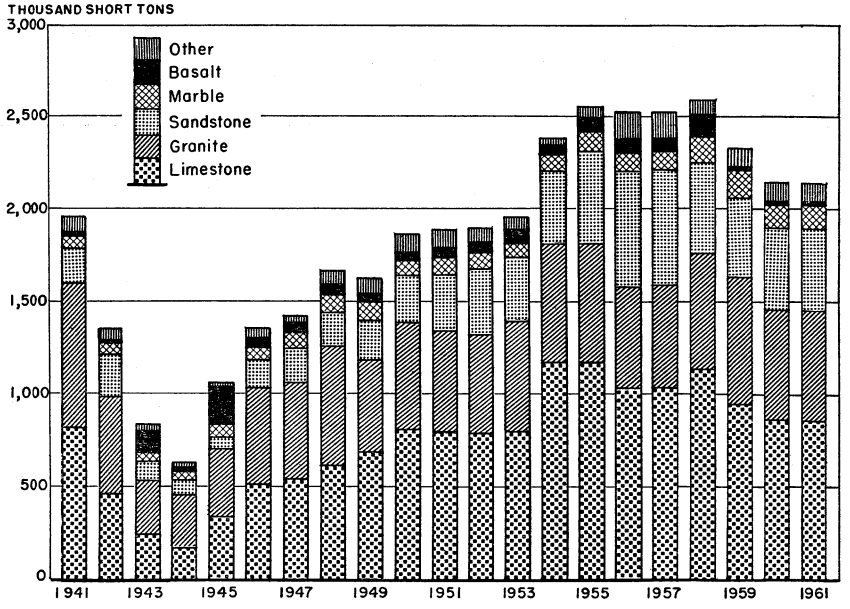


FIGURE 1.—Sales of dimension stone, except slate, in the United States, by kinds, 1941–61.

Trends in Use.—The continuing growth of memorial parks and other types of cemeteries that restricted memorials to flat ground-level stones reduced the market for monuments and mausoleums. Dimension stone producers also faced challenging competition from certain types of substitute materials, including ceramic tile, glass curtain walls, porcelain enamels, steel panels, aluminum, and precast concrete.

TABLE 4.—Dimension stone sold or used by producers in the United States, by uses

Use	1960			1961		
	Thousand short tons	Thousand cubic feet	Value (thousands)	Thousand short tons	Thousand cubic feet	Value (thousands)
Building:						
Rough:						
Construction	200		$1,853	197		$2,114
Architectural [1]	378	5,010	7,112	353	4,692	6,722
Dressed:						
Sawed [1]	555	7,276	20,305	489	6,355	19,242
Cut	183	2,364	23,683	201	2,514	26,688
Rubble	330		1,743	424		2,143
Roofing (slate)	25		1,611	31		1,796
Millstock (slate)	23		3,053	26		3,202
Monumental (rough and dressed) [2]	221	2,683	19,254	226	2,745	18,770
Paving blocks [3]	31		131	76		295
Curbing	157	1,891	3,929	149	1,807	3,862
Flagging [4]	154	1,033	3,335	143	939	3,259
Total	2,257		86,009	2,315		88,093

[1] Includes stone for refractory use to avoid disclosing individual company confidential data.
[2] Includes stone for precision surface plates.
[3] Includes a substantial quantity of blocks for other uses.
[4] Includes a small quantity of slate for miscellaneous uses.

For example, the largest and tallest office building in Indiana was almost entirely encased in glass. The 28-story building, of modular construction, was faced with insulating glass supported on an aluminum grid. Using this type of glass reduced the cost of air-conditioning and heating.[7]

Use of lightweight concrete for construction was expanding, and frequently the material was combined with facings of natural stone slabs for protection and ornamentation.

A method for making and setting marble-faced concrete panels for wall facings was developed.

The increased use of modular construction by architects and builders, in efforts to counteract increasing labor costs, affected producers of building stone. To meet this challenge of changing construction patterns, many domestic producers of native building stone were importing different varieties of marble, granite, and other stones specified by architects.

GRANITE

Production of dimension granite increased 10 percent in volume and 6 percent in value compared with 1960. Substantial increases were reported in production of dressed construction and architectural granite. Georgia, Massachusetts, Texas, Vermont, and Minnesota were leading producers in tonnage. Vermont, with eight active plants, reported the highest total value.

[7] Hegg, Clinton F. Glass Curtain Wall Horizons Expanding. American Glass Rev., v. 82, No. 1, July 1961, pp. 30, 51.

TABLE 5.—Granite (dimension stone) sold or used by producers in the United States, by uses

Use	1960			1961		
	Thousand short tons	Thousand cubic feet	Value (thousands)	Thousand short tons	Thousand cubic feet	Value (thousands)
Building:						
Rough:						
Construction	62		$629	41		$541
Architectural	30	357	1,031	23	271	867
Dressed:						
Construction	20	237	1,255	23	279	1,952
Architectural	33	403	5,294	43	518	7,015
Rubble	67		244	102		438
Monumental: [1]						
Rough	157	1,910	7,997	164	1,989	7,876
Dressed	50	608	8,412	48	578	8,036
Paving blocks [2]	31		131	76		295
Curbing and flagging	150	1,814	3,780	142	1,714	3,552
Total	600		28,773	662		30,572

[1] Includes stone for precision plates.
[2] Includes substantial quantity of blocks for other uses.

TABLE 6.—Granite (dimension stone) sold or used by producers in the United States in 1961, by States

State	Active plants	Short tons	Value	State	Active plants	Short tons	Value
California	8	24,145	$896,692	Pennsylvania	4	11,948	$46,202
Colorado	3	1,078	109,465	South Dakota	8	17,908	2,808,089
Connecticut	5	5,991	196,637	Texas	5	82,667	1,807,317
Georgia	29	169,387	4,292,474	Vermont	8	78,455	5,119,551
Maine	7	24,630	2,775,459	Washington	4	1,486	10,953
Massachusetts	10	110,932	3,953,208	Wisconsin	8	8,095	1,524,639
Minnesota	24	41,430	3,090,098	Other States [1]	17	58,818	2,703,162
Missouri	1	2,624	291,234				
New York	3	17,395	285,505	Total	150	662,328	30,572,305
Oklahoma	6	5,339	661,620	Puerto Rico		6,378	24,740

[1] Includes New Hampshire, 2 plants; North Carolina, 10; Rhode Island, 1; and South Carolina, 4.

BASALT AND RELATED ROCKS (TRAPROCK)

Total output of basalt decreased slightly from the 14,000 tons reported for 1960, but value increased 27 percent to $462,000. The increase in value was due to greater production of dressed architectural stone, which almost doubled. Production of dressed building and monumental stone and precision plates (1,655 short tons valued at $383,680) increased 32 percent in tonnage and 35 percent in value over 1960. Rough-construction stone and rubble was almost 11,500 tons, valued at $78,000.

MARBLE

Production of dimension marble increased 22 percent in quantity and 5 percent in value compared with 1960. Average value of cut and dressed building marble was $18.81 per cubic foot, a decrease of $2.34 per cubic foot from 1960; the value of rough architectural building marble decreased $1.34 per cubic foot.

By mineralogical definition marbles are highly crystalline rocks developed from sedimentary limestones or dolomites by heat and pressure. Commercially the term was used to include a wide variety

of stones—onyx, travertine, and serpentine—which can be highly polished and which present an attractive appearance.

Colorado Yule marble and Carthage marble were used for interior walls of the new extension of the U.S. Capitol.

The original badly weathered statues of the "God of War" and "Goddess of Peace" which dominated the main entrance of the Capitol in Washington, D.C., since 1835, were replaced by exact duplicates carved from Vermont Imperial Danby marble.

Marble was used in every important commercial building constructed in New York City during the past 5 years according to a survey by the Marble Industry Board.[8]

TABLE 7.—Marble (dimension stone) sold or used by producers in the United States, [1] by uses

Use	1960			1961		
	Thousand short tons	Thousand cubic feet	Value (thousands)	Thousand short tons	Thousand cubic feet	Value (thousands)
Building: [2]						
Rough: Architectural	20	229	$925	37	433	$1,168
Dressed:						
Sawed	54	638	3,700	54	631	3,123
Cut	42	493	10,427	52	614	11,547
Monumental (rough and finished)	13	156	2,691	14	169	2,728
Total	129		17,743	157		18,566

[1] Produced by the following States in 1961 in order of value and with number of plants: Vermont, 7; Georgia, 1; Tennessee, 12; Missouri, 4; Alabama, 2; Arkansas, 1; North Carolina, 1; California, 2; Washington, 2; Colorado, 2; Maryland, 1; and New Mexico, 2.
[2] Includes: 1960—748,000 cu. ft., $7,242,000, for exterior use, and 612,000 cu. ft., $7,810,000, for interior use; 1961—1,190,000 cu. ft., $8,934,000 for exterior use, and 488,000 cu. ft., $6,904,000, for interior use.

LIMESTONE

Both hand-cut and machine-shaped limestones were used for building construction. Production decreased slightly in both tonnage and value during 1961. Average value was $19.57 per ton compared with $19.93 per ton in 1960. Seven fewer plants operated than in

TABLE 8.—Limestone (dimension stone) sold or used by producers in the United States, by uses

Use	1960			1961		
	Thousand short tons	Thousand cubic feet	Value (thousands)	Thousand short tons	Thousand cubic feet	Value (thousands)
Building:						
Rough:						
Construction	54		$213	61		$323
Architectural	235	3,238	3,378	223	3,057	3,455
Dressed:						
Sawed	303	4,118	7,766	259	3,475	6,791
Cut	62	849	5,006	71	941	5,275
Rubble	177		532	219		725
Curbing and flagging	29	373	245	22	285	169
Total	860		17,140	855		16,738

[8] Stone Magazine. Apprenticeship Program Produces Skilled Marble Craftsmen. V. 81, No. 12, December 1961, p. 14.

1960. The Bedford-Bloomington, Ind., oolitic limestone district produced 78 percent of the rough-block and dressed limestone in the United States at an average value of $25.16 per ton.

TABLE 9.—Limestone (dimension stone) sold or used by producers in the United States in 1961, by States

State	Active plants	Short tons	Value	State	Active plants	Short tons	Value
California	7	12,447	$34,505	Oklahoma	3	2,716	$23,946
Illinois	7	22,624	232,529	Tennessee	1	108	6,276
Indiana	19	535,898	10,971,730	Texas	5	22,624	807,850
Iowa	3	9,901	150,850	Utah	1	40	1,400
Kansas	5	11,269	140,966	Wisconsin	27	82,961	1,464,664
Michigan	5	27,516	119,950	Other States [1]	4	57,855	923,889
Minnesota	8	34,294	1,740,928				
Missouri	7	23,305	86,587	Total	108	855,215	16,738,361
New York	1	277	3,333	Puerto Rico		61,403	136,241
Ohio	5	11,380	28,958				

[1] Includes Alabama, 1 plant; Florida, 1; Pennsylvania, 1; and Rhode Island, 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)
1952-56 (average)	2,620	$3,039	3,443	$5,784	858	$4,827
1957	2,937	2,928	3,289	6,044	1,007	6,106
1958	2,941	2,967	3,007	5,104	725	4,273
1959	2,719	2,731	3,380	6,037	951	5,443
1960	2,817	2,934	2,846	5,340	528	3,005
1961	2,820	3,159	2,498	4,675	497	2,784

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)
1952-56 (average)	6,921	502	$13,650	166	$409	668	$14,059
1957	7,233	524	15,078	161	388	685	15,466
1958	6,673	484	12,344	168	449	652	12,793
1959	7,050	511	14,211	155	432	666	14,643
1960	6,191	449	11,279	139	413	588	11,692
1961	5,815	422	10,618	161	515	583	11,133

SANDSTONE

The volume of dimension sandstone decreased 11 percent in 1961, and the price was 4 percent lower than in 1960. Increased production and value were reported for both curbing and rough construction sandstone. Active producing plants numbered 183 or 10 more than in 1960. Ohio continued as the leading producing State, followed in order of value of output by New York, Tennessee, and Pennsylvania. Average value increased from $26.29 in 1960 to $28.50 per ton in 1961.

TABLE 11.—Sandstone (dimension stone) sold or used by producers in the United States, by uses

Use	1960			1961		
	Thousand short tons	Thousand cubic feet	Value (thousands)	Thousand short tons	Thousand cubic feet	Value (thousands)
Building:						
Rough:						
Construction	73		$960	83		$1,173
Architectural [1]	93	1,186	1,778	70	931	1,232
Dressed:						
Sawed [1]	125	1,659	4,219	106	1,417	4,226
Cut	46	613	2,826	34	431	2,597
Rubble	48		309	41		368
Curbing	2	21	67	7	93	310
Flagging	52	638	1,382	50	607	1,228
Total	439		11,541	391		11,134

[1] Includes stone for refractory use to avoid disclosing individual company confidential data.

TABLE 12.—Sandstone (dimension stone) sold or used by producers in the United States in 1961, by States

State	Active plants	Short tons	Value	State	Active plants	Short tons	Value
Alabama	1	600	$3,547	New Mexico	2	89	$1,341
Arizona	13	10,294	97,867	New York	14	46,591	1,351,679
Arkansas	7	16,106	182,392	Ohio	20	97,060	5,711,244
California	9	2,863	76,032	Pennsylvania	30	77,873	734,242
Colorado	17	12,865	219,493	Tennessee	11	40,512	1,104,551
Georgia	2	2,165	31,452	Utah	6	4,793	151,202
Kansas	1	425	8,207	Virginia	2	239	3,475
Kentucky	3	1,720	26,940	West Virginia	4	4,335	64,134
Massachusetts	1	1,703	52,600	Wisconsin	10	3,388	50,178
Michigan	6	7,045	54,057	Other States [1]	17	54,422	1,103,652
Missouri	3	2,948	41,690				
Nevada	4	2,634	64,188	Total	183	390,670	11,134,163

[1] Includes Indiana, 6 plants; Maryland, 1; Mississippi, 1; Oklahoma, 1; Texas, 1; Washington, 4; and Wyoming, 3.

SLATE

Production of dimension slate increased 4 percent in tonnage and 7 percent in value. Pennsylvania, Vermont, Virginia, and New York continued to be the leading producers. The average price of roofing slate declined from $24.41 per thousand squares in 1960 to $22.17; the average price for all types of dimension slate was $54.43 per ton compared with $53.10 per ton in the previous year.

Very little change was noted in the production of slate for most uses in 1961, but there was increased demand for slabs for billiard and pool tables.

Black Virginia slate was used in the First Congregational Church of Washington, D.C., for flooring, pew ends, sanctuary, and altar floor.[9]

The Virginia Polytechnic Institute published an article on the slate industry in that State.[10]

[9] Stone Magazine. Pew Ends of Natural Cleft Slate Designed by Architect. V. 81, No. 7, July 1961, p. 31.

[10] Redden, J. A. Slate in Virginia. Mineral Industries J., Virginia Polytechnic Inst., v. 8, No. 3, September 1961, pp. 1–5.

TABLE 13.—Slate (dimension stone) sold or used by producers in the United States, [1] by uses

Use	1960			1961		
	Quantity		Value (thousands)	Quantity		Value (thousands)
	Thousand short tons	Unit of measurement		Thousand short tons	Unit of measurement	
Roofing slate	25	*Thousand squares* 66	$1,611	31	*Thousand squares* 81	$1,796
Millstock:		*Thousand sq. ft.*			*Thousand sq. ft.*	
Electrical, structural, and sanitary slate	20	2,395	2,067	22	2,313	2,141
Blackboards and bulletin boards [2]	3	1,206	939	3	1,272	912
Billiard tabletops	(3)	60	47	1	175	149
Total millstock	23	3,661	3,053	26	3,760	3,202
Flagstones [4]	59	11,501	1,329	57	11,879	1,465
Miscellaneous uses [5]	12	----------	326	10	----------	286
Grand total	119	----------	6,319	124	----------	6,749

[1] Produced by the following States in 1961 in order of value of output and with number of plants: Pennsylvania, 10; Vermont, 14; Virginia, 2; New York, 12; Maine, 1; North Carolina, 2; and California, 2.
[2] Includes small quantity of school slates.
[3] Less than 500 tons.
[4] Includes slate used for walkways and stepping stones.
[5] Includes slate for aquarium bottoms, buildings, fireplaces, flooring, headstones, shims, and unspecified uses.

MISCELLANEOUS STONE

In a few localities small tonnages of various types of stone were used, mostly for rough construction. This category includes volcanic tuffs, rhyolites, obsidian, coral, coquina, mica schists, soapstone, and greenstone; some types were sawed or cut for building and other uses and had a very high unit value.

TABLE 14.—Miscellaneous varieties of dimension stone sold or used by producers in the United States, [1] by uses

Use	1960			1961		
	Thousand short tons	Thousand cubic feet	Value (thousands)	Thousand short tons	Thousand cubic feet	Value (thousands)
Building:						
Sawed [2]	53	624	$3,365	47	553	$3,150
Rubble	37	----------	649	62	----------	611
Flagging	6	71	114	4	47	111
Total	96	----------	4,128	113	----------	3,872

[1] Produced by the following States in 1961 in order of value of output and with number of plants: Virginia, 2; California, 43; Maryland, 2; Pennsylvania, 4; Connecticut, 1; New Jersey, 1; Colorado; 1; Washington, 2; Oregon, 5; Hawaii, 2; Nevada, 1, and New Mexico, 1.
[2] Includes rough and cut stone and stone for refractory use to avoid disclosing individual company confidential data.

FOREIGN TRADE [11]

Most of the imported marble block, slabs, and monuments came from Italy; smaller quantities were imported from Portugal, Belgium, and other countries.

Unmanufactured granite was imported from Canada, Norway, Brazil, Sweden, Finland, and Italy, in decreasing order of volume of imports. Dressed and polished granite was imported from West Germany, Finland, Italy, and 13 other countries. U.S. imports of dressed granite decreased in both volume and value,

Figures on imports and exports of the various types of stone are given under Foreign Trade in the Crushed Stone section of this chapter.

WORLD REVIEW

Canada.—Production of all types of building and ornamental stone was estimated at 200,000 short tons valued at Can$5.7 million in 1960, an increase in quantity of 17 percent over that of 1959. Ontario was the largest producer of all types of stone, with almost 120,000 short tons. Quebec, the second-ranking producer, shipped 59,000 short tons. Ontario was the chief producer of limestone and sandstone; Quebec was the chief producer of granite.[12]

Greece.—Greek Marble-Industrial and Trading Corporation was established to develop Greek marble deposits. The Ministry of Industry considered classifying marble as an ore to make it eligible for the special treatment accorded to ore mining enterprises.[13]

Jordan.—Production of marble in 1961 was 17,000 square yards valued at US$150.000 as compared with 13,300 square yards in 1960.[14]

Peru.—A preliminary estimate for production of limestone in 1961 was 1,081,000 short tons, a slight decrease from 1960. Exports of onyx to the United States amounted to 61,569 tons valued at US$1,984,880.[15]

United Kingdom.—The British Ministry of Labor reported that there were insufficient skilled granite trade workers, and that about 75 percent of the yards were producing thin-slab facing material for exteriors of multi-story buildings. The shortage of skilled masons induced many plants to install new high-speed wire saws and faster polishing equipment and to streamline production methods to reduce costs.[16]

TECHNOLOGY

A new type of wire saw was introduced in the granite dimension stone industry. The wire used was only 50 feet long compared with the normal length of 500 to 700 feet. Less wire weight, shorter time required for replacement, and lower initial investment were claimed.[17]

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[11] Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.
[12] Hanes, F. E. Stone, Building and Ornamental. Canadian Mineral Industry—1960 (Preliminary) Review 53, November 1961, 10 pp.
[13] U.S. Embassy, Athens, Greece. State Department Dispatch 317. Nov. 20, 1961, p. 6.
[14] U.S. Embassy, Amman, Jordan. State Department Dispatch 307. Apr. 2, 1962, p. 1.
[15] U.S. Embassy, Lima, Peru. State Department Dispatch 627. Apr. 15, 1962, pp. 12, 15.
[16] Quarry Managers' Journal (London). Notebook. V. 45, No. 9, September 1961, p. 342.
[17] Quarry Managers' Journal (London). A New Wire Saw for the Working Granite. V. 45, No. 11, November 1961, p. 438.

Jet-piercing techniques were employed in drilling, cutting, shaping, and surface finishing of dimension stone. The flame finish was stated to develop a texture on finished stone not obtainable by mechanical finishing methods.[18]

According to tests made by the Diamond Research Laboratory of Johannesburg, Union of South Africa, adding one-half ounce of soft soap per gallon of cooling water increased the cutting speed of diamond saws and drills 20 percent.[19]

CRUSHED AND BROKEN STONE

The 1961 production of 613 million short tons of crushed and broken stone valued at $862 million represented a slight decrease in both tonnage and value from the 1960 figures. The average value remained the same, $1.41 per ton. Concrete and roadstone increased 1 percent in both tonnage and value, with no change reported in the average price of $1.35 per ton.

The total value of construction put-in-place was $57.4 billion, an increase of 3 percent over the value in 1960 and $1 billion more than the record value of 1959. Outlays for public construction were up 7 percent to a record high of $17 billion. Highway construction expenditures advanced 6 percent to $5.8 billion, which was also a new record.[20]

TABLE 15.—Crushed and broken stone sold or used by producers in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1960		1961	
	Quantity	Value	Quantity	Value
Agriculture	22,804	$39,260	22,498	$38,992
Cement	85,551	91,964	85,471	91,942
Concrete and roadstone	[1] 387,084	[1] 520,669	390,398	526,597
Fill	7,782	6,297	4,325	4,263
Filtration	213	472	189	362
Flux	[1] 31,878	[1] 46,312	27,623	41,220
Glass	1,504	4,565	1,599	5,007
Lime and dead-burned dolomite	19,724	30,850	19,544	30,065
Mineral food	571	2,991	698	3,737
Poultry grit	1,047	8,628	893	7,458
Railroad ballast	11,158	12,780	7,883	10,155
Refractory	749	6,082	2,431	6,156
Riprap	[1] 23,863	[1] 32,468	27,085	33,695
Roofing granules, aggregates, and chips	1,958	8,962	2,114	9,585
Stone sand	3,200	4,289	3,527	4,130
Terrazzo	434	5,140	407	4,667
Other uses [2] and unspecified	[1] 15,007	[1] 44,817	16,388	44,436
Total	[1] 614,527	[1] 866,546	613,073	862,467

[1] Revised figure.
[2] Includes some uses listed separately in the Limestone and Sandstone sections.

[18] Quarry Managers' Journal (London). The Jet-Flame Method of Cutting, Shaping, and Texturing Granite. V. 45, No. 12, December 1961, pp. 509–510.
[19] Stone Magazine. Diamond Sawing, Drilling Improved by Addition of Soap to Cooling Water. V. 81, No. 11, November 1961, p. 35.
[20] Construction Review. Construction in 1961. V. 8, No. 3, March 1962, p. 5.

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	1960		1961	
	Quantity	Value	Quantity	Value
Concrete and roadstone	52,427	$54,958	45,832	$52,465
Riprap	11,159	12,940	13,092	15,275
Agricultural (limestone)	357	522	227	317
Other uses	6,185	5,772	4,979	5,007
Total	70,128	74,192	64,130	73,064

[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.—Sixty-four percent of the crushed and broken stone produced in 1961 was utilized for concrete and roadstone; 14 percent in the manufacture of cement; and 16 percent as fluxstone and riprap, in agricultural applications, and in the manufacture of lime and dead-burned dolomite. Many small but important uses consumed the remaining 6 percent. The percentages varied slightly from the 1960 figures, when concrete and roadstone accounted for 63 percent of the total production and minor uses consumed 7 percent.

Crushed stone produced by various governmental agencies or by their contractors declined 9 percent in volume and 2 percent in value.

Prices.—The unit value of crushed stone ranged from $0.99 per ton for unprocessed fill material to $11.47 for graded material used in terrazzo flooring. Competition and improvements in production methods tended to keep the average unit values from rising in spite of higher labor costs. Blast-furnace slag and crushed gravel competed with crushed stone for the construction market.

Size of Plants.—A total of 2,885 commercial crushed-stone plants operated in 1961. The number of plants producing over 500,000 tons annually decreased by 15. Plants producing over 900,000 tons per year constituted only 3 percent of the total number but accounted for 26 percent of production. Plants producing between 100,000 and 500,000 tons supplied 44 percent of the total crushed stone.

Portable crushing and processing plants increased in number, capacity, and versatility. Some plants, although not portable, were designed so that they could be easily disassembled and set up rapidly at a new location.

Transportation.—The use of trucks to transport crushed stone to jobsites increased 1 percent. Transportation by barge on the Great Lakes, inland rivers, and on coastal waterways was of considerable local importance although the tonnage moved by this means was relatively small. Tonnage moved by rail was slightly less than in 1960.

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	1960		1961	
	Quantity	Value	Quantity	Value
Alabama	[1] 5,731	[1] $6,990	7,208	$8,859
Alaska	193	720	(2)	(2)
Arizona	2,292	2,147	1,422	1,447
Arkansas	[1] 4,408	[1] 6,672	5,997	5,839
California	10,660	13,154	11,483	14,442
Colorado	516	736	273	571
Connecticut	[1] 4,550	[1] 6,821	4,830	7,153
Delaware	(2)	(2)	(2)	(2)
Florida	[1] 21,789	[1] 28,314	24,912	30,804
Georgia	[1] 10,177	[1] 15,134	[1] 10,897	[1] 15,931
Hawaii	3,301	6,140	3,995	7,029
Idaho	[1] 852	[1] 1,185	1,503	2,058
Illinois	32,420	43,641	27,237	36,169
Indiana	13,245	16,695	12,746	16,040
Iowa	18,066	23,513	16,996	22,215
Kansas	[1] 7,867	[1] 10,622	8,626	11,818
Kentucky	12,866	17,737	13,579	18,678
Louisiana	[1] 3,402	[1] 6,953	[1] 3,358	[1] 6,034
Maine	403	864	304	669
Maryland	5,728	9,830	8,292	13,366
Massachusetts	[1] 3,773	[1] 6,125	3,859	6,144
Michigan	5,476	6,283	4,675	5,365
Minnesota	[1] 2,951	[1] 3,391	3,168	3,861
Mississippi			(2)	(2)
Missouri	[1] 15,474	[1] 21,380	[1] 14,217	[1] 19,653
Montana	275	290	602	547
Nebraska	(2)	(2)	1,575	2,882
Nevada	20	12	22	19
New Hampshire	(2)	(2)	(2)	(2)
New Jersey	8,804	18,469	8,931	18,582
New Mexico	856	1,117	1,266	1,488
New York	20,849	33,333	18,780	30,392
North Carolina	14,508	20,651	15,515	22,542
North Dakota			40	40
Ohio	[1] 17,255	[1] 22,473	[1] 16,701	[1] 21,681
Oklahoma	[1] 9,271	[1] 9,902	11,055	11,828
Oregon	[3] 12,102	[3] 14,346	11,000	13,970
Pennsylvania	20,364	31,284	21,343	31,563
Rhode Island	[1] 348	[1] 587	(2)	(2)
South Carolina	[1] 5,196	[1] 7,277	4,768	6,896
South Dakota	1,766	2,962	[1] 1,674	[1] 2,306
Tennessee	15,426	19,282	19,125	23,891
Texas	[1] 27,772	[1] 27,837	25,224	27,516
Utah	135	114	31	17
Vermont	1,636	1,986	2,249	3,129
Virginia	[3] 13,035	[3] 18,207	15,894	23,284
Washington	6,837	6,752	6,743	7,417
West Virginia	[1] 2,748	[1] 4,407	3,918	6,359
Wisconsin	12,990	12,961	10,019	10,097
Wyoming	[1] 128	[1] 166	1,761	1,840
Undistributed	8,623	[3] 11,207	2,585	4,166
Total	[3] 387,084	[3] 520,669	390,398	526,597

[1] To avoid disclosing individual company confidential data, total is somewhat incomplete, the portion not included being combined as "Undistributed."
[2] Included with "Undistributed."
[3] Revised figure.

GRANITE

Crushed granite production was 43 million tons valued at $63 million, an increase of 3 percent in volume and 4 percent in value over 1960. Average price was $1.46 per ton. Five States—California, Georgia, North Carolina, South Carolina, and Virginia—produced 89 percent of the total. An increase of 1.6 million tons over the 1960 figure was reported for concrete and roadstone. Stone sand output was 27 percent greater and sold for 11 percent more. Of all crushed stone reported as used for concrete and roadstone, granite made up 9 percent.

TABLE 18.—Number and production of commercial crushed-stone plants in the United States, by size of operation

Annual production (short tons)	1960				1961			
	Number of plants	Production		Cumulative total, thousand short tons	Number of plants	Production		Cumulative total, thousand short tons
		Thousand short tons	Percent of total			Thousand short tons	Percent of total	
Less than 25,000	803	6,626	1.2	6,626	811	6,641	1.2	6,641
25,000 to 50,000	[1] 343	[1] 12,520	2.3	19,146	323	11,586	2.1	18,227
50,000 to 75,000	233	13,830	2.5	32,976	270	16,536	3.0	34,763
75,000 to 100,000	212	18,226	3.4	51,202	186	15,922	2.9	50,685
100,000 to 200,000	[1] 475	[1] 67,295	12.4	118,497	495	69,934	12.7	120,619
200,000 to 300,000	262	63,933	11.7	182,430	248	60,715	11.1	181,334
300,000 to 400,000	167	57,407	10.5	239,837	172	59,452	10.8	240,786
400,000 to 500,000	110	48,312	8.9	288,149	113	50,604	9.2	291,390
500,000 to 600,000	86	46,488	8.5	334,637	81	43,944	8.0	335,334
600,000 to 700,000	49	31,099	5.7	365,736	46	29,909	5.5	365,243
700,000 to 800,000	35	25,958	4.8	391,694	33	24,622	4.5	389,865
800,000 to 900,000	23	19,347	3.6	411,041	20	17,009	3.1	406,874
900,000 tons and over	89	133,358	24.5	544,399	87	142,069	25.9	548,943
Total	[1] 2,887	[1] 544,399	100.0	544,399	2,885	548,943	100.0	548,943

[1] Revised figure.

TABLE 19.—Crushed stone sold or used in the United States, by methods of transportation

Method of transportation	1960		1961	
	Thousand short tons	Percent of total	Thousand short tons	Percent of total
Commercial:				
Truck	[1] 347,578	57	359,247	59
Rail	81,572	13	78,674	13
Waterway	54,687	9	50,805	8
Unspecified	60,562	10	60,217	10
Total commercial	[1] 544,399	89	548,943	90
Government-and-contractor: Truck [2]	70,128	11	64,130	10
Grand total	[1] 614,527	100	613,073	100

[1] Revised figure.
[2] Entire output of Government-and-contractor operations assumed to be moved by truck.

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	1960		1961	
	Quantity	Value	Quantity	Value
Concrete and roadstone	[1] 35,100	[1] $49,817	36,658	$53,332
Railroad ballast	1,424	1,721	1,291	1,568
Riprap	2,977	5,756	3,051	5,141
Fill	1,236	791	666	604
Stone sand	1,227	1,093	1,555	1,212
Poultry grit	138	1,222	142	1,269
Other uses [2]	46	481	33	175
Total	[1] 42,148	[1] 60,881	43,396	63,301

[1] Revised figure.
[2] Includes stone used for agriculture, filtration, roofing granules, and unspecified uses.

TABLE 21.—Granite (crushed and broken stone) sold or used by producers in the United States in 1961, by States

State	Short tons	Value	State	Short tons	Value
Arizona	7,155	$7,155	Oregon	30,000	$45,000
California	4,842,505	6,336,574	South Carolina	5,511,059	7,460,947
Colorado	9,450	36,523	South Dakota	8,568	15,352
Georgia	11,846,519	17,269,523	Tennessee	35,000	52,500
Idaho	792,828	904,550	Virginia	5,212,969	8,341,445
Minnesota	334,160	575,312	Washington	58,216	156,255
Missouri	1,908	3,903	Wisconsin	196,655	36,418
Montana	521,127	443,113	Wyoming	189,134	208,498
Nevada	27,170	47,569	Other States [1]	1,866,606	3,464,551
New Jersey	691,098	1,489,324			
North Carolina	11,197,972	16,386,763	Total	43,396,464	63,300,591
Oklahoma	16,365	19,316	Puerto Rico	107,547	258,340

[1] Includes Alaska, Arkansas, Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Pennsylvania, Rhode Island, Texas, and Vermont.

BASALT AND RELATED ROCKS (TRAPROCK)

This group of rocks, primarily of igneous origin, hard, tough, and available in limited areas, was used mainly for concrete and roadstone. The average value was $1.51 per ton, unchanged from 1960. Production increased in quantity and value. Use for riprap increased 108 percent in volume. Dominant States in production were Oregon, New Jersey, Washington, and Connecticut; together they accounted for 62 percent of the total tonnage.

MARBLE

Crushed and graded marble was produced at a number of plants for terrazzo, whiting, and roofing granules. Some of this material was produced as a byproduct of dimension stone quarrying, and some came from imported marble; some of the material was artificially

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	1960		1961	
	Quantity	Value	Quantity	Value
Concrete and roadstone	46,244	$71,165	50,456	$77,652
Railroad ballast	1,358	1,864	1,561	2,194
Riprap	4,294	7,019	8,935	10,861
Fill	5,304	4,620	1,719	2,144
Stone sand	82	138	65	105
Other uses [1]	588	2,528	508	2,722
Total	57,870	87,334	63,244	95,678

[1] Includes stone used for agriculture, concrete blocks, filtration, filler, roofing granules, and unspecified uses.

colored. The average price for terrazzo marble was $11.42 per ton, but small quantities of rare or particularly beautiful chips sold for $40 and $50 per ton. Less valuable products from the marble industry were burned for lime or finely ground and used for stock feed and agricultural soil conditioning.

TABLE 23.—Basalt and related rocks (traprock) (crushed and broken stone) sold or used by producers in the United States in 1961, by States

State	Short tons	Value	State	Short tons	Value
Arizona	285,371	$285,850	New Mexico	2,025	$2,025
California	1,877,186	2,216,435	North Carolina	2,671,270	3,761,389
Connecticut	4,860,228	7,226,159	Oregon	14,511,856	17,793,702
Hawaii	2,759,523	5,196,326	Pennsylvania	3,250,877	5,678,599
Idaho	726,013	1,128,307	Virginia	2,777,172	4,361,328
Maryland	3,463,717	5,191,188	Washington	9,764,871	11,450,571
Massachusetts	3,813,494	5,899,895	Other States [1]	2,210,122	4,905,341
Michigan	25,753	41,203			
Minnesota	25,602	54,850	Total	63,243,661	95,678,283
Montana	208,025	208,130	American Samoa	65,709	178,181
Nevada	10,000	6,200	Panama Canal Zone	(2)	(2)
New Jersey	10,000,556	20,280,785	Virgin Islands	20,302	75,399

[1] Includes Alaska, New York, Texas, and Wisconsin.
[2] Figure withheld to avoid disclosing individual company confidential data.

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	1960		1961	
	Quantity	Value	Quantity	Value
Terrazzo	412	$4,937	397	$4,535
Other uses [2]	1,103	8,380	1,038	7,859
Total	1,515	13,317	1,435	12,394

[1] Produced by the following States in 1961, in order of tonnage: Georgia, Alabama, Missouri, Texas, California, New York, Virginia, Tennessee, Maryland, Vermont, Washington, Colorado, New Jersey, Arizona, Arkansas, North Carolina, Wisconsin, Utah, and Nevada.
[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.

LIMESTONE

Production of crushed and broken limestone and dolomite decreased 3 percent in volume and 2 percent in value. Declines were reported for nearly all use categories except riprap and those requiring finely ground material.

Output for concrete and roadstone dropped 8.7 million tons and for flux 4.2 million tons. Limestone quarries provided 71 percent of all stone crushed and 66 percent of all stone used for concrete and roadstone. Illinois again led in production of crushed limestone although its tonnage for concrete and roadstone dropped over 5 million tons.

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	1960		1961	
	Quantity	Value	Quantity	Value
Concrete and roadstone	267,657	$347,428	258,997	$338,798
Flux	[1] 31,415	[1] 45,082	27,198	39,725
Agriculture	22,518	38,863	22,250	38,613
Railroad ballast	5,428	6,884	4,260	5,376
Riprap	[1] 8,414	[1] 10,228	9,138	10,440
Alkali manufacture	2,637	2,961	2,560	2,878
Calcium carbide manufacture	1,016	1,092	764	785
Cement-portland and natural	79,851	85,652	79,779	85,883
Coal-mine dusting	424	1,668	372	1,527
Fill material	476	366	266	277
Filler (not whiting substitute):				
Asphalt	2,391	5,604	2,130	5,408
Fertilizer	424	1,036	438	1,080
Other	193	805	219	873
Filtration	169	269	148	221
Glass manufacture	1,232	3,720	1,211	3,736
Lime and dead-burned dolomite	18,568	29,019	18,124	28,283
Limestone sand	1,845	3,004	1,693	2,596
Limestone whiting [2]	657	7,101	802	9,242
Mineral food	568	2,972	695	3,723
Paper manufacture	491	2,052	400	1,129
Poultry grit	146	1,106	153	1,185
Refactory (dolomite)	92	244	235	465
Sugar refining	875	2,268	828	2,080
Other uses [3]	1,968	5,312	2,838	4,603
Use unspecified	938	1,561	1,900	2,475
Total	450,393	606,297	437,398	591,401

[1] Revised figure.

[2] 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, soap, wire coating, and unspecified uses. Excludes limestone whiting made by companies from purchased stone.

[3] Includes stone for acid neutralization, cast stone, chemicals (unspecified), concrete products, disinfectant and animal sanitation, electrical products, magnesite, magnesium, mineral wool, oil-well drilling, patching plaster, rice milling, road base, roofing granules, stucco, terrazzo, and water treatment.

TABLE 26.—Limestone and dolomite (crushed and broken stone) sold or used by producers in the United States in 1961, by States and uses

State	Riprap		Fluxing stone		Concrete and roadstone	
	Short tons	Value	Short tons	Value	Short tons	Value
Alabama	(1)	(1)	1,269,291	$2,047,720	6,495,775	$8,324,452
Arizona			180,478	282,483	244,569	261,043
Arkansas	(1)	(1)	(1)	(1)	1,356,672	1,593,047
California	1,459,606	$1,454,881	(1)	(1)	1,386,415	1,486,514
Colorado	(1)	(1)	462,868	1,003,089	(1)	(1)
Connecticut			(1)	(1)		
Florida					21,764,593	27,546,130
Georgia	(1)	(1)			971,842	1,518,350
Hawaii					671,110	1,076,038
Idaho						
Illinois	890,341	909,401	737,411	1,268,435	27,237,398	36,169,143
Indiana	43,941	48,947	46,632	61,833	12,745,508	16,039,673
Iowa	300,429	405,458	(1)	(1)	16,996,422	22,215,403
Kansas	608,903	769,704			8,240,175	11,414,813
Kentucky	(1)	(1)	(1)	(1)	13,579,183	18,677,507
Maine	(1)	(1)				
Maryland	(1)	(1)	(1)	(1)	4,316,817	7,312,131
Massachusetts			(1)	(1)	(1)	(1)
Michigan	(1)	(1)	10,565,419	11,855,938	4,649,369	5,324,073
Minnesota	28,894	27,103	25	88	2,993,177	3,492,429
Mississippi	4,972	4,972			320	714
Missouri	1,876,340	2,024,905	(1)	(1)	14,216,555	19,653,009
Montana	(1)	(1)	(1)	(1)	(1)	(1)
Nebraska	849,091	1,131,992			1,575,038	2,882,499
Nevada			(1)	(1)	11,885	12,443
New Jersey			(1)	(1)	(1)	(1)
New Mexico	786	998	22,487	21,198	(1)	(1)
New York	84,685	132,599	63,238	101,919	16,148,359	25,668,675
North Carolina					1,934,170	2,890,523
Ohio	121,101	168,841	4,432,666	6,807,105	16,700,520	21,680,840
Oklahoma	887,229	948,121			9,825,904	10,488,018
Oregon			(1)	(1)	(1)	(1)
Pennsylvania	(1)	(1)	4,924,382	8,953,062	16,733,759	24,355,091
Rhode Island			(1)	(1)		
South Carolina					(1)	(1)
South Dakota	(1)	(1)			761,379	1,015,359
Tennessee	(1)	(1)	(1)	(1)	19,032,061	23,687,729
Texas	852,420	900,573	537,912	596,578	15,126,940	14,616,651
Utah	38,194	187,900	559,843	783,042	(1)	(1)
Vermont	(1)	(1)			1,195,451	1,771,861
Virginia	5,976	7,760	972,454	1,697,462	8,013,598	10,934,629
Washington			(1)	(1)		
West Virginia	(1)	(1)	1,479,548	2,818,445	2,782,916	4,575,429
Wisconsin	143,238	117,902	31,691	44,826	9,895,140	9,960,396
Wyoming	(1)	(1)	(1)	(1)	180,966	258,459
Undistributed	942,228	1,198,239	911,802	1,381,991	1,212,888	1,894,477
Total	9,138,374	10,440,296	27,198,147	39,725,214	258,996,874	338,797,548
American Samoa					1,269	866
Guam					279,106	574,903
Johnston Island					675	1,500
Midway Island					10,902	33,544
Puerto Rico					1,869,605	3,459,154
Wake Island					23,330	62,338

[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 1961, 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)	672,271	$1,085,552	4,758,936	$4,357,948	13,354,165	$16,000,304
Arizona			(1)	(1)	(1)	(1)	2,099,455	2,458,371
Arkansas			212,681	313,953	955,303	1,233,541	3,054,871	3,758,436
California	(1)	(1)	(1)	(1)	12,870,659	19,912,397	15,763,946	23,003,043
Colorado			219	1,752	1,618,486	2,962,467	2,221,902	4,255,761
Connecticut			62,667	284,008	(1)	(1)	156,040	607,812
Florida	(1)	(1)	666,979	1,950,071	(1)	(1)	25,675,967	32,589,084
Georgia	3,234	$4,689	(1)	(1)	(1)	(1)	1,800,320	2,858,888
Hawaii			9,219	25,134	279,456	401,735	959,785	1,502,907
Idaho					(1)	(1)	(1)	(1)
Illinois	269,200	267,569	3,413,576	5,029,972	3,789,609	4,057,044	36,337,535	47,701,564
Indiana	203,411	252,955	2,001,510	2,776,127	2,333,631	2,197,631	17,374,633	21,377,166
Iowa	(1)	(1)	1,101,640	1,483,310	(1)	(1)	22,008,291	28,765,465
Kansas	(1)	(1)	437,803	718,186	(1)	(1)	11,936,474	16,100,959
Kentucky	317,244	335,780	1,535,086	2,098,297	815,923	1,063,626	17,082,967	23,282,180
Maine			(1)	(1)	(1)	(1)	(1)	(1)
Maryland	(1)	(1)	43,874	128,345	2,033,593	5,393,227	6,442,704	12,915,733
Massachusetts			163,703	512,808	389,969	1,579,502	579,894	2,134,867
Michigan	(1)	(1)	520,680	872,080	(1)	(1)	28,503,600	29,781,604
Minnesota			383,899	578,513	45,964	253,084	3,451,959	4,351,217
Mississippi			99,151	89,236	(1)	(1)	(1)	(1)
Missouri	(1)	(1)	2,613,463	4,169,255	6,034,721	7,625,568	24,829,158	33,629,142
Montana	(1)	(1)	(1)	(1)	(1)	(1)	670,715	1,024,325
Nebraska			(1)	(1)	(1)	(1)	3,620,875	6,322,184
Nevada	(1)	(1)			(1)	(1)	(1)	(1)
New Jersey			(1)	(1)	(1)	(1)	(1)	(1)
New Mexico					(1)	(1)	1,164,575	1,516,250
New York	327,392	531,761	425,605	1,240,004	6,985,633	8,637,753	24,034,912	36,312,711
North Carolina	20,298	27,402	7,858	15,716			1,962,326	2,933,641
Ohio	900,359	1,124,409	1,987,540	3,478,042	8,956,218	14,664,629	33,098,404	47,923,866
Oklahoma			162,681	183,774	1,652,555	2,067,571	12,528,369	13,687,484
Oregon			(1)	(1)	941,557	1,283,552	951,698	1,304,848
Pennsylvania	(1)	(1)	1,078,392	2,973,326	13,196,910	17,757,875	36,102,118	54,282,406
Rhode Island			(1)	(1)	(1)	(1)	(1)	(1)
South Carolina			(1)	(1)	(1)	(1)	(1)	(1)
South Dakota	(1)	(1)			589,691	897,787	1,378,062	1,939,293
Tennessee	345,778	409,972	1,390,923	1,949,195	2,763,803	4,387,867	23,582,229	30,504,735
Texas	343,902	305,388	92,738	92,061	7,462,173	8,398,677	24,416,085	24,909,928
Utah	(1)	(1)			(1)	(1)	1,621,088	2,814,452
Vermont			80,405	414,936	(1)	(1)	1,428,590	4,088,607
Virginia	260,916	326,758	875,293	1,785,132	3,777,122	6,061,073	13,905,359	20,812,814
Washington			(1)	(1)	1,116,767	1,835,560	1,169,771	1,996,607
West Virginia	500,970	700,285	(1)	(1)	1,580,014	2,906,204	6,436,112	11,237,999
Wisconsin			1,322,265	1,836,827	186,700	237,855	11,579,034	12,197,806
Wyoming	(1)	(1)			(1)	(1)	817,611	1,454,848
Undistributed	767,488	1,088,907	888,133	2,527,257	30,418,558	38,274,968	3,296,193	7,061,636
Total	4,260,192	5,375,875	22,250,254	38,612,869	115,553,951	158,449,141	437,397,792	591,400,943
American Samoa					294,536	107,104	295,805	107,970
Guam					13,125	16,400	292,231	591,303
Johnston Island							675	1,500
Midway Island							10,902	33,544
Puerto Rico			46,548	132,290	1,801,858	954,814	3,718,011	4,546,258
Wake Island							23,830	62,338

[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
1952–56 (average)	29,575	$37,025	6,435	$9,262	1,079	$1,399	273	$411	37,362	$48,097
1957	29,352	41,733	9,012	12,924	809	1,086	211	370	39,384	56,113
1958	19,427	28,153	4,777	6,641	866	975	546	768	25,616	36,537
1959	19,752	28,683	6,439	8,963	965	1,223	1,050	1,573	28,206	40,442
1960	[3] 21,627	[3] 30,809	7,409	10,958	997	1,311	1,382	2,004	[3] 31,415	[3] 45,082
1961	18,129	25,891	6,412	10,056	896	1,205	1,761	2,573	27,198	39,725

[1] Includes flux for copper, gold, lead, zinc, and unspecified smelters.
[2] Includes flux for foundries and for cupola and electric furnaces.
[3] Revised figure.

Shell.—Various types of fresh- and salt-water shell were used for concrete and roadstone, cement, lime, poultry grit, and soil beneficiation. Production was up 11 percent from 1960, but value declined 2 percent. Average price was $1.57 per ton.

A barge-mounted crushing and washing plant operated in conjunction with a dredge was used by a Mobile, Ala., producer of oyster shell for poultry feed.[21]

TABLE 28.—Shell sold or used by producers in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1960		1961	
	Quantity	Value	Quantity	Value
Concrete and road material	12,447	$20,192	14,310	$20,889
Cement	4,452	4,823	4,563	4,881
Lime	1,156	1,831	1,420	1,782
Poultry grit	763	6,300	598	5,004
Mineral food	3	19	3	14
Other uses [1]	113	541	79	439
Total	18,934	33,706	20,973	33,009

[1] Includes agriculture, asphalt filler, filtration, whiting, and unspecified uses.

TABLE 29.—Shell sold or used by producers in the United States in 1961, by States

State	Short tons	Value	State	Short tons	Value
Florida	3,178,662	$3,715,675	Virginia	14,460	$88,375
Louisiana	4,641,276	7,655,928	Other States [1]	2,606,954	6,160,903
New Jersey	832	15,500			
Texas	10,531,247	15,372,759	Total	20,973,431	33,009,140

[1] Includes Alabama, California, Maryland, Mississippi, and Pennsylvania.

[21] Virtue, John C. Floating Plant in Mobile Bay Produces Crushed, Clean Oyster Shell. Pit and Quarry v. 53, No. 10, April 1961, pp. 94–97.

Calcareous Marl.—Marls are earthy deposits, chiefly calcium carbonate, commonly mixed with clay sand and organic material. The principal use of fresh-water marl was for liming acid soils. Marine shell marls were an important source of material for the manufacture of cement.

TABLE 30.—Calcareous marl sold or used by producers in the United States, [1] by uses

(Thousand short tons and thousand dollars)

Use	1960		1961	
	Quantity	Value	Quantity	Value
Agriculture [2]	260	$190	223	$168
Cement	1,023	1,163	876	819
Total	1,283	1,353	1,099	987

[1] Produced by the following States in 1961, in order of tonnage: Mississippi, Virginia, Michigan, Indiana, Minnesota, Wisconsin, Nevada, and Ohio.
[2] Includes marl used in mineral food.

SANDSTONE, QUARTZ, AND QUARTZITE

Sales of sandstone, quartz, and quartzite increased 12 percent in volume and 2 percent in value. Chief increases were in material sold for roadstone, concrete, riprap, and glass. Leading States in production were Arkansas and California.

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	1960		1961	
	Quantity	Value	Quantity	Value
Concrete and roadstone	13,356	$19,139	14,688	$19,843
Railroad ballast	800	1,031	771	1,017
Riprap	3,389	4,072	4,061	4,196
Refractory stone (ganister)	657	5,838	462	4,616
Abrasives	30	251	52	362
Ferrosilicon	129	532	132	508
Filtration	21	96	13	45
Flux	463	1,230	423	1,495
Foundry	360	895	373	1,034
Glass	272	845	388	1,271
Other uses [2]	1,097	3,301	1,632	3,593
Total	20,574	37,230	22,995	37,980

[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 1961, by States

State	Short tons	Value	State	Short tons	Value
Arizona	324,263	$844,288	South Dakota	984,512	$1,493,464
Arkansas	5,962,613	5,904,677	Tennessee	220,000	654,050
California	3,282,837	5,145,782	Texas	2,265,040	1,507,762
Colorado	39,416	207,863	Utah	121,677	178,203
Illinois	540	5,400	Vermont	874,262	1,033,298
Michigan	9,804	7,020	Virginia	515,225	925,425
Nebraska	840	1,432	Washington	94,700	346,989
New Mexico	115,242	86,246	West Virginia	1,187,927	1,942,272
New York	515,500	1,079,598	Wisconsin	1,257,801	2,887,420
Ohio	445,022	2,037,121	Other States [1]	2,079,554	5,083,651
Oklahoma	1,133,505	1,529,352			
Pennsylvania	1,564,473	5,078,342	Total	22,994,753	37,979,655

[1] Includes Alabama, Connecticut, Georgia, Idaho, Indiana, Kansas, Maine, Maryland, Minnesota, Montana, Nevada, North Carolina, Oregon, South Carolina, and Wyoming.

CRUSHED AND BROKEN SLATE

Production of crushed and broken slate declined 10 percent in volume and 11 percent in value. Although some waste slate was bloated for use as lightweight aggregate, no economical use has been discovered for the great amount of waste material available.

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	1960		1961	
	Quantity	Value	Quantity	Value
Granules [2]	284	$2,304	257	$2,014
Flour	115	571	108	565
Other uses [3]	14	39	7	6
Total	413	2,914	372	2,585

[1] Produced by the following States in 1961 in order of tonnage: Georgia, Arkansas, Pennsylvania, Virginia, California, and New York.
[2] Includes crushed slate used for lightweight aggregates to avoid disclosing individual company confidential data.
[3] Includes asphalt filler and unspecified uses.

MISCELLANEOUS STONE

The miscellaneous stone classification included volcanic rocks, cherts, flint conglomerates, limestone chats from mining operations, and various other varieties. Their chief use was for local construction. Output increased 4 percent, and value increased 7 percent. Average value was $1.13 per ton. California reported 32 percent of the tonnage.

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	1960		1961	
	Quantity	Value	Quantity	Value
Concrete and roadstone	[1] 12,280	[1] $12,928	15,289	$16,083
Railroad ballast	2,148	1,280	1,734	1,075
Riprap	4,789	5,393	1,900	3,057
Fill	696	466	1,572	1,169
Other uses [2]	[1] 1,484	[1] 3,447	1,666	3,748
Total	[1] 21,397	[1] 23,514	22,161	25,132

[1] Revised figure.
[2] 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 1961, by States

State	Short tons	Value	State	Short tons	Value
Arizona	851,276	$872,217	Oregon	1,708,072	$1,553,981
California	7,050,953	10,403,371	Pennsylvania	495,896	710,128
Colorado	156,059	381,088	South Dakota	417,391	385,953
Hawaii	709,626	962,973	Texas	904,550	694,844
Indiana	8,000	4,000	Utah	59,681	69,774
Kansas	379,446	160,718	Washington	359,061	375,867
Maine	900	5,400	Wisconsin	89,425	61,675
Maryland	300,000	600,000	Wyoming	1,581,720	1,601,216
Missouri	631,250	399,233	Other States [1]	4,480,611	4,531,021
Nevada	71,810	92,476			
New Mexico	571,017	586,993	Total	22,161,305	25,132,081
North Dakota	40,021	40,198	Panama Canal Zone	51,191	71,288
Oklahoma	1,294,540	638,955	Puerto Rico	1,097,466	2,153,352

[1] Includes Alaska, Arkansas, Louisiana, Massachusetts, Montana, New Hampshire, New Jersey, New York, Rhode Island, Vermont, and Virginia.

FOREIGN TRADE [22]

Imports of crushed limestone from Canada increased 136 percent to 287,000 short tons. Quartzite was imported from Mexico, Canada, Sweden, Norway, and Netherlands. Whiting for pigment or polishing was imported from France, the United Kingdom, and Belgium; and also, in smaller quantities, from Japan, West Germany, and Netherlands.

[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	1960		1961	
	Quantity	Value	Quantity	Value
Marble, breccia, and onyx:				
Sawed or dressed, over 2 inches thick---cubic feet--	8,512	$48,048	11,244	$104,096
In blocks, rough, etc---do----	116,278	773,905	123,358	791,638
Slabs or paving tiles---superficial feet--	3,436,011	2,861,890	4,136,448	3,456,596
All other manufactures----	----------	3,302,944	----------	3,766,892
Total----	----------	6,986,787	----------	8,119,222
Granite:				
Dressed---cubic feet--	93,591	879,945	60,041	761,099
Rough---do----	102,935	518,985	102,193	577,702
Paving blocks, wholly or partly manufactured number--	3,242	83,324	1,674	47,332
Total----	----------	1,482,254	----------	1,386,133
Quartzite---short tons--	33,340	112,530	22,989	19,527
Slate----	----------	420,879	----------	481,132
Travertine stone (unmanufactured)---cubic feet--	126,973	394,176	61,054	164,593
Stone (other):				
Dressed: Travertine, sandstone, limestone, etc. cubic feet--	85,281	229,008	147,358	418,758
Rough (monumental or building stone) cubic feet--	4,547	8,058	1,909	3,678
Rough (other)---short tons--	131,164	304,490	301,611	466,180
Marble chip or granite---do----	[1] 32,109	[1] 327,767	26,848	269,938
Crushed or ground, n.s.p.f.----	----------	856,333	----------	656,519
Total----	----------	[1] 1,725,656	----------	1,815,073
Whiting:				
Chalk or whiting, precipitated---short tons--	980	57,612	1,113	65,403
Whiting, dry, ground, or bolted---do----	9,358	161,184	11,667	217,021
Whiting, ground in oil (putty)---do----	13	3,226	([2])	254
Total----	----------	222,022	----------	282,678
Grand total----	----------	[1]11,344,304	----------	12,268,358

[1] Revised figure.
[2] Less than 1 ton.

Source: Bureau of the Census

TABLE 37.—U.S. exports of stone

Year	Building and monumental stone		Crushed, ground, or broken				Other manufactures of stone (value)
			Limestone		Other		
	Cubic feet	Value	Short tons	Value	Short tons	Value	
1952–56 (average)----	387,356	$923,738	812,436	$940,731	153,258	$2,409,070	$391,411
1957----	415,903	1,157,728	1,088,004	1,649,697	129,559	2,699,023	506,180
1958----	349,366	1,236,205	767,757	1,390,365	173,340	3,696,951	432,072
1959----	425,194	1,261,687	1,085,553	1,999,107	157,911	3,388,372	643,102
1960----	431,262	1,250,365	[1] 926,197	[1] 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

[1] Revised figure.

Source: Bureau of the Census.

TABLE 38.—U.S. exports of slate, by uses [1]

(Value)

Use	1952-56 (average)	1957	1958	1959	1960	1961
Roofing	$12,184	$6,168	$12,026	(2)	(2)	(2)
Structural (including floors and walkways) and granules and flour	213,830	(2)	212,460	$89,912	$47,811	$9,154
Other uses [3]	151,185	276,177	84,629	126,683	100,247	73,918
Total	377,199	282,345	309,115	216,595	148,058	83,072

[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.—Production of limestone amounted to 46.2 million tons in 1961. Quebec and Ontario Provinces provided 93 percent of the total. Of the 56.2 million tons of stone produced, limestone accounted for 82 percent. During 1961, 733,000 tons of crushed stone valued at Can$1,091,000 was exported. Imports were 790,000 tons valued at Can$1,185,000. This trade was nearly all in crushed limestone for construction.[23]

Consumption of all types of roofing granules in 1960 declined 18 percent in volume and 29 percent in value. Artificially colored granules were in greatest demand. Most popular colors, in order of demand, were green, black, white, gray, and buff to blue.[24]

Nigeria.—Extensive drilling near Itobe delineated a deposit of at least 20 million tons of limestone suitable for use as flux for Nigeria's proposed iron and steel industry. Samples were uniform and contained 98.5 percent calcium carbonate.[25]

Rhodesia and Nyasaland, Federation of.—Northern and Southern Rhodesia in 1960 produced 807,129 short tons of limestone valued at US$630,745. Production decreased from 995,920 tons in 1959 because of completion of the Kariba Dam and a cutback in construction activity.[26]

Taiwan.—Because of increased demand for cement, output of limestone, including crystalline limestone or marble, was up 20 percent to 2,735,000 short tons.[27]

Union of South Africa.—Limestone production was 8,016,626 short tons. Two-thirds of production went to cement plants.[28]

TECHNOLOGY

The results of experiments to determine correlation between petrology and rate and degree of polishing of various types of British road stones were reported. Among the rock types studied, for which

[23] Ross, J. S. Limestone. Ch. in The Canadian Mineral Industry, 1961. Canada Dept. Mines and Tech. Surveys, Ottawa. April 1962, 5 pp.
[24] Hanes, F. E. Roofing Granules. Canadian Mineral Industry—1960 (Preliminary). Review 48, 5 pp.
[25] Mining Journal (London). Raw Materials for Nigeria's Proposed Iron and Steel Industry. V. 257, No. 6577, Sept. 8, 1961, p. 231.
[26] Bureau of Mines. Mineral Trade Notes. V. 53, No. 5, November 1961, p. 43.
[27] U.S. Embassy, Taipai, Taiwan. State Department Dispatch 427. May 2, 1961, p. 2.
[28] U.S. Embassy, Johannesburg, South Africa. State Department Dispatch 7. July 7, 1961, p. 24.

experimental polished-stone coefficients were established, were basalts, gritstones, limestones, granites, gabbros, porphyries, flints, and quartzites.[29]

At a symposium on rock mechanics, held at Pennsylvania State University under the sponsorship of the University of Minnesota, Missouri School of Mines, and Colorado School of Mines, in cooperation with the National Science Foundation, the following subjects were discussed: (1) Strata movement from underground openings, (2) behavior of rock under static loading, (3) behavior of rock under dynamic loading, (4) stress movement and ground control, and (5) dynamic loading in rock penetration.

Triangular coordinate paper was used with the plotted percentages of available aggregates to determine the possibility of producing certain desired blends.[30]

The procedures for manufacturing colored roofing granules were discussed.[31]

Limestones in southern Ontario were analyzed for trace elements important to the productivity capacity of soils. It was found that some limestones carried excessive quantities of lead which, carried over into certain grains, might be detrimental to health. The report suggested that it was necessary to determine the presence of these trace elements in all limestones used for soil conditioning.[32]

Specifications that directly affect the production of miscellaneous types of aggregates were discussed in three classifications: Before production, during production, and after production.[33]

More than 70 uses of limestone and dolomite were discussed in a publication. Chemical and physical specifications were given for most of the uses, and a comprehensive bibliography was included.[34]

Extensive use of fused cast basalt for ball-mill linings, pipes for pneumatic transfer of abrasive silicates, troughs for drain conveyors and sluiceways, and for lining cyclones was reported from Germany and the United Kingdom. The abrasion ratio ranged from a half to a fortieth of rates reported for other wear-resistant materials.[35]

Drilling and Blasting.—By using 1.3 pounds of explosive per cubic yard instead of .78 pounds per cubic yard, well-broken limestone in the range of 8 to 10 inches and under was produced, thus eliminating crusher jamming at a Rockland, Maine, quarry producing agricultural limestone.[36]

One man was killed and another injured on January 30 in the Jefferson Island (Louisiana) underground salt mine while holes were being loaded with ammonium nitrate-fuel oil (ANFO) explosive.

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[29] Knill, Diane C. Petrographical Aspects of the Polishing of Natural Roadstones. Crushed Stone J., v. 36, No. 2, June 1961, pp. 13–20.
[30] Driscoll, George F. Graphical Method Simplifies Economical Blending of Aggregates. Eng. News-Record, v. 167, No. 12, Sept. 21, 1961, pp. 134–135.
[31] Weaver, Leonard W. Manufacturing Roofing Granules. Am. Ceram. Soc. Bull., v. 40, No. 9, Sept. 15, 1961, pp. 556–558.
[32] Warren, H. V., and R. E. Delavault. The Lead, Copper, Zinc and Molybdenum Content of Some Limestones and Related Rocks in Southern Ontario. Economic Geology, v. 56, No. 7, November 1961, pp. 1265–1272.
[33] Gray, J. E. Specifications for Mineral Aggregates. Crushed Stone J., v. 36, No. 2, June 1961, pp. 3–10, 20.
[34] Lamar, J. E. Uses of Limestone and Dolomite. Illinois State Geol. Survey Circ. 321, 1961, 41 pp.
[35] Engineering. Abrasion Won't Hurt Basalt. V. 211, No. 5495, May 20, 1960, p. 678.
[36] Pit and Quarry. Modern Blasting Methods Pay Off in Historic Limestone Quarries. V. 54, No. 2, August 1961, pp. 108–110.

A second accident, the first recorded in a mixing plant for preparing ANFO explosive, occurred at Norton, Va., on December 27,1961. There were no fatalities, although 26 persons were injured, and there was much property damage.[37] The occurrence of two accidents within 11 months points up the necessity for observing recommended safety practices while using this new explosive. Many users had failed to observe good safety practices, and these explosions emphasized the danger from what was considered to be a relatively safe explosive.

A report was published to bring attention to possible use hazards.[38]

A series of three articles which surveyed the development and applications of ammonium nitrate-fuel oil mixtures used for blasting was published. Aspects reported were theory of slurry explosives, mixing systems, charging, blasting techniques, operational practices, and the blasting techniques and cost accounting at a typical British limestone quarry.[39]

Advantages to be derived by inclined drilling for surface mining were appraised. Estimated savings in drilling and blasting by use of this method are 1 percent per degree of drill inclination.[40]

The blasting procedures successfully adopted by a New Jersey traprock quarry to minimize complaints by neighbors were itemized.[41]

Mining and Processing.—Refraction seismograph soundings were found to be particularly effective in determining rippability of various types of quarry rock.[42]

A combination bulldozer and 3-tooth ripper enabled a Florida producer to quarry a limestone deposit that contained large flint boulders. Previous attempts to quarry using a shovel were not satisfactory.[43]

A comprehensive review of the problems inherent in selecting and installing high-capacity rock-crushing plants was published. Factors governing choice of primary, secondary, and finishing crushers were evaluated. Conveying, screening, storage, and reclamation arrangements were illustrated by flow diagrams.[44]

A diesel dragline was used to remove 20 to 60 feet of sandstone and shale overburden from a 17-foot vein of limestone in a Pennsylvania quarry. Crushed stone to meet seven types of highway specifications was produced at the rate of 200 to 250 tph.[45]

The completely portable equipment used by an Iowa producer to furnish aggregate and agricultural lime from four separate quarry locations was described.[46]

[37] Van Dolah, Robert W., and Joseph S. Malesky. Fire and Explosion in a Blasting Agent Mix Building, Norton, Va. BuMines Rept. of Inv. 6015, 1961, 12 pp.
[38] Bureau of Mines. Tentative Safety Recommendations for Field-Mixed Ammonium Nitrate Blasting Agents. Inf. Circ. 7988, 1960, 12 pp.
[39] Fish, Brian G. Ammonium Nitrate as a Bulk Blasting Agent. Quarry Managers' J. (London), v. 45, No. 6, June 1961, pp. 235–238; No. 7, July 1961, pp. 275–278; and No. 8, August 1961, pp. 295–302.
[40] Kochanowsky, B. J. Theory and Practice of Inclined Drilling for Surface Mining. Pit and Quarry, v. 53, No. 10, April 1961, pp. 128–132, 136, 139.
[41] Miller, Daniel J., Jr. Blasting Vibrations in Quarry Operations. Min. Cong. J., v. 47, No. 8, August 1961, pp. 84–86.
[42] Mine and Quarry Engineering (London). Rock Ripping. V. 27, No. 5, May 1961, pp. 212–217.
[43] Pit and Quarry, v. 53, No. 12, June 1961, p. 32.
[44] Brown, G. J. High-Capacity Rock Crushing Plants: Selection, Installation and Operation. Quarry Managers' J. (London), v. 46, No. 1, January 1962, pp. 19–26.
[45] Trauffer, Walter E. Many Handicaps Overcome in Pennsylvania Plant To Produce State Specification Rock. Pit and Quarry, v. 54, No. 3, September 1961, pp. 84–88.
[46] Herod, Buren C. Iowa Producer Keeps on the Move. Pit and Quarry, v. 53, No. 12, June 1961, pp. 109–111.

Details of the modernization of an English granite quarry and plant by which production was increased from approximately 115,000 tons per year to about 350,000 tons per year were reported. The problem of utilization of small-sized crushed waste was solved by installing equipment for making precast concrete products.[47]

Results of a 5-year program of research and investigation of operating conditions required to produce aggregates from 12 different types of rock were published. Crusher types studied were jaw, impact, roll, and cone. Determinations were made on grading of feed, output in tph, grading and shape of product, and energy consumed. Tables illustrated the effects of these various factors.[48]

Twin reversible hammermills operating in parallel following a 42- by 65-inch gyratory crusher were used to reduce 400 tph of extremely hard and tough high-silica limestone.[49]

Transportation.—A 5½-mile-long conveyor belt was installed at Ada, Okla., to carry 1,000 tph of shale and limestone from quarries to the new plant of Ideal Cement Co. The conveyor assembly was supported and roofed with prestressed concrete manufactured with lightweight aggregate.[50]

A belt conveyor was used to transport crushed traprock 2 miles along Interstate Highway 95 in New Jersey. Using a belt conveyor instead of trucks allowed day-and-night operation without interfering with traffic and required only four or five operators.[51] A 276-foot prestressed concrete T-beam was used to support a wire rope conveyor moving 300 tph of sand and crushed stone across a highly traveled highway.[52] The various factors to be considered when selecting a belt conveyor system were analyzed.[53]

[47] Quarry Managers' Journal (London). Modernization of a Large Granite Quarry and Plant. V. 45 No. 9, September 1961, pp. 343, 350.
[48] Shergold, F. A. Results and Conclusions from Research on Granulation. Quarry Managers' J. (London), v. 45, No. 4, April 1961, pp. 133-139.
[49] Rock Products. Tough Limestones Yield to Hammermills. V. 64, No. 9, September 1961, pp. 132-134, 148.
[50] Mine & Quarry Engineering (London). 5½-Mile Belt Conveyor Installation. V. 27, No. 8, August 1961, pp. 374-376.
[51] Roads and Streets. Brewster Belts Rock Two Miles in Unique Freeway Grading Operation. V. 104, No. 10, October 1961, pp. 51-52, 82, 86-88.
[52] Pit and Quarry. Unusual Conveyor Erected to Solve Transport Problem. V. 54, No. 2, August 1961 p. 32.
[53] Meschter, Elwood. Let's Take a Sharp Look at Belt Conveyor Design. Rock Products, v. 64, No. 9 September 1961, pp. 113, 114, 116, 118, 120.

Strontium

By Milford L. Skow [1] and Victoria R. Schreck [2]

CONSUMERS of strontium minerals continued to depend on imports for their supply, as the domestic strontium-mining industry was again inactive in 1961.

LEGISLATION AND GOVERNMENT PROGRAMS

A proposal to dispose of 28,816 short tons of celestite from the strategic stockpile was announced by General Services Administration in the Federal Register of March 16, 1961. This material was determined by the Office of Civil and Defense Mobilization to be below specification and not contributing to the stockpile objective. The necessary Congressional approval of the disposition was not received during 1961.

No celestite was contracted for under barter contracts for surplus agricultural commodities, but the Commodity Credit Corporation, U.S. Department of Agriculture, continued to consider offers.

DOMESTIC PRODUCTION

The celestite deposit of Pan Chemical Co. in the Fish Creek Mountains, San Diego County, Calif., and that of Mineral Products Corp. near La Conner, Skagit County, Wash., were inactive again in 1961. As a result, no domestic production of strontium minerals was reported for the second 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.; Mineral Products Div., FMC Corp.,[3] Modesto, Calif.; and Barium and Chemicals, Inc., Willoughby, Ohio.

King Laboratories, Inc., Syracuse, N.Y., produced a small quantity of strontium metal.

CONSUMPTION AND USES

Strontium minerals, chiefly celestite, continued to be used largely in manufacturing strontium chemicals. Small quantities also were consumed in producing ceramics and glass and in refining caustic soda.

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[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.
[3] Name changed from Food Machinery and Chemical Corp., May 23, 1961.

Strontium chemicals, particularly the nitrate, were used principally in pyrotechnics to impart a brilliant red color to the flame. Common applications were tracer bullets, distress signal rockets and flares, tactical military signal flares, highway and railroad warning fusees, and fireworks. Strontium compounds also were used in ceramics, greases, medicines, corrosion inhibitors, plastics, and luminous paints, and in manufacturing high-purity electrolytic zinc.

Strontium metal was used as a getter in the manufacture of vacuum tubes.

Strontium 90, in the form of titanate pellets, was used as the heat source for thermoelectric production of current to power a Coast Guard navigational buoy and a remote automatic weather station. The buoy in Chesapeake Bay was expected to last 10 years, emitting a flash every 5 seconds.[4] The weather station in the Canadian Arctic was expected to last 2 years.[5]

PRICES

Prices of various strontium compounds were quoted in Oil, Paint and Drug Reporter throughout 1961 as follows: Strontium sulfate, air-floated, 90-percent, 325-mesh, bags, works, $56.70–$66.15 per short ton; strontium carbonate, pure, drums, 5-ton lots or more, works, 35 cents per pound, and drums, 1-ton lots, works, 37 cents per pound; strontium carbonate, 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 1960.

FOREIGN TRADE[6]

Quantity and value of strontium minerals imported were the highest since 1951, as they increased 60 and 63 percent, respectively, over 1960. The United Kingdom supplied about 73 percent of the 1961 imports and Mexico, virtually all the remainder.

Strontium chemicals (carbonate, nitrate, or oxide) were not imported in 1961.

TABLE 1.—U.S. imports for consumption of strontium minerals,[1] by countries

Country	1960		1961	
	Short tons	Value	Short tons	Value
Italy	11	$2,700	11	$2,700
Mexico	[2] 2,881	56,530	2,642	48,713
United Kingdom	3,294	90,476	7,278	193,064
Total	[2] 6,186	149,706	9,931	244,477

[1] Strontianite or mineral strontium carbonate and celestite or mineral strontium sulfate.
[2] Revised figure.

Source: Bureau of the Census.

[4] Chemical Week. Use Atomic Power for Light. V. 89, Dec. 30, 1961, p. 14.
[5] Signal. Signalgram, General. V. 16, October 1961, p. 25.
[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.

WORLD REVIEW

Strontium minerals were produced in several countries; the United Kingdom and Mexico continued to furnish most of the output.

Pakistan.—Two large deposits of celestite were reported in the Dador district.[7]

United Kingdom.—The strontium-90 content of rainwater, soil, grass, and a number of biological materials in the Scottish highlands was studied. A downward trend in radioactivities of these materials was indicated.[8]

TABLE 2.—Free world production of strontium minerals, by countries[1 2]

(Short tons)

Country[1]	1957	1958	1959	1960	1961
Argentina	(3)	240	(3)	(3)	(3)
Italy	1,226	703	353	915	[4] 1,000
Mexico[5]	1,896	2,336	2,182	2,880	2,642
Morocco: Southern Zone	661	1,124	435		
Pakistan	956	510	744	1,492	461
United Kingdom	7,728	6,272	6,720	[4] 7,000	[4] 7,000
United States	(6)		(6)		
Free world total[1]	[4] 13,000	11,185	[4] 10,700	[4] 12,500	[4] 11,400

[1] In addition to countries listed, strontium minerals are produced in Germany, Poland, and U.S.S.R., but data on production are not available; no estimates are included in the total for these countries.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Data not available; estimate 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

Optical and X-ray data were given for celestite and calciostrontianite from a deposit in Wise County, Va. Other occurrences of celestite were reported in Virginia at Hayfield, Frederick County, and near Fulks Run, Rockingham County; calciostrontianite was reported near Dublin, Pulaski County, and near Harrisonburg, Rockingham County.[9]

The occurrence, properties, and uses of strontianite were summarized briefly,[10] and the uses of strontium compounds were traced from earliest applications to the present.[11]

Methods were devised for recovering strontium from an aqueous solution of fission products by precipitating the nitrate from an 18 molar nitric acid solution [12] and from a complete brine by precipitating the chromate.[13] A foam-separation technique for removing strontium

[7] Mining Journal (London). Mining Miscellany. V. 257, July 14, 1961, p. 47.
[8] Stanwix, P., and J. Hawthorn. Strontium-90 From Radioactive Fallout in Central Scotland. Chem. and Ind. (London), No. 17, Apr. 29, 1961, pp. 524–529.
[9] Mitchell, R. S., and R. F. Pharr. Celestite and Calciostrontianite From Wise County, Virginia. Am. Mineral., v. 46, January–February 1961, pp. 189–195.
[10] Mine and Quarry Engineering (London). Strontianite. V. 27, January 1961, pp. 14–15.
[11] Chemical Trade Journal and Chemical Engineer (London). Strontium Compounds, Modern Applications and Uses. V. 149, Sept. 15, 1961, pp. 573–574.
[12] Glueckauf, E. (assigned to The United Kingdom Atomic Energy Authority). Method of Separating Strontium From Other Fission Products. U.S. Pat. 3,010,788, Nov. 28, 1961.
[13] Goodenough, R. D., and V. A. Stenger (assigned to The Dow Chemical Co.). Strontium Chromate From Brine. U.S. Pat. 2,980,502, Apr. 18, 1961.

90 as well as a number of other constituents from solutions was scaled up to pilot plant size.[14] In recovering strontium 90 from fission products, the process should remove at least 99 percent of the calcium and recover at least 95 percent of the strontium 90 to meet product purity specifications. This removal was accomplished by a multistage liquid-liquid extraction process using a buffered aqueous phase and an alcohol additive which reduced the effect of organic-phase loading on the distribution coefficient.[15] Production of strontium 90 titanate for use as the heat source in thermoelectric power plants was described.[16]

A number of articles related to the assimilation of strontium 90 by plant and animal life.[17] Concern over the effects of the absorption of such radioactivity generated a number of studies of analytical methods for determining strontium in biological materials[18] and a process for removing strontium 90 from milk.[19]

Reaction rates of strontium with oxygen and nitrogen were measured as a function of temperature and pressure, and tentative reaction mechanisms were proposed.[20]

Oxide systems containing strontium oxide were studied for compositions useful in developing frits and glazes for ceramic bodies.[21] Highly refractory properties and good chemical stability were reported for strontium zirconate ceramics,[22] and the production, properties, and uses of strontium hexaboride were described.[23]

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[14] Chemical Engineering. Foam Separation Set To Go. V. 68, Apr. 3, 1961, pp. 100–102.

[15] McHenry, R. E., and J. C. Posey. Separation of Strontium-90 From Calcium by Solvent Extraction. Ind. and Eng. Chem., v. 53, August 1961, pp. 647–650.

[16] Chemical & Engineering News. Oak Ridge Details Sr^{90} Production. V. 39, Dec. 11, 1961, pp. 62–64.

[17] Langham, W. H. Some Considerations of Present Biospheric Contamination by Radioactive Fallout. J. Agr. and Food Chem., v. 9, March 1961, pp. 91–95.

Roberts, H., Jr., and R. G. Menzel. Availability of Exchangeable and Nonexchangeable Strontium-90 to Plants. J. Agr. and Food Chem., v. 9, March 1961, pp. 95–98.

Science Newsletter. Strontium-90 in U.S. May Double Next Spring. V. 80, Nov. 18, 1961, p. 336.

Wasserman, R. H., and C. L. Comar. Dietary Considerations of the Radionuclide Contamination of Nonmilk Foods. J. Agr. and Food Chem., v. 9, March 1961, pp. 113–116.

[18] Collin, R. L. X-Ray Fluorescence Analysis Using Ion Exchange Resins for Sample Support; Determination of Strontium in 0.1 M Calcium Acetate Solution. Anal. Chem., v. 33, April 1961, pp. 605–607.

Dumont, P. A. Paper Chromatographic Separation and Complexometric Titration of Trace Amounts of Strontium and Calcium in Biological Material. Anal. Chem., v. 33, April 1961, pp. 565–567.

Natelson, S., and B. Sheid. X-Ray Spectormetric Determination of Strontium in Human Serum and Bone. Anal. Chem., v. 33, March 1961, pp. 396–401.

Porter, C., D. Cahill, R. Schneider, P. Robbins, W. Perry, and B. Kahn. Determination of Strontium-90 in Milk by an Ion Exchange Method. Anal. Chem., v. 33, September 1961, pp. 1306–1308.

Upham, F. T., F. T. Lundgren, and A. V. Nichols. Some Characteristics of a Strontium-90 Beta-Particle Detector for Gas-Liquid Chromatography. Anal. Chem., v. 33, June 1961, pp. 845–849.

Wade, M. A., and H. J. Seim. Ion Exchange Separation of Calcium and Strontium; Application to Determination of Total Strontium in Bone. Anal. Chem., v. 33, May 1961, pp. 793–795.

[19] Science Newsletter. Process Removes 98 Percent of Strontium-90 From Milk. V. 80, Sept. 16, 1961, p. 193.

[20] Chandrasekharaiah, M. S., and J. L. Margrave. The Kinetics of Oxidation and Nitridation of Lithium, Calcium, Strontium, and Barium. J. Electrochem. Soc., v. 108, November 1961, pp. 1008–1012.

[21] Watts, A. S. Control of the Properties of Glazes by the Aid of Eutetics, Part III. The Alkaline Earth-Boric Oxide-Silica Systems Separately and in Combinations. J. Am. Ceram. Soc., v. 44, June 1961, pp. 272–276.

[22] Keler, E. K., and A. K. Kuznetsov. (Synthesis and Physiotechnical Properties of Strontium and Barium Zirconates.) Zhur. prikladnoy Khim. (U.S.S.R.), v. 34, October 1961, pp. 2146–2153; U.S. Department of Commerce, Current Review of the Soviet Technical Press, Off. of Tech. Serv., Dec. 22, 1961, p. 1 (603).

[23] Samsonov, G. V., T. I. Serebryakova, and A. S. Bolgar. (Strontium Hexaboride.) Zhur. Neorg. Khim. (U.S.S.R.), v. 6, October 1961, pp. 2243–2248; U.S. Department of Commerce, Current Review of the Soviet Technical Press, Off. of Tech. Serv., Dec. 22, 1961, p. 1 (600).

The existence of a high-temperature form of strontium orthophosphate (beta-strontium orthophosphate) was established, and the ranges of composition and temperature were determined for stabilizing this crystalline modification at room temperature by solid solution of orthophosphates of magnesium, calcium, zinc, cadmium, and aluminum. Luminescence studies were made on tin-activated beta-strontium orthophosphate solid solution phosphors.[24]

As strontium content in barium-strontium titanates and stannates increased, the shrinkage increased, the Curie point tended toward a lower temperature, and the minimum value of resistivity tended to be higher.[25]

Strontium fluoride crystals doped with divalent samarium were reported to be a new laser material,[26] and strontium halophosphates could be activated with antimony and manganese to form green phosphors.[27] A process for reducing color and increasing transparency in a strontium titanate boule was described.[28]

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[24] Sarver, J. F., M. V. Hoffman, and F. A. Hummel. Phase Equilibria and Tin-Activated Luminescence in Strontium Orthophosphate Systems. J. Electrochem. Soc., v. 108, December 1961, pp. 1103–1110.

[25] Saburi, Osamu. Semiconducting Bodies in the Family of Barium Titanate. J. Am. Ceram. Soc., v. 44, February 1961, pp. 54–63.

[26] Kovac, Carl. Strontium Fluoride Laser Crystals Now Available. Electronic News, v. 6, Oct. 30, 1961, p. 54.

[27] Rimbach, H. W. (assigned to Westinghouse Electric Corp.). Green Halophosphate Phosphor. U.S. Pat. 2,968,626, Jan. 17, 1961.

[28] Beals, M. D., and Leon Merker (assigned to National Lead Co.). Metal Titanate Preparation. U.S. Pat. 2,985,518, May 23, 1961.

Sulfur and Pyrites

By Paul M. Ambrose,[1] Leonard P. Larson,[2] and Betty I. Stanley [3]

SPARKED by great industrial activity in many parts of the free world, production and consumption of sulfur in all forms reached a new record in 1961. Production rose substantially, but consumption grew only moderately. Increased production was mostly in the form of elemental sulfur. The U.S. production of sulfur, in all forms, increased at a greater rate than world output, mainly because new sulfur terminals were stocked with molten sulfur. Prices were slightly strengthened during the year. Exports from the United States were lower, and imports increased. The most notable event that occurred during the year was the conversion, by a large segment of the sulfur-consuming industry, to the use of molten sulfur. Estimates indicated that 50 percent of the elemental sulfur delivered to the consumer was in the molten form.

TABLE 1.—Salient sulfur statistics

(Long tons, sulfur content)

	1952-56 (average)	1957	1958	1959	1960	1961
United States:						
Production	5,670,416	5,578,525	4,645,577	4,639,816	5,037,292	5,477,493
All forms	6,810,450	7,003,888	6,141,169	6,167,740	6,660,541	7,170,279
Imports, pyrites and sulfur	193,552	668,501	754,987	776,888	884,838	966,417
Exports, sulfur	1,519,098	1,592,979	1,602,126	1,635,607	1,786,543	1,596,043
Stocks Dec. 31: Producer, Frasch and recovered sulfur	3,397,559	4,579,623	4,619,028	3,949,954	3,777,799	4,813,521
Consumption, apparent, all forms [1]	5,232,800	5,553,700	5,262,800	5,917,100	[2] 5,863,500	5,435,500
World: Production:						
Sulfur, elemental	(3)	8,740,000	8,370,000	9,190,000	10,290,000	11,380,000
Pyrites	(3)	8,000,000	7,800,000	7,700,000	8,100,000	8,200,000

[1] Measured by quantity sold plus imports minus exports.
[2] Revised figure.
[3] Data not available.

DOMESTIC PRODUCTION

Production of sulfur in all forms totaled 7.2 million tons, approaching for the first time in 4 years the record 7.8 million ton output of 1956. The major production increases were reported for Frasch and recovered sulfur, which gained 443,000 tons (9 percent) and 89,000

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[2] Physical scientist, Division of Mineral Resources, Denver, Colo., formerly with Division of Minerals, Washington, D.C.
[3] Statistical clerk, Division of Minerals.

tons (12 percent), respectively. About 5,385,000 tons of the total production was Frasch process sulfur obtained from Gulf Coast mines in Texas and Louisiana. Other sources were native ore, 92,000 tons; byproduct of sour-natural and refinery gases, 856,000 tons; burning of pyrites, 399,000 tons; and various forms from other source, 438,000 tons.

TABLE 2.—Production of sulfur and sulfur-containing raw materials by producers in the United States

(Long tons)

	1952–56 (average)		1957		1958	
	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content
Native sulfur or sulfur ore:						
Frasch-process mines	5,625,198	5,625,198	5,491,212	5,491,212	4,643,243	4,643,243
Other mines [1]	157,377	45,218	276,868	87,313	6,292	2,334
Total		5,670,416		5,578,525		4,645,577
Recovered elemental sulfur:						
Brimstone	364,287	362,516	511,936	510,307	641,890	640,096
Paste	1,307	617	452	204		
Total		363,133		510,511		640,096
Pyrites (including coal brasses)	980,510	408,901	1,067,396	436,012	974,114	403,373
Byproduct sulfuric acid (basis 100 percent) produced at Cu, Zn, and Pb plants	879,521	287,427	1,194,230	390,394	1,101,754	359,723
Other byproduct sulfur compounds [2]	92,756	80,573	102,157	88,446	106,527	92,400
Total		6,810,450		7,003,888		6,141,169

	1959		1960		1961	
	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content
Native sulfur or sulfur ore:						
Frasch-process mines	4,553,634	4,553,634	4,942,935	4,942,935	5,385,468	5,385,468
Other mines [1]	331,237	86,182	379,067	94,357	400,015	92,025
Total		4,639,816		5,037,292		5,477,493
Recovered elemental sulfur:						
Brimstone	688,487	686,407	769,319	766,566	859,213	855,969
Paste						
Total		686,407		766,566		855,969
Pyrites (including coal brasses)	1,056,617	436,871	1,016,263	416,213	987,309	398,519
Byproduct sulfuric acid (basis 100 percent) produced at Cu, Zn, and Pb plants	969,678	316,600	1,056,890	345,075	1,016,731	331,963
Other byproduct sulfur compounds [2]	104,887	88,046	114,359	95,395	126,923	106,335
Total		6,167,740		6,660,541		7,170,279

[1] Sulfur content estimated for 1952.
[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 during 1961, unchanged from the number of plants (erroneously reported as 13) operating at the close of the preceding year. The 12 facilities operating during 1961 were Texas Gulf Sulphur Co. at Boling, Moss Bluff,

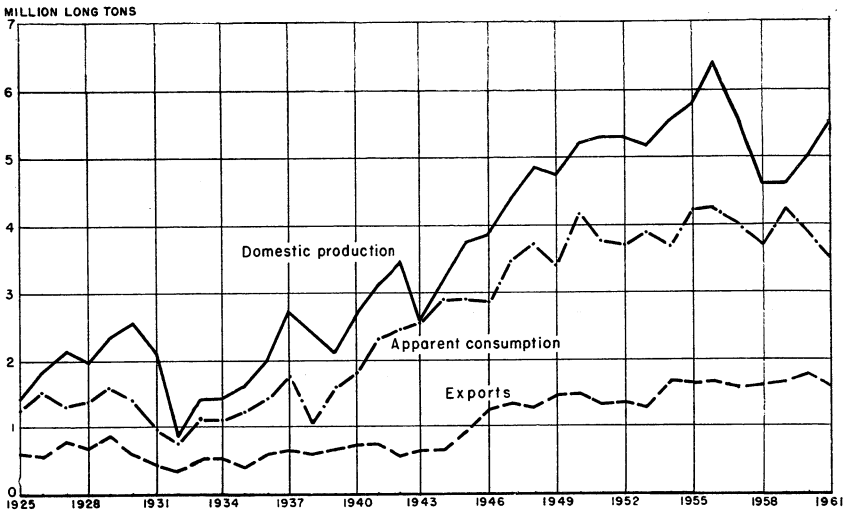


FIGURE 1.—Domestic production, apparent consumption, and exports of native sulfur, 1925–61.

Spindletop, and Fannett domes in Texas; Freeport Sulphur Co. at Grande Ecaille, Garden Island Bay, Grand Isle, Lake Pelto, and Chacahoula in Louisiana; and 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.

Production of sulfur by Duval Sulphur & Potash Co. approximated that of the preceding year. Production from the deep mining area, begun in 1959, continued to increase during the year. Fuel costs were reduced as the quantity of hot water required to produce a ton of sulfur declined significantly owing to a carefully planned water conservation program.[4]

The Freeport Sulphur Co. Frasch-producing properties, all in or off the coast of Louisiana, attained record output, but overall sales decreased from 2.2 million tons in 1960 to 2.1 million. This production made the company the leading producer of the year. Facilities for storage or transshipment of liquid sulfur by independent terminal companies were completed at Joliet, Ill.; Wellsville, Ohio; Tampa, Fla.; Everett, Mass.; and Bucksport, Maine. Receiving facilities also were completed at Warners, N.J. and Savannah, Ga. Freeport had facilities for storing 60,000 tons of liquid sulfur at its principal shipping point, Port Sulphur, La. The Joliet terminal stocked about 150,000 tons of solid sulfur.[5]

Texas Gulf Sulphur Co. produced about 2,450,000 tons of sulfur, an increase of 115,000 tons over the output in 1960, mostly Frasch process material. Some recovered sulfur was produced in a company-owned plant at Worland, Wyo. In 1960 one-fifth of this company's sulfur was shipped in the molten state. Because of cost advantages in handling and storage, the company maintained storage facilities for liquid

[4] Duval Sulphur & Potash Co. Annual Report, 1961. P. 4.
[5] Freeport Sulphur Co. Annual Report, 1961. Pp. 4–6.

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)
1952–56 (average)	3,691,313	1,933,885	5,625,198	5,441,769	$141,501
1957	3,366,377	2,124,835	5,491,212	5,035,240	122,915
1958	2,587,760	2,055,483	4,643,243	4,644,021	109,272
1959	2,519,090	2,034,544	4,553,634	5,222,206	121,777
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

sulfur at Cincinnati, Ohio; Carteret, N.J.; Norfolk, Va.; Tampa and Jacksonville, Fla.; and Savannah, Ga. Additional liquid sulfur storage terminals were under construction at Marseilles, Ill., and Baltimore, Md. In January, the S.S. *Marine Sulphur Queen*, a 15,000-ton tanker and the largest ocean-going vessel used exclusively for transporting molten sulfur, was placed in service. During 1961 the vessel carried 434,000 tons of liquid sulfur from Beaumont, Tex., to Tampa, Fla., and East Coast terminals.[6]

TABLE 4.—Sulfur ore (10–70 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)
1952–56 (average)	157,377	145,535	$1,128	1959	331,237	151,932	$1,418
1957	276,868	172,169	1,521	1960	379,067	181,422	1,732
1958	6,292	153,574	1,505	1961	400,015	177,549	1,694

[1] California, Nevada (except 1954), Utah, and Wyoming (1952 only).

The Long Point, Tex., plant of Jefferson Lake Sulphur Co., produced 230,000 tons of sulfur in 1961. Operations at the Trans-Jeff plant, Tilden, Tex., and the Peace River plant in British Columbia recovered 57,473 tons.[7]

RECOVERED SULFUR

Production of recovered sulfur from sour-natural and refinery gases increased to 856,000 long tons, about 12 percent higher than the 1960 output. Included in the total was production from four new plants. In 1961, 59 sulfur-recovery plants were operated by 43 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. Texas, California, and Delaware produced the largest tonnage of recovered sulfur, furnishing 58 percent of the total output. The largest sulfur-recovery plant produced less than 100,000 long tons, and only a few plants produced more than 50,000 tons.

[6] Texas Gulf Sulphur Co. Annual Report, 1961. Pp. 6–7.
[7] Jefferson Lake Sulphur Co. Annual Report, 1961. P. 6.

Atlantic Refining Co. awarded a contract to Pona Engineers to construct a 30-ton-per-day, $250,000 sulfur-recovery plant at Atlantic's Port Arthur, Tex., refinery. The plant will use hydrogen sulfide waste gases produced at the refinery.

Shell Oil Co., New York, awarded Brown & Root, Inc., Houston, the construction contract for a gas-processing and sulfur-recovery plant. The plant, in Bryans Mill gasfield in Cass County, Tex., was designed to process 30 million cubic feet of gas per day. The rated capacity was 5,700 barrels of condensate, 130 long tons of sulfur, and 18 million cubic feet of residue gas.

PYRITES

Production of pyrites (ores and concentrates) totaled 987,000 tons, 3 percent less than in 1960.

The quantity of pyrites sold or consumed by producing companies totaled 990,697 tons. Of this amount, 117,957 tons, having a sulfur content of 56,870 tons and valued at $815,537, was sold; and 872,740 tons, having a sulfur content of 344,529 tons and valued at $664,396, was consumed.

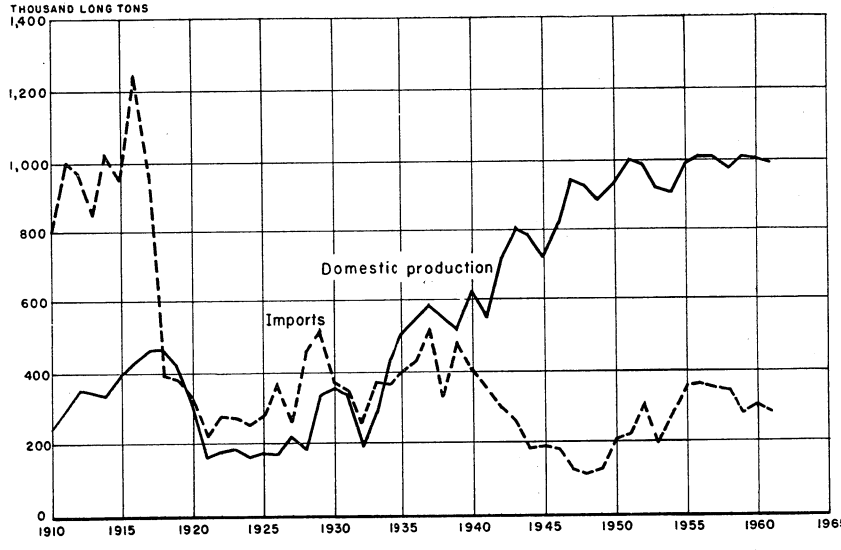


FIGURE 2.—Domestic production and imports of pyrites 1910–61.

Tennessee was the leading pyrite-producing State, followed by California, Virginia, Colorado, Arizona, Pennsylvania, and South Carolina. Tennessee Copper Co. recovered a pyrite flotation concentrate in Polk County, Tenn., as a coproduct of copper. The concentrate was roasted, and the recovered gas was used in manufacturing sulfuric acid and liquid sulfur dioxide. General Chemical Division, Allied Chemical Corp., produced a substantial quantity of pyrites at the Gosson mine in Carroll County, Va. Bethlehem Steel Co. recovered pyrites from its Cornwall and Grace mines in Lebanon and Berks Counties, Pa.

TABLE 5.—Pyrites (ores and concentrates) produced in the United States

Year	Gross weight, long tons	Sulfur content, long tons	Value (thousands)	Year	Gross weight, long tons	Sulfur content, long tons	Value (thousands)
1952–56 (average)	980,510	408,901	$7,049	1959	1,056,617	436,871	$8,148
1957	1,067,396	436,012	9,087	1960	1,016,263	416,213	7,936
1958	974,114	403,373	7,987	1961	987,309	398,519	7,418

In California, Mountain Copper Co., Ltd., produced pyrites at the Hornet mine in Shasta County. In Colorado, pyrites was recovered by Rico Argentine Mining Co. at the Mountain Springs mine, Dolores County; by Climax Molybdenum Co. in Lake County; and by S. N. N. Mining Co., Inc., in Custer County. Other pyrites producers were: Commercialores, Inc., York County, S.C.; and Ray Mines Division, Kennecott Copper Corp., and Magma Copper Co., Pinal County, Ariz.

BYPRODUCT SULFURIC ACID

Copper and zinc plants in the United States produced 1,139,000 tons (100 percent basis) of byproduct sulfuric acid, compared with 1,184,000 tons in 1960. Output decreased 4 percent in 1961 and, except for 1959, was the lowest since 1955.

Copper plants recorded a 12-percent decrease whereas production at zinc plants rose slightly. The acid reported was produced only from the sulfur content of the sulfide ores.

TABLE 6.—Byproduct sulfuric acid [1] (basis, 100 percent) produced at copper, zinc, and lead plants in the United States

(Short tons)

Plants	1952–56 (average)	1957	1958	1959	1960	1961
Copper [2]	284,215	482,181	495,576	282,461	412,845	362,630
Zinc [3]	700,849	855,357	738,385	803,578	770,872	776,109
Total	985,064	1,337,538	1,233,961	1,086,039	1,183,717	1,138,739

[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.

OTHER BYPRODUCT-SULFUR COMPOUNDS

Interest in manufacturing sulfur dioxide increased during the year. Three firms either completed or announced expansions, and two producers announced construction of new facilities. Capacity for the production of liquid sulfur dioxide was estimated to total 98,000 to 107,000 long tons.[8]

A new sulfur dioxide unit was placed on stream by Tennessee Copper Co. in July at Copperhill, Tenn. The new unit doubled the company's previous capacity, increasing output to 90 tons per day. The

[8] Sulfur Institute News. V. 1, No. 10, November 1961, p. 1.

rapid expansion of the paper industry in the Southeast created an increased demand for greater capacity, since more than half of the Tennessee Copper sales were for woodpulp and paper products.[9]

Dixon Chemical Industries, Inc., announced plans to construct a 10,000-ton-per-year liquid sulfur dioxide facility at Newark, N. J. The plant, estimated to cost $660,000, was scheduled for completion by March 1962. Its capacity will represent 12.5 percent of the U.S. sulfur dioxide capacity, according to company spokesmen.[10]

CONSUMPTION AND USES

U.S. consumption of sulfur in all forms decreased for the second successive year and was 5,435,500 long tons, 7 percent below the 5,863,500 long tons used in 1960.

Apparent consumption of all forms of sulfur in the free world was an estimated 18.1 million long tons, a 2-percent increase over the 17.8 million long tons reported for 1960.[11]

Consumption of nonelemental sulfur increased at a slightly higher rate than that of elemental sulfur and was 48 percent of the total sulfur used. Of the nonelemental sulfur consumed, 6 million tons was contained in pyrites and 2.7 million tons was in other forms.

Consumption of elemental sulfur increased 123,000 tons or 1 percent during the year. Frasch sulfur, long the dominant source, relinquished 5 percent of its market to a rapidly expanding recovered-sulfur industry. Contributing to this loss was the increased competition from the recovered-sulfur industries in France, Canada, and the United States, and from the sales of Russian and Polish sulfur in Western European areas. Competition from Lacq, France, was particularly notable, as output from this one source increased from 778,000 tons in 1960 to about 1.1 million tons in 1961. Sales of Russian and Polish sulfur increased sharply from 50,000 tons in 1960 to about 200,000 tons in 1961. Canadian sulfur was sold mainly in the United States and Canada, as less than 20,000 tons was exported to overseas markets in 1961.

STOCKS

On December 31, 1961, producer stocks of Frasch sulfur totaled 4,691,000 long tons, 28 percent above the 3,668,000 tons on hand December 31, 1960. Of this quantity, 4,070,000 tons was at the mines; 300,000 went to storage at new liquid sulfur terminals; and 621,000 tons was elsewhere. Stocks of recovered sulfur in the hands of producers totaled 122,000 tons at yearend, compared with 109,000 tons at the end of 1960. Data on pyrite stocks were not available.

The major marketing development during the year was the change to the delivery of molten sulfur. More than 60 consuming plants were reported to have been converted to the use of liquid in 1961, and others were being converted. Frasch sulfur was delivered to consumers by truck and railroad cars from 11 producer-controlled ter-

[9] Oil, Paint and Drug Reporter. Tennessee Copper Doubling SO_2 Capacity. V. 179, No. 23, June 5, 1961., pp. 3, 58.
[10] Oil, Paint and Drug Reporter. Sulfur Dioxide Facility an "Opening Gun" for Dixon. V. 179, No. 15, Apr. 10, 1961, p. 3.
[11] Guisti, Gino P. Sulphur. Min. Cong. J., v. 48, No. 2, February 1962, pp. 127–129. Carrington, J. C. Sulphur. Eng. Min. J., v. 163, No. 2, February 1962, p. 128, 130.

TABLE 7.—Production of new sulfuric acid [1] (100 percent H_2SO_4) by geographic divisions and States

(Short tons)

Division and State	1957	1958	1959	1960	1961
New England [2]	183,092	174,531	195,614	192,664	179,341
Middle Atlantic:					
Pennsylvania	795,929	647,972	764,239	754,703	770,272
New York and New Jersey	1,541,278	1,458,124	1,673,150	1,681,302	1,652,868
Total	2,337,207	2,106,096	2,437,389	2,436,005	2,423,140
North central:					
Illinois	1,241,474	1,219,517	1,368,644	1,355,647	1,399,349
Indiana	493,151	468,993	479,064	485,297	456,372
Michigan	241,587	298,946	334,609	324,318	307,979
Ohio	713,201	607.791	767,089	742,287	684,312
Other [3]	760,127	697,879	849,807	715,137	781,046
Total	3,449,540	3,293,126	3,799,213	3,622,686	3,629,058
South:					
Alabama	314,669	243,899	309,516	312,996	242,996
Florida	1,738,945	1,830,104	2,036,707	2,272,039	2,518,215
Georgia	318,325	302,195	345,552	337,140	345,775
North Carolina	120,207	119,613	149,774	131,221	133,115
South Carolina	131,933	133,748	152,241	142,652	149,493
Virginia	488,707	469,182	504,223	460,098	448,839
Kentucky and Tennessee	995,277	893,530	1,014,735	997,379	1,024,717
Texas	1,605,445	1,600,683	1,674,284	1,593,303	1,585,307
Delaware and Maryland	1,094,275	1,081,210	1,153,071	1,119,452	1,077,644
Louisiana	727,144	653,573	640,180	595,232	598,534
Other [4]	428,682	496,206	541,565	584,181	606,031
Total	7,963,609	7,823,943	8,521,848	8,545,693	8,730,666
West [5]	1,834,777	1,882,727	1,950,384	2,288,142	2,095,837
Total United States	15,768,225	15,280,423	16,904,448	17,085,190	17,058,042

[1] Includes information for Government-owned and privately operated plants.
[2] Includes data for plants located in Maine, Rhode Island, and Massachusetts.
[3] Includes data for plants located in Iowa (1961), Minnesota, Missouri, Wisconsin, and Kansas.
[4] Includes data for plants located in Arizona, California, West Virginia, Mississippi, Arkansas, and Oklahoma.
[5] Includes data for plants located in Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Washington, Wyoming, and Hawaii. (Data for Hawaii are not included for 1959.)

Source: U.S. Department of Commerce.

TABLE 8.—Apparent consumption of native sulfur in the United States

(Long tons)

	1952–56 (average)	1957	1958	1959	1960	1961
Apparent sales to consumers [1 2]	5,442,875	5,090,660	4,663,625	5,225,245	5,129,300	4,399,454
Imports	50,832	499,401	590,687	642,488	[3] 607,235	648,910
Total	5,493,707	5,590,061	5,254,312	5,867,733	[3] 5,736,535	5,048,364
Exports:						
Crude	1,488,590	1,578,359	1,577,919	1,612,158	1,775,526	1,585,531
Refined	30,508	14,620	24,207	23,449	11,017	10,512
Total	1,519,098	1,592,979	1,602,126	1,635,607	1,786,543	1,596,043
Apparent consumption	3,974,609	3,997,082	3,652,186	4,232,126	[3] 3,949,992	3,452,321

[1] Production adjusted for net change in stocks during the year.
[2] Includes native sulfur from mines that do not use the Frasch process. A small quantity was consumed before 1954; however, this tonnage was not included in these figures.
[3] Revised figure.

TABLE 9.—Apparent consumption of sulfur in all forms in the United States [1]

(Long tons)

	1952–56 (average)	1957	1958	1959	1960	1961
Native sulfur	3,974,600	3,997,100	3,652,200	4,232,100	[2] 3,950,000	3,452,300
Recovered sulfur:						
Sales	338,600	472,700	590,800	709,100	775,200	828,900
Imports	[3]	[3]	[3]	[3]	[2] 134,100	182,600
Pyrites:						
Domestic production	408,880	436,000	403,400	436,900	416,200	398,500
Imports	142,720	169,100	164,300	134,400	146,000	134,900
Total pyrites	551,600	605,100	567,700	571,300	562,200	533,400
Smelter-acid production	287,440	390,400	359,700	316,600	345,100	332,000
Other production [4]	80,560	88,400	92,400	88,000	95,400	106,300
Grand total	5,232,800	5,553,700	5,262,800	5,917,100	[2] 5,862,000	5,435,500

[1] Crude sulfur or sulfur content.
[2] Revised figure.
[3] Data included with imports in table 8. Not separately available before 1960.
[4] Hydrogen sulfide and liquid sulfur dioxide. In addition, a quantity of acid sludge is converted to H_2SO_4 but is excluded from the above figures.

TABLE 10.—Molten sulfur terminals in operation in 1961

Producer-controlled terminals	Number of storage tanks	Total storage capacity (thousand long tons)
Texas Gulf Sulphur Co.:		
Tampa, Fla.	1	7.5
Carteret, N.J.[1]	2	26.0
Cincinnati, Ohio	3	16.8
Norfolk, Va.[1]	2	20.8
Jacksonville, Fla.[1]	1	11.0
Savannah, Ga.[1]	1	11.0
Total	10	93.1
Freeport Sulphur Co.:		
Bucksport, Me.[1]	2	20.0
Wellsville, Ohio [1]	2	20.0
Joliet, Ill.	3	30.0
Tampa, Fla.[1]	4	40.0
Everett, Mass.[1]	1	10.0
Total	12	120.0
Pan American Sulphur Co.:		
Tampa, Fla.[1]	2	20.0
Grand total	24	233.1

Customer-controlled terminals	Number of storage tanks	Total storage capacity (thousand long tons)
American Cynamid Co.:		
Savannah, Ga.[1]	1	10.0
Warners, N.J.[1]	2	12.0
E. I. du Pont de Nemours & Co., Inc.:		
LaPorte, Tex.[1]	1	5.0
Wurtland, Ky.[1]	1	8.0
Carney's Point, N.J.[1]	2	10.0
Grasselli, N.J.[1]	2	10.0
Thompson's Pt., N.J.[1]	2	10.0
Richmond, Va.[1]	2	10.0
Costal Chemical Co.: Pascagoula, Miss.	1	3.0
Monsanto Chemical Co.:		
E. St. Louis, Ill.	1	8.0
El Dorado, Ark.	1	5.0
National Lead Co.		
Sayreville, N.J.	1	10.0
St. Louis, Mo.	1	13.5
Olin Mathieson: Houston, Tex.	1	2.9
Reichhold Chemicals: Tuscaloosa, Ala.	1	3.0
Consolidated Chemical Division of Stauffer Chemical Co.:		
Houston, Tex.	1	3.0
LeMoyne, Ala.	1	11.0
U.S. Phosphoric Products Division of Tennessee Corp.: E. Tampa, Fla.	2	20.6
Total	24	155.0
Total producer and customer terminals	48	388.1

[1] Began operating in 1961.

Source: Mining Congress Journal, v. 48, No. 2, February 1962, p. 129.

minals installed on inland waterways and along the East Coast. More than 70 percent of all domestic shipments in 1962 were expected to be in liquid form.[12]

PRICES

Posted prices of Frasch sulfur in the United States remained unchanged at $25 per long ton f.o.b. Gulf ports for bright sulfur, with a discount of $1 per ton for offcolor material. The average price received for sulfur marketed in 1961 was substantially unchanged from 1960, indicating a halt in the downward trend since 1954. Actual sulfur prices were strengthened in 1961, even though a weak condition persisted, owing to the anticipated large increase in production over consumption during the next few years. Price increases were reported on the East Coast of the United States as well as in overseas markets. Prices in Northwestern United States remained unchanged.

Prices for European pyrites remained unchanged during the year. Spanish crude fines pyrite, Rio Tinto was US$8.40 and Tharsis $8.54 per ton, 48 percent sulfur, f.o.b. Values for residues were reported to have remained firm both on the continent and in the United Kingdom. Quotations indicated $10.50 per ton for cupreous residues and $9.80 per ton for noncupreous residues free Ruhr.[13]

FOREIGN TRADE[14]

Imports.—Sulfur imports rose 12 percent to a new record of 831,000 long tons. Included in this total was 649,000 tons of sulfur from Mexico and 182,000 tons of sulfur from Canada. Recovered sulfur from Canada was marketed chiefly in the Northwest, and Frasch sulfur from Mexico went principally to East Coast markets. Com-

TABLE 11.—U.S. imports for consumption and exports of sulfur

Year	Imports				Exports			
	Ore		In any form, n.e.s.		Crude		Crushed, ground, refined, sublimed and flowers	
	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)
1952-56 (average)	8,873	$215	41,959	[1] $1,067	1,488,590	$43,089	30,509	$2,173
1957	14,454	350	484,947	[1] 11,882	1,578,359	43,940	14,620	1,458
1958	18,906	445	571,781	13,106	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	[2] 103,281	[2] 2,268	[2] 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

[1] Data known to be not comparable with other years.
[2] Revised figure.

Source: Bureau of the Census.

[12] Carrington, J. C. Sulphur. Eng. and Min. J., v. 163, No. 2, February 1962, pp. 128, 130.
[13] Chemical Trade Journal and Chemical Engineer (London). V. 149, No. 3871, Aug. 11, 1961, p. 318.
[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.

pared with 1960 figures, imports of Mexican Frasch sulfur increased 5 percent, 625,000 tons; imports of recovered sulfur from Canada increased 58 percent to 112,000 tons. Imports of Canadian pyrites were 282,000 tons, down 9 percent from the 305,000 tons imported in 1960. A Federal court decision upholding railway freight-rate reductions for sulfur shipped from Western Canada to the Chicago area was expected to result in increased imports of Canadian recovered sulfur. Canadian producers were planning to capture a significant part of the Chicago market.

Exports.—Exports of sulfur by U.S. producers declined to 1.6 million tons from the record 1.8 million tons of 1960. This decline in exports was attributed to a slower rate of industrial growth in overseas markets and to increased competition from recovered sulfur, particularly that recovered from sour natural gas at Lacq, France. Sales of Polish and Russian sulfur contributed to the decline in U.S. exports by absorbing an increased part of the overseas market.

TABLE 12.—U.S. exports of sulfur, by countries

Destination	Crude				Crushed, ground, refined, sublimed, and flowers			
	1960		1961		1960		1961	
	Long tons	Value (thousands)	Long tons	Value (thousands)	Pounds	Value (thousands)	Pounds	Value (thousands)
North America:								
Canada	296,548	$6,394	302,221	$7,028	5,464,045	$291	2,055,169	$200
Central America	3,955	127	4,088	110	624,428	24	695,306	30
Mexico					280,940	36	418,412	58
West Indies	32,335	713	19,140	436	220,152	13	127,146	4
Total	332,838	7,234	325,449	7,574	6,589,565	364	3,296,033	292
South America:								
Argentina	21,468	509	24,176	554	131,500	28	202,300	44
Bolivia			2,311	51				
Brazil	129,317	3,041	133,139	3,041	499,100	104	540,065	110
Chile					39,250	10	42,200	11
Colombia					127,527	15	208,805	22
Ecuador			74	3	54,510	2	71,546	3
Paraguay	59	2	3,074	77	87,800	1		
Peru	10,075	232	10,130	230	335,221	17	198,661	17
Uruguay	5,600	139	4,348	108	227,257	7	72,922	5
Venezuela	1,983	66	6,197	174	874,626	60	5,051,417	113
Total	168,502	3,989	183,449	4,238	2,376,791	244	6,387,916	325
Europe:								
Austria	7,000	165	9,500	214				
Belgium-Luxembourg	79,814	1,887	43,500	969	24,000	1		
Czechoslovakia	18,000	390	21,000	470				
Finland	13,750	328	23,600	535				
France	62,230	1,457	62,600	1,373	108,980	3	28,000	2
Germany, West	90,237	2,108	56,495	1,272	883,024	163	621,375	104
Greece					32,700	1	21,704	1
Netherlands	87,334	2,004	83,976	1,799	21,800	1	8,718	(1)
Norway	3,920	88	1,604	36	266,296	8	160,000	4
Portugal					11,000	2	10,000	(1)
Spain	9,841	216			83,500	17	58,150	12
Sweden	13,203	298	5,615	127	38,800	6	12,740	(1)
Switzerland	37,984	930	37,077	836	177,300	31	120,600	22
United Kingdom	314,274	7,300	285,511	5,998	145,600	27		
Yugoslavia					21,670	1	43,720	4
Other	15,830	377	19,637	452	21,796	1	4,977	(1)
Total	753,417	17,548	650,115	14,081	1,836,466	262	1,089,984	149

See footnotes at end of table.

TABLE 12.—U.S. exports of sulfur, by countries—Continued

Destination	Crude				Crushed, ground, refined, sublimed, and flowers			
	1960		1961		1960		1961	
	Long tons	Value (thousands)	Long tons	Value (thousands)	Pounds	Value (thousands)	Pounds	Value (thousands)
Asia:								
Ceylon	50	$2			30,338	$1	1,552,220	$28
India	144,835	3,419	120,572	$2,734	4,806,901	161	4,222,542	144
Indonesia	3,100	76	5,735	138	296,950	13	279,600	15
Iran	2,000	44			29,270	2	151,541	12
Israel	19,975	449	18,400	380	180,708	19	283,326	17
Japan					190,000	36	153,883	28
Jordan			20	1			752,576	15
Korea, Republic of	1,042	38	7,631	208	3,559,884	75	1,318,449	29
Lebanon	27	2	255	6	141,515	5	175,061	6
Malaya, Federation of					26,070	1	707,422	20
Pakistan	3,090	78	3,024	75	455,609	10	226,619	6
Philippines	1,040	38	1,121	29	828,927	30	738,840	36
Saudi Arabia	1,181	40	2,709	74			1,135,850	19
Taiwan	12,397	289	984	20				
Other	1,655	45	2,368	62	37,070	3	106,332	3
Total	190,392	4,520	162,819	3,727	10,583,242	356	11,804,261	378
Africa:								
Congo, Republic of the, and Ruanda-Urundi [2]					230,601	4		
Morocco	1,766	44			2,400	(1)	3,000	1
Mozambique					274,400	6		
Tunisia	25,250	584						
Union of South Africa	58,000	1,298	46,163	952	2,164,975	106	517,977	67
United Arab Republic (Egypt)	5,060	126			51,120	1	19,140	3
Other	6,428	154	5,412	123	2,200	1		
Total	96,504	2,206	51,575	1,075	2,725,696	118	540,117	71
Oceania:								
Australia	147,000	3,381	141,454	3,076	222,989	37	70,900	15
New Zealand	86,873	2,002	70,670	1,599	343,075	32	357,783	24
Total	233,873	5,383	212,124	4,675	566,064	69	428,683	39
Grand total	1,775,526	40,880	1,585,531	35,370	24,677,824	1,413	23,546,994	1,254

[1] Less than $1,000.
[2] Effective July 1, 1960; formerly Belgian Congo.

Source: Bureau of the Census.

Major exports went to Canada, 302,000 tons; United Kingdom, 286,000 tons; Australia, 141,000 tons; and Brazil, 133,000 tons. All sales of U.S. sulfur outside the North American continent were handled by the Sulphur Export Corp., jointly owned by four major Frasch sulfur producers.

WORLD REVIEW

World production of sulfur in all forms reached a new record of 19.6 million long tons, 7 percent higher than the 18.4 million tons produced in 1960. Output of recovered sulfur (produced from sour natural and refinery gases) made greater gains during 1961 than sulfur from any other source. Canada, France, and the United States contributed to this increase. Worldwide Frasch production increased 5 percent. Production of Frasch sulfur declined 9 percent in Mexico

TABLE 13.—U.S. imports for consumption of pyrites, containing more than 25 percent sulfur, by customs districts

(Long tons)

Customs district	1952–56 (average)	1957	1958	1959	1960	1961
Buffalo	[1] 113, 553	[1] 40, 842	296, 002	230, 606	[2] 244, 103	249, 230
Chicago						52
Connecticut	[2] 18			262		
Michigan	9, 959	20, 744	16, 768	13, 182	11, 870	12, 583
Montana and Idaho					37	14
New York	45		217			
Pittsburgh	289	54				
Rochester		208				
St. Lawrence	5, 794		13, 373	14, 640	21, 338	
Vermont	7, 706	8, 766	16, 523	21, 948	28, 868	19, 725
Washington	[2] 18	18	177			
Total: Long tons	[1] 137, 354	[1] 70, 632	343, 060	280, 638	[3] 306, 216	281, 604
Value	[1] $567, 409	[1] $408, 342	$1, 193, 973	$868, 495	[3] $1, 075, 271	$741, 942

[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] 1956 only.
[3] Revised figure.

Source: Bureau of the Census.

and increased 9 percent in the United States. Output of nonelemental sulfur increased mainly in the form of smelter gases and pyrite.

NORTH AMERICA

Canada.—Production of sulfur in all forms, measured by shipments, totaled 893,151 long tons in 1960, 100,026 tons more than the 793,125 long tons produced in 1959. Of this total, 389,597 tons was sulfur contained in pyrites; 258,590 tons was the sulfur equivalent of smelter gases; and 244,964 tons was elemental sulfur recovered from natural gas and from treating nickel sulfide matte at Port Colborne, Ontario.[15] A preliminary estimate for 1961 indicated that production in all forms measured by shipments in 1961 was 822,633 long tons. Of this total, 190,937 tons was sulfur contained in pyrites; 277,868 tons of sulfur contained in smelter gases; and 353,828 tons elemental sulfur recovered from natural gas and nickel sulfide matte.[16]

The recovered-sulfur industry of Canada was discussed.[17] In Western Canada at the close of 1961, 15 sulfur-recovery plants were operating, 13 in Alberta and 1 each in Saskatchewan and British Columbia. Five of the plants were new, all in Alberta. The new plants were British American Oil Co., Ltd., Homeglen-Rimbey; Petrogas Processing, Ltd., East Calgary; Jefferson Lake Petrochemical of Canada, Ltd., Coleman; Western Lease Holds, Ltd., Wildcat Hills; and Home Oil Company, Ltd., Carstairs. The largest new ones were the Petrogas Processing plant at East Calgary and the new plant at Savannah Creek operated by Jefferson Lake. Annual pro-

[15] Bartley, C. M. Sulphur. Canadian Mineral Industry 1960 (Preliminary). Canada Dept. Mines and Tech. Surveys, Ottawa, July 1961, 17 pp.
Dominion Bureau of Statistics. Preliminary Estimate of Canada's Mineral Production. Catalog No. 26–202, Jan. 2, 1962, 4 pp.
[16] Canadian Mining and Metallurgical Bulletin. Canada's Mineral Industry in 1961. No. 597, January 1962, pp. 1, 2.
[17] Woodrooffe, H. M. Industrial Minerals, Sulfur. Canadian Min. J., v. 83, No. 2, February 1962, pp. 115–116.

TABLE 14.—World production of elemental sulfur by countries[1 2]

(Long tons)

Country	1957	1958	1959	1960	1961
Native sulfur:					
Frasch:					
Mexico	990,118	1,201,483	1,293,181	1,261,574	1,148,494
United States	5,491,212	4,463,243	4,553,634	4,942,935	5,385,468
Total	6,481,330	5,844,726	5,846,815	6,204,509	6,533,962
From sulfur ores:					
Argentina	28,788	31,545	25,207	39,265	[3] 25,000
Bolivia (exports)	783	392		1,175	4,896
Canary Islands	2,900	2,900	2,900	3,900	3,900
Chile	18,492	24,015	21,676	30,900	39,368
China [3]	50,000	70,000	100,000	120,000	120,000
Colombia	5,905	6,693	8,824	8,899	9,941
Greece	2,826				
Italy:					
Crude	175,982	154,137	119,272	79,703	68,668
Ground	19,904	18,619	69,437	34,687	17,567
Japan	253,548	178,052	215,669	243,684	238,562
Mexico	17,797	35,446	[3] 17,700	[3] 17,700	25,116
Philippines	[3] 1,300	1,200		43	158
Poland		9,200	10,500	25,000	130,220
Spain	3,356	3,055	2,851	1,336	[3] 1,500
Taiwan	9,433	6,178	5,533	4,797	5,472
Turkey	12,893	12,622	13,174	16,830	15,506
U.S.S.R.[3]	300,000	400,000	600,000	800,000	900,000
United Arab Republic (Egypt)		7,127	6,013	[3] 6,000	[3] 6,000
United States	87,313	2,334	86,182	94,357	92,025
Total [3 4]	990,000	960,000	1,305,000	1,530,000	1,700,000
Total native sulfur	7,470,000	6,810,000	7,150,000	7,730,000	8,240,000
Other elemental:					
Recovered:					
Algeria [5]	18,275	21,062	21,416	23,221	[3] 24,000
Bulgaria	2,591	2,800	4,000	5,000	[3] 5,000
Canada (shipments) [6]	95,962	166,121	263,192	244,964	353,828
China [3 5]	80,000	100,000	100,000	120,000	120,000
France [7]	27,528	126,542	419,273	778,018	1,088,000
Germany:					
East	100,190	104,679	106,153	100,130	[3] 100,000
West	76,569	75,566	78,474	82,807	[3] 82,000
Iran [8]	16,665	12,800	[3] 19,000	[3] 19,000	[3] 19,000
Italy [3]	2,000	4,000	4,000	3,200	3,200
Japan [8]	5,486	7,889	7,829	8,326	8,163
Mexico [7]	41,642	27,641	46,231	46,839	52,849
Netherlands [5]	14,400	20,800	30,700	30,500	[3] 30,000
Netherlands Antilles: Aruba [3]	30,000	30,000	30,000	30,000	30,000
Norway [5]	95,149	89,126	77,111	71,254	61,156
Portugal [5]	16,675	17,373	15,888	10,915	8,813
Spain [5]	50,200	25,251	25,719	40,194	[3] 40,000
Sweden [9]	33,310	33,465	37,576	38,000	[3] 38,000
Taiwan [8]			810	875	1,968
Trinidad [3 8]	5,000	5,000	5,000	5,000	5,000
Union of South Africa [8]					2,163
U.S.S.R.[3]	[10]	[10]	[10]	50,000	100,000
United Arab Republic (Egypt)	3,445	[3] 3,000	2,403	17,716	44,692
United Kingdom	39,142	49,561	53,173	62,402	[3] 62,000
United States	510,511	640,096	686,407	766,566	855,969
Total other elemental	1,270,000	1,560,000	2,040,000	2,560,000	3,140,000
World total (estimate)	8,740,000	8,370,000	9,190,000	10,290,000	11,380,000

[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] In some years Iran produces mine sulfur equivalent to 250–1,500 tons of sulfur. No estimate in total.
[5] From sulfide ores.
[6] Produced from natural gas, includes a small quantity derived from treating nickel-sulfide matte at Port Colborne, Ontario.
[7] From natural gas.
[8] From refinery gases.
[9] From shale oil.
[10] Negligible.

Compiled by Helen L. Hunt, Division of Foreign Activities.

TABLE 15.—World production of pyrites (including cupreous pyrites)[1 2]

(Thousand long tons)

Country [1]	1952–56 (average) gross weight	1957		1958		1959		1960		1961	
		Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content
North America:											
Canada (sales)	638	1,041	460	1,064	458	982	416	922	396	452	223
Cuba	75	36	17	23	17	[3] 25	[3] 12	[4]	[4]		
United States	981	1,067	436	974	403	1,057	437	1,016	416	987	399
South America: Venezuela	[5] 59	15	4	14	4	4	1				
Europe:											
Bulgaria:											
Pyrites	141	107	45	69	28	31	13	36	15	[3] 36	[3] 15
Pyrites concentrates	45	89	37	83	34	113	47	[3] 113	[3] 48	[3] 113	[3] 48
Czechoslovakia	280	364	[3] 153	379	[3] 143	365	[3] 144	384	148	394	[3] 155
Finland	266	292	[3] 126	249	[3] 105	259	109	255	107	265	112
France	364	402	146	420	149	401	130	406	130	280	123
Germany:											
East	130	152	53	[3] 146	51	[3] 141	49	[3] 132	46	[3] 132	[3] 46
West	552	596	237	557	224	462	189	529	219	523	221
Greece	220	231	102	160	71	127	56	[3] 128	[3] 56	[3] 167	[3] 75
Italy	1,243	1,448	652	1,490	677	1,498	674	1,521	692	1,555	708
Norway	777	830	360	780	339	732	320	820	356	709	311
Poland	137	207	76	208	75	217	79	223	83	198	76
Portugal	696	656	302	589	271	622	286	645	297	643	296
Rumania	151	174	70	202	81	231	93	263	105	[3] 271	[3] 108
Spain	2,106	2,225	1,041	2,014	931	2,086	961	2,217	1,053	[3] 2,018	[3] 965
Sweden	411	494	245	329	163	341	169	406	203	[3] 443	[3] 217
United Kingdom	7	4	[3] 1	3	[3] 1	1	[6]	[6]	[6]	[6]	[6]
Yugoslavia	198	308	123	326	130	285	114	410	164	358	143
Asia:											
China [3]	[4]	[4]	[4]	492	221	689	310	984	443	1,181	531
Cyprus	1,215	1,650	[3] 792	1,658	[3] 796	1,226	[3] 589	[7] 1,064	[7] 515	961	465
Japan	2,654	3,324	1,404	3,306	1,378	3,336	1,396	3,634	1,517	3,869	[3] 1,637
Korea, North	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[3] 400	[3] 160
Philippines	7	18	8	19	[3] 8	25	[3] 11	25	[3] 11	51	[3] 22
Taiwan	28	33	12	32	12	33	13	42	16	47	16
Turkey	23	48	23	80	39	87	42	42	20	97	46
Africa:											
Algeria	23	19	8	24	11	29	13	38	17	48	22
Morocco	2	6	2	18	6	14	5	13	5	[3] 13	[3] 5
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	26	20	8	58	24	40	17	49	19	58	[3] 25
Union of South Africa	226	388	160	493	205	495	195	492	[3] 197	440	176
Oceania: Australia	194	229	109	227	109	223	107	239	115	235	113
World total (estimate) [1 2]	16,100	18,900	8,000	18,700	7,800	18,400	7,700	19,300	8,100	19,400	8,200

[1] Brazil and U.S.S.R. produce pyrites, but production data are not available; estimate is included in the total for U.S.S.R. Negligible quantities are produced in Austria, India, Republic of Korea, and Tunisia.

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

[3] Estimate.

[4] Data not available; estimate included in total.

[5] One year only, as 1956 was first year of commercial production.

[6] Less than 500 tons.

[7] Exports.

Compiled by Helen L. Hunt, Division of Foreign Activities.

duction capacity of the newly installed plants totaled 576,000 long tons. The capacity was mostly in Alberta where 13 plants having a production capacity of 1,097,681 long tons were operating. Of the remainder, 2,188 tons was in Saskatchewan, and 102,679 tons in British Columbia. Major new additions to Canadian recovered sulfur capacity scheduled for completion in 1962 were the new 484,000-ton-per-year plant being built by Shell Oil Co. at Pincher Creek, Alberta, and a 559,000-ton-per-year plant under construction in the Windfall area of Alberta by Pan American Petroleum Corp. The Shell plant will use natural gas containing 22 percent H_2S, and the feed to the Pan American plant will contain from 15 to 20 percent H_2S. When these plants are constructed, the production capacity from sour gas in Canada will be 2,246,302 long tons per year.

TABLE 16.—Sulfur recovery plants in Western Canada, 1961

Company	Location	Approximate H_2S, percent	Capacity, long tons	
			Daily	Annual
British American Oil Company, Ltd.	Pincher Creek, Alberta	10	674	235,715
Do.	Nevis, Alberta	6	99	34,822
Do.	Homeglen-Rimbey, Alberta	4–8	250	87,500
Canadian Oil Companies, Ltd.	Innisfail, Alberta	14	98	33,929
Home Oil Co., Ltd.	Carstairs, Alberta	1	60	20,893
Imperial Oil, Ltd.	Redwater, Alberta	3	9	3,125
Jefferson Lake Petrochemicals of Canada, Ltd.	Coleman, Alberta	14	375	131,250
Do.	Taylor Flats, British Columbia	3	295	102,679
Petrogas Processing, Ltd.	Calgary, Alberta	16	857	300,001
Royalite Oil Company, Ltd.	Turner Valley, Alberta	4	29	10,268
Shell Oil Company of Canada, Ltd.	Jumping Pound, Alberta	3	98	33,929
Standard Oil of California and others.	Nevis, Alberta	6	116	40,179
Steelman Gas, Ltd.	Steelman, Saskatchewan	1	6	2,188
Texas Gulf Sulphur Co. and others.	Okotoks, Alberta	35	371	129,465
Western Lease Holds, Ltd.	Wildcat Hills, Alberta	4	104	36,607
Total			3,441	1,202,550

Source: Canadian Min. J., v. 83, No. 2, p. 116.

Output in Alberta came from sulfur-recovery plants in Calgary, Carstairs, Homeglen-Rimbey, Innisfail, Jumping Pound, Nevis, Okotoks, Pincher Creek, Redwater, and Turner Valley. The remainder was produced at sulfur-recovery plants in Saskatchewan and British Columbia, at oil refineries in Quebec, and at nickel refineries in Ontario. Of 434,396 long tons produced in Alberta in 1961, 302,748 tons was delivered, 129,881 tons was stocked, and 1,767 tons was lost.[18]

The recovery plant at Taylor Flats, British Columbia, produced 53,977 long tons of sulfur, of which 33,678 tons was sold. The inventory on December 31, 1961, was 87,323 tons.[19]

The first full bulk cargo (10,000 tons) of elemental sulfur produced from Canadian sour gases was exported from Vancouver, British Columbia, during October. The cargo, destined for Taiwan, was expected to be the forerunner of many similar cargoes.[20] Exports of sulfur from Canada increased from 127,715 long tons in 1960 to an

[18] Oil and Gas Conservation Board. Alberta Oil and Gas Industry Monthly Report. December 1961, p. 92.
[19] Department of Mines and Petroleum Resources. British Columbia Monthly Oil and Gas Report. December 1961, p. 22.
[20] Chemical Trade Journal and Chemical Engineer (London). V. 149, No. 3885, Nov. 17, 1961, p. 1076.

estimated 195,000 tons in 1961. Most of the elemental sulfur and over 80 percent of the pyrites were exported to the United States. The total value of sulfur and pyrites exported from Canada totaled US$3,971,166.

Imports of sulfur totaled 293,541 long tons, valued at US$6,547,036. Of this total, the United States supplied 293,521 tons valued at $6,545,063.

The competitive position of the Canadian recovered sulfur industry was strengthened during 1961 by the reduction in freight rates from Calgary, Alberta, to Chicago, from $0.8900/cwt. to $0.5750/cwt., equivalent to US$12.88 per long ton. The new rate, effective in August, was contested by Freeport Sulphur Co. on grounds that the Interstate Commerce Commission proceedings had been illegal. However, the rate was upheld by a three-judge federal court on December 22.

Rail rates on the movement of Canadian sulfur from Calgary, Alberta, to Vancouver, British Columbia, were reduced 22.2 percent, from $0.45/cwt. to $0.35/cwt. earlier in the year, making Canadian sulfur competitive in certain foreign markets with sulfur from other areas. Rail charges for transporting sulfur 647 miles from the gasfields of Alberta to Vancouver, totaled $7.84 per long ton.

Jefferson Lake Petrochemical of Canada Ltd., joined with Mobil Oil of Canada, Ltd., and 26 other oil and gas companies owning reserves in the Calgary, Alberta gasfield to form Petrogas Processing, Ltd. Jefferson Lake Petrochemical and Mobil Oil of Canada each were reported to own 31.35 percent of Petrogas. The new company was building a $13 million gas-treating and sulfur-recovery plant, capable of treating 150 million cubic feet of natural gas daily and producing 875 long tons of elemental sulfur, 107 million cubic feet of pipeline gas, and 2,200 barrels of stablized condensate. The plant was to be operated by Jefferson Lake Petrochemical.

The Alberta Oil and Gas Conservation Board approved plans by Shell Oil Co. of Canada, Ltd., to construct a gas-processing and sulfur-recovery plant in the Waterton Pincher Creek area of southwestern Alberta. Estimated cost of the facility, to be built 15 miles south of Pincher Creek and 11 miles west of the British American Oil Co. gas-processing and sulfur-recovery plant, was reported to be $20 million. Construction was expected to be completed by the end of 1961.[21]

Costa Rica.—Costa Rica reduced import duties more than 50 percent on refined sulfur effective September 20, 1961.[22]

Mexico.—Production of sulfur in all forms in Mexico totaled 1,224,000 long tons, 8 percent below the 1,326,000 tons produced in 1960. Of the 1961 total, 1,156,000 tons (95 percent) was produced at three Frasch mines, 18,000 tons (1 percent) from volcanic sulfur, and 51,000 tons (4 percent) from oil refineries. The lessened production of sulfur in 1961 may have resulted from the closing in February of Nopalapa Dome, which did not report production for the year.

Stocks in the hands of producers on December 31, 1961, totaled 639,000 tons, 34 percent less than the 971,000 tons on hand December 31, 1960. Of the sulfur on hand, 630,000 tons was Frasch sulfur;

[21] Sulfur Institute News. V. 1, No. 3, April 1961, p. 3.
[22] Foreign Commerce Weekly. Costa Rica Cuts Imports Duty on Sulfur and Copper Tubing. V. 66, No. 16, Oct. 16, 1961, p. 25.

6,000 tons was recovered sulfur; 3,000 tons was sulfur from volcanic sources.

Exports of sulfur from Mexico totaled 1,130,000 long tons, about 8 percent less than the 1,234,000 tons reported for 1960. Over half of the exports, 649,000 tons, went to the United States.

TABLE 17.—Mexico: Exports of sulfur (Frasch) by countries

(Long tons)

Destination	1960	1961	Destination	1960	1961
North America:			Europe—Continued		
Canada		2,905	Sweden	1,968	
Cuba	4,348		United Kingdom	89,034	102,356
Nicaragua		3,133	Asia:		
United States	719,032	649,207	India	26,699	39,497
South America:			Indonesia	3,000	700
Brazil	3,880		Israel	19,344	14,644
Peru	798		Africa:		
Europe:			Tunisia		25,157
Belgium	52,019	53,320	Union of South Africa	66,581	62,078
France	96,655	29,525	Oceania:		
Germany, West	25,193	23,165	Australia	62,046	61,325
Greece		4,665	New Zealand	45,905	44,059
Italy	5,404				
Netherlands	11,789	13,788	Total	1,233,695	1,129,524

Source: Compiled from Customs Returns of Mexico and U.S. Embassy, Mexico, D.F., Mexico, State Department Dispatch 896: Jan. 25, 1962, p. 2, by Bertha M. Duggan, Division of Foreign Activities.

SOUTH AMERICA

Brazil.—Industria Brasileira de Enxofre began manufacturing flowers of sulfur at its plant at Capuava near São Paulo. This was the first output of byproduct sulfur in Brazil.[23]

Peru.—Cia Minera Regato S.A. and Industrial Azufre Peruana S.A. announced plans to open a sulfur mine and mill near Piura, to supply all of Peru's [24] sulfur requirements. The first shipments were expected to be made early in 1962.

EUROPE

Belgium.—Construction of a 60-ton-per-day sulfur recovery plant was planned at the Antwerp refinery of Société Industrielle des Petrolés as part of a US$30.8 million expansion program. The program would require about 2 years to complete.[25]

Germany, East.—Production of 40,000 tons of elemental sulfur from crude oil at VEB Erdölverarbeitungswerk Schwedt an der Oder (Schwedt Oil Refinery) was expected by the end of 1963.[26]

Germany, West.—The principal pyrites producer in West Germany, Sachtleben A. G. was building a new plant to produce 300,000 tons of new sulfuric acid annually from pyrites. The bulk of the acid was to be used by Ruhrstickstoff A. G. in manufacturing ammonium sulfate. The new plant was to replace a number of obsolete sulfuric acid plants that were supplying Ruhrstickstoff.[27]

[23] U.S. Consulate, São Paulo, Brazil. State Department Dispatch 362, Apr. 4, 1961.
[24] Mining Journal (London), v. 257, No. 6584, Oct. 27, 1961, p. 427.
[25] Chemical Engineering. International, Belgium. V. 68, No. 6, Mar. 20, 1961, p. 198.
[26] Sulphur (London). Current Events, East Germany, Sulphur Recovery at Schwedt. No. 37, December 1961, p. 40.
[27] Chemical Trade Journal and Chemical Engineer (London). The Pyrites Trade. V. 149, No. 3871, Aug. 11, 1961, p. 318.

Gelsenkirchener Bergwerks A. G. was the leading producer of recovered sulfur in West Germany, processing 17,677 tons, of which 31 percent was derived from H_2S extracted at coke ovens and 49 percent from oil refinery gases. In addition the company delivered to Ruhr Gas A. G. 7,200 tons of sulfur in spent oxide; by catalytic conversion of H_2S it produced 35,035 tons of sulfuric acid. Of this output, 75 percent came from H_2S in coke oven gas; 25 percent, from H_2S recovered from oil refinery gas.[28]

Greece.—Over 85 percent of the 12,000 to 13,000 long tons of sulfur imported a year was used to control powdery mildew in vineyards. In December 1960 the Greek Government approved the application of Sulphur S.A., subsidiary of Continental Ore Corp., New York, to invest US$700,000 for constructing a 40,000-ton-per-year sulphur-graining plant at Soussaki, 73 miles from Athens. It was reported that Sulphur Hellas, the subsidiary of Sulphur S.A., operating in Greece, would operate the plant which was expected to satisfy local requirements and provide 25,000 tons annually for export. Imported sulfur would be used; however, the company planned to explore the possibility of developing sulfur deposits on the island of Melos and near the plant site at Soussaki. The Greek Government also approved the investment of US$850,000 for another plant, which would be integrated with the phosphate fertilizer plant planned by Freeport Sulphur Co.[29]

Italy.—Montecatini Mining and Smelting Co. began constructing a new pyrite-roasting plant scheduled for completion by June 1962 at Casone, near Follonica in Grosseto Province, Italy. Initially the plant was to produce 170,000 long tons of iron ore (pyrite cinder) annually and 350,000 tons of sulfuric acid as coproducts. About 150 persons were to be employed at the new plant.

Aerial conveyors will carry the pyrite ore from the Niccioleta mine at Massa Marittima (Grosseto) to the plant at the rate of 1,300 tons daily. The ore will be roasted in two furnaces to liberate sulfuric anhydride. Special furnaces will purify the solid iron oxide residue (about 65 percent iron), which will be formed into pellets for shipment to steel manufacturers. The sulphuric anhydride will be transformed into sulphuric acid in an adjoining plant. Montecatini will use part of the sulfuric acid produced; the remainder will be sold on the open market.

Heat from the plant's furnaces was to be used in a 90,000-kilowatt-capacity thermoelectric plant to generate 60 million kilowatt-hours of electricity annually for use in Montecatini mines in the area.

This proposed new sulfuric acid supply would add to the problems facing the Italian sulfur industry, which had difficulty in disposing of output because of high production costs.[30] In this connection, a special commission appointed by the Italian Government to study the sulfur industry in Sicily recommended the mechanization of the sulfur mines and the development of chemical manufacturing. It also recommended that the number of operating mines be reduced from 39 to 9, and that the annual output of sulfur be reduced from 1.2 million to 630,000 tons. The mines to be kept in operation would

[28] Sulphur (London). Current Events, West Germany. No. 37, December 1961, p. 40.
[29] Bureau of Mines. Mineral Trade Notes. V. 54, No. 2, February 1962, p. 50.
[30] Bureau of Mines. Mineral Trade Notes. V. 53, No. 1, July 1961, p. 35.

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have a reserve adequate for 20 years. The commission also recommended that a large new chemical fertilizer plant needing 130,000 tons of Sicilian sulfur annually be constructed at the port of Gela. The cost of the project was estimated at US $75.2 million.[31]

Reports from Italy indicated that a special committee was being formed by the European Economic Community Commission (EEC) to develop a solution to the Italian sulfur industry's problems. The committee was to be composed of 15 members: 6 from Italy, including 1 representing the Italian Government and 1 representing Sicily, 5 from other EEC countries, 3 experts of the EEC commission, and 1 representative of the European Investment Bank.[32]

Ente Zolfi Italiana, the Italian Sulphur Board, concluded an agreement with Snia Viscosa of Milan for installing a small refining plant to treat sulfur concentrate and produce refined sulfur at Licata. Output was expected to total about 140 tons of high purity (minimum 99.5 percent) molten sulfur, all of which was to be used by Snia Viscosa.[33]

Norway.—Large deposits estimated to contain 15 to 20 million tons of cupreous pyrites were discovered in the north Trondelag district near Lake Limingen on the Swedish border. Surveys and preparations for mining were being made by the State-owned Joma Bergverk A/S.[34]

The State-owned Rana Gruber A/S, prepared plans for developing the Dunderland pyrite deposits in northern Norway.[35]

Poland.—Production of elemental sulfur from deposits near Piaseczno in the Tarnobrzeg region was estimated at 200,000 long tons in 1961, the first full year of production.[36] By 1965 output was expected to be 400,000 tons. When mining operations begin at Machow, total capacity should increase to 1 million tons. The deposits, which were discovered in 1953, occur on both sides of the Biala River and extend over an area of approximately 7,400 acres. Near Piaseczno the ore is shallow and may be recovered by open-pit methods, but at Machow the ore is deeper and of a better grade. Sulfur reserves in Poland were estimated at 95 to 110 million tons.[37]

United Kingdom.—R. & J. Dempster, Ltd., Manchester, received an order from the Eastern Gas Board for a Stretford sulfur extraction plant to be installed at the Norwich gasworks to treat 4 million cubic feet of gas a day.[38] The Stretford process was patented by the North Western Gas Board and Clayton Aniline Co.[39]

Simon-Carves, Ltd., Cheadle Heath, Stockport, was awarded the contract to design and to construct a waste-gas disposal plant at the Scottish Gas Board high-pressure coal-gasification plant at Westfield (Fife). Catalytic oxidation of hydrogen sulfide to sulfur dioxide be-

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[31] Chemical Trade Journal and Chemical Engineer (London). Sicilian Sulphur Prospects. V. 148, No. 3861, June 2, 1961, p. 198.
[32] Chemical Age (London). V. 86, No. 2208, Nov. 4, 1961, p. 721.
[33] Sulphur (London). Current Events, Italy. No. 35, August 1961, p. 41.
[34] Mining Journal (London). Mining Miscellany. V. 257, No. 6571, July 28, 1961, p. 97.
[35] Canadian Mining Journal (Quebec). Outside Canada, Norway. V. 82, No. 10, October 1961, p. 106.
[36] Mining Journal (London). Polish Sulphur Output. V. 258, No. 6603, Mar. 9, 1962, p. 244.
[37] Oil, Paint and Drug Reporter. Poland Soon To Be Power in Sulfur Mart. V. 179, No. 16, Apr. 17, 1961, pp. 5, 62.
[38] Iron and Coal Trades Review (London). Orders Placed. V. 182, No. 4838, Apr. 7, 1961, p. 755.
[39] Chemical Age (London). Second Stretford Process Order for Dempster. V. 85, No. 2178, Apr. 8, 1961, p. 577.

fore it mixes with the flue gases was selected as the most suitable process.[40]

Consumers and merchants in the United Kingdom received an increased number of offers to sell Russian pyrites. Included in the offers were pyrite fines containing 47 to 47.5 percent sulfur, 0.3 to 0.4 percent copper, and flotation pyrites containing 45.5 to 46 percent sulfur and 0.3 to 0.4 percent copper. Both grades had under 0.05 percent arsenic.[41]

ASIA

India.—Sulfur requirements of India were supplied entirely by imports, which increased to 177,296 long tons in 1960. Crude sulfur was obtained principally from the United States and Mexico.[42] Consumption in 1960 was 183,000 tons, about 80 percent in the manufacture of sulfuric acid. Consumption was expected to increase to 600,000 tons in 1966.

The average price of sulfur c.i.f., Indian ports, increased from US$31 in 1959 to US$32 a ton in 1960.

The Pyrites & Chemicals Development Co., subsidiary of the Government-owned National Industrial Development Corp., was formed to exploit high-grade pyrite deposits (45 percent sulfur) at Amjor in Bikar and to manufacture sulfur and sulfuric acid, using technical aid from a Norwegian firm. The cost of the mine and plant was estimated at US$14.7 million. Transportation of the pyrite ore from Amjor to Sindri, the proposed site of a 200- to 300-ton-per-day sulfur plant, was estimated at US$3 a ton.

Owing to the installation of about 100,000 tons of additional capacity and the availability of more sulfur during the year, production of sulfuric acid increased to 350,000 tons in 1960 from 292,000 tons in 1959. About one-fourth of the total sulfuric acid capacity of 475,000 tons was idle.

An increase in sulfuric acid capicity to 1.5 million tons by the end of the Third 5-Year Plan in March 1966 was proposed. A part of the additional capacity would use byproduct smelter gases (zinc and copper smelters) and sulfur gases produced from pyrite from the Amjor deposits in Bihar.

The annual requirements of sulfuric acid by the end of the Third Plan were estimated at 1,250,000 tons, about 780,000 tons of which would be needed for manufacturing superphosphate, ammonium phosphate, and other fertilizers. About 190,000 tons would be required to manufacture synthetic yarns and fibers.

Indonesia.—The sulphuric acid plant at Sepandjang, East Java, a nationalized Dutch enterprise formerly known as C.I.H. Mij., was the only producer of sulfuric acid in Indonesia. The plant produced 3 tons of sulfuric acid daily, using raw sulfur from East Java (30 tons a year) and West Java (300 tons a year).

Plans were drafted for constructing a 25-ton-per-day plant as part of the initial phase of the 8-Year Plan. The new plant was designed to use the vanadium-contact process and to operate 24 hours a day at

[40] Iron and Coal Trades Review (London). Waste-Gas Disposal and Sulphur Recovery at Westfield. V. 183, No. 4853, July 21, 1961, p. 148.
[41] Chemical Trade Journal and Chemical Engineer (London). The Pyrites Trade. V. 149, No. 3871, Aug. 11, 1961, p. 318.
[42] Bureau of Mines. Mineral Trade Notes. V. 53, No. 5, November 1961, pp. 43–45.

98 percent capacity. The Eight-Year Plan called for increased production to 1,000 tons of sulfuric acid daily.[43]

Iraq.—Large deposits of sulfur were reported to have been found in northern Iraq by Iraq and Soviet surveyors. The Soviets worked under a technical and economic cooperation agreement.[44]

Jordan.—The Minister of Economy issued a license to Jordan Sulphur Co. to mine sulfur near the Dead Sea. The sulfur was to be used locally, principally by the petroleum refinery and the match factory.[45]

Taiwan.—Production of sulfur continued to decline during 1960 because of high production costs. Four of the eight privately owned plants active in 1959 suspended operations. Because supply was erratic and because prices for local material were high, sulfur was imported to meet the demand of Taiwan's principal consumers—Kaohsiung Ammonium Sulfate Corp., China Artifical Fiber Corp., and the major paper manufacturers.

The China Petroleum Corp. 3,000-ton-per-year sulfur recovery plant began operating in 1959 and produced 200 tons of sulfur during the first year. In 1960 the price of refined sulfur in Taiwan averaged about US$61.88 a ton.[46]

Turkey.—Production of pyrite decreased from 88,675 tons in 1959 to 42,285 tons in 1960. The Etibank Keciborlu mines in Isparta Province, the only producer of refined sulfur, increased output to 17,000 long tons in 1960, compared with 13,385 tons in 1959. The local market was unable to consume the increased output, and reportedly stocks have accumulated to about 5,000 tons.

In 1960, 52,410 tons of unroasted pyrite (1.9 percent copper) valued at US$553,524 was exported from the Etibank copper-pyrite operations at Kure to a metallurgical plant in West Germany. Exports of pyrite in 1959 totaled 65,802 tons. During 1960, an aerial tramway was completed from the mine to the port of Inebolu.[47]

United Arab Republic (Syria Region).—Plans were being made by the United Arab Republic's General Petroleum Authority to include a 28,000-ton-per-year sulfur recovery plant as part of a US$75-million petrolchemical complex to be built at Suez. Sulfur produced at the plant was to be used for captive conversion to sulfuric acid and carbon disulfide.[48]

AFRICA

Rhodesia and Nyasaland, Federation of.—Production of iron pyrites, containing about 38 percent sulfur, increased to 49,298 long tons, valued at US$220,825, in 1959. Virtually the entire output, which came from the Iron Duke mine north of Salisbury, Southern Rhodesia, was used by African Explosives & Chemical Industries Ltd., at Msasa, Salisbury, in manufacturing sulfuric acid.[49]

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[43] Page 45 of work cited in footnote 42.
[44] Chemical Trade Journal and Chemical Engineer (London). Sulphur Deposits in Iraq. V. 148, No. 3852, Mar. 31, 1961, p. 716.
[45] Bureau of Mines. Mineral Trade Notes. V. 53, No. 6, December 1961, p. 46.
[46] Bureau of Mines. Mineral Trade Notes. V. 53, No. 3, September 1961, p. 43.
[47] Bureau of Mines. Mineral Trade Notes. V. 54, No. 1, January 1962, pp. 42, 43.
[48] Chemical Engineering, v. 68, No. 10, May 15, 1961, p. 202.
[49] Bureau of Mines. Mineral Trade Notes. V. 53, No. 5, November 1961, p. 39.

OCEANIA

Australia.—More than 20,000 tons of sulfur reportedly was lost annually in stack gases at Kalgoorlie. Gold mines at Kalgoorlie shipped about 5,000 tons of sulfur to Fremantle. The manufacture of sulfuric acid at Kalgoorlie, was not economical because of transportation costs.

TECHNOLOGY

Two new micromethods for determining sulfur in organic compounds by gas chromatography were devised.[50] Both methods offered speed of analysis, simplicity of apparatus and procedure, and the ability to handle extremely small samples. One is based on a reduction technique; the other is based on oxidation. Each method reduces time needed for analyses from hours to 30 minutes or less.

Laboratory-scale tests indicated the economic probability of recovering sulfur from low-grade deposits by leaching low grade ores with dimethyl disulfide (DMDS) which is a moderately flammable chemical having a boiling point of 109° C. In tests on Sicilian ores crushed to minus 10-mesh leaching was found to be 99 percent efficient at temperatures between 85° and 90° C. When crushing was coarse (to minus ¼-inch) efficiency fell to 91 percent. Solvent loss per ton of crystallized sulfur produced was less than 20 pounds, when high-grade ores were treated. The octahedral crystals, produced by slowly cooling the pregnant solution, assayed more than 99.9 percent sulfur and were 90 percent plus 28-mesh.[51]

A fluor-solvent process for acid gas removal was described.[52] Three steps were employed in operating the process: Natural gas containing hydrogen sulfide (H_2S) and carbon dioxide (CO_2) was passed upward through a conventional absorption tower, countercurrent to the flow of solvent. The temperature of the solvent on entering the column was slightly below room temperature. Solvents used included propylene carbonate, glycerol triacetate, butoxy diethylene acetate, and methoxy triethylene glycol acetate. The solvent absorbed carbon dioxide, water vapor, hydrogen sulfide, mercaptans, and small quantities of hydrocarbons and absorbed mixture left the bottom of the column at an elevated temperature owing to the heat of absorption. The saturated solution was then passed to an intermediate flash drum, where light hydrocarbons were flashed off and returned as a recycle to the raw gas absorber. In the last step the semistripped solvent passed through a power recovery hydraulic turbine and was fed to an atmospheric-pressure flash vessel. At this point, carbon dioxide, water vapor, hydrogen sulfide, and mercaptans were stripped from the solvent. Cooled stripped solvent was then recycled to the top of the absorber, the acid feed gas passed to the fluor-modified Claus sulfur-recovery plant, where any entrained liquids were removed by passing the gas through a knockout drum, and the feed gas was burned to produce elemental sulfur in the presence of a bauxite catalyst.

[50] Chemical & Engineering News. Two New Methods Speed Organic Sulfur Analysis. V. 39, No. 39, Sept. 25, 1961, pp. 44, 46.
[51] Mining Magazine (London). Sulphur Extraction. V. 105, No. 4, October 1961, pp. 222–223.
[52] Sulphur (London). Fluor-Solvent H_2S/CO_2 Process for Wentushall A. G. No. 35, August 1961, pp. 31–34.

A process was developed to produce sulfur dioxide from sulfur and sulfur trioxide for liquefaction.[53] Molten sulfur was fed into a tile-lined reactor, containing 30 percent sulfur trioxide oleum solution where it reacted at 230° to 250° F to produce sulfur dioxide gas. The sulfur dioxide gas passed through a sulfur filter, sulfuric acid drying tower and demister, and then through the conventional liquefaction sequence.

The preparation of sulfide minerals by biological methods was investigated by the Bureau of Mineral Resources, Canberra.[54]

Carbon disulfide was produced by passing hydrogen sulfide upward through a fluidized bed of finely divided carbon on silicon carbide particles maintained at temperatures of 1,200° to 1,600° C.[55] Carbon particles obtained from the fluidized-bed petroleum-coking process were preferred to those obtained from metallurgical or stoker coke. Optimum results were obtained with a 2-second contact time of the gas with the bed; alternating or direct current could be used, and open arcs were avoided. Several carbon electrodes could be arranged in the bed to provide even heating.

An aerosol layer consisting mainly of sulfur particles was discovered in the atmosphere by workers at the Cambridge Research Laboratories of the U.S. Air Force.[56] This layer completely envelops the earth with a shell 3 miles thick about 11 miles above the earth. The existence of this layer was first indicated by air samples collected during studies of fallout distribution. Detailed studies showed that the concentration of particles between 0.1 and 2 microns in size within the layer was about 16 per cubic inch—three times the number at adjacent levels. Electron microprobe analyses of samples showed that the layer was about 85 percent sulfur; silicon, iron, and aluminum also appear in some samples. This analysis, together with particle absorbency determinations and electron diffraction studies, indicated that the particles were ammonium sulfate. Iron and silicon content of some samples may have been due to temporary fluctuations in micrometeorite influx. The aerosol layer was thought to originate at its observed position from hydrogen sulfide or sulfur dioxide that were chemically changed by sunlight or ozone. The layer may explain purple light, the red disk seen above the point of sunrise or sunset.

The physical conditions of sulfur usage which should be taken into account to avoid explosion hazards were discussed in a paper presented at the 1961 annual conference of the New Zealand Institute of Chemistry, Wellington, New Zealand.[57] The relationship between the particle size of sulfur and the effects of diluents and explosives, inflammability, and electrostatic discharge risks were emphasized. The limiting safe sulfur content is inversely proportional to the specific surface of sulfur in fertilizer mixtures.

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[53] Chemical Engineering. Plant Takes Novel Route to SO_2—Reacts Sulfur and Sulfur Trioxide. V. 68, No. 9, May 1, 1961, pp. 29, 32.
[54] Baas Becking, L. G. M. and D. Moore. Biogenic Sulfides. Econ. Geol., v. 56, No. 2, March–April 1961, pp. 259–272.
[55] Sulphur (London). Shawinigan's CS_2 Process. No. 35, August 1961, p. 18.
[56] Chemical & Engineering News. V. 39, No. 17, Apr. 24, 1961, p. 59.
[57] Fertiliser and Feeding Stuffs Journal (London). Sulphur Top-Dressing. V. 55, No. 7, Oct. 4, 1961, p. 299.

Talc, Soapstone, and Pyrophyllite

By Harold J. Drake [1] and Betty Ann Brett [2]

WORLD PRODUCTION of talc, soapstone, and pyrophyllite in 1961 increased 5 percent from the 1960 level. Domestic mine production of talc and soapstone decreased 1 percent, and sales increased 1 percent. Production of pyrophyllite increased 26 percent, and sales declined 2 percent. Domestic mine production and sales for the three commodities combined increased 4 and 1 percent, respectively.

TABLE 1.—Salient talc, soapstone, and pyrophyllite statistics
(Thousand short tons and thousand dollars)

	1952–56 (average)	1957	1958	1959	1960	1961
United States:						
Mine production	663	684	718	792	734	761
Value [1]	[2] $4,098	$4,796	$4,718	$5,641	$5,378	$5,267
Sold by producers	651	692	694	782	722	726
Value	$13,123	$14,411	$14,206	$17,068	$16,073	$15,266
Imports for consumption	24	20	23	25	24	27
Value	$771	$701	$785	$861	$849	$1,054
Exports [3]	30	40	59	59	60	48
Value	$871	$1,265	$1,451	$1,707	$1,893	$1,805
World: Production	1,800	[4] 2,220	[4] 2,270	[4] 2,550	[4] 2,750	2,890

[1] Partly estimated.
[2] Average for 1953–56.
[3] Excludes powders—talcum (in package), face, and compact.
[4] Revised figure.

DOMESTIC PRODUCTION

New York, California, and North Carolina—in that order—were the leading producers of talc, soapstone, and pyrophyllite in 1961. New York, California, and Texas produced the most talc and soapstone, and North Carolina, California, and Pennsylvania produced all the pyrophyllite. Talc and soapstone were produced in 13 States at 74 mines, and pyrophyllite was produced in 3 States at 13 mines.

The first in-plant system in the tile industry for fine grinding of crude pyrophyllite was described.[3] It included a crude-ore storage building, a grinding plant, and a pneumatic conveying unit to transport the ground material to the manufacturing area.

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.
[3] Ceramic Age. American Olean Installs In-Plant Pyrophyllite Processing System. V. 77, No. 11, November 1961, pp. 23–24, 26.

TABLE 2.—Crude talc, soapstone, and pyrophyllite produced in the United States, by States

State	1960		1961	
	Short tons	Value [1] (thousands)	Short tons	Value [1] (thousands)
California	130,539	$1,396	161,068	$1,524
Georgia	40,200	88	47,950	98
Maryland and Virginia	32,789	95	28,548	72
Nevada	4,882	30	3,090	33
North Carolina	100,593	549	90,711	367
Texas	67,031	336	78,214	376
Washington	2,406	12	2,927	23
Other States [2]	356,033	2,872	348,810	2,774
Total	734,473	5,378	761,318	5,267

[1] Partly estimated.
[2] Includes Alabama, Arkansas, Montana, New York, Pennsylvania, and Vermont.

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		Short tons	Value at shipping point	
		Total	Average per ton		Total	Average per ton
1952-56 (average)	29,124	$237,128	$8.14	1,057	$358,828	$339.48
1957	57,382	330,131	5.75	1,212	519,664	428.77
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
	Ground [1]			Total		
	Short tons	Value at shipping point		Short tons	Value at shipping point	
		Total	Average per ton		Total	Average per ton
1952-56 (average)	621,059	$12,526,628	$20.17	651,240	$13,122,584	$20.15
1957	633,330	13,561,497	21.41	691,924	14,411,292	20.83
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	659,168	14,514,296	22.02	725,568	15,265,956	21.04

[1] Includes some crushed material.

CONSUMPTION AND USES

In 1961, 78 percent of the talc and soapstone consumed went to manufacturers of ceramics, paint, roofing material, insecticides, rubber, and paper. The three major consuming industries—ceramics, paint, and roofing—used 62 percent of the total, and the ceramic industry, the largest user, consumed 35 percent. Most of the pyrophyllite was used for insecticides (28 percent) and for ceramics (23 percent).

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
1952–56 (average)	140,374	10,178	$62,088	[2] 126,094	$1,721,841	136,272	$1,783,929
1957	160,538	26,414	127,865	135,368	1,925,973	161,782	2,053,838
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

[1] Includes sericite schist, 1953–61.
[2] Includes a small quantity of sawed material for 1955 only.

TABLE 5.—Talc, soapstone, and pyrophyllite sold or used by producers in the United States, by uses

(Short tons)

Use	Talc and soapstone		Pyrophyllite	
	1960	1961	1960	1961
Asphalt filler	18,822	(1)	(1)	(1)
Ceramics	206,843	209,492	36,525	30,368
Crayons	654	320		
Foundry facings	6,264	3,092		
Insecticides	47,554	46,581	33,831	36,445
Paint	108,407	110,225	844	274
Paper	26,302	21,048		
Plaster products			6,658	6,279
Rice polishing	2,231	1,697		
Roofing	51,599	50,251		
Rubber	27,828	24,806	7,319	7,136
Textile	9,351	7,538		
Toilet preparations	10,237	10,463		(1)
Other	[2] 73,232	[2] 110,348	[3] 47,180	49,205
Total	589,324	595,861	132,357	129,707

[1] Figure included with "Other" to avoid disclosing individual company confidential data.
[2] Includes adhesive, composition floor and wall tile, exports, instrument wire and cable, joint cement, refractories, stucco, vault manufacturing, and miscellaneous products.
[3] Includes uses indicated by footnote 1 and battery, joint cement, refractories, and related products.

STOCKS

According to the Office of Emergency Planning, Government stockpiles contained 1,200 short tons of block and lump steatite talc, all in the national (strategic) stockpile. This was 900 short tons above the maximum stockpile objective. Some of this material was offered for sale on a competitive basis by the General Services Administration.

PRICES

Talc price quotations in trade journals remained unchanged throughout 1961. Quotations in the journals indicate the range in prices; actual prices are negotiated between buyer and seller and are based on a wide range of specifications.

TABLE 6.—Prices quoted on ground talc, in bags, carlots, in 1961

(Per short ton)

Grade	1961
Domestic, f.o.b. works:	
Ordinary:	
California	$34.00–$39.50
Vermont	19.40
Fibrous (New York):	
Off-color	28.00
325-mesh:	
99.5 percent	31.00
99.95 percent, micronized	38.00
Imported (Canadian) f.o.b. mines	20.00– 35.00

Source: Oil, Paint and Drug Reporter.

TABLE 7.—Prices quoted on talc, carlots, f.o.b. works, in 1961

(Per short ton)

Grade [1]	1961
Georgia: 98 percent minus 200-mesh:	
Gray, packed in paper bags	$10.50–$11.00
White, packed in paper bags	12.50– 15.00
New Jersey: Mineral pulp, ground, bags extra	10.50– 12.50
Vermont:	
100 percent through 200-mesh, extra white, bulk basis [2]	12.50
99½ percent through 200-mesh, medium white, bulk basis [2]	11.50– 12.50
Virginia:	
200-mesh	10.00– 12.00
325-mesh	12.00– 14.00
Crude	5.50

[1] Containers included unless otherwise specified.
[2] Packed in paper bags, $1.75 per ton extra.

Source: E&MJ Metal and Mineral Markets.

FOREIGN TRADE[4]

Imports.—Imports, principally from Italy (73 percent) and France (17 percent), increased in quantity (14 percent) and in value (24 percent). The amount of material entering the United States from Italy increased 13 percent, and that from France increased 34 percent.

Exports.—Exports of crude and ground material declined 19 percent although the value of the material fell only 4 percent.

WORLD REVIEW

World production increased 5 percent as Japan, Republic of Korea, and Italy recorded substantial increases.

Canada.—In 1960 production of talc and soapstone declined 14 percent, and production of pyrophyllite increased 40 percent. Imports continued to increase, while exports declined. An increasing local demand for higher grade material was met by imports.[5]

[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] Reeves, J. E. Talc, Soapstone, and Pyrophyllite. Dept. of Mines and Tech. Surveys (Canada), Rev. 55, May 1961, 6 pp.

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		Cut and sawed		Total unmanufactured	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1952–56 (average)	152	$27,510	23,304	[1] $713,281	83	$30,615	23,539	[1] $771,406
1957	277	42,265	20,032	[1] 622,472	86	36,616	20,395	[1] 701,353
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:								
Canada	60	1,583	1,514	25,532			1,574	27,115
France			3,476	75,890	2	580	3,478	76,470
India	14	1,793	741	17,452			755	19,245
Italy			17,713	693,211	6	1,966	17,719	695,177
Japan					43	21,870	43	21,870
Korea, Republic of			5	300			5	300
Mexico			401	8,669			401	8,669
Total	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
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	[2] 27,231	[2] 1,011,775	84	37,527	[2] 27,355	[2] 1,054,161

[1] Data known to be not comparable with other years.
[2] 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		Manufacturers, n.e.c.		
	Short tons	Value (thousands)	Short tons	Value (thousands)	
1952–56 (average)	29,388	$766	177	$105	$1,247
1957	39,985	1,127	291	138	1,322
1958	58,647	1,358	212	93	1,341
1959	58,751	1,532	197	175	1,276
1960	59,457	1,801	158	92	1,378
1961	47,912	1,721	134	84	1,396

Source: Bureau of the Census.

TABLE 10.—World production of talc, soapstone, and pyrophyllite, by countries[1 2]

(Short tons)

Country[1]	1952–56 (average)	1957	1958	1959	1960	1961
North America:						
Canada (shipments)	27,413	34,725	35,405	39,176	41,636	48,095
United States	663,237	684,453	718,165	791,558	734,473	761,318
Total	690,650	719,178	753,570	830,734	776,109	809,413
South America:						
Argentina	29,819	26,239	30,060	29,938	[3] 30,000	[3] 30,000
Brazil	25,020	23,023	31,442	23,369	21,956	[3] 22,000
Paraguay	[4] 90	[3] 110	[3] 110	[3] 110	[3] 110	[3] 110
Peru	1,603	2,689	2,073	1,694	1,732	3,246
Uruguay	1,145	1,566	1,990	2,335	3,297	1,857
Total	57,677	53,627	65,675	57,446	[3] 57,100	[3] 57,200
Europe:						
Austria	66,305	80,915	78,074	56,475	90,695	93,639
Finland	6,460	10,092	6,522	8,261	11,008	6,967
France	126,647	145,482	185,643	193,528	193,032	196,983
Germany, West (marketable)	35,585	32,854	[3] 33,000	[3] 33,000	35,274	35,274
Greece	1,423	2,205	1,962	327	[3] 2,200	[3] 2,200
Italy	98,134	110,591	120,704	120,436	137,117	146,584
Norway	78,001	117,965	107,828	93,783	[3] 100,000	[3] 100,000
Portugal	28			243	750	[3] 660
Spain	23,977	35,091	33,360	30,661	30,853	[3] 30,000
Sweden	12,474	13,918	14,581	15,873	17,527	[3] 17,600
U.S.S.R.	[5]	[5]	220,462	[3] 275,000	[3] 300,000	[3] 330,000
United Kingdom	4,333	4,256	4,645	6,365	7,244	[3] 7,000
Yugoslavia	[6] 1,462					
Total[1 3]	565,000	720,000	810,000	835,000	925,000	970,000
Asia:						
Afghanistan	892	[3] 770	[3] 770	[3] 770	[3] 770	[3] 770
China	[5]	[5]	[5]	[5]	[5]	[3] 165,000
India	40,651	49,253	50,906	71,082	102,947	102,370
Japan	311,335	469,109	377,994	535,140	652,953	[3] 690,000
Korea, Republic of	18,144	12,434	17,581	19,272	24,889	50,330
Taiwan	4,894	5,938	3,677	7,079	11,637	13,685
Total[3]	460,000	705,000	615,000	800,000	960,000	1,020,000
Africa:						
Kenya	109					
Swaziland		22	157	1,008	1,714	2,955
Union of South Africa	5,812	2,314	765	1,412	1,979	3,279
United Arab Republic (Egypt)	4,997	6,031	7,253	6,708	6,614	6,565
Total	10,918	8,367	8,175	9,128	10,307	12,799
Oceania: Australia	12,680	16,575	17,539	18,729	18,112	15,680
World total (estimate)[1 2]	1,800,000	2,220,000	2,270,000	2,550,000	2,750,000	2,890,000

[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] Average annual production 1953–56.
[5] Data not available; estimate by senior author of chapter included in total.
[6] Average annual production 1955–56.

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	
	1960	1961	1960	1961	1960	1961
Algeria			4,801	4,137	1	
Belgium-Luxembourg	4,022	3,965	5,159	5,466	(2)	(2)
Denmark	264	319	244	225		
France	1,515	1,659			(2)	(2)
Germany:						
East	455	1,791				
West	22,214	21,149	8,881	10,144	10,132	7,869
Hungary	2,382	2,319				
Italy	765	4,276	402	557		
Morocco: Southern zone			1,268	1,032		
Netherlands	1,438	1,358	1,388	1,381	(2)	(2)
Philippines	29				(2)	(2)
Poland	33,091	26,950	1,095			
Portugal	11		476	607	(2)	(2)
Sweden	55	104	972	941		
Switzerland	3,148	4,211	9,940	8,842	(2)	(2)
United Kingdom	416	524	6,074	7,275	11,799	10,048
United States			3,815	4,348	16,973	18,973
Yugoslavia	141	90				
Other countries		49	3,082	3,830	16,333	18,416
Total	69,946	68,764	47,597	48,785	55,238	55,306

[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.—Mexico: Imports of talc, steatite, and pyrophyllite, by countries[1]

(Short tons)

Countries of origin	Talc		Steatite[2]	Pyrophyllite	Total
	Crude	Ground			
1957:					
United States	12,728	2,880	1,260	483	17,351
Italy		621	6		627
Total	12,832	3,536	1,281	483	18,132
1958:					
United States	26,558	4,347		1,003	31,908
Italy		516			516
Total	26,558	4,878		1,003	32,439
1959:					
United States	18,462	2,619		515	21,596
Italy		561		92	653
Total	18,463	3,184		607	22,254
1960:					
United States	21,023	3,034		1,487	25,544
Italy		1,098		176	1,274
Total	21,023	4,151		1,663	26,837

[1] Totals include small quantities in some years of talc, steatite, and/or pyrophyllite from various other countries.
[2] Mexico recorded no imports of steatite in 1958, 1959, and 1960.

Compiled from Customs Returns of Mexico by Corra A. Barry, Division of Foreign Activities.

Korea, Republic of.—Korea produced 17,614 short tons of talc and 7,275 short tons of pyrophyllite in 1960. Shipments to Japan, the principal export market, were 7,243 short tons.[6]

Mexico.—Major sources of imports of talc and pyrophyllite were the United States and Italy. About 85 percent of the talc from the United States was crude ore; all the talc from Italy was ground.

Nepal.—Two deposits of high-grade talc were discovered and one, the Palung mine, was producing block talc for sale in Calcutta as basic furnace lining. The other mine, the Kharidhunga, was not producing.[7]

Poland.—Imports of talc in 1960 amounted to 42,990 short tons. Austria supplied 78 percent of this tonnage, and China, 13 percent.[8]

U.S.S.R.—A large deposit of talc reportedly containing 30 million tons was discovered near the town of Miass in the foothills of the Ural Mountains.[9]

Union of South Africa.—Interest in exports of ceramic raw materials led to the development of talc and other refractory materials. Anticipated markets are in Europe.[10] The pyrophyllite industry continued to expand as production and exports increased 46 and 28 percent, respectively.

TABLE 13.—Union of South Africa: Salient statistics of pyrophyllite (wonderstone)

	1960 [1]	1961 [2]
Production short tons	699	1,023
Exports do.	562	722
Value	US$54,917	US$73,196
Local sales short tons	108	265
Value	US$9,413	US$23,166

[1] U.S. Embassy, Johannesburg, Union of South Africa. State Department Dispatch 358. May 4, 1961, p. 3.
[2] U.S. Embassy, Johannesburg, Union of South Africa. State Department Dispatch 390. Mar. 14, 1962, p. 4.

TECHNOLOGY

Increasing demand by consumers for uniformity in ground talc resulted in new blending methods.[11] The new blending technique, involving the introduction of fluidized ground talc near the base of storage silos, assures continuous mixing as the silo is filled. The talc will be withdrawn simultaneously through several ports around the bottom of the silo to maintain uniformity.

Ground talc or soapstone was combined with pulverized iron ore to form a granular tire ballast.[12] A patent was issued for a concrete slurry that contains about 9 percent talc.[13] The talc was believed to

[6] Bureau of Mines. Mineral Trade Notes. V. 53, No. 4, October 1961, p. 57.
[7] Mining World. Nepal. V. 23, No. 4, April 1961, p. 25.
[8] State Statistical Publishing House (Warsaw). Handel Zagraniczny, Statystyka Handlu Zagranicznego (Foreign Trade, Foreign Statistical Handbook Supplement). June 1961, p. 23.
[9] Mining Journal (London). Mining Miscellany. V. 257, No. 6583, Oct. 20, 1961, p. 405.
[10] Mine and Quarry Engineering (London). South African Ceramic Materials. V. 27, No. 6, June 1961, pp. 292–293.
[11] McClellan, Robert S. Gouverneur Talc Co.'s Dry Blending Method for Finely Ground Materials. Min. Eng., v. 13, No. 3, November 1961, pp. 272–273.
[12] Hicks, W. L. (assigned to Lead Ballast, Inc.) Pneumatic Tire Ballast. U.S. Pat. 3,008,506, Nov. 14, 1961.
[13] Furlan, U. Concrete Composition. U.S. Pat. 2,991,186, July 4, 1961.

make the concrete more resistant to breakdown upon exposure to temperature variations around the freezing point. A filler composition containing powdered talc was found to stop leakage of oil from transformers, X-ray apparatus, and similar devices.[14] A dry fire-extinguishing composition that consists of powdered potassium bicarbonate, ground aluminum or calcium stearate, and ground talc was developed.[15]

A method and apparatus were patented for controlling the density of talc particles in slurries in fluid-energy grinding operations.[16] The addition of deflocculants, such as tannin extracts or caustic soda, in the fluid-energy grinding of talc and other soft minerals tended to keep the vapor-mineral mixture more flowable.[17] The formation of silica scale on processing equipment during fluid-energy grinding of talc and similar minerals was prevented by introducing a magnesium compound.[18] The magnesium combined with the silica to form insoluble compounds that passed through the heating zone as solids.

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[14] Manaka, K., and T. Kondo (assigned to Tokyo Shibaura Electric Co.). Japanese Pat. 3,989, June 20, 1957.
[15] Cawood, E. E. C. (assigned to Nu-Swift Ltd.). British Pat. 868,993, May 25, 1961.
[16] Guptill, F. E., Jr. (assigned to Texaco, Inc.). Continuously Measuring Slurry Density. U.S. Pat. 3,004,544, Oct. 17, 1961.
[17] Eastman, de B., and L. P. Gaucher (assigned to Texaco Development Corp.). Canadian Pat. 613,099, Jan. 24, 1961.
[18] Dille, R. M., and R. W. Chapman (assigned to Texaco Development Corp.). Canadian Pat. 630,486, Nov. 7, 1961.

Thorium

By Don H. Baker, Jr.,[1] and Ethel M. Tucker[2]

THORIUM application in high-temperature alloys and in nuclear energy continued to hold attention in 1961. Progress was shown in the research and development of effective thermal breeder reactors as a part of the nuclear energy program for using thorium.

Domestic mine production of thorium-containing minerals was negligible, amounting to less than 50 short tons of contained thorium oxide (ThO_2). Reevaluation of the thorium-bearing deposits in the Idaho-Montana area indicated a reserve of about 100,000 tons of ThO_2.[3] Domestic consumption of thorium remained about the same as in 1960, with approximately 60 percent of the total used in magnesium-thorium alloys.

LEGISLATION AND GOVERNMENT PROGRAMS

The program for using thorium as a nuclear fuel was gaining impetus as reactors were constructed to test concepts and to develop additional engineering data.

Effective April 11, 1961, the U.S. Atomic Energy Commission (AEC) amended its licensing regulation, 10 CFR (Code of Federal Regulations) 40, reestablishing an exemption for rare-earth materials containing not more than 0.25 percent thorium and uranium.

Procurement was begun for 4 million pounds of thorium nitrate for the supplemental stockpile in exchange for surplus agricultural commodities, under the U.S. Department of Agriculture Commodity Credit Corporation (CCC) barter program. Part of the thorium nitrate was to be produced in the United States from Union of South Africa raw materials, and the remainder in France from raw materials supplied from the Malagasy Republic.

The Office of Minerals Exploration (OME) continued to include thorium in the list of minerals eligible for financial assistance. No exploration contracts for thorium were made in 1961.

DOMESTIC PRODUCTION

Mine Production.—Domestic mine production was less than 50 tons of ThO_2, a byproduct from processing southeastern U.S. beach sands.

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.
[3] Atomic Energy Commission. Major Activities in the Atomic Energy Programs. January–December 1961, 540 pp.

Increased activity in preparing properties in Montana and Idaho to produce thorite was indicated.

The continuity of ore bodies and additional reserves was established by exploration and development in Idaho by Northwest Prospecting and Development Co., Rare Metals Corporation of America, Techmanix Corp., Porter Brothers Corp., and Nuclear Fuels and Rare Metals Corp. Improved and new access roads to properties also were built. Metallurgical testing of various ores was continued.

Late in 1961, the AEC reevaluated the thorium reserves in the Lemhi Pass area of Idaho and Montana. Revised figures released by the AEC indicated that there was 100,000 tons of ThO_2 in ore of probable commercial grade at 1961 prices. Because of favorable geological conditions, the quantity might be greatly increased.

Refinery Production.—Principal domestic refiners of thorium were American Potash and 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. Some thorium was offered commercially by Davison Chemical, Erwin, Tenn.; Dominion Magnesium, Ltd., Toronto, Canada; Sylvania-Corning Nuclear Corp., Bayside, N.Y.; Westinghouse Electric Corp., Lamp Division, Bloomfield, N.J.; National Research Corp., Cambridge, Mass.; Nuclear Materials and Equipment Corp., Apollo, Pa.; Vitro Corporation of America, Chattanooga, Tenn.; and Cerium Metals and Alloys Division, Ronson Metals Corp., Newark, N.J. Metal Hydrides, Inc., Beverly, Mass., offered for sale thorium metal powders and crystal bar.

Reactor-grade (high-purity) thorium oxide was produced by Davison Chemical and American Potash and Chemical Corp. High-purity thorium oxide ceramic was offered by national Beryllia Corp., Haskell, N.J.

CONSUMPTION AND USES

Nonenergy Uses.—Consumption of thorium by domestic industry decreased slightly, just over 2 percent, from the high of 1960. Utilization of thorium in thorium-magnesium alloys remained nearly constant, and the use of thorium nitrate in gas-mantle manufacture decreased about 13 percent. These two fields of use represented about 93 percent of the total consumption. The use of thorium compounds in refractories and polishing compounds increased 80 percent, but still represented less than 4 percent of total consumption.

TABLE 1.—Thorium consumption for nonenergy uses

(Pounds of contained ThO_2)

Use	1960	1961
Magnesium alloys	139,000	140,800
Gas-mantle manufacture	96,000	84,000
Refractories and polishing compounds	5,000	9,000
Chemical and medical products	5,000	5,500
Electronic products	2,500	3,000
Total	247,500	242,300

The increased use of thorium in refractories resulted from using increasingly high temperatures in metallurgical and chemical processing. Magnesium-thorium alloys continued to be used extensively in missiles, satellites, and aircraft.

The principal supplier of thorium-magnesium master alloy for magnesium-thorium alloys was Dominion Magnesium, Ltd., Toronto, Canada; others included Magnesium Elektron, Ltd., Davison Chemical, Rio Tinto Dow, and Vitro Chemical Co.

The chief producer of thorium-magnesium alloys was The Dow Chemical Co.

Energy Uses.—Thorium as a nuclear fuel for electrical power generation was under study throughout the world. In the United States, the efforts toward using thorium were not as great as those directed toward development of uranium, but much of the engineering developed for uranium will be applicable to thorium-based fuels. The AEC had in operation one experimental reactor, with a metallic core of thorium alloyed with 7.6 percent uranium enriched to about 90 percent U^{235}. This reactor, known as the Sodium Reactor Experiment, is a sodium-cooled, graphite-moderated reactor designed to operate at 20 megawatts (Mw) (thermal). Operation was at approximately 25 percent of designed power.

Two additional reactors using the thorium fuel cycle were to be in operation by the end of 1961. One of these was a boiling-water reactor at Elk River, Minn., with a rated capacity of 22 Mw (electrical), including a fossil-fuel-fired superheater. The core was a mixture of thorium and uranium oxides encapsulated in stainless steel. The other was the Consolidated Edison Thorium Reactor at Indian Point, N.Y., which also used a mixture of thorium and uranium oxides clad in stainless steel as the core. The rating of this plant was 275 Mw (electrical), including a contribution of about 112 Mw (electrical) from a fossil-fuel-fired superheater.

Two additional reactors using a thorium fuel cycle, making a total of five in service or to be built, were committed for construction in the United States. Under construction were the High-Temperature Gas Cooled Reactor, at Peach Bottom, Pa., and the Molten Salt Reactor at Oak Ridge, Tenn.

PRICES

Monazite quotations listed in E&MJ Metal and Mineral Markets remained steady during 1961 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 thorite-type minerals were on a negotiated basis between buyer and seller but probably ranged from $1.25 per pound of contained thoria for 10-percent concentrates to $2.25 for 20-percent concentrates.

Thorium compounds offered for sale by a leading producer, in 100-pound lots or more, were as follows:

Thorium compound:	ThO_2, percent	Price per pound
Carbonate	80–85	[1] $7.25–8.00
Chloride	50	7.00
Fluoride	80	5.50
Nitrate (mantle grade)	46	3.00
Oxide	97–99	5.50–8.50
Other forms:		
Metal (nuclear grade) [2]	-----	19.55
Thorium hardener (for alloying)	20–40	12.50–15.00

[1] Variable, depending on rare-earth content.
[2] F.o.b. AEC, Feed Materials Production Center, Fernald, Ohio.

The following prices per pound for nuclear-grade thorium metal remained in effect:

Pounds:	Powder or pellets	Thorium ingot
Less than 10	$50	$54
10 to 100	41	45
100 to 500	34	38
500 to 2,000	26	30
Over 2,000	20	24

Prices for domestic concentrates ranged from $1.75 to $2.25 per pound of ThO_2 content for 20- to 30-percent thorium concentrates.

FOREIGN TRADE

The United States imported 2,591 tons of monazite and other types of thorium ore from the Union of South Africa, Australia, the Federation of Malaya, and Canada, and 15 tons of thorium metal from Canada, United Kingdom, the Netherlands, and West Germany. Exports of 51 tons of thorium compounds and metal, excluding special nuclear material, were made to 19 countries. The value of thorium-bearing materials exported was set at $396,000.

WORLD REVIEW

World requirements for thorium were met by production of monazite in Austrialia, Federation of Malaya, Malagasy Republic, and India, and from stockpiled material in the Union of South Africa and the United States. Byproduct thorium from a Canadian uranium mill also supplied the world markets. India and Brazil retained embargoes on exports of thorium.

At the end of 1961, increased activity by the world's thorium producers, both abroad and domestically, was noted.

NORTH AMERICA

Canada.—Thorium extraction from uranium-mill waste liquors by Rio Tinto Dow, at the Nordic plant of Rio Algom mines, was initiated early in 1961.

Canadian Thorium Corp., through new financing arrangements and the acquisition of extensive properties in the Mattagami Lake-Joutel

Township district of Northwestern Quebec, planned to resume exploration and thorium activities.[4]

EUROPE

Germany, West.—Bayerische Berghuetten und Salzwerke A. G., the State-held mining Company, discovered what was reported to be the largest thorium deposit so far found in Europe. Located in the Bavarian mountains, near the Czech border, the deposit is deeply bedded in granite. The ore was reported to contain 0.28 percent of thorium and 0.17 percent of uranium per ton.[5]

Italy.—The Comitato Nazionale per l'Energia Nucleare awarded the prime contract for a uranium-thorium fuel processing plant to Allis-Chalmers Manufacturing Co. of the United States.[6]

ASIA

Malaya, Federation of.—Monazite produced as a byproduct of tin in Malaya supplied some of the thorium requirements in the free world.

AFRICA

Malagasy Republic.—Approximately 515 tons of uranothorianite averaging 18.9 percent uranium oxide (U_3O_8) and 57 percent thorium oxide was supplied to France by the Malagasy Republic for the production of thorium and uranium.[7]

Union of South Africa.—The monazite mine of Anglo-American Corporation of South Africa, Ltd., near Van Rhynsdorp, a major source of thorium in the free world, remained closed in 1961, but indications were it would be reopened early in 1962.

OCEANIA

Australia.—Monazite recovered from processing beach-sand deposits of heavy minerals was exported to countries of the free world.

TECHNOLOGY

Russian scientists reported on the possibility of using amine salts, in place of ion-exchange resins, for extracting thorium from sulfate solutions and on the composition of the extracted compounds. Results showed that two molecules of amine sulfate pass into the organic phase with one molecule of thorium sulfate.[8]

Egyptian researchers described the equipment, techniques, and results obtained in separating thorium and rare-earth elements through the direct chlorination of monazite.[9] Good recoveries and separations were indicated.

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[4] Northern Miner (Toronto, Canada). Plan to Reactivate Canadian Thorium. V. 47, No. 25, Sept. 14, 1961, p. 3.
[5] Mining Journal (London). V. 257, No. 6574, Aug. 18, 1961, p. 167.
[6] Chemical & Engineering News. V. 39, No. 33, Aug. 14, 1961, p. 42.
[7] Engineering and Mining Journal. V. 163, No. 2, February 1962, p. 93.
[8] Vdovenko, V. M., M. P. Koval'skaya, and Ye. V. Shirvinskiy. Thorium Extraction From Sulfate Solutions Using Octylamine. Radiokhimiya, v. 3, No. 1, 1961, pp. 3–6.
[9] Hilal, O. M., and F. A. El Gohary. Chlorination of Monazite. Ind. and Eng. Chem., v. 53, No. 12, December 1961, pp. 997–998.

Techniques for extracting thorium from Western United States thorite ores,[10] the radiological hazards associated with the reduction, melting, and fabrication of thorium metal, and the active metal reduction of thorium halides[11] were released by Bureau scientists and engineers.

The continuous preparation of thorium alloys by electrolysis, using fused cathode and exchange reactions in fused salts, might be possible on the basis of experiments.[12]

Fundamental studies of the constitution of thorium alloy systems with the platinum-group metals indicated a new group of intermetallic compounds.[13]

Effects of hydrogen on the ductility of calcium-reduced thorium in room-temperature tensile and impact tests were shown to be insignificant when the hydrogen level of contamination was less than 100 ppm.[14]

The corrosion-resistance of uncoated and organic- or metal-coated thorium in humid, salt-spray, and humid-freezing conditions was evaluated. Results showed thorium to be fairly resistant, and when coated with nickel thorium showed excellent resistance.[15]

Phase diagrams, phase equilibria, and thermodynamic properties for several binary thorium-containing systems were reported.[16]

A quantitative measure of how the utilization of uranium and thorium is affected by recycle, by the conversion ratio of the reactor, and by losses outside the reactor was published by AEC.[17] The AEC also reported on the advantages and disadvantages of thorium as a nuclear fuel.[18] The advantages and disadvantages discussed were primarily technological, but long-range economic factors were pointed out.

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[10] Borrowman, S. R., and J. B. Rosenbaum. Recovery of Thorium From Ores in Colorado, Idaho, and Montana. BuMines Rept. of Inv. 5916, 1962, 35 pp.
Borrowman, S. R., and J. B. Rosenbaum. Recovery of Thorium From a Wyoming Ore. BuMines Rept. of Inv. 5917, 1962, 8 pp.

[11] Campbell, T. T., F. E. Block, R. E. Mussler, and G. B. Robidart. Preparation and Metallic Reduction of Rare-Earth Halides and Oxides. BuMines Rept. of Inv. 5880, 1961, 29 pp.
Lowery, R. R. Radiation Hazards Encountered in Arc Melting Thorium. BuMines Rept. of Inv. 5969, 1962, 22 pp.

[12] Ogawa, Yoshiki, Yoshihiro Hisamatsu, and Kazutaka Kuwamura. (The Preparation of Thorium Alloys by Electrolysis, Using Fused Cathode and Exchange Reaction in Fused Salt). J. Inst. of Metals (London), v. 29, pt. 2, October 1961, p. 168 (in English).

[13] Thompson, J. R. Some New Intermetallic Compounds of Thorium of the Type Th_7X_3. Nature, v. 189, No. 4760, Jan. 21, 1961, p. 217.

[14] Peterson, D. T. Effect of Hydrogen on Tensile and Impact Properties of Thorium. Reactor Core Materials, v. 4, No. 4, November 1961, p. 5.

[15] Stephan, Elmer F., Paul D. Miller, and Frederick W. Fink. Corrosion of Thorium and Uranium Under Storage Conditions. J. Inst. of Metals (London), v. 29, pt. 2, October 1961, p. 162.

[16] McMasters, O. D., and W. L. Larsen. Phase Equilibria in the Thorium-Tantalum System. J. Less-Common Metals, v. 3, No. 4, August 1961, pp. 313–320.
Brown, A., and J. J. Norreys. The System Thorium-Silicon. J. Inst. of Metals, v. 89, No. 7, March 1961, pp. 238–240.
Chiotti, P., and K. J. Gill. Phase Diagram and Thermodynamic Properties of the Thorium-Zinc System. AIME Met. Society Trans., v. 221, No. 3, June 1961, pp. 573–580.

[17] Kuhn, Donald W., and Ray D. Walton, Jr. Long Term Utilization of Uranium and Thorium. U.S. Atomic Energy Commission, Washington, D.C. TID–13901, October 1961, 33 pp.

[18] Staebler, U. M. Address. 6th Nuclear Cong. (Rome, Italy), June 1961.

Tin

By John E. Shelton [1] and John B. Umhau [2]

CONSUMPTION of tin in the United States decreased 3 percent in 1961, and tin imports declined 9 percent. However, tinplate production was the second largest recorded. The price rose above the International Tin Agreement ceiling when buffer stocks were exhausted, and the market became virtually free from control.

World tin production increased, but it was lower than world consumption and stocks were drawn upon to meet demand. The U.S Government sold pig tin not in the national stockpile and discontinued procurement of tin by agricultural surplus barter transactions. Congressional authority was requested to sell some of the tin in the national stockpile.

The Second International Tin Agreement went into effect, and the First Agreement was terminated. The United States considered accession to the agreement. The flow of tin from the Republic of the Congo continued to be retarded by internal disorders. Nigeria began smelting tin and shipped metallic tin to the United States for the first time. Free world tin exports to the U.S.S.R. and its European satellites were resumed.

TABLE 1.—Salient tin statistics

(Long tons)

	1952-56 (average)	1957	1958	1959	1960	1961
United States:						
Production:						
Mine	91.72			50	10	(1)
Smelter	[2] 25,547	1,564	(1)	(1)	(1)	(1)
Secondary	28,074	24,260	22,810	23,700	22,050	21,690
Imports for consumption:						
Metal	69,623	56,158	41,149	43,578	[3] 39,538	39,898
Ore (tin content)	24,281	94	5,440	10,773	14,026	8,917
Exports	681	1,531	1,341	1,371	857	800
Consumption:						
Primary	54,801	54,429	47,998	45,833	51,530	49,699
Secondary	30,750	28,078	24,587	31,540	29,030	28,551
Price: Straits tin, New York, average cents per pound	100.80	96.17	95.09	102.01	101.40	113.27
World:						
Production:						
Mine	191,400	[3] 200,400	[3] 153,500	[3] 161,500	[3] 181,500	188,000
Smelter	193,600	195,100	158,400	[3] 155,700	[3] 192,400	190,000

[1] Figures withheld to avoid disclosing individual company confidential data.
[2] Includes tin content of alloys made directly from ores.
[3] Revised figure.

[1] Commodity specialist, Division of Minerals.
[2] Mineral specialist, Division of Minerals.

LEGISLATION AND GOVERNMENT PROGRAMS

The Export Control Act of 1949, extended to June 30, 1962, governed the destination of tin shipments. Exports were under general license to the free world. Regulations administered by the Office of Export Supply, U.S. Department of Commerce, required a license for export of detinned tinplate and terneplate scrap and detinned cans. However, exports of tinplate, and terneplate scrap, and old cans were exempted from licensing.

The foreign assets control regulations of the U.S. Treasury Department prohibited the entry of Chinese tin. Tin of Soviet origin could enter the United States but required a license (none were 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 (OME) offered financial assistance to the extent of 50 percent of total allowable costs for exploration of eligible domestic tin deposits.

On May 18, the U.S. Department of Agriculture, Commodity Credit Corporation (CCC), announced removal of tin from the list of materials eligible for acquisition for the Government supplemental stockpile through agricultural surplus barter transactions.

The General Services Administration (GSA) gave notice in an announcement September 1 (published in press releases September 5 and 8, and in the Federal Register, September 7) of the proposed disposition of 50,000 long tons of pig tin in excess of national stock pile needs, upon express approval by the Congress. The announcement also stated, "It is proposed to begin making available for sale in small lots approximately 10,000 long tons of the total as soon as possible." Legislation introduced September 11 (H.R. 9119) to authorize the disposition of the 10,000 tons and waiving the 6-month waiting period was referred to the Committee on Armed Services. Congress adjourned without approving the release.

Administration of the production-payment provisions of the Texas City tin smelter sales contract was transferred to GSA when the Federal Facilities Corporation (FFC) was dissolved September 30, as provided by Public Law 87–190, approved August 30 (75 Stat. 418).

DOMESTIC PRODUCTION

MINE PRODUCTION

A small tonnage of tin 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 administration of the production-payment provisions of the sales contract was transferred from FFC to GSA September 30. Under this program in fiscal year 1961, FFC received $143,000 (mortgages repaid, $90,000; interest on mortgages, $40,000; smelter production $13,000).[3] On June 30 and September 30, 1961,

[3] Budget of the United States Government for the Fiscal Year Ending June 30, 1963, appendix, p. 702.

TABLE 2.—Mine production of tin (content) in the United States, 1910–61 by States

Year	Long tons				Value
	Alaska	South Dakota	Other States [1]	Total	
1910	9.0	17.0	10.0	36.0	$23,447
1911	54.0	(2)	(2)	63.0	56,635
1912	116.0			116.0	124,800
1913	45.0	1.0	3.0	49.0	46,699
1914	93.0			93.0	66,560
1915	91.0			91.0	78,846
1916	124.0		1.0	125.0	122,000
1917	89.0	9.0		98.0	135,600
1918	61.0	.1	.9	62.0	118,500
1919	50.0			50.0	73,400
1920	14.0	6.0		20.0	22,000
1921	3.6			3.6	2,400
1922	1.3			1.3	912
1923	1.7			1.7	1,623
1924	6.3			6.3	7,028
1925	12.3			12.3	15,980
1926	7.1			7.1	10,400
1927	23.9	.1		24.0	34,600
1928	36.6	1.8	3.6	42.0	47,400
1929	34.5	.2	.3	35.0	35,600
1930	13.1	.2	1.7	15.0	10,500
1931	3.6	.1		3.7	2,050
1932		.4		.4	220
1933	2.6	.1		2.7	2,400
1934	8.0	.2		8.2	9,600
1935	44.1	.4		44.5	50,200
1936	[3] 101.0	(2)		101.0	105,000
1937	166.0	.8	1.6	168.4	205,300
1938	94.0	1.0		95.0	90,000
1939	33.0	.5	.5	34.0	38,400
1940	46.0	2.0	1.0	49.0	54,900
1941	46.8	1.4	8.1	56.3	65,600
1942	2.8	1.4	2.1	6.3	7,300
1943	.1	.6	5.2	5.9	6,800
1944		(2)	(2)	5.4	6,200
1945					
1946					
1947	1.3			1.3	2,200
1948	[3] 4.7	(3)		4.7	10,380
1949	51.6		[4] 16.8	68.4	152,210
1950	79.5		[4] 14.6	94.1	201,446
1951	68.6		[4] 19.4	88.0	252,920
1952	81.9		[4] 16.8	98.7	266,280
1953	49.0		[4] 7.0	56.0	120,000
1954	199.3		[4] 5.4	204.7	421,053
1955	86.0		[4] 13.24	99.24	207,618
1956					
1957					
1958					
1959			[4] 50.0	50.0	60,000
1960			[4] 10.0	10.0	12,300
1961			(2 4)	(2 4)	(2 4)

[1] Alabama, California, Colorado, Montana, Nevada, New Mexico, North Carolina, South Carolina, Texas, and Wyoming.
[2] Figure withheld to avoid disclosing individual company confidential data.
[3] Very small quantity from South Dakota included with Alaska.
[4] Colorado.

FFC held a note with a balance of $940,000 bearing interest at 4 percent a year, obtained from the sale of the tin smelter. Payment of $12,989 was made on 11,597 long tons of tin produced during the year ending April 22, 1961.

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, plus an additional $2.50 for each of the next 1,000 tons and another $2.50 (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 short ton on all metal produced in excess of 2,000 short tons until April 22, 1960, when they were further reduced to $1 per ton for a 2 year period ending April 22, 1962.[4]

SECONDARY TIN [5]

Secondary tin production decreased slightly from 1960. Almost 85 percent was recovered from seven scrap items—drosses, composition or red brass, tinplate, bronze, railroad-car boxes, auto radiators, and solder. Tin from old scrap dropped for the sixth successive year to the lowest recorded. New scrap supplied 126 tons more than in 1960. The largest tonnage was recovered in bronze and brass; however, recovery in this category declined the most (605 tons). Next in rank was tin reclaimed in solder, which showed the largest gain (305 tons). Tin in chemical compounds rose 13 percent to the highest since 1938.

The quantity of tinplate scrap treated rose 2 percent and was exceeded only by the peak of 702,875 long tons in 1959. Lower recovery per ton of scrap (for the 15th consecutive year) continued to reflect treatment of a larger proportion of electrolytic tinplate carrying a thinner coating of tin.

TABLE 3.—Secondary tin recovered from scrap processed at detinning plants in the United States

	1960	1961
Tinplate scrap treated [1] long tons	684,247	700,628
Tin recovered in the form of—		
Metal do	2,620	2,520
Compounds (tin content) do	655	710
Total [2] do	3,275	3,230
Weight of tin compounds produced do	1,295	1,439
Average quantity of tin recovered per long ton of tinplate scrap used pounds	10.72	10.33
Average delivered cost of tinplate scrap per long ton	$27.55	$31.55

[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 366 long tons (281 tons in 1960) of tin as metal and in compounds from tin-base scrap and residues in 1961.

[4] U.S. General Accounting Office, Report to the Congress of the U.S., Audit of Federal Facilities Corp., General Services Administration, Fiscal Year 1961, and the Final 3-Month Period Ended Sept. 30, 1961, p. 5.

[5] The assistance of Edith E. den Hartog is acknowledged.

TABLE 4.—Stocks, receipts, and consumption of new and old scrap and tin recovered in the United States in 1961

(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)	2,343	34,396	-------	34,435	34,435	2,304	------	1,480	1,480
Brass, composition or red	3,704	74,369	24,579	49,969	74,548	3,525	1,053	1,880	2,933
Brass, low (silicon bronze)	336	1,542	1,010	635	1,645	233	2	3	5
Brass, yellow	3,895	47,642	6,401	38,278	44,679	6,858	15	355	370
Bronze	2,196	26,864	7,070	20,588	27,658	1,402	542	1,621	2,163
Low-grade scrap and residues	3,422	24,268	17,279	7,137	24,416	3,274	14	------	14
Nickel silver	808	2,771	262	2,638	2,900	679	2	21	23
Railroad-car boxes	137	1,117	-------	929	929	325	------	44	44
Total	16,841	212,969	56,601	154,609	211,210	18,600	1,628	5,404	7,032
Brass mills: [1]									
Brass, low (silicon bronze)	2,333	18,781	18,781	-------	18,781	2,218	------	------	------
Brass, yellow	14,081	137,539	137,539	-------	137,539	14,167	5	------	5
Bronze	381	1,803	1,803	-------	1,803	311	87	------	87
Mixed alloy scrap	7,628	10,179	10,179	-------	10,179	7,884	10	------	10
Nickel silver	2,307	6,465	6,465	-------	6,465	2,467	------	------	------
Total	26,730	174,767	174,767	-------	174,767	27,047	102	------	102
Foundries and other plants: [2]									
Auto radiators (unsweated)	200	5,311	-------	5,158	5,158	353	------	232	232
Brass, composition or red	1,791	5,260	3,509	2,548	6,057	1,434	163	121	284
Brass, low (silicon bronze)	181	394	26	350	376	247	------	------	------
Brass, yellow	1,309	7,510	3,635	3,250	6,885	1,216	4	28	32
Bronze	957	2,474	1,167	1,328	2,495	1,039	93	105	198
Low-grade scrap and residues	583	6,646	1,769	4,799	6,568	710	------	------	------
Nickel silver	33	83	61	19	80	54	1	------	1
Railroad-car boxes	1,756	36,075	-------	35,950	35,950	1,923	------	1,709	1,709
Total	6,810	63,753	10,167	53,402	63,569	6,976	261	2,195	2,456
Total tin from copper-base scrap	------	------	------	------	------	------	1,991	7,599	9,590
Lead-base scrap:									
Smelters, refiners, and others:									
Babbitt	1,263	11,811	-------	12,490	12,490	584	------	605	605
Battery lead plates	16,212	320,061	-------	321,734	321,734	14,539	------	338	338
Drosses and residues	16,411	71,685	73,303	-------	73,303	14,793	2,495	8	2,503
Solder and tinny lead	391	7,559	37	7,705	7,742	208	6	1,338	1,344
Type metals	1,602	21,630	-------	22,074	22,074	1,158	------	1,048	1,048
Total	35,879	432,746	73,340	364,003	437,343	31,282	2,501	3,337	5,838
Tin-base scrap:									
Smelters, refiners, and others:									
Babbitt	43	500	-------	480	480	63	------	402	402
Block-tin pipe	22	407	1	400	401	28	1	396	397
Drosses and residues	573	3,371	3,475	-------	3,475	469	2,182	------	2,182
Pewter	26	48	-------	60	60	14	------	51	51
Total	664	4,326	3,476	940	4,416	574	2,183	849	3,032
Tinplate scrap: Detinning plants	------	------	700,628	-------	700,628	-------	3,230	------	3,230
Total tin recovered	------	------	------	------	------	------	9,905	11,785	21,690

[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."

TABLE 5.—Tin recovered from scrap processed in the United States, by form of recovery

(Long tons)

Form of recovery	1960	1961	Form of recovery	1960	1961
Tin metal:			Solder	4,515	4,820
At detinning plants	2,745	2,670	Type metal	1,610	1,570
At other plants	270	330	Babbitt	1,245	1,030
			Antimonial lead	325	390
Total	3,015	3,000	Chemical compounds	905	1,020
			Miscellaneous [1]	60	90
Bronze and brass:					
From copper-base scrap	10,045	9,335	Total	8,660	8,920
From lead and tin-base scrap	330	435	Grand total	22,050	21,690
			Value (thousands)	$50,084	$55,033
Total	10,375	9,770			

[1] Includes foil, cable lead, and terne metal.

CONSUMPTION

Total tin consumption in the United States declined 3 percent. Three items—tinplate, solder, and bronze and brass—consumed more than 80 percent of the tin in 1961 and 1960. Consumption of tin in tinplate (the leading use of primary tin, which took 63 percent of the 1961 total) dropped 6 percent.

Tinplate production was 5 percent lower but was the second highest recorded, being exceeded only in 1960. Of the total output, electrolytic tinplate represented 95 percent (92 percent in 1960), and hot-dipped, 5 percent.

The United States required 47 percent of the world consumption of tin for tinplate in 1961 and 1960. Nearly 90 percent of the tinplate was used for making cans, of which 62 percent was for food packing and 38 percent was for nonfood products. The tonnage of tinplate shipments to canmakers rose 7 percent to a new record. Can shipments increased 4 percent to the highest recorded. Vegetable and vegetable juice cans showed the largest gain in tonnage. Cans for soft drinks increased for the fifth consecutive year to a new high. Cans for coffee, fish and seafood, and pet foods also reached new peaks in 1961. Beer cans were 2 percent less.

The data in table 6 show the apparent consumption of tin from 1910 to 1961. The calculated consumption figure for each year does not take into account movements in or out of consumer, dealer, and Government stocks; consequently the calculated figures may vary widely from the actual, on an annual basis.

TABLE 6.—Smelter production, imports, exports, and apparent consumption of tin in the United States, 1910–61[1]

(Long tons)

Year	Smelter production	Imports for consumption	Exports (domestic and foreign)	Apparent consumption[2]
1910		46,900		46,900
1911		47,792		47,792
1912		51,800		51,800
1913		46,722		46,722
1914		42,438		42,438
1915		51,600	341	51,259
1916	2,019	61,638	449	63,208
1917	5,415	64,434	263	69,586
1918	9,182	63,620	254	72,548
1919	10,925	40,044	341	50,628
1920	15,761	56,067	927	70,901
1921	10,305	24,197	1,393	33,109
1922	8,132	60,193	1,098	67,227
1923	6,666	68,934	1,046	74,554
1924	434	65,059	959	64,534
1925		76,646	932	75,714
1926		77,159	1,980	75,179
1927		71,142	2,239	68,903
1928		77,970	1,617	76,353
1929		87,127	1,930	85,197
1930		80,734	2,233	78,501
1931		66,064	[3] 1,661	64,403
1932		34,819	[3] 1,117	33,702
1933		63,718	[3] 1,041	62,677
1934		39,986	[3] 1,216	38,770
1935		64,258	[3] 2,292	61,966
1936		76,029	[3] 386	75,643
1937		88,115	[3] 313	87,802
1938		49,699	[3] 205	49,494
1939		70,102	[3] 2,105	67,997
1940	1,391	124,810	[3] 2,664	123,537
1941	1,839	140,873	[3] 1,094	141,618
1942	16,168	26,753	409	42,512
1943	21,489	11,919	1,770	31,638
1944	30,884	13,338	843	43,379
1945	40,475	8,493	882	48,086
1946	43,500	15,559	881	58,178
1947	33,300	24,899	420	57,779
1948	36,703	49,196	91	85,808
1949	35,834	60,224	154	95,904
1950	33,118	82,838	799	115,157
1951	31,852	28,255	1,513	58,594
1952	22,805	80,543	380	102,968
1953	37,562	74,570	203	111,929
1954	27,407	65,599	822	92,184
1955	22,329	64,815	1,107	86,037
1956	17,631	62,590	890	79,331
1957	1,564	56,158	1,531	56,191
1958	[4] 5,440	41,149	1,341	45,248
1959	[4] 10,773	43,578	1,371	52,980
1960	[4] 14,026	39,538	857	52,707
1961	[4] 8,917	39,898	800	48,015

[1] Domestic mine production of tin was exported for smelting from 1910 to 1939, and from 1959 through 1961; between 1940 and 1955, inclusive, it was treated by domestic smelters. Various metallurgical plants treated imported concentrate averaging 50 long tons annually between 1900 and 1915, and 150 tons annually between 1925 and 1939.

[2] Measured by quantity of smelter production, plus imports for consumption, minus exports.

[3] Foreign only, 1931–41; domestic not separately recorded.

[4] Imports for consumption—ore (tin content); smelter production figure withheld to avoid disclosing individual company confidential data.

TABLE 7.—Consumption of primary and secondary tin in the United States

(Long tons)

	1952-56 (average)	1957	1958	1959	1960	1961
Stocks Jan. 1 [1]	23,895	28,446	32,030	30,003	35,521	33,459
Net receipts during year:						
Primary	57,188	59,215	46,553	51,269	50,661	53,565
Secondary	2,330	2,868	2,524	2,471	2,217	2,897
Terne	290					
Scrap	30,107	26,758	23,680	30,814	27,448	26,344
Total	89,915	88,841	72,757	84,554	80,326	82,806
Available	113,810	117,287	104,787	114,557	115,847	116,265
Stocks Dec. 31 [1]	25,432	32,030	30,003	35,521	33,459	36,209
Total processed during year	88,378	85,257	74,784	79,036	82,388	80,056
Intercompany transactions in scrap	2,295	2,750	2,199	1,663	1,828	1,806
Tin consumed in manufactured products	[2] 86,083	82,507	72,585	77,373	80,560	78,250
Primary	54,801	54,429	47,998	45,833	51,530	49,699
Secondary	30,750	28,078	24,587	31,540	29,030	28,551

[1] Stocks shown exclude tin in transit or in other warehouses on Jan. 1, as follows: 1952–56 (average), 1,016 tons; 1957, 1,815 tons; 1958, 1,310 tons; 1959, 1,940 tons; 1960, 1,900 tons; 1961, 2,570 tons; 1962, 425 tons.
[2] Includes tin losses in manufacturing.

TABLE 8.—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)	Gross weight (short tons)	Tin content (long tons) [1]	Tin per short ton of plate (pounds)
1952–56 (average)	1,218,487	14,432	26.7	3,575.773	16,723	10.3	[2] 294,767	5,089,027	[3] 31,996	14.1
1957	686,616	8,370	27.3	4,593,587	23,676	11.6	435,181	5,715,384	32,046	12.6
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

[1] Includes small tonnage of secondary pig tin and tin acquired in chemicals.
[2] Not reported during January–June 1954.
[3] Includes 840 long tons in tinplate waste-waste, strips, and cobbles through June 1954; thereafter not separately reported.

TABLE 9.—Consumer receipts of primary tin, by brands

(Long tons)

Year	Banka	English	Katanga	Longhorn	Straits	Others	Total
1952–56 (average)	3,523	4,410	4,519	3,181	39,198	2,357	57,188
1957	6,897	3,726	3,154		41,460	3,978	59,215
1958	8,785	4,779	2,143		25,999	4,847	46,553
1959	8,369	10,537	595		24,496	7,272	51,269
1960	[1] 10,065	1,635	1,546		31,355	6,006	50,661
1961	[1] 7,763	2,074	579	2,234	37,420	3,495	53,565

[1] Total deliveries of Banka tin to domestic consumers reported as 10,225 long tons in 1960 and 9,845 tons in 1961.

TABLE 10.—Consumption of tin in the United States, by finished products

(Long tons of contained tin)

Product	1960			1961		
	Primary	Secondary [1]	Total	Primary	Secondary [1]	Total
Alloys (miscellaneous)	260	141	401	300	120	420
Babbitt	1,841	1,780	3,621	1,744	1,794	3,538
Bar tin	894	216	1,110	1,165	108	1,273
Bronze and brass	3,350	11,986	15,336	3,168	13,025	16,193
Chemicals including tin oxide	648	1,284	1,932	674	1,415	2,089
Collapsible tubes and foil	788	127	915	939	59	998
Pipe and tubing	35	43	78	31	28	59
Solder	6,660	11,618	18,278	7,009	10,436	17,445
Terne metal	132	337	469	51	167	218
Tinning	1,996	39	2,035	2,035	41	2,076
Tinplate [2]	33,238		33,238	31,185		31,185
Type metal	98	1,333	1,431	96	1,193	1,289
White metal	1,452	90	1,542	1,190	124	1,314
Other	138	36	174	112	41	153
Total	51,530	29,030	80,560	49,699	28,551	78,250

[1] Includes 3,090 long tons of tin contained in imported 94/6 tin-base alloys in 1960 and 3,360 tons in 1961; also tin content of alloys imported in 1960 and 1961 under the category of "babbitt metal and solder."

[2] Includes secondary pig tin and tin acquired in chemicals.

STOCKS

Tinplate mills, holding nearly 76 percent of plant stocks of pig tin in the United States, increased inventories 4,400 long tons. Tin in process at tin mills on December 31 rose to 6,530 tons, a new record; pig tin stocks at other plants were 1,610 tons lower.

GSA sold 3,200 long tons of pig tin from the FFC stock of 3,933 tons excess to the Government's needs and not in the national stockpile. On December 31, 349,000 long tons of tin was in Government stockpiles; 341,000 tons of this was in the national (strategic) stockpile and 7,505 tons, obtained largely through the CCC barter program, was in the supplemental stockpile.

TABLE 11.—U.S. industry tin stocks

(Long tons)

	1952–56 (average)	1957	1958	1959	1960	1961
Plant raw materials:						
Pig tin:						
Virgin	14,031	20,126	18,173	22,830	20,881	23,679
Secondary	292	327	281	270	257	249
In process [1]	11,109	11,577	11,549	12,421	12,321	12,281
Total	25,432	32,030	30,003	35,521	33,459	36,209
Additional pig tin:						
In transit in United States	1,185	1,310	1,940	1,900	2,570	425
Jobbers-importers	574	660	1,050	1,945	1,090	2,675
Afloat to United States	4,808	1,735	1,660	1,855	2,990	3,170
Total	6,567	3,705	4,650	5,700	6,650	6,270
Grand total	31,999	35,735	34,653	41,221	40,109	42,479

[1] Tin content, including scrap.

PRICES

The tin market became virtually free from controls for the first time in almost 5 years when buffer-stock selling suddenly ceased on the London Metal Exchange. The lowest price for 1961 of Straits tin for prompt delivery in New York was 100.125 cents a pound on January 11 and 12. On August 29, the price rose to 125.75 cents a pound, the highest since June 12, 1951.

On the London market the cash price averaged £888.6 per long ton, against £796.7 in 1960. On June 20 the price rose above the ceiling of £880 set by the International Tin Agreement when buffer-stock supplies of tin metal were exhausted. After the high of £823.3 on July 12, 1960, the price moved downward to a low of £779 on January 12, 1961. Subsequently the price rose until September 1, when it reached £993, the high for 1961. The price for 3-month tin exceeded the cash price during most of 1961.

On the Singapore market, the average price of Straits tin ex-works was £877.2 (£775.1 for 1960). The lowest quotation was £762.5 on January 17, and the highest was £980 on August 29.

TABLE 12.—Monthly prices of Straits tin for prompt delivery in New York

(Cents per pound)

Month	1960			1961		
	High	Low	Average	High	Low	Average
January	100.500	99.250	99.850	100.750	100.125	100.381
February	101.875	100.375	100.974	102.375	100.250	100.979
March	100.750	99.625	100.092	104.625	101.625	103.403
April	99.625	98.875	99.244	109.500	104.500	107.075
May	100.125	98.875	99.542	111.250	107.500	110.034
June	102.000	100.123	101.307	120.000	111.125	114.551
July	104.750	102.250	103.494	118.000	115.250	116.250
August	104.625	101.000	102.853	125.750	116.500	119.783
September	102.625	101.750	102.232	125.500	120.500	121.850
October	103.750	102.875	103.275	122.500	120.125	121.054
November	103.375	102.000	102.822	123.625	121.875	122.894
December	102.000	100.250	101.143	122.250	119.625	120.981
Total	104.750	98.875	101.402	125.750	100.125	113.270

Source: American Metal Market.

FOREIGN TRADE [6]

The principal tin items in the foreign trade of the United States in 1961 were imports of metallic tin, high-tin alloys, and tin concentrates, and exports of tinplate and tin cans. Of less importance was the trade in tin scrap, including tin-alloy scrap, tinplate scrap, and tinplate circles, cobbles, strip, and scroll. Significant quantities of tin ingot, miscellaneous tin manufactures, and tin compounds were exported. Tin contained in babbitt, solder, type metal, and bronze imported and exported is shown in the "Lead" and "Copper" chapters. Ferrous scrap exports include tinplate and terneplate scrap not separately classified.

[6] 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 13.—U.S. imports for consumption of tin concentrate (tin content), by countries

(Long tons)

	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950
Algeria				8							
Argentina	288	102			60						
Australia								2			
Bolivia	2,285	22,021	20,750	17,351	27,701	25,936	28,520	20,984	20,367	19,265	14,419
Brazil	(1)	(1)					7	1	2		
British East Africa							(1)				
Burma										11	209
Cameroun			161	72	177	46	37				
Canada											
China									16	348	63
Congo, Republic of the (Belgian Congo)	27			4,094	7,549	7,401	7,214	379		695	1,526
Congo, Republic of (Fr. Eq. Africa)	32	179		211		83	21				
Hong Kong											
Indonesia		6,220	7,977				2,206	5,208	13,195	15,223	6,925
Japan											147
Malaya, Federation of										22	26
Mexico	313	114	45	121	61	13		5	36	116	118
Netherlands											
Nigeria											
Portugal	52	8					38			61	70
Spain									11		
Thailand								2,826	3,865	2,570	2,457
Union of South Africa	1	19									
United Arab Republic (Egypt)											
United Kingdom	2						27	5	(1)		
Viet-Nam, Laos, Cambodia (French Indochina)		7									
Total	3,000	28,670	28,933	21,857	35,548	33,479	38,070	29,410	37,492	38,311	25,960

Country	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
Algeria											
Argentina							(1)	1	(1)	(1)	
Australia			(1)			76					
Bolivia	13,085	12,639	18,571	12,575	9,765	8,533	11	81	106	117	262
Brazil	2										
British East Africa											
Burma		8		59							
Cameroun			43								
Canada			280	97	168	221		14			
China	1										
Congo, Republic of the (Belgian Congo)	1,585	1,192	2,638	880	713	969					
Congo, Republic of (Fr. Eq. Africa)											
Hong Kong				4							
Indonesia	11,684	7,321	8,678	7,228	6,969	3,548		5,105	7,946	12,509	8,556
Japan								(1)			
Malaya, Federation of									6		
Mexico	106	154	223	72	254	156	9	45	100	64	87
Netherlands				1							
Nigeria							34				
Portugal	19	808	795	162	30						
Spain											
Thailand	3,114	4,327	4,690	1,062	2,208	3,144	40	194	2,615	1,336	12
Union of South Africa											
United Arab Republic (Egypt)	11		5		5						
United Kingdom						25					
Viet-Nam, Laos, Cambodia (French Indochina)	14	42	50			16					
Total	29,621	26,491	35,973	22,140	20,112	16,688	94	5,440	10,773	14,026	8,917

[1] Less than 1 ton.

Source: Bureau of the Census.

TABLE 14.—U.S. imports for consumption of tin concentrate (tin content), by countries

Country	1960		1961	
	Long tons	Value	Long tons	Value
Argentina	[1]	$152		
Bolivia	117	151,366	262	$538,851
Indonesia	12,509	28,003,464	8,556	21,175,902
Mexico	64	134,901	87	189,048
Thailand	1,336	2,813,899	12	19,374
Total	14,026	31,103,782	8,917	21,923,175

[1] Less than 1 ton.

Source: Bureau of the Census.

TABLE 15.—U.S. imports for consumption of tin,[1] by countries

Country	1960		1961	
	Long tons	Value (thousands)	Long tons	Value (thousands)
Belgium-Luxembourg	1,601	$3,572	680	$1,530
Bolivia	939	2,015	1,677	3,843
Canada	[2]	2	7	23
Congo, Republic of the, and Ruanda-Urundi	336	752	4	11
Germany, West	10	22		
Indonesia	550	1,253	150	337
Malaya, Federation of, and Singapore	29,521	64,728	32,955	80,243
Netherlands	432	962	55	118
Nigeria			544	1,310
Portugal	225	502	1,016	2,455
United Kingdom	[3] 5,924	[3] 12,526	2,810	7,039
Total	[3] 39,538	[3] 86,334	39,898	96,909

[1] Bars, blocks, pigs, grain, or granulated.
[2] Less than 1 ton.
[3] Revised figure.

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
1952-56 (average)	279	$534	402	$849	681	605,354	13,975	33,463
1957	1,112	1,526	419	919	40	625,666	19,531	31,431
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	[1] 36,352
1961	543	1,264	257	626	13,527	358,707	20,960	29,499

[1] Revised figure.

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 tinplate scrap, value (thousands)	Imports (long tons)	Exports (long tons)
		Long tons	Value (thousands)	Long tons	Value (thousands)			
1952-56 (average)	[1] $600	6,474	[2] $11,704	30,467	$13,109	$2,522	4	115
1957	[1] 561	5,077	9,485	30,166	14,309	3,911	10	218
1958	619	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]

[1] Data for 1956 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.

Source: Bureau of the Census.

WORLD REVIEW

INTERNATIONAL TIN AGREEMENT

The Second International Tin Agreement came into force provisionally on July 1, 1961, having been formally ratified or signed by 6 producing countries and 14 consuming countries (accession of Korea as a consuming member was approved). Meetings were held July 3–7 and October 9–11. Contributions to the new buffer stock, entirely in cash by praticipating producers, amounted to £14.6 million, representing the equivalent of 20,000 long tons of tin at £730 per ton (91.25 cents per pound). A proposal by producing countries to raise the floor price to £800 a ton (100 cents per pound) and the ceiling price to £1,000 a ton (125 cents per pound) was rejected. As conditions had not been met for converting the agreement to a definitive entry into force at the end of 1961, it was continued on a provisional basis until June 30, 1962.

The first International Tin Council met for the last three times. In March it decided not to fix an export quota for the second quarter of 1961. At a May meeting the statistical position of tin was surveyed. In May, the Canadian government announced it would sell 3,000 tons of tin from its stockpile at the rate of 300 tons a month, not for export, and at prices in the same range as that in which the buffer-stock manager may sell (£830 to £880 per ton). The buffer stock held 10,030 long tons of tin metal from April 1, 1960, to December 13, 1960, and 10,080 tons on March 31, 1961. Sales begin-

ning in April exhausted the buffer stock by June 20. At this time the buffer-stock manager withdrew as a seller on the London Metal Exchange and was unable to maintain the ceiling at £880 per ton. The 28th and last meeting, June 28, approved procedures to liquidate assets of the first buffer stock.

TABLE 18.—Second International Tin Agreement; percentages and voting powers of producing countries [1]

Country	Percentages	Votes allocated	Country	Percentages	Votes allocated
Bolivia	18.21	182	Nigeria	6.32	66
Congo, Republic of the	8.18	84	Thailand	9.11	93
Indonesia	19.73	197	Total	100.00	1,000
Malaya, Federation of	38.45	378			

[1] Established at first meeting July 3-7, 1961.

TABLE 19.—Second International Tin Agreement; voting power of consuming countries [1]

Country	Votes	Country	Votes
Australia	49	Japan	156
Austria	13	Korea, Republic of	8
Belgium	35	Mexico	19
Canada	53	Netherlands	43
Denmark	58	Spain	16
France	145	Turkey	15
India	58	United Kingdom	275
Italy	57	Total	1,000

[1] International Tin Council, 1961 Statistical Supplement, p. 9.

TABLE 20.—World mine production of tin (content of ore), by countries [1]

(Long tons)

Country	1952-56 (average)	1957	1958	1959	1960	1961
North America:						
Canada	218	317	355	334	278	389
Mexico	469	473	544	377	365	530
United States	92	----------	----------	50	10	(2)
Total	779	790	899	761	653	(2)
South America:						
Argentina	137	182	205	225	244	[3] 350
Boliva (exports)	30,074	27,794	17,731	23,811	19,406	20,408
Brazil	185	293	409	380	1,556	(4)
Peru	7	12	30	25	25	17
Total	30,403	28,281	18,375	24,441	21,231	(4)
Europe:						
Czechoslovakia [5]	200	200	200	200	200	200
France	437	445	----------	----------	21	141
Germany, East [3]	591	670	720	720	720	720
Portgual [6]	1,345	1,127	1,249	1,129	772	683
Spain	877	498	467	326	196	255
U.S.S.R. [7 8]	10,000	13,000	13,500	15,000	17,000	20,000
United Kingdom	1,005	1,028	1,087	1,252	1,199	1,210
Total [3 8]	14,500	17,000	17,200	18,600	20,100	23,200
Asia:						
Burma [8]	1,139	1,200	1,300	1,300	1,100	[3] 1,100
China [3]	12,880	23,000	23,000	26,000	28,000	30,000
Indonesia	33,621	27,723	23,201	21,616	22,599	18,574
Japan	782	949	1,108	998	842	852
Laos	207	274	301	294	383	332
Malaya, Federation of	59,464	59,293	38,458	37,525	51,979	56,028
Thailand	10,577	13,528	7,720	9,526	12,080	13,270
Total [3 8]	118,700	126,000	95,100	97,300	117,000	120,200
Africa:						
Cameroun	85	71	75	62	69	59
Congo, Republic of the (formerly Belgian)	12,828	12,478	9,689	9,190	[3] 8,900	[3] 6,570
Congo, Republic of	----------	----------	26	32	34	31
Morocco	10	8	6	9	10	[3] 12
Niger, Republic of	77	50	61	57	53	47
Nigeria	8,339	9,534	6,200	5,541	7,675	7,779
Rhodesia and Nyasaland, Federation of	131	283	534	665	705	782
Ruanda-Urundi	1,965	1,803	1,490	1,124	[3] 1,200	[3] 1,429
South-West Africa	312	636	164	4	255	293
Swaziland	32	25	15	5	6	8
Tanganyika (exports)	37	14	19	65	138	163
Uganda	77	40	41	36	33	33
Union of South Africa	1,267	1,463	1,416	1,272	1,276	1,430
Total	25,160	26,405	19,736	18,062	20,354	18,636
Oceania: Australia	1,867	1,952	2,237	2,351	2,202	2,593
World total (estimate)	191,400	200,400	153,500	161,500	181,500	188,000

[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] 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 48th annual issue of Metal Statistics (Metallgesellschaft) through 1960.
[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 Augusta W. Jann, Division of Foreign Activities.

TABLE 21.—World smelter production of tin, by countries [1]

(Long tons)

Country	1952–56 (average)	1957	1958	1959	1960	1961
North America:						
Mexico	230	207	460	377	365	[2] 504
United States [3]	25,547	1,564	[4] 5,440	[4] 10,773	[4] 14,026	[4] 8,917
Total	25,777	1,771	5,900	11,150	14,391	9,421
South America:						
Argentina	107	39				
Bolivia (exports) [3]	231	266	705	955	1,468	2,015
Brazil	1,049	1,401	629	1,227	1,311	[2] 1,320
Total	1,387	1,706	1,334	2,182	2,779	3,335
Europe:						
Belgium	10,230	9,869	8,723	5,945	7,947	6,002
Germany:						
East [2]	570	600	600	600	600	600
West	483	955	646	1,010	769	947
Netherlands	27,614	29,259	17,098	9,592	6,393	2,729
Portugal	724	1,072	1,259	1,174	601	677
Spain	687	783	449	323	299	659
U.S.S.R. [2 5]	10,000	13,000	13,500	15,000	17,000	20,000
United Kingdom [6]	27,906	34,174	32,551	27,229	27,404	25,773
Total [2 5]	78,200	89,700	74,800	60,900	61,000	57,400
Asia:						
China [2]	13,000	23,000	23,000	26,000	28,000	30,000
Indonesia	818	322	[2] 600	[2] 1,600	[2] 1,800	[2] 1,800
Japan	878	1,260	1,307	1,308	1,261	1,644
Malaya, Federation of	68,060	71,289	45,336	45,729	76,130	79,114
Total [2 5]	82,800	95,900	70,200	74,600	107,200	112,600
Africa:						
Congo, Republic of the (formerly Belgian)	2,749	3,105	2,642	3,291	[2] 3,500	[2] 2,400
Morocco	9	[2] 12	[2] 12	[2] 12	[2] 12	[2] 12
Nigeria						623
Rhodesia and Nyasaland, Federation of	23	253	503	631	671	742
Union of South Africa	815	825	901	726	622	870
Total	3,596	4,195	4,058	4,660	4,805	4,647
Oceania: Australia	1,812	1,806	2,121	2,226	2,254	2,566
World total (estimate)	193,600	195,100	158,400	155,700	192,400	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] Estimated by authors of the chapter and in a few instances from the Statistical Bulletin of the International Tin Council, London, England.
[3] Includes tin content of alloys made directly from ores.
[4] Imports for consumption (tin content).
[5] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.
[6] Including secondary metal as follows: 1959, 615 tons; 1960, 1,118 tons; 1961, 1,324 tons.

Compiled by Augusta W. Jann, Division of Foreign Activities.

REVIEW BY COUNTRIES

SOUTH AMERICA

Bolivia.—Exports of tin, mostly in concentrate, totaled 20,400 long tons valued at U.S. $50.3 million, an increase of 5 percent in tonnage and 18 percent in value compared with 1960. Tin represented 73 percent of the gross value of Bolivian minerals exported in 1961. The bulk of the tin exported went to the United Kingdom. Shipments to West Germany were the highest ever recorded. Tin production in nationalized mines dropped for the eighth consecutive year. To encourage production of higher grade concentrate, a new

scale of royalties for export and sale of tin was approved August 1. Implementation began of the "triangular plan" decreed August 31, whereby U.S. $38 million may be made available in stages for rehabilitation of the mining industry by the United States Government, the Inter-American Development Bank, and Salzgitter Maschinen A.G., representing the West German Government.

Five-year extensions of ore-smelting contracts were secured by Consolidated Tin Smelters, Ltd. (Williams, Harvey & Co., Ltd.), and Capper Pass and Son, Ltd.

TABLE 22.—Bolivia: Tin production by nationalized mines

(Long tons of contained tin)

Mine	1960	1961	Mine	1960	1961
Caracoles	713	774	Oploca-Santa Ana	25	25
Catavi	4,666	4,196	San Jose	831	869
Chorolque	585	492	Santa Fe	653	486
Colavi	108	148	Tasna	410	485
Colquechaca	46	47	Unificada	906	976
Colquiri	2,811	2,566	Viloco	268	463
Huanuni	2,627	2,628	Others	23	29
Japo	82	91			
Morococala	236	304	Total	14,990	14,579

Source: U.S. Embassy, La Paz, Bolivia, from data furnished by Corporation Minera de Bolivia.

TABLE 23.—Bolivia: Exports of tin by groups

(Long tons of contained tin)

Group	1954–58 (average)	1959	1960	1961
Corporation Minera de Bolivia [1]	21,311	17,590	12,677	12,622
Banco Minero:				
Medium mines	1,914	2,173	2,393	2,475
Small mines	2,240	3,024	2,868	3,297
Smelter (tin metal)	357	[2] 1,024	1,468	2,015
Total	25,822	23,811	19,406	20,409

[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 24.—Bolivia: Exports of tin by countries

(Long tons of contained tin)

Destination	1960	1961	Destination	1960	1961
Argentina	3	----	Netherlands	19	564
Brazil	954	476	Peru	----	2
Chile	9	----	United Kingdom	16,088	15,147
Germany, West	924	1,467	United States	1,373	2,743
Korea, Republic of	----	10			
Mexico	36	----	Total	19,406	20,409

Source: Departmento de Estadistica—Direccion General de Minas, Ministrio de Mines y Petroleo.

TABLE 25.—Bolivia: Percentage of tax for tin concentrate [1]

Concentrate grade (percent)	Royalty rate as percent of official quoted price in US$ when tin price per pound is—					
	$0.90	$1.00	$1.10	$1.20	$1.30	$1.40
Up to 15	1.30	2.00	3.90	5.20	6.50	7.80
18.5	1.30	2.00	5.35	7.15	8.95	10.76
20	1.30	2.60	5.95	8.00	10.00	12.00
25	1.30	4.70	7.95	10.60	13.33	15.96
30	2.85	6.50	9.90	13.03	15.98	18.61
35	4.10	8.20	11.80	15.13	18.08	20.71
40	5.16	9.55	13.35	16.68	19.63	22.26
45	6.16	10.55	14.35	17.68	20.63	23.26
50	7.06	11.45	15.25	18.58	21.53	24.16
55	7.86	12.25	16.05	19.38	22.33	24.96
60	8.56	12.95	16.75	20.08	23.03	25.66
65 and up	9.16	13.55	17.35	20.68	23.63	26.26

[1] Supreme decree 05245 approved Aug. 1, 1961. Royalty calculated on established gross value and official price based on London and New York market quotation, and a biweekly established free rate of exchange.

EUROPE

U.S.S.R.—Imports from China were 15,000 tons (estimated), compared with 17,500 in 1960. Tin imported from Western European markets was 3,000 tons in 1961, the largest since 1953. Exports of tin to free Europe dropped sharply. Under a trade agreement signed in April, China was to continue supplying tin. Other trade pacts provided for acquiring tin from Indonesia and Thailand. The U.S.S.R. imported 36,580 long tons (34,450 in 1960) of tinplate from Western Europe in 1961, and exported 3,570 tons to India. Tinplate production was 335,500 tons in 1961, against 341,500 tons in 1960.

TABLE 26.—Sino-Soviet Bloc: Shipments of tin metal

(Long tons)

Source and destination	1960	1961	Source and destination	1960	1961
From U.S.S.R. to—			From China to—Continued		
Austria	225	----	Finland	10	50
Denmark	13	----	France	----	150
Finland	453	----	Germany, West	2,932	2,783
France	135	----	Hong Kong	----	115
Germany, West	3,584	519	Japan	153	1,635
India	600	200	Netherlands	909	1,325
Iran	79	----	Sweden	85	120
Italy	322	----	Switzerland	58	73
Japan	1,022	720	United Kingdom	300	901
Netherlands	787	----	Yugoslavia	200	----
Sweden	10	----			
Switzerland	17	----	Total	4,647	7,455
United Arab Republic	178	----			
United Kingdom	896	51	From Poland to—		
Yugoslavia	650	----	Germany, West	162	----
			United Kingdom	30	----
Total	8,971	1,490			
			Total	192	----
From China to—					
Austria	----	5	Grand total	13,810	8,945
Denmark	----	298			

Source: Statistical Bulletin of the International Tin Council.

United Kingdom.—Mine production in Cornwall, England, was 1,210 long tons of tin, derived principally from 680 tons of black tin (65 percent) produced by Geevor Tin Mines, Ltd., and 855 tons (70 percent) produced by South Crofty, Ltd.

The United Kingdom ranked second as a free world smelter of tin ore, third as a consumer of pig tin, and second as a producer of tinplate. Most of the concentrate treated was from Bolivia and Nigeria; receipts were the lowest since 1944. Primary tin consumption was 21,360 long tons (22,550 in 1960), of which about 45 percent was for making tinplate. Tinplate production was 1 million tons, 12 percent less than 1960 (1,191,500 tons). The last old-type tinplate works at Redbrook, South Wales, originally established in 1771, closed. Two firms comprised the tinplate industry of the United Kingdom: Richard Thomas and Baldwins, Ltd., and Steel Company of Wales, Ltd. Of the 1961 tinplate output, 71 percent was electrolytic and 29 percent was hot dipped. The second electrolytic tinplate line at Richard Thomas and Baldwins, Ltd., and the sixth at Steel Company of Wales, Ltd., began production in 1961. Tinplate exports dropped to 424,600 tons from the record high of 488,500 tons in 1960. Sharp declines in shipments to Australia, South America, and China offset peak tonnages to Bulgaria, Italy, Sweden, Switzerland, Union of South Africa, and Yugoslavia. Exports to Sweden rose for the sixth successive year. The United States took 14,930 tons, compared with 11,540 tons in 1960.

Imports of tin metal, mainly from China and Malaya, dropped to 1,800 long tons (2,900 in 1960). Tin metal exports, mostly to the United States and the U.S.S.R., rose to 12,190 long tons (8,470 in 1960).

Pig-tin stocks totaled 11,780 long tons at the beginning of 1961 and 6,380 long tons at the end. Stocks of tin-in-concentrate were 1,960 tons at the beginning of 1961, compared with 1,876 at the end. Year-end stocks of tin-in-concentrate afloat were 952 tons (1,725 at beginning of 1961).

ASIA

Indonesia.—Tin output in 1961 dropped 18 percent to the lowest since 1947. The islands of Banka, Billiton, and Singkep furnished 61, 32, and 7 percent, respectively, of the total.

Tin exports totaled 18,585 tons in 1961. Exported tin-in-concentrate was 16,788 tons; 8,742 tons went to Malaya-Singapore, 7,611 to the United States, 292 to Spain, and 143 to Mexico. The remaining 1,797 tons, was metal shipped to Belgium, France, West Germany, and Japan.

An agreement was signed with West Germany under which Klockner-Industrie-Analgen was to complete an installation in Muntok on Banka enabling Indonesia to smelt its own output of tin ore by 1964.

An amendment signed with the U.S.S.R. in December 1961 provided for inclusion of tin as part of the long-term trade agreement of July 1960.

Malaya, Federation of.—Of the total mine production of 56,000 long tons, 65 percent came from European mines (mostly by dredges) and 35 percent came from Asian mines (mostly by gravel pumps), including 2 percent from dulang washing. European mines produced 36,243 long tons (33,505 in 1960), and Asian mines, 19,785 (18,475

in 1960). Gains in output over 1960 were made by virtually all mining methods, with the largest by dredging (1,620 tons) and gravel pumps (1,500 tons). Output of open-pit mines rose 480 tons to the highest quantity since 1941. Open-pit mining featured new bucket-wheel excavators. Export duties on tin were M$65 (US$21.3) million, compared with M$55.2 (US$18.4) million in 1960.

Active mines totaled 591 at the beginning of 1961 and 696 at year-end. Dredges increased from 69 to 72; gravel-pump units increased from 470 to 572. The labor force was 32,459 on December 31, 1961, against 29,242 on December 31, 1960.

Producers received refunds from Malaya's M$55 (US$18.3) million contribution to the first buffer stock, plus sums representing their share of the profit realized by the buffer-stock management. The M$47 (US$15.7) million contribution to the second buffer stock was to be collected by the Malayan government by a 2-year levy on exports of tin concentrate beginning August 1, 1961. The amount was M$39 a picul (US$218.4 per long ton) for August, M$36 a picul (US$201.6 per long ton) for September, and M$24 a picul (US$134.4 per long ton) for the last 3 months of 1961.

The principal world source of tin continued to be the large plants of the Eastern Smelting Co., Ltd., on the island of Penang, and the Straits Trading Co., Ltd., at Pulau Brani, Singapore, and Butterworth, Wellesley Province. The residence and seat of control of Eastern Smelting Co., Ltd., was transferred from the United Kingdom to the Federation of Malaya on September 29, 1961. Concentrate treated was derived mostly from the Federation of Malaya, Thailand, and Indonesia. Total tin-in-concentrate available for the Federation smelters was 72,209 tons (72,440 in 1960). Tin-in-concentrate received by the Singapore smelter was 3,308 tons, against 1,200 in 1960. Smelter production was the highest since 1941. Exports of tin metal, mostly from Penang, were the largest since 1950. Ishihara Sangyo Kaisha, Osaka, Japan, received permission from the Malayan Government to establish a new company, Malaya Tin Smelting Co., in Malaya, to operate a tin smelter it plans to build at Port Swettenham.

Stocks of tin metal increased from 2,967 tons at the beginning of 1961 to 3,966 tons at yearend. Tin-in-concentrate (including mine stocks) declined from 9,697 tons at the beginning of 1961 to 5,995 at the end.

TABLE 27.—Federation of Malaya and Singapore: Exports of tin-in-metal, by countries

(Long tons)

Destination	1960	1961	Destination	1960	1961
Argentina	1,830	1,669	Japan	10,796	10,629
Australia-New Zealand	2,049	1,002	Netherlands	806	842
Belgium	5,280	4,275	United Kingdom	2,816	1,490
Canada	2,040	2,153	United States	29,616	33,596
Denmark	485	194	Yugoslavia	474	781
France	2,961	3,940	Others	3,495	2,811
Germany, West	6,831	5,561			
India	3,263	4,332	Total	76,367	78,025
Italy	3,625	4,750			

Source: Federation of Malaya, Department of Statistics, Monthly Statistical Bulletin, March 1962.

TABLE 28.—Federation of Malaya and Singapore: Imports of tin-in-concentrate, by countries

(Long tons)

Country	1960	1961	Country	1960	1961
Burma	1,394	1,323	Other countries	119	145
Indonesia	9,695	8,068			
Laos	445	550	Total	21,512	19,025
Thailand	9,859	8,939			

Thailand.—Tin was the most important mineral resource of Thailand and ranked third as a major export, being exceeded in value only by rice and rubber. A 6-year plan to increase industrial income includes raising tin ore production 40 percent over the 1959 level by 1963. Company contributions were being made to the second buffer stock, but no Government refund had been made from the first buffer stock. Tin was one of the export items of a trade agreement with the U.S.S.R. Tantalco Tin Mines Co. began shipping tin concentrate to Japan.

TABLE 29.—Thailand: Exports of tin-in-concentrate, by countries [1]

(Long tons)

Destination	1959	1960	1961	Destination	1959	1960	1961
Brazil	1,081	1,062	607	Spain			1,021
Germany, West	9	53		Switzerland	11		
Japan	43	58	503	United Kingdom			14
Malaya-Singapore	6,932	9,961	9,089	United States	2,000	938	
Mexico	14	28	96				
Netherlands	10	446	1,616	Total	10,100	12,618	12,946
Portugal		72					

[1] This table incorporates some revisions.

AFRICA

Congo, Republic of the.—Mining and smelting declined to the lowest levels since the 1930's. The tin situation was confused, with communications and transport disrupted because of continued political turmoil. However, tin concentrate moved slowly to Belgium for smelting, with large tonnages accumulating periodically at mines and shipping points. At the close of 1961 an improvement in the flow of concentrate was reflected in a higher operating rate of the Belgian smelter. Only a trickle of the tin smelted in Katanga entered usual markets in 1961. Mining by Symetain-Société Congolaise was curtailed owing to shortages of fuel and spare parts and manpower problems. Minière des Ingenieurs de Industriels Belges (Geomines) operated intermittently. Its properties were virtually at a standstill at yearend. Slight damage to the Manono smelter was repaired, but the plant was inactive at the close of 1961.

Nigeria.—Of the 10,500 long tons of tin concentrate produced in 1961, 70 percent was from mechanized mines and 30 percent was from mines worked largely by hand labor. Columbium was produced as a byproduct. From 1914 through 1960, all the Nigerian concentrate went to the United Kingdom for smelting. In 1961, a significant part was shipped to other countries or retained for smelting locally.

Smelter output of 623 long tons was exported, mostly to the United States. Stocks of tin-in-concentrate at mines increased from 500 tons at the beginning of the year to 1,030 at yearend. Second buffer-stock contributions to the Nigerian Government were set off against refunds due under the first buffer stock.

In the year ended March 31, 1961, Nigeria's largest tin producer—Amalgamated Tin Mines of Nigeria, Ltd.—reported treating about 13.7 million cubic yards, compared with 9.1 million in the preceding year. Cassiterite production was the highest since 1950. The company approved a 5-year equipment program which included replacing two 5-cubic-yard-bucket walking dragline excavators.

The output (in long tons) was obtained by the following methods:

Method:	*Cassiterite*	*Columbite*
Jig plants	623	288
Dragline washing plants	1,023	37
Gravel pumps and elevators	2,127	223
Dorowa dredge	136	20
Contractors	779	70
Mill tailing treatment	120	84
Total	4,808	722

Nigerian Embel Tin Smelting Co., Ltd. (Portuguese-Nigerian), began operating in March. Makeri Smelting Co., Ltd. (subsidiary of Consolidated Tin Smelters, Ltd.), started receiving concentrate for smelting in December. The Northern Region government held an option to participate in the Makeri project.

OCEANIA

Australia.—Tin production in Queensland, the principal Australian source, was the highest since 1915. Tableland Tin Dredging, N.L., and Ravenshoe Tin Dredging, Ltd., were the major producers. Tin consumption in Australia was 3,370 long tons, against 3,830 (revised) tons in 1960; tinplate required 1,460 tons in 1961 and 1,495 tons in 1960. The Fort Kembla mill, in its fourth year of operation, produced 101,595 long tons of tinplate (101,620 in 1960), and the output of 10,340 tons in March equaled rated mill capacity. The new electrolytic tinning line was scheduled to begin production early in 1962.

Tinplate production supplied about 85 percent of domestic requirements in 1961; the United Kingdom and the United States supplied most of the remainder. Receipts of tinplate from the United States dropped to 3,000 long tons in 1961.

TECHNOLOGY

Indicated and inferred reserves of cassiterite in the Tofty tin belt, Alaska, were reported to total about 2,000 tons. The tailings piles had an additional indicated reserve of about 222 tons.[7] Information on cassiterite occurrences in Colorado,[8] tin-bearing deposits in Coosa County, Ala.,[9] and the famous Kinta Valley, Federation of Malaya,

[7] Wayland, Russell G. Tofty Tin Belt, Manley Hot Springs District, Alaska. Geol. Survey Bull 1058-I, 1961, pp. 363-412.

[8] Eckel, Edwin B. Minerals of Colorado. A 100-Year Record. Geol. Survey Bull. 1114, 1961, pp. 91-92.

[9] Lee, F. W., Guy E. Dent, and Hugo E. Kuehn. Geophysical Investigation Relating to Tin Deposits in Coosa County, Ala., 1961 Bu Mines open File Rept. Report may be consulted at the Central Library of the Department of the Interior, Washington, D.C., and at the Bureau of Mines research center, Tuscaloosa, Ala.

tin field were made available.[10] A method was developed for determining tin in the range of 0.5 to 100 ppm in soil and stream samples.[11] A review of the historical background and production statistics of tin mining in South Africa was presented.[12]

The Federal Bureau of Mines reported the results of research on volatilization of tin chloride from Bolivian ores and concentrates [13] and the recovery of tin from hardhead.[14] The tin in Bolivian ores and concentrates was reduced to stannous oxide and then converted to stannous chloride by treatment with gaseous mixtures of hydrogen and hydrogen chlorides at 520° to 565° C. Approximately 95 percent of the tin was converted to volatile chlorides. The iron content of hardhead was decreased from 16 to 0.06 percent by blowing air into molten hardhead, followed by filtration. Tin recovery was over 90 percent. In other experiments mercury was used to leach tin from hardhead. Subsequent electrolytic refining resulted in a tin product that was 99.9 to 99.99 percent tin. Recovery of tin was as high as 81 percent.

Research on the production and use of thin tinplate continued during the year. Thin tinplate with weights ranging from 45 to 60 pounds per base box was produced for the canning industry.[15] Methods and economic factors of rolling tinplate to a weight of 40 pounds per base box were discussed.[16]

Superconducting magnets that had zero electrical resistance in magnetic fields up to 88,000 gauss were made from columbium-tin compounds.[17] Electromagnets made from these compounds and operated at about minus 268° C did not consume electrical energy once the magnetic field was established, even while carrying electrical currents up to 3,000 amperes. In comparsion, a magnet using copper as a conductor would consume 1.5 megawatts of electric power.

The Tin Research Institute reported on studies on uses of tin. These reports covered the addition of tin to cast-iron tinplate organotin for fungicidal paints and as an antifouling agent, and tin-base bearings and solders.[18]

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[10] Ingham, F. T., and E. F. Bradford. Geology and Mineral Resources of the Kinta Valley, Perak Federation of Malaya Geol. Survey District Memoir 9, 285 pp.

[11] Stanton, R. E., and Alison J. McDonald. Field Determination of Tin in Geochemical Soil and Stream Sediment Survey. Inst. of Min. and Met. Bull., v. 71, No. 659, pt. 1, October 1961, pp. 27-29.

[12] McDermott, E. K., and G. St. J. Oxley-Oxland. Tin Mining in South Africa. The Seventh Commonwealth Min. and Met. Cong., South Africa, Apr. 10-May 20, 1961. 7 pp.

[13] Kershner, K. K., F. W. Hoertel, and A. A. Cochran, Volatilization of Tin Chlorides From Bolivian Low-Grade Ores and Concentrates. BuMines Rept. of Inv. 5811, 1961, 16 pp.

[14] Sullivan, P. M., and D. H. Chambers. Recovery of Zinc from Dross and Tin From Hardhead by Amalgam Electrolysis. BuMines Rept. of Inv. 5827, 1961, 18 pp. Wilson, D. A., and P. M. Sullivan. Recovering Tin From Hardhead by Selective Oxidation of Iron. BuMines Rept. of Inv. 5756, 1961, 17 pp.

[15] Tin (London). Thin Tin A New Development in Packaging. March 1961, pp. 57-59.

[16] Stone, Morris D. The Rolling of Ultra-Thin Tin Plate. Iron and Steel Eng., v. 38, No. 6, June 1961, pp. 67-77.

[17] Tin (London). Remarriage of Niobium and Tin Leads to Superconducting Magnets—Key to Cheap Power From Nuclear Fusion. August 1961, pp. 193-195.

[18] Quarterly Journal of the Tin Research Institute. Tin and Its Uses. No. 51, 16 pp., No. 52, 16 pp., No. 53, 16 pp., 1961.

Titanium

By John W. Stamper [1]

CONSUMPTION of ilmenite in the United States reached a record peak in 1961, and the gross weight production of titanium pigments, which traditionally utilized over 95 percent of all ilmenite concentrate produced, was 6.5 percent above 1960 output, nearly equal to the record high level of 1959. Rutile output was up 3 percent to 9,000 tons but shipments dropped 19 percent. However, owing chiefly to an increase in requirements for making titanium sponge metal, consumption of rutile increased 22 percent.

Production and consumption of titanium ingot increased significantly for the third successive year and resulted in a near record output of 5,600 tons of titanium mill products. The use of titanium metal as a basic material of construction for the spacecraft used in America's first manned orbital space flight, dramatically illustrated the degree of technical reliability achieved in fabricating and joining the metal.

World output of ilmenite and slag reached a record 2.3 million tons, as increased production in Australia, Canada, and Norway more than offset a sharp decline in production in India. World rutile output also was at a high level, 12 percent above the 1960 figure. The beginning of commercial utilization of rutile for making titanium dioxide pigment by the chloride process in the United States foreshadowed a significant future increase in demand for rutile.

New titanium dioxide (TiO_2) producing facilities in the United States and foreign countries were installed, and additional expansion programs to meet increased domestic and foreign demand for titanium pigments were announced during the year.

LEGISLATION AND GOVERNMENT PROGRAMS

The U.S. Department of Agriculture, Commodity Credit Corporation (CCC) continued to barter surplus agricultural products for titanium sponge metal from Japan. Government cash commitments under Defense Production Act (DPA) contracts for delivery of rutile and other materials, which would be surplus to maximum stockpile objectives, were reduced by converting the contracts to barter, and the Government acquired rutile from Australia under this program.

[1] Commodity specialist, Division of Minerals.

TABLE 1.—Salient titanium statistics

	1952–56 (average)	1957	1958	1959	1960	1961
United States:						
Ilmenite concentrate:[1]						
Mine shipments.....short tons	575,033	782,975	565,164	637,263	789,283	782,629
Value.....thousands	$9,418	$21,802	$11,155	$12,106	$14.655	$13,320
Imports[2].....short tons	291.659	460,353	348,144	371,687	265,645	195,836
Consumption.....do	731,298	840,719	731,424	917,747	868,080	929,147
Titanium slag: Consumption.....do	99,195	116,465	117,581	143,329	120,492	130,184
Rutile concentrate:						
Mine shipments.....do	8,380	10,644	1,863	8,648	9,433	7,664
Value.....thousands	$1,032	$1,544	$210	$877	$879	$778
Imports.....short tons	[3] 23,778	84,837	36,563	23,228	29,235	27,497
Consumption.....do	26,953	53,393	21,677	23,741	24,229	29,548
Sponge metal:						
Production.....do	6,136	17,249	4,585	3,898	5,311	6,727
Imports for consumption.....do	569	3,532	2,073	1,563	2,231	2,490
Consumption.....do	[4] 5,805	8,221	4,147	3,953	5,487	6,991
Price: Grade A-1, Dec. 31 per pound	$3.91	$2.25	$1.82	$1.60	$1.60	$1.60
World production:						
Ilmenite concentrate.....short tons	1,302,600	1,972,200	1,710,300	1,936,900	2,204,800	2,313,300
Rutile concentrate.....do	71,100	156,200	103,200	106,400	114,200	128,300
Sponge metal.....do	7,828	22,300	7,700	7,900	9,200	9,800

[1] Includes a mixed product containing rutile, leucoxene and altered ilmenite.
[2] Includes titanium slag.
[3] Includes 109 tons rutile content of zirconium ore as reported to the Bureau of Mines by importers.
[4] 1954–56 only. Data for previous years not available.

DOMESTIC PRODUCTION

Concentrates.—Production of 782,000 tons of ilmenite was slightly less than the 1960 output. Mine production of rutile increased 3 percent, but shipments declined 19 percent.

Output of ilmenite was reported by the following companies: American Cyanamid Co., Piney River, Va.; E. I. du Pont de Nemours & Co., Inc., Starke and Lawtey, Fla.; Metal & Thermit Corp., Beaver

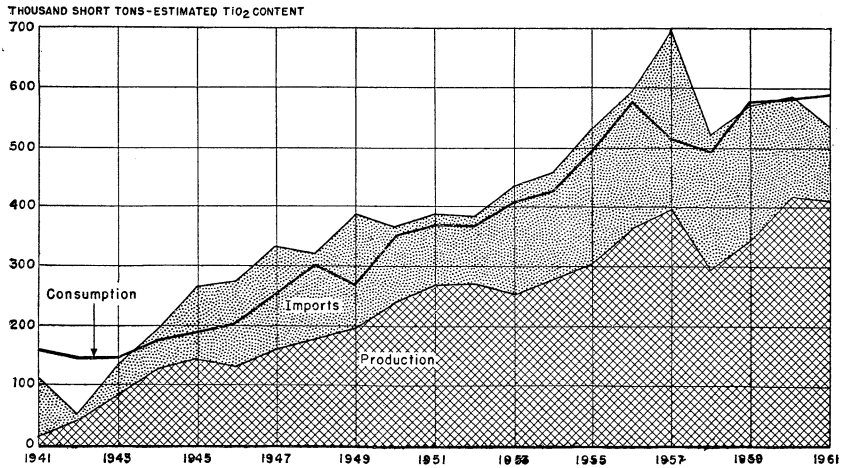


FIGURE 1.—Domestic production, imports, and consumption of ilmenite (includes titanium slags and mixed product), 1941–61.

Dam, Va.; National Lead Co., Tahawus, N.Y.; Titanium Alloy Manufacturing Division, National Lead Co., Skinner, Fla.; and The Florida Minerals Co., Vero, Fla. The J.R. Simplot Co. and Porter Brothers Corp. shipped 1,900 tons of ilmenite from stockpiles at Boise and Lowman, Idaho.

Rutile producers were as follows: Metal & Thermit Corp., Beaver Dam, Va.; Titanium Alloy Manufacturing Division, National Lead Co., Skinner, Fla.; and The Florida Minerals Co., Vero, Fla.

The Glidden Co. was expected to begin production of ilmenite from its mine at Lakehurst, N.J., early in 1962. The mine and concentrating plant were described in a report which is discussed in the technology section of this chapter.

Metal.—Production of titanium sponge metal was 6,700 tons compared with 5,300 tons in 1960. Consumption of titanium sponge and ingot increased 27 and 11 percent, respectively.

Commercial producers of titanium sponge were as follows: E. I. du Pont de Nemours & Co., Inc., Newport, Del.; Reactive Metals, Inc., Ashtabula, Ohio; and Titanium Metals Corp. of America (TMCA), Henderson, Nev. Du Pont and TMCA used magnesium to reduce titanium tetrachloride to titanium metal; Reactive Metals used sodium.

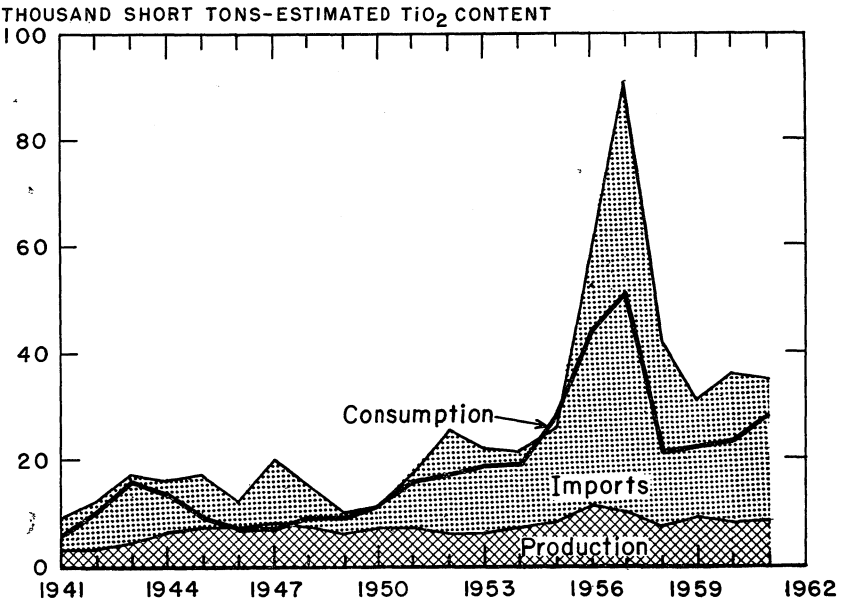


FIGURE 2.—Domestic production, imports, and consumption (excluding consumption (1961) for making TiO_2 pigments) of rutile, 1941–61.

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]				
1952–56 (average)	571,599	575,033	295,765	$9,418
1957	757,180	782,975	407,167	21,802
1958	563,338	565,164	297,021	11,155
1959	634,886	637,263	342,746	12,106
1960	786,372	789,283	417,202	14,655
1961	782,412	782,629	410,254	13,320
Rutile				
1952–56 (average)	8,374	8,380	7,849	1,032
1957	10,702	10,644	10,025	1,544
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

[1] Includes a mixed product containing rutile, leucoxene and altered ilmenite.

Titanium melters were: Harvey Aluminum, Inc., Torrance, Calif.; Reactive Metals, Inc., Niles, Ohio; Oregon Metallurgical Corp., Albany, Oreg.; Crucible Steel Co. 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 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.

TABLE 3.—Titanium-metal data

(Short tons)

	1957	1958	1959	1960	1961
Sponge metal:					
Production	17,249	4,585	3,898	5,311	6,727
Imports for consumption	3,532	2,073	1,563	2,231	2,490
Industry stocks	2,800	1,000	1,100	1,100	1,200
Government stocks (DPA inventories)	19,821	22,463	22,474	22,474	22,461
Consumption	8,221	4,147	3,953	5,487	6,991
Scrap-metal consumption	1,743	1,336	1,690	2,027	2,501
Ingot: [1]					
Production	10,009	5,408	6,017	8,297	9,371
Consumption	10,428	4,971	5,964	7,978	8,878
Mill shape production	5,658	2,594	3,211	[2] 5,071	5,621

[1] Includes alloy constituents.
[2] Revised figure.

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.

TMCA began construction of a $2 million tube mill at its Toronto, Ohio, titanium rolling plant. The tubing facilities, which will pro-

duce seamless and welded tubing in diameters up to 3 inches and in lengths up to 30 feet, were expected to be on stream by early 1962.[2] Reactive Metals also was expanding its titanium mill products line by adding a tubing mill to its Niles, Ohio, plant.[3] Harvey Aluminum planned to put a new bar and rod rolling mill in operation at its Torrance, Calif., plant.[4]

Pigments.—On a gross-weight basis, production of titanium dioxide pigments increased 6.5 percent and shipments increased 1 percent above the levels of 1960. 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.

New Jersey Zinc completed expansion of its Gloucester City, N.J., titanium dioxide plant to a reported 46,000 tons a year—about double its previous capacity.

Du Pont announced it was considering the construction of a titanium dioxide plant on the West Coast using the chloride process, which was used at the company's plant in New Johnsonville, Tenn., and Edge Moor, Del.

TABLE 4.—Titanium pigment data (TiO_2 content)

Year	Production (short tons)	Shipments [1]	
		Quantity (short tons)	Value, f.o.b. (thousands)
1952–56 (average)	379,091	369,288	$177,651
1957	456,610	399,476	213,761
1958	403,867	425,765	231,888
1959	506,334	481,930	259,944
1960	[2] 455,583	468,228	252,835
1961	502,879	[3]	[3]

[1] Includes interplant transfers.
[2] Revised figure.
[3] 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 the Business and Defense Services Administration, U.S. Department of Commerce.

Because of increasing demand for titanium dioxide several domestic companies were interested in entering into its production for the first time.[5]

Welding-Rod Coatings.—A total of 216,000 tons of welding rods containing titaniferous materials in their coatings was produced. Of the total output, 41 percent contained rutile; 19 percent, ilmenite; 17

[2] Chemical Week. Titanium. V. 88, No. 11, Mar. 18, 1961, p. 25.
[3] American Metal Market. Reactive Metals, Inc. Adds Tube Mill. V. 68, No. 37, Feb. 24, 1961, p. 14.
[4] Kuxela, Ladd. Harvey Sets Ti Bar, Rod Rolling Mill for '62. Metalworking News, v. 3, Whole No. 66, Jan. 8, 1962, p. 22.
[5] Chemical Week. Behind Titanium Dioxide Buildup. V. 90, No. 17, Apr. 28, 1962, pp. 87–88.
Chemical Age (London). Cabot TiO_2 Agreement. V. 86, No. 2210, Nov. 18, 1961, p. 819.

percent, a mixture of rutile and manufactured titanium dioxide; 14 percent, manufactured titanium dioxide; and 9 percent, slag.

CONSUMPTION AND USES

Concentrates.—Consumption of ilmenite, which is used principally for making titanium dioxide pigments, increased 7 percent to 929,000 tons. Titanium slag consumption, also used chiefly for pigment production, increased 8 percent above 1960. Increased consumption of rutile for making titanium tetrachloride for metal production more than offset a slight decrease in its use in welding rod coatings; thus, overall consumption increased.

Metal.—Titanium sponge consumption increased 27 percent over 1960 to 7,000 tons. Titanium melters used an average of 530 pounds of titanium scrap per ton of ingot produced. Consumption of titanium metal, as gaged by mill shape production, increased 11 percent to 5,600 tons. Increased use of titanium in the chemical process industries contributed significantly to total usage; however, the chief use of titanium mill products continued to be in aircraft and space vehicles.

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
1952–56 (average)	731,298	384,865	99,195	70,001	26,953	25,492
1957	840,719	434,077	116,465	82,545	53,393	50,870
1958	731,424	379,765	117,581	82,937	21,677	20,579
1959	917,747	476,660	143,329	101,106	23,741	22,462
1960:						
Pigments (mfg. TiO_2) [2]	864,794	462,623	119,308	84,257		
Titanium metal	(3)	(3)			8,073	7,685
Welding-rod coatings	658	390	968	680	13,406	12,668
Alloys and carbide	2,584	1,574	(4)	(4)	377	360
Ceramics	27	17			374	350
Fiberglass					704	686
Miscellaneous [5]	17	10	216	158	1,295	1,193
Total	868,080	464,614	120,492	85,095	24,229	22,942
1961:						
Pigments (mfg. TiO_2) [2]	[6] 926,241	495,745	129,292	91,379	(7)	(7)
Titanium metal	(3)	(3)			13,558	12,917
Welding-rod coatings	542	320	667	468	13,285	12,550
Alloys and carbide	2,302	1,410	(4)	(4)	346	333
Ceramics	59	37			366	342
Fiberglass					732	714
Miscellaneous [5]	3	2	225	164	1,261	1,160
Total	929,147	497,514	130,184	92,011	29,548	28,016

[1] Includes a mixed product containing rutile, leucoxene, and altered ilmenite used to make pigments and metal.
[2] "Pigments" include all manufactured dioxide.
[3] Included with "Pigments" to avoid disclosing individual company confidential data.
[4] Included with "Miscellaneous" to avoid disclosing individual company confidential data.
[5] Includes consumption for chemicals and experimental purposes and losses in grinding.
[6] 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.
[7] Figure withheld to avoid disclosing individual company confidential data.

The largest single installation of chemical processing equipment made of titanium in the United States was reportedly under construction in Texas.[6] Various heat exchangers, condensers, towers, and pipe reactors were expected to require 15,000 to 30,000 pounds of titanium mill products.

After extensive laboratory and in-plant testing of titanium metal in a variety of corrosive environments, a large chemical company concluded that use of the metal offered immediate benefits in reduced maintenance, down time, replacement, and other costs for chemical processors.[7] At one of the company's plants a cast titanium gate valve exposed to 17-percent hypochlorous acid solution was in excellent condition after more than 3 years' service. Made from other materials, valves in similar use had to be replaced after only 6 to 9 months' service.

Platinized titanium electrodes were used for electrolytic chlorine production in a 15-month plant-scale test conducted by Du Pont. Higher output and improved product quality were reported, as well as increased diaphragm life.[8]

Imperial Chemical Industries, Ltd. (ICI), London, England; Magneto-Chimie, N.V., Schiedam, Netherlands; Engelhard Industries, Newark, N.J.; and Amalgamated Curaçao Patents Co., Curaçao, Dutch West Indies, reportedly agreed to pool their appropriate patents to develop the use of titanium anodes coated with platinum or a similar metal. Largest potential use for the anodes is in electrolytic cells producing chlorine from brine.[9]

Other electrochemical applications of platinized titanium and discussion of possible benefits derived from its use were given in other reports.[10]

An additional use of titanium in the electrochemical industry was for baskets to contain nickel anode material in nickel-plating baths. Use of the baskets permitted the nickel anode material to be completely used. Formerly the partially spent anodes had to be replaced.[11]

Significant applications for titanium in the chemical industry included heat exchangers in chlorine production,[12] exhaust fans handling acid chloride fumes,[13] and submerged pumps handling 99.8 percent nitric acid.[14]

Trends in aeronautical applications of titanium, pertinent design criteria, available titanium products, fabrication, and estimates of future consumption were discussed.[15] The report gives the following

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[6] Chemical Processing. Titanium Catches on in CPI. V. 24, No. 10, October 1961, pp. 33–36.

[7] Pittsburgh Plate Glass Company. Chemicals. V. 4, No. 1, 1961, pp. 18–20.

[8] Chemical Age (London). Better Yield and Chlorine Product Reported with Du Pont's Platinised Ti Anodes. V. 85, No. 2179, Apr. 15, 1961, p. 624.

[9] Chemical and Engineering News. International. V. 39, No. 38, Sept. 18, 1961, p. 40.

[10] Crucible Steel Company of America. Titanium Review. V. 9, No. 2, July 1961, 8 pp.
American Metal Market. Englehard Says Platinum-Titanium Electrode Cuts Chlorine Cost. V. 68, No. 226, Nov. 27, 1961, pp. 2, 14.

[11] Metal Progress. From Here and There. V. 80, No. 1, July 1961, p. 10.
American Metal Market. Titanium Baskets Hold Spherical Nickel Anodes in New Plating Method. V. 68, No. 115, June 16, 1961, p. 14.

[12] Chemical Engineering. Titanium Exchangers Defy Chlorine. V. 68, No. 15, July 24, 1961, pp. 170, 172, 174.

[13] Steel. Other Fans Failed, Titanium Holds Up. V. 149, No. 18, Oct. 30, 1961, p. 59.

[14] Chemical Age (London). Use of Titanium in New Submerged Nitric Acid Pump Gives Longer Life Says I.C.I. V. 85, No. 2185, May 27, 1961, p. 850.

[15] Defense Metals Information Center, Battelle Memorial Institute, Columbus, Ohio. Titanium in Aerospace Applications. Memorandum 133, Oct. 24, 1961, 56 pp.

estimated distribution of titanium mill product consumption in 1960:

Application:	*Consumption, percent*
Military aircraft	65
Commercial aircraft	13
Missiles and space vehicles	17
Chemicals	3
Ordnance	2

According to the report, Ti-6Al-4V and Ti-5Al-2.5Sn dominated alloy consumption because of their extensive use in jet engine compressors, the major end-use of titanium. Two sheet alloys, Ti-8Mn and Ti-2Fe-2Cr-2Mo, were used extensively in airframes. Newer alpha alloys such as Ti-7Al-4Mo and the beta alloy Ti-13V-11Cr-3Al alloy were used less extensively, but were considered to have a large potential. Consumption of other alloys also was discussed.

Pigments.—Consumption of titanium pigments, based on gross weight and using shipments as a gage, increased 1 percent above 1960. Consumption of pigments not separately classified in table 6 included use in ceramics, roofing, siding, gems, titanium chemicals, and plastics.

TABLE 6.—Distribution of titanium-pigment shipments, by industries

(Percent)[1]

Industry	1952–56 (average)	1957	1958	1959	1960	1961
Distribution by gross weight:						
Paints, varnishes, and lacquers	66.6	64.9	65.8	64.8	65.1	63.4
Paper	9.4	10.9	11.5	11.7	11.3	12.5
Floor coverings (linoleum and felt base)	4.6	4.1	5.0	4.9	4.8	4.5
Rubber	3.2	3.6	3.9	4.2	4.0	4.1
Coated fabrics and textiles (oilcloth, shade cloth, artificial leather, etc.)	2.4	3.2	2.9	3.1	2.8	3.3
Printing ink	1.2	1.4	1.5	1.7	1.3	1.6
Other	12.6	11.9	9.4	9.6	10.7	10.6
Total	100.0	100.0	100.0	100.0	100.0	100.0
Distribution by titanium dioxide content:						
Paints, varnishes, and lacquers	58.8	57.7	59.1	58.2	58.5	57.0
Paper	13.1	14.2	15.2	15.1	14.6	15.7
Floor coverings (linoleum and felt base)	5.3	5.0	6.4	6.3	6.2	5.6
Rubber	4.2	4.6	5.1	5.4	4.9	5.1
Coated fabrics and textiles (oilcloth, shade cloth, artificial leather, etc.)	3.1	4.1	3.7	3.9	3.5	4.1
Printing ink	1.7	1.9	1.9	2.2	1.7	2.0
Other	13.8	12.5	8.6	8.9	10.6	10.5
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.

STOCKS

Industry stocks of rutile increased slightly and represented nearly 3 years' supply at the 1961 rate of consumption. Government stocks of rutile totaled 47,782 short tons of which 18,599 tons was in the National (strategic) stockpile, 17,552 tons was in Defense Production Act (DPA) inventories, 10,433 tons was in the supplemental stockpile, and 1,198 tons was in CCC inventories. Ilmenite and titanium slag stocks decreased. Yearend stocks of titanium sponge held by producers, melters, and semifabricators totaled 1,100 tons, about the same as stocks

at the end of 1960, and represented a 2 months' supply at the 1961 consumption rate. An additional 31,007 tons was held in Government stockpiles—22,461 tons in DPA inventories; 900 tons in CCC inventories and 7,646 tons in the supplemental stockpiles.

Titanium metal scrap held by melters and semifabricators decreased from 3,600 tons at the beginning of 1961 to 3,300 tons at yearend.

TABLE 7.—Stocks of titanium concentrates in the United States, December 31

(Short tons)

Year and stocks	Ilmenite		Titanium slag		Rutile [1]	
	Gross weight	TiO_2 content estimated	Gross weight	TiO_2 content estimated	Gross weight	TiO_2 content estimated
1959:						
Mine	[2] 33,515	[2] 15,537			6,444	[2] 5,851
Distributor	114	68			3,524	3,367
Consumer	679,527	355,365	155,011	109,507	66,422	63,081
Total	[2] 713,156	[2] 370,970	155,011	109,507	76,390	[2] 72,299
1960:						
Mine	30,650	[2] 14,243			5,819	[2] 5,474
Distributor	3,632	1,988			5,417	5,177
Consumer	745,202	387,679	132,621	93,706	66,545	62,946
Total	779,484	[2] 403,910	132,621	93,706	77,781	[2] 73,597
1961:						
Mine	30,954	14,379			7,200	6,776
Distributor	303	177			3,434	3,286
Consumer	675,052	351,862	130,916	92,436	68,524	64,699
Total	706,309	366,418	130,916	92,436	79,158	74,761

[1] In addition, on Dec. 31, 1961 Government stocks of rutile totaled 47,782 short tons of which 18,599 tons was in the national (strategic) stockpile; 17,552 tons was in Defense Production Act inventories; 10,433 tons was in the supplemental stockpile; and 1,198 was in CCC inventories.
[2] Revised figure.

PRICES

Concentrates.—The price quoted for ilmenite in E&MJ Metal and Mineral Markets remained unchanged in 1961 at $23 to $26 per long ton (59.5 percent TiO_2, f.o.b. Atlantic seaboard).

The price of rutile (94 percent TiO_2, f.o.b. Atlantic seaboard) quoted by E&MJ Metal and Mineral Markets also was unchanged during the year at $80 per short ton.

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 Oil, Paint and Drug Reporter at yearend:

	Price Per Pound
Anatase, chalk-resistant, regular and ceramic, carlots, delivered	$0.25½
Less than carlots, delivered	.26½
Rutile, nonchalking, bags, carlots, delivered East	.27½
Less than carlots, delivered East	.28½
Titanium pigment, calcium-rutile base, 30 percent TiO_2, bags, carlots, delivered	.09⅜
Less than carlots, delivered	.09⅞

Metal.—Prices per pound for titanium sponge metal, quoted in E&MJ Metal and Mineral Markets were unchanged during the year at $1.60 for Grade A–1, and $1.50 for Grade A–2.

Quoted prices of titanium rod declined. Prices of other mill shapes of commercially pure titanium were unchanged. Prices per pound of mill shapes (f.o.b mill, commercially pure grades, in lots of 10,000 pounds) were quoted as follows:

	Price
Sheet: Jan. 1 to Dec. 31	$7.25 to $8.00
Strip: Jan. 1 to Dec. 31	6.75 to 7.50
Plate: Jan. 1 to Dec. 31	5.25 to 6.00
Wire: Jan. 1 to Dec. 31	5.55 to 6.05
Forging billets: Jan. 1 to Dec. 31	3.20 to 3.70
Hot rolled bars:	
Jan. 1 to Sept. 1	4.00 to 4.50
Sept. 1 to Dec. 31	3.10 to 3.35

Ferrotitanium.—Nominal prices at yearend for various grades of ferrotitanium quoted in E&MJ Metal and Mineral Markets were as follows:

	Price
Low-carbon:[1]	
Titanium, 40 percent; carbon, 0.10 percent maximum	$1.35
Titanium, 25 percent; carbon, 0.10 percent maximum	1.50
Medium-carbon:[2]	
Titanium, 17 to 21 percent; carbon, 3 to 5 percent	300
High carbon:[2]	
Titanium, 15 to 19 percent; carbon, 6 to 8 percent	250

[1] Price per pound in 1-ton lots or more, lump (½ inch, plus), packed; f.o.b. destination Northeastern United States.
[2] Price per short ton, carload lots, lump, packed; f.o.b. destination Northeastern United States.

FOREIGN TRADE[16]

Imports.—Imports of ilmenite and titanium slag dropped 26 percent to 196,000 short tons. Slag containing 70 percent titanium dioxide was imported from Canada. Rutile imports decreased 6 percent to 27,000 tons; Australia, as in past years, was the chief source.

Imports of titanium sponge metal were 2,490 tons. Titanium included 1,765 tons of metal imported from Japan under the CCC barter agreements. About 60 tons of metal was imported from Canada and classified free under certain public laws (scrap). About 44 tons also was imported from the United Kingdom under this category. The remainder was from Japan and was dutiable.

Imports classified by the Bureau of the Census as "Titanium Potassium Oxylate and All Compounds and Mixtures Containing Titanium," which are virtually all titanium dioxide pigments, were 9,022 tons in 1961, compared with 6,184 tons in 1960. Most of the material under this classification came from Japan, France, West Germany, the United Kingdom, and Italy.

Exports.—Titanium dioxide and pigment exports declined for the fifth straight year. Canada, as in past years, was the destination of most of the pigments, accounting for 15,987 tons. Other countries that received 1,000 tons or more were as follows: Philippines, 2,200;

[16] 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 titanium concentrates,[1] by countries

Country	1952–56 (average)	1957	1958	1959	1960	1961
Ilmenite:						
Australia, short tons	50		22,736	47,317	33,089	35,362
Canada [2], do	129,705	217,762	112,874	157,296	104,243	115,808
India, do	156,123	240,279	212,479	167,074	128,313	44,666
Malaya, Federation of, do	5,773	2,279				
Other countries, do	8	33	55			
Total, do	291,659	460,353	348,144	371,687	265,645	195,836
Value	[3]$5,832,780	[3]$10,316,853	$6,766,391	$7,991,208	$5,066,502	$4,603,689
Rutile:						
Australia, short tons	23,766	84,743	36,507	22,954	27,847	26,047
Union of South Africa, do				274	1,358	1,450
Other countries, do	12	94	56		30	
Total, do	[4] 23,778	84,837	36,563	23,228	29,235	27,497
Value	$2,795,148	$11,843,295	$4,512,937	$2,943,258	$3,610,616	$2,544,312

[1] Classified as "ore" by Bureau of the Census.
[2] Chiefly titanium slag averaging about 70 percent TiO_2.
[3] Data known to be not comparable with other years.
[4] Includes 109 tons rutile content of zirconium ore as reported to Bureau of Mines by importers.

Source: Bureau of the Census.

Italy, 1,700; Japan, 1,600; France, 1,500; and the Netherlands, 1,100.

Exports of 1,436 tons of titanium ores and concentrates included 800 tons to Canada, 220 tons to the United Kingdom, and 200 tons to Hong Kong. Small quantities were sent to Mexico, Columbia, Chile, Uruguay, Argentina, Israel, Philippines, and Japan.

For the sixth successive year exports of titanium sponge and scrap increased significantly over the previous year. Of the 886 tons exported, 654 was sent to the United Kingdom; 138 to West Germany; 52 to France; and the remainder to Sweden, Canada, the Netherlands, Austria, Japan, Poland, Switzerland, and Spain. Exports of titanium metal products declined 10 percent to 384 tons. Most of the titanium products (345 tons) went to Canada. West Germany received 19 tons, and nearly all of the remainder went to France, Italy, and the Netherlands. Of the 212 tons of ferroalloys exported, Canada received 207 tons; Colombia, Norway, Belgium-Luxembourg, and Italy received the remainder.

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
1952–56 (average)	1,176	$162,510	167	$249,384	160	$2,788,121	258	$78,164	51,675	$17,835,942
1957	2,019	276,472	71	77,629	779	9,404,232	367	130,046	52,960	19,687,188
1958	1,246	172,481	97	172,285	336	5,227,932	323	138,431	37,016	11,346,651
1959	4,656	289,507	496	543,104	499	5,161,074	321	145,621	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

[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.

Source: Bureau of the Census.

WORLD REVIEW

United States continued to be the free world's principal source and consumer of ilmenite, and the chief market for rutile. As in preceding years Australia was the leading rutile producer, accounting for 88 percent of the world total. Expansion of titanium dioxide pigment capacity was reportedly planned in France, Brazil, Argentina, and Spain. As discussed under Domestic Production several United States companies also planned expansion of TiO_2 production capacity.

TABLE 10.—World production of titanium concentrates (ilmenite and rutile) by countries [1] [2]

(Short tons)

Country [1]	1952–56 (average)	1957	1958	1959	1960	1961
Ilmenite:						
Australia (shipments)	1,193	79,694	78,342	93,606	120,097	193,312
Canada [3]	140,600	269,690	161,312	270,477	389,586	463,362
Ceylon					6,720	11,199
Finland	[4] 53,268	116,568	117,384	94,966	92,219	21,272
Gambia	[5] 406	15,297	31,851	14,553		
India	283,815	331,768	346,260	334,024	275,575	191,800
Japan (titanium slag)	4,246	8,998	3,932	3,445	1,444	1,778
Malagasy Republic (Madagascar)			1,151	659	3,008	3,640
Malaya, Federation of (exports)	60,292	102,742	83,806	81,593	132,255	119,812
Mexico	[6] 7		166			
Mozambique				11,400	784	
Norway	164,003	231,693	233,585	249,274	255,643	342,820
Portugal	666	388	506	2,113	1,002	[7] 1,100
Senegal	14,614	39,573	36,927	32,941	24,159	[7] 17,200
Spain	3,547	9,796	18,161	8,113	12,267	[7] 31,600
Thailand	[8] 386	2,039	922	550		
Union of South Africa	[4] 946	3,120	29,611	87,232	90,431	99,009
United Arab Republic (Egypt Region)	3,026	[7] 3,700	[7] 3,000	17,100	13,200	[7] 33,000
United States [9]	571,599	757,180	563,338	634,886	786,372	782,412
World total ilmenite (estimate) [1] [2]	1,302,600	1,972,200	1,710,300	1,936,900	2,204,800	2,313,300
Rutile:						
Australia	62,080	144,372	93,327	91,734	99,266	113,344
Brazil	130	270	269	231	238	[7] 220
Cameroun	132	44				
India	234	530	503	429	1,082	898
Norway	18	22				
Senegal	136	243	1,157			[7] 220
Union of South Africa		32	552	3,381	3,695	3,483
United Arab Republic (Egypt Region)				1,157	[7] 1,100	[7] 1,100
United States	8,374	10,702	7,406	9,466	8,808	9,045
World total rutile (estimate) [1] [2]	71,100	156,200	103,200	106,400	114,200	128,300

[1] In addition to the countries listed, titanium concentrates are produced in U.S.S.R., and Brazil produces ilmenite, 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] Chiefly titanium slag containing approximately 70 percent TiO_2.
[4] Average annual production 1953–56.
[5] Average annual production 1954–56.
[6] Average annual production 1955–56.
[7] Estimate.
[8] One year only, as 1956 was the first year of commercial production.
[9] Includes a mixed product containing ilmenite, leucoxene, and rutile.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

NORTH AMERICA

Canada.—According to the Department of Mines and Technical Surveys [17] commercial production and fabrication of titanium mill products and forgings from imported ingots and billets were carried out by the following Canadian companies: Canadair Ltd., Montreal, Quebec; Atlas Titanium Ltd., Welland, Ontario; Thompson Products Ltd., St. Catharines, Ontario; and Canadian Steel Improvement Ltd., Toronto, Ontario. In 1960 Atlas Titanium Ltd., reportedly began installation of a reactive metals research laboratory, and a vacuum-consumable-arc furnace that would melt ingots up to 30 inches in diameter by 96 inches long. Much of the Atlas Titanium production was material converted for U.S. companies. Macro Division of Kennametal, Inc., Port Coquitlam, British Columbia, made tungsten-titanium carbide and titanium-carbide powder for use in cemented-carbide alloys.

TABLE 11.—Quebec Iron & Titanium Corp. smelting operations

(Short tons)

	1952–56 (average)	1957	1958	1959	1960	1961
Ore smelted	311,047	627,255	420,932	626,310	967,373	1,155,977
Titanium slag produced	137,669	258,920	161,312	243,700	386,639	463,361
Estimated TiO_2 content	98,328	186,422	116,150	175,464	278,380	333,620
Value of slag produced	$4,233,419	$9,740,570	$6,575,077	$8,509,149	$14,257,292	(1)
Desulfurized iron produced	102,209	187,529	117,878	163,509	248,578	310,360

[1] Data not available.

Operating all eight of its furnaces at Sorel, Quebec, Quebec Iron & Titanium Corp., (QIT) produced a record of 463,400 short tons of titanium slag—20 percent above 1960 output. Technical improvements and the installation of a 50,000-kva transformer to be completed in 1962, were expected to raise annual total slag capacity to 511,000 tons.[18]

SOUTH AMERICA

Argentina.—Titanit Compañía Industrial de Pigmentos y Afines was constructing new facilities at a plant near Buenos Aires to increase titanium dioxide capacity to 15,000 tons a year by 1966.[19]

Technical assistance in developing the plant was reportedly obtained by a royalty agreement from Laporte Titanium Ltd., of England.

Brazil.—Two United States companies, National Lead and Du Pont, announced plans to participate in construction of titanium dioxide pigment plants. National Lead and Companhia Brasileira de Productos Quimicas Copebras planned to build a US$8 to $10 million plant near Cubatão, São Paulo, and Du Pont do Brasil, S.A.,

[17] Schneider, V. B. Titanium, 1960, Review 24. Canada. Dept. of Mines and Tech. Surveys, April 1961, 10 pp.
[18] Kennecott Copper Corporation. Ann. Rept., 1961, pp. 13, 14.
[19] Chemical Age (London). Laporte Know-How for Argentine Titanium Oxide Producers. V. 86, No. 2190, July 1, 1961, p. 11.
Chemical & Engineering News. V. 39, No. 29, July 17, 1961, p. 39.

and Industrias Quimicas S.A. were investigating possible sites in São Paulo and Bahia.[20]

Titanium dioxide had been manufactured in São Paulo since 1952 by Companhia Quimicas Industrial S.A. For some years output of this company was limited to a few hundred tons annually; however, production increased substantially in 1960 to 1,100 tons and was expected to increase again in 1961.

EUROPE

Finland.—The new 16,000-ton-a-year titanium dioxide plant at Mantylouoto started production early in 1961. Ilmenite from the Otanmäki mine and sulfur pyrites from the Harjavalta Works were used in the plant.[21]

France.—Société Les Produits du Titane, which had expanded its titanium oxide productive facilities from 15,000 to 18,000 tons annually, planned to increase capacity further to 36,000 tons. Output of titanium oxide by Les Produits du Titane and its parent company, Fabriques de Produits Chimiques de Thann et de Mulhouse, the only producers, increased from 21,000 tons in 1959 to 30,000 tons in 1960.[22]

Norway.—National Lead Co. (U.S.A.) announced that an engineering investigation to develop a smelting process to produce titanium slag from the ilmenite mined by its subsidiary, Titania, A/S, at Tellnes, Rogaland County, would be undertaken in cooperation with Quebec Iron & Titanium Corp. (QIT) (Canada). Norwegian ilmenite was shipped directly to European titanium pigment producers.[23]

Spain.—Nevin S.A. reportedly was constructing a plant to produce titanium dioxide at its lithopone works in the Free Port of Barcelona.[24]

Spanish production of titanium dioxide had more than doubled since 1957. Production of titanium dioxide and other pigments is given in table 12.

TABLE 12.—Spain: Production of titanium and other pigments

(Short tons)

	1957	1958	1959	1960
Titanium dioxide	2,460	2,880	4,080	5,850
Lithopone	9,780	10,032	9,168	9,534
Red lead	2,448	3,168	1,632	2,737
White lead	62	70	134	70

SOURCE: Sulphur Institute News, Titanium Dioxide. V. I, No. 10, November 1961, p. 5.

United Kingdom.—Production of titanium sponge metal by Imperial Chemical Industries, Ltd., at Wilton, North Yorkshire, the only producer, was estimated at 600 short tons.

[20] Foreign Commerce Weekly. Brazil. V. 66, No. 16, Sept. 18, 1961, p. 24.
U.S. Consulate General, São Paulo, Brazil. State Department Dispatch 125, Oct. 13, 1961.
[21] Mining Journal (London). V. 256, No. 6561, May 19, 1961, p. 577.
[22] Bureau of Mines, Mineral Trade Notes. V. 53, No. 6, December 1961, p. 50.
[23] Mining Engineering. National Lead to Study Titanium Smelting. V. 14, No. 1, January 1962, p. 21.
[24] Chemical Trade Journal and Chemical Engineer (London). Spanish Titanium Oxide. V. 149, No. 3874, Sept. 1, 1961, p. 480.

ASIA

India.—The 50-year history of the beach sand industry in South India was described.[25] Development of the beaches, which contain ilmenite, rutile, sillimanite, and monazite, was traced from the discovery in 1909 to 1960. The technical problems involved and their solution, as well as a discussion of the companies involved, and the Government's role in developing the beaches were given.

Japan.—Output of titanium slag, which is used chiefly in making titanium tetrachloride for metal production, increased 23 percent to 1,778 tons. Hokuetsu Electric Chemical Industries Co. produced 76 percent of the total and Nisso Steel Manufacturing Co., Ltd., produced the remainder.

Titanium sponge metal production was virtually the same as in 1960 (2,516 short tons). Osaka Titanium Co., Ltd., was the principal producer, accounting for 1,417 tons. Toho Titanium Industry Co., Ltd., produced the remainder. Part of the output by Osaka and Toho was exported to the United States under CCC barter agreement.

TABLE 13.—Japan: Titanium metal and titanium dioxide data

(Short tons)

	1957	1958	1959	1960	1961
Titanium metal:					
Production	3,393	1,812	2,730	2,543	2,516
Exports	2,734	1,962	1,982	2,130	1,728
Stocks, Dec. 31	940	677	1,148	1,100	1,289
Titanium dioxide:					
Production	36,811	33,285	39,192	54,446	54,210
Exports	16,590	15,223	15,587	21,160	17,353
Stocks, Dec. 31	2,490	2,754	1,077	2,295	2,113

Titanium dioxide production was at a near record level despite a strike of several months at the main plant of Ishihara Sangyo Kaisha, Ltd., at Yokkaichi, Mie Prefecture. Ishihara was the largest producer of TiO_2. Exports of titanium dioxide, which normally accounted for about half the output, were down 18 percent and accounted for only 32 percent of the total output.

AFRICA

Union of South Africa.—Mining and processing at Umgababa Minerals, Ltd., ilmenite mine at Umgababa on the Natal coast was described in detail.[26] The ore was mined hydraulically from a large dune formation and concentrated in Humphrey spirals after desliming in a special cyclone. The heavy minerals in the rough concentrate were separated in high tension and magnetic separators. Minerals of economic importance in the deposit are ilmenite, rutile, magnetite, monazite, and zircon.

[25] Viswanathan, P. The Beach Sands Industry in South India: A Fifty Year Review. Science and Culture, Calcutta. V. 27, No. 1, January 1961, pp. 16–21.

[26] Langton, G., E. J., Jackson. Recovery of Ilmenite, Rutile and Zircon at Umgababa. Paper presented at the Seventh Commonwealth Min. and Met. Cong., Johannesburg, South Africa, Apr. 10 to May 7, 1961.

TABLE 14.—Union of South Africa: Exports of ilmenite concentrate by countries

(Short tons)

Destination	1957	1958	1959	1960	1961 [1]
Belgium	112		22		45
France	692			5	
Germany, West	241		2,483	1,120	2,465
Italy	729		7,633	23,735	22,372
Japan	362	612	224	1,846	1,064
Netherlands		102		27	
Norway			33	140	44
United Kingdom	826	16,916	43,353	84,514	41,460
United States			10,641		
Total	2,962	17,630	64,389	111,387	67,450

[1] January through September, inclusive.

Compiled from Quarterly Information Circular of Minerals for the Union of South Africa and the Territory of Southwest Africa, by Corra A. Barry, Division of Foreign Activities.

TABLE 15.—Union of South Africa: Exports of rutile concentrate by countries

(Short tons)

Destination	1958	1959	1960	1961 [1]
Austria		23	23	
Belgium		2	113	90
Finland		22	90	
France		112	342	112
Germany, West	6	280	466	
Italy			105	
Netherlands		74	224	224
Switzerland			11	
United Kingdom	56	589	1,342	403
United States	112	476	1,414	1,136
Total	174	1,578	4,130	1,965

[1] January through September, inclusive.

Compiled from Quarterly Information Circular of Minerals for the Union of South Africa and the Territory of Southwest Africa, by Corra A. Barry, Division of Foreign Activities.

OCEANIA

Australia.—An engineering and construction contract for the 10,000-ton-a-year titanium dioxide pigment plant at Bunbury, Western Australia, planned by Laporte Titanium, Ltd., was awarded to the Bechtel Organization (Bechtel Pacific Corp., Ltd., Melbourne, and Bechtel International Ltd., London).[27]

A reported 3-year contract beginning in 1962 between Australian producers and Du Pont (U.S.A.) for delivery of 30,000 tons of rutile to the United States was expected to result in an increase in Australian output over the next few years.

TECHNOLOGY

Technological progress in fabricating titanium metal was dramatically illustrated by announcements that the spacecraft used in the two American-manned orbital flights during the year were made largely of titanium. The basic structure of the spacecraft consisted of an inner skin of two layers of titanium welded to a titanium frame.

[27] Chemistry and Industry (London). Australian Contract Awarded to Bechtel. No. 41, Oct. 14, 1961, p. 1673.

TABLE 16.—Australia: Exports of ilmenite concentrate by countries

(Short tons)

Destination	1957	1958	1959	1960	1961 [1]
Belgium-Luxembourg	802	3,228	3		
France	340	5,730	6,274	2,011	
Japan	30,775	10,848	9,969	25,500	
Netherlands	90	3,395	34	698	[2]
United Kingdom	10,341	13,693	354	35,159	
United States		22,738	60,108	20,377	
Other countries		3,360	145	612	
Total	42,348	62,992	76,887	84,357	[1] 55,162

[1] January through June, inclusive.
[2] Countries of destination not available for 1961.

Compiled from Customs Returns of Australia by Corra A. Barry, Division of Foreign Activities.

TABLE 17.—Australia: Exports of rutile concentrate by countries [1]

(Short tons)

Destination	1957	1958	1959	1960	1961 [2]
Belgium	4,114	2,532	1,390	1,314	[3]
France	4,620	5,459	7,482	9,675	[3]
Germany, West	5,964	4,114	10,037	10,546	[3]
Italy	3,644	3,293	3,519	4,536	[3]
Japan	4,232	2,920	7,967	9,042	[3]
Netherlands	11,056	10,579	12,243	11,091	7,237
Sweden	3,938	3,687	2,824	3,771	[3]
United Kingdom	12,345	13,026	9,690	14,243	7,516
United States	79,086	29,365	25,241	29,360	14,306
Other countries	4,339	9,714	10,258	11,372	25,852
Total	133,338	84,689	90,651	104,950	54,911

[1] This table incorporates some revisions.
[2] January through June, inclusive.
[3] Data not separately recorded.

Compiled from Customs Returns of Australia by Corra A. Barry, Division of Foreign Activities.

Successful performance of the craft attested to the reliability of some 3,700 feet of titanium welds in each of the structures.[28]

Under a cooperative agreement with the General Services Administration, the Bureau of Mines determined the processing costs in refining titanium metal in a 10,000-ampere electrolytic cell. The research showed that high purity titanium metal (less than 100 Brinell hardness) could be made for $0.60 a pound, exclusive of capital and crude titanium costs.[29]

Various methods for determining oxygen in titanium were investigated.[30] Those found suitable for oxygen determination of titanium in the range 0.02 to 1.00 percent oxygen were the dry crucible and platinum-flux vacuum fusion methods and the inert-gas fusion method. For accuracy and speed in routine analysis of titanium metal the inert-gas fusion method and a modified platinum-flux technique [31]

[28] Brooks and Perkins, Inc. Magnesium Products. Titanium and Beryllium Prove Their Reliability in the Mercury Capsules. August 1961, p. 8.
[29] Haver, F. P., and D. H. Baker, Jr. Development of a 10,000 Ampere Cell for Electrorefining Titanium. BuMines Rept. of Inv. 5805, 1961, 42 pp.
[30] Sullivan, T. A., B. J. Boyle, A. J. Mackie and R. A. Plott. Determination of Oxygen in Titanium. BuMines Rept. of Inv. 5834, 1961, 30 pp.
[31] Covington, L. C., and S. J. Bennett. New Rapid Vacuum Fusion Apparatus for Determining Oxygen in Titanium and Steel. Anal. Chem., vol. 32, No. 10, September 1960, p. 1334.

were the most promising. For determining oxygen in titanium metal, which contains less than 0.02 percent oxygen, the platinuum-flux vacuum fusion method was preferred.

The heat capacities of several titanium halides of metallurgical significance were determined and combined with other selected thermodynamic properties to obtain improved values of the heats and free energies of formation of these compounds at high temperature.[32]

The Glidden Co. ilmenite mine and concentrating plant at Lakehurst, N.J., which was expected to begin operation in 1962, was described by John V. Beall.[33] The company's placer sand deposit was reported to contain 2 million tons of heavy minerals, of which 82 percent is ilmenite, 4 percent zircon, 4 percent leucoxene, 1 percent rutile, and the remainder kyanite and sillimanite. The deposit (to be mined by bucket dragline excavator to a depth of 25 feet) averages 5 percent TiO_2. Slurry containing 35 percent solids will be pumped to the concentrating plant where the ore will be screened and deslimed in 24-inch cyclones; the heavy minerals will be rough concentrated in Cannon circle concentrators. A bank of 40 Humphrey spirals will be used to produce a final wet-plant concentrate. The heavy minerals will then be separated by electrostatic and magnetic methods into two products – a high magnetic ilmenite concentrate containing 62 percent TiO_2 and a leucoxene-rutile concentrate containing 78 percent TiO_2. When the mine begins production the company plans to operate on a 24-hour basis and employ approximately 120 persons. About 100,000 tons of the heavy minerals is expected to be handled annually.

Several patents were granted during the year on the production of titanium dioxide by the chloride process (oxidation of titanium tetrachloride in the vapor phase). According to the abstract[34] one patent describes the use of a fluidized bed to carry out the reaction. A second patent gives results of the addition of small quantities of an aromatic organic compound to the titanium tetrachloride. In this method the reaction is conducted in a tower.[35] A third patent describes methods to control the moisture content during reaction and prevent formation of hydrochloric acid.[36]

Rutile was used for making titanium tetrachloride, whereas the conventional process for making titanium dioxide (the sulfuric acid process) utilized ilmenite or titanium slag as raw material. Adaptation of the chloride process by the industry would have a significant effect on the utilization of rutile, and would probably require the development of efficient methods for chlorinating materials other than rutile, such as titanium slags or ilmenite. In 1961 the Du Pont 50,000-ton-a-year plant at New Johnsonville, Tenn., was the only plant known to utilize the chloride process on a commercial scale.

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[32] King, E. G., W. W. Weller, A. U. Christensen, and K. K. Kelly. Some Thermodynamic Values for Four Titanium Halides. BuMines Rept. of Inv. 5799, 1961, 20 pp.

[33] Beall, John V. Glidden Readies New Jersey Heavy Mineral Operation. Min. Eng., v. 14, No. 1, January 1962, pp. 38–39.

[34] Chemical Trade Journal and Chemical Engineer (London). Recent Patent Abstracts, Titanium Dioxide, Laporte Titanium, Ltd., British Pat. 866,363. V. 149, No. 3879, Oct. 6, p. 773.

[35] Wilson, William W. (assigned to Columbia-Southern Chemical Corporation, Allegheny County, Pa.). Production of Metal Oxide Pigments. U.S. Pat. 2,968,529, Jan. 17, 1961.

[36] Frey, Walter (assigned to Fabriques de Produits Chimiques de Thann et de Mulhouse, Thann, France). Vapor Phase Process for the Production of Titanium Dioxide. U.S. Pat. 2,980,509, Apr. 18, 1961.

Research by the Bureau of Mines on domestic ilmenite showed that chlorination of ilmenite containing as little as 28 percent titanium dioxide and up to 36 percent iron is technically feasible.[37]

A company in Canada reportedly was building a small-scale plant to test a new continuous process for making titanium dioxide from ilmenite.[38] This process is based on utilization of a pressure leaching apparatus described in a Canadian patent[39] and was reported to be more economical than conventional processes using ilmenite.

New developments in titanium casting technology were announced. In one method a mild steel mold that can be used to cast up to 100 parts was described.[40] In another method, developed specifically for casting small titanium parts, the center portion of a solid titanium block is melted by a tungsten arc. By adjusting the arc the metal is melted through the underside of the block and permitted to flow into a mold directly beneath.[41]

The methods used at the Oregon Metallurgical Corp., Albany, Oreg., titanium melting and casting plant were described by a company official.[42] The maximum overall dimensions of the castings made at the plant were: Length, 6 feet; width, 3 feet; and height, 2 feet; and a maximum pouring weight of 300 pounds, including gating.

Recommendations on the design of titanium melting furnaces of a joint safety practices committee, representing titanium melters, were published.[43] Arc conditions which tend to damage crucibles, and details of the possible mechanisms leading to crucible rupture and explosive reactions in titanium melting furnaces were discussed.[44]

Progress was made in developing methods to weld titanium. Crack-free welds in 2-inch-thick titanium alloy plate were reportedly accomplished.[45] Other advances made in welding titanium included the development of a weld-through method for welding flanges to extremely thin sections of titanium sheet and corrugated sections.[46] Rollwelding of titanium sandwich panels also was reported.[47]

A method for cladding steel plate with titanium was described.[48] The method consists of making a four-deck sandwich of steel-titanium-titanium-steel enclosed on the sides with welded steel strips. Hot rolling the composite joins the titanium to the steel. A compound between the titanium sheets permits separation of the composite after rolling.

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[37] Perkins, E. C., H. Dolezal, and R. S. Lang. Chlorination of an Idaho Ilmenite. BuMines Rept. of Inv. 5763, 1961, 16 pp.

[38] Chemical Age (London). Pressure Recycling System is Key to New Canadian TiO_2—From—Ilmenite Process. V. 86, No. 2196, Aug. 12, 1961, p. 226.

[39] Soladucha, Nicolas. Pressure Leaching Apparatus. Canadian Pat. 610,334, Feb. 5, 1960.

[40] Chemical Week. New Deal for Titanium. V. 88, No. 9, Mar. 4, 1961, pp. 29–30, 32.

[41] Westwood, A. R. C. Casting Small Parts of Refractory Metals. Foundry, v. 89, No. 7, July 1961, pp. 68–71.

[42] Hardy, R. G. Casting Titanium Shapes. Metal Industry (London), v. 99, No. 11, Sept. 16, 1961, pp. 202–206.

[43] Light Metal Age. Recommendations for Design of Titanium Melting Furnaces. V. 19, Nos. 9 and 10, October 1961, pp. 5–6.

[44] Wood, F. W., and R. R. Lowery. Discharge Behavior in Vacuum Arc Melting. BuMines Rept. of Inv. 5749, 1961, 32 pp.

[45] Light Metal Age. Welding Thick Light Metal Plate. V. 19, Nos. 9 and 10, pp. 7–8.

[46] Steel. How Planemakers Weld Thin. V. 148, No. 21, May 22, 1961, pp. 116–117.

[47] American Metal Market. Sandwich Panels Roll Welded From Titanium and Moly. V. 68, No. 67, Apr. 10, 1961, p. 16.

[48] Lobrin, C. L. Argon Flush: Key to Fabrication of Titanium-Clad Steel. Iron Age, v. 187, No. 17, Apr. 27, 1961, pp. 110–111.
Hughson, Roy V. New Process For Ti-Clad Steel Plate. Chem. Eng. v. 68, No. 10, May 15, 1961, pp. 194, 196, 198.

659873—62——80

Tungsten

By Andrew S. Prokopovitsh [1] and Mary J. Burke [2]

DOMESTIC production of tungsten concentrate rose to 8.2 million pounds of contained tungsten, which was greater than any of the 4 preceding years. Imports declined to the lowest level in 20 years.

Foreign production also rose for the fourth successive year, though a persistent world trend in declining tungsten prices restrained marketing activity in the later half of 1961.

LEGISLATION AND GOVERNMENT PROGRAMS

General Services Administration announced on January 17, 1961, that it was soliciting proposals for the upgrading of Government-owned tungsten concentrate into higher use forms. Proposals were to be received not later than March 10, 1961. Approximately 800,000 pounds of tungsten concentrates were involved in the original announcement.

According to the Office of Barter and Stockpiling of the Foreign Agricultural Service of the U.S. Department of Agriculture, a commodity exchange contract was executed in April 1961, covering the acquisition of approximately 1.1 million pounds of tungsten carbide powder, which was processed from tungsten originating in the Republic of Korea. The material delivered under this transaction was to be transferred to the supplemental stockpile as authorized by the Agricultural Trade Development and Assistance Act of 1954 (P.L. 480).

TABLE 1.—Salient tungsten statistics

(Thousand pounds of contained tungsten)

	1952-56 (average)	1957	1958	1959	1960	1961
United States:						
Mine production	12,050	8,032	(1)	(1)	6,669	8,188
Mine shipments	11,810	5,254	3,605	3,473	6,972	7,847
Imports, general	22,363	14,186	6,873	6,248	5,178	2,744
Imports for consumption	22,245	14,018	6,542	5,435	3,525	2,123
Consumption	7,687	8,544	5,320	9,835	11,605	11,128
Stocks:						
Producer	587	4,326	(1)	(1)	2,402	2,667
Consumer and dealer	3,509	4,103	4,670	3,196	3,143	3,212
World: Production	75,567	[2] 64,241	[2] 53,392	[2] 54,438	[2] 66,049	70,618

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

[1] Commodity specialist, Divisions of Minerals.
[2] Statistical assistant, Division of Minerals.

DOMESTIC PRODUCTION

U.S. mine production of tungsten increased 23 percent in 1961. Tungsten concentrate was produced by 17 operators in 7 States—California, Colorado, Idaho, Montana, Nevada, North Carolina, and Washington. The Pine Creek mine of Union Carbide Nuclear Co., near Bishop, Calif., the Hamme mine of Tungsten Mining Corp., in Vance County, N.C., the Climax mine of American Metal Climax, Inc., near Leadville, Colo., and Calvert mine of Minerals Engineering Co., in Beaverhead County, Mont., supplied most of the tungsten output.

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
1952-56 (average)	12,408	744,522	11,810	$45,678	$61.35	$3.87
1957	5,520	331,208	5,254	[3] 8,186	24.72	1.56
1958	3,788	227,255	3,605	3,991	17.56	1.11
1959	3,649	218,927	3,473	4,502	20.56	1.30
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

[1] Values apply to finished concentrate and are in some instances f.o.b. custom mill.
[2] A short-ton unit equals 20 pounds of tungsten trioxide (WO_3) and contains 15.862 pounds of tungsten (W).
[3] Estimate.

CONSUMPTION AND USES

Consumption of tungsten concentrate decreased 4 percent in 1961. In the major use categories, consumption of tungsten in pure-metal uses increased 12 percent; consumption in high-speed and other alloy steels decreased 4 percent, and consumption in high-temperature and other nonferrous alloys decreased 3 percent.

Carbides accounted for 40 percent of total consumption, cemented carbides for 30 percent, and other carbides for 10 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.

The increasing demand for pure tungsten metal sheet, rod, and wire, particularly in the development of missiles and space vehicles, resulted in the expansion of commercial production facilities. General Electric Co., Euclid, Ohio, installed a series of large rolling mills in its new plant for the production of wide tungsten sheet by powder metallurgy methods. The new facility was to produce 24-inch wide sheet in thicknesses from ⅛ inch to ½ inch for structural uses and close-tolerance electronic sheet in widths not exceeding 12 inches. The facilities were designed to handle reasonably heavy starting ingots and to provide maximum control over rolling conditions. Consumption of tungsten

sheet for uses in components requiring high-temperature strength was expected to increase.

Linde Co. of Union Carbide Corp. opened a new flame-plating plant in North Haven, Conn., for applying tungsten and other refractory compounds to base metals.

Oregon Metallurgical Corp., Albany, Oreg., expanded its operations to accommodate large tungsten castings produced by a centrifugal process from vacuum-arc-melted tungsten.

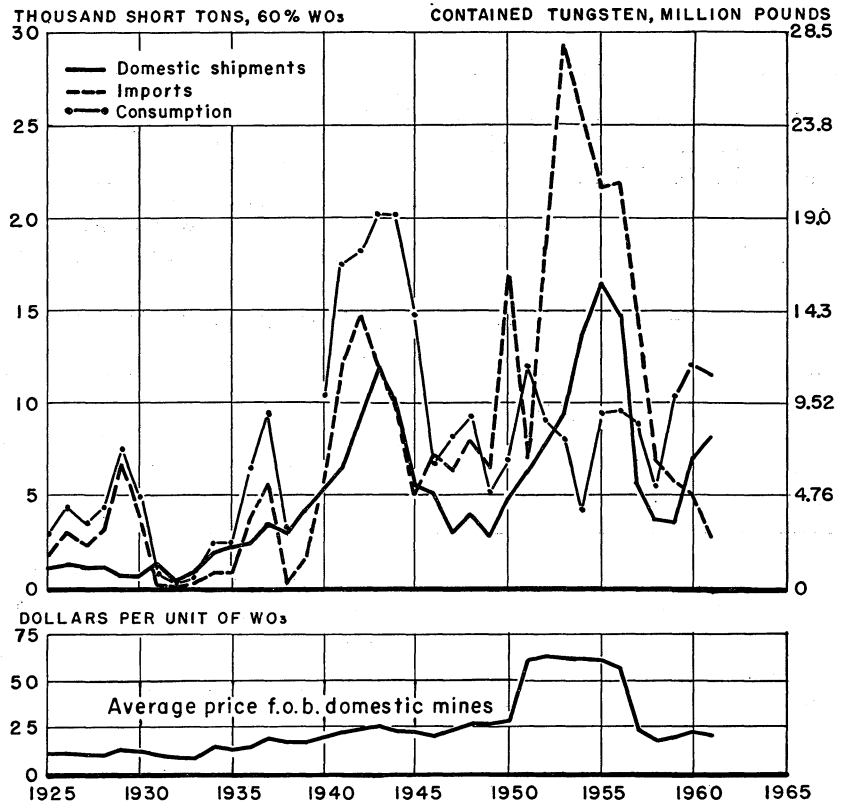


FIGURE 1.—Domestic shipments, imports, consumption, and average price of tungsten ore and concentrate, 1925–61.

TABLE 3.—Distribution of tungsten concentrate consumed

	Tungsten content (thousand pounds)		Short tons (60 percent WO_3)		Percent of total	
	1960	1961	1960	1961	1960	1961
Manufacturers of steel ingots and ferrotungsten	2,121	2,071	2,228	2,176	18	19
Manufacturers of hydrogen-reduced metal powder	5,691	4,900	5,980	5,148	49	44
Manufacturers of carbon-reduced metal powder and tungsten chemicals, and consumption by firms making several products	3,793	4,157	3,986	4,368	33	37
Total	11,605	11,128	12,194	11,692	100	100

TABLE 4.—Production, shipments, and stocks of tungsten products in the United States in 1961

(Thousand pounds of contained tungsten)

	Product				
	Hydrogen- and carbon-reduced metal powder	Tungsten carbide powder		Chemicals	Other [1]
		Made from metal powder	Crushed cast		
Received from other producers	2,424			1,385	887
Gross production during year	6,129	3,431	1,083	6,086	1,569
Used to make other products listed here	4,207			4,398	403
Net production	1,922	3,431	1,083	1,688	1,166
Shipments [2]	4,798	3,501	1,080	2,983	1,983
Producer stocks, Dec. 31	1,451	182	47	1,283	776

[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 1961

(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	502	23					805	105	1,435
Hot work and other tool	285	4					104	97	490
Alloy (other than tool) [3]	165	8	2				86	68	329
High-temperature nonferrous alloys [4]	50	14	18				181	151	414
Other nonferrous alloys [5]	18	5	119	9	247	219	3	66	686
Tungsten metal:									
Wire, rod, and sheet			1,419						1,419
Other			544	1					545
Carbides:									
Cemented or sintered			1	2,254	409			70	2,734
Other (including cast or fused)	2	45	26	12	697			83	865
Chemicals [6]						113			113
Total	1,022	99	2,129	2,276	1,353	332	1,179	640	9,030
Stocks at consumer plants Dec. 31	177	19	108	98	5	32		261	700

[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 and 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

Industry stocks at all locations are given in table 1.

Stocks of concentrate held by consumers and dealers at yearend increased 2 percent.

Tungsten materials in Government inventories on December 31, 1961, are presented in table 6.

TABLE 6.—Tungsten materials in Government inventories, as of Dec. 31, 1961

(Thousand pounds, tungsten content)

	National (strategic) stockpile [1]	DPA Inventory [2]	CCC and supplemental stockpile [3]	Total
Tungsten, all forms	103,752	53,797	3,915	161,464
Ferrotungsten [4]	(1,617)			(1,617)
Tungsten metal powder, hydrogen reduced [4]	(1,087)			(1,087)

[1] The national (strategic) stockpile describes the accumulation of materials under the Strategic and Critical Materials Stock Piling Act (Public Law 520, 79th Cong., July 1946—a revision of Public Law 117 passed by the 76th Cong. in 1939). The Office of Emergency Planning is responsible for planning, policy, and programing for the strategic stockpile. General Services Administration is the custodian of the inventory and does all the buying and selling.

[2] The Defense Production Act (DPA) inventory was accumulated under provisions of the Defense Production Act of 1950. It authorized the Government, as an incentive toward expansion of productive capacity and supply, to purchase materials for Government use or resale.

[3] Materials for the supplemental stockpile, authorized by the Agricultural Trade Development and Assistance Act of 1954 (Public Law 480, 83rd Cong.), were acquired by the Department of Agriculture in exchange for surplus agricultural commodities that deteriorate and are costly to store. The Commodity Credit Corporation (CCC) inventory was acquired by the Department of Agriculture by barter of surplus agricultural commodities under several statutes. If there is no other Government use for the materials, they are required by law to be transferred to the supplemental stockpile.

[4] Figures in parentheses are upgraded forms of preceding items and are included in the figures for tungsten.

PRICES AND SPECIFICATIONS

Prices of domestic concentrate quoted in E&MJ Metal and Mineral Markets from January to November 1961, ranged from $22 to $24 per short-ton unit of tungsten trioxide (WO_3) f.o.b. mine or mill. Thereafter, quoted prices dropped to $20 to $22 and remained at this level at yearend. In contrast, prices of foreign tungsten ore declined steadily from the quoted price in January 1961, of $18.50 to $19.00 per short-ton unit of WO_3 c.i.f. U.S. ports, duty extra, until in December when prices were at the lowest level of the year, $11.25 to $11.75, a decline of 40 percent.

Tungsten metal powder (98.8 percent in 1,000-pound lots) was quoted at $2.75 to $2.90 throughout the year in E&MJ Metal and Mineral Markets.

TABLE 7.—Prices of tungsten concentrate in 1961

	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	$18.50–$19.00	$18.50–$19.00	148s.–153s.
Feb. 2	17.75–18.25	17.75–18.25	140s.–145s.
Mar. 2	16.25–16.75	16.25–16.75	126s.–131s.
Apr. 6	15.50–15.75	15.50–15.75	120s.–125s.
May 4	15.50–15.75	15.50–15.75	119s.–124s.
June 1	15.50–15.75	15.50–15.75	119s.–124s.
July 6	16 –16.50	16 –16.50	128 ½s.–132 ½s.
Aug. 3	16 –16.50	16 –16.50	128 ½s.–132 ½s.
Sept. 7	16 –16.50	16 –16.50	126s.–130s.
Oct. 5	15.75–16.25	15.75–16.25	120s.–125s.
Nov. 2	14.50–15.00	14.50–15.00	117s.–119s.
Dec. 7	11.25–11.75	11.25–11.75	89s.–92s.
Average price	15.93	15.93	
Duty	7.93	7.93	
Average price duty paid	23.86	23.86	

Source: E & MJ Metal and Mineral Markets.

The price of hydrogen-reduced tungsten-metal powder (99.99 percent) ranged from $2.70 to $3.90.

Ferrotungsten prices in January remained at the 1960 quotation of $2.15 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 W). By June the price had risen to $2.25, and at yearend a price of $2.45 was quoted.

FOREIGN TRADE [3]

Imports.—General imports of tungsten concentrate decreased 47 percent, continuing a trend in declining imports that began in 1957; 88 percent of the total imports came from the Republic of Korea, Bolivia, Australia, Portugal, and Burma, in order of importance, and 12 percent from eight other countries. Imports for consumption of tungsten concentrate decreased 40 percent and were the smallest in 20 years. Imports of tungsten metal, tungsten carbide, and combinations con-

TABLE 8.—U.S. imports for consumption of tungsten ore and concentrate, by countries

(Thousand pounds and thousand dollars)

Country	1960			1961		
	Gross weight	Tungsten content	Value	Gross weight	Tungsten content	Value
North America: Mexico	2	1	$1			
South America:						
Argentina	276	142	158			
Bolivia	801	451	314	502	203	$133
Brazil	936	560	618			
Peru	115	66	82	97	29	17
Total	2,128	1,219	1,172	599	232	150
Europe:						
Netherlands	48	28	30	55	33	35
Portugal	1,713	1,017	1,146	822	468	442
Spain	13	8	5	66	39	42
United Kingdom	22	13	15			
Total	1,796	1,066	1,196	943	540	519
Asia:						
Burma	228	128	123			
Hong Kong	101	57	52			
Korea, Republic of	396	225	116	1,455	805	760
Malaya, Federation of				19	11	16
Total	725	410	291	1,474	816	776
Africa:						
British East Africa				112	58	54
Congo, Republic of the, and Ruanda-Urundi [1]	201	113	88	109	62	63
Total	201	113	88	221	120	117
Oceania: Australia	1,245	716	730	722	415	421
Grand total	6,097	3,525	3,478	[2] 3,959	[2] 2,123	[2] 1,983

[1] Effective July 1, 1960; formerly Belgian Congo.
[2] Adjusted by Bureau of Mines to exclude West Germany.

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.

taining tungsten or tungsten carbide in lumps, grains, or powder, contained 55,613 pounds of tungsten valued at $139,370.

Imports of tungstic acid and other tungsten compounds not specifically provided for contained 388,882 pounds valued at $373,503. Imports of tungsten or tungsten carbide scrap were 128,130 pounds, gross weight, valued at $147,449. Imports of ore and concentrate free for U.S. Government were 1,009,136 pounds tungsten content, valued at $962,746 and came from—Spain 27,455 pounds, the Republic of Korea 749,116 pounds, and Australia 232,565 pounds.

TABLE 9.—U.S. imports for consumption of ferrotungsten, by countries

(Thousand pounds and thousand dollars)

Country	1960			1961		
	Gross weight	Tungsten content	Value	Gross weight	Tungsten content	Value
Austria	163	120	$150	325	257	$315
Belgium-Luxembourg				24	19	22
France				12	10	13
Germany, West	11	7	8	24	19	27
Portugal				6	5	5
Sweden	39	31	39			
United Kingdom	11	9	10	37	30	40
Total	224	167	207	428	340	422

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.		Total	
	Gross weight (pounds)	Value	Gross weight (pounds)	Value	Gross weight (pounds)	Value
1952–56 (average)	264,435	$525,101	54,272	[1] $184,010	318,707	[1] $709,111
1957	66,717	[1] 130,139	190,413	[1] 483,195	257,130	[1] 613,334
1958	53,299	57,543	196,190	348,179	249,489	405,722
1959	258,051	199,464	193,061	367,324	451,112	566,788
1960	[2] 170,383	[2] 207,217	174,877	528,035	[2] 345,260	[2] 735,252
1961	131,117	164,460	93,199	551,473	224,316	715,933

[1] Data known to be not comparable with other years.
[2] Revised figure.

Source: Bureau of the Census.

Exports.—Exports and reexports of tungsten concentrate were 414,734 and 1,377,568 pounds, gross weight, respectively, valued at $249,542 and $791,138. Exports of ferrotungsten were 800 pounds, gross weight, valued at $1,569—shipped to Canada.

Exports of tungsten metal powder totaled 112,831 pounds, gross weight, valued at $661,505. Exports of tungsten metal and alloys in crude form and scrap were 221,979 pounds, gross weight, valued at $213,490; reexports were 1,500 pounds, gross weight, valued at $5,175.

Exports of semifabricated forms were 31,129 pounds, gross weight, valued at $1,086,659.

WORLD REVIEW

The declining price of tungsten ore and concentrate in the world market overshadowed most other developments during 1961. Although significant production increases were achieved by Australia, Austria, Bolivia, the Republic of Korea, Ruanda-Urundi, and the United States, which resulted in a 7 percent rise in world output of tungsten, the persistent downward trend in world tungsten prices restrained marketing activity in the later half of 1961.

China was again the leading producer of tungsten, followed by the U.S.S.R., the United States, the Republic of Korea, North Korea, Portugal, and Bolivia. China and the U.S.S.R. attempted to acquire a larger share of the world tungsten market during the year, and, as a result, competition was intense and a number of producers that depended on an export market were forced to curtail operations, or close their mines. Surplus stocks of tungsten held in industrial and governmental inventories were not without effect. At yearend, the world tungsten market was depressed, prices were at the lowest level of the year, and offerings of ore on the open market were meager. Despite these conditions, the traditional reliance on long-term contracts and established sources of supply for the bulk of world tungsten requirements had prevailed. In addition, research and development programs were being conducted vigorously in several countries for new applications and markets for tungsten.

NORTH AMERICA

Canada.—Tungsten production in the Northwest Territories was expected to begin late in 1962. Canada had produced no tungsten since July 1958, when Canadian Exploration Limited closed its tungsten operations at Salmo, British Columbia. Three companies, American Metal Climax, Inc., Dome Mines Limited, and Ventures Limited, arranged to finance the new deposit just east of the Yukon-Northwest Territories boundary and 135 miles north of Watson Lake. The Department of Northern Affairs and National Resources was building an 80-mile development road and a 50-mile access road to the mine site. The geology of the tungsten deposits was described.[4]

Nicaragua.—Presidential Decree No. 60 of September 21, 1961, authorizes the National Development Institute to explore and exploit for a period of 10 years the deposits of tungsten which exist in the Department of Nueva Segovia. The mineral area was declared national reserves at least until 1962.

SOUTH AMERICA

Argentina.—Free trade in tungsten minerals was established by Law No. 16096 promulgated December 11, 1961. Previously, only the Government agency Commercial Committee for Minerals (COCOMINE) was authorized to purchase domestically produced minerals. COCOMINE was to continue to maintain official support prices and buy the minerals, if the producers choose to sell to the agency. COCOMINE

[4] Brown, C. J. Geology of the Flat River Tungsten Deposits. Canadian Min. and Met. Bull., v. 54, No. 591, July 1961, pp. 510–513.

TABLE 11.—World production of tungsten ore and concentrate, by countries[1]

(Short tons, 60 percent WO_3 basis)

Country	1952–56 (average)	1957	1958	1959	1960	1961
North America:						
Canada	1,721	1,602	575			
Mexico	619	294	8	138	198	193
United States (shipments)	12,408	5,520	3,788	3,649	7,325	8,245
Total	14,748	7,416	4,371	3,787	7,523	8,438
South America:						
Argentina	1,000	1,441	1,127	827	[2] 840	[2] 830
Bolivia (exports)	4,879	4,809	2,457	2,671	2,370	3,104
Brazil (exports)	1,811	2,304	2,596	1,609	2,205	1,607
Peru	926	1,215	992	542	538	474
Total	8,616	9,769	7,172	5,649	5,953	6,015
Europe:						
Austria		140	146	152	243	317
Finland	87		163	42		63
France	1,304	1,091	1,152	959	783	834
Italy	26	20	10	6	8	[2] 8
Portugal	5,422	4,756	2,109	2,478	3,189	3,213
Spain	2,421	1,319	1,301	854	1,028	[2] 1,100
Sweden	475	557	660	375	386	440
U.S.S.R.[3]	8,300	8,800	9,400	9,900	10,500	11,000
United Kingdom	74	55	2			
Yugoslavia	[3] 109	90	99	86	86	[2] 110
Total [2]	18,200	16,800	15,050	14,900	16,200	17,100
Asia:						
Burma [4]	2,390	1,910	1,100	820	1,215	[2] 1,150
China [2]	20,100	16,500	16,500	19,800	22,000	22,000
Hong Kong	74	42	46	47	39	20
India	7	2		1	3	11
Japan	877	1,144	881	1,194	1,082	1,031
Korea:						
North [2]	1,800	2,665	3,300	4,400	5,500	5,500
Republic of	5,250	4,567	3,597	3,492	5,870	7,529
Malaya, Federation of	126	63	57	24	46	41
Thailand	1,559	1,080	725	553	486	565
Total [2]	32,200	28,000	26,200	30,350	36,250	37,850
Africa:						
Algeria	18					
Congo, Republic of the (formerly Belgian)[4]	844	1,055	1,200	1,038	634	640
Morocco: Southern zone	10					
Nigeria	11					
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	338	180	103	36	11	55
Ruanda-Urundi	772	797	279	171	504	734
South-West Africa [4]	255	278	64	2	154	192
Tanganyika (exports)	10	1				3
Uganda (exports)	187	224	31	14	84	116
Union of South Africa	485	290	61	42	37	30
United Arab Republic (Egypt Region)	13					[2] 95
Total	2,943	2,825	1,738	1,303	1,424	1,865
Oceania:						
Australia	2,666	2,629	1,587	1,218	2,069	2,877
New Zealand	43	36	3	11	9	[2] 9
Total	2,709	2,665	1,590	1,229	2,078	2,886
World total (estimate)	79,400	67,500	56,100	57,200	69,400	74,200

[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] Average annual production 1953–56.
[4] Including WO_3 in tin-tungsten concentrates.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

also determined export prices for minerals during the year, usually adopting the prices in the international market.

Bolivia.—No production figures were available for those medium tungsten mines that export directly, without going through the Mining Bank. Thus, no complete national production figures were available.

The Bolivian Mining Corp. announced that one of the country's biggest tungsten producers, the Kami mine, would be closed. The mine was not operated profitably after the drop in world tungsten prices.

Peru.—Pasto Bueno, Peru's only active tungsten mine, continued to operate at reduced capacity. Supreme Decree No. 2, issued by the Government, suspended the 4-percent tax on exportation of tungsten ore and concentrate while low world market prices prevail.

EUROPE

Austria.—A large expansion program for the Metallwerk Plansee, Reutte, Tyrol, will include new rolling mills for the production of wide tungsten sheet and equipment for flow-turning.

Germany, West.—Tungsten concentrate scheduled to be imported from the U.S.S.R. totaled 2,300 tons in 1961, 1962, and 1963. Beginning January 1, 1961, a 6-percent external tariff on tungsten was established. Also, 7-percent tariff on ingot tungsten was established to protect the industries that refined both domestic and imported ores.

U.S.S.R.—Several thousand tons of tungsten concentrate was imported from China for export to the European market. Most domestic needs were supplied from a large number of scheelite and wolframite deposits in central Asia, the Far Northeast, and north Caucasus.

ASIA

Burma.—Mineral Resources Development Corp. continued to operate the Yadanabon wolfram mine on a small scale. The Mawchi wolfram mine, once among the richest in the world, went into liquidation. This mine had an estimated reserve of 500,000 tons of ore and continued to be operated on a small scale.

China.—China led the world in the production of tungsten concentrate for many years. Statistics on output in recent years were difficult to obtain. Most of the tungsten was produced for export, primarily to the U.S.S.R. Soviet trade import statistics do not show tungsten as a separate item, but annual shipments from China to the U.S.S.R. could be over 10,000 tons. Some tungsten also was exported to east European countries. Concentrates sold in Western Europe were believed to be of Chinese origin. Despite low prices, China seems anxious to expand its export markets. Most of China's tungsten is wolframite, but scheelite is becoming important, and one of the major producers is Yao-Kang-hsien in Hunan. Efforts have been directed towards mechanizing mining and ore dressing facilities and improving extraction procedures.[5]

Hong Kong.—The Needle Hill wolfram mine, the largest in Hong Kong, was the only mine producing in 1961. Operation was on a reduced scale with about 50 miners, half of whom worked underground.

[5] Wei, A. W. T. Minerals in China in 1961. Min. J. (London), v. 258, No. 6610, Apr. 27, 1962, pp. 409–411.

The daily output averaged between 30 to 40 tons of ore containing less than 1 percent wolframite.[6]

India.—Philips India, Ltd., a majority-owned subsidiary of N. V. Gloeilampenfabriken of the Netherlands, planned to manufacture tungsten wire at Hadapsar, near Poona, Maharashta State. The capacity of the plant was estimated at about 5,000 pounds and 180 million feet of wire per year.

Korea, Republic of.—Korea Tungsten Mining Co. established its own selling organization in London and New York to assure a regular and even distribution of its products to consumers and merchants. The company also announced a 5-year plan to improve export trade by investing about US$1,500,000 in building a metallic tungsten plant and improving its mining and processing facilities.

The Sandong mine of Korea Tungsten Mining Co. accounted for most of the tungsten output, although about 50 mines, mostly marginal producers, operated during the year. Tungsten concentrate was exported mostly to western European countries, the United States, and Japan, with minor quantities to several other countries.

Mongolia.—Construction at the Ikhe Khayran (Hairan) tungsten mine was completed. A power station was built at the mine site and mining and milling facilities were installed. Tungsten deposits had been reported for Mongolia in the past, but this was the first serious attempt at exploitation.

TECHNOLOGY

The Federal Bureau of Mines published the results of its studies on the feasibility of beneficiating Colorado ferberite ore for the production of specification grade synthetic scheelite.[7] In other reports, tungsten deposits in Gila, Yavapai, and Mohave Counties, Ariz., were described, the status of tungsten deposits in Utah was reviewed,[8] and investigation of new approaches for preparing tungsten and its alloys in high-purity form was described.[9]

In the field of thermodynamics, research on low-temperature heat capacities and entropies of monotungstates was published.[10] Several studies describing the spectrochemical analysis of high-purity tungsten also were issued.[11]

For several years interest in tungsten had centered on its strength at elevated temperatures. While this remained an important con-

[6] Davis, S. G. Mineralogy and Genesis of the Wolframite Ore Deposits, Needle Hill Mine, New Territories, Hong Kong. Econ. Geol., v. 56, No. 7, November 1961, pp. 1238–1249.

[7] Dean, K. C., and I. L. Nichols. Froth Flotation and Chemical Processing of Colorado Ferberite Ores. BuMines Rept. of Inv. 5869, 1961, 15 pp.

[8] Everett, F. D. Tungsten Deposits in Utah. BuMines Inf. Cir. 8014, 1961, 44 pp.
Dale, V. B. Tungsten Deposits of Gila, Yavapai, and Mohave Counties, Ariz. BuMines Inf. Cir. 8078, 1961, 104 pp.

[9] Good, P. C., and F. E. Block. Preparation of Tungsten by Reduction of Tungsten Hexachloride. BuMines Rept. of Inv. 5861, 1961, 9 pp.
Good, P. C., D. H. Yee, and F. E. Block. Preparation of Tungsten and Its Alloys by Bomb Reduction. BuMines Rept. of Inv. 5828, 1961, 10 pp.

[10] King, E. G., and W. W. Weller. Low-Temperature Heat Capacities and Entropies at 298.15° K of Monotungstates of Sodium, Magnesium, and Calcium. BuMines Rept. of Inv. 5791, 1961, p. 6.

[11] Lewis, R. W., C. F. Earl, J. L. Potter, and J. R. Wells. Spectrochemical Analysis of High-Purity Tungsten. BuMines Rept. of Inv. 5814, 1961, 12 pp.
Peterson, M. J. Spectrochemical Analysis of High-Purity Metals: A Review and Bibliography of Recent Literature. BuMines Inf. Cir. 8039, 1961, 47 pp.
Peterson, M. J., and C. L. Chaney. Semiquantitative Spectrographic Analysis of Tungsten. BuMines Rept. of Inv. 5903, 1961, 17 pp.
Prokopovitsh, A. S., and T. E. Green. Spectrophotometric Determination of Trace Amounts of Copper in Tungsten Metal Powder. BuMines Rept. of Inv. 5720, 1961, 7 pp.

sideration, interest in other properties developed as fabrication techniques improved. Tungsten was being used increasingly for rocket nozzles, as a protective coating on nuclear fuel particles, as a heavy density material for shielding, and in sheet form. The expanded use of tungsten sheet, because of the good performance of the welded metal and its consequent amenability to fabrication in intricate shapes, could be of major significance. A tungsten sheet rolling program was established by the U.S. Department of Defense to accelerate the development of production techniques for high-quality sheet products having the basic properties needed for space-age applications. Three tungsten projects were conducted as part of the program. Fansteel Metallurgical Corp. investigated powder-metallurgy consolidation of tungsten and its alloys, and fabrication techniques to obtain sheet products from sintered billets. Universal-Cyclops Steel Corp. investigated arc melting as the consolidation method followed by fabrication techniques to produce sheet from arc-melted ingots. Both programs used conventional rolling equipment for conversion of bar to sheet. The third project, conducted by Wah Chang Corp., with Pratt & Whitney Aircraft Division, United Aircraft Corp. as the subcontractor, investigated flow turning as the method of converting billets to sheet.[12]

Among new uses for tungsten were wafers for semiconductor devices, emitters for thermionic power conversion, ionic propulsion, chemicals for high temperature lubrication, and solid state optical masers. The new maser used a single-crystal rod of calcium tungstate and has applications in medicine, communication, welding, cutting, and defense. Another important new development was the commercial production of ultrapure single crystals of tungsten metal up to 10 inches long exhibiting ductility at temperatures as low as minus 300° F. A number of new uses, especially that of tungsten sheet for complex shapes and unsymmetrical parts, resulted from the successful welding of tungsten metal.[13]

The literature describing significant government and industry development in tungsten technology was extensive. Status reports and reviews of the more outstanding projects and accomplishments in production, consolidation, fabrication, alloy development, mechanical properties, physical metallurgy, oxidation, and structural development were published.[14]

Literature published on the metallurgy and chemistry of tungsten contained information on recrystallization and ductile-brittle transition, and cold-working grain orientation.[15]

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[12] Ogden, H. R. Status Report No. 1, Dept. of Defense Refractory Metals Sheet Rolling Program. DMIC Rept. 161, Nov. 2, 1961, pp. 18–29.

[13] Jaffee, R. I., D. J. Maykuth, and V. D. Barth. Fabrication of Tungsten for Solid-Propellant Rocket Nozzles. DMIC Memo. 136, Nov. 2, 1961, 27 pp.

[14] Barth, V. D. Review of Recent Developments in the Technology of Tungsten. Battelle Memorial Inst., DMIC Rept. 127, Sept. 22, 1961, 7 pp.

Barth, V. D., and G. W. Rengstorf. Oxidation of Tungsten. DMIC Rept. 155, July 17, 1961, 166 pp.

Neiman, A. S., O. Preston, and D. A. Brown. Tungsten and Rocket Motors. Stanford Research Inst., Final Rept. on Contract Nord 18619 (FBM), Mar. 23, 1961, 44 pp.

Ogden, H. R. Status Rept. No. 1 on Dept. of Defense Refractory Metals Sheet-Rolling Program. DMIC Rept. 161, Nov. 2, 1961, 32 pp.

Work cited in footnote 13.

[15] Allen, B. C., D. J. Maykuth, and R. I. Jaffee. The Recrystallization and Ductile-Brittle Transition Behavior of Tungsten. J. Inst. Metals (London), v. 90, December 1961, pp. 120–128.

A final report outlining the data accumulated in evaluating the vacuum-arc skull-casting technique as a method for producing tungsten metal and alloys was published. The report also described efforts to determine hardness, soundness, contamination, and grain size of the castings.[16]

Quantitative determinations of the surface self-diffusion constants of tungsten were made by using the field-emission microscope.[17]

The oxidation behavior of tungsten in air at low pressures and temperatures as high as 3,000° C was studied and summarized.[18] Problems connected with the prevention of oxidation of tungsten also were summarized.[19]

Continuing research on tungsten fabrication by using plasma arc spraying resulted in the development of a process for making free-standing tungsten bodies.[20]

Other significant fabrication processes for tungsten that were intensively studied included high energy rate forming techniques, such as explosive forming and electric arc discharge and extrusion. The status of the refractory metals sheet-rolling program initiated by the U.S. Department of Defense to develop production techniques for high-quality sheet products from tungsten and its alloys was published.[21]

Several new alloys containing significant quantities of tungsten were developed for purposes such as tool steel dies, radioactive shielding, and electronics.[22] A new alloy production process that made use of tungsten carbide particles uniformly distributed in a metal matrix by subjecting the material to ultrasonic vibrations was also reported.[23] Specifications, trade names, and standard designations of more than 252 alloys containing tungsten were published.[24]

Tungsten-columbium-tantalum alloys were reported to exhibit a tenfold improvement in oxidation resistance at high temperatures over that of the pure metal.[25]

New tungsten-rhenium alloys were made in wire and strip form and showed high tensile strength at elevated temperatures, good electrical resistivity, and retention of ductility after being heated to high

(Continued from p. 1270.)

Koo, R. C. Recovery in Cold-Worked Tungsten. J. Less-Common Metals, v. 3, No. 5, October 1961, pp. 412–428.

Opinsky, A. J., J. L. Orehotsky, L. L. Seigle. Orientations of Large Grains in Tungsten Wire. Trans. Metallurgical Soc. AIME, v. 221, No. 5, October 1961, pp. 1083–1084.

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[18] Perkins, R. A., and D. D. Crooks. Low-Pressure and High-Temperature Oxidation of Tungsten. J. Metals, v. 13, No. 7, July 1961, pp. 490–493.

[19] Klopp, W. D. Oxidation-Resistant Coatings for Refractory Metals. Review of Recent Developments. Battelle Memorial Inst., Feb. 2, 1962, pp. 3–4.

[20] Singleton, R. H., E. L. Bolin, and F. W. Carl. Tungsten Fabrication by Arc Spraying. J. Metals, v. 13, No. 7, July 1961, pp. 483–486.

[21] Ogden, H. R. Status Report No. 1. Battelle Memorial Inst., DMIC. November 1961, 32 pp.

[22] Materials in Design Engineering. New Tungsten Steel for Tools and Dies. V. 53, No. 5, May 1961, p. 5.

American Metal Market. Newer Metals. V. 68, No. 101, May 26, 1961, p. 14.

American Metal Market. Newwer Metals for High-Temperature Applications. V. 68, No. 132, July 12, 1961, p. 11.

[23] Smith, C. O. A New Alloy Production Process. Metal Prog., v. 79, No. 5, May 1961, pp. 162, 164.

[24] Vagi, J. J., and A. F. Haskins. Standard Designations of Alloys for Aircraft and Missiles. Battelle Memorial Inst., DMIC 42 R, May 24, 1961, 78 pp.

[25] Wilson, J. L., and C. R. McKinsey. Tungsten-Columbium-Tantalium Alloys. J. Metals, v. 13, No. 7, July 1961, pp. 494–496.

temperatures. This development was considered to be the most significant improvement in tungsten wire manufacturing in 25 years.[26]

Other improvements in tungsten alloy production included the use of centrifugally cast material that was directly rollable to strip with no necessity for forging breakdown or extruding. The future of tungsten alloys for application to the high temperature field was summarized.[27]

The constitution diagram of the little known tungsten-osmium binary alloy system was determined by using a combination of X-ray and micrographic techniques.[28]

[26] Steel, v. 149, No. 7, Aug. 14, 1961, p. 155.
American Metal Market, v. 68, No. 237, Dec. 12, 1961, pp. 1, 14.
[27] Materials in Design Engineering, v. 54, No. 2, August 1961, pp. 127–148.
[28] Taylor, A., B. J. Kagle, and N. J. Doyle. The Constitution Diagram of the Tungsten-Osmium Binary System. J. Less-Common Metals, v. 3, No. 4, August 1961, pp. 333–347.

Uranium

By Don H. Baker, Jr.,[1] and Ethel M. Tucker [2]

DOMESTIC uranium ore production in 1961 was the highest in history; over 1,000 mines produced just over 8 million tons of ore valued at $148 million. Concentrate production was 17,400 tons of U_3O_8 valued at about $290 million. Free world uranium production totaled 36,000 tons of U_3O_8, compared with 41,000 tons in 1960. Continued reorientation of uranium mine and mill production because of a stretchout of procurement was evident in the free world.

TABLE 1.—Salient uranium statistics

(Short tons)

	1957	1958	1959	1960	1961
United States:					
Production:					
Mine (ore shipments)	3,695,478	5,178,315	6,934,927	7,970,221	8,041,329
Mill (U_3O_8 content)	8,640	12,570	16,420	[1] 17,760	[2] 17,399
Imports: Ore and concentrate (U_3O_8 content)	11,826	16,500	18,120	15,770	12,915
World: Production (U_3O_8 content)	23,270	36,050	43,320	40,740	35,850

[1] Revised figure.
[2] Includes uranium production from phosphate rock in Eastern United States.

Although peaceful uses of uranium were being investigated and developed, its chief use was for military applications.[3] A total of 173 nuclear reactors of different types were in operation in the United States by the end of 1961. The authorized nuclear naval fleet of the United States comprised 65 vessels. The cooperation of the United States in sharing data about peaceful uses of atomic energy with foreign countries was broadened through agreements with the European Atomic Energy Community (Euratom), the International Atomic Energy Agency (IAEA), the Inter-American Nuclear Energy Commission, and the Organization for European Economic Cooperation (OEEC).

LEGISLATION AND GOVERNMENT REGULATIONS

The Atomic Energy Commission (AEC) published on January 25, 1961, in the Federal Register, part 9–12, "Labor," of the AEC Procurement Regulations. Various additions and clarifications of regulations were made, including adoption of standard clauses relating to the Davis-Bacon Act for use in contracts, convict labor, the 8-hour law (other than construction), nondiscrimination in employment, the

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.
[3] Atomic Energy Commission. Major Activities in the Atomic Energy Programs. January–December 1961, 540 pp.

Walsh-Healey Public Contracts Act, the Fair Labor Standards Act of 1938, and special considerations affecting construction laborers and mechanics on Commission projects.

Also, during 1961 two new regulations and several amendments to existing regulations pertaining to licenses were adopted. The new regulations were "Procedures for the Review of Certain Nuclear Reactors Exempted from Licensing Requirements" (10 Code of Federal Regulations (CFR) part 115 and "Radiation Safety Requirements for Radiographic Operations" (10 CFR part 31). Amendments were made to "Rules of Practice" (10 CFR part 2), "Standards for Protection Against Radiation" (10 CFR part 20), "Licensing of By-Product Material" (10 CFR part 40), "Licensing of Production and Utilization Facilities" (10 CFR part 50), "Special Nuclear Material" (10 CFR part 70), and "Financial Protection Requirements and Indemnity Agreements" (10 CFR part 140). Early in the year the amendment to the "Licensing of Source Material" (10 CFR part 40) was changed so that uranium mines no longer are required to have an AEC license to transfer uranium ores from the mine to the mill or ore-buying station.

President Kennedy, on September 26, 1961, increased from 100,000 to 165,000 kilograms of contained uranium 235 the quantity of enriched uranium to be made available for peaceful uses domestically and abroad.

DOMESTIC PRODUCTION

Mine Production.—Uranium ore production in the United States reached a new high, totaling just over 8 million dry tons valued at $148 million, slightly above the 1960 production. A small additional quantity of uranium was produced as a byproduct from the processing of phosphate rock in the Eastern United States. The United States was the largest free world producer. Producing States in order of value of mine production were New Mexico, Wyoming, Utah, Colorado, Arizona, Washington, Texas, South Dakota, Alaska, Oregon, Idaho, Montana, and Nevada.

Mill Production.—Domestic uranium concentrate production from all sources totaled 17,399 tons of U_3O_8, compared with 17,760 tons in 1960. The 26 ore-processing mills in the United States supplied 17,348 tons

TABLE 2.—Uranium mine production in 1961, by States

State	Ore shipped		U_3O_8 content	
	Short tons	Value (thousands)	Percent	Pounds
Arizona	228,225	$4,965	0.26	1,190,297
Colorado	1,282,462	21,509	.22	5,558,762
Montana	729	10	.19	2,768
New Mexico	3,631,036	62,482	.22	15,696,876
Oregon	2,160	66	.35	15,162
South Dakota	43,588	495	.17	148,688
Utah	1,098,783	25,734	.28	6,160,406
Washington	175,327	3,582	.25	870,073
Wyoming	1,521,064	28,218	.23	7,091,426
Other States [1]	57,955	1,238	.25	294,381
Total	8,041,329	148,299	----------	37,028,839

[1] Includes Alaska, Idaho, Nevada, and Texas.

of U_3O_8 valued at nearly $290 million, compared with 17,646 tons valued at about $330 million in 1960. The additional production of 51 tons of U_3O_8 in 1961 and 114 tons in 1960 came from processing phosphate rock in the Eastern United States; the procurement contracts, which expired in June 1961, showed that should a market develop in the future, byproduct uranium could be produced from processing phosphate rock to superphosphate at a direct cost, exclusive of plant costs, of $8 or less per pound of U_3O_8. There is a production potential of about 1,000 tons of U_3O_8 per year at the 1961 rate of triple superphosphate production.

AEC had 25 domestic contracts for procuring uranium from 27 mills at the end of 1961. During the year six AEC contracts with ore-processing mills were modified and extended to provide the 1962–66 market with concentrates that could be produced from reserves developed before November 24, 1958. This brought the total mill contracts extended through 1966 to 19, including a contract with the Petrotomics Co. mill which was still under construction in Carbon County, Wyo. Three other mill contracts were being renegotiated and three were to terminate before 1966 because of a limited eligible ore supply.

The contract under discussion in 1960 for the proposed mill at Bowman, N. Dak., to treat uraniferous lignite was not executed.

TABLE 3.—Uranium-processing plants,[1] December 31, 1961

State and company	Plant location	Present contract termination	Tons of ore per day	Estimated cost (thousands)
Arizona: Rare Metals Corporation of America	Tuba City	Mar. 31, 1962	300	$3,600
Colorado:				
American Metal Climax, Inc.[2]	Grand Junction	Dec. 31, 1966	330	3,088
Cotter Corp	Cannon City	Feb. 28, 1965	200	1,800
Gunnison Mining Co	Gunnison	Dec. 31, 1966	200	2,025
Trace Elements Corp	Maybell	do	300	2,208
Union Carbide Nuclear Co	Rifle[3]	do	1,000	8,500
Do	Uravan[3]	do	1,000	5,000
Vanadium Corporation of America	Durango	do	750	813
New Mexico:				
The Anaconda Company	Grants	do	3,000	19,358
Homestake-Sapin Partners	do	do	1,500	9,000
Do	do.[4]	do	750	5,325
Kermac Nuclear Fuels Corp	do	do	3,300	16,000
Kerr-McGee Oil Industries, Inc	Shiprock	do	300	3,161
Phillips Petroleum Co	Grants	do	1,725	9,500
Oregon: Lakeview Mining Co	Lakeview	Nov. 30, 1963	210	2,600
South Dakota: Mines Development, Inc	Edgemont	Mar. 31, 1962	400	1,900
Texas: Susquehanna-Western Inc	Falls City	Dec. 31, 1966	200	2,000
Utah:				
Texas-Zinc Minerals Co	Mexican Hat	do	1,000	7,000
Uranium Reduction Co	Moab	do	1,500	11,172
Vitro Chemical Co	Salt Lake City	Mar. 31, 1962	600	5,500
Washington: Dawn Mining Co	Ford	Dec. 31, 1966	400	3,100
Wyoming:				
Federal-Radorock-Gas Hills Partners	Fremont County	do	520	3,370
Globe Mining Co	Natrona County	do	490	3,100
Petrotomics Co	Carbon County[5]	do	200	1,500
Susquehanna-Western Inc	Riverton	do	500	3,500
Utah Construction & Mining Co	Fremont County	do	980	6,900
Western Nuclear, Inc	Jeffrey City	do	845	4,300
Total			22,500	145,320

[1] The mills are privately owned and operated, and all are licensed to buy uranium ore from producers. AEC buys the concentrate product under the terms of contracts with each mill operator.
[2] Formerly Climax Uranium Co.
[3] New contract agreement, signed in May 1961, replaced contracts for these two mills.
[4] Formerly owned by Homestake-New Mexico Partners and acquired by Homestake-Sapin Partners in November 1961.
[5] Under construction.

In the early 1950's AEC depended heavily upon foreign suppliers, but by calendar year 1961 domestic producers supplied 57 percent of the total U_3O_8 received; under projected commitments through December 1966, domestic producers will supply approximately 72 percent of the total U_3O_8 purchases.

TABLE 4.—Procurement record for uranium oxide (U_3O_8), by fiscal years[1]

Fiscal year	United States		Canada		Other		Total short tons
	Short tons	Percent of total	Short tons	Percent of total	Short tons	Percent of total	
ACTUAL PROCUREMENT							
1952	830	23	210	6	2,620	71	3,660
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
Total	76,920	45	53,590	32	39,820	23	170,330
PROJECTED PROCUREMENT							
1962	17,820	60	7,825	26	4,280	14	29,925
1963	17,300	60	7,100	25	4,200	15	28,600
1964	16,900	73	2,400	10	3,810	17	23,110
1965	16,000	81	1,000	5	2,805	14	19,805
1966	16,000	88	500	3	1,600	9	18,100
1967 (6 months)	8,000	91	200	2	600	7	8,800
Total	92,020	72	19,025	15	17,295	13	128,340
Grand total	168,940	57	72,615	24	57,115	19	298,670

[1] July 1 to June 30.

The projection of receipts is based upon current contractual commitments. Barring major economic or political disturbances, it is anticipated that foreign deliveries and a large percentage of domestic deliveries will be made on schedule. However, a number of domestic production allocations are assigned to economically marginal mines, and projected domestic deliveries may fall several thousand tons short as a result of failure to produce the full quantities covered by allocations and milling contracts.

The small independent mining operations and mining properties that contain irregular deposits, which under normal procedures are not developed far in advance of mining, were given recognition early in 1961 as sources of uranium ore. AEC announced in February that the historical production rate of a mining property rather than the developed ore reserve would be considered as a basis for establishing a market. When an historical production rate is used, allocation will relate to ore production over the period July 1, 1956, through June 30, 1960.

Refinery Production.—Three feed-material plants refined uranium concentrates from foreign and domestic sources. Two refineries were

Government-owned plants operated under AEC contracts, and one was privately owned. The operators and locations of the Government-owned plants were Mallinckrodt Chemical Works, Weldon Springs, Mo., and National Lead Co., Fernald, Ohio. The privately owned plant was Allied Chemical Corp., Metropolis, Ill.

Raw materials receipts at these feed-material plants were adjusted to the requirements of AEC. The extent to which commercial processing of fuel from commercial sources has increased is given in table 5, which shows enriched uranium furnished in the form of uranium hexafluoride compared with that furnished in other forms that require further processing in AEC facilities.

TABLE 5.—Enriched uranium furnished to all sources (excluding the weapons production chain)

(Pounds)

	Fiscal year				
	1957	1958	1959	1960	1961
Furnished as UF_6	13,230	52,910	243,170	190,040	271,025
Furnished in forms other than UF_6	8,200	46,300	13,890	7,500	15,210
Total	21,430	99,210	257,060	197,540	286,235

All the enriched uranium furnished in 1956 required processing beyond the uranium hexafluoride stage in AEC facilities. In 1961, 95 percent was processed beyond this stage in commercial plants.

TABLE 6.—Employment in domestic uranium mills

Fiscal year	Number of employees	Fiscal year	Number of employees
1954	1,619	1958	2,857
1955	1,840	1959	3,185
1956	2,059	1960	3,535
1957	2,413	1961	4,000

Firms producing uranium fuel materials commercially included W. R. Grace & Co., Davison Chemical Division, Erwin, Tenn.; M & C Nuclear, Inc., Attleboro, Mass.; Mallinckrodt Nuclear Corp., subsidiary of Mallinckrodt Chemical Works, Hematite, Mo.; National Lead Co., Fernald, Ohio; Nuclear Materials and Equipment Corp., Apollo, Pa.; Spencer Chemical Co., Kansas City, Mo.; Vanadium Corporation of America, New York, N.Y.; Var-Lac-Oid Chemical Co., New York, N.Y.; and Vitro Engineering Co., New York, N.Y.

Production of Fissionable Material.—Enriched uranium (U^{235}) was produced in three Government-owned gaseous diffusion plants operated by private industry. They were Union Carbide Nuclear Co., Oak Ridge, Tenn., and Paducah, Ky.; and Goodyear Atomic Corp., Portsmouth, Ohio.

Plutonium and related reactor products, intended primarily for use in weapons, were produced in Government facilities by General Electric Co., at the Hanford Works, Hanford, Wash., and by E. I. du Pont de Nemours & Co., Inc., at the Savannah River Plant, Aiken, S.C.

AEC expanded its research and development in the field of separating U^{235} and U^{238} by gas centrifuge.

Nuclear Fuel Processing.—Responsibility for reprocessing irradiated fuels from research, test, power, and propulsion reactors and for making financial settlement for the contained fuel values has been consolidated at the Savannah River and Idaho Operating Offices of AEC.

Expansion of AEC reprocessing facilities was deferred to give private industry an opportunity in this field, since private facilities are considered to be a key requirement for a self-sufficient nuclear power industry.

The Industrial Reprocessing Group (IRG), composed of Davison Chemical Division of W. R. Grace & Co. and a number of utility companies, continued its studies during 1961. IRG has determined that a plant for reprocessing irradiated fuel is technically feasible, and acceptable solutions to the remaining problems are anticipated.

CONSUMPTION AND USES

Uranium was used in AEC programs chiefly as material for weapons production and as fuel for nuclear reactors.

A total of 173 nuclear reactors of various types were operating in the United States at the end of 1961. These reactors were classified as production, civilian, and military reactors.

The first fatal accident in AEC's history involving a nuclear reactor took place at the National Reactor testing station in Idaho on January 3, 1961. A nuclear excursion at Stationary Low Power Plant No. 1 (SL–1) led to the death of three military technicians working on the reactor. After operating for more than 2 years, the reactor had been shut down for maintenance, and the excursion occurred during prestartup activities before operation was resumed.

Production Reactors.—Plutonium produced in eight graphite-type production reactors in Hanford, Wash., and in five heavy-water-type reactors in Savannah River, S.C., was delivered to the weapons stockpile under Presidential authorization. The New Production Reactor at Hanford, capable of producing some power, was under construction at the end of 1961. A total of 19 reactors were being used in the United States for material production and process development.

Civilian Reactors.—Of the 151 civilian reactors in the United States at the end of 1961, 93 were operable, 46 were under construction, and 12 were planned. The three central-station electrical prototype plants (the Shippingport Atomic Power Station, Shippingport, Pa., Dresden Nuclear Power Station, Morris, Ill., and the Yankee Nuclear Power Station, Rowe, Mass.) had a capacity of 386,000 net kilowatts (e) of electricity. This was four times the quantity generated by nuclear power in any previous year.

The *Savannah*, the world's first nuclear merchant ship, was completed in August, and the nuclear reactor was loaded with fuel in November. Low-level criticality of the vessel's 69–Mw(t) powerplant was achieved in December for dockside tests. Full-power tests were scheduled for 1962.

Table 7 summarizes the types of civilian reactors.

TABLE 7.—Civilian reactors operable, being built, and planned in the United States in 1961

	Operable	Being built	Planned
Power reactor prototypes:			
Large central-station plants	3	6	4
Small central-station plants		4	
Maritime propulsion (seagoing)	1		
Experimental power reactors and reactor experiments:			
Experimental power reactors (generate electricity)	3	4	
Power reactor experiments (token electrical production, if any)	4	6	2
Space propulsion experiments (ROVER)		(1)	(1)
Auxiliary power for space (SNAP)			3
Test, research, and teaching reactors:			
General irradiation test (Government-owned)	3	1	
General irradiation test (privately owned)	2		
Special test	8	2	
Research	32	10	1
Teaching	37	13	2
Total	93	46	12

[1] Several Kiwi B series expected to be tested in 1962.

Source: AEC Annual Report for 1961.

Of the 52 tests and research reactors used in teaching, 37 were operable, 13 were being built, and 2 were planned at the end of 1961. Twenty-nine of the reactors in operation were at universities.

Military Reactors.—The U.S. Navy had 61 nuclear-powered submarines and 4 surface vessels in operation, under construction, or authorized at yearend. Of the submarines 24 were in operation, including 8 Polaris-missile submarines, and an additional 24 had been launched or were under construction. The nuclear-powered surface fleet consisted of the guided-missile cruiser *Long Beach* and the aircraft carrier *Enterprise*, both in operation; the guided-missile destroyer *Bainbridge*, to start sea trials early in 1962; and a second guided-missile destroyer authorized.

The Navy maintained several land-based test reactors besides the pressurized water-type shipboard reactors. Total military reactors were 115, of which 61 were operable, 49 were being built, and 5 were in the planning stage as shown in table 8. Naval propulsion reactors accounted for 76 of this total.

TABLE 8.—Military reactors operable, being built, and planned in the United States in 1961

	Operable	Being built	Planned
Defense power reactor applications:			
Electric power reactors, remote installations	2	2	1
Propulsion reactors (naval)	37	39	
Developmental power reactors:			
Electric power reactor experiments and prototypes	2	1	1
Special purpose reactors (auxiliary power for space)	1		2
Naval propulsion reactor prototypes	5	2	
Aircraft propulsion reactor experiments	2		
Missile propulsion reactor experiments		1	
Test and research reactors:			
Test	6	2	
Research	6	2	1
Total	61	49	5

Source: AEC Annual Report for 1961.

Reactors for Export.—Of 57 reators to be exported, 35 were operable, 17 were being built, and 5 were in the planning stage. Central-station electric power reactors for export were being built for Belgium, Italy, and Japan.

Radioisotopes.—A marked increase over 1960 was shown in both production and sales of radioistopes. In the first 11 months of 1961, 436,205 curies valued at $2.7 million was shipped. In the same period of 1960, the figures were 191,122 curies valued at $1.9 million; the 1959 figures were 222,703 curies valued at $2.0 million. Total sales of radioisotopes from AEC's primary point of shipment, Oak Ridge National Laboratory (ORNL), had reached 1,557,784 curies since the first shipment was made in August 1946. The total of individual shipments, domestic and foreign, made in 1961 was 11,907, slightly below the record number of 12,028 shipments established in 1959.

Imports of radioactive isotopes from foreign suppliers, primarily Canada, the United Kingdom, Belgium, France, Czechoslovakia, the Netherlands, West Germany, and Israel, also continued to increase.

During the first 11 months of the year shipments of certain isotopes showed unusual increases: Cobalt 60 rose from 133,000 curies in 1960 to 235,298 curies; strontium 90, from 338 to 98,000 curies; and carbon 14, from 7 to 40 curies. The increase in cobalt 60 was attributed to increased demands for teletherapy and radiographic sources, and the increased demand for strontium 90 was for use as heat and electric power sources in remote weather stations. The National Bureau of Standards received the largest single radioisotope shipment to a licensee in the history of ORNL, 50,000 curies of cobalt 60, which was more than twice the previous record shipment of 22,900 curies of cobalt 60, made to Budd Co., Philadelphia, Pa., in 1960.

The licensing of industrial users of radioistopes continued to increase. The increase was 10 percent over 1960, compared with an 11-percent increase in 1960 over 1959 and a 16-percent increase in 1959 over 1958.

Of the new licenses issued during the year, 367 were for radioisotope utilization in the field of medicine; 330, for industrial uses; 251, for Federal and State laboratory use; and 77, for uses in miscellaneous fields.

AEC, as part of its program to encourage industry to provide services previously available only from AEC facilities, withdrew from additional services in 1961. On May 2, AEC announced its immediate withdrawal from the routine production and distribution of cobalt 60. AEC was to continue to provide cobalt 60 only in quantities greater than 100,000 curies to encourage development of ionizing radiation as a major processing tool. Two of the industrial concerns that were to produce and market cobalt 60 were General Electric Co. at Vallecitos, Calif., and Westinghouse Electric Corp. at Waltz Mill, Pa. The 13-year-old program of providing radioisotopes made in AEC facilities at a discount for domestic research in biology, medicine, and agriculture was discontinued on July 1. Industrial capability to produce and supply plutonium-beryllium neutron sources comparable in design and price with those fabricated by AEC was shown, and on November 1, AEC withdrew from this field with minor exceptions.

Weapons.—Production of nuclear weapons was continued in 1961 by AEC as authorized by President Kennedy. The production effort was responsive to such Department of Defense requirements as warheads for new weapon systems and bombs that could be delivered by more flexible methods. The program for retirement of obsolescent weapons also was continued.

Late in the year accelerated efforts were applied to weapon development and improvement at the Sandia Corp., Los Alamos, and Livermore weapon laboratories.

The moratorium on nuclear testing was broken by the U.S.S.R. on September 1, 1961, with the launching of an extensive test program which included some 50 atmospheric detonations. On September 15, the United States initiated an underground weapons test program which by yearend involved eight underground detonations of low yield.

Other Uses.—AEC's Plowshare program of research to investigate possible uses of nuclear explosives included theoretical studies and laboratory and field experiments.

The first of several peaceful experimental nuclear detonations planned under Plowshare, Project Gnome, was carried out near Carlsbad, N. Mex., on December 10. An approximately 5-kiloton nuclear device was detonated in salt about 1,200 feet below the surface. Some of the objectives of the test were to provide scientific and technical information on the possibility of recovering useful power from the heat generated by a nuclear explosion, the feasibility of recovering valuable isotopes produced by such explosions, and the effects of a nuclear explosion in salt.

Sales of U_3O_8 outside AEC continued, amounting to about 2,900 pounds in fiscal year 1961 and bringing the total authorized outside sales to 27,300 pounds in the past 4 years.

PRICES AND SPECIFICATIONS

Uranium Ore and Concentrate.—Purchase prices for uranium ore established by AEC remained in effect during 1961. Minimum base prices for ores of various types and grades were guaranteed under AEC Domestic Uranium Program Circular 5 (revised), which expires March 31, 1962. An initial mining property, guaranteed under Circular 6, expired March 31, 1960. Haulage and mine development allowances remained in effect. Circulars 5 (revised) and 6 were published in part 60, title 10, Code of Federal Regulations. Through March 31, 1962, the price per pound paid for concentrates varied from mill to mill.

For U_3O_8 purchased after March 31, 1962, the price paid by AEC, with a few minor exceptions, would be the established price of $8 per pound. These exceptions included final deliveries under contracts terminating March 31, 1962, some deferred deliveries as a result of stretchout provisions, and some contracts extended beyond that date. All but three of these uranium concentrate procurement contracts with milling companies were extended in accordance with AEC's announcement of November 24, 1958, which provided for the purchase of uranium concentrates (U_3O_8) in the 1962–66 period.

AEC contracts for the post-1962 period had many similar provisions. The ores to be treated were to come only from properties designated in the contracts. The contracts give AEC the option of adding, at any time, specified quantities of U_3O_8 produced by independent mine operators from eligible properties. Subject to suitable license arrangements, there are no restrictions on commercial sales by milling companies above the amount to be sold to AEC.

Uranium Metal.—The price of natural uranium metal made available by AEC to qualified licensed buyers remained $40 per kilogram.

Special Nuclear Materials.—Charges for U^{235} in the form of UF_6, in varying degrees of enrichment, ranged from $4.99 per gram of contained U^{235} for material with 1.0 percent U^{235} weight-fraction to $13.65 for material with 90 percent U^{235} weight-fraction.

Base charges for plutonium and U^{233} remained at $12 and $15 per gram, respectively; in each instance the annual lease charge was 4.75 percent of the base charge.

Depleted Uranium.—Prices for depleted uranium furnished by AEC as UF_6 f.o.b. Paducah, Ky., varied from $2.50 per kilogram of uranium assaying less than 0.004 U^{235} weight-fraction to $22.60 per kilogram assaying 0.007 weight-fraction. If the user specified a U^{235} assay of between 0.004 and 0.0022, the charge per kilogram was $3.

Uranium Concentrate Specifications.—Specifications shown in the "Uranium" chapter of Minerals Yearbook, 1958, remained in effect.

FOREIGN TRADE

Uranium from foreign sources supplied 43 percent of the Nation's requirement in 1961, compared with 48 percent in 1960. Deliveries to the United States during 1961 totaled 12,915 short tons of contained U_3O_8. Of this quantity, 8,735 tons was imported from Canada and the rest came from Australia, Belgium, the Republic of the Congo, Portugal, and the Union of South Africa, under contracts of the Combined Development Agency.

Total remaining deliveries to AEC from Australia and Portgual after December 31, 1961, will be approximately 200 tons of U_3O_8, which is to be delivered by January 1963.

Radioisotopes valued at approximately $1.6 million were exported during the year.

WORLD REVIEW

Free world production of uranium oxide totaled 35,850 tons, a decrease of 12 percent from the 1960 production of 40,740 tons. About 75 percent of the total was supplied by the North American continent. U.S. production remained virtually the same, but Canadian production dropped 23 percent.

The International Atomic Energy Agency (IAEA), in cooperation with some of its member states and specialized agencies of the United Nations, organized a series of courses on practical uses of nuclear energy. With the Food and Agriculture Organization (FAO) and the Netherlands Government, it held a course at Wageningen, Netherlands, on the use of radioisotope techniques in agricultural and forestry research. With the World Health Organization (WHO), it gave

a 4-week training course on radiation health and safety. This course was given in Chiba City, Japan, with the help of the Japanese Government.

The Israeli Government, with the assistance of IAEA, held a 4-month course in biological effects of radiation at Rehovoth, Israel.

TABLE 9.—Free world production of uranium oxide (U_3O_8), by countries[1 2 3]

(Short tons)

Country[1]	1957	1958	1959	1960	1961
North America:					
Canada	6,636	13,403	15,392	12,748	9,822
United States[4]	8,640	12,570	16,420	17,760	17,399
South America: Argentina[5]	20	20	13	10	10
Europe:					
Finland[5]				40	30
France	465	660	955	[6] 1,388	[7] 1,637
Germany, West[5]			3	12	12
Spain[5]				60	60
Sweden	10	10	[5] 10	[5] 10	[5] 10
Africa:					
Congo, Republic of the (formerly Belgian)	1,300	2,300	2,300	1,200	
Malagasy Republic (Madagascar)[5]	70	95	115	(6)	(7)
Rhodesia and Nyasaland, Federation of	25	50	38		
Union of South Africa	5,700	6,245	6,445	6,409	5,468
Oceania: Australia[5]	400	700	1,100	1,100	1,400
Free world total (estimate)[1 3]	23,270	36,050	43,320	40,740	35,850

[1] In addition to the countries listed, uranium is also known to have been produced in Colombia, India, Italy, Japan, Morocco, Mozambique, and Portugal. 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 Czechoslavakia, East Germany, Hungary, the U.S.S.R., and other Communist countries. Production data are not available, and no estimate for these countries has been included in the world total. Estimates of production for the Communist countries range from 10,000 to 20,000 tons per year.

[3] This table incorporates a number of revisions of data published in previous "Uranium" chapters. 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 the Eastern United States.

[5] Estimate.

[6] Madagascar included with France.

[7] Madagascar and Gabon included with France.

Compiled by Augusta W. Jann, Division of Foreign Activities.

The United Arab Republic and IAEA held lectures in Cairo, Egypt, on medical applications of radioisotopes.

Nuclear equipment was made available to IAEA by AEC for the development of peaceful uses of atomic energy in Argentina, Brazil, and Israel.[4]

NORTH AMERICA

Canada.—Canadian shipments of U_3O_8 amounted to 9,822 short tons, a decrease of 23 percent from the 1960 total.

Renegotiation of the British-Canadian contract was being considered. The United Kingdom was not anxious for early delivery of the 12,000 tons stipulated in the contract, nor was it in favor of the original contract price of $8 a pound. A lower price suggested by the British negotiators was deemed inadequate by the Canadian faction, and an investigation of production costs was under way.[5]

As of December 31, approximately 21,000 tons of uranium oxide (U_3O_8) was still to be delivered under the stretchout program ending

[4] Chemistry & Industry (London), No. 37, Sept. 16, 1961, p. 1480.

[5] Northern Miner, v. 47, No. 22, sec. 1, Aug. 24, 1961, pp. 1, 5.

in November 1966, exclusive of the unallocated 12,000 tons scheduled for the United Kingdom Atomic Energy Authority (UKAEA).

Of the 11 mines in operation at the beginning of 1961, 3 were closed before the middle of the year.

Ontario.—Four mines were producing at the Elliot Lake district at the end of 1961—Denison Mines, Ltd., Stanrock Uranium Mines, Ltd., and the Milliken and Nordic mines of Rio Algom Mines, Ltd. In the Bancroft area, Bicroft Uranium Mines, Ltd., and Farraday Uranium Mines, Ltd., were still in operation.

Eldorado Mining and Refining, Ltd., installed a $200,000 vacuum-melt induction furnace at its Port Hope, Ontario, refinery. The furnace was undergoing tests at yearend. One of the largest in the world, it will make possible the manufacture of various types of uranium metal, alloys, and fuels for nuclear powerplants.[6] Market surveys indicated possible use of the furnace also in making nonuranium, high-temperature alloys. The furnace was expected to give impetus to the Canadian uranium industry.[7]

Saskatchewan.—Two mines in the Beaverlodge area of northern Saskatchewan operated throughout the year. Open-pit mining at the Gunnar mine ceased in November, however, and mill feed was supplied from existing underground operations, daily output of which was increased to 2,000 tons of ore. Eldorado completed an electronic ore-sorting plant at its Beaverlodge mine, and the company's entire 1961 output came from this mine.

Mexico.—Rayón, Sonora, was the center of important uranium ore discoveries according to preliminary tests, the Mexican National Nuclear Energy Commission announced. A deposit, estimated to contain 17,000 tons of ore also was reported near Aldama in the State of Chihuahua, and two deposits of undisclosed size were reported in the Bermejillo and Santiago Papasquiaro regions in Durango State.

Two concentrating plants were planned, one at Cerro de la Cal, Durango, and the other at Sierra de Gomez, Chihuahua.[8]

SOUTH AMERICA

Argentina.—A deposit of uranium ore in the Province of Chubut, near Rawson, was reported by the Comision de Energia Atomica.[9]

Brazil.—Intended installation in the State of Guanabara of Brazil's first nuclear powerplant was announced. The unit was to have a 300,000-kilowatt generating capacity and would use natural uranium as fuel. Construction, expected to take 4 years, was to begin early in 1962. Additional nuclear-power installations in the northeastern section of Brazil were anticipated.[10]

EUROPE

Several projects for the propulsion of ships were submitted to the European Atomic Energy Community (Euratom), and it was expected that Euratom would extend aid to more than one of these proj-

[6] Chemical Engineering, v. 68, No. 16, Aug. 7, 1961, p. 166.
[7] Eldorado Mining and Refining, Limited. Annual Report. 1961, p. 8.
[8] Mining Journal (London), v. 257, No. 6588, Nov. 24, 1961, p. 546.
[9] Mining Journal (London), v. 257, No. 6570, July 21, 1961, p. 69.
[10] U.S. Embassy, Rio de Janeiro, Brazil. State Department Dispatch 369, Oct. 31, 1961.

ects to determine the best reactor for shipping. Specifications were submitted for an advanced boiling-water reactor proposed by the Netherlands Nuclear Reactor Center.[11]

Euratom signed contracts with the Societa Elettronuclearia Nazionale (Italy) for a boiling-water reactor near Naples and with the Dutch Government for the Research Center at Petten.[12]

Research on radioactivity caused by atomic waste disposal at sea was undertaken by the Atomic Energy Agency at Monaco Scientific Center.[13]

Austria.—The nuclear research center at Seibersdorf, on the outskirts of Vienna, headquarters of IAEA, began operating Austria's first nuclear reactor. Built by American Machine and Foundry Co., it would enable scientists, for the first time, to study experiments as irradiation took place in the center of the reactor.[14]

Belgium.—The water-cooled nuclear reactor at Mol, owned and operated by Centre d'Étude de l'Énergie Nucleaire, went critical. Euratom will carry part of the $2.5 million operating costs, and the reactor will increase by almost 50 percent the free world's nuclear materials and testing capabilities.[15]

Construction of a plant for chemically reprocessing irradiated fuel at Mol was authorized by Eurochemie Co., and site development for proposed research laboratories was started.[16]

Finland.—Late in December, shipments of fuel for Finland's Triga Mark II training and research reactor were made from U.S. sources. This was the first transaction involving enriched fuel in which IAEA participated and consisted of 65 fuel elements and 3 fission counters. The fuel elements, enriched 20 percent, contained 2,500 grams of U^{235}.[17]

France.—Production in 1961 of 3,730 tons of uranium concentrate was reported by the Commissariate de L'Énergie Atomique. French mining districts contributed 1,480 tons of uranates (73.2 percent U_3O_8) and 1,200 tons of nitrate d'uranyle (29.5 percent U_3O_8). The remainder was obtained from uranothorianite from Malagasy and nitrate d'uranyle from Gabon.[18]

A reportedly rich deposit of uranium ore was discovered at Chanteloube (Haute Vienne Department), close to pits already being exploited and near the Bessines processing plant. The new deposit is said to be near the surface, and working it will necessitate diversion of the Gartempe River and cancellation of a projected improvement program on the Paris-Limoges road. This was requested by the French Atomic Energy Commission so that the deposit could be developed.[19]

Contracts were awarded for construction of a 242,000-kilowatt underground nuclear powerplant at Chooz, near the Belgian border, in the Ardennes region. Société d'Énergie Nuclaire Franco-Belge des Ardennes (SENA) received $8 million from Euratom toward financ-

[11] Foreign Commerce Weekly, v. 65, No. 10, Mar. 6, 1961, p. 39.
[12] Chemical Age, v. 86, No. 2194, July 29, 1961, p. 157.
[13] Chemical & Engineering News, v. 39, No. 12, Mar. 20, 1961, p. 49.
[14] Chemistry, v. 34, No. 7, March 1961, p. 9.
[15] Chemical Engineering, v. 68, No. 17, Aug. 21, 1961, pp. 156, 158.
[16] Chemical Trade Journal and Chemical Engineer, v. 149, No. 3867, July 14, 1961, p. 88.
[17] Chemical Age, v. 85, No. 2174, Mar. 11, 1961, p. 412.
[18] Engineering and Mining Journal, v. 163, No. 2, February 1962, p. 93.
[19] U.S. Consulate, Bordeaux, France. State Department Dispatch 75, Mar. 28, 1962.

ing the project. Électricité de France (the French national utility) and Centre et Sud (a group of six privately owned utilities) are co-owners of SENA. The closed-cycle water reactor was scheduled for completion in 1965.[20]

Germany, East.—It was reported that the East German-U.S.S.R.-owned uranium deposits near Erzegebirge in the Soviet Zone were almost exhausted and would be closed.[21]

Germany, West.—Because of possible radioactivity near Zeckern, the Geological Institute of the University of Erlangen decided not to exploit the newly found uranium deposits in the area.[22]

As part of the Atoms for Peace program, Mallinckrodt Nuclear Corp., St. Louis, Mo., was requested to supply 325 pounds of 20-percent enriched uranium for the pebble-bed reactor at Dusseldorf. This high-temperature, gas-cooled reactor uses fuel elements of graphite pebbles containing uranium carbide in the center. It was believed to be the first reactor of this type to go beyond the research stage and was scheduled to go into operation in 1963. Cost of the $9.6 million installation was to be divided equally between the West German Government and private industry.[23]

Atomics International Division of North America Aviation, Inc., was awarded the preliminary-design contract for a 150,000-kilowatt organic-reactor nuclear powerplant by the Baden-Wurttemberg Nuclear Power Plant Planning Association.[24]

One of two cobalt 60 large-scale radiating units was received at the Mineral Oil Research Institute at Hanover. Made in the United States, it had a 7,000-curie capacity and was to be used for developing radio-active processes for mineral oil processing and the petrochemical industry. A british-made unit of 5,000-curie capacity also was to be imported for comprehensive study of radioactive reactions. Purchase of the larger unit was financed by the West German Ministry for Nuclear Power and Water, and a German chemical company was to purchase the smaller unit.[25]

Hungary.—A newly established station at Mecsekalja, supplied with uranium ore from Fuenfkirchen, shipped approximately 350 tons daily to U.S.S.R. processing plants.[26]

Italy.—Fiat Co. and Ansaldo Shipyards, under contract with Euratom, planned to build a 50,000-ton nuclear-powered tanker. About 60 percent of the cost was to be paid by Fiat and Ansaldo, and 40 percent by Euratom.[27]

Netherlands.—The Dutch Government relinquished control of its high-flux nuclear reactor and testing facilities at Petten to Euratom. Euratom was to add additional research equipment and buildings, worth about US $11 million to the original US $7 million establishment within 3 to 5 years. The facility became the fourth under Euratom control.[28]

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[20] Chemical Engineering, v. 68, No. 22, Oct. 30, 1961, p. 149.
[21] Bureau of Mines. Mineral Trade Notes. V. 53, No. 4, October 1961, p. 61.
[22] Mining Journal (London), v. 256, No. 6563, June 2, 1961, p. 630.
[23] Chemical Week, v. 88, No. 9, Mar. 4, 1961, p. 48.
[24] Chemical Engineering, v. 68, No. 10, May 15, 1961, p. 206.
[25] Chemical Age, v. 85, No. 2181, Apr. 29, 1961, p. 699.
[26] Bureau of Mines. Mineral Trade Notes. V. 53, No. 4, October 1961, p. 61.
[27] Chemical & Engineering News, v. 39, No. 52, Dec. 25, 1961, p. 31.
[28] Chemical & Engineering News, v. 39, No. 33, Aug. 14, 1961, p. 75.

Norway.—Delivery of 1,000 fuel elements containing 3,102 pounds of uranium enriched to 3 percent was made to the Government of Norway in October, at New York, N.Y.[29]

Spain.—Andújar, Andalusia, was chosen as the location of Spain's first uranium treatment plant. Initially, the plant would treat 200 tons of local ore; later, 500 tons. The ore reserve of uranium metal was estimated at 1,500 tons of contained uranium.

Madrid's Colmenar Viejo region was declared a State reserve for the exploitation of radioactive minerals.[30]

Sweden.—Allis-Chalmers Manufacturing Co. received a design contract entailing a 56,000-kilowatt boiling-water nuclear powerplant for Aktiebolaget Atomkraftverck, to be built at Simpevarp.[31]

A/B Atomenergi was building a uranium extraction plant with an annual production capacity of 126 tons of uranium concentrate at Ransted near Skörcle. The new plant will treat about 850,000 tons of Bellingen shale, which contains about 300 grams of uranium per ton. The shale, after being crushed underground, will be concentrated by flotation and then treated with sulfuric acid.[32]

U.S.S.R.—The Soviet Union expected to have 2.5 million kilowatts of atomic-power-generating capacity by 1965.[33]

Two new atomic powerplants were under construction, at Belyy Yar and at Novo-Voronezh.[34] The latter is a redesigned U.S. type. The Belyy Yar plant, which superheats steam, has a graphite cylinder permeated with a multitude of thin-walled steel pipes which are coated with a uraniferous substance and encased in a steel sheath. Some of these channels heat and evaporate water, and others superheat steam to 450° C at 90 atmospheres of pressure. A third turbine for the proposed 70,000-kilowatt-capacity station was assembled at the Kirov Memorial plant, Khar'kov.[35]

United Kingdom.—On February 22, the low-power reactor VERA (Versatile Experimental Reactor Assembly) went into operation. By appropriate loadings, the composition and size of the reactor core may be varied to examine the nuclear importance of materials over a wide range of neutron energies.[36]

The first British company to enter the civilian nuclear fuel field, Nuclear Developments, Ltd., was formed by Imperial Chemical Industries, Ltd., Rolls Royce, Ltd., and Rio Tinto Co., Ltd. The new enterprise was licensed to make fuel elements for civilian reactors[37] and to process and manufacture nuclear fuel materials.[38]

ASIA

India.—India's main source of uranium ore, the Jadugudu (Bihar) deposits, was to be expanded, and a processing plant was to be erected

[29] U.S. Embassy, Vienna, Austria. State Department Dispatch 394, Nov. 17, 1961, 1 p.
[30] Canadian Mining Journal, v. 82, No. 3, March 1961, pp. 115–116.
[31] Chemical & Engineering News, v. 39, No. 31, July 31, 1961, p. 28.
[32] Bureau of Mines. Mineral Trade Notes. V. 54, No. 4, April 1962, p. 27.
[33] Annales de Minas. Les Relations Internationals dans la Domaine de l'Énergie Atomique. February 1962, pp. 65–66.
[34] Stroitel'naya Gazeta, Feb. 7, 1962, p. 4.
[35] Ekonomicheskaya Gazeta, May 31, 1961, p. 6.
[36] Chemistry & Industry (London), No. 11, Mar. 18, 1961, p. 348.
[37] Chemical Week, v. 88, No. 17, Apr. 19, 1961, p. 26.
[38] Chemical Trade Journal and Chemical Engineer, v. 149, No. 3871, Aug. 11, 1961, p. 320.

in the vicinity. The expansion was expected to take care of the country's future atomic energy demands.[39]

The Department of Atomic Energy explored newly found uranium deposits in the Udaipur district of Rajasthan.[40]

A proposal to duplicate Canada's 200,000-kilowatt Douglas Point nuclear powerplant in the general area of East Punjab-Delhi-Rajasthan was under consideration.

Japan.—Japan's Atomic Energy Commission anticipated that by 1970, 1 million kilowatts of electric power would be generated from nuclear reactors, and that by 1980, 7 to 9.5 million kilowatts would be so generated.

Early in 1961, the Commission adopted a 20-year program for development and utilization of the resultant energy. The program included (1) use of radioisotopes in manufacturing processes, agriculture, and medicine; (2) construction of a nuclear-powered ship; (3) development of technology for enriching uranium and utilizing plutonium, as well as development of overseas nuclear fuel resources; (4) budgeting of $500 million to $555.5 million within the next 10 years for atomic energy research and increasing the number of Japan's scientists and engineers; and (5) insuring safe operation of all reactor stations by a safety screening program for all nuclear reactor designs and a state inspection system for nuclear plants.[41]

Orders for a uranium-base alloy (11 to 45 percent uranium and 55 to 89 percent iron) were being placed with the producers, Mitsubishi Metal Mining Co. The new alloy has effects similar to those of certain ferroalloys in the production of special steels. Mitsubishi makes the alloy at a lower cost than Japan could import it.[42]

The Togo mine in Katamo, Tottori Prefecture, Southern Honshu, was reported to be one of the world's richest uranium mines.[43] The mine was said to have a reserve of about 22,000 tons.[44]

Taiwan.—The General Electric Co. Atomic Power Equipment Department, San Jose, Calif., shipped 35 uranium fuel elements for use in Taiwan's first nuclear reactor, at the National Tsing-Hua University, Hsinchu. The reactor is of the open-pool type.[45]

Turkey.—Aerial surveys indicated possible uranium ore deposits in Aydin, Cine, Kocardi, and Milas.

AFRICA

Gabon Republic.—The Compagnie de Mines d'Uranium de Franceville mine at Mouana, near Franceville, began producing in March 1961, and the first shipment was dispatched to Pointe Noire. Complete output was intended for the French Atomic Energy Commission. The mine, one of France's most important sources of uranium, was expected to provide one-fourth of France's uranium needs in its first years of operation.[46] In 1961, 1,068 short tons of concentrate, averaging 30 percent U_3O_8, was produced.

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[39] Mining Journal (London), v. 256, No. 6563, June 2, 1961, p. 630.
[40] Mining Magazine, v. 105, No. 1, July 1961, p. 37.
[41] Chemical Engineering, v. 68, No. 6, Mar. 20, 1961, pp. 96, 98.
[42] Japan Metal Bulletin, Oct. 26, 1961, p. 2.
[43] Mining Gazette, v. 6, No. 4, April 1961, p. 91.
[44] Industrial Review of Japan, v. 6, 1961, p. 282.
[45] Chemical Week, v. 88, No. 9, Mar. 4, 1961, p. 48.
[46] Mining Journal (London), v. 257, No. 6580, Sept. 29, 1961, p. 317.

Malagasy Republic.—Approximately 515 tons of uranothorianite averaging 18.9 percent U_3O_8 and 57 percent thorium oxide was supplied to France by the Malagasy Republic for the production of uranium concentrate.[47]

Union of South Africa.—Production of uranium concentrate (U_3O_8 content) in the Union of South Africa was 5,468 tons during 1961. Exports for the period totaled 5,719 tons.[48]

Under the Combined Development Agency, the U.S. AEC was obligated to purchase 18,900 tons of U_3O_8 through the end of 1966 at $11.80 per pound. A new contract between AEC and the South African Atomic Energy Board (AEB) remained virtually the same except that a small quantity of the material meant for delivery in 1961–62 would be delivered after 1962, and the price was to be about 60 cents less per pound. Individual mine production quotas were changed from high-cost to low-cost producers owing to the stretchout. Four uranium plants were closed, but it was expected that, where uranium oxide was the principal product, operators of gold mines would continue to treat the accumulated uranium residue.[49]

Two of the closed plants were the Welkam and the President Steyn, of the Orange Free State Joint Production Scheme, which had treated the slimes from President Brand, Freddies Consolidated, Loraine, Free State Geduld, and the Western Holdings, in addition to their own. All produced low-grade ore.

The small production of high-grade ore from the closed Caal Reefs plant was to be treated by the Western Reefs plant.

The Stilfontain plant, with four other contributors, also was closed. Ore from its own holdings was low grade and high cost; the Ellaton contributor was a small operation on the brink of closing, Afrikander was a primary-uranium producer that yielded insufficient gold to operate profitably, New Klerksdorp was a small primary-uranium producer, and Babrosco was contributing only dump slimes.[50]

A new deposit of high-grade uranium was discovered in the Namib Desert near the Walue's Bay-Usakos rail line.[51]

Collaboration between the gold-mining industry and AEB culminated in the commissioning of South Africa's first uranium-refining pilot plant, situated at the Government Metallurgical Laboratories in Johannesburg. The plant will have a 100-ton-a-year capacity and will give basic information for the manufacture of refined uranium metals and the development of nuclear energy. Nuclear fuels produced are to be tested in a proposed reactor at Pelindaba. Refining the ore will enable South Africa to sell uranium metal and salts, as well as the oxides.[52]

United Arab Republic (Egypt).—Two Ilyshin-14 planes were acquired from the U.S.S.R. to make further aerial magnetic reconnaissance surveys of the Egyptian deserts.[53]

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[47] Engineering and Mining Journal, v. 163, No. 2, February 1962, p. 93.
[48] U.S. Embassy, Johannesburg, Republic of South Africa. State Department Dispatch 390, Mar. 14, 1962, p. 5.
[49] Mining World, v. 23, No. 3, March 1961, p. 67.
[50] U.S. Consulate General, Johannesburg, Republic of South Africa. State Department Dispatch 7, July 7, 1961, p. 29.
[51] Mining Magazine, v. 104, No. 4, April 1961, p. 230.
[52] South African Mining and Engineering Journal, v. 72, pt. 1, No. 3558, Apr. 14, 1961, pp. 793. 795.
[53] Engineering and Mining Journal, v. 162, No. 3, March 1961, p. 157.

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Construction in Egypt of an 80- to 100-megawatt atomic powerplant was again discussed by West German experts with the UAR Atomic Energy Establishment at Cairo.[54]

OCEANIA

Australia.—The Sterrits workings of the Alligator mine were found early in the year to have additional tonnages of uranium; these were treated at the reopened Rockhole treatment plant for shipment to Britain.[55]

Rio Tinto Co. of Australia felt that, after expiration of the United Kingdom Atomic Energy contract, it would be difficult to maintain profits at the Mary Kathleen mine. Depletion of the reserve was expected in 9 years, and Rio Tinto was considering other areas, particularly the copper fields surrounding the Mary Kathleen, for diversification.[56]

The Australian Government decided to continue, under the operation of Territory Enterprises Pty. Ltd., to work Rum Jungle's newly discovered lode in the Northern Territory. The new ore supply may not be drawn upon for sale at competitive prices until after the present reserve is exhausted, presumably in 1963. The new reserve was established by diamond drilling, and the tonnage was reported to be comparable to that already mined. Open-pit mining by contract was being considered.[57] The output would be treated at the existing Rum Jungle plant.

Although the Government, in March, ceased paying for new discoveries of uranium, it continued aerial geophysical prospecting in several parts of the country. A total of £92,950 (US $208,208) had been paid to individual prospectors and syndicates since the inception of the awards program.

Tax concessions on the mining and treatment of ore were to be extended to June 30, 1968, according to a Government announcement.[58]

Ore production at the Government-owned Radium Hill mine in South Australia ceased on December 15, owing to the diminished ore reserve, lack of markets, and high cost of production. Closing of the Radium Hill concentrating plant and the Port Pirie chemical treatment plant was to be effected as soon as the material on hand had been processed and treated.[59] Group Ventures N.L., a new company formed by United Uranium N.L. and South Alligator Uranium N.L., planned to exploit mineral deposits other than uranium in the Northern Territory so that activities of the parent companies could continue. Formation of the new company resulted partly from an imbalance of supply under the United Kingdom Atomic Energy contract. South Alligator, with an ample ore reserve and no outlet, was to complete its contract early in 1962, whereas United Uranium, whose contract was for a much greater tonnage through 1965, was expected to deplete its ore by June 1962.[60]

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[54] Foreign Commerce Weekly, v. 66, No. 12, Sept. 18, 1961, p. 4.
[55] Queensland Government Mining Journal, v. 62, No. 719, September 1961, p. 459.
[56] Mining Journal (London), v. 256, No. 6556, Apr. 14, 1961, p. 419.
[57] Mining Journal (London), v. 256, No. 6555, Apr. 7, 1961, p. 377.
[58] Metal Industry, v. 98, No. 11, Mar. 17, 1961, p. 215.
[59] Mining Journal (London), v. 257, No. 6585, Nov. 3, 1961, p. 456.
[60] Financial Standard (Melbourne), v. 117, No. 2939, Sept. 27, 1961, pp. 35, 37.

DOMESTIC RESERVES

As of December 31, 1961, the estimated domestic uranium reserve was 74 million tons containing 0.28 percent U_3O_8, a decrease of about 8 million tons from the previous yearend estimate. In addition, approximately 1.3 million tons of ore was in Government and private stockpiles. Domestic ore reserves were being reviewed by AEC in the light of new information developed in the course of mining.

TECHNOLOGY

Investigations indicated that the uranoorganic association in hydrothermal deposits of the Colorado Plateau resulted from a hydrothermal source for the original uranium ions rather than from asphalites.[61]

The use of infrared aerial photography for detecting radioactive mineralized areas had not proven as practicable as first suggested.[62]

Improved techniques of earthmoving proved beneficial to uranium open-pit mining and their applications were described in two articles.[63] The application of a rotary oil-well-drilling rig to the sinking of a 72-inch-diameter, 710-foot-deep ventilation shaft at the New Mexico uranium mine of Kermac Nuclear Fuels Corp. proved successful and rapid.[64] Geology and its application to uranium mining and mining problems at the Pitch mine of Pinnacle Exploration, Inc., in Colorado[65] and at the Lance's Uranium mines of the Sabre-Pinon Corp. in New Mexico[66] were the subjects of comprehensive articles.

Canadian studies of the preconcentration of uranium ores prior to hydometallurgical treatment showed that the fatty acid flotation process may have economic advantages during periods of reduced demand for uranium.[67] By preconcentration, the processing cost per pound of uranium for some ores may be cut by sacrificing the percent recovery.

Improved extraction of uranium from ores in the acid-leaching process by the addition of wetting agents was announced by Cyanamid International Corp.[68]

The commercial recovery of scandium as a byproduct of uranium extraction and the production of high-purity scandium oxide were expected to open new sources of scandium and assist the uranium industry.[69]

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[61] Abdel-Gawad, A. M., and Paul F. Kerr. Urano-Organic Mineral Association. Am. Mineralogist, v. 46, Nos. 3–4, March–April 1961, pp. 402–419.

[62] Winkler, Erhard M., and Barry Voight. Scientific Communications. Econ. Geol., v. 56, No. 1, January–February 1961, pp. 211–212.

[63] Bogert, John R. Ore Requirements. Min. World, v. 23, No. 4, April 1961, pp. 14–16. Grant, Norman A. Modern Open-Pit Mining. Mines Mag., v. 50, No. 4, pp. 15–17.

[64] Wolff, P. A., and R. K. Pertile. How Kerr-McGee Drilled 90-Inch Ambrosia Lake Ventilation Shaft. Min. World, v. 23, No. 3, March 1961, pp. 34–37.

[65] Baker III, Arthur, and Bill C. Scott. Past Problems, Present Purpose at Pitch. Min. Eng., v. 13, No. 5, May 1961, pp. 488–491.

[66] Fitch, Richard. Let's Look at Lance's Uranium Mines. Min. World, v. 23, No. 11, October 1961, pp. 23–27.

[67] Light, D. E., C. A. Freitag, G. B. Hudson, and E. J. Nurse. The Flotation of Radioactive Minerals, Part II. Canadian Min. and Met. Bull., v. 55, No. 597, January 1962, pp. 30–34.

[68] South African Mining and Engineering Journal. How To Scuttle a Duck—and Increase Uranium Production. V. 72, pt. 2, No. 3576, Aug. 18, 1961, p. 391.

[69] Lash, L. D., and J. R. Ross. Scandium Recovery From Uranium Solutions. J. Metals, v. 13, No. 8, August 1961, pp. 555–558.

The extraction of uranyl nitrate from slurries by tributyl phosphate in kerosine with a rotary-film contactor was described in a report.[70] Uranium recoveries were excellent and, even with a recovery of 99 percent of the uranium, solvent losses were moderate.

High-purity magnesia-alumina spinel was found to be one of the best refractories from which to fabricate induction containers for the process of magnesium reduction of uranium tetrafluoride because of its inertness toward reactants and products.[71] Refractories made from hexaboron silicide were capable of withstanding 2,500° F in air for use as control devices and shielding structures in nuclear reactors.[72]

Uranium dioxide for reactor fuel elements of improved quality can be obtained by reducing aqueous slurries of uranyl carbonate at elevated temperature with compressed hydrogen in the presence of metal catalysts and certain organic promoters.[73] Articles describing new and improved techniques for fabricating and coating uranium fuel particles, such as uranium carbide and uranium oxide, with beryllium, graphite, and zirconium carbide were published during 1961.[74]

The Tokai refining plant of Atomic Fuel Corp. of Japan discovered that metallic uranium could be obtained by a direct-refining technique using an amine. The new method was said to be simpler and less bulky, as well as cheaper and faster, than the commonly used method.[75]

Higher purity plutonium with a greatly reduced neutron radiation exposure during production was obtained by ultilizing the chloride rather than the fluoride compound.[76] The technique of preparing and reducing plutonium trichloride, though known since 1944, had not been previously developed for industrial use. Solutions were given to problems of integrating a nuclear power station into utility systems and the performance of the radioactive waste disposal system of the Shippingport atomic power station.[77]

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[70] Beaumont, J. H., J. M. Cox, D. G. Grant, A. A. North, and A. D. Sperrin. Development of a Rotary-Film Contactor for the Solvent Extraction of Metals From Slurries, Part II, The Extraction of Uranyl Nitrate by Tributyl Phosphate in Kerosene. N.C.L./A.E. Sci. Rept. 209, December 1961, 11 pp.

[71] Arenberg, C. Arne, Carl W. Boquist, and O. R. Magoteaux. Refractories for Uranium Reduction. Am. Ceram. Soc. Bull., v. 40, No. 5, May 15, 1961, pp. 304–308.

[72] Colton, Ervin. Hexaboron Silicide, Promising Material in Nuclear Control Devices. Ceram. Ind., v. 76, No. 3, March 1961, pp. 70–71.

[73] Warren, I. H., and F. A. Howard. Hydrometallurgical Production of Uranium Dioxide for Reactor Fuel Elements. Canadian Min. and Met. Bull., v. 54, No. 594, October 1961, pp. 743–749.

[74] American Metal Market. GE Develops Wire Type Fuel With Uranium Oxide. V. 68, No. 61, Mar. 30, 1961, p. 14.

Ceramic Industries. Fossil Fuel Economy Promised by New Fuel Particles. V. 77, No. 1, July 1961, p. 32.

Chemical & Engineering News. Beryllium Oxide Protective Coatings on Nuclear Fuel Elements Are Now Possible. V. 39, No. 21, May 22, 1961, p. 39.

Stephas, Paul, and E. W. Hoyt. Reactive Hot Pressing of ZrC–UC Solid Solution. Am. Ceram. Soc. Bull., v. 40, No. 5, May 15, 1961, pp. 320–323.

[75] Chemical Ave, v. 86, 2191, July 8, 1961, p. 59.

[76] Rasmussen, M. J., and H. H. Hopkins, Jr. Preparing Plutonium Metal—via the Chloride Process. Ind. and Eng. Chem., v. 53, No. 6, June 1961, pp. 453–457.

[77] Abrams, C. S., W. J. Hahn, and J. R. LaPointe. Performance of the Radioactive Waste Disposal System of the Shippingport Station. Chem. Eng. Prog., v. 58, No. 1, January 1962. pp. 70–78.

Duvall, F. C. Operation of the Shippingport Atomic Power Station. Chem. Eng. Prog., v. 57, No. 3, pp. 46–49.

The substantial contribution to high-temperature metals and nuclear technology made by the investigations utilizing nuclear propulsion in aircraft and space was described.[78]

Small quantities of uranium as alloying additions to steel were reported to improve the fatigue life, delay rupture and reduce the acid-corrosion rate.[79] Investigations also were being carried out on uranium additions to cast iron, copper, aluminum, magnesium, and zinc-base alloys.

During 1961 the Bureau of Mines published reports dealing with the disposal of liquid radioactive wastes from uranium mills,[80] uranium-mining costs and practices[81], beneficiation of uranium ores,[82] and the high-temperature heat content of uranium tetrafluoride.[83]

To enhance the basic knowledge of the structure of matter and develop new knowledge of the universe, more powerful "atom-smashers" were constructed or planned. The construction and operation of the Brookhaven National Laboratory's Alternating Gradient Synchrotron was described.[84] Stanford University and the National Bureau of Standards initiated programs which will lead to the installation of large linear accelerators.[85] A tandem ion accelerator for studies in low-energy nuclear physics at the University of Pennsylvania was under consideration.[86]

Carbon 12 was adopted as the new standard for atomic weights, replacing oxygen which gave a difference of 3 parts in 10,000 in atomic weights owing to the existence of three natural isotopes.[87]

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[78] Hendry, W. J., and Walter J. Koshuba. Nucleonics in Flight. Metal Prog., v. 80, No. 2, August 1961, pp. 132, 134, 138, 139, 142, 144.
McGuire, Frank G. Crucial Rover Rocket Program Picks Up. Missiles and Rockets, v. 9, No. 7, Aug. 14, 1961, pp. 22–23, 45.
Hendel, F. J. Exotic Rocket-Propulsion Systems. Chem. Eng., v. 68, No. 15, July 24, 1961, pp. 135–142.

[79] Gertsman, S. L. Can Uranium Improve Steel? Iron Age, v. 187, No. 14, Apr. 6, 1961, pp. 110–111.

[80] Tame, K. E., E. G. Valdez, and J. B. Rosenbaum. Disposal of Liquid Waste in the Durango-Type Uranium Milling Flowsheet. BuMines Rept. of Inv. 5874, 1961, 12 pp.

[81] Dare, W. L. Uranium Mining in the Lukachukai Mountains, Apache County, Ariz., Kerr-McGee Oil Industries, Inc. BuMines Inf. Circ. 8011, 1961, 30 pp.
Dare, W. L. Uranium Mining Methods and Costs at Several Mines on the Colorado Plateau. BuMines Inf. Circ. 8015, 1961, 48 pp.

[82] Tame, K. E., and J. B. Rosenbaum. Beneficiation of Uranium Ores. BuMines Rept. of Inv. 5884, 1961, 28 pp.

[83] King, E. G., and A. U. Christensen. High-Temperature Heat Content of Uranium Tetrafluoride. BuMines Rept. of Inv. 5709, 1961, 4 pp.

[84] Engineering Journal. World's Most Powerful Atom Smasher. V. 44, No. 1, January 1961, pp. 73, 97.

[85] Business Week. Contracts to RCA and Sperry for Work on Big Atom Smasher. No. 1644, Mar. 4, 1961, p. 47.
Chemistry. Atom Smasher. V. 34, No. 6, February 1961, p. 37.

[86] Chemistry. Million-Dollar Atom Smasher. V. 34, No. 6, February 1961, p. 18.

[87] Chemical & Engineering News. A New Standard for Atomic Weights, and Differences Between Surface and Bulk Compositions. V. 39, No. 33, Aug. 14, 1961, p. 51.

Vanadium

By Richard F. Stevens, Jr.[1] and Claudia V. Davis [2]

THE YEAR 1961 marked substantial changes in the pattern of the vanadium industry. World production was the highest on record, an increase of 22 percent compared with 1960, and, although the United States produced 7 percent more, it exported 43 percent less. Apparently, other countries captured part of the market previously held by the United States, and the market for vanadium in the Soviet bloc countries was satiated in the latter part of the year. Interest in research on high-purity vanadium declined, but efforts to develop better vanadium-bearing alloys were intensified.

TABLE 1.—Salient vanadium statistics

(Short tons of contained vanadium)

	1952–56 (average)	1957	1958	1959	1960	1961
United States:						
Production:						
Ore and concentrate processed	4,677	7,307	6,829	8,026	8,800	6,772
Recoverable vanadium [1]	3,161	3,691	3,030	3,719	4,971	5,343
Value—thousands	(2)	(2)	$10,817	$13,278	$17,748	$19,076
Vanadium pentoxide	3,086	3,612	2,791	4,092	5,495	5,817
Imports:						
Ore and concentrate	234	----	----	3	3	----
Exports:						
Ferrovanadium and other vanadium alloying materials containing over 6 percent vanadium (gross weight)	[3] 131	134	76	152	162	120
Vanadium pentoxide, vanadic oxide, vanadium oxide, and vanadates [4]	376	500	631	1,240	3,690	2,081
World: Production	4,024	4,275	4,235	5,321	7,090	8,650

[1] Measured by receipts at mills.
[2] Figures withheld to avoid disclosing individual company confidential data.
[3] Classified as ferrovanadium, 1952.
[4] Classified as ore and concentrate, 1952, but probably included vanadium pentoxide.

LEGISLATION AND GOVERNMENT PROGRAMS

During 1961, the General Services Administration (GSA) sold 7,277 short tons of lead vanadate ores and concentrates for $201,991, ($0.014 a pound) and 35,343 pounds of fused vanadium pentoxide for $23,856.52, ($0.675 a pound).[3]

[1] Commodity specialist, Division of Minerals.
[2] Statistical clerk, Division of Minerals.
[3] Office of Emergency Planning, Executive Office of the President. Stockpile Report to the Congress, January–June 1961, p. 9.

Bids were opened in January on 1.5 million pounds (750 tons) of vanadium pentoxide (V_2O_5) offered for sale by the Atomic Energy Commission Grand Junction office. However, only 570 tons of the concentrate was sold; Union Carbide Metals Co., Division of Union Carbide Corporation, obtained 424 tons, Vanadium Corporation of America obtained 98 tons, and Derby and Company obtained 48 tons. The average sales price was $1.011 per pound. A bid of $0.91 per pound for 180 tons was rejected.[4]

DOMESTIC PRODUCTION

Most of the vanadium produced domestically during 1961 was obtained as a byproduct of uranium mining. However, since all contracts by the Atomic Energy Commission (AEC) for the purchase of uranium ore were to expire December 31, 1966, and the AEC gave no indication that it would buy uranium after that date, many vanadium producers sought new sources.

Susquehanna Minerals Company constructed a refinery at Magna, Utah, to recover high-purity vanadium pentoxide (V_2O_5 from ferrophosphorus slag, mostly waste from phosphorus production operations. This refinery began producing vanadium late in 1961.[5] A second refinery to recover vanadium from ferrophosphorus slag was planned by Kermac Nuclear Fuels Corp.[6] Early research on methods of recovering vanadium from ferrophosphorus slag was conducted by the Bureau of Mines.[7]

TABLE 2.—Recoverable vanadium in ore and concentrate produced in the United States, by States

(Short tons of contained vanadium)

State	1952–56 (average)	1957	1958	1959	1960	1961
Colorado	2,343	3,132	2,395	2,949	4,026	4,149
Utah	325	508	376	536	462	514
Arizona and other States [1]	493	51	259	234	483	680
Total	3,161	3,691	3,030	3,719	4,971	5,343

[1] Includes Idaho, 1952–54, 1961: Montana, 1957; New Mexico, 1952–54, 1956–61; South Dakota, 1954, 1960–61; and Wyoming 1954, 1956–58, 1960–61.

Oxide.—Production of vanadium pentoxide increased 6 percent compared with 1960. As in 1960, six plants produced vanadium pentoxide from domestic ores, but, in addition, the Susquehanna Minerals plant at Magna, Utah, extracted vanadium pentoxide from ferrophosphorus slag that originated at a plant treating domestic phosphate rock ores in Idaho. Data in table 4 include vanadium pentoxide produced as a byproduct of foreign chromium ores, 1952–61; produced from peruvian concentrate, 1952–55, produced as a by-

[4] Atomic Energy Commission. Public Sale of Vanadium Pentoxide, Major Activities in the Atomic Energy Programs, January–December 1961. January 1962, p. 174.
[5] Engineering and Mining Journal. Garfield, Utah, Plant Begins Producing V_2O_5. V. 162, No. 9, September 1961, p. 125.
[6] Mining World. What's Going on in Mining—Idaho. V. 24, No. 3, March 1962, p. 51.
[7] Banning, L. H., and R. T. C. Rasmussen. Processes for Recovering Vanadium From Western Phosphate. BuMines Rept. of Inv. 4822, 1951, 44 pp.

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
1952–56 (average)	4,756	3,161	1959	7,392	3,719
1957	7,294	3,691	1960	8,047	4,971
1958	7,266	3,030	1961	6,359	5,343

[1] Measured by receipts at mills.

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
1952–56 (average)	6,236	5,510	1959	7,906	7,305
1957	7,224	6,449	1960	10,767	9,812
1958	5,470	4,983	1961	[2] 10,796	10,520

[1] Includes a relatively small quantity recovered as a byproduct of Peruvian concentrate and foreign chromium ore.
[2] Does not include weight of ferrophosphorus slag treated as solutions.

product of domestic phosphate rock, 1952–54; and also produced from ferrophosphorus slags in 1961.

Ferrovanadium.—Ferrovanadium was produced in the United States principally by Vanadium Corporation of America, Union Carbide Metals Co., and Shieldalloy Corp. Output in 1961 was slightly less than in 1960.

Vanadium Metal.—The domestic industry reported only 7 tons of high-purity vanadium (99 percent plus) produced in 1961. This was 22 tons less than in 1960. Although it does not yet stand out in the alloy statistics, the decrease probably reflects the success of research in producing acceptable vanadium alloys for specialty uses without using high-purity vanadium.

CONSUMPTION AND USES

Ore and Concentrates.—Domestic and foreign vanadium-bearing ores and concentrates consumed at domestic plants contained 6,772 tons of vanadium, 2,028 tons less than was in the ores and concentrates processed in 1960.

Alloys and Compounds.—Coincidentally, the domestic industry reportedly consumed the same quantity of ferrovanadium in 1961 as in 1960. Steelmakers, although they reported the same total quantity of vanadium consumed, indicated that they used 6 percent less in high-speed steel, 23 percent less in tool steel, and 10 percent more in other alloy steels than in 1960. As heretofore, this division in uses may not be precise because the steelmakers do not always classify their pro-

ducts the same way. The concerns producing nonferrous vanadium-bearing alloys reported that they used about 13 percent more vanadium in 1961 than in 1960. This increase continued to reflect researchers' success in developing vanadium-bearing alloys in the last few years.

TABLE 5.—Vanadium consumed and in stock in the United States in 1961, by forms

(Short tons of vanadium)

Form	Stocks at consumer plants, Dec. 31, 1960	Consumption	Stocks at consumer plants, Dec. 31, 1961
Ferrovanadium	259	1,488	262
Oxide	24	143	108
Ammonium metavanadate	29	84	17
Other	63	300	68
Total	375	2,015	455

TABLE 6.—Vanadium consumed in the United States in 1961, by uses

Use	Short tons	Use	Short tons
Steel:		Steel—Continued:	
High-speed	275	Gray and malleable castings	17
Hot-work tool	79	Nonferrous alloys	298
Other tool	68	Chemicals	116
Stainless	28	Other	45
Other alloy [1]	1,018		
Carbon	71	Total	[2] 2,015

[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 statistics on the inventory of vanadium ore, concentrate, or pentoxide held at primary producers' plants. Consumer stocks on December 31, 1961 were 21 percent more than on December 31, 1960.

The National (strategic) stockpile inventory on December 31, 1961 was 7,965 short tons of contained vanadium; this included 989 short tons of upgraded ferrovanadium.

PRICES

The prices of vanadium pentoxide, ferrovanadium, and vanadium metal remained constant during 1961, but the base price for high-purity vanadium was reduced slightly from the price quoted in 1960.

Vanadium pentoxide contained in ore was quoted at 31 cents per pound. This quotation disregards penalties based upon the grade of ore or the presence of objectionable impurities, such as lime, which lower recovery because of their adverse reactions during refining operations.

The quoted price of technical grade vanadium pentoxide was $1.38 per pound of V_2O_5; the price of ferrovanadium ranged from $3.20 to $3.40 per pound of contained vanadium, depending upon the grade of the alloy. Vanadium (90 percent purity) for alloying, in 100-pound lots, ranged from $3.45 to $3.65 per pound. High-purity vanadium (over 99 percent vanadium) was quoted at $30 per pound (99.5 percent) and $35 per pound (99.8 percent) in 1,000-pound lots.

Quantity extras were quoted as follows:

Less than 5 pounds	Base price+$13 per pound
5–25 pounds	Base price+$3 per pound
26–100 pounds	Base price+$1 per pound
101–1,000 pounds	Base price+$0.50 per pound
Over 1,000 pounds	Base price

FOREIGN TRADE[8]

The substantial export trade in vanadium oxides that the United States enjoyed in 1959 and 1960 was sharply curtailed owing to lessened activity in the ferroalloy industries in Europe and the Soviet bloc countries. Shipments of vanadium pentoxide through Austria stopped almost completely, and those through the Netherlands were 75 percent less than in 1960. Shipments to Sweden were 66 percent less, to France 31 percent less, and to West Germany 18 percent less. However, Belgium-Luxembourg received over 1 million pounds of vanadium contained in concentrate and oxides in 1961, compared with only 50,000 pounds in 1960. The ferroalloy industry in Japan apparently continued to depend on the United States for its supply of vanadium as it received 22 percent more vanadium from the United States than in 1960.

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

TABLE 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 oxide, vanadium oxide, and vanadates (except chemically pure grade) (vanadium content)		Vanadium flue dust and other vanadium waste materials (vanadium content)	
	1960	1961	1960	1961	1960	1961
North America:						
Canada	290,962	230,503	8,851	15,689		
Mexico		500	7,369	5,208		
Nicaragua			61			
Total	290,962	231,003	16,281	20,897		
South America:						
Argentina		278	392	100		
Brazil			2,914	4,964		
Chile	6,050		196	246		
Total	6,050	278	3,502	5,310		
Europe:						
Austria			3,125,590	249,091		
Belgium-Luxembourg	220		50,489	[1] 1,080,864	3,472	38,391
Czechoslovakia			61,711	54,661		
France	2,205	1,675	659,579	455,150		
Germany, West		928	533,581	438,806		10,080
Italy			190,147	143,638		
Netherlands	23,358	43	1,702,777	409,614	70,593	135,427
Norway		600				
Spain				410		
Sweden		331	249,821	86,244		
Switzerland	114					
Trieste				37,240		
United Kingdom	300	567	28	223,631		
Total	26,197	4,144	6,573,723	3,179,349	74,065	183,898
Asia:						
Hong Kong		144				
India			956	1,286		
Japan		660	784,970	955,136	3,769	425
Pakistan		1,120				
Philippines		2,000				
Viet-Nam		200				
Total		4,124	785,926	956,422	3,769	425
Grand total:						
Quantity	323,209	239,549	7,379,432	[1] 4,161,978	77,834	184,323
Value	$506,624	$436,208	$14,123,653	[1] $7,657,955	$59,389	$29,077

[1] Adjusted by Bureau of Mines.

Source: Bureau of the Census.

WORLD REVIEW

Australia.—Geologists of Union Carbide Corp. investigated and evaluated vanadium resources in western Australia.[9]

Finland.—Finland produced approximately 7 percent of the world's vanadium, most of which was consumed by the steel industries of continental Europe.[10]

[9] Mining World. Oceana—Union Carbide Prospecting Big Australian V_2O_5 Deposits. V. 23, No. 1, January 1961, p. 58.

[10] Engineering and Mining Journal. Finland. V. 162, No. 2, April 1961, p. 166.

Germany, West.—Gesellschaft fur Elektrometallurgie mbH, a West German metallurgical company, announced the development of a new process for producing high-purity (99.9 percent) vanadium in large quantities. The process, described as chemical and metallothermal, is based upon extraction of vanadium from vanadic acid under pressure at high temperature.[11]

TABLE 8.—World production of vanadium in ores and concentrates, by countries[1]

(Short tons)

Country	1952-56 (average)	1957	1958	1959	1960	1961
North America: United States (recoverable vanadium)	[2] 3,161	3,691	3,030	3,719	4,971	5,343
South America:						
Argentina	([3])	2	4	4	([4])	([4])
Peru (content of concentrate)	227					
Europe: Finland	[5] 43	290	430	556	625	[6] 630
Africa:						
Angola	[7] 12	1	20	3		
Rhodesia and Nyasaland, Federation of: Northern Rhodesia (recovered vanadium)	10					[6] 110
South-West Africa (recoverable vanadium)	571	283	435	719	838	1,145
Union of South Africa (Transvaal)		8	316	320	656	1,422
World total (estimate)[1 8]	4,024	4,275	4,235	5,321	7,090	8,650

[1] This table incorporates some revisions.
[2] Includes vanadium recovered as a byproduct of phosphate-rock mining, 1952–54.
[3] Less than one ton.
[4] Data not available.
[5] One year only, as 1956 was the first year of commercial production.
[6] Estimate.
[7] Average annual production 1955–56.
[8] Total represents data only for countries shown in table and excludes vanadium in ores produced in Congo, Republic of the (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 Pearl J. Thompson, Division of Foreign Activities.

The West German Government required that all shipments of ferroalloys into the country be accompanied by a certificate of origin to prevent ferromolybdenum and ferrovanadium of Soviet bloc origin from entering freely via other western countries (for example, Canada).[12]

Union of South Africa.—Production of vanadium in South Africa increased steadily during 1961 as a result of expansion at the vanadium production plant at Witbank of the Anglo-American Corporation of South Africa, Ltd. All vanadium produced in South Africa was shipped to Europe.[13]

TECHNOLOGY

The Bureau of Mines continued research on the production of high-purity vanadium alloys during 1961. Some of the work was directed to the determination of physical and mechanical properties of vanadium and its alloys. The open-vessel method of reducing vanadium metal from vanadium pentoxide was successfully scaled up to produce

[11] Mining Journal (London). U.S. Uses More Vanadium. V. 256, No. 6549, Feb. 24, 1961, pp. 223–224.
[12] U.S. Embassy, Bonn, Germany, State Department Dispatch 897, Jan. 4, 1962.
[13] U.S. Embassy, Pretoria, South Africa, State Department Dispatch 175, Oct. 25, 1961.

15-pound ingots; eventually, 50-pound ingots of vanadium and vanadium alloys were to be made.

Chemical and galvanic corrosion tests conducted by Bureau metallurgists on high-purity vanadium and vandium-base alloys indicated that although vanadium has good corrosion resistance to sulfuric and hydrochloric acids at 35° and 60° C., the metal corrodes rapidly in nitric acid, 20-percent ferric chloride, and 5-percent mercuric chloride solutions.[14]

During 1961, Bureau scientists reported the investigation and development of metallic reduction of vanadium chloride as a new method for preparing vanadium metal adaptable to large-scale plant production operation.[15]

Metal produced by the metallic reduction method was consolidated into ingots in a consumable-electrode arc furnace designed for use with high-melting-point metals.[16]

Bureau metallurgists conducted investigation of the physical and mechanical properties of electrorefined vanadium to evaluate the workability, recrystallization, characteristics, and effect of interstitial elements. The study revealed that the properties of high-purity vanadium were greatly affected by small quantities of the interstitially soluble nonmetallic elements oxygen, nitrogen, and carbon. This study indicated that the strength and hardness of electrorefined vanadium are functions of the oxygen content.[17]

Thermodynamics was another field studied and reported on by Bureau scientists during 1961. Data reported were more accurate than previously available information. The heat-of-formation and free energy values were determined for four oxides of vanadium.[18]

Accurate thermodynamic data were also obtained on three sodium vanadates. This basic thermodynamic information will allow accurate calculations of metallurgical reactions involving interoxidic vanadium compounds.[19]

Vanadium was considered for use in medicine as a cure for hardening of the arteries. When tested on rabbits, vanadium in the form of vanadium salts stopped hardening by preventing fatty deposits from accumulating on the artery walls.[20]

Oregon Metallurgical Corp, reported successful preparation of more than 55,000 pounds of high-purity vanadium. The metal was obtained by bomb reduction of high-purity vanadium chloride and was then consolidated into ingot forms by arc-melting. The corporation

[14] Schlain, D., C. Kenahan, and W. Acherman. Corrosion Properties of High-Purity Vanadium. J. of the Less-Common Metals (Netherlands), v. 3, No. 6, December 1961, pp. 456–501.

[15] Block, F. E., R. R. Brown, and M. J. Ferrante. Metallothermic Reduction of Vanadium Chlorides. BuMines Rept. of Inv. 5722, 1961, 17 pp.

[16] Clites, P. G., and E. D. Calvert. Laboratory-Scale Casting Furnace for High-Melting-Point Metals. BuMines Rept. of Inv. 5726, 1961, 13 pp.

[17] Ramsdell, J. D., W. L. O'Brien, J. S. Winston, and D. R. Schuyler II. Physical and Mechanical Properties of Electrorefined Vanadium. BuMines Rept. of Inv. 5769, 1961, 22 pp.

[18] Mah, A. D., and K. K. Kelly. Heats and Free Energies of Formation of Oxides of Vanadium. BuMines Rept. of Inv. 5858, 1961, 11 pp.

[19] King, E. G., and W. W. Weller. Low-Temperature Heat Capacities and Entropies of Three Sodium Vanadates at 298.15° K. BuMines Rept. of Inv. 5715, 1961, 5 pp.

[20] American Metal Market. Vanadium Cure Hardening of Arteries? V. 68, No. 234, Dec. 7, 1961, p. 20.

also produced spun-cast cylinders of pure vanadium 14 inches in diameter.[21]

The principal use of high-purity vanadium has been as an alloying material in binary and ternary systems. These alloys exhibit the desirable properties of vanadium, excellent workability and ductility, low liquid-metal corrosion, low thermal-neutron cross section, and high melting point, but do not have the undesirable susceptibility to oxidation of pure vanadium. The columbium-vanadium alloys developed by the metals industry to withstand high temperatures without significant loss of strength in space vehicles were produced commercially for the first time in 1961. Westinghouse Electric Corp. began producing a columbium-vanadium alloy (designated B–33) and announced plans to produce B–66, an alloy of columbium, vanadium, molybdenum, and zirconium, and B–77, an alloy of columbium, tungsten, vanadium, and zirconium.[22]

Scientists at the Watertown Arsenal investigated titanium-vanadium alloys, using charpy impact tests as the method of evaluation; this alloy system compared favorably with 4340 alloy steels.[23] Lighter weight, better corrosion resistance, and greater strength-weight ratios, were among the advantages offered by the titanium-vanadium alloys.

Several vanadium alloys having both good hot-strength and oxidation-resistent properties were developed by U.S. Air Force investigators.[24] The most promising were, by percent, as follows: 50 vanadium, 40 titanium, 5 aluminum, 5 chromium; 59 vanadium, 30 titanium, 5 aluminum, 5 chromium 1 silicon; and 50 vanadium, 41 titanium, 2 aluminum, 7 nickel.

Metallurgists at Armour Research Foundation investigated vanadium-base alloys for high temperature service. Binary vanadium-base alloys containing titanium, columbium, molybdenum, tantalum, and tungsten exhibited excellent strength at elevated temperatures. These alloys appeared to be superior to the best nickel and cobalt-base sheet materials on a density-corrected tensile strength basis at temperatures exceeding 2,000° F.[25]

Interest in methods of obtaining or using the vanadium in petroleum oils was reflected by the patents issued during 1961.[26]

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[21] Journal of Metals. Pure Tungsten Castings. V. 13, No. 4, April 1961, p. 251.
[22] American Metal Market. New Columbium Alloys. V. 68, No. 206, Oct. 26, 1961, p. 17.
[23] Iannelli, A. A., and F. J. Rizzitano. Charpy Impact Tests of 4340 Steel and 6Al–6V–2Sn–Titanium Alloys Using Standard and Thin Charpy Specimens. Watertown Arsenal Rept. WAL TR 112.5/3, January 1962, 31 pp.
[24] Iron Age. Curbs Vanadium Oxidation. V. 188, No. 25, Dec. 21, 1961, p. 15.
[25] Holtz, F. C. High-Temperature Oxidation Protective Coatings for Vanadium-Base Alloys. Armour Research Foundation Rept. ARF 2227–2, Nov. 6, 1961, 13 pp.
[26] Northcott, R. P., and R. Lester (assigned to British Petroleum Co., Ltd., London, England), Removal of Vanadium and/or Sodium From Petroleum Hydrocarbons: U.S. Pat. 2,970,957, Feb. 7, 1961.
Selbin, Joel (assigned to American Cyanamid Co., New York, N.Y.), Removal of Vanadium From Petroleum Oils by Pyridine Treatment: U.S. Pat. 2,972,577, Feb. 21, 1961.
Selbin, Joel (assigned to American Cyanamid Co., New York, N.Y.), Removal of Vanadium From Petroleum Oils by Oxidation: U.S. Pat. 2,976,233, March 21, 1961.
Kirk, James H. (assigned to Sinclair Refining Co., New York, N.Y.), Mineral Base Vanadium-Containing Residual Fuel Oil Composition and Method of Preparation: U.S. Pat. 3,000,710, Sept. 19, 1961.
Rocchini, A. G., and C. E. Trautman (assigned to Gulf Research and Development Co., Pittsburgh, Pa.), Wear-Reducing Lubricating Composition: U.S. Pat. 3,001,937, Sept. 26, 1961.

Vermiculite

By John W. Hartwell [1] and Nan C. Jensen [2]

CONSUMPTION of vermiculite in the United States during 1961 remained the same as in 1960. Domestic crude production and imports both increased 4 percent.

TABLE 1.—Salient vermiculite production statistics

	1952-56 (average)	1957	1958	1959	1960	1961
United States:						
Production:						
Crude---thousand short tons--	198	184	191	207	199	206
Average value---per ton--	$13.02	$14.15	$14.28	$14.89	$15.62	$16.26
Exfoliated--thousand short tons--	[1] 154	161	155	153	151	151
Average value---per ton--	$65.97	$61.55	$63.13	$62.69	[2] $68.25	$71.44
World: Production, crude thousand short tons--	247	248	246	[2] 261	269	279

[1] Average 1954-56.
[2] Revised figure.

DOMESTIC PRODUCTION

Crude Vermiculite.—Four producers reported an output of over 206,000 short tons of crude vermiculite in 1961. Golden Clover Corp., Encampment, Wyo., reported production of 30 tons, valued at $300. Other producers were Zonolite Co., Libby, Mont., and Lanford, S.C.; Patterson Vermiculite Co., Enoree, S.C.; and American Vermiculite Co., Woodruff, S.C.

Zonolite Co. stripped overburden from a 30-acre area adjacent to its producing pit in Montana to develop additional milling ore. In Montana the screened and cleaned crude vermiculite, sold or used, was about 15 percent of the total ore mine, compared with an average of 25 percent from mines in South Carolina.

Exfoliated Vermiculite.—Production of exfoliated vermiculite was 151,000 tons, the same as in 1960. The average value per ton increased $3.19, resulting in a 5-percent gain in value to $10,787,000. This rise in value per ton was principally due to increases in wages and other production costs.

Reports from the 20th annual meeting of the vermiculite producers in association with the Vermiculite Institute indicated that large

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[2] Supervisory statistical assistant, Division of Minerals.

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tonnages of vermiculite were being used for conditioning fertilizers and in mosquito abatement programs. Field testing of vermiculite as a carrier of granular DDT and paris green was planned in Delaware, Georgia, New Jersey, Virginia, and Washington. Similar work was being done in other States.

A long-term soil-conditioning study at Pennsylvania State University was sponsored by institute members, and a new fertilizer conditioner was being developed.

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
1952–56 (average)	198	$2,577	1959	207	$3,082
1957	184	2,603	1960	199	3,108
1958	191	2,728	1961	206	3,350

TABLE 3.—Exfoliated vermiculite sold or used by producers in the United States

Year	Operators	Plants	States	Thousand short tons	Value (thousands)
1954–56 (average) [1]	27	53	33	154	$10,160
1957	26	54	35	161	9,910
1958	25	51	35	155	9,785
1959	25	52	34	153	9,591
1960	27	[2] 53	[2] 34	151	[2] 10,305
1961	28	56	35	151	10,787

[1] Data not compiled before 1954.
[2] Revised figure.

CONSUMPTION AND USES

Available data indicated that the quantities of exfoliated vermiculite used in acoustical, fireproofing, and building plaster, in insulating cement, and as an aggregate remained about the same as in 1960. The total quantities used for insulation and agriculture increased although miscellaneous vermiculite uses, which included insulation for pipes, stoves, refrigerators, and safes and carriers for herbicides, fungicides, and fumigants, were slightly less.

PRICES

E&MJ Metal and Mineral Markets quoted nominal yearend prices for crude vermiculite as follows: Per short ton, f.o.b. mines, Montana, $9.50 to $18; South Africa, c.i.f. Atlantic ports, $24.75 to $38.50.

The average mine value of all domestic crude vermiculite sold or used in 1961 was $16.26 per ton, compared with $15.62 in 1960, and $14.89 in 1959.

The average value of all exfoliated vermiculite, f.o.b. processors' plants, was $71.44 per ton, compared with $68.25 (revised) in 1960.

FOREIGN TRADE

Crude vermiculite was imported into the United States duty free. The Union of South Africa continued to be virtually the only source of imports. The United States received 18 percent of the South African exports, 2 percent less than in 1960; but the quantity imported was 517 tons more than in 1960.

WORLD REVIEW

The United States produced about 74 percent of the total world crude vermiculite, followed by the Union of South Africa with 26 percent. Quantities produced by other countries were insignificant.

Canada.—Canada exfoliated crude vermiculite that had been imported entirely from the United States and the Union of South Africa. Five companies at 10 locations exfoliated 312,000 cubic yards of vermiculite valued at Can$2.1 million during 1960, a 9-percent decrease in quantity and value under 1959 production. Seventy-four percent of the exfoliated material was used as loose insulation, 18 percent in insulating plaster, 3 percent as an aggregate in concrete, and 5 percent for other uses.[3]

Kuwait.—Studies were made on the use of exfoliated vermiculite for hydroponic farming and as a soil conditioner. In 1959, a British research team calculated that 9 tons of exfoliated vermiculite per acre would be needed to make desert soil suitable for horticulture.[4]

TABLE 4.—World production of vermiculite by countries [1 2]

(Short tons)

Country [1]	1952-56 (average)	1957	1958	1959	1960	1961
Argentina	682	287	161	[3] 880	[3] 880	[3] 880
Australia	21					
India	240			2	17	1
Kenya	353	33	96	112	283	
Morocco		147				
Rhodesia and Nyasaland, Federation of:						
Southern Rhodesia	61	460	280	50		
Sudan			[3] 130	[3] 130		55
Tanganyika			91	125	20	157
Union of South Africa	47,119	62,619	54,314	52,398	69,022	71,118
United Arab Republic (Egypt)	35	33	302	331	132	
United States (sold or used by producers)	198,129	183,987	190,564	206,579	199,072	206,637
World total [1 2]	246,640	247,566	245,938	260,607	269,426	278,848

[1] Vermiculite is produced in Brazil and U.S.S.R., but data are not available, and no estimates of their production are included in the total.
[2] This table incorporates some revisions.
[3] Estimate.

Source: Compiled by Helen L. Hunt, Division of Foreign Activities.

[3] Wilson, H. S. Lightweight Aggregates, 1960 (Prelim). Department of Mines and Tech. Surveys, Min. Res. Div., Ottawa, Canada, Review 29, May 1961, 5 pp.
[4] Mine and Quarry Engineering (London). New Oases? V. 27, No. 3, March 1961, p. 113.

Union of South Africa.—Transvaal Ore Company, Ltd., continued to mine vermiculite at near capacity during 1961 from its mine near Phalaborwa in northeastern Transvaal. Reserves were reported good and an increase in output a possibility.[5]

Principal countries to which the crude material was exported, in order of importance, were the United Kingdom, United States, Italy, France, and West Germany.

U.S.S.R.—Several deposits of vermiculite were discovered on the Kola Peninsula. The Kovdora deposit was the only one explored in detail; it was estimated to contain 60 million tons of vermiculite ore. The ore grades from 1 to 45 percent vermiculite, averaging 14 percent. The ore body was a surface deposit with virtually no overburden and no drainage problems. A concentrating plant was planned.[6]

TABLE 5.—Union of South Africa: Exports of crude vermiculite by countries[1]

(Short tons)

Destination	1960	1961
North America:		
Canada	3,335	2,593
Mexico	143	111
Puerto Rico	10	151
United States	12,396	12,913
South America: Uruguay	103	
Europe:		
Austria	214	123
Belgium	766	971
Denmark	1,415	857
Finland	225	201
France	6,620	9,133
Germany, West	5,704	7,239
Italy	8,054	11,154
Netherlands	1,633	1,330
Spain		389
Sweden	533	431
Switzerland	389	206
United Kingdom	16,255	18,813
Asia:		
Israel	284	124
Japan	774	989
Kuwait	667	334
Turkey	216	37
Africa:		
Algeria	449	376
Mali, Republic of	175	
Rhodesia and Nyasaland, Federation of	288	168
Oceania: Australia	1,913	1,911
Other countries	477	509
Total	63,038	71,063
Total value[2]	$1,192,650	$1,328,250
Average value	$18.92	$18.69

[1] This table incorporates some revisions.

[2] Converted to U.S. currency at the rate of SA£=US$2.7971 (1960) and 1 rand equals US$1.3957 (1961). Effective Feb. 14, 1961, the new currency unit, the rand, replaces the pound. It is equivalent to 10 shillings or ½ the former pound.

Source: Compiled from Customs Returns of Union of South Africa by Bertha M. Duggan, Division of Foreign Activities.

[5] U.S. Consulate General, Johannesburg, Union of South Africa. State Department Dispatch 7. July 7, 1961, p. 31.

[6] Bureau of Mines. Mineral Trade Notes. V. 52, No. 2, February 1961, p. 31.

TECHNOLOGY

A geologic map of a 400-square-mile area near Perth, Ontario was published. A brief description was attached which contained information on vermiculite and other minerals of economic interest.[7]

A 40-page handbook on vermiculite and its uses was published by Mandoval, Ltd. (London).[8]

A patent was granted for a method of grinding micaceous materials, including vermiculite, either wet or dry, at a temperature range of 800° to 1,600° F for at least 5 minutes.[9]

A method of expanding vermiculite or perlite using a vertical stationary furnace was described.[10]

A new semiportable furnace for exfoliating vermiculite was developed and tested by Mandoval, Ltd. (London), importers of crude vermiculite. The new furnace provided a working temperature up to 1,200° C. A special feature of the design allowed optimum heat to be applied equally to all particles. The furnace was designed to be mobile within the plant.[11]

A method was devised in U.S.S.R. for testing vermiculite for new deposits for use in sound-absorbing and heat-insulating materials.[12]

A method of making a ready-mixed gypsum plaster containing exfoliated vermiculite or expanded perlite and a wetting-antifoaming agent was patented.[13]

An improved plaster mix for acoustical or insulating purposes using exfoliated vermiculite and other materials was described.[14]

A quick-setting, easily dissolved casting plaster for use in the fiber glass industry was composed of 7 to 13 parts each of exfoliated vermiculite and gypsum plaster, and one part of bentonite or kaolin.[15]

The properties of a lightweight vermiculite concrete for use in underground structures were determined. Results indicated that for a cement-to-vermiculite mix of one-to-eight, the initial peak crushing strength was between 420 and 570 psi; the average crushing stress to produce 30-percent strain was between 350 and 450 psi. The energy dissipated to 30-percent strain was between 8.8 and 10.9 ft lb per cu in.[16]

The use of vermiculite in a compressible, lightweight ventilation brick by underground mines was proved successful.[17]

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[7] Wilson, M. E., and Jean Dugas. Geology of Perth, Lanark, and Leeds Counties, Ontario. Canada, Geol. Survey, Map 1039A, 1961; Geol. Sci. Abs., published by Am. Geol. Inst., v. 3, No. 11, November 1961, p. 6.

[8] Chemical Age (London). Vermiculite Publication. V. 85, No. 2188, June 17, 1961, p. 1003.

[9] Leblanc, R. British Pat. 872,231. July 5, 1961.

[10] Robinson, D. W. (assigned to Zonolite Co., Chicago, Ill.). Method of and Apparatus for Heat Processing Particulate Solids. U.S. Pat. 3,010,911, Nov. 28, 1961.

[11] Iron and Coal Trades Review (London). New Furnace for Exfoliation of Vermiculite. V. 182, No. 4836, Mar. 24, 1961, p. 647.

[12] Nikol'skiy, G. G., and A. P. Pozhnin. (Testing of Vermiculite, Technology and Uses of Vermiculite Base Concrete Products.) Referativnyy Zhur., Khimiya, No. 22, 1961, pp. 312–313.

[13] Hampton, A. L. (assigned to United States Gypsum Co., Chicago, Ill.). Plaster Composition. U.S. Pat. 2,980,548, Apr. 18, 1961.

[14] Sucetti, G. Dry plaster Mix Comprising Aggregate, Clay, Cellulose Derivative and Amine Aldehyde Resin. U.S. Pat. 2,993,061, July 18, 1961.

[15] Clark, C. C., and D. V. Noble (assigned to each other, San Diego, Calif.). Casting Plaster. U.S. Pat. 3,007,803, Nov. 7, 1961.

[16] Covington, Clarke. Dynamic Energy-Absorbing Characteristics of Lightweight Vermiculite Concrete. Univ. of Texas, Structural Mech. Res. Lab., Austin, Tex., DASA–1238, June 1961, 44 pp.

[17] South African Mining Journal (Johannesburg). Compressible, Light-Weight Ventilation Brick Passes Test. V. 72, pt. 2, No. 3574, Aug. 4, 1961, p. 259.

Fire-resistant, acoustic, ceiling panels were made of gypsum plastic and exfoliated vermiculite or expanded perlite and mineral wool.[18]

The Vermiculite Institute was striving to develop installation standards for vermiculite concrete roofs. Member companies were to assume responsibility for the quality of finished vermiculite roofs and to install them in strict accordance with the Institute's specifications.[19]

Fifteen brands of high-temperature block insulation, including those made of vermiculite, were evaluated for petrographic composition, bulk density, permeability, modulus of rupture, resistance to water disintegration, hot compressive strength, refractoriness, and thermal conductivity. Four brands, including two of vermiculite, met tentative requirements for blast-furnace-stove insulation. Six brands, including two of vermiculite, met tentative requirements for other steel-plant insulation.[20]

A plastic insulating composition consisting of exfoliated vermiculite or expanded perlite, asbestos fiber, and other materials was patented.[21]

The use of vermiculite as an insulator in kiln walls was investigated at the University of Pennsylvania. Vermiculite used as a core filler in masonry walls was reported to have reduced fuel and labor costs.[22]

A water-repellent aggregate was made by mixing bituminous particles with exfoliated vermiculite or like products and heat treating.[23]

A composition for filtering exhaust gases using exfoliated vermiculite with bentonite and other materials was described.[24]

A new method of filtering poisonous nitrous fumes in mines was developed. The fumes, produced from blasting, were filtered through a bed of vermiculite impregnated with special chemicals.[25]

A pneumatic apparatus for filling cavities with exfoliated vermiculite, expanded perlite, or other lightweight insulating materials was described.[26]

Exfoliated vermiculite impregnated with a pesticide was used as a coating for seeds.[27]

Uses for exfoliated vermiculite in a process of propagating grasses,[28] a method for making a cigarette filter,[29] and as an animal litter and sanitary composition.[30]

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[18] Harris, J. Australian Pat. 232,806. Feb. 17, 1961.
[19] Pit and Quarry. New Vermiculite Policy Adopted by Vermiculite Institute. V. 54, No. 2, August 1961, p. 44.
[20] Eusner, G. R., and J. T. Shapland. Block Insulation for Stoves and Bustle Pipes. Am. Ceram. Soc. Bull., v. 40, No. 7, July 1961, pp. 439–444.
[21] Sucetti, G. Insulating Composition Containing Sodium Carboxymethylcellulose, Aluminum Acetate and Polyvinyl Acetate. U.S. Pat. 2,993,017, July 18, 1961.
[22] Concrete. Less Steam is Needed in Kilns With New Method of Insulation. V. 68, No. 11, November 1960, pp. 20, 26.
[23] Goff, D. C., and G. E. Ziegler (assigned to Zonolite Co., Chicago, Ill.). Water Repellent Aggregate. U.S. Pat. 3,010,840, Nov. 28, 1961.
[24] Duncan, D. D., and D. H. Wood. Method of and Filter for Purifying Exhaust Gases of Internal Combustion Engines. U.S. Pat. 3,000,692, Sept. 19, 1961.
[25] Northern Miner (Toronto). Vermiculite Filters Remove Mine Fumes. V. 46, No. 50, Mar. 9, 1961, p. 23.
[26] Blattner, R. H., and F. Blick (assigned to Expanded Perlite Ltd.). British Pat. 871,635, June 28, 1961.
[27] Scott, D. B., Jr. (assigned to Soilserve, Inc., Salinas Calif.). Method for Treating Seeds, and Product of Said Method. U.S. Pat. 2,967,376, Jan. 10, 1961.
[28] Tukacs, G. (assigned to Lawn Grass Pellets Co., Houston, Tex.). Method and Means for Propagating Stoloniferous Grasses and The Like. U.S. Pat. 3,009,289, Nov. 21, 1961.
[29] North, O. S. Method for Forming Filter Cigarettes. U.S. Pat. 2,996,065, Aug. 15, 1961.
[30] Jeckel, A. (assigned to Colibiri Hygiene Ltd.). British Pat. 878,423, Sept. 27, 1961.

A nitrogen fertilizer containing a filler such as vermiculite was patented. The high-water-retention capacity of the fertilizer permits it to be applied in the form of a water slurry to loosed soils.[31]

Up to 5 percent sulfuric acid-treated crude vermiculite was mixed with prilled ammonium nitrate and other hygroscopic fertilizers to inhibit their caking tendencies.[32] In producing fertilizers, nitrogen oxide gases were absorbed with an aqueous suspension of vermiculite, bentonite, or glauconite, and the slurry ammoniated, dried and granulated.[33] Another method of making fertilizers containing vermiculite was patented.[34]

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[31] Szepesi, K., T. Jancso, E. Varga, and T. Varga. British Pat. 881,517. Nov. 1, 1961.
[32] Hayes, J. C. (assigned to Zonolite Co.). Canadian Pat. 624,435. July 25, 1961.
[33] Szepesi, K., T. Jansco, and J. Varga. Process for the Manufacture of Fertilizers Containing Water-Soluble Nitrogen Compounds. U.S. Pat. 2,991,170, July 4, 1961.
[34] Harvey, E. W. (assigned to Allied Chemical Corp., New York, N.Y.). Method of Making Mixed Fertilizers Containing Vermiculite. U.S. Pat. 3,006,753, Oct. 31, 1961.

Water

By Robert T. MacMillan [1]



WATER SUPPLY measured by total streamflow continued to be lower than normal in many of the Western States and particularly in the Southwest. Although potential supply was normal or above in most other parts of the Nation, the long-range supply situation continued to cause concern as growth in population, industry, and pollution demanded ever-increasing quantities of potable water. Several objectives were achieved in the program of the Federal Government to insure adequate water supply for the future.

LEGISLATION AND GOVERNMENT PROGRAMS

A bill was passed extending and expanding the Federal Water Pollution Control Act (33 U.S.C. 466–466j). Public Law 87–88 authorized the Secretary of the Department of Health, Education, and Welfare to assume responsibility for administering the act in place of the Surgeon General who formerly held this responsibility.[2] A sum not to exceed $25 million was authorized to conduct basic and applied research needed to determine practical means of treating sewage and waterborne wastes to remove maximum quantities of pollutants so that the treated water would be suitable for repeated reuse. Field laboratories were authorized to be established and equipped in various sections of the United States to conduct experiments and demonstrations relating to the prevention and control of water pollution. Construction grants totaling $570 million were authorized through fiscal year 1966.

The final report of the Senate Select Committee on National Water Resources was published.[3] Besides summarizing the individual reports on various aspects of water resource problems, the report contains the conclusions and recommendations of the Committee the magnitude of the problem required the use of every available means for its solution, including (1) regulating streamflow by constructing surface reservoirs and improving watershed management; (2) promoting more adequate pollution abatement programs to improve water quality in the Nation's streams; (3) using underground storage facilities to better advantage; (4) eliminating all wasteful water-use practices; (5) improving sewage treatment, water recirculation, and

[1] Commodity specialist, Division of Minerals.
[2] U.S. Congress. Federal Water Pollution Control Act Admendments of 1961. U.S. Government Printing Office, Public Law 87–88, July 20, 1961, 75 Stat. 204–210.
[3] Select Committee on National Water Resources. Report of the Select Committee on National Water Resources. U.S. Senate Committee Print No. 29, January 1961, 147 pp.

irrigation efficiency; and (6) increasing natural water supplies by weather modification, saline water conversion, and other artifical means.

It was recommended that the Federal Government, in cooperation with the States, prepare and keep up-to-date comprehensive water development plans for all the major river basins of the United States. The ultimate need for optimum development of all water resources should be considered and long-range water demands for all purposes, including streamflow regulation, outdoor recreation, and the preservation of fish and wildlife, should be taken into account.

The Committee further recommended that the Federal Government undertake a coordinated scientific research program on water encompassing basic research on atmospheric physics, solar activity, hydrology of groundwater, physical chemistry and molecular structure of water, climatic cycles, and other natural phenomena related to water and the application of the principles derived from this research toward weather modification, evaporation reduction, desalinization, pollution abatement, and water storage. It also recommended that the Federal Government stimulate active participation by the States in long-range water resource planning by setting up a 10-year program of grants to be matched by the States.

The cost of the program to insure adequate water supply for the United States was estimated to be $42.2 billion by 1980 and $81.6 billion by the year 2000.

New legislation to expand and extend the saline water conversion program of the U.S. Department of the Interior was enacted.[4] The Saline Water Act of 1952 (66 Stat. 328), as amended (42 U.S.C. 1951–58), was further amended to provide for an expanded Federal program of fundamental research and engineering development to discover the best and most economical means of making saline water suitable for beneficial consumptive purposes. Construction and operation of demonstration plants other than the five already authorized would require congressional approval. A sum not to exceed $75 million was authorized to carry out the provisions of the act during the period 1962–67.

The Office of Saline Water announced the opening of two demonstration plants and the completion of a third.[5] Two other plants were in the construction or planning stage.

On June 21, 1961, the first demonstration plant was opened officially by President Kennedy through remote control from his office in the White House. The plant in Freeport, Tex., exceeded expectations in many respects and produced 1 million gallons per day of potable water from sea water by distillation, using long-tube vertical evaporators arranged in 12 effects.

The second demonstration plant was dedicated at Webster, S. Dak. Using brackish water (1,800 parts per million dissolved solids) this plant produced 250,000 gallons per day of potable water using an electrolytic membrane process.

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[4] U.S. Congress. Saline Water Conversion Program. U.S. Government Printing Office, Public Law 87–295, Sept. 22, 1961, 75 Stat. 628.

[5] U.S. Department of the Interior. Saline Water Conversion Report for 1961. January 1962, 123 pp.

At San Diego, Calif., construction was completed on a 1-million-gallon-per-day flash-evaporation plant designed to operate on sea water. Testing procedures were underway at the close of the year.

Bids were received for constructing a forced-circulation vapor-compression demonstration plant at Roswell, N. Mex. The plant was designed to convert an especially corrosive type of brackish water into potable water.

A site was chosen at Wrightsville Beach, N.C., for the fifth and last of the series of demonstration plants. It was designed to produce 250,000 gallons of potable water per day from sea water, using a freezing process.

Lower activity was reported under the Joint Federal-State Anthracite Mine Water Control Program established in 1955. One new project was authorized in 1961, raising the total to 29 mine-water control projects having Federal participation. The projects included the installation of pumps to control ground water levels and surface drainage improvements to prevent surface water from entering mines.

Revised Federal Specifications for drinking water used on interstate carriers were established by the Department of Health, Education, and Welfare. Bacteriological standards remained about 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.[6]

DOMESTIC SUPPLY

The flow of water or runoff of major river systems is a convenient measure of potential water supply. In 1961 the runoff was deficient in a belt extending from Arizona and California northeastward to Montana and North Dakota. In most other States west of the 100th meridian runoff was average except for sections near the Gulf of Mexico and the Pacific Northwest where it was above average. Potential water supply in the Eastern States was mostly average except for areas of the Southern and Central States where it was above average. An area of deficiency extended from New Hampshire westward into Canada and southward into Ohio and Michigan.

In 1961 the average flow of the Mississippi River at Vicksburg, Miss., was 102 percent of median; near the Grand Canyon the average flow of the Colorado River was only 62 percent of the median. The flow of the Columbia River at The Dalles, Oreg., was 101 percent of median after adjusting for change of storage in eight major power reservoirs. In the Northeast the average flow of the St. Lawrence River at Lake St. Lawrence was 98 percent of the median.[7]

Recordbreaking floods occurred in Alabama and Mississippi, and parts of Texas and Louisiana were flooded by exceptionally high tides caused by Hurricane Carla. Local floods occurred in several other Southern and Central States and in Oregon and Hawaii.

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[6] Chemistry. Drinking Water Standards. V. 35, No. 2, October 1961, p. 29.

[7] Geological Survey (in collaboration with Canada—Department of Northern Affairs and Natural Resources). Water Resources Review. Annual Summary, Water Year 1961, 20 pp.

Water storage in major power reservoirs continued to be above average with few exceptions; however, water levels in irrigation reservoirs were generally below average. Municipal and industrial storage was about average or slightly below. Contents of Lakes Mead and Mohave were 95 percent of average, about 10 percent less than in 1960. Missouri River reservoirs contained about 30 percent less water than in 1960. The level of water in Great Salt Lake continued to decline and reached a new low in 1961.

Ground water levels fluctuated seasonally and were near normal in most Eastern States except where changes in pumping rates either raised or lowered the water table. In many Western States, particularly in the Southwest where ground water pumpage was high, the ground water levels continued to fall.

CONSUMPTION AND USES

Estimates of total water withdrawal use in 1961 ranged up to 320 billion gallons per day.[8] Slightly more than half was used by industry; another large percentage was used for irrigation, and the remaining portion, about 8 percent, was for municipal and rural use. Water withdrawn for generating hydroelectric power was estimated at 2,000 billion gallons per day including reuse. This quantity was excluded from other withdrawal estimates, because it is returned to the stream immediately and is available for reuse without treatment by downstream users. Nonwithdrawal uses of water include navigation, recreation, waste dilution, and conservation of wildlife.

The third in a series of comprehensive surveys of the water use in the United States was published by the Geological Survey.[9] The use of water by industry increased 27 percent since the previous survey in 1955; water for public supply increased 23 percent; irrigation water, excluding conveyance losses, increased 4 percent; and water for rural use remained the same. Hydroelectric power requirements, often considered separately from other withdrawal uses, increased 33 percent in the 5-year period, and the use of saline water almost doubled.

The upper limit of water supply for the United States was considered to be the average annual runoff of nearly 1,200 billion gallons per day. Estimated withdrawal use was less than one-quarter of this total, and actual water consumption (evaporation or incorporation in a product) was less than one-quarter of that withdrawn. However, available water supply, which was based to some degree on the cost of development, was much closer to the quantity of water withdrawn.

Estimates of water injected into oil-bearing strata for the secondary recovery of oil and for the maintenance of pressure in producing fields were made by Bureau of Mines engineers. About 3.3 billion barrels of water (1 barrel equals 42 gallons) was used in the secondary recovery of 334 million barrels of oil in 1961—an increase, compared with 1960, of more than 20 percent in both water used and oil recovered. Of the water injected approximately 65 percent was saline

[8] Chemical Week. Water. V. 89, No. 14, Oct. 7, 1961, pp. 50–75.
[9] Mackichan, K. A., and J. C. Kammerer. Estimated Use of Water in the United States 1960. Geol. Survey Circ. 456, 1961, 44 pp.

and the remainder fresh. Water injected for pressure maintenance was about the same as in 1960 and was estimated at 850 million barrels, aiding in the production of 208 million barrels of oil. Of the water injected, 80 percent was saline and the remainder fresh. A percentage of the water used for both secondary recovery and pressure maintenance in oil fields was reinjected.

PRICES

Prices paid for water varied widely depending on the area and the type of use. Average municipal water costs for each water resource region ranged from 14 to 28 cents per thousand gallons in 1960; prices in 1961 were not changed significantly.[10] In specific instances water costs exceeded 45 cents per thousand gallons.

Water used by industry was largely self-supplied, and costs depended on the quality of the raw water available and the purity requirements of the process water consumed. Irrigation water was usually much less costly than municipal water; farmers in the Imperial Valley of California paid $2 per acre foot or about 0.6 cent per thousand gallons. Costs between 5 and 10 cents per thousand gallons were common.

The price of heavy water available for sale or lease by the Atomic Energy Commission was maintained at $28 per pound. Leasing charges were 4 percent per year for the monetary value of the water. The lease period was 5 years for domestic reactors; for foreign reactors it was for the estimated life of the reactor.

Costs of desalted water also varied depending on the saltiness of the water, the type of conversion process, and the size of the plant. Cost of converting sea water in 1-million-gallon-per-day distillation plants, including amortization of the plant and equipment, was estimated to be between $1 and $1.25 per thousand gallons. Plants having larger capacities were theoretically capable of converting water at correspondingly lower costs. Initial data indicate a conversion cost of about 85 cents per thousand gallons for the Webster, S. Dak., demonstration plant. Starting with water containing 1,800 parts per million of impurities, the plant was designed to produce 250,000 gallons per day of water containing 300 parts per million of impurities.

FOREIGN TRADE

Heavy water (D_2O) continued to be produced from ordinary water at the Savannah River plant of the Atomic Energy Commission. Under a cooperative agreement with Canada to develop heavy-water-moderated reactors, 169,500 pounds of heavy water was sold to Canada. Smaller quantities were supplied to Norway and Australia. Heavy water has an advantage over light water as a moderator in nuclear reactors and enables natural uranium to be used as fuel.[11] About 500 tons of heavy water had been sold to foreign nations since 1955.

[10] Select Committee on National Water Resources. Water Resources Activities in the United States. U.S. Senate Committee Print No. 7, 1960, 23 pp.
[11] Materials Research and Standards. Uncle Sam Heavy Supplier of Heavy Water. V. 1, No. 9, September 1961, pp. 743, 748.

WORLD REVIEW

A total of 16 sea-water distillation plants with capacities ranging from 0.1 to 3.5 million gallons per day were reported to be in operation in various parts of the world.[12] Aggregate capacity was said to be under 15 million gallons per day; however, many larger and greatly improved plants were planned. More than 30 countries had conducted studies in salt water conversion methods.

Water pollution problems were reported in many nations, including the United Kingdom and the U.S.S.R.[13] The Applied Research Committee of the Organization of European Economic Cooperation recommended improvements in international cooperation in regard to water pollution problems. Standardization of sampling methods and analytical techniques as well as emphasis on detergent pollution problems were advocated.[14]

A survey of the fresh water needs which might be met by saline water conversion in 40 nations was conducted by the Bureau of Foreign Commerce. Replies were received from Argentina, Ceylon, Ecuador, French West Indies (Martinique), Haiti, Jordan, Mexico, Morocco, Portugal, Trinidad, and Turkey.

TECHNOLOGY

Saline water conversion was becoming a large industry in 1961. More than 50 U.S. firms were engaged in research, development, and production relating to desalting water. In addition, 30 or more universities, research organizations, and individuals were conducting research in this field.[15]

The program of the Office of Saline Water (OSW) advanced steadily.[16] Four of the five demonstration plants originally authorized were either operating or under construction; plans for the fifth plant were advancing. The purpose of the demonstration plant program was to gain practical knowledge and operating experience on five different types of saline water conversion plants of up to 1-million-gallon-per-day capacity; however, the most important function of the saline water program was to conduct fundamental research aimed at gaining new knowledge, concepts, and ideas broadly applicable to conversion processes and to all areas of natural science and engineering. The future success of low-cost water desalinization was thought to be in the development of novel processes and combinations rather than in older processes which were being tested.

The Division of Research of the OSW was supporting, through contracts with and grants to universities and research organizations, the following areas of interest relevant to the conversion of saline water: (1) Composition, structure, and properties of water ions,

[12] Technical Survey. Water Supplies Treatment. V. 17, No. 14, Apr. 8, 1961, p. 242.
[13] Chemical Trade Journal and Chemical Engineer (London). Water Pollution Research. V. 149, No. 3881, Oct. 20, 1961, pp. 882, 884.
Chemical Week. The Russians Are Having Trouble With Water Pollution Too. V. 89, No. 21, Nov. 1961, p. 47.
[14] Chemical Age (London). OEEC Urges World Cooperation on Water Pollution Research. V. 85, No. 2180, Apr. 22, 1961, p. 658.
[15] Steel. Sweet Water from Salty Seas. V. 149, No. 6, Aug. 7, 1961, pp. 41–44.
[16] U.S. Department of the Interior. Saline Water Conversion Report for 1961. January 1962, 123 pp.

aqueous solutions, chelates, hydrates, and crystalline and polymeric materials; (2) studies in the transfer of mass, energy, charge, and momentum; (3) phase transitions of gases, liquids, and solids, including nucleation and crystal growth; (4) colloid and surface chemistry and physics; (5) biological and organic exchange systems; and (6) economic studies.

Research studies during 1961 included (1) the removal of scale-forming compounds from sea water prior to conversion, (2) demineralization by hydrate formation, (3) study of scale deposition on heated surfaces, (4) electrical demineralization on carbon electrodes of large surface area, (5) use of vibrations to improve heat-transfer rates and reduce scaling, (6) studies on the preparation of polymer films, (7) the effect of impressing an electrostatic field on the salt water/air interface, and (8) the utilization of radioactive wastes from nuclear reactors as heat sources for conversion processes.

In addition to the above studies, development continued on several types of distillation processes, solar distillation, a number of processes involving membranes, an ion exchange processes, freezing processes, and processes involving gas hydrates and solvent extraction.

Water-pollution problems received increasing attention, particularly with regard to effect of synthetic detergents containing alkyl benzene sulfonate (ABS). The resistance of this compound to biochemical degradation was responsible for frothing problems in streams receiving sewage treatment plant effluents. Although the compound was not considered toxic, its presence in water was unappealing. Several detergents which are more subject to biodegradation were known, but they were more expensive and less efficient than ABS. More efficient sewage treatment plants were considered to help solve the problem.[17]

Development of methods for conserving water now wasted were advocated.[18] In addition to retarding surface evaporation from reservoirs by thin films of hexadecanol, the use of an emulsified petroleum compound was claimed to reduce water seepage through earthen canals by forming an impermeable layer at a predetermined depth in the soil. The emulsion was said to have no effect on plants or animals.

A secondary sewage treatment process was tested in which algae were used to remove calcium, magnesium, bicarbonate, nitrate, sulfate, and phosphate ions from the effluent of conventional sewage treatment plants. The successful growth of algae was attributed to the addition of carbon dioxide to the sewage effluent water.

Algae failed to remove ABS from the sewage effluent; however, an electrodialysis process, designed to remove ABS and other wastes which pass through conventional sewage treatment plants, was being studied.

Government-operated heating and power plants continued to receive consulting boiler-water service from the Bureau of Mines

[17] Chemical Week. New Challenge in Water Cleanup. V. 89, No. 6, Aug. 19, 1961, pp. 41, 42, 45, 46.

[18] Chemical Engineering. Wave of Developments Aims at Salvaging Water. V. 68, No. 17, Aug. 21, 1961, pp. 60, 62.

through its Industrial Water Laboratory. Boiler-water-testing equipment and reagents were distributed to various plants to provide quality control of both boiler-feed-water and condensate return. About 13,500 water and condensate samples were analyzed from more than 10,000 boilers. These analyses were helpful in spotting and correcting corrosion problems in boilers and condensate return lines.

Zinc

By H. J. Schroeder[1] and Esther B. Miller[2 3]

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THE DOMESTIC zinc industry recorded a 6-percent increase in slab zinc consumption, a 4-percent increase in slab zinc production, and a 7-percent increase in mine output. Smelter output was curtailed from February through September; however, increased consumption after April finally led to significantly stepped-up production in the last 3 months of the year. Producer stocks declined 40,000 tons to 145,500 tons, and consumer stocks increased 25,000 tons to 93,800 tons.

Prices decreased from 12.0 to 11.5 cents a pound, East St. Louis, in early January and remained at this level until December 1, when the price returned to 12.0 cents.

Import quotas remained in effect, and general imports decreased 6 percent to 543,300 tons for ores and metal combined. Exports of zinc metal decreased 33 percent to 50,100 tons.

Government stockpiles contained 1,580,000 tons of zinc. No additions or withdrawals were made during the year.

Authorizing legislation was passed, but funds remain to be appropriated for subsidy payments to qualified small lead-zinc producers.

LEGISLATION AND GOVERNMENT PROGRAMS

The International Lead-Zinc Study Group held meetings at Mexico City March 20–24 and at Geneva October 18–24. Worldwide statistics showed record zinc consumption in 1960 and an indicated increase for 1961. At the October meeting it was estimated that metal supply would exceed consumption by 66,000 tons.

[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.

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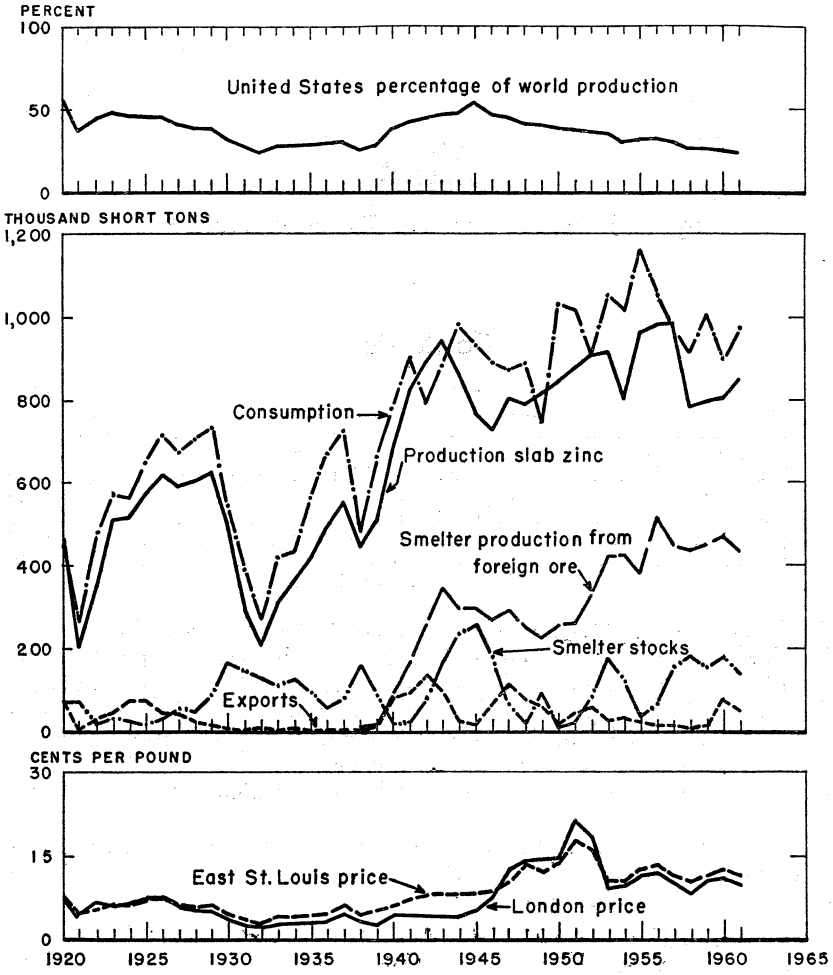


FIGURE 1.—Trends in the zinc industry in the United States, 1920–61. Consumption figures represent primary slab zinc plus zinc contained in pigments made directly from ore.

No specific action was undertaken to curtail further increases in zinc stocks. A special group was established to study the causes and possible solution of the instability in lead-zinc markets.

Import quotas on zinc metal and ore, established October 1, 1958, were in effect throughout 1961. 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.

On October 2, the U.S. Tariff Commission submitted a second periodic report to the President, advising that conditions had not changed enough to warrant a formal inquiry into the question of relaxing existing restrictions on imports of unmanufactured lead and zinc. In response to a U.S. Senate resolution, the Tariff Commis-

TABLE 1.—Salient zinc statistics

	1952–56 (average)	1957	1958	1959	1960	1961
United States:						
Production:						
Domestic ores, recoverable content.....short tons	548,783	531,735	412,005	425,303	435,427	464,390
Value.....thousands	$145,119	$123,235	$84,113	$97,787	$112,365	$106,848
Slab zinc:						
From domestic ores short tons	500,917	539,692	346,240	348,443	[1] 334,101	419,206
From foreign ores...do	413,108	446,104	435,006	450,223	[1] 465,415	427,589
From scrap.....do	62,833	72,481	46,605	57,818	68,731	55,237
Total.....do	976,858	1,058,277	[2] 827,851	[2] 856,484	[1 2] 868,247	[2] 902,032
Secondary zinc [3].....do	230,765	192,367	184,182	219,027	197,810	183,357
Imports (general):						
Ores (zinc content).....do	484,436	526,014	461,560	500,115	[1] 457,155	415,700
Slab zinc.....do	189,563	269,007	195,199	156,963	120,767	127,562
Exports of slab zinc.....do	25,512	10,785	2,073	11,629	75,144	50,055
Stocks, December 31:						
At producer plants.....do	98,910	155,833	184,020	156,210	[1] 185,882	145,540
At consumer plants...do	101,863	88,342	93,609	102,428	[1] 68,871	93,782
Consumption:						
All classes [4].....do	1,305,359	1,231,593	1,142,165	1,278,376	1,158,938	1,207,469
Price, Prime Western, East St. Louis.....cents per pound	12.71	11.40	10.31	11.46	12.95	11.55
World:						
Production:						
Mine.....short tons	3,140,000	[1] 3,470,000	[1] 3,360,000	[1] 3,380,000	[1] 3,590,000	3,720,000
Smelter.....do	2,780,000	[1] 3,200,000	[1] 3,010,000	[1] 3,120,000	[1] 3,280,000	3,550,000
Price: Prime Western London cents per pound	12.25	10.18	8.24	10.27	11.05	9.78

[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.

sion began an investigation to update the March 1960 report to Congress relating to the lead-zinc industries and scheduled public hearings in this connection for January 16, 1962.

Authorizing legislation was passed, but funds were not appropriated, for subsidy payments to begin in 1962 for small lead-zinc producers. Those qualifying would receive payment for the difference between the market price of zinc and 14½ cents per pound.

Zinc was not included in 1961 on the U.S. Department of Agriculture, Commodity Credit Corporation (CCC) list for barter of surplus perishable goods for foreign produced metal. No deliveries were made against previous contracts, and the 323,925 tons acquired from 1956 through 1960 under this program remained in the supplementary stockpile.

The Office of Minerals Exploration (OME), authorized in 1958 as the successor to the Defense Minerals Exploration Administration, continued to encourage exploration of strategic and critical minerals and metals. Exploration assistance for zinc by the Government amounts to 50 percent of the approved costs of qualifying projects. During 1961, OME received 25 applications requesting aid in exploring for zinc or zinc and other metals. Eleven of these applications were denied, five were withdrawn, four were still under consideration, and five contracts were awarded; Government participation totaled $175,205. One discovery was certified, making a total of 95 certified discoveries or developments in zinc-bearing ore under the DMEA–OME program.

TABLE 2.—OME contracts involving lead and zinc executed in 1961, by States

State and contractor	Property	County	Date approved	Total amount[1]
Colorado:				
Consolidated Parnett Corp.	Wellington	Summit	June 23	$49,700
Humphreys Exploration Co.	Bulldog Mountain	Mineral	Sept. 12	187,600
Montana:				
Swansea Mines, Inc.	Carbonate	Lewis and Clark	June 5	18,260
Oregon:				
Emerald Empire Mining Co.	Musick Mine	Lane	May 10	54,300
Utah:				
Larsen, Glen L.	Iron Blossom	Juab and Summit	Aug. 17	40,550
Total				350,410

[1] Government participation was 50 percent in exploration projects for lead and zinc in 1961.

DOMESTIC PRODUCTION

MINE PRODUCTION

Mine production of recoverable zinc was 464,400 tons, an increase of 7 percent; 1961 was the third successive year of increased output. The year was almost free of labor strikes, and there were no pronounced monthly variations in production. States east of the Mississippi River accounted for 50 percent of total output; Western States, 48 percent; and West Central States, 2 percent.

Tennessee continued to be the leading zinc-producing State, although marketing conditions caused curtailments in operations leading to an 11-percent decline from the 1960 output. The Jefferson City mine of The New Jersey Zinc Co. suspended operations in November due to severe flooding when a water-bearing fault was encountered. New Market Zinc Co., jointly owned by American Zinc Co. of Tennessee and Tri-State Zinc, Inc., began shaft sinking on property southwest of New Market, Tenn., and construction of a mill with initial capacity of 2,800 tons of ore daily. The mill was scheduled to be in operation in the fall of 1962, and ore was to be supplied by American Zinc's Coy, Grasselli, and Young mines until underground development at the new property would permit mining at a rate equal to the milling capacity.[4]

Production in Idaho increased 58 percent to 58,300 tons of zinc, the largest quantity mined since 1954; this amount was sufficient to make Idaho the leading producer in the Western States and second in the Nation. The Star mine of The Bunker Hill Co. continued to be the principal zinc mine in the State. Other major zinc producers were Page mine of American Smelting and Refining Co. and Bunker Hill mine of The Bunker Hill Co.

New York's production decreased 17 percent to 54,800 tons. Output declined because the workweek was reduced from 48 to 40 hours at the end of February at Balmat and Edwards mines of St. Joseph Lead Co., the only zinc producer in the State.[5]

Increased output in Colorado, from 31,300 to 42,600 tons, reflected absence of labor strikes which reduced production in 1960. Lead-

[4] American Zinc, Lead & Smelting Co., Annual Report. 1961, pp. 10–11.
[5] St. Joseph Lead Co., Annual Report. 1961, p. 8.

TABLE 3.—Mine production of recoverable zinc in the United States, by States

(Short tons)

State	1952–56 (average)	1957	1958	1959	1960	1961
Arizona	28,880	33,905	28,532	37,325	35,811	29,585
Arkansas	5			49	50	37
California	6,215	2,969	51	78	465	304
Colorado	40,352	47,000	37,132	35,388	31,278	42,647
Idaho	62,175	57,831	49,725	55,699	36,801	58,295
Illinois	18,708	22,185	24,940	26,815	29,550	26,795
Kansas	23,277	15,859	4,421	1,017	2,117	2,446
Kentucky	929	837	1,258	673	869	1,147
Missouri	7,607	2,951	362	92	2,821	5,847
Montana	72,503	50,520	33,238	27,848	12,551	10,262
Nevada	6,472	5,292	91	217	420	453
New Jersey	31,723	12,530	607			112
New Mexico	22,928	32,680	9,034	4,636	13,770	22,900
New York	49,898	64,659	53,014	43,464	66,364	54,763
North Carolina		2				
Oklahoma	40,111	14,951	5,267	1,049	2,332	3,148
Oregon						3
Pennsylvania			10,812	16,718	13,746	23,428
Tennessee	38,610	58,063	59,130	89,932	91,394	81,734
Texas	1					
Utah	36,419	40,846	44,982	35,223	35,476	37,239
Virginia	16,870	23,080	18,472	20,334	19,885	29,163
Washington	26,067	24,000	18,797	17,111	21,317	20,217
Wisconsin	19,033	21,575	12,140	11,635	18,410	13,865
Total	548,783	531,735	412,005	425,303	435,427	464,390

ing zinc producing mines were Eagle of The New Jersey Zinc Co.; Idarado of Idarado Mining Co.; Camp Bird of Camp Bird Colorado, Inc.; Emperius of Emperius Mining Co.; and Rico Argentine of Rico Argentine Mining Co. The Idarado Mining Co. reported milling 406,500 tons of ore during the year and having reserves at the end of the year of 3.5 million tons containing 4.2 percent zinc, 3.0 percent lead, and 0.8 percent copper.[6]

Mine output in Utah increased 5 percent. The United States and Lark mine of United States Smelting, Refining and Mining Co. was the leading zinc producer in the State. Other producers were United Park City Mines Co., International Smelting & Refining Co., and New Park Mining Co.

Arizona mine output declined 17 percent, largely due to a 2-month strike at the Iron King mine of Shattuck Denn Corp., the State's leading producer. Included in other zinc mines operating during the year were Old Dick of Cyprus Mines Corp., Johnson Camp of McFarland & Hullinger, Atlas of B. S. & K. Mining Co., and Flux of Nash & McFarland.

Virginia output was 29,200 tons, the largest quantity reported for the 1938–61 period. Prior output figures were combined with other states and cannot be compared. The New Jersey Zinc Co. treated ore at its Austinville mill from the company's Austinville and Ivanhoe mines. Tri-State Zinc Co., Inc., operated a mine and mill at Timberville.

In the northern Illinois-Wisconsin district, output declined owing to marketing conditions. Producers included The Eagle-Picher Co.; Tri-State Zinc Co., Inc.; American Zinc, Lead and Smelting Co.; and Piquette Mining and Milling Co. The New Jersey Zinc Co.

[6] Newmont Mining Corp. Annual Report. 1961, p. 10.

continued development at its new mine near Elmo, but deferred planned construction of a mill.

Pennsylvania's output increased to 23,400 tons, the largest production since The New Jersey Zinc Co. opened a mine near Friedensville in 1958, re-establishing zinc production in the State after a lapse of more than 60 years.

Production in New Mexico increased from 13,800 to 22,900 tons, largely owing to reactivation of the Peru Mining Co. Kearney mine. Other output included that of Hanover and Linchburg mines of The New Jersey Zinc Co.

In Washington, the principal producing mines were Pend Oreille, Pend Oreille Mines and Metals Co., and Grandview and Mineral Rights mines, American Zinc, Lead & Smelting Co. Pend Oreille milled 742,900 tons of ore, yielding 15,924 tons of zinc in concentrate.[7]

Production of zinc in Montana declined to 10,300 tons, largely from The Anaconda Company zinc-fuming plant at East Helena. According to the company's annual report, no ore was mined during the year because of depressed metal prices. At yearend, however, development was resumed on the Elm Orlu—Black Rock low-grade zinc project.

Output of zinc in the West Central States of Kansas, Oklahoma, and Missouri increased from 7,300 to 11,500 tons. Part of the increase resulted from additional mining in the Tri-State district. However, a significant part of the output represented recovery of byproduct zinc from lead mining in southeast Missouri.

In the southern Illinois-Kentucky fluorspar district 9,500 tons of zinc was produced as a byproduct.

Production was resumed in New Jersey in December as The New Jersey Zinc Co. began operating its Sterling mine which had been maintained on a standby basis since 1958.

TABLE 4.—Mine production of recoverable zinc in the United States, by months

(Short tons)

Month	1960	1961	Month	1960	1961
January	37,350	40,227	August	34,451	40,431
February	38,130	38,676	September	30,734	37,380
March	42,821	43,007	October	28,101	38,939
April	41,774	38,989	November	28,014	36,011
May	40,830	39,464	December	36,728	36,596
June	39,240	39,643			
July	37,254	35,027	Total	435,427	464,390

The 25 leading zinc-producing mines in the United States in 1961, listed in table 5, yielded 81 percent of the total domestic output. The four leading mines supplied 25 percent, and the first eight contributed 43 percent.

SMELTER AND REFINERY PRODUCTION

The zinc smelting and refining industry operated 16 primary reduction plants and 10 secondary plants producing slab zinc, zinc pigments, zinc dust, and zinc alloys. Some manufacturers of chemicals, pig-

[7] Pend Oreille Mines and Metals Co. Annual Report. 1961, p. 2.

TABLE 5.—Twenty-five leading zinc-producing mines[1] in the United States in 1961 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	Eagle	Red Cliff (Battle Mountain).	Colorado	The New Jersey Zinc Co.	Do.
(2)	Star	Coeur d'Alene	Idaho	The Bunker Hill Co.	Do.
(2)	Austinville & Ivanhoe.	Austinville	Virginia	The New Jersey Zinc Co.	Do.
(2)	Friedensville	Lehigh County	Pennsylvania	do	Zinc ore.
(2)	Jefferson City	Eastern Tennessee	Tennessee	do	Do.
(2)	United States & Lark.	West Mountain (Bingham).	Utah	United States Smelting, Refining & Mining Co.	Gold-silver-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	Page	Coeur d'Alene	Idaho	American Smelting and Refining Company.	Lead-zinc ore.
13	Mascot No. 2	Eastern Tennessee	Tennessee	American Zinc Co. of Tennessee.	Zinc ore.
14	Pend Oreille	Metaline	Washington	Pend Oreille Mines & Metals Co.	Lead-zinc ore.
15	Idarado[3]	Eureka (Red Mountain) & Upper San Miguel.	Colorado	Idarado Mining Co.	Copper-lead-zinc ore.
16	Hanover	Central	New Mexico	The New Jersey Zinc Co.	Zinc ore.
17	Edwards	St. Lawrence County.	New York	St. Joseph Lead Co.	Do.
18	Kearney	Central	New Mexico	Hydrometals, Inc., American Peru Mining Co.	Do.
19	Boyd, Calloway, Eureka and Mary.	Eastern Tennessee	Tennessee	Tennessee Copper Co.	Copper-zinc ore.
20	Gray	Upper Tennessee Valley.	Illinois	Tri-State Zinc, Inc.	Zinc ore.
21	United Park City	Park City Region	Utah	United Park City Mines Co.	Silver-lead-zinc ore.
22	Bowers-Campbell	Rockingham County.	Virginia	Tri-State Zinc, Inc.	Zinc ore.
23	Old Dick	Eureka	Arizona	Cyprus Mines Corp.	Copper-zinc ore.
24	Shullsburg	Upper Mississippi Valley.	Wisconsin	The Eagle-Picher Co.	Zinc ore.
25	Bonne Terre, Leadwood & Federal.	Tri-State	Missouri	St. Joseph Lead Co.	Lead-zinc ore.

[1] Excludes old slag dumps.
[2] Not listed in order of rank.
[3] Formerly Treasury Tunnel—Black Bear—Smuggler Union.

ments, die-casting alloys, rolled zinc, and brass also produced secondary zinc.

Large zinc stocks at smelters and unfavorable marketing conditions caused many producers during the period from January through April to announce curtailments of 10 to 25 percent in their production rate. The only loss in output from a labor strike occurred at the Monsanto, Ill., plant of American Zinc, Lead and Smelting Co. from July 6 to early October. Improved marketing conditions in the latter half of the year led to an increased smelter output rate by October, and production in the last quarter was significantly greater than for any other 3-month period in the year.

Slab Zinc.—Domestic smelter output of slab zinc increased 4 percent over 1960. Included in the 902,000 tons of slab zinc production was molten zinc used directly in alloying operations. Of the output, 846,800 tons was primary metal and 55,200 tons redistilled secondary zinc. Primary production was 50 percent from domestic ores and 50 percent from foreign ores; 38 percent was electrolytic, and 62 percent was distilled slab zinc. Primary smelters produced 64 percent of the redistilled secondary slab zinc; the remainder was obtained from secondary smelters.

Prime Western grade zinc, which furnished 41 percent of the total (39 percent in 1960), was the principal grade produced. Special High Grade zinc constituted 39 percent (41 percent in 1960); High Grade, 10 percent (8 percent); Brass Special, 8 percent (10 percent); and Intermediate, 2 percent (2 percent).

Texas led in production of slab zinc; Pennsylvania ranked second and Oklahoma third. The slab zinc output of Pennsylvania, West Virginia, Oklahoma, and Arkansas was distilled; that of Montana and Idaho was electrolytic. Part of the Illinois and Texas slab output was distilled, and part was electrolytic.

TABLE 6.—Primary and redistilled secondary slab zinc produced in the United States

(Short tons)

	1952-56 (average)	1957	1958	1959	1960	1961
Primary:						
From domestic ores	500,917	539,692	[1] 346,240	348,443	[2] [3] 334,101	419,206
From foreign ores	413,108	446,104	435,006	450,223	[3] 465,415	427,589
Total	914,025	985,796	[2] 781,246	[2] 798,666	[2] [3] 799,516	846,795
Redistilled secondary	62,833	72,481	46,605	57,818	68,731	55,237
Total (excludes zinc recovered by remelting)	976,858	1,058,277	[2] 827,851	[2] 856,484	[2] [3] 868,247	[2] 902,032

[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 figures.

TABLE 7.—Distilled and electrolytic zinc, primary and secondary, produced in the United States, by method of reduction

(Short tons)

	1952-56 (average)	1957	1958	1959	1960	1961
Electrolytic primary	366,704	409,483	326,449	280,813	319,777	324,399
Distilled	547,321	576,313	454,797	517,853	[1] 479,739	522,396
Redistilled secondary:						
At primary smelters	24,626	35,215	24,297	28,451	40,009	35,319
At secondary smelters	38,207	37,266	22,308	29,367	28,722	19,918
Total	976,858	1,058,277	[2] 827,851	[2] 856,484	[1] [2] 868,247	[2] 902,032

[1] Revised figure.
[2] Includes production of zinc used directly in alloying operations.

Primary Smelters and Electrolytic Plants.—Primary reduction plants processed zinc ore and concentrate, zinc fume from Waelz kilns and slag-fuming plants, other primary zinc-bearing materials, and 64 percent of all zinc-base scrap used for redistilled slab zinc.

TABLE 8.—Distilled and electrolytic zinc, primary and secondary, produced in the United States, by grades

(Short tons)

	1952–56 (average)	1957	1958	1959	1960	1961
Special High Grade	322,748	354,042	298,442	331,312	[1] 357,205	353,466
High grade	159,271	152,317	86,859	71,792	[1] 71,332	89,496
Intermediate	22,678	32,262	19,388	17,493	15,841	15,368
Brass Special	66,840	84,291	81,841	75,305	83,507	69,681
Select	4,615	1,150	1,300	1,414	73	
Prime Western	400,706	434,215	340,021	359,168	340,289	374,021
Total	976,858	1,058,277	[2] 827,851	[2] 856,484	[1 2] 868,247	[2] 902,032

[1] Revised figure.
[2] Includes production of zinc used directly in alloying operations.

TABLE 9.—Primary slab zinc produced in the United States, by States where smelted

(Short tons)

	1952–56 (average)	1957	1958	1959	1960	1961
Arkansas	19,946	23,080	17,952	15,964	1,521	12,342
Idaho	54,041	68,831	55,454	61,191	26,449	74,736
Illinois	108,426	[1] 107,294	[1] 82,844	102,708	[1] 88,291	78,814
Montana	202,696	198,036	148,921	86,620	132,290	111,223
Oklahoma	155,428	157,633	122,138	152,072	161,894	164,319
Pennsylvania	196,847	[2] 247,836	[2] 187,243	[2] 217,368	[2 3] 194,514	[2] 214,308
Texas and West Virginia [4]	176,641	[5] 183,086	[5] 166,694	[5] 162,743	[5] 194,557	[5] 191,053
Total	914,025	985,796	[6] 781,246	[6] 798,666	[3 6] 799,516	[6] 846,795
Value (thousands)	$238,344	$229,493	$159,687	$183,214	[3] $205,476	$193,916

[1] Includes Missouri.
[2] Includes West Virginia.
[3] Revised.
[4] Includes Missouri 1952–53, 1955, 1956.
[5] Texas only.
[6] Includes production of zinc used directly in alloying operations.

Production at primary zinc plants totaled 882,100 tons of slab zinc, 35,300 tons being 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 16 operating zinc plants at yearend was reported to be 1,171,800 tons. Five electrolytic plants reported 2,860 of their 4,072 electrolytic cells in use at yearend and an output of 324,400 tons (67 percent of their 483,500 tons of capacity). The seven horizontal-retort plants reported 35,088 of their 43,648 retorts in use during the year. 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 557,700 tons was 82 percent of the reported 1961 capacity of 683,300 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 at the following plants in 1961:

California: Selby—American Smelting and Refining Company.
Idaho: Kellogg—The Bunker Hill Co.
Montana: East Helena—The Anaconda Company.
Texas: El Paso—American Smelting and Refining Company.
Utah: Tooele—International Smelting & Refining Co.

These five plants treated 685,400 tons of hot and cold lead slag (including some crude ore and zinc residue), which yielded 120,700 tons of oxide fume, containing 79,500 tons of recoverable zinc. Corresponding figures for 1960 were 621,700, 105,000, and 74,300 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 usually was 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 10.—United States primary zinc plants, their location and group capacity for slab zinc in 1961

Type of plant	Plant location	Slab-zinc capacity (short tons)
Primary plants:		
Electrolytic plants:		
American Smelting and Refining Company	Corpus Chirsti, Tex.	483,500
American Zinc Co. of Illinois	Monsanto, Ill.	
The Anaconda Company	Anaconda, Mont.	
Do.	Great Falls, Mont.	
The Bunker Hill Co.	Kellogg, Idaho	
Horizontal-retort plants:		
American Smelting and Refining Company	Amarillo, Tex.	688,300
American Zinc Co. of Illinois	Dumas, Tex.	
Athletic Mining & Smelting Co.	Fort Smith, Ark.	
Blackwell Zinc Co.	Blackwell, Okla.	
The Eagle-Picher Co.	Henryetta, Okla.	
Matthiessen & Hegeler Zinc Co.	LaSalle, Ill.	
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.	Josephtown, Pa.	
Do [1]	Herculaneum, Mo.	

[1] Electrothermic slag-fuming unit, yielding a slab zinc product.

TABLE 11.—United States secondary zinc plants, their location and capacity for slab zinc in 1961

Type of plant	Plant location	Slab-zinc capacity (short tons)
Secondary plants:		
American Smelting and Refining Company	Beckemeyer, Ill.	61,000
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 12.—Stocks and consumption of new and old zinc scrap in the United States in 1961

(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	61	1,457	1,416		1,416	102
Old zinc	736	2,986		2,874	2,874	848
Engravers' plates	348	2,999		3,012	3,012	335
Skimmings and ashes	4,324	36,889	33,682		33,682	7,531
Sal skimmings	411	548	689		689	270
Die-cast skimmings	1,331	5,688	6,367		6,367	652
Galvanizers' dross	5,074	54,420	53,582		53,582	5,912
Die castings	5,521	33,109		33,731	33,731	4,899
Rod and die scrap	329	946		1,104	1,104	171
Flue dust	211	5,186	5,265		5,265	132
Chemical residues	1,528	12,270	8,645		8,645	5,153
Total	19,874	156,498	109,646	40,721	150,367	26,005
Chemical plants, foundries and other manufacturers:						
New clippings	1	27	24		24	4
Old zinc						
Engravers' plates						
Skimmings and ashes	2,043	5,659	5,311		5,311	2,391
Sal skimmings	10,516	16,199	19,291		19,291	7,424
Die-cast skimmings						
Galvanizers' dross	14		1		1	13
Die castings						
Rod and die scrap	9	59		64	64	4
Flue dust	32	858	859		859	31
Chemical residues	2,378	16,560	16,846		16,846	2,092
Total	14,993	39,362	42,332	64	42,396	11,959
Grand total:						
New clippings	62	1,484	1,440		1,440	106
Old zinc	736	2,986		2,874	2,874	848
Engravers' plates	348	2,999		3,012	3,012	335
Skimmings and ashes	6,367	42,548	38,993		38,993	9,992
Sal skimmings	10,927	16,747	19,980		19,980	7,694
Die-cast skimmings	1,331	5,688	6,367		6,367	652
Galvanizers' dross	5,088	54,420	53,583		53,583	5,925
Die castings	5,521	33,109		33,731	33,731	4,899
Rod and die scrap	338	1,005		1,168	1,168	175
Flue dust	243	6,044	6,124		6,124	163
Chemical residues	3,906	28,830	25,491		25,491	7,245
Total	34,867	195,860	151,978	40,785	192,763	37,964

[1] Figures partly revised.

Primary and secondary smelting plants treating zinc-base scrap produced 55,200 tons of redistilled zinc, 4,300 tons of remelt, and 34,800 tons of zinc dust. The zinc content of these products totaled 93,100 tons.

Additional details on 99,500 tons of zinc recovered in processing copper-base scrap (table 14) may be obtained in the secondary section of the Copper chapter in this volume.

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 776,100 short tons, valued at $9.5 million, and from elemental sulfur, 66,500 tons, valued at $810,000.

TABLE 13.—Production of secondary zinc and zinc-alloy products in the United States

(Short tons, gross weight)

Product	1952–56 (average)	1957	1958	1959	1960	1961
Redistilled slab zinc	62,833	[1] 72,481	46,605	[1] 57,818	[1] 68,731	[1] 55,237
Zinc dust [2]	27,058	26,715	26,512	32,758	30,788	34,772
Remelt spelter	4,702	6,404	5,236	4,718	4,883	4,260
Remelt die-cast slab	9,568	10,328	12,980	13,150	7,800	9,548
Zinc-die and die-casting alloys	4,306	6,440	6,082	5,864	6,945	5,894
Galvanizing stocks	238	240	249	245	222	117
Rolled zinc	2,775	185	10	14	18	19
Secondary zinc in chemical products	30,311	33,361	32,482	40,204	38,007	35,639

[1] Includes redistilled slab made from remelt die-cast slab.
[2] Includes zinc dust produced from other than scrap.

TABLE 14.—Zinc recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

Kind of scrap	1960	1961	Form of recovery	1960	1961
New scrap:			As metal:		
Zinc-base	116,222	101,846	By distillation:		
Copper-base	79,351	74,874	Slab zinc [1]	68,010	54,610
Aluminum-base	1,802	1,809	Zinc dust [2]	30,144	34,095
Magnesium-base	76	31	By remelting	5,031	4,352
Total	197,451	178,560	Total	103,185	93,057
Old scrap:			In zinc-base alloys	13,738	14,400
Zinc-base	38,056	32,759	In brass and bronze	107,422	90,956
Copper-base	28,866	24,628	In aluminum-base alloys	3,277	3,789
Aluminum-base	1,381	1,925	In magnesium-base alloys	191	126
Magnesium-base	66	95	In chemical products:		
Total	68,369	59,407	Zinc oxide (lead-free)	17,679	17,189
			Zinc sulfate	[3]	[3]
Grand total	265,820	237,967	Zinc chloride	11,994	11,426
			Miscellaneous	8,334	7,024
			Total	162,635	144,910
			Grand total	265,820	237,967

[1] Includes zinc content of redistilled slab made from remelt die-cast slab.
[2] Includes zinc content of dust made from other than scrap.
[3] Included with "Miscellaneous."

ZINC DUST

Zinc dust included in data in tables 13, 14, and 15 is restricted to commercial grades that comply with close specifications as to percentage of unoxidized metal, evenness of grading, and fineness of particles, and it does not include blue powder. Zinc content of

TABLE 15.—Zinc dust produced in the United States

Year	Short tons	Value		Year	Short tons	Value	
		Total	Average per pound			Total	Average per pound
1952–56 (average)	27,058	$8,474,684	$0.157	1959	32,758	$9,683,265	$0.148
1957	26,715	7,859,583	.147	1960	30,788	10,283,192	.167
1958	26,512	7,253,683	.137	1961	34,772	10,570,688	.152

the dust produced ranged from 95.0 to 99.7 percent, averaging 98.1 percent. Total shipments of zinc dust were 35,200 tons, 100 tons being shipped abroad. Producer stocks of zinc dust were 1,600 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.

CONSUMPTION AND USES

Zinc consumed as refined metal in slab or other forms totaled 931,200 tons (877,900 tons in 1960); as ore and concentrate to make pigments and salts and used directly in galvanizing, 97,300 tons (88,300); and as scrap to make alloys, zinc dust, pigments and salts, 179,000 tons (192,800). These uses totaled 1,207,500 tons of primary and secondary zinc, increasing 4 percent over 1960. The quantity of zinc consumed directly in making pigments and salts is reported in table 16. Zinc consumed in scrap form, and the manufactured products other than remelt and redistilled are reported in tables 12, 13, and 14.

TABLE 16.—Consumption of zinc in the United States

(Short tons)

	1952–56 (average)	1957	1958	1959	1960	1961
Slab zinc	970,322	935,620	868,327	956,197	877,884	931,213
Ores (recoverable zinc content)	111,651	[1] 110,311	[1] 94,938	[1] 108,070	[1] 88,275	[1] 97,251
Secondary (recoverable zinc content) [2]	223,386	185,662	178,900	214,109	192,779	179,005
Total	1,305,359	1,231,593	1,142,165	1,278,376	1,158,938	1,207,469

[1] Includes ore used directly in galvanizing.
[2] Excludes redistilled slab and remelt zinc.

Slab zinc consumption, as reported by 650 plants, increased 6 percent to 931,200 tons. Slab zinc used in galvanizing steel products increased 3 percent and was again the leading industry use, accounting for 41 percent of total slab zinc consumed. Die castings and zinc-base alloys used 1 percent more zinc than in 1960 and accounted for 37 percent of the total. Zinc used in brass products increased 30 percent to 128,500 tons and represented 14 percent of the total. The remaining 8 percent was used in rolled zinc, zinc oxide, slush castings, wet batteries, zinc dust, chemicals, bronze powders, desilverizing lead, light-metal alloys, and zinc used for cathodic protection.

Of the commercial grades of slab zinc used, Special High Grade was 44 percent of the total; Prime Western, 33 percent; Brass Special, 11 percent; High Grade, 10 percent; Intermediate, 1 percent; Select and Remelt, together, 1 percent. All grades of slab zinc were used in making brass products and in galvanizing. More than 98 percent of the slab zinc used in making zinc-base alloys was Special High Grade.

Rolling mills used 41,200 tons of slab zinc and remelted and rerolled 12,700 tons of metallic scrap produced in fabricating plants operated 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.

TABLE 17.—Reported Slab-zinc consumption in the United States, by industries

(Short tons)

Industry and product	1952–56 (average)	1957	1958	1959	1960	1961
Galvanizing: [1]						
Sheet and strip	179,230	168,221	194,196	175,691	196,057	211,300
Wire and wire rope	45,747	36,468	35,638	35,602	35,262	37,608
Tubes and pipe	86,369	70,463	67,318	59,830	56,680	54,957
Fittings	10,489	9,965	8,904	10,239	9,258	6,540
Other	93,850	[2] 82,640	[2] 75,173	[2] 79,665	[2] 74,332	[2] 71,672
Total galvanizing	415,685	367,757	381,229	361,027	371,589	382,077
Brass products:						
Sheet, strip, and plate	68,515	52,873	46,967	61,234	45,870	60,018
Rod and wire	42,857	33,711	32,568	40,286	29,971	41,018
Tube	15,264	11,915	9,645	11,808	8,504	10,168
Castings and billets	6,952	5,818	4,423	4,967	4,699	4,061
Copper-base ingots	7,547	7,286	7,094	10,276	9,412	12,874
Other copper-base products	1,326	787	678	707	567	384
Total brass products	142,461	112,390	101,375	129,278	99,023	128,523
Zinc-base alloy: [3]						
Die castings	313,873	363,830	309,408	383,358	331,112	337,227
Alloy dies and rod	9,262	10,149	5,400	3,745	3,442	1,629
Slush and sand castings	2,124	2,060	2,022	2,228	3,819	2,910
Total zinc-base alloy	325,259	376,039	316,830	389,331	338,373	341,766
Rolled zinc	50,480	41,269	40,616	42,949	38,696	41,204
Zinc oxide	19,635	20,428	13,331	18,248	15,593	18,137
Other uses:						
Wet batteries	1,368	1,336	846	1,244	1,152	1,058
Desilverizing lead	2,630	2,808	2,521	1,949	2,521	2,630
Light-metal alloys	4,409	4,958	3,657	3,363	3,181	4,347
Other [4]	8,395	8,635	7,922	8,808	7,756	11,471
Total other uses	16,802	17,737	14,946	15,364	14,610	19,506
Total consumption [5]	970,322	935,620	868,327	956,197	877,884	931,213

[1] Includes zinc used in electrogalvanizing and electroplating, but excludes sherardizing.
[2] Includes 28,286 tons used in job galvanizing in 1957, 28,502 tons in 1958, 31,521 tons in 1959, 31,616 tons in 1960, and 30,954 tons in 1961.
[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 6,805 tons of remelt zinc in 1957, 8,073 tons in 1958, 5,209 tons in 1959, 6,622 tons in 1960, and 7,528 tons in 1961.

Output of salable rolled zinc increased to 39,600 tons. Stocks of rolled zinc at the mills declined to 2,900 tons by yearend. Besides shipments of 21,100 tons of rolled zinc, the rolling mills consumed 31,400 tons of rolled zinc in manufacturing 19,600 tons of semi-fabricated and finished products.

TABLE 18.—Reported slab zinc consumption in the United States in 1961, by grades and industries

(Short tons)

Industry	Special High Grade	High Grade	Intermediate	Brass Special	Select	Prime Western	Remelt	Total
Galvanizers	17,341	12,666	2,956	79,149	11	267,844	2,110	382,077
Brass mills [1]	26,308	66,538	976	10,304	3,337	16,648	4,412	128,523
Die casters [2]	338,229	1,317	47			1,615	558	341,766
Zinc rolling mills	14,891	10,347	4,981	10,974		11		41,204
Oxide plants	4,068			56		14,013		18,137
Other	9,076	1,172	309	134		8,367	448	19,506
Total	409,913	92,040	9,269	100,617	3,348	308,498	7,528	931,213

[1] Includes brass mills, brass ingotmakers, and brass foundries.
[2] Includes producers of zinc-base die castings, zinc-alloy dies, and zinc-alloy rods.

Rolled zinc was used to make sheet, strip, ribbon, foil, plate, rod, and wire. 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 19.—Rolled zinc produced and quantity available for consumption in the United States

	1960			1961		
	Short tons	Value		Short tons	Value	
		Total	Average per pound		Total	Average per pound
Production:						
Sheet zinc not over 0.1 inch thick	12,897	$8,023,358	$0.311	12,683	$7,186,096	$0.283
Boiler plate and sheets over 0.1 inch thick	171	75,471	.221	201	84,662	.210
Strip and ribbon zinc [1]	22,186	9,343,955	.211	24,908	10,410,161	.209
Foil, rod, and wire	1,741	1,146,333	.329	1,806	996,341	.276
Total rolled zinc	36,995	18,589,117	.251	39,598	18,677,260	.236
Imports	904	301,667	.167	1,183	354,034	.150
Exports	3,324	2,443,165	.368	3,219	2,271,467	.353
Available for consumption	34,439			37,810		
Value of slab zinc (all grades)			.129			.115
Value added by rolling			.122			.121

[1] Figures represent net production. In addition, 11,290 tons of strip and ribbon zinc in 1960 and 12,699 tons in 1961 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 59 percent of the slab zinc consumed 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 many other items.

Connecticut again ranked first in consuming slab zinc in brass-making. Michigan, Illinois, Ohio, and New York led the 20 States using zinc in making zinc-base alloys.

ZINC PIGMENTS AND SALTS

Production of zinc pigments and salts increased 6 percent over 1960, but was 13 percent below 1959. The production of natural and synthetic rubber, a major zinc-pigment consuming product, declined 5 percent; paint, varnish and lacquer industries, also using large quantities of zinc pigments, recorded a 1-percent decrease in value of shipments.

Production.—Production of lead-free zinc oxide increased 7 percent, and output of leaded zinc oxide rose 41 percent. Output of zinc chloride declined 6 percent, but that of zinc sulfate rose 6 percent.

Pigments and salts were made from various zinc-bearing materials, including ore, slab zinc, scrap, and residues. Zinc in pigments and salts produced directly from ore, both domestic and foreign,

TABLE 20.—Reported zinc consumption in the United States in 1961, by industries and States

(Short tons)

State	Galvanizers	Brass mills [1]	Die casters [2]	Other [3]	Total
Alabama	(4)	(4)		(4)	(4)
Arizona	(4)			(4)	(4)
Arkansas				(4)	(4)
California	22,130	(4)	14,521	(4)	38,766
Colorado	(4)	(4)			(4)
Connecticut	(4)	38,533	3,166	(4)	45,264
Delaware	(4)	(4)	(4)	(4)	(4)
Florida	(4)		(4)		735
Georgia	(4)				(4)
Hawaii	(4)				(4)
Idaho			(4)	(4)	(4)
Illinois	45,022	19,152	51,531	18,829	134,534
Indiana	47,836	(4)	19,833	(4)	89,896
Iowa	(4)			(4)	916
Kansas			(4)		(4)
Kentucky	(4)	(4)			(4)
Louisiana	(4)			(4)	699
Maine	(4)				(4)
Maryland	(4)	(4)			(4)
Massachusetts	3,196	(4)		(4)	6,403
Michigan	(4)	14,390	76,724	(4)	95,119
Minnesota	(4)	(4)		(4)	1,278
Mississippi	(4)				(4)
Missouri	(4)	(4)	5,026	(4)	10,400
Nebraska	(4)	(4)		(4)	1,797
New Hampshire		(4)			(4)
New Jersey	4,532	5,416	(4)	(4)	23,948
New York	5,697	(4)	29,885	(4)	60,278
North Carolina	(4)		(4)		(4)
Ohio	78,254	(4)	46,093	(4)	135,497
Oklahoma	(4)		(4)	(4)	8,800
Oregon	(4)	(4)	(4)	(4)	1,015
Pennsylvania	51,874	7,816	15,521	(4)	103,558
Rhode Island	593	(4)		(4)	622
South Carolina	(4)				(4)
Tennessee	(4)		(4)	(4)	1,533
Texas	(4)	(4)	(4)	(4)	32,915
Utah	(4)	(4)		(4)	(4)
Virginia	(4)	(4)		(4)	(4)
Washington	(4)			(4)	1,500
West Virginia	6,676	(4)		(4)	6,806
Wisconsin	1,512	(4)	(4)	(4)	10,875
Undistributed	112,645	38,804	68,908	59,570	110,531
Total [5]	379,967	124,111	341,208	78,399	923,685

[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.

exceeded 87,000 tons; that 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 37,000 tons.

Lead-free zinc oxide was made by several processes: 64 percent from ores and residues by the American process, 24 percent from metal by the French process, and 12 percent by other processes from scrap residues and scrap materials. Leaded zinc oxide was made from ores; zinc chloride, from slab zinc and secondary zinc materials; and zinc sulfate, from ores and scrap zinc.

Four grades of leaded zinc oxide, classified according to lead content, were produced. Only a very small quantity of 5-percent-or-less leaded zinc oxide was produced; the grade of more-than-5-to-35-percent lead constituted most of the production. Small quantities of the more-than-35-through-50-percent and over-50 percent grades were produced.

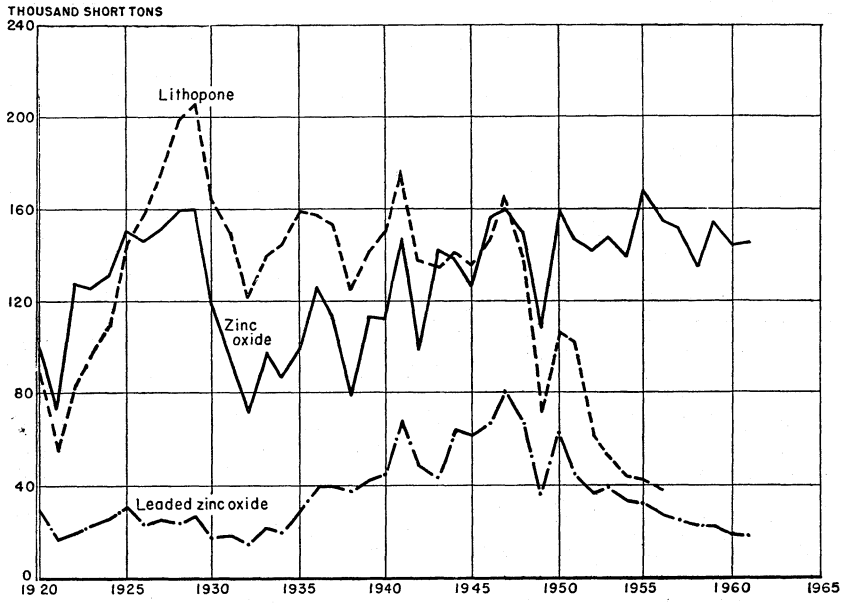


FIGURE 2.—Trends in shipments of zinc pigments, 1920–61.

TABLE 21.—Production and shipments of zinc pigments and salts[1] in the United States

Pigment or salt	1960				1961			
	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]	138,128	144,778	$38,538,393	$266	147,555	145,208	$33,219,370	$229
Leaded zinc oxide[3]	14,379	19,278	5,187,006	269	20,335	18,007	4,204,066	233
Zinc chloride, 50° B[4]	55,802	55,037	(5)	(5)	52,479	53,099	(5)	(5)
Zinc sulfate	27,628	28,796	4,480,683	156	29,269	28,891	(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.

Both ordinary lithopone, a coprecipitate of zinc sulfide and barium sulfate, and high strength (titanated) lithopone were produced.

Consumption and Uses.—Shipments of lead-free zinc oxide were 145,200 tons. Shipments to the rubber, paint, coated fabrics and textiles, and floor coverings industries showed a combined decline of 5 percent; ceramic and other industries reported a 16-percent increase.

Consumption of leaded zinc oxide by the paintmaking industries (92 percent of the total consumption) declined 7 percent below 1960.

Lithopone was used in paint, varnish and lacquer, floor covering, coated fabrics and textiles, and rubber.

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TABLE 22.—Zinc content of zinc pigments[1] and salts produced by domestic manufacturers, by sources

(Short tons)

Pigment or salt	1960					1961				
	Zinc in pigments and salts produced from—				Total zinc in pigments and salts	Zinc in pigments and salts produced from—				Total zinc in pigments and salts
	Ore		Slab zinc	Secondary material[2]		Ore		Slab zinc	Secondary material[2]	
	Domestic	Foreign				Domestic	Foreign			
Zinc oxide	57,296	13,028	15,393	24,716	110,433	63,872	10,305	17,936	25,639	117,752
Leaded zinc oxide	5,704	2,831	-------	-------	8,535	7,665	4,752	-------	-------	12,417
Total pigments	63,000	15,859	15,393	24,716	118,968	71,537	15,057	17,936	25,639	130,169
Zinc chloride[3]	-------	-------	(4)	12,625	12,625	-------	-------	(4)	11,410	11,410
Zinc sulfate	(4)	(4)	-------	(4)	9,740	(4)	(4)	-------	(4)	10,667

[1] Excludes zinc sulfide and lithopone; figures withheld to avoid disclosing individual company confidential data.
[2] These figures are higher than those shown in the report on Secondary Metals—Nonferrous because they include zinc recovered from byproduct sludges, residues, etc., not classified as purchased scrap material.
[3] Includes zinc content of zinc ammonium chloride and chromated zinc chloride.
[4] Figure withheld to avoid disclosing individual company confidential data.

TABLE 23.—Distribution of zinc oxide shipments, by industries

(Short tons)

Industry	1952–56 (average)	1957	1958	1959	1960	1961
Rubber	77,881	81,745	68,176	79,505	75,120	71,534
Paints	32,184	32,605	33,335	33,708	31,610	30,405
Ceramics	9,278	8,459	9,095	10,486	9,840	10,058
Coated fabrics and textiles[1]	8,202	3,623	2,327	2,125	1,331	1,185
Floor coverings	2,023	1,249	971	1,207	1,316	1,174
Other	21,356	23,586	22,087	27,203	25,561	30,852
Total	150,924	151,267	135,991	154,234	144,778	145,208

[1] Includes the following tonnages for rayon: 1957—2,838; 1958—1,149. Figure for 1959, 1960, and 1961 withheld to avoid disclosing individual company confidential data.

TABLE 24.—Distribution of leaded zinc oxide shipments, by industries

(Short tons)

Industry	1952–56 (average)	1957	1958	1959	1960	1961
Paints	33,915	23,904	23,021	20,748	17,616	16,533
Rubber, Other	365	299	267	1,878	1,662	1,474
Total	34,280	24,203	23,288	22,626	19,278	18,007

Statistics on distribution of zinc chloride shipments were not available. The principal uses were for batterymaking, galvanizing, vulcanizing fiber, preserving wood, refining oil, fungicides, and solder and tinning fluxes.

Rayon and agriculture were the chief consumers of zinc sulfate, receiving 42 and 20 percent, respectively, of the total shipments. Other uses were in chemicals, flotation reagents, glue, medicine, and

rubber; these combined uses accounted for 38 percent of the shipments. Zinc sulfate consumed by rayon manufacturers decreased 22 percent, agricultural uses increased 31 percent, and other uses increased 25 percent compared with 1960.

TABLE 25.—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
1952-56 (average)	11,124	9,705	6,838	5,972	5,418	4,192	23,380	19,869
1957	19,903	17,785	9,818	8,261	3,899	3,465	33,620	29,511
1958	19,796	17,747	11,525	9,819	2,416	2,191	33,737	29,757
1959	26,062	23,354	5,262	4,696	9,346	7,428	40,670	35,478
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

Prices.—American process lead-free zinc oxide was quoted at 14.5 cents per pound in carlots at the beginning of the year, but had decreased to 13.00 cents by the end of December. Leaded zinc oxide of the 35-percent grade was quoted at 15.375 cents per pound for carlots at the beginning of the year. After several price changes during the year, the quotation was 13.875 cents at yearend.

Red-seal French process zinc oxide prices ranged from 15.75 cents to 14 cents per pound in carlots and closed the year at 14.75 cents. Green-seal French process zinc oxide in carlots ranged from 16.25 to 14.25 cents and closed the year at 14.75 cents. White-seal zinc oxide sold in carlots was quoted at 16.75 cents a pound at the beginning of the year, but had decreased to 15.00 cents per pound by yearend. Zinc chloride (50 percent solution) was quoted throughout the year at 5.15 cents per pound. Zinc sulfate (less than carlots) was priced at 9.75 cents in January but declined to 9.00 cents in April and remained so for the rest of the year.

Foreign Trade.—Imports of zinc pigments and salts dropped 19 percent in quantity and 23 percent in value below 1960. Of the 12,600 tons imported, 10,200 tons was zinc oxide.

Exports of zinc oxide were 2,200 tons and lithopone exports were 600 tons compared with 2,100 and 200 tons, respectively, in 1960.

TABLE 26.—U.S. imports for consumption of zinc pigments and salts

Kind	1960		1961	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Zinc oxide	12,695	$2,632	10,222	$1,962
Zinc sulfide	193	63	353	118
Lithopone	62	8	74	9
Zinc arsenate	(1)	(2)		
Zinc chloride	889	151	800	137
Zinc sulfate	1,743	198	1,159	128
Total	15,582	3,052	12,608	2,354

[1] Less than 1 ton.
[2] Less than $1,000.

Source: Bureau of the Census.

TABLE 27.—U.S. exports of zinc pigments

Kind	1960		1961	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Zinc oxide	2,137	$659	2,183	$671
Lithopone	190	35	608	88
Total	2,327	694	2,791	759

Source: Bureau of the Census.

STOCKS

National Stockpile.—Zinc at yearend in the national (strategic) stockpile was 1,256,000 tons and in the supplementary stockpile 324,000 tons, a combined total of 1,580,000 tons, and a surplus of 1,402,000 tons over the maximum objective.

Producer Stocks.—Smelter stocks of slab zinc began the year at 185,900 tons and rose to 222,900 tons by the end of March. Thereafter a steady decline began, and by the end of 1961 stocks totaled 145,500 tons.

TABLE 28.—Stocks of zinc at zinc-reduction plants in the United States, Dec. 31

(Short tons)

	1957	1958	1959	1960	1961
At primary reduction plants	153,338	182,111	152,410	[1] 178,209	142,147
At secondary distilling plants	2,495	1,909	3,800	7,673	3,393
Total	155,833	184,020	156,210	[1] 185,882	145,540

[1] Revised figure.

Consumer Stocks.—Stocks of slab zinc at consumer plants were 68,900 tons at the beginning of the year. During the first four months inventories declined to 57,000 tons, followed by an upward trend to 93,800 tons by yearend. An additional 7,800 tons of slab zinc was in transit to consumer plants. At the average monthly rate of consumption, total consumer stocks plus metal in transit represented about a 6-weeks' supply.

TABLE 29.—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, 1960 [3]	36,091	7,823	19,234	3,771	689	1,263	[4] 68,871
Dec. 31, 1961	58,599	11,124	19,980	1,918	577	1,584	[4] 93,782

[1] Includes brassmills, brass ingotmakers, and foundries.
[2] Includes producers of zinc-base die castings, zinc-alloy dies, and zinc-alloy rods.
[3] Figures partly revised.
[4] Stocks on Dec. 31, 1960, and Dec. 31, 1961, exclude 1,490 and 1,332 tons, respectively, of remelt spelter.

PRICES

Quoted price for Prime Western zinc at East St. Louis was 12 cents per pound at the beginning of the year. Early in January the quotation fell to 11.50 cents per pound, where it remained until December 1 when the price returned to 12 cents for the rest of the year.

The average monthly zinc quotation, London Metal Exchange, was £78.123 a long ton (equivalent to 9.78 cents per pound computed at the exchange rate recorded by the Federal Reserve Board). Average price for January was £78.452 (9.81 cents per pound). By April the quotation was £83.849 (10.48 cents per pound), but it declined thereafter, reaching £70.688 (8.91 cents per pound) in November, followed by a slight rise to £72.434 (9.05 cents per pound), in December.

Average price for new clippings was 5.89 cents per pound in January; it declined to 5.12 cents in July, where it remained to yearend.

TABLE 30.—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	1960			1961		
	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	$78.91	12.90	11.47	$69.09	11.56	9.81
February	80.00	13.00	11.12	68.00	11.50	10.25
March	80.00	13.00	11.11	68.00	11.50	10.44
April	80.00	13.00	11.22	68.00	11.50	10.48
May	80.00	13.00	11.43	68.00	11.50	10.34
June	80.00	13.00	11.27	68.00	11.50	10.01
July	80.00	13.00	11.22	68.00	11.50	9.80
August	80.00	13.00	10.93	68.00	11.50	9.67
September	80.00	13.00	10.89	68.00	11.50	9.39
October	80.00	13.00	10.91	68.00	11.50	9.18
November	80.00	13.00	10.94	68.00	11.50	8.91
December	77.10	12.48	10.34	72.00	12.00	9.05
Average for year	73.13	12.95	11.05	68.42	11.55	9.78

[1] Joplin: Metal Statistics, 1962, p. 535. East St. Louis: Metal Statistics, 1962, p. 533. London: E&MJ Metal and Mineral Markets.
[2] Conversion of English quotations into American money based on average rates of exchange recorded by Federal Reserve Board.
[3] Average of daily mean of bid and asked quotations at morning session of London Metal Exchange.

TABLE 31.—Average price received by producers of zinc, by grades

(Cents per pound)

Grade	1957	1958	1959	1960	1961
Special High Grade	12.13	10.45	11.78	[1] 13.68	11.58
High Grade	11.70	10.13	11.42	[1] 13.19	11.42
Intermediate	11.69	10.81	11.85	13.34	12.12
Brass Special	11.31	10.38	11.39	12.89	11.52
Select	10.56	10.48	10.93	12.64	11.60
Prime Western	11.24	9.98	11.18	12.15	11.32
All grades	11.64	10.22	11.47	[1] 12.85	11.45
Prime Western; spot quotation at St. Louis [2]	11.40	10.31	11.46	12.95	11.55

[1] Revised figure.
[2] Metal Statistics, 1962, p. 533.

Yearly average was 5.36 cents per pound, compared with 7.08 cents in 1960. Quotations for old zinc scrap averaged 3.07 cents per pound in January and ranged from 2.87 cents in February to 3.75 cents in May; average for the year was 3.18 cents.

FOREIGN TRADE

Import quotas imposed October 1, 1958, by Presidential Proclamation 3257, dated September 22, 1958, remained in effect through 1961. 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

TABLE 32.—U.S. imports [1] of zinc, by countries

(Short tons)

Country	1952–56 (average)	1957	1958	1959	1960	1961
Ores (zinc content):						
North America:						
Canada	164,423	158,220	155,506	152,134	[2] 120,336	119,113
Cuba	1,006	1,209	223	188	78	
Guatemala	7,952	9,313	6,483	8	6,063	13,870
Honduras	1,093	2,589	1,435	1,427	4,714	6,851
Mexico	184,986	192,519	158,609	182,409	[2] 190,621	186,174
Other North America	1	(3)	(3)	1		
Total	359,461	363,850	322,256	336,167	[2] 321,812	326,008
South America:						
Argentina	121	165	9	101		
Bolivia	11,540	7,633	7,328	2,530	[2] 1,214	572
Chile	2,056	1,400	977	479	30	(3)
Peru	80,875	119,004	102,990	86,672	[2] 80,100	74,369
Other South America	219	8	121	66	[2] 58	53
Total	94,811	128,210	111,425	89,848	[2] 81,402	74,994
Europe:						
Germany, West				5,756	2	11
Italy	1,748			14,766		
Spain	5,053			16,479	18,913	
Other Europe	5,238	1,398	80	3,613	100	109
Total	12,039	1,398	80	40,614	19,015	120
Asia:						
Philippines	1,101	777	92	48	[2] 4,774	3,203
Other Asia	447	79	240	1	24	
Total	1,548	856	332	49	[2] 4,798	3,203
Africa:						
Union of South Africa	8,181	21,048	21,700	7,957	12,300	7,551
Other Africa	601	1,896	1,032	787	39	2
Total	8,782	22,944	22,732	8,744	12,339	7,553
Oceania: Australia	7,795	8,756	[4] 4,735	24,693	[2] 17,789	3,822
Grand total: Ores	484,436	526,014	461,560	500,115	[2] 457,155	415,700
Blocks, pigs, or slabs:						
North America:						
Canada	102,626	103,964	93,475	88,414	74,168	71,628
Mexico	19,785	23,536	23,256	9,338	8,950	8,598
Total	122,411	127,500	116,731	97,752	83,118	80,226
South America: Peru	6,624	22,947	9,736	12,337	7,517	7,519
Europe:						
Austria	459	1,020	110	220		
Belgium-Luxembourg	17,209	34,163	21,707	7,666	5,724	12,854
Germany, West	9,312	8,772	2,673	55	2,680	779

See footnotes at end of table.

TABLE 32.—U.S. imports [1] of zinc, by countries—Continued

(Short tons)

Country	1952–56 (average)	1957	1958	1959	1960	1961
Blocks, pigs, or slabs—Continued						
Europe—Continued						
Italy	10,599	10,010	6,166	7,459	3,517	1,820
Netherlands	3,364	2,504	2,520			120
Norway	1,531		2,769	168		
United Kingdom	1,406	1,791	672	841	333	(3)
Yugoslavia	1,038	10,909	5,781	3,643	4,520	3,198
Other Europe	57				2,986	7,197
Total	44,975	69,169	42,398	20,052	19,760	25,968
Asia: Japan	1,021	2,887	2,039			
Africa:						
Congo, Republic of the, and Ruanda-Urundi [5]	9,557	33,007	20,991	12,790	9,307	11,420
Rhodesia and Nyasaland, Federation of [6]	381	3,974	1,064	4,667	615	1,400
Other Africa	925					
Total	10,863	36,981	22,055	17,457	9,922	12,820
Oceania: Australia	3,669	9,523	2,240	9,365	450	1,029
Grand total: Blocks, pigs, or slabs	189,563	269,007	195,199	156,963	120,767	127,562

[1] Data include zinc imported for immediate consumption plus material entering country under bond.
[2] Revised figure.
[3] Less than 1 ton.
[4] Includes 52 tons imported from French Pacific Islands.
[5] Effective July 1, 1960; formerly Belgian Congo.
[6] Effective July 1, 1954; formerly Northern Rhodesia.

Source: Bureau of the Census.

TABLE 33.—U.S. imports for consumption [1] of zinc, by classes

Year	Ore (zinc content)		Blocks, pigs, slabs		Sheets		Old and worn out	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1952–56 (average)	463,998	[2] $58,374	188,126	$46,341	277	[2] $102	918	$117
1957	679,416	88,516	268,824	[2] 64,129	732	245	227	32
1958	537,699	51,121	185,693	35,511	901	285	235	31
1959	424,134	37,475	164,462	33,996	951	311	183	26
1960	[3] 382,938	[3] 38,704	120,925	29,639	904	302	106	14
1961	357,653	31,920	125,186	27,540	1,183	354	303	32

Year	Dross and skimmings		Zinc dust		Total value [4]
	Short tons	Value (thousands)	Short tons	Value (thousands)	
1952–56 (average)	1,357	$147	264	[2] $47	[2] $105,128
1957	363	57	112	[2] 28	[2] 153,007
1958	737	77	96	14	87,039
1959	955	116	44	6	71,930
1960	1,099	175	19	7	[3] 68,841
1961	1,107	146	86	28	60,020

[1] Excludes imports for manufacture in bond and export, which are classified as "imports for consumption" by Bureau of the Census.
[2] Data known to be not comparable with other years.
[3] Revised figure.
[4] In addition manufactures of zinc were imported as follows: [2] 1952–56 (average), $107,293; [2] 1957—$264,348; 1958—$389,803; 1959—$811,916; 1960—$836,871; 1961—$787,496.

Source: Bureau of the Census.

TABLE 34.—U.S. imports for consumption [1] of zinc, by countries

(Short tons)

Country	1952–56 (average)	1957	1958	1959	1960	1961
Ores (zinc content):						
North America:						
Canada	161,419	217,441	169,474	137,426	[2] 133,080	110,312
Cuba	341	1,247	52	72	17	
Guatemala	7,986	10,337	6,093	10	1,811	7,244
Honduras	360	3,562	1,428	1,116	2,140	1,574
Mexico	180,748	261,265	208,202	147,877	[2] 142,478	140,057
Other North America	3	2	111	1		[3]
Total	350,857	493,854	385,360	286,502	[2] 279,526	259,187
South America:						
Argentina	882	105	9	[3]	45	6
Bolivia	10,189	8,644	6,838	1,704	790	1,018
Chile	2,019	3,035	1,072	34	5	7
Peru	71,936	147,073	110,165	80,616	[2] 71,391	69,473
Other South America	268	70	121	[3]	49	75
Total	85,294	158,927	118,205	82,354	72,280	70,579
Europe:						
Germany, West	[3]	8		7,290		12
Italy	2,054			9,930	4,241	2,189
Spain	6,087			13,476	10,405	8,122
Other Europe	5,022	215	11	2,344	982	
Total	13,163	223	11	33,040	15,628	10,323
Asia:						
Philippines	1,099	942	92	29	679	4,426
Other Asia	446	9	211		1	16
Total	1,545	951	303	29	680	4,442
Africa:						
Union of South Africa	6,342	19,751	27,190	4,331	5,333	6,218
Other Africa	589	[3]	524	1,140	[2] 131	9
Total	6,931	19,751	27,714	5,471	[2] 5,464	6,227
Oceania: Australia	6,208	5,710	[4] 6,106	16,738	9,360	6,895
Grand total: Ores	463,998	679,416	537,699	424,134	[2] 382,938	357,653
Blocks, pigs, or slabs:						
North America:						
Canada	102,634	103,964	93,327	88,414	74,168	71,628
Mexico	18,378	23,690	22,804	9,718	8,675	8,527
Total	121,012	127,654	116,131	98,132	82,843	80,155
South America: Peru	6,620	22,947	9,736	12,337	7,517	7,582
Europe:						
Austria	459	1,020	55	305	2	
Belgium-Luxembourg	17,209	34,163	17,969	11,648	5,724	12,380
Germany, West	9,307	8,772	2,035	662	1,619	1,431
Italy	10,571	10,010	5,816	7,173	4,237	1,820
Netherlands	3,364	2,504	730	1,705		
Norway	1,531		2,601	329	7	
United Kingdom	1,406	1,791	112	1,363	373	[3]
Yugoslavia	1,038	10,572	5,009	3,384	5,640	3,277
Other Europe	57				2,809	4,977
Total	44,942	68,832	34,327	26,569	20,411	23,885
Asia: Japan	1,021	2,887	1,708	355		
Africa:						
Congo, Republic of the and Ruanda-Urundi [5]	9,557	33,007	20,991	12,790	9,308	11,420
Rhodesia and Nyasaland, Federation of [6]	1,030	3,974	560	4,840	396	1,107
Other Africa	275			298		8
Total	10,862	36,981	21,551	17,928	9,704	12,535
Oceania: Australia	3,669	9,523	2,240	9,141	450	1,029
Grand total: Blocks, pigs, or slabs	188,126	268,824	185,693	164,462	120,925	125,186

[1] Excludes imports for manufacture in bond and export, classified as "imports for consumption" by Bureau of the Census.
[2] Revised figure.
[3] Less than 1 ton.
[4] Includes 52 tons imported from French Pacific Islands.
[5] Effective July 1, 1960; formerly Belgian Congo.
[6] Effective July 1, 1954; formerly Northern Rhodesia.

Source: Bureau of the Census.

quotas were assigned to those countries supplying substantial quantities of U.S. imports, and an "all other" quota was established to cover the remaining eligible countries.

Imports for consumption (imports for immediate consumption plus withdrawals from bonded warehouses for consumption) given in table 34 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 43,000 tons, averaging 77 percent zinc (40,000 tons in 1960). Mexico was the primary source.

Imports.—General imports (imports for immediate consumption plus entries into bonded warehouses) presented in table 32 show all physical entries of unmanufactured zinc into the United States. General

TABLE 35.—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.			
	1958	1959	1960	1961	1958	1959	1960	1961
North America:								
Canada	6	13	11	382	1,864	1,790	1,516	1,356
Cuba	31	114	105	-------	132	76	64	-------
Mexico	845	1,255	1,119	-------	425	316	283	56
Other North America	46	55	1	19	57	71	42	65
Total	928	1,437	1,236	401	2,478	2,253	1,905	1,477
South America:								
Argentina	-------	43	-------	61	-------	-------	17	35
Brazil	-------	135	2,414	4,598	87	26	28	27
Chile	36	523	10	314	-------	14	53	36
Colombia	14	37	1,045	404	195	134	55	55
Venezuela	8	-------	10	161	86	105	75	78
Other South America	-------	-------	463	233	61	11	12	18
Total	58	738	3,942	5,771	429	290	240	249
Europe:								
Belgium-Luxembourg	-------	1,624	340	-------	47	19	3	21
Denmark	-------	-------	140	56	105	111	107	173
Germany, West	-------	56	3,364	336	73	174	121	63
Italy	-------	-------	560	224	1	4	12	33
Netherlands	-------	280	2,522	2,252	122	60	42	170
Sweden	-------	2,475	4,847	1,993	149	123	84	140
Switzerland	-------	-------	336	-------	87	133	142	165
United Kingdom	672	4,065	25,394	12,265	106	162	302	335
Other Europe	-------	-------	700	1,806	29	81	103	229
Total	672	8,500	38,203	18,932	719	867	916	1,329
Asia:								
India	-------	635	11,172	10,490	36	3	3	10
Japan	1	25	18,125	7,353	11	1	-------	29
Korea, Republic of	-------	-------	75	3,139	-------	-------	-------	1
Philippines	5	-------	979	1,685	73	35	54	22
Other Asia	405	14	1,403	2,274	21	4	97	9
Total	411	674	31,754	24,941	141	43	154	71
Africa:								
Union of South Africa	-------	-------	-------	-------	42	50	74	76
Other Africa	4	-------	9	8	3	4	2	4
Total	4	-------	9	8	45	54	76	80
Oceania	-------	280	-------	2	6	22	33	13
Grand total	2,073	11,629	75,144	50,055	3,818	3,529	3,324	3,219

Source: Bureau of the Census.

imports of ores and concentrates declined 9 percent to 415,700 tons. Zinc metal imports increased 6 percent. Mexico, Canada, Peru, and Guatemala supplied most of the zinc imported in ores and concentrates, and Canada, Belgium-Luxembourg, Republic of the Congo, and Mexico supplied most of the metal imported.

Exports.—Exports of slab zinc declined from 75,100 tons in 1960 to 50,100 tons in 1961. The United Kingdom, India, Japan, and Brazil received most of these exports.

TABLE 36.—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)
1952-56 (average)	1,435	$364	25,512	$8,233	4,201	$2,601	11,039	$1,253	[1]	$239	[2]	[2]
1957	7	[3]	10,785	2,553	4,056	2,950	5,469	822	485	247	595	$195
1958	------	------	2,073	704	[4]3,818	[4]2,637	5,344	364	11,168	542	519	170
1959	1	[3]	11,629	2,673	[4]3,529	[4]2,708	11,332	1,053	[4]1,071	612	521	182
1960	13	3	75,144	18,122	[4]3,324	[4]2,443	12,169	1,499	[4]2,569	1,195	777	267
1961	1,670	124	50,055	11,196	[4]3,219	[4]2,271	5,900	871	3,036	1,317	717	224

[1] Effective Jan. 1, 1952, zinc and zinc-alloy semifabricated forms, n.e.c. were exported as follows: 1952—quantity not available; 1953—286 tons; 1954—543 tons; 1955—651 tons; 1956—582 tons.
[2] Not included in 1952-56 averages: 1952 included with "scrap," 1953—502 tons ($181,055); 1954—509 tons ($150,756); 1955—455 tons ($161.956); 1956—372 tons ($136,096).
[3] Less than $1,000.
[4] Owing to changes in classification by Bureau of the Census, data not strictly comparable to earlier years.

Source: Bureau of the Census.

Tariff.—Duty on slab zinc remained throughout 1961 at 0.7 cent a pound, that on zinc contained in ore and concentrate at 0.6 cent a pound, and that on zinc scrap at 0.75 cent a pound. Duties on zinc articles covered by the Tariff Act of 1930 were unchanged, remaining as shown on page 1290, Volume 1, 1953 Minerals Yearbook.

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Canada.—Consolidated Mining & Smelting Co. of Canada, Ltd., continued as the principal Canadian zinc producer. According to the annual company report, the Sullivan silver-lead-zinc mine at Kimberly, British Columbia, produced 2,460,000 tons of crude ore. A new lower level crushing installation and extensions to a conveyor haulage belt system were nearing completion at yearend. The Bluebell lead-zinc mine at Riondel, British Columbia, produced 253,000 tons of ore. A heavy inflow of water at lower levels was combated by extensive ground cementation. Production from H. B. zinc-lead mine near Salmo, British Columbia, was 473,000 tons of ore. Pine Point Mines, Ltd., a company subsidiary, reached agreement with the Canadian Government to construct a railroad to its zinc-lead property near Great Slave Lake. Completion of the railroad and first production at the mine was expected by the end of 1966. Exploration extended the mineralized zone at Duncan Lake lead-zinc property in the Lardeau district of British Columbia and tested for occurrence of lead-

zinc ore near Red Bird adit in the Salmo area of British Columbia. Production of slab zinc at the Consolidated Mining electrolytic plant at Trail, British Columbia, was 193,100 tons, 72 percent of total Canadian output. A major part of the zinc was derived from concentrates at company-owned mines, with lesser quantities obtained from plant residues and slags and from purchased concentrates. At Trail, facilities were under construction to provide for treating of additional concentrates when the supply of stockpiled residues became exhausted.

Reeves McDonald Mines, Ltd., reported in its annual report that the company mined and milled 420,500 tons of ore at its Remac, British Columbia, mine, and produced concentrates containing 16,456 tons of zinc plus values in lead, silver, and cadmium. Development included 4,500 feet of drifts and raises, 693 feet of shaft sinking, and 3,692 feet of test drilling.

Sheep Creek Mines, Ltd., Windermere, British Columbia, reported production for the year ending May 31, 1961, to be 201,500 tons of ore grading 5.28 percent zinc and 2.63 percent lead. Milling yielded 16,440 tons of zinc concentrate plus values in lead and silver. Exploratory drilling intersected ore at a vertical depth of 200 feet below the present bottom level.[8]

TABLE 37.—World mine production of zinc (content of ore) by countries [1, 2, 3]

(Short tons)

Country [2]	1952–56 (average)	1957	1958	1959	1960	1961
North America:						
Canada [4]	401,209	413,741	425,099	396,008	406,873	415,852
Cuba	[5] 1,387	752	[6] 110	[7] 188	[7] 77	
Greenland [6]	[8] 6,050	9,350	6,700	8,350	11,000	7,500
Guatemala [4]	8,538	10,300	5,278		11,070	8,746
Honduras [7]	1,093	2,589	1,435	1,427	4,714	6,857
Mexico	263,621	267,891	247,033	290,938	289,274	296,491
United States [4]	548,783	531,735	412,005	425,303	435,427	464,390
Total	1,230,681	1,236,358	1,097,660	1,122,214	1,158,435	1,199,836
South America:						
Argentina	21,029	32,420	40,100	44,100	38,200	33,300
Bolivia (exports)	26,084	21,678	15,677	3,740	4,439	5,878
Chile	2,994	2,747	1,340	1,116	1,159	443
Colombia [6]				800	350	800
Peru	169,030	170,258	149,094	157,739	196,346	194,307
Total	219,137	227,103	206,211	207,495	240,494	234,728
Europe:						
Austria	5,423	6,334	6,463	6,522	7,250	6,651
Bulgaria [6]	32,100	50,000	55,000	61,300	64,700	61,300
Finland	16,453	47,400	51,800	59,600	46,328	51,363
France	13,838	13,642	16,386	17,616	19,090	17,200
Germany:						
East [6]	6,800	7,700	7,700	7,700	7,700	7,700
West	99,372	104,015	94,232	90,566	95,159	96,185
Greece	6,940	10,700	16,200	12,300	15,700	17,200
Ireland	2,000	1,792	463	1,303	1,429	809
Italy	128,180	143,400	150,800	145,200	141,400	146,400
Norway	6,431	7,735	10,016	10,907	11,395	10,251
Poland	177,100	144,600	135,300	142,500	158,800	153,857
Spain	96,298	89,096	90,764	94,645	94,920	97,964
Sweden	58,816	74,528	77,808	82,783	77,492	82,893
U.S.S.R. [6 9]	256,200	330,000	360,000	370,000	380,000	445,000
United Kingdom	2,706	1,085	283			
Yugoslavia	62,219	64,032	66,160	66,882	62,150	66,008
Total [3 6]	979,000	1,110,000	1,154,000	1,184,000	1,198,000	1,275,000

See footnotes at end of table.

[8] Canadian Mining and Metallurgical Bulletin. V. 54, No. 591, July 1961, p. 568.

TABLE 37.—World mine production of zinc (content of ore) by countries[1 2 3]—Continued

(Short tons)

Country	1952–56 (average)	1957	1958	1959	1960	1961
Asia:						
Burma	6,100	10,200	12,100	12,100	11,000	8,100
China [6]	23,400	44,000	50,000	72,000	88,000	110,000
India	3,000	4,500	4,300	6,000	5,800	5,600
Iran [10]	5,800	5,000	9,900	7,400	7,700	7,000
Japan	115,776	149,921	157,601	156,899	172,769	185,050
Korea:						
North [6]	[11] 40,000	80,000	90,000	90,000	90,000	90,000
Republic of	203	311	369	4	46	500
Philippines	728	330	----------	6	5,487	3,652
Thailand	2,227	1,820	600	840	1,170	1,000
Turkey [6]	2,664	2,120	2,090	1,650	3,000	2,200
Total [6]	199,000	298,000	327,000	347,000	385,000	413,000
Africa:						
Algeria	27,370	32,743	36,725	42,774	43,320	47,000
Congo, Republic of the (formerly Belgian)	108,983	117,682	125,646	77,130	120,352	109,692
Morocco: Southern zone	40,458	53,864	54,257	61,301	54,199	44,951
Rhodesia and Nyasaland, Federation of: Northern Rhodesia	31,989	40,353	38,034	46,497	49,242	50,081
South-West Africa [4]	19,796	25,349	15,910	12,395	13,119	14,906
Tunisia	5,029	3,867	4,566	3,656	4,212	3,747
Total	233,625	273,858	275,138	243,753	284,444	270,377
Oceania: Australia	273,684	326,573	294,609	278,631	325,012	322,781
World total (estimate) [2]	3,140,000	3,470,000	3,360,000	3,380,000	3,590,000	3,720,000

[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] In addition to countries listed, Czechoslovakia and Rumania also produce zinc, but production data are not available; estimates for these countries are included in totals.
[3] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[4] Recoverable.
[5] Average annual production, 1955–56.
[6] Estimate.
[7] United States imports.
[8] One year only as 1956 was first year of commercial production.
[9] Smelter production.
[10] Year ended March 21 of year following that stated.
[11] Average annual production, 1953–56.

Compiled by Augusta W. Jann, Division of Foreign Activities.

Hudson Bay Mining & Smelting Co., Ltd., operated its zinc-copper-lead mines along the Manitoba-Saskatchewan boundary and ranked second in production of zinc in Canada. The mill treated 1,683,000 tons of ore, an increase of 700 tons over 1960. Millfeed was 60.3 percent from Flin Flon mine, 17.5 percent from Coronation mine, 16.3 percent from Chisel Lake mine, and 5.9 percent from Schist Lake mine. Exploration and development were underway at Osborne Lake and Stall Lake properties in the Snow Lake area. Hudson Bay's ore reserve on December 31 was given as 15.3 million tons with an average zinc content of 4.9 percent. Slab-zinc production at the company electrolytic plant at Flin Flon (Manitoba) was 74,900 tons, the highest in the history of the plant and 28 percent of the Canadian output.[9]

Stall Lake Mines, Ltd., began shaft sinking on its Manitoba property adjacent to Hudson Bay Co. property at Stall Lake.[10]

[9] Hudson Bay Mining & Smelting Co., Ltd. Annual Report. 1961, pp. 7–9.
[10] Mineral Resources Division, Department of Mines and Technical Survey. Mineral Information Bulletin. M.R. 56, Ottawa, Canada, p. 31.

TABLE 38.—World smelter production of zinc by countries [1, 2, 3]

(Short tons)

Country	1952–56 (average)	1957	1958	1959	1960	1961
North America:						
Canada	247,726	247,316	252,093	255,306	260,968	268,006
Mexico [4]	59,703	62,353	63,329	61,362	58,318	57,119
United States	914,025	985,796	781,246	798,666	799,516	846,795
Total	1,221,454	1,295,465	1,096,668	1,115,334	1,118,802	1,171,920
South America:						
Argentina	13,404	16,150	17,400	14,100	17,600	15,900
Peru	12,345	32,483	32,034	29,595	35,712	35,567
Total	25,749	48,633	49,434	43,695	53,312	51,467
Europe:						
Austria	[5] 4,712	10,291	11,698	12,608	12,700	13,302
Belgium [6]	228,388	259,755	236,730	247,250	272,891	270,670
Bulgaria	[5] 3,966	8,282	9,000	9,900	18,600	[7] 24,000
France	109,490	143,646	163,606	161,218	165,471	183,024
Germany:						
East [7]						4,400
West	182,501	202,548	146,816	152,046	156,299	155,373
Italy	70,766	82,107	78,656	83,499	87,518	75,401
Netherlands	29,673	33,085	29,285	35,445	39,771	43,643
Norway	47,793	53,299	50,180	53,767	48,460	51,012
Poland	156,500	175,013	179,252	185,263	193,501	200,633
Spain	25,273	24,138	27,239	27,039	49,565	57,910
U.S.S.R. [7]	256,000	330,000	360,000	370,000	380,000	445,000
United Kingdom	86,353	86,111	83,537	81,722	83,219	104,030
Yugoslavia	16,817	32,473	34,445	35,220	39,612	40,750
Total [1] [7]	1,225,000	1,452,000	1,421,000	1,466,000	1,559,000	1,680,000
Asia:						
China (refined) [7]	22,700	41,000	45,000	66,000	77,000	100,000
Japan	110,199	152,152	155,401	175,642	198,920	234,165
Korea, North [7]		5,260	22,000	27,000	50,000	65,000
Total [7]	133,000	198,000	222,000	269,000	326,000	399,000
Africa:						
Congo, Republic of the (formerly Belgian)	[8] 31,926	54,227	58,905	60,418	58,817	62,799
Rhodesia and Nyasaland, Federation of: Northern Rhodesia	29,576	33,040	33,880	33,483	33,368	33,444
Total	61,502	87,267	92,785	93,901	92,185	96,243
Oceania: Australia	109,361	123,589	128,547	130,436	134,658	155,342
World total (estimate)	2,780,000	3,200,000	3,010,000	3,120,000	3,280,000	3,550,000

[1] In addition to countries listed, 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 the 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: 1953–56 (average), 31,458 short tons; 1957—30,504; 1958—19,572; 1959—314; 1960—1,246; and 1961—1,992.

[5] Average annual production 1955–56.

[6] Includes production from reclaimed scrap.

[7] Estimate.

[8] Average annual production 1953–56.

Compiled by Augusta W. Jann, Division of Foreign Activities.

According to the annual report of Willroy Mines, Ltd., the company milled 421,800 tons of ore from its Manitouwadge (Ontario) mine. Average grade decreased from 7.39 to 6.68 percent zinc and yielded concentrate containing 22,800 tons of zinc plus quantities of copper, lead, silver, and gold. The shaft was extended 413 feet to 2,240 feet total depth, and lower working levels were being developed. Ore reserves were estimated to be adequate for 5 years' operation at the 1961 rate of extraction.

Geco Mines, Ltd., at Manitouwadge retained its rank as the third largest zinc producer in Canada by milling 1,277,000 tons of ore with a calculated grade of 3.99 percent zinc, 1.54 percent copper, and 1.52 ounces of silver per ton. The ore yielded 77,379 tons of zinc concentrate containing 42,005 tons of zinc, an increase of 48 percent. Based on results of drilling, there was a net increase in reserves of 700,000 tons to 18.3 million tons, containing 4.23 percent zinc, 1.94 percent copper and 2.32 ounces of silver per ton.[11]

The zinc sulfide concentrate roasting plant of Sherbrooke Metallurgical Co., that started operating in 1960, was approaching plant roasting capacity of 500 tons of concentrate per day by yearend.

In Quebec, Quemont Mining Corp., Ltd., milled 822,000 tons of ore containing 2.53 percent zinc plus values in copper, gold, and silver. Production was 29,323 tons of zinc concentrate containing 52.1 percent zinc.[12] In its annual report, Solbec Copper Mines, Ltd., stated that extensive underground development and construction of a 1,000-ton-per-day concentrator, at a site about 50 miles east of Sherbrooke, was expected to be in production early in 1962. The copper-zinc deposit reserve was 1.4 million tons of ore, grading 3.80 percent zinc. On an adjoining property an associated company, Cupra Mines, Ltd., was sinking a shaft to a planned depth of 1,600 feet to a copper-zinc ore body with a drilled reserve of 817,000 tons, containing an average 3.53 percent zinc. Other Quebec producers of zinc concentrate included Normetal Mining Corp., Ltd., which milled 355,000 tons of a copper-zinc-gold-silver ore, yielding 23,557 tons of zinc concentrate containing 53.0 percent zinc; Waite Amulet Mines, Ltd., which treated 248,800 tons of ore and produced 8,890 tons of zinc concentrate with 50.7 percent contained zinc; and East Sullivan Mines, Ltd., which for the first 8 months of 1961 milled 674,800 tons of a copper-zinc-ore, yielding concentrate containing 2,800 tons of zinc.

In Northwestern Quebec, Coniagas Mines, Ltd., began producing zinc concentrate in a new 350-ton-per-day-capacity mill at its Bachelor Lake property. Ore reserves were estimated at 407,000 tons averaging 15.7 percent zinc.[13]

Mattagami Lake Mines, Ltd., continued underground development and arranged for construction of a 3,000-ton-per-day concentrator at its Mattagami Lake district property. Initial output was expected in mid-1963. Mattagami and associated companies completed financing for a 200-ton-per-day electrolytic zinc plant with production planned to begin in late 1963. Contracts were made with underwriting mining companies to supply zinc concentrates.[14]

In New Brunswick, Heath Steele Mines, Ltd., continued underground development. A milling agreement was made to make available one-half of the mill capacity for treating copper ore from the Wedge mine of The Consolidated Mining & Smelting Co. of Canada, Ltd., and to reserve the remaining one-half for Heath Steele Mines' own ore.[15]

In Newfoundland, Buchans Mining Co., Ltd., operated its lead-zinc-copper mine and concentrator at Buchans.

[11] Geco Mines, Ltd. Annual Report. 1961, pp. 3–5.
[12] Quemont Mining Corp., Ltd. Annual Report. 1961, p. 3.
[13] Canadian Mining and Metallurgical Bulletin. V. 54, No. 591, July 1961, p. 574.
[14] Northern Miner. V. 47, No. 52, Mar. 22, 1962, pp. 1, 12.
[15] American Metal Climax, Inc. Annual Report. 1961, p. 20.

Mexico.—An agreement was reported signed by the Mexican Government and the Belgian firm, Sybetra, for constructing a 30,000-ton-per-year zinc smelter. Zincamex, a newly formed Government-owned company, expected to assume operation of the facility by 1964.[16]

American Smelting and Refining Company continued operating its extensive zinc-producing units in Mexico. Efforts were being made to arrange for Mexican capital to purchase a majority of the company assets so that advantage could be taken of the 1960 mining law providing for special tax rebates and other benefits to Mexican-controlled companies.[17]

American Metal Climax lead-zinc operations in Mexico were assumed by Metalurgica Mexicana Penoles, successor to former American Metal Climax subsidiary, Cia. Minera de Penoles, S.A.[18]

According to the annual report of San Francisco Mines of Mexico, Ltd., for the year ending September 30, 1961, a total of 920,000 tons of ore was milled from the company's San Francisco and Clarines mines and produced 108,153 tons of 57.32 percent zinc concentrate plus values in lead, copper, silver, and gold. Ore reserve was increased during the year by 60,000 tons to a total of 6.6 million tons averaging 7.95 percent zinc, 5.61 percent lead, and 0.57 percent copper. During the year majority ownership was attained by Mexican investors, and Cia. Minera Plomosa, S.A., subsequently renamed Minera Frisco, S.A., assumed operation.

Fresnillo Co. operated its lead-zinc mining and milling units at Fresnillo in Zacatecas and at Naica in Chihuahua. In the year ending June 30, 1961, the company milled 607,000 tons of ore, including 41,900 tons of custom ore, at Fresnillo mill and 345,700 tons of ore at Naica mill. The Fresnillo mill yielded 36,360 tons of 51.6 percent zinc concentrate; the Naica mill yielded 34,556 tons of 54.5 percent zinc concentrate. Production was halted at Naica for 7 weeks due to a strike. The company transferred a 51-percent interest in its various Mexican activities to Matelurgica Mexicana Penoles, S.A.[19]

SOUTH AMERICA

Argentina.—Cia. Minera Aguilar, S.A., a subsidiary of St. Joseph Lead Co., operated its lead-zinc-silver mine in the Province of Jujuy. The mill produced 55,600 tons of zinc concentrate, compared with 57,600 tons in 1960. Cia. Metalurgica Austral-Argentine, S.A., smelted the concentrate at its electrothermic zinc smelter and produced 9,671 tons of slab zinc, compared with 11,720 tons in 1960.[20]

Cia. Minera Castano Viejo, S.A., a subsidiary of National Lead Co., operated its mine at full capacity throughout the year.

Bolivia.—The Bolivian Congress authorized the Government agency, Corporation Minera de Bolivia, to solicit proposals for exploiting the Matilde zinc-lead-silver ore deposit near Lake Titicaca. Exploratory drilling and underground workings had developed a reserve of about 3 million tons of ore averaging 18 percent zinc.

Peru.—Cerro de Pasco Corp. produced 35,006 tons of slab zinc at its La Oroya electrolytic zinc plant from concentrates produced at com-

[16] Foreign Trade (Ottawa). V. 116, No. 13, Dec. 16, 1961, p. 22.
[17] American Smelting and Refining Co. Annual Report. 1961, p. 13.
[18] American Metal Climax, Inc. Annual Report. 1961, p. 26.
[19] The Fresnillo Co. Annual Report. 1961, pp. 10–13.
[20] St. Joseph Lead Co. Annual Report. 1961, p. 9.

pany-operated mines. Sales of zinc concentrate for export decreased 24 percent to 83,283 tons, largely because concentrates were being stockpiled while capacity of the zinc plant was being expanded from 35,000 to 55,000 tons per year. The expansion is scheduled to be completed in 1962.[21] Output increased at two copper-lead-zinc mines operated by Compania de Minas Buena Ventura, S.A. The open-pit zinc-lead Santander mine of Cia. Minerales Santander, Inc., produced 37,806 tons of zinc concentrate, an increase of 16 percent. Other significant zinc producers in Peru included Cia. Minera Atacocha; Volcan Mines Co.; Mauricio Hochchild and Co.; Compagnie des Mines de Huaron; Northern Peru Mining Corp.; Cia. Minera Milpo, S.A.; Cia. Minas de Cercapuquio, S.A.; and Sindicato Minero Rio Pallauga, S.A.

EUROPE

Bulgaria.—The zinc section of the lead-zinc plant being built at Plovdiv was completed. Planned annual output is 30,000 tons of zinc and 40,000 tons of lead.[22]

Finland.—The Vihanti mine continued as the leading zinc producer in Finland, yielding 94,140 tons of zinc concentrate containing 54.57 percent zinc from 482,000 tons of ore. Outokumpu Oy continued construction at its copper-zinc mine at Pyhasalmi, scheduled to begin operating in 1962 with a planned annual output rate of 44,000 tons of zinc cencentrate.

Italy.—Montevecchio and Monteponi, the two largest lead-zinc producers in Sardinia, merged under the new company name of Monteponi e Montevecchio Societi per Azioni.[23] At the Monteponi mine a new plant for recovering zinc from oxidized ores in old tailings began operation. In northern Italy, the Salafossa mine increased output from new facilities installed in 1960.[24]

Norway.—Det Norske Zinkkompani A/S, only zinc producer in Norway, planned to expand plant capacity from 48,000 to 65,000 tons of zinc a year.[25]

Poland.—Zinc output for both ore and metal increased, and zinc remained the leading nonferrous metal in the Polish economy. Further expansion in output was planned, including greater production from the Olkuze-Chrzanow and Trzelionka mines.[26]

Rumania.—A zinc-lead smelting plant, using the Imperial smelting process, was to be built for Masinimport. The construction contract was awarded to Power-Gas Corp., Ltd., and Huntington Heberlein & Co., Ltd., both English concerns.[27]

Spain.—Asturiana del Zinc, SA, planned to double the capacity of its electrolytic zinc plant at San Juan de Nieva in northern Spain to bring total annual capacity to 29,000 tons.[28]

Sweden.—Boliden Mining Co. announced plans for a slag-fuming plant, with operation anticipated in 1964. Approximately 20,000 to 25,000 tons of zinc fume was to be produced per year from treatment

[21] Cerro Corp. Annual Report. 1961, pp. 10–11.
[22] Mining Journal (London). V. 258, No. 6595, Jan. 12, 1962, p. 39.
[23] The Mining Journal (London). Annual Review. May 1962, p. 277.
[24] Mining World. Catalog Survey and Directory Number. Apr. 25, 1962, p. 133.
[25] Foreign Trade (Ottawa). V. 116, No. 14, Dec. 30, 1961, p. 21.
[26] Mining Journal (London). Annual Review. May 1962, p. 261.
[27] Chemical Trade Journal and Chemical Engineer (London). V. 150, No. 3895, Jan. 26, 1962, p. 192.
[28] Mining Journal (London). Annual Review. May 1962, p. 282.

of 200,000 tons of copper slag. The product was to be shipped to other European plants for further processing.[29]

United Kingdom.—British Government, through the Board of Trade, announced that it was offering for sale about 970 tons of high-grade or special high-grade zinc for delivery and pricing between December 1961 and April 1962.[30]

Yugoslavia.—At Novo Brdo, 30 miles southeast of Yugoslavia's largest lead-zinc mine at Trepca, a mine described as the oldest lead-zinc mine in the world was to be reopened. After extensive operations in the Middle Ages, the mine was closed in 1445, reopened from 1952 to 1959, and after discovery of 6 to 7 million tons of new ore containing 8 to 10 percent of lead and zinc combined plus values in silver, the mine was expected to again become an important producer.[31]

ASIA

Burma.—Burma Corp., Ltd., continued to operate Bawdwin lead-zinc-silver mine in the Shan States of northern Burma. The Government of the Union of Burma and the United Nations signed an agreement for a jointly sponsored study of the mining industry of Burma. This study will determine the low-grade reserve, the economic feasibility of using this resource, and the possibility of installing a zinc smelter to operate in part on a large stockpile of lead-slag containing an appreciable percentage of zinc.[32]

China.—Main zinc mining and smelting centers were Shenyang, Shao-Kuan, Hu-lu-tao, and Shui-k'ou-shan. The latter two centers reportedly had annual slab zinc output capacities of 22,000 tons each. There are large lead-zinc deposits at T'ao-lin, Hunan, and a mine-mill operation of about 1,200,000 tons annual ore output was planned.[33]

India.—Metal Corporation of India, Ltd., continued operating Zawar mines in Rajasthan, India's only lead-zinc producer. Initial construction was begun on an 18,000-ton-annual-capacity electrolytic zinc plant at Udaipur scheduled for production in 1963. The Government granted a license to G. D. Binani & Co. for building a zinc smelter in the Calcutta area with a 12,000-ton-per-year capacity.

Japan.—A survey of Japanese ore reserves by the Ministry of International Trade and Industry gave total lead-zinc ore in 42 mines on April 1, 1960, as 60 million tons containing 3.3 million tons of zinc and estimated that 72 percent of the zinc would be recoverable.

Turkey.—Zinc-lead ore mining continued at Etibank's Keban mine in Euphrates Valley; 16,500 tons was milled; this quantity yielded 2,770 tons of zinc concentrate averaging 44 percent zinc.

AFRICA

Algeria.—Zinc ore production continued the gradual upward trend of the past several years. Five mines were in operation, with principal output coming from SA Mines d'Ain-Arko and Societe Algerienne du Zinc permits near the Moroccan border.

[29] Mining Journal (London). V. 258, No. 6596, Jan. 19, 1962, p. 61.
[30] Metal Industry (London). V. 99, No. 20, Nov. 17, 1961, p. 405.
[31] Enginering and Mining Journal. V. 162, No. 10, October 1961, p. 180.
[32] Mining Magazine (London). V. 106, No. 3, March 1962, p. 135–136.
[33] Mining Journal (London). Annual Review. May 1962, p. 243.

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Congo, Republic of the.—Prince Leopold copper-zinc mine of Union Miniere du Haut Katanga near Elizabethville supplied 1,046,000 tons of ore for milling at the Kipushi concentrator to produce 201,810 tons of zinc concentrate containing 54.43 percent zinc. A subsidiary of the company roasted 125,000 tons of the concentrate, producing sulfuric acid and 102,900 tons of roasted calcines. During the year 115,700 tons of roasted concentrate was sold to Societe Metallurgique du Katanga (Metalkat) for reduction to zinc, and 89,000 tons of raw and roasted concentrate was delivered for export. Metalkat produced 62,798 tons of electrolytic zinc, a record quantity.[34]

Rhodesia and Nyasaland, Federation of.—At Broken Hill, Rhodesia Broken Hill Development Co., Ltd.,[35] mined 246,700 tons of ore. The heavy-medium separation plant treated 167,600 tons of ore to recover 115,500 tons of sink product that was part of 171,800 tons of feed for the sulfide flotation plant. The flotation plant produced 54,126 tons of concentrate containing 55.2 percent zinc. The leach plant treated 115,700 tons of feed material composed of calcines, flotation plant tailings, and zinc silicate ore, averaging 37.7 percent zinc. Leach solution and calcined concentrate were processed in the company electrolytic plant to yield 32,573 tons of slab zinc. An additional 682 tons of slab zinc was recovered from 2,600 tons of smelter dross. Construction of the new Imperial-type vertical-furnace was virtually completed, with operation scheduled for early 1962. Reserves at yearend totaled 6.2 million tons grading 27.0 percent zinc and 13.7 percent lead.[36]

South-West Africa.—Tsumeb Corp., Ltd., mined and milled 652,000 tons of lead-zinc-copper ore averaging 4.35 percent zinc during the year ending June 30, 1961. Proven ore reserve above the 30th level was 7.4 million tons, averaging 4.33 percent zinc. Underground exploration and development below the 30th level is now possible since an internal shaft was completed to a depth of 4,269 feet below the surface.[37]

OCEANIA

Autralia.—The Broken Hill district of New South Wales continued to be the leading Australian zinc-producing area. Mining companies operating were New Broken Hill Consolidated, Ltd.; Consolidated Zinc Corp., Ltd.; Broken Hill South, Ltd.; and North Broken Hill, Ltd. Output from the district was approximately 2,200,000 tons of zinc-lead-silver ore, yielding about 460,000 tons of zinc concentrate averaging 51 percent zinc.

During the fiscal year ending June 30, 1961, Mount Isa Mines, Ltd., milled 3,227,000 tons of silver-lead-zinc ores from its properties in the Conclurry district of Queensland. Production of zinc in concentrate amounted to 34,699 tons, an increase of 77 percent.[38] Sinking was in progress on a new 3,200-foot-deep, 24-foot-diameter shaft, and design work was completed for a new 6,000-ton-per-day flotation mill. The Townsville-Mount Isa railway was being rehabilitated by the State of Queensland.

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[34] Union Miniere du Haut Katanga. Annual Report. 1961, 51 pp.
[35] The Rhodesia Broken Hill Development Co., Ltd. Annual Report. 1961, 20 pp.
[36] Work cited in footnote 35.
[37] Newmount Mining Corp. Annual Report. 1961, p. 6.
[38] American Smelting and Refining Company. Annual Report. 1961, pp. 15–16.

Lake George Mines, Pty., Ltd., during the fiscal year ended June 30, 1961, mined and milled 215,000 tons of zinc-lead-copper ore in the Captain's Flat district of New South Wales. The ore yielded 32,200 tons of zinc concentrate averaging 57.25 percent zinc.[39] Exploration failed to disclose additional ore, and the reserve at year-end was estimated to be 370,000 tons.

For the fiscal year ending June 30, 1961, Electrolytic Zinc Co. of Australasia, Ltd., milled a record 247,000 tons of ore from its mines in the Read-Rosebery district. Ore averaged 18.47 percent zinc and yielded 69,500 tons of zinc concentrate containing 54.37 percent zinc. Zinc concentrates from this district and the Broken Hill district were treated in the company Risdon electrolytic plant to produce 141,000 tons of slab zinc. During the year additional zinc making capacity was brought into operation, and output for the year was a record high.[40]

TECHNOLOGY

The American Zinc Institute Expanded Research Program sponsored research on numerous projects to increase fundamental knowledge and promote zinc use. Included in the program were studies to improve the zinc lithographic process; to determine the effect of zinc galvanizing bath composition on coating properties; to test use of galvanized steel reinforcing rods in concrete; and to expand knowledge on use of zinc oxide in paint, ceramics, glass, and phosphor compounds.

Several papers reported research by the Federal Bureau of Mines [41] and Geological Survey.[42]

A rapid field method for determining zinc in geochemical prospecting [43] and an analytical procedure for determining iron in sphaler-

[39] Lake George Mining Corp., Ltd. Annual Report. 1961, 16 pp.

[40] E Z Industries, Ltd. Annual Report. 1961, 24 pp.

[41] Gajan, R. J., and D. M. Geehan. Rapid Determination of Aluminum, Iron, Copper, Cadmium, and Lead in Zinc-Base Alloys. BuMines Rept. of Inv. 5727, 1961, 10 pp.

Caldwell, H. S. Jr., and M. J. Spendlove. Using Molten Zinc to Extract Aluminum From Aluminum-Silicon Alloys. BuMines Rept. of Inv. 5781, 1961, 15 pp.

Caldwell, H. S. Jr., H. W. St. Clair, J. H. Bilbrey, Jr., and M. J. Spendlove. Gas-Fired Vacuum Retort for Distilling Metals. BuMines Rept. of Inv. 5764, 1961, 11 pp.

Gallagher, A. E. J., W. A. Stickney, J. E. Shelton, and F. W. Wessel. Selective Flotation of Fine-Grained Lead-Zinc Sulfides From Idaho and Washington. BuMines Rept. of Inv. 5765, 1961, 20 pp.

Sullivan, P. M., and D. H. Chambers. Recovery of Zinc From Dross and Tin From Hardhead by Amalgam Electrolysis. BuMines Rept. of Inv. 5827, 1961, 18 pp.

Dressel, W. M., and W. A. Calhoun. Experimental Tertiary Amine Flotation of Zinc Silicate (Hemimorphite) From Missouri. BuMines Rept. of Inv. 5854, 1961, 7 pp.

Stanczyk, Martin H., and Carl Rampacek. Dissolution of Zinc From Spalerite at Elevated Temperatures and Pressures. BuMines Rept. of Inv. 5848, 1961, 23 pp.

Eng, Harvard, and H. Kenworthy. Waterborn Wastes and Water Use by Metal-Processing Industries in the Missouri Basin, Kansas and Missouri: BuMines Inf. Circ. 8058, 1961, 26 pp.

Kershner, K. K., and J. G. Donaldson. Chloridizing the Sulfides of Lead, Zinc and Copper. BuMines Rept. of Inv. 5894, 1961, 19 pp.

Starliper, A. G., H. Kenworthy, and P. T. Goin. Recovery of Germanium, Cadmium, and Lead as Sulfides From Zinc Concentrates by Batch and Fluid-Solids Roasting. BuMines Rept. of Inv. 5891, 1961, 21 pp.

Kenahan, Charles B., and David Schlain. Effects of Ultrasonics on Electrolytic Deposition of Copper and Zinc From Sulfate and Cyanide Electrolytes. BuMines Rept. of Inv. 5890, 1961, 53 pp.

[42] Kennedy, V. C., and S. W. Hobbs. Geochemical Studies in the Coeur d'Alene District, Shoshone County, Idaho. Geol. Survey Bull. 1098–(a), 1961, pp. 1–55.

King, P. B., H. W. Ferguson, and Warren Hamilton. Geology of Northeasternmost Tennessee. Prof. paper 311, 1961, 136 pp.

Brown, C. E., and J. W. Whitlow. Geology of the Dubuque South Quadrangle. Geol. Survey Bull. 1123–(a), 1961, pp. 1–93.

Campbell, A. B. Geology and Mineral Deposits of the St. Regis-Superior Area, Mineral County, Mont. Geol. Survey Bull. 1082–(i), 1961, pp. 545–612.

[43] Stanton, R. E., and Alison J. McDonald. Application of Automated Analysis to the Determination of Zinc, Lead, Molybdenum, and Nickel in Extracts of Soils. Chem. and Ind. (London) No. 35, Sept. 2, 1961, p. 1406–1407.

rite[44] were reported. Pend Oreille Mines and Metals company reported substituting, at a considerable reduction in cost, long-hole drilling for diamond drilling in exploration and development.

In extractive metallurgy, patents were granted on a method of leaching a zinciferous sulfide,[45] for mineral recovery by solvent extraction of the copper-zinc values in an aqueous acidic solution,[46] and for electrodepositing zinc from a germanium-contaminated solution.[47] A Russian development using an aluminum belt for a cathode, with continuous removal of the deposited zinc was reported.[48] Articles described Belgian experience using the Overpelt-type horizontal retort furnace,[49] use of oxygen and other operating performance in zinc roasters,[50] and corrosion-resistance tests of materials for containing molten zinc.[51]

Four hundred delegates from 20 countries discussed 26 papers on galvanizing at an international galvanizing conference.[52] A spangle-free galvanized sheet with improved paintability was developed,[53] and adding magnesium to zinc for galvanizing was claimed to improve corrosion resistance.[54] Studies showed that the protection afforded columbium by a zinc coating is due to formation of intermetallic compounds.[55] Patents were issued for a zinc dust paint,[56] a method to produce a pigment,[57] a zinc electroplating method,[58] and a process for anodic coating.[59]

Articles were published on phase diagrams and properties of two zinc alloys[60] and on intercrystalline corrosion of zinc-aluminum alloys.[61] A patent was granted for use of 6 to 8-percent zinc in a self-

[44] Doe, B. R., A. A. Chados, A. W. Rose, and E. Godijn. The Determination of Iron in Sphalerite by X-Ray Fluorescence Spectrometry. Am. Min. v. 46, September–October 1961, p. 1056–1063.

[45] Forward, Frank Arthur, and Herbert Viltman (assigned to Sheritt Gordon Mines, Ltd.). Method for Production of Zinc. U.S. Patent 2,996,440, Aug. 15, 1961.

[46] Hazen, Wayne C., and Angus V. Hendrickson (assigned to Kerr-McGee Oil Ind., Inc.). Process for Concentrating Copper and Zinc Values Present in Aqueous Solution. U.S. Patent 2,992,894, July 18, 1961.

[47] Saubestre, Edward B. (assigned to Sylvania Electric Products, Inc.). Electrodeposition of Zinc. U.S. Patent 2,975,112, Mar. 14, 1961.

[48] Chemical Week, Processes. Continuous Zinc. V. 89, Nov. 11, 1961, p. 73.

[49] Morrison, Jim. Improved Design Doubles Output of Horizontal Retort Zinc Furnaces. Eng. and Min. J. (London), v. 162, 1961, pp. 74–78.

[50] Landucci, L., and F. T. Fuller. Oxygen-Enriched Air in Lead and Zinc Smelting. J. Metals, v. 13, October 1961, pp. 759–763.

Schneider, Ben. The Multiple Hearth Roasting of Sulphides in the Zinc Roasting Plant of the Hudson Bay Mining and Smelting Co., Ltd., Flin Flon, Manitoba. Canadian Min. and Metal. Bull., v. 54, August 1961, pp. 585–588.

Engineering and Mining Journal. Oxygen Boosts Risdon's Zinc Output. V. 162, September 1961, pp. 106–107.

[51] DeKany, J., H. Lavendel, and L. Burris. The Corrosion of Containment Materials by Molten Zinc and Cadmium Alloys. Metal Progress, v. 80, October 1961, p. 252.

[52] Metal Industry. 6th Internat. Galvanizing Conf. June 23, 1961, p. 491.

[53] American Metal Market. Claim Galvanized Paintability Better With New Sheet. V. 68, No. 76, Apr. 21, 1961, pp. 1–13.

[54] Chemical Engineering. Magnesium in Galvanizing-Zinc Improves Corrosion Resistance. V. 68, No. 21, Oct. 16, 1961, p. 226.

[55] Metal Progress. Zinc Coatings Keep Columbium From Oxidizing at Elevated Temperatures. V. 80, No. 6, December 1961, pp. 158–159.

[56] Lantz, Willard J., and N. J. Nixon (assigned to American Smelting and Refining Co.). Low Gassing Zinc Dust Paint. U.S. Patent 2,968,571, v. 762, No. 3, Jan. 17, 1961, p. 553.

[57] Merson, David A., Mill Neck, and Edward J. Dunn, Jr. (assigned to National Lead Co.). Corrosion-Inhibitive Pigment. U.S. Patent 3,004,857, v. 771, No. 3, Oct. 17, 1961, p. 798.

[58] Safranek, William H., and Hugh R. Miller (assigned to American Zinc Institute). Zinc Electroplating. U.S. Patent 3,005,759, v. 771, No. 4, Oct. 24, 1961, p. 1065.

[59] White, Arnold G. (assigned to The Consolidated Mining and Smelting Co.). Anodic Treatment of Zinc and Zinc-Base Alloys. U.S. Patent 3,011,958, v. 773, No. 1, Dec. 5, 1961, p. 237.

[60] Chiotti, P., and K. J. Gill. Phase Diagram and Thermodynamic Properties of the Thorium-Zinc System. Trans. Metal. Soc. AIME, v. 221, No. 3, June 1961, pp. 573–580.

Rennhack, E. H. Zinc-Rich Corner of the Zn-Fe-Al System. Trans. Metal. Soc. AIME, v. 221, No. 4, August 1961, pp. 775–779.

[61] Roberts, C. W. An Investigation Into the Causes of Intercrystalline Corrosion in Zinc-Aluminum Alloys. Metal. (England) v. 64, No. 382, August 1961, pp. 57–66.

aging aluminum-base alloy [62] and for a zinc-base alloy containing titanium, copper, chromium, and manganese.[63]

An accelerated effort on research and development in using zinc in fuel cells was reported.[64] Work was continued on a silver-zinc battery by the Naval Research Laboratory and others.[65]

A number of patents [66] were issued for preparing and using zinc-containing compounds. Research was described on coating Pyrex and silica glass with zinc phosphor films.[67]

Basic research results were reported on growth of zinc whiskers,[68] deformation and other physical property changes in single zinc crystals under stress,[69] use of unit-cell edge measurements to determine other minor metal constituents found in solid solution in sphalerite [70] and wurtzite,[71] properties of relatively thin zinc films,[72] electroluminescent properties of zinc sulfide-type phosphors,[73] growth of zinc sulfide single crystals,[74] and discovery of a new zinc compound.[75]

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[62] Martin, Wayne (assigned to William F. Jobbins, Inc.). Aluminum Base Alloys. U.S. Patent 2,993,783, v. 768, No. 4, July 25, 1961, p. 943.

[63] Giuliani, Raymond E. Park Forest, and John D. Scudder (assigned to Hydrometals, Inc.). Zinc Alloy. U.S. Patent 3,006,758, v. 771, No. 5, Oct. 31, 1961, p. 1381.

[64] Ruth, John P. Exide Hastens Research on Fuel Cells Using Zinc. Am. Metal Market, v. 68, No. 167, Aug. 30, 1961, pp. 1–14.

[65] Palagyi, Tivadar Z. Investigation on the Silver-Zinc Storage Battery With Radioactive Ag^{110} Isotope. J. Electrochem. Soc., v. 108, No. 9, September 1961, pp. 904–906.

[66] Lehissa, Sabino, and Arsizio Busto (assigned to Montecatini, Societa Generale per l'Industria Mineraria e Chimica). Process for the Preparation of Crystalline Zinc-Ethylene-Bis-Dithiocarbamate and Product Obtained. U.S. Patent 2,995,589 (Italy), v. 769, No. 2, Aug. 8, 1961, p. 430.

Johannsen, Smith Robert (assigned to Chemelex, Inc.). Zinc Silicate Sols, Their Preparation and Use in Making Electrically Conductive Compositions, Films, and Heating Elements. U.S. Patent 2,995,529, v. 769, No. 2, Aug. 8, 1961, p. 419.

May, Robert L., and Lee V. Brown (assigned to Sinclair Refining Co.). Manufacture of Mixed Nickel and Zinc Dithiophosphate. U.S. Patent 3,008,900, v. 772, No. 2, Nov. 14, 1961, p. 529.

Wahlig, Frederick Charles, and Hilmer Ernest Winberg (assigned to E. I. du Pont de Nemours & Co.). Infrared-Sensitive Metal-Activated Zinc Silicate Phosphors and Their Preparation. U.S. Patent 2,984,627, v. 766, No. 3, May 16, 1961, p. 767.

Chemical Trade Journal and Chemical Engineer. Zinc Oxide-Zinc Titanate Pigments. British Patent 866,359 (London), v. 149, No. 3879, Oct. 6, 1961, p. 773.

Lessoff, Howard (assigned to Radio Corp. of America). Method for Preparing Nickel-Zinc Ferrites. U.S. Patent 3,009,880, v. 772, No. 3, Nov. 21, 1961, p. 823.

Peyssou, Jean, and Avenir Vassiliev (assigned to Steatite Research Corp.). Process of Manufacturing Ternary Ferrites Containing Manganese and Zinc. U.S. Patent 3,007,874, v. 772, No. 1, Nov. 7, 1961, p. 219.

Feldman, Charles (assigned to Davohn Corp.). Method for Making Zinc Sulfide Luminescent Screens. U.S. Patent 2,996,402, v. 769, No. 3, Aug. 15, 1961, p. 679.

[67] Kirk, Russell D., and James H. Schulman. Transparent Luminescent Films by Solution Spraying. J. Electrochem. Soc., v. 108, No. 5, May 1961, pp. 455–457.

[68] Steel. How Crystals Grow. V. 149, No. 5, July 31, 1961, p. 55.

[69] Rezek, J., and G. B. Craig. The Effect of Striation Substructure on the Critical Resolved Shear Stress of Zinc Single Crystals. Trans. Metal. Soc. AIME, v. 221, No. 4, August 1961, pp. 715–720.

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[70] Skinner, Brian J. Unit-Cell Edges of Natural and Synthetic Sphalerites. The Am. Min., v. 46, Nos. 11–12, November-December 1961, pp. 1399–1411.

[71] Skinner, Brian J. The Relationship Between Unit-Cell Edges and Composition of Synthetic Wurtzites. Am. Min., v. 46, Nos. 11–12, November-December 1961, pp. 1382–1398.

[72] Taylor, C. G., and C. Tolley. Some Properties of Unsupported Sprayed Zinc Films. J. Inst. of Metals (London), v. 90, pt. 4, 1961, pp. 114–120.

[73] Thornton, W. A. Electroluminescence in Zinc Sulfide as Due to Minority Carrier. J. Electrochem. Soc., v. 108, No. 7, July 1961, pp. 636–645.

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[74] Samelson, Harold, and Vincent A. Brophy. The Synthesis and Crystallography of Structurally Pure Cubic and Hexagonal Single Crystals of ZnS. J. Electrochem. Soc., v. 108, No. 2, February 1961, pp. 150–154.

[75] Bartram, Stanley F., and Richard A. Slepetys. Compound Formation and Crystal Structure in the System ZnO-TiO_2. J. Am. Ceram. Soc., v. 44, No. 10, Oct. 1, 1961, pp. 493–499.

Zirconium and Hafnium

By F. W. Wessel [1]

ZIRCONIUM sponge and ingot were produced at new records in 1961. Imports of zircon were substantially unchanged, but domestic production and consumption increased slightly, principally because of greater demand for foundry sand. Hafnium production remained constant.

LEGISLATION AND GOVERNMENT PROGRAMS

The General Services Administration sold 8,407 tons of zircon from the national stockpile during the year. At yearend 16,533 tons of baddeleyite, 5,698 tons of zircon, and 1,723 tons of a semifinished concentrate containing 26 percent zirconium oxide (ZrO_2) remained unsold.

TABLE 1.—Salient zirconium and hafnium statistics in the United States

	1957	1958	1959	1960	1961
Zircon:					
Production, short tons	[1] 56,802	30,443	(2)	(2)	(2)
Price: Dec. 31, per short ton	$55.00	$41.00	$47.25	$47.25	$47.25
Imports, short tons	41,692	19,225	54,878	34,280	33,805
Price: Dec. 31, per short ton	$45.10	$42.00	$44.60	$44.60	$44.60
Zirconium sponge:					
Production, short tons	(2)	1,265	1,404	1,423	1,697
Price: Dec. 31, per pound	$7.50	$6.25	$6.25	$6.25	$6.25
Hafnium: Production, short tons	(2)	[3] 31	[4] 17	[5] 53	[5] 47

[1] Florida only.
[2] Data not available.
[3] Includes metal content of oxide.
[4] Sponge only, estimated.
[5] 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. continued to produce zircon at a rate slightly greater than in 1960. These companies operated mines in Florida at Trail Ridge, South Jacksonville, and Vero Beach, respectively.

[1] Commodity specialist, Division of Minerals.

Production of zirconium sponge amounted to 1,697 short tons, a 19-percent increase over 1960. This quantity was produced by Reactive Metals, Inc., Ashtabula, Ohio; Carborundum Metals Co., Parkersburg, W. Va.; Columbia-National Corp., Pensacola, Fla.; and Wah Chang Corp., Albany, Oreg. About two-thirds of this metal was produced under long-term Atomic Energy Commission (AEC) purchase contracts, which begin to expire in 1962.

These zirconium producers also reported production of 111,412 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.

Reactive Metals, Inc., Niles, Ohio, took over from Bridgeport Brass Co., a facility for producing tubing of various rare metals including zirconium. National Distillers & Chemical Corp., parent corporation of Reactive Metals, Inc., merged with Bridgeport Brass Co. during the year.

Production of zirconium ingot reached 2,810,000 pounds, an increase of 4 percent over 1960. Leading producers were Reactive Metals, Inc., Niles, Ohio; Westinghouse Electric Corp., Pittsburgh, Pa.; and Harvey Aluminum, Inc., Torrance, Calif.

Melters and fabricators generated 485,000 pounds of scrap and drew from inventory to return 517,000 pounds to ingot production.

Union Carbide Metals Co. produced zirconium ferroalloys, and Vanadium Corporation of America produced zirconium-bearing Grainal 79. Total production declined 10 percent from the 1960 volume.

Temescal Metallurgical Corp. installed a 25-ton electron-beam furnace at its Berkeley, Calif., plant for producing zirconium and other metals in high-purity form.

A zirconium-2-percent-tin alloy in spherical metal powder particles was made available by Linde Co., East Chicago, Ind.

Output of zirconium oxide, not including that produced as an intermediate step in zirconium metal production, totaled 11,463,000 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 20,737 short tons of zircon and zirconia refractories were Corhart Refractories Co., with plants at Louisville, Ky., Buckhannon, W. Va., and Corning, N.Y.; Harbison-Carborundum Corp.; The Chas. Taylor Sons Co., Cincinnati, Ohio; and Walsh Refractories Corp., St. Louis, Mo. Corhart Refractories Co. announced its production of cast shapes of a zirconia-alumina-silica refractory for use in applications where abrasion resistance is essential.

Foote Mineral Co., Carborundum Metals Co., Nuclear Materials & Equipment Corp., and Wah Chang Corp. produced 33,555 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 about 92,100 tons. This quantity was distributed approximately as follows:

Use:	*Percent*
Ceramic and foundry zircon	58.0
Refractories	16.5
Chemicals, abrasives, and ceramic compounds	8.5
Metal and alloys	11.0
Oxide	6.0

Consumption of zirconium ingot was 1,938,000 pounds; Reactive Metals, Inc., Westinghouse Electric Corp., and Jessop Steel Co. were major fabricators.

The newest atomic reactor under construction at Hanford, Wash., will use zircaloy process tubes and fuel cladding.

A new application for zirconium metal is based on its resistance to mineral acids in handling pickle liquor in steel plants.

Several refractory and ceramic uses were developed or expanded during 1961. Ipsen Industries, Rockford, Ill., marketed a zirconia-hafnia insulating brick of 89 percent porosity, capable of withstanding 4,200° F temperatures. Zirconium Corp. of America, Solon, Ohio, developed a gastight zirconia ceramic body for highly corrosive boiler environments and other zirconia formulations for use at critical points of pilot-controlled glide vehicles (Project Dyna-Soar). Use of zirconia to resist erosion in magnetohydrodynamic generators at 5,000° F is foreseen. Because of its low coefficient of thermal expansion, zirconia was used as a coating for kitchenware subject to rapid changes from low to high temperatures. Zircon or zirconia may find application as ceramic facing of dies operated up to 4,000° F. A mixture of zircon with 35 percent glass was used to protect tungsten wire at 3,000° F. A zirconate and titanate of lead was found to have piezoelectric properties and was used in compact weight-measuring devices.

STOCKS

Dealer stocks of zircon concentrate decreased from 5,805 tons (revised figure) to 5,426 tons at the end of 1961, and consumer stocks, from 15,807 (revised figure) to 12,337 tons. Total inventory change was 3,849 tons. Inventories of zirconium sponge and ingot were 4,088,000 and 570,000 pounds, respectively. The four zirconium producers ended the year with a total inventory of 2,131,000 pounds of hafnium-free zirconia.

PRICES

Prices for major zirconium commodities remained unchanged during the year. Domestic zircon sold at $47.25 per short ton, f.o.b. Starke, Fla., and imported zircon, at $50 per long ton, c.i.f. Atlantic ports. At yearend, Australian zircon was quoted at £15 to £16 15s. on the London exchange.

Reactor-grade zirconium sponge prices averaged about $6.25; prices of other forms of the metal and of ferroalloys similarly remained unchanged.

At the close of the year, E. I. du Pont de Nemours & Co., Inc., was negotiating with two small Australian producers, Coffs Harbour Rutile N.L. and Peko-Wallsend Investments, Ltd., for delivery of 30,000 to 50,000 tons of rutile annually. Some uncertainty was evident concerning the effect of this action, if concluded, on the quantity and price of zircon available.

FOREIGN TRADE [2]

Imports.—Imports of zircon amounted to 33,805 short tons, virtually unchanged from 1960. Australian material again dominated the market, supplying 92 percent of all imports; the remainder came mostly from the Union of South Africa. No Nigerian zircon entered the United States during 1961.

The principal port of entry was Philadelphia, which received 55 percent of the Australian imports. Other Atlantic ports received 20 percent; Pacific ports, 20 percent; and Gulf ports, 5 percent. A trend toward wider geographical distribution among ports of entry was evident.

Less than 1 ton of zirconium metal was imported.

Exports.—Exports of zircon totaled 1,277 short tons; 618 tons were shipped to Canada, 190 tons to Italy, 154 tons to Colombia, and 315 tons to other countries. Total value of these shipments was $278,244, or about $218 per ton. Zircon reexported totaled 473 short tons, all shipped to Canada.

TABLE 2.—U.S. imports for consumption of zircon, by countries

(Short tons)

Country	1952–56 (average)	1957	1958	1959	1960	1961
Australia [1]	24,108	41,659	19,175	53,650	29,183	31,225
Brazil [2]	1,293	----	----	----	----	4
Canada [3]	60	14	----	24	2	----
Nigeria	----	----	50	868	1,850	----
Union of South Africa	----	----	----	280	3,133	2,576
United Kingdom [3]	31	19	----	56	112	----
Total: Quantity	25,492	41,692	19,225	54,878	34,280	33,805
Value	[4] $658,791	$1,142,472	$467,391	$1,517,485	$1,233,815	$873,376

[1] Imports from Australia through 1954 were partly in the form of mixed concentrate containing small quantities of rutile and ilmenite.
[2] Concentrate from Brazil includes some baddeleyite.
[3] Believed to be country of shipment rather than country of origin.
[4] 1954 data known to be not comparable with other years.

Source: Bureau of the Census.

Exports of 44 tons of crude metal, alloy, and scrap, principally to the United Kingdom, were valued at $442,436. Semifabricated forms

[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.

weighing 45 tons and valued at $1,029,823 were exported, principally to the United Kingdom and Canada.

WORLD REVIEW

Argentina.—A new company, Talamuchita, S.A., was formed to develop and mine a heavy-sand deposit, recently found on the Rio Tercero, Cordoba.

Australia.—Ilmenite, zircon, rutile, and monazite sands on the beaches of Western Australia were mined on a substantial scale by Western Titanium, N.L., Ilmenite Pty., Ltd., Cable, Ltd., and Western Oil, Ltd. The mineral sands extend over a 30-mile length of ocean beach south of Bunbury, where the mineral concentrates are loaded for export.

Production of these minerals from the beach deposits of New South Wales and Queensland has been concentrated in the hands of about seven major producers by purchase and merger. Consolidated Gold Fields Pty., Ltd., National Lead Co., and N.S.W. Rutile Mining Co., Pty., Ltd., appear to have been the major producers at the close of 1961.

France.—The Société Industrielle du Zirconium was formed to produce zirconium sponge and ingot. Partners in this company were Metallgesellschaft A.G., Deutsche Gold-und-Silber Scheideanstalt, Soc. Générale Montecatini, and Cie. de Produits Chimiques Pechiney.

TABLE 3.—Free world production of zirconium ores and concentrates by countries [1]

(Short tons)

Country	1952–56 (average)	1957	1958	1959	1960	1961
Australia	49,124	99,188	66,381	125,834	114,384	[2] 156,900
Brazil[3]	3,627	1,799	10,471	10,846	6,358	[4]
India	[5] 3	10	10	[2] 10	[2] 10	[2] 10
Malagasy Republic (Madagascar)	1	1	58	50	375	[2] 220
Malaya, Federation of	51	[6] 47	[6] 28	130	63	[6] 80
Nigeria		101		1,080	1,619	686
Senegal, Republic of	665	3,197	7,606	9,557	11,408	[2] 6,100
Union of South Africa			1,129	5,924	7,366	7,607
United Arab Republic (Egypt)	207	45	[2] 45	[2] 65	408	[4]
United States	27,740	[7] 56,802	30,443	[8]	[8]	[8]

[1] This table incorporates some revisions.
[2] Estimate.
[3] Chiefly baddeleyite.
[4] Data not available.
[5] Average annual production 1955–56.
[6] Exports.
[7] Florida only.
[8] Figure withheld to avoid disclosing individual company confidential data.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

Japan.—Statements in the Japanese press concerning resumption of barter arrangements by the United States for Japanese reactor-grade

zirconium were apparently unfounded. Japanese zirconium production data were reported as follows:

Year	Reactor-grade, short tons	Commercial-grade, short tons
1957	144	(1)
1958	68	(1)
1959	35	15
1960	15	54

[1] Data not available.

Malaya, Federation of.—Japanese interests acquired two properties in Trengganu from which ilmenite, monazite, and zircon were to be recovered.

RESERVES

Examinations and estimates made since 1957 permitted revision of the tabulations of domestic and foreign reserves published in that year.

Bureau of Mines resource investigations showed that zirconferous sandstone was present in New Mexico, Utah, and Wyoming and zircon in placer deposits in Mississippi and Texas. The quantities measured are shown in table 4. Deposits of zircon in certain areas in Florida and South Carolina, and in Virginia, Washington, and several other States had not been quantitatively examined.

Data for many foreign sources were reexamined; table 5 gives the revised figures, as well as additional information developed since 1957. Deposits of considerable importance were known in Egypt, the Republic of Senegal, Western Australia, and the Indian Provinces of Bihar and Orissa, but quantitative data were lacking.

TABLE 4.—Reserves of zircon in the United States, by States

(Short tons of concentrate)

State	Thousand short tons	State	Thousand short tons
California	1,500	New Mexico, Utah, Wyoming	290
Florida	7,155	Oregon	90
Georgia	345	South Carolina	1,350
Idaho	82	Other States	87
Maryland	162		
New Jersey	1,520	Total	12,581

TABLE 5.—Free world reserves of zirconium minerals, by countries

(Short tons of concentrate)

Country	Thousand short tons	Country	Thousand short tons
Australia	2,882	Union of South Africa	564
Brazil	2,552	United States	12,581
Ceylon	1,000	Other countries [1]	404
India	3,360		
		Total	23,343

[1] Includes Ivory Coast, Korea, Malagasy Republic, Nigeria, and Uruguay.

TECHNOLOGY

Phosphorite, a colloidally precipitated material containing an average of 0.085 percent ZrO_2 and significant quantities of iron, manganese, and phosphorus, was shown to exist in large tonnage on the continental shelf off both coasts of the United States.[3]

The mineral dressing processes and equipment used at various blacksand deposits in Western Australia were described.[4]

The U.S. Industrial Chemicals Co., a division of National Distillers & Chemical Corp., in April announced the further development of a process for zirconium-hafnium separation.[5] This process, developed in Australia,[6] depends on a series of oxidation-reduction reactions and fractionation of the chloride products.

Research by the Bureau of Mines showed that ductile hafnium could be obtained consistently by reduction with a blend of magnesium and sodium.[7]

General Electric Co., using powder metallurgy techniques, made compacts of zircaloy-2 showing no porosity under the microscope.[8]

A thorough analysis of the mechanism by which zirconium ignites showed pressure and concentration of oxygen to be critical.[9]

The feasibility of electrorefining off-grade zirconium and hafnium was demonstrated; metals of Brinnell hardness number 90 and about 140, respectively, were recovered.[10]

The binary constitution diagrams for zirconium and platinum [11] and for hafnium and molybdenum [12] were described, the latter diagram for the first time. In addition, results of many other investigations of phase diagrams, physical properties, and uses of zirconium and hafnium alloys were reported.

Further analysis of the economics of zirconium compared with stainless steel for nuclear reactors was reported. Principles on which to base a choice were outlined.[13]

Research at the U.S. Naval Ordnance Station, China Lake, Calif., led to synthesis of metal-containing resins.[14] Surfaces requiring protection against heat were coated with the resins that upon exposure to temperature broke down to the highly refractory carbides.

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[3] Mero, John L. Sea Floor Phosphorite. Miner. Inf. Service, v. 14, No. 11, November 1961, pp. 1–11.
[4] Mining Journal (London), v. 256, No. 6546, Feb. 3, 1961, pp. 118–119.
[5] Chemical & Engineering News, v. 39, No. 14, Apr. 3, 1961, pp. 71–72.
[6] Wessel, F. W. Zirconium and Hafnium. BuMines Minerals Yearbook, v. 1, 1957, p. 1330.
[7] Richardson, D. W. Production of Bimetal-Reduced Hafnium. BuMines Rept. of Inv. 5734, 1961, p. 21.
[8] Metal Progress, v. 80, No. 1, July 1961, p. 8.
[9] Littman, F. E., F. M. Church, and E. M. Kinderman. The Spontaneous Ignition of Zirconium. J. Less-Common Metals, v. 3, No. 5, October 1961, pp. 379–397.
[10] Baker, D. H., Jr., J. R. Nettle, and H. Knudsen. Electrorefining Zirconium. BuMines Rept. of Inv. 5758, 1961, 12 pp.
Nettle, J. R., J. M. Hiegel, and D. H. Baker, Jr. Hafnium Electrorefining. BuMines Rept. of Inv. 5851, 1961, 18 pp.
[11] Kendall, E. G., C. Hays, and R. E. Swift. The Zirconium-Platinum Alloy System. AIME Met. Soc. Trans., v. 221, No. 3, June 1961, p. 445.
[12] Taylor, A., N. J. Doyle, and B. J. Kagle. The Constitution Diagram of the Molybdenum-Hafnium Binary System. J. Less-Common Metals, v. 3, No. 4, August 1961, pp. 265–280.
[13] Baroch, Charles J. Stainless Steel and Zirconium. Mines Mag., v. 51, No. 2, February 1961, pp. 17–22.
[14] Chemical Engineering, v. 60, No. 4, Feb. 20, 1961, p. 80.

Minor Metals

By F. W. Wessel,[1] Donald E. Eilertsen,[1] John E. Shelton,[1] Don H. Baker, Jr.,[1] and John G. Parker [1]

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CESIUM AND RUBIDIUM [2]

PRODUCTION of cesium in the United States increased several-fold in 1961, whereas output in rubidium declined. Imports of pollucite increased again; virtually all of the imports came from Africa.

Legislation and Government Programs.—The Office of Emergency Planning considered stockpiling cesium metal or compounds.

Domestic Production.—No cesium or rubidium ores were produced domestically in 1961; however, Leprechaun Mining & Chemical Co. reportedly was developing a lithium-cesium-rubidium saline deposit in Esmeralda County, Nev. American Potash & Chemical Corp., Trona, Calif.; and Penn Rare Metals, Inc., Revere, Pa., were the major producers of a total of 208 pounds of cesium metal; The Dow Chemical Co., at Midland, Mich.; and Fairmount Chemical Co., Inc., Newark, N.J., were minor producers. Rubidium production declined about 20 percent from 1960; American Potash & Chemical Corp. and Penn Rare Metals, Inc., were the only producers. These two companies and Dow Chemical produced 12,157 pounds of cesium and rubidium compounds, slightly more than a 100-percent increase from 1960. The principal compounds produced were cesium carbonate, halides, nitrate, and hydroxide; cesium and rubidium alums; and rubidium carbonate.

Kawecki Chemical Co. in 1960 purchased a 50-percent interest in Penn Rare Metals, and not, as reported in the 1960 Yearbook, the entire company.

[1] Commodity specialist, Division of Minerals.
[2] Prepared by F. W. Wessel.

Consumption and Uses.—Increased research, development, and testing activities consumed substantial quantities of cesium and rubidium in 1961.

A major item was the ion propulsion engine. In this device, cesium is vaporized and passed through a heated porous tungsten disc. Cesium atoms lose an electron to the tungsten; the cesium, now with a positive charge, is accelerated tremendously by an electrical field. Thrust is developed by exhausting the stream of ions through a nozzle. The engine is intended for use outside the earth's atmosphere. Hughes Aircraft Co., Malibu, Calif.; National Research Corp., Cambridge, Mass.; Radio Corporation of America; and North American Aviation, Inc., Canoga Park, Calif., were working on various components of the system.

Of equal importance were developments on the plasma thermionic converter. One such device, developed by General Electric Co., will transform the heat of a nuclear reactor core directly into electricity by application of the thermocouple principle. Cesium vapor forms the anode against a uranium-bearing cathode.

The Research Projects Division, National Aeronautics and Space Administration (NASA), Huntsville, Ala., late in 1961 estimated that the ion propulsion engine and the thermionic converter programs would require a total of 600 pounds of cesium in 1962, and that the demand would reach 2,000 pounds between 1965 and 1970.[3]

Royal Industries, Los Angeles, Calif., contracted with the Atomic Energy Commission to make a long-lived, compact 5-watt nuclear powerpack, using cesium 137 as a heat source. Cesium 137 also was reported to be superior to cobalt 60 for cancer therapy.[4]

A cesium-vapor lamp with a ceramic bulb was reportedly under development at the Cleveland, Ohio, plant of General Electric Co.

Welding electrodes coated with rubidium and cesium compounds were used in a welding technique developed by Air Reduction Sales Co. and applied to steel down to 0.062 inches thick.

Various devices based on optically pumped resonance systems and using rubidium vapor were developed and marketed by Varian Associates, Palo Alto, Calif., Space Technology Laboratories, Inc., and NASA.

Stocks.—Consumers and dealers held a yearend inventory of 30,700 pounds of pollucite, an increase of about 10,000 pounds. (A large stockpile of South Dakota pollucite held by Maywood Chemical Division of Stepan Chemical Co., at Maywood, N.J., is not included.) Producers' yearend stocks of cesium and rubidium metal were 229 pounds and less than 100 pounds, respectively.

Prices and Specifications.—The Dow Chemical Co. offered high-purity cesium metal containing 36 p.p.m. oxygen; 29 p.p.m. silicon; a maximum of 16 p.p.m. each of sodium, potassium, rubidium, and boron; 10 p.p.m. calcium; and lesser amounts of other impurities. This metal was priced at $325 per pound in 5-pound lots.

Kawecki Chemical Co., marketing cesium for Penn Rare Metals, Inc., similarly offered cesium of 99.9 percent purity at $375 per pound

[3] Chemical Week, v. 89, No. 22, Dec. 2, 1961, pp. 57–58.
[4] Science News Letter, v. 79, No. 5, Feb. 4, 1961, p. 70.

for lots of 1 to 9 pounds, scaling down to $125 per pound in lots of 1,000 pounds or more. A 99.5 percent metal was offered at $300 and $100 for similar quantities.

MSA Research Corp., Callery, Pa., offered for sale, packaged in glass ampoules, cesium (99.9 percent) at $1.50 per gram, cesium (99.5 percent) at $1.25 per gram, and rubidium (99.0 percent) of $1 per gram, each in 50-gram lots. This company and Fairmount Chemical Co., also marketed various chemically pure cesium and rubidium salts.

World Review.—*Canada.*—Chemalloy Minerals, Ltd., suspended operations at its lithium-cesium operation at Bernic Lake, Manitoba, early in 1961, later announcing a reserve of 300,000 tons of pollucite at about 25 percent cesium content.

Mozambique.—Metallium Corp., New York, N.Y., examined pegmatite deposits in Mozambique, and reported the existence of potentially commercial quantities of pollucite in waste dumps from beryl-tantalite operations. Six tons of pollucite was produced during the year.

Technology.—A brief survey of pollucite deposits in Canada was published,[5] mentioning, in addition to the Montgary pegmatite, a small reserve at the Valor Mine at Lac Lacorne, Quebec. A field test for cesium, based on its reaction with potassium bismuth iodide, was described.[6] A detailed geological description of the pegmatite deposits at Kings Mountain, N.C., which included an estimate of the lithium ore reserve, showed the presence of a biotite schist containing 1.85 percent Rb_2O and 0.47 percent Cs_2O.[7]

At Huntsville, Ala., NASA continued to develop ion propulsion engines, using cesium as a propellant. Of interest to workers in the ion propulsion field was a report of studies of the mechanism by which cesium is ionized by diffusion through porous tungsten.[8] A history and description of the thermionic converter included a forecast of its possible use as a silent portable power source for military purposes.[9] Research on thermionic conversion, using cesium vapor as one element of the couple, continued at the Los Alamos National Laboratory, Los Alamos, N. Mex. General Electric Co. reported efficiencies of 15 to 17 percent in a new model thermionic cesium-vapor converter operated at 1,530° C. General Atomics Division of General Dynamics Corp. began research in its San Diego laboratories, in which a similar converter will be used to obtain very high frequency electric current from a heat source.

The Army Signal Corps experimented with the use of cesium or a compound thereof to form a reflector in the atmosphere from which to reflect radar or microwave signals. Production of rubidium metal by reducing the iodide with calcium was described briefly.[10]

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[5] Mulligan, R. Pollucite in Canada. Min. J. (London), v. 265, No. 6562, May 26, 1961, p. 600.
[6] Hosking, K. F. G. The Identification of Pollucite. Min. J. (London), v. 104, No. 5, May 1961, pp. 280–282.
[7] Kesler, Thomas L. Exploration of the Kings Mountain Pegmatites. Min. Eng., v. 13, No. 9, September 1961, pp. 1063–1068.
[8] Stavisskii, Y. Y., and S. Y. Lebedev. Surface Ionization of Cesium Upon Diffusion Through Porous Tungsten. Zhur. Tekh. Fiz., v. 30. No. 10, pp. 1222–1226.
[9] Sullivan, L. T. Thermionic Power Becomes of Age. Signal, v. 16, No. 2, October 1961, pp. 17, 20.
[10] Mingazin, T. A. The Production of Metallic Rubidium from Rubidium Iodide. Zhur. Neorg. Khim., v. 2, No. 5, 1957, pp. 995–996.

The effect of rubidium in increasing the durability of lime and borate glasses was described;[11] rubidium content in the range of 35 to 40 pecent gave very good resistance to atmospheric conditions.

GALLIUM [12]

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, gallium sesquioxide, and gallium arsenide. Production and shipments of gallium metal were the largest ever reported.

Uses.—Principal uses were small-scale applications such as a sealant for glass joints and vacuum equipment valves, as a backing material for optical mirrors, and in thermometers and low-melting alloys. New uses were being studied in intermetallic compounds for semiconductor applications in solar batteries, high-temperature rectifiers and transistors, infrared optics, and devices utilizing photovoltaic effect.

Prices.—Market prices for standard, intermediate, and high-purity gallium from bauxite sources were as follows:

Quantity	99.99 percent	99.999 percent	99.9999 percent
Up to 100 grams	$1.85	$2.15	$2.65
100-gram lots	1.60	1.85	2.40
1,000-gram lots	1.45	1.70	2.25

Technology.—A selective bibliography [13] and a comprehensive report [14] on gallium were published. Factors which control the impurity segregation in gallium were studied.[15] A procedure was developed for the production of large multicrystalline ingots of gallium phosphide.[16] A technique that permits the reproducible production of a specific crystal habit in the gallium arsenide system was reported.[17]

GERMANIUM [18]

Germanium production and consumption decreased. Although the electronic industry expanded, refinements in processing caused a drop in the quantity of germanium used in individual devices.

Domestic Production.—Production of germanium from primary ores and concentrates was estimated to be 40,000 pounds. Some of the raw germanium concentrate processed in the United States was derived from base-metal mines in South-West Africa. Germanium recovered from scrap metal sources augmented the supply.

[11] Simpson, H. E. Rubidium in Lime and Borate Glasses. Glass Industry, v. 42, No. 4, April 1961, pp. 189–193, 222–223.
[12] Prepared by Donald E. Eilertsen.
[13] U.S. Department of Commerce, Office of Technical Services. OTS Selective Bibliography, Antimony, Bismuth, Gallium, Indium, Selenium, and Tellurium (1950–October 1960). SB–438, September 1960, 16 pp.
[14] Thompson, A. P. Gallium. Ch. in Rare Metals Handbook. Reinhold Pub. Corp., New York, N.Y., 1961, 2d ed., pp. 178–187.
[15] Weisberg, Leonard R., and P. R. Celmer. Dependence of Segregation of Impurities on the Crystallinity of Gallium. Trans. Met. Soc. AIME, v. 221, No. 4, August 1961, p. 889.
[16] Frosch, C. J., and L. Derick. The Preparation of Floating Zone Processing of Gallium Phosphide. J. Electrochem. Soc., v. 108, No. 3, March 1961, pp. 251–257.
[17] McAleer, W. J., H. R. Barkemeyer, and P. I. Pollak. Vapor Phase Growth of Gallium Arsenide Crystals. J. Electrochem. Soc., v. 108, No. 12, December 1961, pp. 1168–1169.
[18] Prepared by John E. Shelton.

Germanium was produced as a byproduct from domestic zinc ores by The Eagle-Picher Co., Miami, Okla.; and American Zinc Co., Fairmont, Ill. The other producers, American Metal Climax, Inc., Carteret, N.J.; and Sylvania Electric Products, Inc., Towanda, Pa., relied upon foreign sources of supply. In addition, all the companies recovered germanium from scrap metal. Each company produced germanium dioxide and several electronic grades of single-crystal and polycrystalline germanium.

Consumption and Uses.—The primary use of germanium was in the electronic industry. The production of transistors, diodes, and rectifiers increased, but the quantity of germanium used to manufacture these devices declined. Refinements of manufacturing techniques resulted in reduction of losses and rejects during the assembly of semiconductors. Germanium also was used as a color modifier in fluorescent lights.

Prices.—The quoted price for germanium was unchanged for the second consecutive year. Price quotations in American Metal Market, based on quantity purchased, were as follows:

Grade:	*Price (Cents per gram)*
First reduction	28.15–35.15
Intrinsic quality	29.95–36.95
Single crystal	60.50–68.50
Dioxide, high-purity	16.75–21.75

Foreign Trade.—Imports of germanium metal and germanium dioxide totaled 30,748 pounds valued at almost $2 million. Of the total imported, 21,935 pounds came from Belgium, 8,697 pounds from West Germany, 110 pounds from Austria, and the remaining 6 pounds from the United Kingdom and Italy. In addition, a significant quantity of germanium-bearing concentrate was imported from South-West Africa for refining.

World Review.—*Belgium.*—Germanium concentrates from the Republic of the Congo and South-West Africa were refined at Société Générale Métallurgique de Hoboken and the Société Vieille-Montagne at Balen.

Japan.—Production of germanium was 53,300 pounds in 1961, compared with 48,800 pounds in 1960. Consumption was estimated at 80,000 pounds.

South-West Africa.—Operations began in 1961 at a metallurgical plant with a capacity of 10,000 pounds of semirefined germanium dioxide. The concentrate was shipped to the United States for refining. Production of germanium was about 31,000 pounds of contained germanium in concentrate; approximately 11,000 pounds of this quantity was refined to germanium oxide at the plant, and the balance was exported for refining.

Technology.—Exploration by private companies and individuals revealed occurrences of germanium in New Mexico, California, and Montana. Investigations showed that germanium is present in some copper sulfide minerals.[19] Some samples of bornite and enargite were

[19] Fleischer, Michael. Germanium Content of Enargite and Other Copper Sulfide Minerals. U.S. Geol. Survey Prof. Paper 424–B, 1961, pp. 259–261.

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reported to contain over 1,000 p.p.m. of germanium. Research by the Federal Bureau of Mines resulted in a process for recovering germanium from zinc concentrate by roasting.[20] Volatilization studies showed that over 90 percent of the germanium could be recovered by roasting zinc concentrate in stationary or fluid beds. The volatilized fractions contained germanium, cadmium, and lead. The heat content and entropies of germanium and germanium dioxide were reported.[21]

Research by industry was directed mainly toward the application of germanium in electronics and improving the performance of semiconductors. A germanium information center was established at the Midwest Research Institute, Kansas City, Mo., by the germanium producers. The center will collect information relating to all phases of the industry.

INDIUM [22]

Domestic Production.—American Smelting and Refining Co., at Perth Amboy, N.J., was the only domestic producer of indium in 1961. This firm also produced some indium chloride. Production and shipments of indium continued at a high level.

Uses.—Largest uses for indium were in electronic devices, bearings, and low-melting alloys. Indium arsenide, indium phosphide, and indium antimonide were of interest for electronic applications. Infrared detectors and magnetoresistors containing indium antimonide were available.

Prices.—Prices quoted 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.—A selective bibliography [23] and a comprehensive report on indium were published.[24]

The Office of Naval Research, U.S. Navy, sponsored research on the thermal properties on indium.[25]

The production of indium-antimonide p–n junctions, grown by doping very pure n-type melts with zinc, and the properties of these junctions were discussed.[26]

A process for preparing indium phosphide by reacting phosphine with an organic indium compound at temperatures under 300° C. was patented.[27]

The phase diagram for indium-tellurium was studied and corrected, especially in the region near In_2Te_3.[28]

[20] Starliper, A. G., H. Kenworthy, and P. T. Goin. Recovery of Germanium, Cadmium, and Lead as Sulfides from Zinc Concentrates by Batch and Fluid-Solids Roasting. BuMines Rept. of Inv. 5891, 1961, 21 pp.

[21] Kelley, K. K., and A. U. Christensen. High-Temperature Heat Content and Entropies of Crystalline and Glassy Germanium Dioxide. BuMines Rept. of Inv. 5710, 1961, 5 pp.

[22] Prepared by Donald E. Eilertsen.

[23] Work cited in footnote 13.

[24] Mills, J. R., R. A. King, and C. E. T. White. Indium. Ch. in Rare Metals Handbook. Reinhold Pub. Corp., New York, N.Y., 1961, 2d ed. pp. 220–238.

[25] Kaznoff, Alexis I., Raymond L. Orr, and Ralph Hultgren. Thermal Properties of Indium. Univ. of Calif., Berkeley, Calif., Second Tech. Rept. Contract Nonr–222(63), series 155, No. 2, Apr. 1, 1961, 83 pp.

[26] Gorton, H. C., A. R. Zacaroli, F. J. Reid, and C. S. Peet. (Battelle Memorial Institute, Columbus, Ohio). Preparation and Properties of Grown P–N Junctions of InSb. J. Electrochem. Soc., v. 108, No. 4, April 1961, pp. 354–356.

[27] Didchenko, Rostislav (assigned to Union Carbide Corp., New York, N.Y.). Preparation of Indium Phosphide. U.S. Pat. 3,010,792, Nov. 28, 1961.

[28] Crochowski, E. G., and D. R. Mason. Phase Diagram for the Binary System Indium-Tellurium. J. Electrochem. Soc., v. 108, No. 3, March 1961, p. 61C.

RADIUM [29]

Domestic radium consumption decreased considerably in 1961, and the quantity of radium and radium salts imported was about 45 percent less than in 1960.

Domestic Production.—There was very little domestic production of radium in 1961, all from rich sludges, solutions, and scrap. Requirements for the element and its salts were met primarily by imports. Principal domestic distributors for radium, its derivatives, and related compounds were Radium Chemical Co., Inc., New York, N.Y., and Canadian Radium and Uranium Division of Canrad Precision Industries, Inc., New York, N.Y. Other firms in the radium industry were United States Radium Corp., Morristown, N.J., and A. Bruce Edwards, Philadelphia, Pa. Radium Chemical Co., Inc., was sales representative for Union Minière du Haut-Katanga, the world's leading radium producer, and A. Bruce Edwards was sales representative for the Atomic Energy of Canada, Ltd.

Consumption and Uses.—Radium and radium salts were used by the medical profession and in industry.

The radioactive emissive properties of radium led to its use in telecuritherapy, industrial nondestructive testing, self-activated luminous paint, radium-beryllium neutron sources, and radium foil used as an ionizing agent and in static-elimination equipment.

Prices.—Throughout 1961, the price of radium was quoted by E&MJ Metal and Mineral Markets at $16 to $21.50 per milligram of radium content, depending on quantity.

Foreign Trade.—Radium and radium salts were imported from Belgium, the United Kingdom, and Canada. Union Minière du Haut-Katanga, of Belgium, processed Republic of the Congo ores and slimes. Export sales of radium and radium compounds were made to Japan, the Republic of Korea, West Germany, and Central and South American countries.

Technology.—An informative article on radium in general, and on its occurrence and recovery in Canada in particular, was published.[30]

TABLE 1.—U.S. imports for consumption of radium salts and radioactive substitutes

Year	Radium salts		Radioactive substitutes value [1] (thousands)
	Milligrams	Value (thousands)	
1952–56 (average)	85,082	$1,363	[2] $222
1957	76,206	1,061	844
1958	38,419	538	908
1959	32,967	518	1,145
1960	23,333	364	1,394
1961	12,947	185	1,509

[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.

[29] Prepared by Don H. Baker, Jr.
[30] Sanderson, L. Radium. Canadian Min. J., v. 82, No. 12, December 1961, pp. 57–58.

RHENIUM [31]

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 1961. Production and stocks of contained rhenium in metal, alloys, and compounds were the largest ever reported.

Uses.—Uses developed for rhenium included applications in electronics, electromagnets and electrical contacts, thermocouples, filler rod for welding molybdenum and tungsten, and nuclear energy. Rhenium-tungsten alloy wire was used for igniters in photo flashbulbs.

Prices.—Chase Brass & Copper Co., Inc., quoted the following prices for various materials, minimum order $50: Ammonium perrhenate, $425 a pound up to 5 pounds, and $400 a pound for larger quantities; potassium perrhenate, $395 a pound up to 5 pounds, and $370 a pound for larger quantities; first-grade rhenium powder, $650 a pound up to 1 pound, and decreasing prices to $580 a pound for lots of 20 or more pounds; rhenium sintered bar (melting stock), $800 a pound up to 1 pound and decreasing prices to $750 a pound for lots of 5 or more pounds. Also available were rhenium strip and wire, molybdenum-rhenium alloy rod and wire (50 percent Mo-50 percent Re and 60 percent Mo-40 percent Re by weight), molybdenum-rhenium alloy sheet, and tungsten-rhenium alloy sheet, rod, and wire.

Technology.—The Federal Bureau of Mines continued its research on rhenium sources and rhenium extraction. Studies on recovering rhenium from molybdenite roaster dusts and fumes were underway. The feasibility of extracting rhenium directly from molybdenite concentrate also was investigated. Patents were sought for a method developed to recover rhenium by solvent extraction and also for a process developed to recover rhenium by electrodeposition. A modification of a procedure was developed to detect as little as 0.1 part of rhenium per million and measure 1 part of rhenium per million in siliceous and calcareous ores, molybdenite concentrate, fumes, flue dusts, and other metallurgical products; the method consisted of colorimetric analysis using a spectrophotometer.[32]

A constitution diagram for columbium-rhenium [33] and a comprehensive chapter [34] on rhenium were published. A patent relating to the production of high-purity rhenium was issued.[35]

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[31] Prepared by Donald E. Eilertsen.

[32] Peterson, H. E., J. S. MacDuff, and M. W. Hovey. Isolation and Colorimetric Determination of Rhenium. BuMines Rept. of Inv. 5889, 1961, 32 pp.

[33] Giessen, Bill C., Rolf Nordheim, and Nicholas J. Grant. The Constitution Diagram Niobium (Columbium-Rhenium. Trans. Met. Soc. AIME, V. 221, No. 5, October 1961, pp. 1009–1013.

[34] Melaven, A. D. Rhenium. Ch. in Rare Metals Handbook. Reinhold Pub. Corp., 2d ed., pp. 418–433.

[35] Zimmerley, Stuart R., Emil E. Malouf, and John D. Prater (assigned to Kennecott Copper Corp., New York, N.Y.). Process for Production of Ultra-High Purity Rhenium. U.S. Pat. 2,972,531, Feb. 21, 1961.

SCANDIUM [36]

Domestic Production.—Scandium oxide became available from uranium mill waste liquors. The few pounds of scandium metal produced used Australian scandium oxide derived from such a source.

American Scandium Corp., Cincinnati, Ohio, and Research Chemicals Division, Nuclear Corporation of America, Phoenix, Ariz., continued as producers of scandium metal; Michigan Chemical Corp. and Vitro Chemical Co. were able to supply high-purity scandium oxide. However, sales of these materials were limited.

Uses.—The scandium 46 radioisotope has been used as a tracer in analytical work and in oil-well drilling. Water-soluble salts of scandium and some other elements can be used, when subjected to neutron bombardment, to determine the underground flow of liquids.[37] Technical articles appearing in 1961 indicated that metallurgical research on scandium had shown it to have some useful alloying characteristics. Reduced cost of the oxide might encourage the use of the metal for certain unusual applications.

Prices.—Scandium 46 was reduced from $3.00 to $0.20 per millicurie, according to information received from the AEC. Scandium oxide, available in 99- to 99.9-percent grades, sold for $5.50 to about $9.00 per gram, depending upon purity of the material and lot size. Scandium metal prices were reported to be somewhat lower than those of the preceding year. Prices for the metal and for pound lots of the oxide were available upon request to the producers.

World Review.—*Australia.*—It was reported that a multipound lot of scandium oxide, extracted from uranium mill waste liquors, had been sold to a United States company at a price considerably below that for domestic material for conversion to metal.

Technology.—Sublimed, calcium-reduced scandium metal was found to have properties similar to those of yttrium.[38] Scandium added to titanium almost doubled its hardness at room temperature, and increased its oxidation resistance. Scandium metal was also studied in the U.S.S.R.[39] Russian scientists reported that scandium of 96 percent purity added to metallic titanium showed eutectic crystallization at 1,440° C. and formed solid solutions but no metallic compounds.[40] Thermal analysis, electrical resistivity, and X-ray diffraction studies of scandium metal were conducted to determine its alloying behavior with plutonium.[41] Certain ternary zirconium alloys containing scandium were said to be superior to those contain-

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[36] Prepared by John G. Parker.

[37] Armstrong, Frederick E. (assigned to the U.S. Department of the Interior). Method of Tracing the Flow of Liquids by Use of Post Radioactivation of Tracer Substances: U.S. Pat. 3,002,091, Sept. 26, 1961.

[38] Geiselman, Doyle. The Metallurgy of Scandium. Wright Aeronautical Systems Division, WADD Technical Report 60–894, August 1961, 54 pp.

[39] Spitsyn, V. I., L. N. Komissarova, and A. A. Men'kov. (Properties of Scandium). Doklady Akad. nauk S.S.S.R., v. 139, No. 4, Aug. 1, 1961, pp. 903–906; Current Rev. of the Soviet Tech. Press, Nov. 24, 1961, p. 3 (584).

[40] Savitskii, Ye. M., and G. S. Burkhanov. (Phase Diagram of Alloys of the System Titanium-Scandium). Zhur. Neorg. Khim., v. 6, No. 5, 1961, pp. 1253–1255.

[41] Mardon, P. G., J. L. Nichols, J. H. Pearce, and D. M. Poole. Some Properties of Scandium Metal. Nature (London), v. 189, Feb. 18, 1961, pp. 566–568.

ing yttrium and had relatively long lifetimes in high-temperature water and steam.[42]

Cooperative research by industry and government was conducted on the extraction of scandium from uranium mill waste solutions.[43] The Federal Bureau of Mines also considered other economical, by-product sources of the metal. (See Review of Metallurgical Technology chapter).

Sensitive quantitative determinations depended upon the fluorescent reactions of various dyes with scandium in the presence of thorium at different pH values.[44] Direct determination, without preliminary separations, of scandium in ores, process materials, and rare-earth mixtures by X-ray spectrographic techniques used vanadium pentoxide as an internal standard.[45] Scandium was determined by activation analysis simultaneously with dysprosium in rare-earth-rich ores, soil, yttrium oxide, and dilute solutions.[46] Sensitivity limits extend down to a few parts per million of each element. Scandium was extracted and determined by gravimetric techniques.[47]

A separatory technique using a water-immiscible alkyl phosphate medium to extract scandium from an aqueous nitric acid solution was disclosed.[48] Scandium was separated from cerium subgroup rare-earth elements by precipitation with p-halogen-mandelic acids and extraction as halogen mandelates by immiscible organic solvents or isoamyl alcohol.[49] Other research included an investigation of the electrode properties of ion-exchange membrane saturated with scandium ions and the degree of reversibility of the electrode with respect to scandium ions.[50]

X-ray diffraction data on scandium hydride prepared at the Los Alamos Scientific Laboratory late in 1960 revealed that the material has a face-centered cubic structure and a theoretical density of 2.581 g./cm^3.[51] Specific heat measurements were made at low temperatures on scandium.[52]

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[42] Misch, R. D., and C. VanDrunen. Corrosion Studies of Ternary Zirconium Alloys in High-Temperature Water and Steam. ANL–6370, July 1961, 37 p.; Nuclear Sci. Abs., v. 15, No. 24A, Dec. 31, 1961, p. 4190.

[43] Lash, L. D., and J. R. Ross. Scandium Recovery from Uranium Solutions. J. Metals, v. 13, No. 8, August 1961, pp. 555–558.

[44] Korenman, I. M., and G. P. Starostin. (Fluorescent Reactions with Scandium.) Izvestiia vysshikh uchebuykh zavedenii. Khimiia i khimicheskaia tekhnologiia,, v. 4, No. 4, 1961, pp. 561–564; Current Rev. of the Soviet Tech. Press, Nov. 24, 1961, p. 1 (582).

[45] Heidel, Robert H., and Velmer A. Fassel. Fluorescent X-ray Spectrometric Determination of Scandium in Ores and Related Materials. Anal. Chem., v. 33, No. 7, June 1961, pp. 913–916.

[46] Okada, Minoru. Rapid Microdetermination of Scandium and Dysprosium in Rare-Earth-Rich Materials by Neutron Activation and Gamma-Ray Spectrometry. Anal. Chem., v. 33, No. 13, December 1961, pp. 1949–1953.

[47] Alimarin, I. P., and Yun-Syan Tsze (Yung-Schaing Tze). Separation and Determination of Scandium Using N-Benzoylphenylhydroxyamine. Talanta, v. 8, May 1961, pp. 317–321; Nuclear Sci. Abs., v. 15, No. 16, Aug. 31, 1961, p. 2677.

Alimarin, I. P., and N. V. Shakhova. (Gravimetric Determination of Scandium by Means of Benzeneseleninic and Benzenesulfinic Acids.) Zhur. Analiticheskoi Khimii, v. 16, July–August 1961, pp. 412–416; Nuclear Sci. Abs., v. 15, No. 24A, Dec. 31, 1961, p. 4142.

[48] Kuhlman, Carl William, Jr., and Gerhard P. Lang (assigned to the U.S. Atomic Energy Commission), Separation of Scandium Values From Iron Values by Solvent Extraction. U.S. Pat. 3,013,859, Dec. 19, 1961.

[49] Alimarin, I. P., and Han-hsi Shen. (Quantitative Determination of Scandium by Means of Halogen-Substituted Mandelic Acid.) Zhur. Analiticheskoi Khimii, v. 16, May–June 1961, pp. 279–283; Nuclear Sci. Abs., v. 15, No. 21, Nov. 15, 1961, p. 3557.

[50] Samodelov, A. P. (Electrode Properties of the Scandium Membrane Electrode.) Izvestiia Sibirskogo Otdelenie Akad. Nauk S.S.S.R., No. 4, April 1961, pp. 43–47.

[51] McGuire, J. C., and C. P. Kempter. Preparation and Properties of Scandium Dihydride. J. Chem. Phys., v. 33, November 1960, pp. 1584–1585; Reactor Core Materials, Battelle Memorial Institute, v. 4, No. 4, November 1961, p. 28.

[52] Montgomery, H., and G. P. Pells. The Low-Temperature Specific Heat of Scandium and Yttrium. Proc. Phys. Soc. (London), v. 78, Oct. 1, 1961, pp. 622–625; Nuclear Sci. Abs., v. 16, No. 2, Jan. 31, 1962, p. 206.

It was claimed that scandium is concentrated in two types of geochemical provinces and that formation of deposits is particularly favored by rock assimilation by ore-bearing granite magma intruded into alumino-silicate rocks.[53]

SELENIUM [54]

Production and consumption of selenium increased sharply in 1961. The rise in consumption was due to increased demand for commercial-grade selenium.

Selenium remained in Group I of the National Stockpile List of Critical and Strategic Materials, but it was removed from the barter program of the U.S. Department of Agriculture, Commodity Credit Corporation. The Office of Minerals Exploration (OME) included selenium among minerals and mineral products eligible for up to 50 percent Government financial participation of approved costs.

Producers' stocks of marketable-grade selenium were 515,000 pounds at the end of 1961, an increase of 47 percent over stocks at yearend 1960.

Domestic Production.—Production of primary selenium was 1,022,000 pounds, up 90 percent from 1960. Recovery of selenium from secondary sources was the lowest recorded and represented less than 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., Garfield, Utah. All except Kawecki Chemical Co. produced selenium as a byproduct of the electrolytic refining of copper.

TABLE 2.—Salient selenium statistics

(Thousand pounds of contained selenium)

	1952–56 (average)	1957	1958	1959	1960	1961
United States:						
Production [1] [2]	896	1,060	683	728	539	1,022
Shipments to consumers [1]	905	615	723	790	552	787
Imports for consumption	167	148	184	224	[3] 162	117
Consumption, apparent [4]	1,072	763	907	1,014	[3] 714	904
Stocks, Dec. 31, producers	118	651	551	339	[3] 273	515
Price per pound, commercial grade	$4.85–$7.65	$7.50–$12.00	$7.00–$7.50	$7.00	$6.50–$7.00	$5.75–$6.50
World: Production [1]	1,627	1,922	1,462	1,649	1,667	2,056

[1] Production and shipment data 1957–60 have been revised to eliminate duplication resulting from intercompany transactions of intermediate-grade products.
[2] Includes small quantities of secondary selenium, 1953–61.
[3] Revised figure.
[4] Measured by shipments plus imports.

Consumption and Uses.—Shipments to consumers increased to 787,000 pounds, up 43 percent from 1960. The rise in shipments was due to

[53] Kalenkov, A. D. (Some Peculiarities of Scandium Concentration). Geokhimiia, No. 3, 1961, pp. 243–251; Battelle Tech. Rev., v. 10, No. 7, July 1961, p. 692.
[54] Prepared by John E. Shelton.

increased use of commercial grades in the chemical, rubber, metallurgical, ceramic, and glass industries. Shipments of high-purity grade and compounds decreased slightly.

Commercial-grade and high-purity selenium furnished about 60 and 30 percent, respectively, of total consumption. Ferroselenium accounted for most of the remainder.

High-purity selenium was used chiefly in electronic applications. The xerography and photoluminescence industries, although requiring only small quantities of high-purity selenium, used more than in 1960.

The use of ferroselenium in improving the machinability of stainless steel castings increased during the year.

Stocks.—Producers' stocks of marketable selenium at yearend increased from 273,000 pounds to 515,000 pounds. These stocks represented about a 6-month supply, based on the apparent consumption for 1961. At yearend there was 254,000 pounds of selenium in Government stockpiles, 97,000 pounds in the National (strategic) stockpile, and 157,000 pounds in the CCC and supplemental stockpiles.

Prices.—Commercial-grade selenium was quoted at $6.50–$7.00 per pound most of the year. On November 13, the price dropped to $5.75–$6.25 per pound. High-purity-grade selenium was $7.50 per pound, dropping to $6.75 per pound on November 13. Ultra-high-purity selenium (99.999 percent) and ferroselenium were quoted at $13.00 and $6.25 per pound, respectively, at yearend.

TABLE 3.—Free world production of selenium by countries [1]

(Pounds)

Country	1952–56 (average)	1957	1958	1959	1960	1961
North America:						
Canada	317,081	321,392	306,990	368,107	521,638	469,892
Mexico	70,425	175,475	107,576	8,891	6,944	4,409
United States	896,000	1,060,000	683,000	728,000	539,000	1,022,000
South America:						
Argentina	[2] 1,268	[3]	[3]	[3]	[3]	[3]
Peru	[4] 5,142	6,865	8,419	8,155	10,681	16,305
Europe:						
Belgium-Luxembourg (exports)	61,377	24,471	48,942	124,560	72,531	[5] 55,100
Finland	6,907	9,219	13,051	13,196	11,358	13,296
Sweden	139,612	143,300	84,135	132,276	176,368	[5] 156,500
Asia: Japan	101,315	154,335	182,406	229,486	278,234	275,696
Africa: Rhodesia and Nyasaland, Federation of: Northern Rhodesia	24,947	24,206	24,388	33,448	46,827	39,362
Oceania: Australia	2,854	3,002	[5] 3,000	[5] 3,000	[5] 3,500	[5] 3,000
World total [1]	1,627,000	1,922,000	1,462,000	1,649,000	1,667,000	2,056,000

[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, 1955–56.
[3] Data not available; no estimate included in world total.
[4] Average annual production, 1954–56.
[5] Estimate.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

Foreign Trade.—Imports for consumption of selenium and selenium salts totaled 117,100 pounds, down 28 percent from 1960. Imports from Canada were 99,500 pounds, valued at US$583,765. Imports from other countries were: Japan, 7,800 pounds; Sweden, 1,100 pounds; U.S.S.R., 200 pounds; and West Germany, 8,500 pounds.

In addition, 10,400 pounds of selenium in selenium-bearing residues was imported from the Federation of Rhodesia and Nyasaland.

World Review.—*Canada.*—Selenium was produced as a byproduct of of the electrolytic copper refineries of The International Nickel Company of Canada, Ltd., at Copper Cliff, Ontario, and Canadian Copper Refiners, Ltd., Montreal East, Quebec.

Belgium.—Selenium was obtained as a byproduct of refining of anode slimes resulting from the electrolytic refining of copper in the Republic of the Congo and Federation of Rhodesia and Nyasaland.

Finland.—Selenium output of Outokumpu Oy at Pori was 13,300 pounds.

Japan.—Selenium was produced as a byproduct of copper, gold, and sulfur operations.

Mexico.—Production of selenium was primarily as a byproduct of lead flue dusts.

Peru.—Selenium was produced by Cerro de Pasco Corp. at Oroya as a byproduct of its electrolytic copper refinery.

Rhodesia and Nyasaland, Federation of.—Selenium contained in slimes from copper production was 39,400 pounds.

Technology.—Studies showed that selenium could be recovered from sandstone ores by flotation.[55]

A review of the toxicological properties of selenium and tellurium was presented.[56] The review surveyed the toxicity, retention, and excretion of selenium and tellurium and their compounds and treatment and prevention of intoxication and dermatitis resulting from exposure.

Abstracts of domestic and foreign research reports on selenium were prepared by Battelle Memorial Institute, Columbus, Ohio.

Continuing research showed that selenium can be effectively used for some thermoelectric applications. In most cases, selenium was used in three- and four-element compounds.

TELLURIUM [57]

Tellurium production decreased during 1961, whereas shipments increased.

The office of Minerals Exploration (OME) included tellurium among minerals and mineral products eligible for up to 50 percent Government financial participation of approved costs.

Domestic Production.—Production of tellurium dropped to 205,000 pounds, a decrease of 24 percent from that of 1960. Output was entirely as a byproduct of electrolytic copper refining and lead refining. Companies reporting stocks, production, and shipments were: American Metal Climax, Inc., Carteret, N.J.; American Smelting and Refining Company, Baltimore, Md.; International Smelting & Refin-

[55] Bhappu, Roshan B. Economic Recovery of Selenium by Flotation from Sandstone Ores of New Mexico. New Mexico Bureau of Mines, Min. Res. Circ. 58, 1961, 42 pp.

[56] Cerwenka, Edward A., Jr., and W. Charles Cooper. Toxicology of Selenium and Tellurium and Their Compounds. AMA Archives of Environmental Health, v. 3, August 1961, pp. 189–200.

[57] Prepared by John E. Shelton.

ing 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. The continued search for new sources of tellurium was unsuccessful.

Consumption and Uses.—Shipments of tellurium increased slightly, to 231,000 pounds. Some of the increase was attributed to the use of tellurium as an additive to improve the machinability of steels. Consumption of tellurium as a thermoelectric material, while not large, increased with the production of thermoelectric icemakers. The quantity used in the ceremic, chemical, metallurgical, and rubber industries was about the same as in 1960.

TABLE 4.—Salient tellurium statistics

(Thousand pounds of contained tellurium)

	1952–56 (average)	1957	1958	1959	1960	1961
United States:						
Production, primary [1]	158	252	123	177	271	205
Shipments to consumers [1]	149	211	159	257	228	231
Stocks, Dec. 31, producers	126	166	131	58	126	64
Imports, general	(2)	2	6	16	[3] 15	(2)
Price per pound, commercial grade	$1.50–$1.75	$1.50–$1.75	$1.65–$1.75	$1.65–$3.00	$3.00–$4.00	$4.00–$5.25
World: Production [1]	166	284	176	255	389	394

[1] Production and shipment data 1957–60 have been revised to eliminate duplication resulting from intercompany transactions of intermediate-grade products.
[2] Data not available.
[3] Revised figure.

TABLE 5.—Free world production of tellurium by countries [1]

(Pounds)

Country	1952–56 (average)	1957	1958	1959	1960	1961
North America:						
Canada	7,156	31,524	38,250	13,023	44,682	95,873
United States	158,000	252,000	123,000	177,000	271,000	205,000
South America: Peru	486	----------	14,868	62,600	59,344	76,280
Asia: Japan	[2] 662	716	110	2,761	13,671	16,486
Free world total [1]	166,280	284,200	176,200	255,400	388,700	393,600

[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.
[2] Average annual production, 1953–56.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

Stocks.—Producers' stocks of marketable-grade tellurium metal and compounds were 64,000 pounds. Tellurium-bearing slimes and residues stored by producers increased slightly.

Prices.—The price of commercial-grade tellurium was $4.00 per pound from January 1 to May 4, when it rose to $5.25 per pound for the remainder of the year. High-purity tellurium (99.999+ percent) was quoted at $21.50–$30.00 per pound at yearend.

Foreign Trade.—Import data for tellurium were not available during 1961.

World Review.—*Canada.*—Tellurium production was 96,000 pounds, up from 44,682 pounds in 1960. Canadian production was as 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.

Japan.—An output of 16,500 pounds of tellurium was produced as a byproduct at copper refineries.

Peru.—Tellurium was produced as a byproduct at the Cerro de Pasco Corp. refinery at Oroya. Exports to the United States were 12,200 pounds.

Technology.—The search by government and private industry for tellurium sources continued. Possible sources that were examined included reported tellurium occurrences, pyrite tailings, slags, and residues from base-metal refining operations.

Research advanced in the application of bismuth-telluride components in thermoelectric devices. Refrigerators, water coolers, icemakers, and air conditioners using these devices were on the threshold of production for the homeowners.[58] Several companies announced that the high-purity tellurium needed to make the thermoelectric components was being produced commercially.

The highlight of tellurium research was the introduction of a tellurium-bearing free-machining steel. Feed rates for screw machine operations could be increased at least one-third, and rejects dropped to almost zero.[59]

Abstracts of domestic and foreign research reports on tellurium were prepared by Battelle Memorial Institute, Columbus, Ohio.

THALLIUM [60]

Domestic Production.—American Smelting and Refining Co., at Denver, Colo., was the only domestic producer of thallium. Production of thallium compounds was about the same as in 1960.

Uses.—The principal use for thallium was as thallium sulfate in rodenticides. There also were small but important uses in the field of electronics, such as thallium-activated sodium-iodide crystals used with photomultiplier tubes. The feasibility of using thallium in mercury lights for very white light was being studied.

Price.—The market price for thallium was $7.50 a pound.

Technology.—A comprehensive report on thallium, containing a large bibliography, was published.[61] A process was patented for growing sodium iodide ingot containing a small quantity of thallium iodide.[62]

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[58] American Metal Market. New Markets for Cooling Metals. V. 68, No. 95, May 18, 1961, p. 1.
[59] Iron Age. New Steel Machines Faster. V. 188, No. 14, Oct. 5, 1961, p. 82.
[60] Prepared by Donald E. Eilertsen.
[61] Howe, Herbert E. Thallium. Ch. in Rare Metals Handbook. Reinhold Pub. Corp., New York, N.Y., 1961, 2d ed., pp. 529–535.
[62] Lefever, Robert A. (assigned to Union Carbide Corp., New York). Production of Metal Halide Ingots. U.S. Patent 2,984,626, May 16, 1961.

YTTRIUM [63]

New technological achievements announced during 1961 could signify a substantial increase in the need for yttrium. A large quantity of readily available raw material, with subsequent lower cost to the user, would be required for new uses and for utilization research.

Domestic Production.—Owing to increased imports of monazite during 1961, more yttrium undoubtedly was recovered as a byproduct, and little effort was expended in extracting the metal from minerals such as euxenite and gadolinite. One importer indicated a desire to market South African gadolinite. General Services Administration distributed a sizable quantity of yttrium compounds and metal to several government agencies for utilization research.

Yttrium compounds were recovered during the processing of rare-earth concentrates by the following companies: American Potash & Chemical Corp., West Chicago, Ill.; W. R. Grace and Co., Davison Chemical Division, Pompton Plains, N. J.; Michigan Chemical Corp., St. Louis, Mich.; and Vitro Chemical Co., Chattanooga, Tenn.

Commercial producers of yttrium metal included American Potash & Chemical Corp.; American Scandium Corp., Cincinnati, Ohio; Lunex Co., Pleasant Valley, Iowa; Michigan Chemical Corp.; and Research Chemicals Division, Nuclear Corporation of America, Phoenix, Ariz.

At the Federal Bureau of Mines Metallurgy Research Center at Reno, Nev., experimental quantities of yttrium metal were produced by fused-salt electrolysis.

Uses.—Yttrium, in various forms, was used in ceramics, chemistry, electronics, medicine, metallurgy, and nucleonics. Yttrium 90, a radioactive isotope, was used to treat certain types of tumors by a technique called hypophysectomy. Low-cost graphite crucibles, used as containers for alloys, have been coated with refractory materials such as yttrium oxide to prevent carbon contamination of the molten alloys.

Availability of very high purity yttrium oxide and improved techniques for growing large single-crystal yttrium iron garnets indicated the attainment of greater efficiency for these materials in microwave applications, especially in laser research.

Production of valves and accessories made from ductile iron, using yttrium as a nodulizer, was anticipated. The addition of small quantities of yttrium improved the ductility and oxidation resistance of stainless steels, reduced grain size in castings of certain ferrous metals, and increased the strength of aluminum and magnesium alloys. Yttrium also was used as a scavenger in an attempt to produce high-purity metals.

Prices.—Yttrium oxide prices ranged from 20 cents per gram for material of 99-percent purity in lots under 100 grams to $84 per pound for electronic grade in lots of 1 to 10 pounds. The highest purity material (99.9999 percent) sold for $1.50 per gram in small lots to $295 per pound in 2- to 99-pound lots.

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[63] Prepared by John G. Parker.

No changes were noted in small-lot prices for yttrium metal, as listed in American Metal Market throughout 1961. High-purity metal (99.99 percent) sold for 81 cents per gram in lots under 100 grams and for 54 cents per gram in 100- to 450-gram lots. Prices for high-purity metal ingots ranged from $205 to $320 per pound in multipound lots, and prices for even larger quantity lots of metals and salts were available upon request. Salts such as sulfates, oxalates, nitrates, and fluorides had prices based on percentages of those of oxides.

Technology.—A metamict borosilicate containing calcium and about 28 percent yttria, which had been collected by the Canadian mineralogist Hugh S. Spence in 1934 from pegmatite in Cardiff Township, Ontario, Canada, was identified as a new mineral and named spencite in his honor.[64]

Yttrium and cerium isotopes were separated on a pilot-plant scale from other rare-earth fission products, using solvent extraction techniques with D2EPHA di (2-ethylhexyl) phosphoric acid as an extractant.[65] Yttrium and scandium were separated by anion exchange methods, using ethanol-water-hydrochloric acid eluants.[66]

Research on the growth of single crystals used the floating-zone technique.[67] Studies were made on ternary phase relationships,[68] and on the causes of imperfections in yttrium iron garnets.[69] Methods for making yttrium garnets were disclosed.[70] At the International Conference on Magnetism and Crystallography, at Kyoto, Japan, yttrium iron garnets were revealed as one-way transmitters of microwave radiation, tunable filters, and power limiters for microwave systems.[71]

Russian scientists produced yttrium monocarbide by vacuum reduction of yttrium oxide with carbon.[72] Data obtained showed the compound to possess semiconducting properties and to have a melting point of about 1,950° C. A purification method for yttrium metal involved filtering tantalum-contaminated molten yttrium through a porous mass of tungsten.[73] Commercial yttrium metal was purified by applying direct current to yttrium metal rods, thus stimulating

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[64] Frondel, Clifford. Two Yttrium Minerals: Spencite and Rowlandite. Canadian Miner., v. 6, pt. 5, 1961, p. 576–581.

[65] Butler, T. A., and E. E. Ketchen. Solvent Extraction Separation of Cerium and Yttrium. Ind. Eng. Chem., v. 53, No. 8, August 1961, pp. 651–654.

[66] Wilkins, D. H., and G. E. Smith. Ethanol-Water-Hydrochloric Acid Eluants in Anion-Exchange Separations. Talanta, v. 8, February–March 1961, pp. 138–142; Nuclear Sci. Abs., v. 15, No. 12A, June 30, 1961, p. 2015.

[67] Abernathy, L. L., T. S. Burkhalter, and G. K. Teal. Research and Development of Yttrium Iron Garnet Single Crystals. Texas Instruments, Inc., Dallas, Texas, Interim Eng. Rept. No. 7, October–December 1960, Feb. 17, 1961, 24 pp.

[68] Van Hook, H. J. Single Crystal Growth of the Garnet Type Oxides. Part II. Phase Relations in the Ternary System Fe_2O_3–FeO–$YFeO_3$. Raytheon Mfg. Co., Waltham, Mass., Sci. Rept. 2, Jan. 9, 1961, 15 pp.

Van Hook, H. J., A. E. Paladino, and others. Research on the Chemistry and Single Crystal Growth of Magnetic Oxides. Raytheon Mfg. Co., Waltham, Mass., Final Rept. S–291, June 5, 1961, 91 pp.

[69] Lefever, R. A., A. B. Chase, and Juanita W. Torpy. Characteristic Imperfections in Flux-Grown Crystals of Yttrium Iron Garnet. J. Am. Ceram. Soc. (Ceram. Abs.), vol. 44, No. 3, March 1961, pp. 141–144.

[70] Calhoun, Bertram A., and Wilbert L. Shevel, Jr. (assigned to the International Business Machines Corp., New York, N.Y.), Method of Making Yttrium-Aluminum-Iron Garnets: U.S. Pat. 3,006,856, Oct. 31, 1961.

Geller, Seymour (assigned to Bell Telephone Laboratories, Inc., New York, N.Y.), Ferrimagnetic Garnet: U.S. Pats. 3,006,854 and 3,006,855, Oct. 31, 1961.

[71] American Metal Market, v. 68, No. 191, Oct. 4, 1961, p. 14.

[72] Samsonov, G. V., G. N. Makarenko, and T. Ya. Kosolapova. (Preparation and Properties of Yttrium Monocarbide). Zhur. prikladnoi khimii, v. 34, No. 7, pp. 1444–1448.

[73] Dennison, David H. (assigned to the U.S. Atomic Energy Commission). Yttrium Decontamination. U.S. Pat. 3,009,807, Nov. 21, 1961.

migration of impurity ions.[74] Another method involved zone melting to purify yttrium metal.[75]

A Japanese company announced that it had produced pure yttrium sponge by passing the oxide through an ion exchange membrane, followed by fluorinating and distilling.[76]

The presence of a thin film of yttrium nitride formed on the surface was believed to account for the powdering in moist air of yttrium hydride specimens.[77] Complete absence of nitrogen contamination during processing, grinding of the nitrides from the surface, or sealing the specimens from air is necessary for the production of stable, solid hydrided yttrium.

The addition of small quantities of yttrium or of some rare-earth metals to iron-chromium alloys imparted good oxidation resistance and scale retention at elevated temperatures.[78] The scale retention resulted from the formation of internal as well as external oxides. According to Russian researchers, the addition of up to 2 percent yttrium improves corrosion resistance of chromium up to 1,200° C and slightly improves its ductility.[79] Work done at the Denver Research Institute, Denver, Colo., showed that the addition of 1 weight-percent yttrium or rare-earth metal to commercial-grade vanadium fluxes out oxygen and nitrogen impurities above the melting point of the alloy and allows cold-rolling of as-cast vanadium alloy to more than 98 percent reduction.[80] Interstitial impurities were removed from molybdenum-base alloys by the addition of yttrium; this method also imparted finer grain size, reduced as-cast hardness, and increased ductility.[81]

Metallographic, X-ray, and melting-point studies of the yttrium-iron, yttrium-nickel, and yttrium-copper systems showed the presence of 16 intermetallic compounds, half in the yttrium-nickel system.[82] Only one of these compounds has a higher melting point than that of yttrium. It was shown that alpha yttrium and erbium are miscible, but there is only partial solubility in the yttrium-neodymium system, and an intermediate phase is present.[83] Alloying with erbium or zirconium improved the tensile properties of yttrium. Alloys of yttrium and titanium were studied to determine the value of the latter metal as a coating or diffusion barrier in coating yttrium metal used

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[74] Williams, J. M., and C. L. Huffine. Solid State Electrolysis in Yttrium Metal. Nuclear Sci. Eng., v. 9, 1961, pp. 500–506.

[75] Necker, William C. The Zone Purification of Yttrium. Trans. Vacuum Met. Conf., 1960. Interscience Pub., New York, N.Y., 1961, pp. 289–298; Nuclear Sci. Abs., vol. 16, No. 2, Jan. 31, 1962, p. 250.

[76] Chemical Age (London), v. 85, No. 2184, May 20, 1961, p. 818.

[77] Roach, John D. Observations on the Powdering of Yttrium Hydride. Trans. Met. Soc. AIME, v. 221, No. 3, June 1961, p. 646.

[78] Felten, Edward J. High-Temperature Oxidation of Iron-Chromium Base Alloys With Particular Reference to Iron-Chromium-Yttrium Alloys. J. Electrochem. Soc., v. 108, No. 6, June 1961, pp. 490–495.

[79] Terekhova, V. F., I. A. Markova, and Ye. M. Savitskii. (Phase Diagram of Alloys of the System Chromium-Yttrium.) Zhur. neorganicheskoi khimii, v. 6, No. 5, 1961, pp. 1252–1253.

[80] Lundin, C. E. Jr., and D. T. Klodt. Improvement of the Ductility of Vanadium by Alloying. Trans. Am. Soc. Metals, v. 53, 1961, pp. 735–742.

[81] Klodt, D. T., and J. F. Nachman. The Effects of Yttrium and Selected Rare Earth Additions on the Removal of Interstitials from Tungsten and Molybdenum. Metal Progress, v. 80, No. 4, October 1961, p. 240.

[82] Domagala, R. F., J. J. Rausch, and D. W. Levinson. The Systems Y-Fe, Y-Ni, and Y-Cu. Trans. Am. Soc. Metals, v. 53, 1961, pp. 137–155.

[83] Love, Bernard. Properties of Yttrium and the Rare Earth Metals-Oxygen and Alloy Systems. Wright Air Development Division Tech. Rept. 61–123, August 1961, 179 pp.

as a container material in molten-metal reactor systems.[84] Alloys containing yttrium and uranium were claimed to be of value as high-temperature fuel elements in nuclear reactors because the two components are completely immiscible, thereby allowing higher operating temperatures, improving dimensional stability, and providing easy reprocessing of uranium from yttrium by melting separation.[85] Cast yttrium was extruded, and its swaging behavior was studied.[86]

An yttrium misch metal, composed of yttrium and yttrium-subgroup rare-earth metals, was claimed to be greatly beneficial in the production of nodular cast iron.[87] It is said to permit a more compact graphite structure than is possible using cerium or cerium-misch metal additions. Flash losses associated with low-boiling-point magnesium additives are eliminated by the use of yttrium, which has a boiling point greater than that of iron. The process is said to make undisrupted production possible and to require less process control.

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[84] Bare, D. W., and O. N. Carlson. Phase Equilibria and Properties of Yttrium-Titanium Alloys. Trans. Am. Soc. Metals, v. 53, 1961, pp. 1–11.
[85] Metal Progress, v. 79, No. 6, June 1961, p. 140.
[86] Nuclear Metals, Inc., Concord, Mass. Fundamental and Applied Res. and Development in Met. Progress Repts., December 1960, 34 pp; March 1961, 25 pp.
[87] Kanter, J. J., J. P. Magos, and W. L. Meinhart. Yttrium Nodular Iron. Winter Ann. Meeting of the Production Eng. Division, ASME, New York, N.Y., 1961, paper 61–WA–314, 7 pp.
Chemical Week, v. 89, No. 23, Dec. 9, 1961, p. 27.

Minor Nonmetals

By Milford L. Skow [1]

DATA on the minor nonmetallic minerals—greensand, meerschaum, staurolite, and wollastonite—are contained in this chapter.

GREENSAND

Domestic production of greensand (glauconite) was reported by three firms—Inversand Co., Kaylorite Corp., and National Soil Conservation, Inc.—at their open pit operations in Gloucester County, N.J., Calvert County, Md., and Burlington County, N.J., respectively. Total output in 1961 was 5 percent lower than in 1960. Average output for the 5-year period, 1957–61, was about 5,600 tons valued at $197,000.

About 73 percent of the quantity sold in 1961 was used as a soil conditioner; the other 27 percent was used in water softening.

Prices of greensand, f.o.b. mine, ranged from $13.26 to $90 per short ton.

Glauconite was identified in six places in the Biwabic iron formation of the Mesabi range. The secondary origin of these occurrences was confirmed and a mechanism of formation suggested.[2]

Petrographic and X-ray data were given for 141 samples of glauconite. Mineralogical composition was not considered a dependable indicator of broad sedimentary environments.[3]

Additional chemical and X-ray diffraction data conformed to a previously published explanation of glauconite formation, and the composition and structure of glauconites were found to differ measurably with geologic age.[4]

MEERSCHAUM

Meerschaum, the mineral sepiolite, was used in manufacturing pipe bowls, cigarette and cigar holders, and other smokers' accessories.

[1] Commodity specialist, Division of Minerals.

[2] Tyler, S. A., and S. W. Bailey. Secondary Glauconite in the Biwabic Iron-Formation of minnesota. Econ. Geol., v. 56, September-October 1961, pp. 1033–1044.

[3] Wermund, E. G. Glauconite in Early Tertiary Sediments of Gulf Coastal Province. Am. Assoc. Petrol. Geol. Bull., v. 45, October 1961, pp. 1667–1696.

[4] Hower, J. Some Factors Concerning the Nature and Origin of Glauconite. Am. Mineral., v. 46, March–April 1961, pp. 313–334.

Again no domestic production was reported, and requirements for the mineral continued to be furnished by imports. Imports in 1961 were almost double those in 1960. Turkey furnished all but a small quantity, which came from France.

Tanganyika Meerschaum Corp. began manufacturing meerschaum pipes in Arusha. The company obtained the meerschaum from its deposit on the Kenya-Tanganyika border.[5]

A method of adjusting the porosity of sepiolite involved subjecting the mass to compression after first regulating its volatile matter content.[6]

TABLE 1.—U.S. imports for consumption of meerschaum [1]

Year	Pounds	Value	Year	Pounds	Value
1952–56 (average)	9,871	[2] $17,671	1959	7,323	$16,333
1957	10,538	20,046	1960	41,564	29,460
1958	17,392	15,432	1961	81,194	55,004

[1] 1952–56: Austria, 3 pounds, $8; Turkey 9,788 pounds, $17,525; Union of South Africa, 80 pounds, $138; 1957: Turkey, 10,426 pounds, $19,649; Union of South Africa, 112 pounds, $397; 1958: All from Turkey; 1959: France, 1,019 pounds, $471; Turkey, 6,304 pounds, $15,862; 1960: France, 2,566 pounds, $1,186; Turkey, 38,998 pounds, $28,274; 1961: France, 821 pounds, $380; Turkey, 80,373 pounds, $54,624.
[2] Data known to be not comparable with other years.

Source: Bureau of the Census.

STAUROLITE

Production and value of staurolite decreased slightly from 1960, its peak year. This brought to an end the increasing production trend that extended from 1953. E. I. du Pont de Nemours & Co., Inc., the sole producer, recovered staurolite at the Highland and Trail Ridge plants in Clay County, Fla. The mineral was used as an iron and aluminum additive in manufacturing portland cement.

WOLLASTONITE

Domestic production of wollastonite continued to rise in 1961, increasing 18 percent over 1960. Cabot Minerals Division of Cabot Corp. supplied most of the production from its Willsboro mine, Essex County, N.Y. Four firms produced the remainder from five deposits in Riverside County, Calif.

The Adirondack Development Corp., Keeseville, N.Y., reported results of the exploratory drilling of a wollastonite deposit near Lewis, N.Y. The deposit was estimated to contain 4.7 million tons of ore averaging 59 percent wollastonite under an average overburden of 18 feet.[7]

The following prices on wollastonite were quoted in Oil, Paint and Drug Reporter throughout 1961: Fine, paint grade, bags, carlots, works, $41 per ton, less than carlots, ex warehouse, $51 per ton; me-

[5] U.S. Embassy, Dar es Salaam, Tanganyika. State Department Dispatch 137. Mar. 7, 1962, p. 11.
[6] Weir, J. V. (assigned to Minerals & Chemicals Phillip Corp.). Absorptive Porous Mineral Mass and Method of Making. U.S. Pat. 2,968,633, Jan. 17, 1961.
[7] Mining Record. New Adirondack Mineral Discovery Is Disclosed. V. 72, July 13, 1961, p. 2.

dium, paint grade, bags, carlots, works, $29 per ton, less than carlots, ex warehouse, $39 per ton. These prices were unchanged from 1960.

The addition of 1 to 3 percent wollastonite to structural clay bodies resulted in reduced losses, lowered costs, and improved product quality. Studies showed that small additions of wollastonite promoted faster drying, reduced cracking during drying and firing, increased dry strength, decreased firing temperature, and produced products with lower moisture absorption and higher impact strength.[8]

Ceramic bodies, based on wollastonite with clay and 10 percent barium carbonate, vitrified in a narrow range at 1,270° C and had low static bending strength. Dielectric properties were given, the literature was reviewed, and the largest deposit of wollastonite in the U.S.S.R. was mentioned.[9]

Up to 30 percent by weight of wollastonite could be added to polystyrene without detrimental effect on the physical properties of the plastic.[10]

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[8] Brick & Clay Record. Wollastonite Brings Benefits to Structural Clays. V. 138, March 1961, pp. 68–69.

[9] Avetikov, V. G., E. I. Zin'ko, and N. A. Zasedateleva. (High Frequency Ceramics Based on Wollastonite.) Steklo i Keramika, v. 17, March 1960, pp. 25–29; Ceram. Abs., v. 44, April 1961, p. 99e.

[10] Virtue, P. Wollastonite, an Extender for Polystyrene. Plastics Technol., v. 7, March 1961, pp. 49–50.

INDEX

By Kathleen J. D'Amico [1]

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 135. 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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[1] Statistical officer.

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