Bromine

By Henry E. Stipp[1] and Annie L. Mattila[2]

PRODUCTION of bromine and bromine compounds in the United States during 1956 reached a new record—7 percent over 1955. Applications of bromine compounds, such as flameproofing material for cotton fabric and fumigation of fruit from deciduous trees, received prominent mention in trade and scientific publications.

DOMESTIC PRODUCTION

In the United States bromine was extracted from sea water, well brines, and saline lake brines during 1956. A large part of production was derived from sea water, an inexhaustible source of bromine. Production (measured by sales) in 1956 resumed an upward trend, which had been interrupted in 1955.

The Ethyl-Dow Chemical Co. recovered bromine from sea water at Freeport, Tex., and Westvaco Chemical Division of Food Machinery & Chemical Corp. operated a sea-water plant at Newark, Calif. The following firms recovered bromine from well brines in Michigan: The Dow Chemical Co., Midland and Ludington; Great Lakes Chemical Corp., Filer City; Michigan Chemical Corp., Eastlake and St. Louis; and Morton Salt Co., Manistee. The Westvaco Chemical Division at South Charleston, W. Va., also treated well brines. American Potash & Chemical Corp. recovered bromine from the brine of Searles Lake in California.

Dow Chemical Co. was expected to spend considerably more than $75 million beginning June 1, 1956, partly for expansion of bromine-production capacity.[3]

TABLE 1.—Bromine and bromine in compounds sold by primary producers in the United States, 1947–51 (average) and 1952–56

Year	Pounds	Value	Year	Pounds	Value
1947–51 (average)	94,203,257	$18,181,003	1954	187,399,110	$41,312,669
1952	156,201,577	30,639,292	1955	184,453,846	39,855,508
1953	164,143,348	35,372,386	1956	196,730,115	47,433,886

Great Lakes Oil & Chemical Co. started construction on a major addition to its bromine plant at Filer City, Mich.[4] It was expected to cost about $350,000.

[1] Commodity specialist.
[2] Statistical assistant.
[3] Paint, Oil and Chemical Review, vol. 119, No. 21, Oct. 18, 1956, p. 36.
[4] Chemical Engineering, Bromine: Vol. 65, No. 9, September 1956, p. 142.

TABLE 2.—Bromine and bromine compounds sold by primary producers in the United States, 1955–56

	Pounds		Value
	Gross weight	Bromine content [1]	
1955			
Elemental bromine	7,643,812	7,643,812	$1,884,715
Sodium bromide	(2)	(2)	(2)
Potassium bromide	2,660,742	1,786,688	753,992
Ammonium bromide	(2)	(2)	(2)
Other, including ethylene dibromide	206,381,298	175,023,346	37,216,801
Total	216,685,852	184,453,846	39,855,508
1956			
Elemental bromine	9,490,006	9,490,006	2,170,056
Sodium bromide	(2)	(2)	(2)
Potassium bromide	2,920,367	1,961,027	878,190
Ammonium bromide	(2)	(2)	(2)
Other, including ethylene dibromide	218,583,248	185,279,082	44,385,640
Total	230,993,621	196,730,115	47,433,886

[1] Calculated as theoretical bromine content present in compound.
[2] Included with "Other, including ethylene dibromide."

CONSUMPTION AND USES

Ethylene dibromide was the chief bromine compound sold in 1956. Antiknock fluid was the principal outlet for this compound, and it was used also as a solvent for celluloid, in gums and waxes, as a reagent in the synthesis of dyes and as a pharmaceutical intermediate. Medicinally it was used as an anaesthetic, sedative, and antispasmodic agent. The use of ethylene dibromide in fumigation mixtures continued to grow during 1956. Methyl bromide and chlorobromopropene were also used as soil fumigants.

The second largest quantity of bromine sold in 1956 was in the form of elemental bromine. It was used as a germicide in treating water, and in manufacturing lachrymators, brominated dyes, and bromides for medicinal, photographic, and industrial uses.

Potassium bromide and sodium bromide were important commercial compounds of bromine. They were used in medicinal and pharmaceutical preparations, photographic emulsions, and analytical reagents. Ammonium bromide, another compound of bromine, was used in pharmaceutical preparations; in the preparation of photographic films, plates and papers, process engraving, and soldering fluxes; and in textile processes.

Potassium bromate was used in soya and high-protein wheat flour to improve baking characteristics and as an ingredient of yeast foods.

Various compounds of bromine were used in permanent-wave preparations and effervescent mineral waters, as a catalyst in controlling oxidations of hydrocarbons, as dehumidifying agents in air conditioning, and in the manufacture of rayon, hydraulic liquids, and fire-extinguishing fluid.

PRICES

According to Oil, Paint and Drug Reporter the following prices were quoted for bromine and bromine compounds in 1956: Bromine, purified, cases, carlots, delivered east of the Rocky Mountains, 31 cents a pound for January to mid-June and 32 cents a pound for the remainder of the year; less than carlots, same basis, 33 to 38 cents a pound for January to mid-June and 34 to 39 cents a pound from mid-June through December; drums, lead-lined, carlots, delivered east of the Rocky Mountains, 30 cents a pound for January to mid-June, and 31 cents a pound for the remainder of the year; potassium bromide, U. S. P., granular, barrels, kegs, 36 cents a pound from January to mid-February, 35 to 36 cents a pound from mid-February through June, and 37 to 38 cents a pound for the remainder of the year; potassium bromate, drums, 1,000 pounds or more, 50 cents a pound from January through December; sodium bromide, U. S. P., barrels, works, 36 cents a pound from January through June and 38 cents a pound from June through December.

FOREIGN TRADE [5]

A total of 6,111,363 pounds of bromine, bromides, and bromates (not separately classified) valued at $2,557,008 was exported from the United States in 1956. Brazil purchased 2,895,586 pounds valued at $1,461,294 and Canada 1,909,092 pounds valued at $434,687, the remaining quantity, in smaller lots, was shipped to 42 other countries.

A total of 233 pounds of sodium bromide valued at $3,430 was imported from the United Kingdom in 1956. An additional 2,685 pounds of bromine and bromine compounds valued at $131,437 was imported from seven other countries. There were no imports of potassium bromide or ethylene dibromide.

TECHNOLOGY

Bromine-containing phosphonitrilates were studied as possible durable flame retardants for cotton fabrics.[6] Tear strength of fabric and durability of the flame resistance to laundering were evaluated. On the basis of the standard vertical test, flame resistance of samples was satisfactory after 15 launderings with detergent but was not durable to boiling for 3 hours in an alkaline-soap solution.

A combination flame retardant based upon THPC resin and a bromine-containing phosphonitrilate was developed.[7] Fabric was treated with a mixture of the flame retardants then dried and cured at an elevated temperature. The THPC resin penetrated fibers of the fabric and the bromine-containing phosphonitrilate was deposited

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[5] Figures on imports and exports compiled by Mae B. Price, and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

[6] Hamalainen, Carl, and Guthrie, John D., Bromine-Containing Phosphonitrilates as Flame Retardants for Cotton: Textile Research Jour., vol. 26, No. 2, February 1956, pp. 141–144.

[7] Hamalainen, Carl, Reeves, Wilson A., and Guthrie, John D., Cotton Made Flame-Resistant With Bromine-Containing Phosphonitrilates in Combination With THPC Resins: Textiles Research Jour. vol. 26, No. 2, February 1956, pp. 145–149.

on the surface. Medium- and light-weight fabrics could be made so flame resistant that ½-inch strips would not burn when held in vertical position and ignited at the bottom. Flame resistance was effective after 15 launderings with a detergent. Tear-strength retention was excellent with 8-ounce twill but only fair with 8-ounce sateen.

Experiments to improve the technique of grain fumigation in storage bins were conducted during 1954 and 1955.[8] Tests included both recirculation and forced distribution of liquid and vaporized fumigants. Satisfactory distribution of methyl bromide in wheat and shelled corn was obtained by applying 2 pounds per 1,000 cubic feet and recirculating it for 1 hour at airflow rates of 800 to 1,200 cubic feet per minute. Good distribution of fumigant was obtained by drawing it through the grain without recirculating. Fumigant was sprayed into the top of the bin and pulled down through the grain by exhausting air at the bottom of the bin. A kill of 99 plus percent with the new technique was indicated by laboratory analysis of test insects. More than 3 million bushels of grain was fumigated at a cost of $1.66 per 1,000 bushels in contrast to $4.41 per 1,000 bushels with old techniques. Further reduction of costs was indicated.

A plant designed to extract bromine from brine of the Smackover oil district at the Catesville oil field, Union County, Ark., was being constructed by Murphy Corp. and Michigan Chemical Corp.[9] The brine contains approximately 44 pounds of bromine per 1,000 gallons or 1½ pounds per barrel. Production of brine from 4 wells has been about 1,200 barrels daily. In the manufacturing process brine will be aerated to remove harmful gases, such as H_2S, and transferred through heat exchangers to granite towers. Heated brine will pass downward in the towers where bromine will be displaced by chlorine. Bromine will be passed off into collector coils, purified, and transferred to storage. Four towers will be operated in pairs. Waste water will be neutralized, filtered, and pumped into a disposal well.

An electrolytic process for producing bromates from bromides using a lead dioxide anode was developed by Sanwa Pure Chemical Co., Ltd., of Japan.[10] Graphite anodes, used in present processes, spall and form a mud that hinders continuous operation and gives yellowish, off-color bromate crystals. These problems appeared to be eliminated by using lead dioxide anodes.

WORLD REVIEW

A number of countries produce bromine and bromine compounds; however, production often is limited due to small domestic requirements and intense competition for foreign markets.

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[8] Schoenherr, William H., and Parker, Richard L., Forced Fumigation Gives Them Plus-Benefits: Food Eng., vol. 28, No. 9, September 1956, pp. 74, 95–96.

[9] Kincaid, E. E., Two Moves Pay off at Catesville: Oil and Gas Jour., vol. 54, No. 83, Dec. 3, 1956, pp. 96–98.

[10] Chemical Engineering, Another Job for Lead Dioxide Anodes: Vol. 63, No. 6, June 1956, p. 103.

Germany, West.—West German production of bromine and bromine compounds totaled 1,394 short tons in 1956.[11]

In the Federal Republic of Germany bromine is recovered as a by-product of potash production. An extensive area containing bedded deposits of potassium salts encircles the Hartz Mountains extending northwest to Hanover and southwest to Thuringia. This area is estimated to be approximately 10,000 square miles in extent and contains potash reserves calculated at 20 billion tons, of which slightly more than one-half lies in the Federal Republic. In addition, there are basins containing potash beds near the Eisenacher, Werra Fulda, and Baden districts.

Plants at Buggingen (Badin Potash Co.), Gross-Giesen and Wathlingen (Burbach Potash Works), Bad Salzdetfurth (United Salzdetfurth Potash Works), and the Heringen plant of the Wintershall A. G. are principal producers of bromine.

Italy.—Production of bromine in Italy during 1956 totaled 48 short tons.[12]

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[11] U. S. Embassy, Bonn, Germany, State Department Dispatch 2133: May 24, 1957, 3 pp.
[12] U. S. Embassy, Rome, Italy, State Department Dispatch 750: Nov. 29, 1956, 1 p.

Cadmium

By Arnold M. Lansche[1]

CADMIUM refined in the United States and metal imported for consumption in 1956 each established new records. Combined supply was 28 percent more than in 1955 and totaled 13.7 million pounds. Demand, as measured by apparent consumption, also increased to a new high of 12.7 million pounds, exceeding the previous record year (1955) by 19 percent. Industry stocks of all kinds decreased almost 2 percent to 5 million pounds. Government-owned stocks were increased by the barter acquisitions of the Commodity Credit Corporation. Contracts negotiated for cadmium in 1956 by the Commodity Credit Corporation totaled $5.1 million.

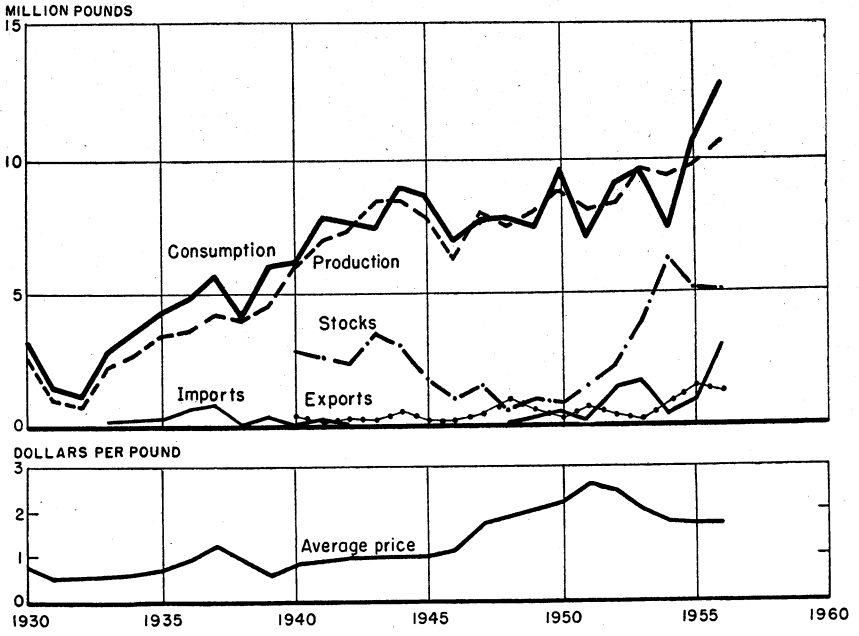

FIGURE 1.—Trends in production, consumption, year-end stocks, imports, exports, and average price, of cadmium metal in the United States, 1930–56.

[1] Commodity specialist.

TABLE 1.—Salient statistics of the cadmium industry in the United States, 1947–51 (average) and 1952–56, in pounds of contained cadmium

	1947–51 (average)	1952	1953	1954	1955	1956
Production (primary)	8,402,430	8,567,159	9,767,197	9,551,710	[1] 9,753,699	[2] 10,604,356
Imports for consumption (metal)	181,496	1,478,770	1,555,140	402,299	927,495	3,115,638
Exports (metal)	556,879	[3] 300,918	[3] 65,866	[3] 998,959	[3] 1,393,915	[3] 1,284,248
Consumption, apparent	7,945,313	9,007,577	[2] 9,570,063	7,498,719	[4] 10,683,705	[5] 12,713,675

[1] Primary metallic cadmium only.
[2] Total metallic cadmium, including secondary.
[3] Includes metal, dross, flue dust, residues, scrap and alloys.
[4] Revised figure.
[5] Apparent consumption of metallic cadmium only.

DOMESTIC PRODUCTION

Domestic production of cadmium, which was primarily a byproduct of slab-zinc production, set a new record in 1956 owing to the alltime high slab-zinc output.

As in other years, cadmium recovered at cadmium refineries was produced from imported and domestic flue dusts and fumes obtained in the process of thermal reduction of zinc concentrate and lead and copper concentrates containing zinc and associated cadmium. Still another large source of raw material for the refineries was the cadmium precipitate made in purifying zinc electrolyte at electrolytic zinc plants and a quite similar precipitate made when zinc sulfate solutions were purified to make lithopone. A relatively small quantity of secondary cadmium was recovered in 1956, as in other recent years, by processing scrap bearings and other scrap alloys.

Of the 10.6 million pounds of cadmium produced in 1956 an estimated 40 percent was derived from domestic ores and secondary material, 18 percent was from flue dusts imported from Mexico, and the remaining 42 percent was derived from imported zinc concentrate or other base-metal concentrates that contained zinc with associated cadmium. Imports of zinc concentrate in 1956 were the highest since 1943. Mexico, Canada, and Peru were the chief source countries, but important quantities were also obtained from Australia, Union of South Africa, and Guatemala. Cadmium in flue dust imported for consumption from Mexico totaled 1.45 million pounds compared with 1.83 million pounds from the same source in 1955.

Plants producing refined cadmium metal and secondary metallic cadmium, and those that did not produce the metal but had facilities for collecting cadmium fume, dust, sponge, and residues, were listed in the 1955 Cadmium chapter of the Minerals Yearbook.

Changes in 1956 included a merger of The Bunker Hill and Sullivan Mining & Concentrating Co. and The Sullivan Mining Co. to form The Bunker Hill Co. The Eagle-Picher Co. reported production of cadmium metal at its Galena, Kans., plant as did The New Jersey Zinc Co. at its plant at Palmerton, Pa.

The cadmium content of cadmium sulfide, cadmium selenide, and cadmium lithopone declined 7 percent in 1956.

TABLE 2.—Cadmium produced and shipped in the United States, 1947–51 (average) and 1952–56, in pounds of contained cadmium

	1947–51 (average)	1952	1953	1954	1955	1956
Production:						
Primary:						
Metallic cadmium	8,115,558	8,387,824	9,682,197	9,415,710	9,753,699	[2] 10,604,356
Cadmium compounds [1]	286,872	179,335	85,000	136,000	[3]	[3]
Total primary production	8,402,430	8,567,159	9,767,197	9,551,710	9,753,699	[2] 10,604,356
Secondary (metal and compounds) [1 4]	241,066	80,000	70,000	138,000	285,800	[3]
Shipments by producers:						
Primary:						
Metallic cadmium	7,995,679	7,746,361	8,137,045	7,921,741	11,166,830	[2] 10,936,459
Cadmium compounds [1]	286,872	179,335	85,000	136,000	[3]	[3]
Total primary shipments	8,282,551	7,925,696	8,222,045	8,057,741	11,166,830	[2] 10,936,459
Secondary (metal and compounds) [1 4]	231,007	122,785	59,636	148,874	285,800	[3]
Value of primary shipments:						
Metallic cadmium	$15,434,874	$17,130,966	$15,229,861	$11,925,068	$15,729,230	[5] $16,283,101
Cadmium compounds [6]	534,402	396,581	158,950	204,000	[3]	[3]
Total value	15,969,276	17,527,547	15,388,811	12,129,068	15,729,230	[5] 16,283,101

[1] Excludes compounds made from metal.
[2] Total metallic cadmium, including secondary.
[3] Figure withheld to avoid disclosing individual company confidential data.
[4] Bureau of Mines not at liberty to publish figures separately for secondary cadmium compounds.
[5] Value of total metallic cadmium shipments, including secondary.
[6] Value of metal contained in compounds made directly from flue dust or other cadmium raw materials (except metal).

TABLE 3.—Cadmium oxide and cadmium sulfide produced in the United States, 1947–51 (average) and 1952–56, in pounds

Year	Oxide		Sulfide [1]	
	Gross weight	Cd content	Gross weight	Cd content
1947–51 (average)	508,321	443,252	3,354,557	1,186,161
1952	608,236	531,018	2,665,955	898,629
1953	1,094,263	956,100	3,920,402	1,229,282
1954	958,709	838,222	3,470,127	1,045,669
1955	[2]	[2]	4,190,837	1,348,100
1956	[2]	[2]	3,936,629	1,258,446

[1] Includes cadmium lithopone and cadmium sulfoselenide.
[2] Figure withheld to avoid disclosing individual company confidential data.

CONSUMPTION AND USES

The apparent consumption of cadmium metal approximated 12.7 million pounds in 1956, as computed by adding production, net imports, and net stock changes of metal at producers', compound manufacturers', and distributors' plants. This record apparent consumption was 19 percent above the peak attained in 1955. Factors that that contributed to the continued increase in apparent consumption in 1956 were: (1) The lack of a premium price on cadmium in special shapes for platers; (2) the high level of production of manufactured goods using cadmium; and (3) barter acquisitions by the Commodity Credit Corporation under provisions of Public Law 480. Imports that were neither consumed nor reported in stocks were also a factor in the record apparent consumption.

TABLE 4.—Cadmium consumption in the United States by uses, 1941–44 and 1955–56

Uses	1941		1942		1943		1944		1955		1956	
	Pounds	Percent of total	Pounds	Percent of total	Pounds	Percent of total	Pounds	Percent of total	Pounds	Percent of total	Pounds	Percent of total
Electroplating	4,586,000	59	6,661,000	87	6,481,000	88	5,496,000	62	4,705,186	57.6	5,121,957	58.7
Pigments and chemicals	1,325,000	17	417,000	5	168,000	2	266,000	3	2,464,488	30.2	2,131,425	24.4
Low-melting alloys									351,931	4.3	412,568	4.7
Brazing alloys									208,697	2.5	281,645	3.2
Other metal and alloys	221,000	3	98,000	1	198,000	3	89,000	1	177,614	2.2	292,051	3.4
Solder	130,000	2	201,000	3	285,000	4	266,000	3	10,209	.1	6,974	.1
Bearing alloys	1,504,000	19	282,000	4	249,000	3	798,000	9	4,550	.1	12,619	.2
Other uses							1,950,000	22	[1] 245,969	3.0	[1] 461,997	5.3
Total	7,766,000	100	7,659,000	100	7,381,000	100	8,865,000	100	[2] 8,168,644	100.0	[2] 8,721,236	100.0

[1] Includes copper-cadmium alloys (1955—1,280 pounds and 1956—622 pounds), paints and varnishes, ceramics, leather, chemical reagents, plastics and photography, (and printing inks in 1956).

[2] Includes cadmium oxide (cadmium content) (522,814 pounds in 1955; 441,410 pounds in 1956) of which 167,371 pounds in 1955 and 162,714 pounds in 1956 were used for electroplating and other metal alloys; 182,609 and 172,834 pounds in 1955 and 113,192 and 165,504 in 1956 were used for pigments and chemicals and other uses, respectively.

A consumption canvass in 1956 established the pattern of cadmium use by industry.

On the basis of the 1956 canvass, consumption of metal was 69 percent of apparent consumption. The difference was attributed to unreported stocks and the incompleteness of the canvass. Electroplating, pigment and chemical production, and low-melting-point alloys accounted for about 88 percent of the measured consumption; electroplating was by far the largest use.

Electroplating.—Cadmium was used as a protective coating on iron and steel and to a smaller extent on copper-base alloys, other metals, and alloys. Such coatings were most commonly electrodeposited but may also be applied by spraying or hot dipping. Cadmium plate protects coated metals electrochemically, as well as by physical enclosure, and thus gives an added element of protection against corrosion. Distribution of electroplated cadmium, by end uses, is given in table 5. In addition to cadmium directly consumed in electroplating, a considerable part of the consumption of such chemicals as cadmium oxide, hydrate, and chloride is properly assigned to electroplating.

TABLE 5.—Distribution of cadmium in electroplating in 1955–56

Use	1955		1956	
	Pounds	Percent of total	Pounds	Percent of total
Nuts, bolts, screws, nails, tacks, rivets, fasteners, etc	880,357	18.71	959,972	18.74
Automobile, truck, tank, and tractor parts	781,224	16.60	672,481	13.13
Aircraft parts (including rivets, bolts, etc.)	516,942	11.00	643,699	12.57
Communications (radio, television, telephone-signal apparatus)	569.788	12.11	642,127	12.54
Electrical equipment (exclusive of communications)	430,044	9.14	498,633	9.73
Hardware (not classifiable elsewhere)	336,502	7.15	479,292	9.36
Building materials and equipment (including conduit fittings)	196,400	4.17	216,833	4.23
Ordnance parts (guns, ammunition, and containers)	193,270	4.11	100,753	1.97
Textile machinery parts	88,638	1.89	78,290	1.53
Office machinery and supplies	95,240	2.02	65,426	1.28
Household appliances and equipment	43,824	.93	60,699	1.18
Metal merchandizing equipment	(1)	(1)	36,363	.71
Steel stampings, castings, etc	(1)	(1)	36,334	.71
Ship parts and equipment	25,647	.55	30,231	.59
Industrial machinery parts	9,063	.19	28,169	.55
Wire products	(1)	(1)	24,900	.48
Bicycles	20,392	.43	17,504	.34
Heating and refrigeration equipment	14,127	.30	16,709	.33
Petroleum-industry equipment	7,044	.15	10,348	.20
Amusement and vending machines	12,306	.26	5,954	.12
Control-instrument parts	22,522	.48	(1)	(1)
Medical, health, and safety equipment	2,504	.05	(1)	(1)
Other or unspecified	459,352	9.76	497,240	9.71
Total	4,705,186	100.00	5,121,957	100.00

[1] Included with "Other."

Cadmium Compounds.—Compounds other than those used in electroplating included the sulfide and sulfoselenide used primarily as paint pigments, providing colors ranging from yellow to dark maroon. These compounds, extended with barium sulfate, are known as cadmium lithopones. They have high heat resistance, which makes them suitable for use as finishes on automobiles. The 25-percent decline in automobile and truck production in 1956 was the primary reason for the 14-percent decline in consumption of cadmium for pigments and chemicals. The new cadmium-mercury lithopones found

increased consumer acceptance during the year, replacing some cadmium-selenium lithopones.

Cadmium bromide, iodide, and some chloride were used in photographic films, process engraving, and lithographing.

Cadmium Alloys.—Low-melting alloys, brazing alloys, other metal and alloys, solder, and bearing alloys composed about 12 percent of the cadmium consumed in 1956. Low-melting-point cadmium bearing alloys for use in fire-detection apparatus, automatic sprinkler heads, firedoor release links, automatic shutoffs for gas and electric water-heating systems, safety plugs for compressed-gas cylinders, and temperature-controlled safety clutches were the largest outlets. Cadmium-base bearing metals are useful in internal-combustion engines for service under high pressure and temperature and high speed. This latter use was quite important during World War II but was relatively unimportant in both 1955 and 1956.

Other Uses.—Storage batteries using nickel cadmium cells were a minor use for the metal. Relatively small quantities of cadmium were also consumed in the atomic energy program.

STOCKS

Industry stocks of cadmium in metal and cadmium compounds (exclusive of consumers' stocks) totaled 3.9 million pounds, a 2-percent decrease from those of 1955. Consumers' stocks increased 1 percent to about 1.1 million pounds.

During 1956 the Commodity Credit Corporation executed contracts for delivering cadmium amounting to $5.1 million, or approximately 3 million pounds.

TABLE 6.—Industry stocks at end of year, 1955–56, in pounds of contained cadmium [1]

	1955 [2]			1956		
	Metallic cadmium	Cadmium compounds	Total cadmium	Metallic cadmium	Cadmium compounds	Total cadmium
Metal producers (primary)	3,128,583		3,128,583	2,845,955		2,845,955
Compound manufacturers	129,294	301,223	430,517	128,808	490,997	619,805
Distributors [3]	367,858	82,742	450,600	373,043	71,016	444,059
Total stocks	3,625,735	383,965	4,009,700	3,347,806	562,013	3,909,819
Consumers' stocks	942,939	186,703	1,129,642	973,074	168,226	1,141,300

[1] Excludes cadmium in national stockpile.
[2] Figures partly revised.
[3] The increase in distributors' stocks above those previously reported is due to the increase in the number of distributors reporting in the cadmium-consumption survey conducted for 1956.

PRICES

The quoted price of cadmium sticks and bars, delivered in 1- to 5-ton lots, was $1.70 a pound for the entire year—the same price held for special platers' shapes. Large quantities of cadmium were sold, both in the domestic and export markets, at prices considerably below the quoted price, which has remained at $1.70 a pound since February 1, 1954. The London market quotation for cadmium sticks and bars increased from 11s. 6d. to 12s. in January (equivalent to $1.68 on the

basis of $2.80 per £), where it remained for the rest of the year. The French market quotation for cadmium was 1,400 francs a kilogram throughout the year (equivalent to $1.54 a pound on the basis of $0.0024 per franc). During the year the quoted price paid in Italy for cadmium increased from 2,350 lira a kilogram ($1.64) to 2,800 lira ($1.95) (on the basis of $0.00154 per lira).

FOREIGN TRADE [2]

Imports.—General imports of cadmium metal and flue dust (cadmium content) in 1956 were, respectively, 1.75 and 1.62 million pounds, or a total of 3.37 million pounds. During the same period cadmium metal and cadmium in flue dust imported for consumption were, respectively, 3.12 and 1.45 million pounds and together were 4.57 million pounds.

Imports for consumption exceeded general imports because metal imported under bond as a general import in previous years was withdrawn from the bonded warehouse and counted as an entry for consumption.

TABLE 7.—Cadmium metal and flue dust imported [1] into the United States, 1954–56, by countries

[Bureau of the Census]

Country	1954		1955		1956	
	Pounds	Value	Pounds	Value	Pounds	Value
METALLIC CADMIUM						
North America: Canada	159,400	$248,529	665,392	$959,236	809,750	$1,211,159
South America: Peru	28,637	50,500	27,826	47,744	28,409	48,295
Europe:						
Belgium-Luxembourg	93,000	165,557	263,344	382,350	287,496	455,990
Germany, West					44,092	67,925
Italy	22,047	28,617	760,587	1,070,797	234,800	363,071
Netherlands			91,557	131,328	33,075	51,897
United Kingdom	224	587			2,094	3,078
Total	115,271	194,761	1,115,488	1,584,475	601,557	941,961
Asia: Japan	44,094	65,224	247,046	347,480	43,951	66,774
Africa: Belgian Congo			220,500	330,750	264,410	407,907
Oceania: Australia	54,897	94,558				
Total metallic cadmium	402,299	653,572	2,276,252	3,269,685	1,748,077	2,676,096
FLUE DUST (CD CONTENT)						
North America:						
Canada			160,774	186,189		
Mexico	1,505,819	1,117,523	1,865,335	1,200,835	1,624,655	1,149,347
Total	1,505,819	1,117,523	2,026,109	1,387,024	1,624,655	1,149,347
South America: Peru	11,400	18,167	32,562	35,330		
Total flue dust	1,517,219	1,135,690	2,058,671	1,422,354	1,624,655	1,149,347
Grand total	1,919,518	1,789,262	4,334,923	4,692,039	3,372,732	3,825,443

[1] Data are "general imports;" that is, include cadmium imported for immediate consumption plus material entering the country under bond.

[2] Figures on U. S. imports and exports compiled by Mae B. Price and Elsie D. Page, Division of Foreign Activities, Bureau of Mines, from records of the Bureau of the Census.

TABLE 8.—Cadmium metal and flue dust imported for consumption in the United States, 1954–56, by countries

[Bureau of the Census]

Country	1954		1955		1956	
	Pounds	Value	Pounds	Value	Pounds	Value
METALLIC CADMIUM						
North America: Canada	159,400	$248,529	565,392	$802,121	932,150	$1,400,474
South America: Peru	28,637	50,500	27,826	47,744	28,409	48,295
Europe:						
Belgium-Luxembourg	93,000	165,557	175,829	252,828	386,034	602,047
Germany, West					44,092	67,925
Italy	22,047	28,617	66,143	88,082	936,745	1,345,780
Netherlands			54,606	77,161	33,075	51,897
United Kingdom	224	587			2,094	3,078
Total	115,271	194,761	296,578	418,071	1,402,040	2,070,727
Asia: Japan	44,094	65,224	37,699	52,025	268,129	382,184
Africa: Belgian Congo					484,910	738,657
Oceania: Australia	54,897	94,558				
Total metallic cadmium	402,299	653,572	927,495	1,319,961	3,115,638	4,640,337
FLUE DUST (CD CONTENT)						
North America: Mexico	1,482,565	1,077,992	1,832,827	1,146,253	1,451,889	876,046
Total flue dust	1,482,565	1,077,992	1,832,827	1,146,253	1,451,889	876,046
Grand total	1,884,864	1,731,564	2,760,322	2,466,214	4,567,527	5,516,383

Exports.—United States 1956 exports of cadmium (metal, alloys, dross, flue dust, residue and scrap), table 9, declined 8 percent in quantity, but only slightly in value. The United Kingdom, 742,000 pounds, and West Germany, 328,000 pounds, received the largest amounts.

TABLE 9.—Cadmium metal, alloys, dross, flue dust, residues and scrap exported from the United States, 1947–51 (average) and 1952–56

[Bureau of the Census]

Year	Pounds	Value	Year	Pounds	Value
1947–51 (average)	623,165	$1,398,672	1954	998,959	$1,422,040
1952	300,918	1,005,370	1955	1,393,915	1,938,355
1953	65,866	60,256	1956	1,284,248	1,932,305

Tariff.—The import duty on cadmium metal in 1956 was 3.75 cents per pound.

A brief review of the history of the tariff on cadmium is included because of the large imports of metal recorded in 1956 and the increasing general interest in tariffs as a whole.

Before 1922 metallic cadmium imports were admitted duty-free. In that year offerings of cadmium from the electrolytic zinc plant at Risdon, Tasmania, became a serious threat to domestic producers. They found relief in the Fordney-McCumber Act of 1922 which imposed a tariff of 15 cents per pound on the metal. Subsequently the 15-cent-per-pound duty became a provision of the Tariff Act of 1930.

The Canadian Trade Agreement signed November 17, 1938, reduced the tariff by 50 percent, effective January 1, 1939. Action taken at the Geneva Trade Conference of 1947 reduced the import duty on cadmium metal, effective January 1, 1948, from 7.50 to 3.75 cents per pound.

Cadmium in flue dusts has never been dutiable. The Tariff Act of August 5, 1909, provided for a 30-percent ad valorem tax on cadmium sulfide. The rate was reduced to 15 percent by the Tariff Act of October 3, 1913, but subsequently was raised to 40 percent by the Fordney-McCumber Tariff Act of 1922. Imports of cadmium sulfide and other cadmium compounds, not specifically provided for, were included either as chemical compounds, dutiable at 25 percent ad valorem or as pigments also dutiable at 25 percent ad valorem. Artists' colors were dutiable at higher rates.

The Tariff Act of 1930 continued cadmium sulfide and other cadmium compounds, as chemical compounds or as pigments, dutiable at 25 percent ad valorem, except artists' colors, which were dutiable at higher rates.

TECHNOLOGY

The high thermal neutron-absorption cross section of cadmium would make it an excellent material for controlling and shielding nuclear reactors, except that several of its other properties put it at a disadvantage for such use; namely, production of gamma rays upon irradiation with neutrons, a relatively low melting point, a relatively high vapor pressure, and a comparatively poor corrosion resistance.[3]

As a research tool in the advance of science in 1956 cadmium aided in the detection and establishment as fact the existence of the very elusive neutrino, the smallest known particle of matter.[4]

WORLD REVIEW

NORTH AMERICA

Canada.—A record 2.3 million pounds of cadmium was produced in 1956, 18 percent above that in 1955 and more than 6 times that in 1945. Consolidated Mining & Smelting Co. of Canada, Ltd., produced about 1.8 million pounds of the metal at its Trail plant in British Columbia and the remainder was produced by the Hudson Bay Mining and Smelting Co. Ltd., at its Flin Flon plant in Manitoba.

About 85 percent of Canadian cadmium was exported, principally to the United States and United Kingdom. Domestic consumption was primarily in the electrical and automotive industries.

In 1956 Consolidated Mining & Smelting Co. delivered 99.95-percent-pure cadmium in sticks, bars, or balls to eastern Canadian cities in lots of 5,000 pounds or more at $1.75 per pound; 2,000–5,000 pounds at $1.85 per pound; and less than 1-ton lots at $1.95 per pound.

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[3] Chemical Rubber Publishing Co., Handbook of Chemistry and Physics: 37th ed., Cleveland, Ohio, 1955–56, pp. 415–416.

[4] Cowan, C. L., Jr., et al., Detection of the Free Neutrino: a Confirmation. Science, vol. 124, No. 3212, July 20, 1956, pp. 103–104.

TABLE 10.—World production of cadmium, by countries, 1947–51 (average) and 1952–56, in thousand pounds [1]

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

Country	1947–51 (average)	1952	1953	1954	1955	1956
North America:						
Canada	901	949	1,118	1,087	1,919	2,258
Guatemala						107
Mexico [2]	1,801	1,618	2,113	1,130	2,855	1,892
United States:						
Metallic cadmium	8,116	8,388	9,682	9,416	9,754	10,414
Cadmium compounds (Cd content)	287	179	85	136	(3)	(3)
South America: Peru	2	38	23	66	138	124
Europe:						
Belgium [4]	532	1,210	1,040	1,100	(5)	(5)
France	136	195	283	313	397	238
Germany, West	40	141	227	618	709	645
Italy	192	293	401	458	433	403
Norway	160	163	197	178	255	277
Poland [4]	346	420	485	500	550	542
Spain	8	12	16	21	22	24
U. S. S. R. [4]	137	214	243	258	300	351
United Kingdom	261	347	380	315	337	251
Asia: Japan	127	367	459	611	757	886
Africa:						
Belgian Congo	54	45	71	139	366	613
Rhodesia and Nyasaland, Fed. of: Northern Rhodesia						117
South-West Africa [6]	1,116	1,112	1,194	1,620	1,402	2,327
Oceania: Australia	573	641	665	645	674	618
World total (estimate)	11,870	13,600	15,380	15,860	17,900	19,020

[1] This table incorporates a number of revisions of data published in previous Cadmium chapters. Data do not add to totals shown due to rounding where estimated figures are included in the detail.
[2] Cadmium content of flue dust exported for treatment elsewhere; represents in part shipments from stocks on hand. To avoid duplicating figures, data are not included in the total.
[3] Bureau of Mines not at liberty to publish figures.
[4] Estimate.
[5] Data not available; estimate by author of chapter included in total.
[6] Cadmium content of concentrates exported for treatment elsewhere. To avoid duplication of figures, data are not included in the total.

EUROPE

Germany, West.—Production of cadmium was down 9 percent from that of 1955. Imports in 1956 amounted to about 645 thousand pounds, and exports 153 thousand pounds. Consumption was at 1.1 million pounds.

United Kingdom.—Production of cadmium was down 26 percent from that in 1955. Apparent consumption was down 6 percent to 2 million pounds in 1956. Details of quantities used during the year for various purposes were as follows: Plating anodes, 1,028,800 pounds; plating salts, 178,080 pounds; cadmium-copper, 112,336 pounds; other alloys, 81,200 pounds; alkaline batteries, 191,296 pounds; dry batteries, 8,960 pounds; solder, 86,688 pounds; colors, 314,272 pounds; miscellaneous uses, 33,936 pounds.

In July the United Kingdom released its cadmium stocks (about 448,000 pounds) from its strategic stockpile of metals. Most of the metal was reported sold in the United States at prices considerably below original cost.

AFRICA

Rhodesia and Nyasaland, Federation of.—The Rhodesian Broken Hill Development Co. in Northern Rhodesia began producing cadmium metal in June. Output in 1956 amounted to 117,000 pounds of refined metal.