Columbium and Tantalum

By Richard F. Stevens, Jr.[1]

Consumption of columbium and tantalum raw materials continued to increase during 1967 and end-use consumption of columbium and tantalum reached new alltime record highs. The primary use of columbium in the form of ferrocolumbium increased 18 percent although steel production decreased from its record high set in 1966. The use of tantalum continued to be primarily in capacitors and other electronic applications required by the military in the Viet Nam conflict. About 1.5 million pounds of combined pentoxides ($Cb_2O_5+Ta_2O_5$) containing some 800,000 pounds of columbium was released from government stockpiles in 1967 compared with releases of approximately twice these amounts made in 1966.

Legislation and Government Programs.—On January 13, 1966, the General Services Administration (GSA) announced a plan for the disposal of about 5 million pounds (columbium content) of columbium concentrate from the Defense Production Act Inventory over several years. Five releases were made in 1966 and three releases were made in 1967. Although classified as columbite (Cb_2O_5), the material is actually columbite-tantalite (Cb_2O_5–Ta_2O_5) and much of it was purchased for its tantalum content. The Cb_2O_5 to Ta_2O_5 ratio of the material sold varied from about 47 to 1 to about 0.95 to 1. Material purchased for its columbium content sold at an average price of between $0.97 and $1.20 per pound of contained pentoxides while material purchased primarily for its tantalum content ranged in price from about $2 to $6 per pound of contained pentoxides.

[1] Commodity specialist, Division of Mineral Studies.

Table 1.—Salient columbium statistics

(Thousand pounds)

	1963	1964	1965	1966	1967
United States:					
Mine production of columbite-tantalite concentrates	-----	-----	-----	W	W
Releases from Government stocks (Cb content)[1]	-----	-----	-----	1,659	779
Consumption of concentrate: Columbium metal contained in all raw materials consumed (Cb content)[1]	2,054	2,758	2,749	3,873	4,366
Production of primary products: Columbium metal (Cb content)	104	95	W	W	W
Ferrocolumbium and ferrotantalum-columbium (Cb+Ta content)	1,576	820	1,961	3,664	1,960
Consumption of primary products:					
Columbium metal (Cb content)	NA	124	33	100	111
Ferrocolumbium and ferrotantalum-columbium (Cb+Ta content)	1,346	1,479	2,199	2,697	3,192
Exports:					
Columbium ore and concentrate (gross weight)	47	343	NA	NA	NA
Columbium metal, compounds and alloys (gross weight)	14	5	4	7	6
Imports for consumption:					
Columbium mineral concentrate (gross weight)	5,910	4,601	4,892	9,278	7,431
Columbium metal and columbium-bearing alloys (Cb content)	1	4	10	4	(2)
Ferrocolumbium (gross weight)[e]	NA	172	691	1,280	629
World: Production of columbium-tantalum concentrates (gross weight)	9,853	11,726	14,618	22,988	20,801

[e] Estimate. [r] Revised. W Withheld to avoid disclosing individual company confidential information.
NA Not available.
[1] Includes columbium content in raw materials from which columbium is not recovered.
[2] Less than ½ unit.

Table 2.—Salient tantalum statistics

(Thousand pounds)

	1963	1964	1965	1966	1967
United States:					
Mine production of columbium-tantalum concentrates	-----	------	------	W	W
Releases from Government stocks (Ta content)[1]	-----	------	------	634	307
Consumption of concentrate: Tantalum metal contained in all raw materials consumed (Ta content)[1]	502	510	775	r 1,392	1,730
Production of primary products:					
Tantalum metal (Ta content)	418	448	712	1,064	1,021
Ferrocolumbium and ferrotantalum-columbium (Cb+Ta content)	1,576	820	1,961	3,664	1,960
Consumption of primary products:					
Tantalum metal (Ta content)	NA	214	435	493	443
Ferrocolumbium and ferrotantalum-columbium (Cb+Ta content)	1,346	1,479	2,199	2,697	3,192
Exports:					
Tantalum ore and concentrate (gross weight)	56	200	284	163	75
Tantalum metal, compounds, and alloys (gross weight)	44	32	21	35	59
Tantalum and tantalum alloy powder (Ta content)	14	32	25	51	157
Imports for consumption:					
Tantalum mineral concentrate (gross weight)	944	981	1,196	2,143	1,675
Tantalum metal and tantalum-bearing alloys (Ta content)	2	3	26	48	55
World: Production of columbium-tantalum concentrates (gross weight)	9,853	11,726	14,618	22,988	20,801

r Revised.
W Withheld to avoid disclosing individual company confidential data.
NA Not available.
[1] Includes tantalum content in raw materials from which tantalum is not recovered.

Table 3.—Columbium materials in Government inventories as of December 31, 1967

(Thousand pounds, columbium content)

Material	Objective	National (strategic) stockpile	Defense Production Act (DPA) inventory	Supplemental stockpile	Total
Columbium concentrates:	-----	[1] 6,247	5,557	376	12,180
Columbium carbide powder:					
Stockpile grade	20	21	----------	----------	21
Ferrocolumbium:					
Stockpile grade	930	368	----------	----------	368
Nonstockpile grade	-----	553	----------	----------	553
Columbium metal:					
Stockpile grade	45	33	----------	----------	33
On order-upgrading [2]	-----	11	----------	----------	11
Columbium oxide powder:					
Stockpile grade	-----	23	----------	----------	23
On order-upgrading [2]	-----	90	----------	----------	90

[1] Includes 83,437 pounds columbium content, reserved for upgrading.
[2] Material on order is to be acquired through upgrading contracts.

Table 4.—Tantalum materials in Government inventories as of December 31, 1967

(Thousand pounds, tantalum content)

Material	Objective	National (strategic) stockpile	Defense Production Act (DPA) inventory	Supplemental stockpile	Total
Tantalum minerals:					
Stockpile grade	2,947	[1] 2,968	849	2	3,819
Tantalum carbide powder:					
Stockpile grade	27	29	---------	----------	29
Tantalum metal:					
Stockpile grade	360	116	---------	----------	116
On order-upgrading [2]	-------	85	---------	----------	85

[1] Includes 111,611 pounds, tantalum content, reserved for upgrading.
[2] Material on order is to be acquired through upgrading contracts.

DOMESTIC PRODUCTION

Two small companies, one in South Dakota and the other in New Mexico, produced columbium-tantalum concentrates during the year. Output increased by a factor of about 30 over that of 1966. Most of the 1967 output and all of the 1966 output remained in mine stocks at yearend.

Production of columbium metal powder continued to increase, although data are withheld to avoid disclosing individual company confidential data. Production of columbium metal ingots totaled 47 tons in 1967. E. I. du Pont de Nemours & Co., Inc., did not produce columbium metal in either 1966 or 1967 but continued to hold significant stocks of the metal. In 1967 the du Pont Metals Center in Baltimore, Md., was sold to Fansteel Metallurgical Corp.

Production of tantalum metal powder (including capacitor-grade powder) in 1967 decreased 4 percent to 510 tons from the 532 tons reported in 1966. Production of tantalum metal ingots increased 15 percent to 291 tons during the year from the 252 tons reported in 1966.

Ferrocolumbium, ferrotantalum-columbium, and columbium-base master alloys were produced by the thermite process by Kawecki Chemical Co., Reading Alloys Co., and Shieldalloy Corp. These ferroalloys were produced in electric furnaces by Molybdenum Corporation of America, Union Carbide Corp., and by the Vancoram Division of Foote Mineral Co. (formerly Vanadium Corporation of America). Union Carbide Corp. (UCC) continued to produce high-purity ferrocolumbium (FeCb) and nickel-columbium (NiCb) at Niagara Falls from Cb_2O_5 recovered by solvent-extraction at UCC's Marietta, Ohio, plant.

Michigan Chemical Corp., Chicago, Ill., purchased the equipment and leases of the Porter Brothers Corp., Boise, Idaho, in 1966. The dredge and related equipment, including a bunkhouse and a small school building, were maintained on a "standby" basis during 1967.

During the year Kawecki Chemical Co. reportedly began construction of a tin slag recovery and concentrating plant at Reading, Pa., to recover the tantalum from this "synthetic" tantalite source.

A placer deposit of potential significance in the Sawtooth Primitive Area of Idaho was examined by Bureau of Mines engineers and reportedly contains reserves of some 200 million cubic yards of gravel containing values in gold, platnium, euxenite, and columbium-tantalum minerals. The deposit extends approximately 6 miles along the South Fork of the Payette River.

Table 5.—Major domestic columbium and tantalum processing and producing companies in 1967

Company	Location	Columbium	Tantalum	Tantalum carbide	Ferrocolumbium	Ferrotantalum-columbium
Fansteel Metallurgical Corp	Muskogee, Okla	X	X	X	-------	--------
General Electric Co	Euclid, Ohio	X	X	-------	-------	--------
Kawecki Chemical Co	Boyertown, Pa	X	X	X	X	--------
Kennametal, Inc	Latrobe, Pa	X	X	X	-------	--------
Linde Division, Union Carbide Corp.	Indianapolis, Ind	X	X	X	-------	--------
Mallinckrodt Chemical Works	St. Louis, Mo	X	X	X	-------	--------
Mining and Metals Division, Union Carbide Corp.	Niagara Falls, N.Y Marietta, Ohio	X	X	-------	X	X
Molybdenum Corporation of America.	Washington, Pa	------	-------	-------	X	X
Metals Division, Norton Co. (formerly National Research Corp., a subsidiary of Norton Co.)	Newton, Mass	X	X	-------	-------	--------
Reading Alloys Co., Inc	Robesonia, Pa	------	-------	-------	X	X
Shieldalloy Corp	Newfield, N.J	------	-------	-------	X	X
Stellite Division, Union Carbide Corp.	Kokomo, Ind	X	X	X	-------	--------
Vancoram Division, Foote Mineral Co. (formerly Vanadium Corporation of America).	Cambridge, Ohio Vancoram, Ohio Graham, W. Va	------	-------	-------	X	X
Wah Chang Albany (A Teledyne Company).	Albany, Oreg	X	X	-------	-------	--------

CONSUMPTION AND USES

Use of columbium in ferroalloys for additions to steels to control grain size accounted for approximately 85 to 95 percent of the metal consumed. Columbium consumed in the form of high-purity metal totaled 111,195 pounds, an 11-percent increase over the 100,106 pounds reported consumed in 1966. Tantalum metal (including capacitor-grade powder) consumed during the year decreased to 443,095 pounds from the 493,062 pounds reported in 1966 and continued to be used primarily in powder or ingot form in the manufacture of capacitors and other electronic equipment and in corrosion-resistant chemical equipment. About 65 to 75 percent of tantalum consumption was in electronic applications, 20 to 30 percent in the chemical industry, and 5 to 10 percent as carbides.

Total consumption of columbium plus tantalum in ferroalloys rose about 18 percent to a new record high of 3,191,711 pounds in 1967. The consumption of ferrocolumbium (FeCb) and ferrotantalum-columbium (FeTa-Cb) in stainless steels, permanent magnet alloys and gray and malleable castings applications decreased compared with that of 1966 while consumption in other steels, carbon steels, welding rods, nickel-base alloys and miscellaneous applications increased. The consumption of tool steels increased slightly while high-temperature nonferrous alloy usage decreased slightly. The greatest single volume increase in the usage of these ferroalloys was reported in other alloy steels. Domestic consumption of ferrocolumbium during 1967, by major use categories, was as follows: Other alloy steels (44 percent), high-temperature nonferrous alloys (17 percent), carbon steels (15 percent), stainless steels (14 percent), and welding rods, nickel-base alloys, permanent magnet alloys, and tool steels (1 percent). Consumption of ferrotantalum-columbium continued to be small and amounted to only slightly more than 2 percent of the total reported FeCb plus FeTa-Cb consumption (table 6) compared with slightly more than 1 percent of the total 1966 consumption. The major uses of ferrotantalum-columbium in 1967 were in the production of stainless steels (61 percent), nickel-base alloys (5 percent), carbon and alloy steels (5 percent), high-temperature nonferrous alloys (3 percent), and cemented carbides (2 percent).

Additional data on ferrocolumbium and ferrotantalum-columbium are contained in the "Ferroalloy" chapter of the 1967 Minerals Yearbook.

The General Electric Co. announced the development of molds and dies composed of the refractory metal alloys, columbium, tantalum, molybdenum, and tungsten, which allowed satisfactory die-casting of steel and iron.

In addition to the high-purity (99.9 percent) columbium and tantalum oxides and chlorides, the Rare Metals Division of CIBA (A.R.L.) Ltd. has available tantalum and columbium pentachlorides for evaluation and has announced plans to make lithium columbate, potassium tantalate, and potassium columbate available shortly.

Gallard-Schlesinger Manufacturing Corp. commercially offered pentamethoxy and pentaethoxy compounds of columbium and tantalum for use in the preparation of high-purity metal powder, dielectric films, coatings, and catalysts.

Randomly or specifically oriented tantalum single crystals of 99.999 percent purity were commercially available from Materials Research Corp. in sizes up to ½ inch in diameter by 3 inches long for $200 per inch. Produced by electron-beam floating-zone refining techniques, these tantalum crystals are believed to have the highest purities available to date.

Tantalum-clad copper bayonet heaters developed by National Research Corp. for use in acid concentrators combine the chemical corrosion resistance of tantalum with the strength and the electrical and heat conductivity of copper.

Fansteel Metallurgical Corp. has successfully produced the widest sheet (42 inches) of tantalum that has ever been rolled in coil form. Virtually any thickness of tantalum sheet can be rolled by this process. At its plant in Torrance, Calif., the firm developed a method of explosive-cladding tantalum on steel for use in chemical reactor vessels to replace glass-coated steel. Fansteel has also developed and made commercially available new tantalum powder which allows the fabrication of superior, but less costly, capacitors at low sintering temperatures.

Designated FD powder, this material is available in both anode and bulk powder form.

A copper-nickel casting alloy modified with columbium additions has been developed which offers excellent corrosion resistance and enhanced weldability for applications in the marine, aerospace, chemical food handling, and petroleum industries.

During 1966, the General Electric Co. completed the construction of a second-generation pilot plant in Philadelphia, Pa., to electroform and electroclad tantalum coatings for nuclear fuel elements.

Two detailed reports on ferroalloys and a comprehensive columbium-tantalum market guide were published which discussed the use of columbium and tantalum in alloy steels, and included a directory of free world companies in the columbium and tantalum industry, their products, programs, and capacities.[2]

[2] Metal Bulletin (London). Ferro-Alloys, A Metal Bulletin Special Issue. July 1966, 158 pp.
Metals Week. Ferro Alloys—Review and Outlook. V. 38, No. 7, Feb. 13, 1967, pp. 13–36.
———. Columbium-Tantalum Market Guide. V. 38, No. 17, Apr. 24, 1967, pp. 21–39.

Table 6.—Consumption by end uses of ferrocolumbium and ferrotantalum-columbium in the United States

(Pounds of contained columbium plus tantalum)

Product	1965	1966	1967
Stainless steels	601,247	567,307	437,116
Other alloy steels	974,999	1,181,467	1,400,805
Carbon steels	265,545	362,114	491,460
Tool steels [1]	1,268	6,013	6,053
Welding rods [2]	11,492	10,813	12,654
Gray and malleable castings	158	857	[e] 300
High-temperature nonferrous alloys	313,043	537,370	536,572
Permanent-magnet alloys	5,222	4,512	[e] 1,700
Nickel-base alloys	11,468	16,684	12,965
Miscellaneous [3]	14,302	9,666	13,662
Unspecified	---	---	278,424
Total	2,198,744	2,696,803	3,191,711

[e] Estimate.
[1] Includes high-speed steel.
[2] Includes hard facing alloys and cutting and wear resistant alloys.
[3] Includes electrical resistance alloys, premixed powders, cemented carbides, capacitors, flame plating high-nickel chromium alloy coatings, metal-to-glass seal materials, and unspecified alloy powders.

STOCKS

Except for pyrochlore stocks which decreased 42 percent, consumer and dealer stocks increased from 11 to 39 percent as consumers built up their inventories which at yearend 1966 and 1967 totaled as follows: (in short tons)—1966 figures in parenthesis: Columbite, 1,298 (936); tantalite, 1,819 (1,640); pyrochlore, 433 (749); and tin slag, 32,852 (26,461).

In addition the following yearend columbium and tantalum inventories (given in pounds) were reported.

Material	*December 31, 1966*	*December 31, 1967*
Columbium:		
Primary metal	37,450	63,873
Ingot	35,728	46,658
Scrap	73,003	35,723
Oxide	431,546	597,438
Other compounds	33,938	24,703
Tantalum:		
Primary metal	103,195	111,071
Capacitor-grade powder	88,492	139,829
Ingot	42,597	136,286
Scrap	178,292	152,292
Oxide	26,784	156,724
Potassium tantalum fluoride (K_2TaF_7)	123,865	268,630
Other compounds	28,720	56,440

Consumer inventories of ferrocolumbium and ferrotantalum-columbium as of December 31, 1967, (with 1966 yearend stocks in parenthesis), were as follows: Ferrocolumbium, 681,778 pounds contained columbium plus tantalum (Cb

+Ta) (799,991); and ferrotantalum-columbium, 21,117 pounds contained Cb+Ta (13,502). Producer stocks of ferrocolumbium at yearend 1967 were 682,000 pounds contained Cb (560,000); producer stocks of ferrotantalum-columbium were withheld to avoid disclosing individual company confidential data.

PRICES

Spot prices for columbite ore, c.i.f. U.S. ports, as reported by Metals Week decreased from $1.05 to $1.15 per pound of contained pentoxides for material having a Cb_2O_5 to Ta_2O_5 ratio of 10:1 at the beginning of the year to $0.90 per pound at yearend. Long-term prices of this material were quoted at $1.03 and material having a ratio of 8.5:1 was quoted at $1.20 (nominal) per pound of contained pentoxides at the beginning of the year. By yearend, these price quotations were discontinued. During 1967 the quoted spot prices for Canadian pyrochlore fell from $1.18 to $1.25 per pound Cb_2O_5, f.o.b. mine or mill, to $1.02 to $1.07. The quoted long-term price decreased from $1.12–$1.15 to $0.95. During the year long-term price quotations for Brazilian phyrochlore dropped from $1.00 to $0.955 per pound of Cb_2O_5, c.i.f. U.S. ports. The price for tantalite ores during 1967, 60 percent basis, c.i.f. U.S. ports, fell from the 1966 high of about $13 per pound to approximately $9.50 to $11 per pound of contained pentoxides having a Ta_2O_5 to Cb_2O_5 ratio of 3:1. The price quotations for various grades of ferrocolumbium per pound of columbium content, ton lots, f.o.b. shipping point, at the beginning of the year were as follows: Low alloy grade, $2.80 to $3.02; standard grade, $3.17 to $3.24; and high purity, $3.82 to $4.50. Quotations for both low alloy grade and standard grade fell to $2.45 to $2.60 at yearend while the quoted price for the high-purity grade remained constant throughout the year.

Through January, tantalum metal was quoted at $30 to $49 per pound for powder, $47 to $60 per pound for roundels, and $52 to $65 per pound for rod. In February these prices were quoted at $32 to $46, $36 to $60, and $40 to $52 respectively, where they remained throughout the remainder of 1967.

Throughout the year, columbium-powder, roundels, 99.5 to 99.8 percent purity, was quoted at $11 to $22 per pound for metallurgical-grade material and at $12 to $23 per pound for reactor grade material. During this period, columbium ingots were quoted at $16 to $27 per pound for metallurgical-grade material and at $17.50 to $28 per pound for reactor-grade material.

Table 7.—Average grade of concentrate received by U.S. consumers and dealers in 1967 by country of origin

(Percent of contained pentoxides)

Country	Columbite			Tantalite	
	Cb_2O_5	Ta_2O_5	Ratio	Ta_2O_5	Cb_2O_5
Australia				47	20
Brazil [1]	55	0.10	550:1	38	31
Canada [2]	51	.72	71:1		
Congo (Kinshasa)	38	35	1.1:1	37	33
Malaysia	56	16	3.5:1	26	50
Mozambique	62	7.5	8.3:1	60	14
Nigeria	67	7	9.6:1	38	32
Portugal	37	31	1.2:1	35	30
Rhodesia, Southern				30	27
South Africa, Republic of	69	12	5.8:1	65	8
Spain	35	32	1.1:1	31	31
Thailand				38	21
Uganda	60	15	4.0:1	53	20

[1] Material reported from Brazil as columbite represents primarily pyrochlore.
[2] Pyrochlore concentrate.

FOREIGN TRADE

Most columbium and tantalum exports during 1967 (table 8) were destined chiefly for India, Japan, and Eastern Europe. The largest item, tantalum metal and alloy powder, was exported primarily to India (68 percent), the United Kingdom (9 percent), Italy (6 percent), West Germany (5 percent), France (4 percent), and Japan and the Netherlands (3 percent each). Tantalum ore and concentrate, believed not to be of domestic origin, was exported to Japan (49 percent), Czechoslovakia (44 percent), France (4 percent), and Canada (3 percent).

Table 8.—U.S. exports of columbium and tantalum, by classes

(Thousand pounds (gross weight) and thousand dollars)

Class	1966		1967	
	Quantity	Value	Quantity	Value
Columbium and columbium alloys unwrought and waste and scrap	4	$93	2	$57
Columbium and columbium alloys, wrought	3	156	4	284
Tantalum ores and concentrates	163	453	75	224
Tantalum and tantalum alloys, wrought	13	1,096	10	704
Tantalum metals and alloys in crude form and scrap	22	249	49	796
Tantalum and tantalum alloy powder	51	1,564	157	1,839

Imports for consumption of unwrought columbium metal decreased slightly to 437 pounds from the 453 pounds reported in 1966. Imports of unwrought columbium alloys in 1967 were reported to total only 14 pounds, columbium content, all from France, and were valued at $47.71 per pound. This represented a significant change from the 3,978 pounds valued at $6,533 ($1.64 per pound) reported in 1966. Imports for consumption of unwrought tantalum metal, including waste and scrap, continued to increase during the year to 54,887 pounds from the 47,507 pounds reported in 1966 and the 26,162 pounds reported in 1965. In 1967 this material was imported primarily from the Netherlands (33 percent), Switzerland (31 percent), the United Kingdom (12 percent), France (8 percent), Belgium-Luxembourg (7 percent), and West Germany (5 percent). In addtion, 102 pounds of unwrought tantalum alloy was imported from West Germany and 32 pounds of wrought tantalum metal was imported from the United Kingdom in 1967 compared with the corresponding figures of 10 pounds and 231 pounds reported in 1966.

Table 9.—Receipts of microlite and tin slags reported by consumers

(Thousand pounds)

Material	1965			1966			1967		
	Gross weight	Cb_2O_5 content	Ta_2O_5 content	Gross weight	Cb_2O_5 content	Ta_2O_5 content	Gross weight	Cb_2O_5 content	Ta_2O_5 content
Microlite	131	3	91	9	(1)	6	--------	-------	-------
Tin slags	8,822	564	429	10,220	889	560	28,913	2,902	1,572

[1] Less than ½ unit.

Table 10.—U.S. imports for consumption of columbium-mineral concentrates, by countries

(Thousand pounds)

Country	1965	1966	1967
Argentina	------	--------	11
Australia	------	--------	1
Belgium-Luxembourg [1]	------	12	33
Brazil	675	4,995	3,536
Burundi and Rwanda	34	--------	15
Canada	1,861	1,524	891
Congo (Kinshasa)	44	128	66
Finland	------	2	--------
Germany, West	------	--------	80
Ivory Coast	------	15	--------
Kenya	------	7	--------
Malagasy Republic	------	--------	7
Malaysia	83	74	202
Mexico	25	--------	--------
Mozambique	32	--------	11
Netherlands [1]	8	--------	--------
Nigeria	2,112	2,421	2,519
Peru	------	14	--------
Portugal	------	28	18
Rhodesia, Southern	------	--------	8
South Africa, Republic of	------	11	--------
Spain	------	10	--------
Switzerland [1]	------	22	--------
Uganda	18	15	4
United Kingdom [1]	------	--------	18
Western Africa, n.e.c	------	--------	11
Total:			
Pounds (thousands)	4,892	9,278	7,431
Value (thousands)	$2,712	$5,678	$5,266

[1] Presumably country of transshipment rather than original source.

Table 11.—U.S. imports for consumption of tantalum-mineral concentrates, by countries

(Thousand pounds)

Country	1965	1966	1967
Argentina	------	10	3
Australia	12	29	58
Belgium-Luxembourg [1]	55	27	60
Brazil	281	287	356
Burundi and Rwanda	15	20	45
Central African Republic	------	--------	5
Congo (Kinshasa)	160	993	313
France	12	--------	--------
French Guiana	1	1	--------
Germany, West [1]	------	109	--------
Indonesia	20	--------	--------
Japan	6	--------	--------
Kenya	------	27	21
Malagasy Republic	8	1	15
Malaysia	97	36	33
Mozambique	276	175	241
Netherlands [1]	82	166	42
Nigeria	36	40	135
Portugal	48	67	99
Rhodesia Southern	8	16	41
Malawi			
South Africa, Republic of	12	8	18
Spain	13	13	11
Surinam	15	--------	--------
Thailand	27	89	138
Uganda	5	7	24
Uruguay	------	2	--------
Western Africa, n.e.c	------	--------	17
Western Portuguese Africa	7	20	--------
Total:			
Pounds (thousands)	1,196	2,143	1,675
Value (thousand)	$2,150	$4,782	$5,510

[1] Presumably country of transshipment rather than original source.

Table 12.—Estimated U.S. imports for consumption of ferrocolumbium by major countries

(Thousand pounds, gross weight)

Country	1964	1965	1966	1967
Austria	93	236	231	22
Brazil	10	370	904	466
Canada	29	52	70	41
Germany, West	20	33	75	90
United Kingdom	20	-----	-------	10
Total	172	691	1,280	629

Table 13.—U.S. imports duties

(Per pound)

Tariff classification	Articles	Rate of duty [1]	
		Through Dec. 31, 1967	Effective Jan. 1, 1968
601.21	Columbium concentrate	Free	Free.
601.42	Tantalum concentrate	Free	Free.
607.80	Ferrocolumbium	10 percent ad valorem	9 percent ad valorem.
	Columbium:		
628.15	Unwrought	10 percent ad valorem	9 percent ad valorem.
628.20	Wrought	18 percent ad valorem	16 percent ad valorem.
628.17	Unwrought Cb alloys	15 percent ad valorem	13 percent ad valorem.
	Tantalum:		
629.05	Unwrought	10 percent ad valorem	9 percent ad valorem.
629.10	Wrought	18 percent ad valorem	16 percent ad valorem.
629.05	Unwrought Ta Talloys	15 percent ad valorem	13 percent ad valorem.
423.00	Columbium and tantalum chemicals	10.5 percent ad valorem	9 percent ad valorem.

[1] Not applicable to Communist countries.

Estimated data on imports of ferrocolumbium are reported in table 12. Because U.S. ferrocolumbium import statistics are not separately classified, exact data are unavailable. This information was obtained from various industry and government sources and from foreign trade statistics.

Imports of both columbium- and tantalum-mineral concentrates fell from the alltime highs reached in 1966 but remained at levels higher than that of most previous years. As in 1966 the bulk of columbium concentrate imports came primarily from Brazil, Nigeria, and Canada. The relative total, provided by these countries in 1967 however varied somewhat from that of 1966. Brazil and Canada supplied primarily pyrochlore concentrate whereas Nigeria supplied columbite concentrate. Relative to the tantalum import pattern in 1967, Brazil replaced the Congo (Kinshasa) as principal supplier. Important quantities of tantalum mineral concentrates were also supplied by Mozambique, Thailand and Nigeria. Most of the tantalum concentrate reported as coming from Europe is believed to represent transshipments of material of African origin.

Receipts of microlite and tin slags came primarily from Mozambique (microlite) and from the Congo (Kinshasa), Malaysia, Nigeria, and Thailand.

In accordance with the Kennedy Round Tariff Negotiations which were completed during the year, the duties on columbium and tantalum were to be reduced in stages by 50 percent over the 5-year period 1968–72. In the first stage, the duties which became effective January 1, 1968, are reported in table 13.

WORLD REVIEW

Australia.—Greenbushes Tin N. L., Australia's new producer of tantalum concentrates, announced that its dredge, which was damaged in late 1965, was back in operation by April 1966. The estimated 1966 output of 12 to 15 tons of 53 to 55 percent Ta_2O_5 concentrate was contracted to Philipp Brothers Corp. of New York. The production goal for 1967 and subsequent years is 45 tons of tantalite concentrate annually.

Tantalum also was recovered as a by-product of tin mining by Northwest Tantalum N.L. in which Philipp Brothers has acquired 13.9 percent interest. Other tantalum production centers were Pilbara and Warra Warra.

During 1967 the Canadian firm, Goldrim Mining Co., explored and began initial recovery of tantalum from the Wodgina dike deposit in the Pilbara area of Western Australia. In addition, Goldrim is exploring some of its holdings in the Northern Territory which are reported to contain tantalum, columbium, and tin.

It was announced that Electrolytic Zinc Co. of Australia, Ltd., is seeking mineral rights to look for possible tantalum deposits in the Port Hedland area of Western Australia.

Brazil.—During 1967 Brazil continued its standing, achieved in 1966, as the major world producer of columbium minerals. The leading producer, Companhia Brasileira de Metalúrgia e Mineraçao (CBMM), known formerly as Distribuidora e Exportadora de Minérios e Adubas, S.A. (DEMA), at Araxá, Minas Gerais, continued to recover columbium concentrates from extremely rich pyrochlore ore (4+percent Cb_2O_5). Operating on a one-shift-per-day basis, CBMM increased production from its open pit mine to about 12 million pounds annually in 1966 to feed the expanded flotation mill adjacent to the mine. About 500 tons per month of 58 percent Cb_2O_5 concentrate was recovered. Early in 1967, CBMM expanded its ferroalloy plant adjoining the mine, which uses the thermite batch process, from 40 to 50 tons per month of ferrocolumbium, and announced plans to increase the total capacity of its three reactors to 1,000 tons per year early in 1968.

Because the pyrochlore concentrate contains significant amounts of radioactive thorium (about 1.5 percent ThO_2), permission to export it was denied by the Comissas Nacional de Energia Nuclear (CNEN) until CBMM arranged to supply the radioactive equivalent of the thorium content to the Government of Brazil in the form of uranium oxide from the Republic of South Africa and more recently from Spain and Portugal.

CBMM plans to increase production of ferrocolumbium, which contains no thorium, obviating need for a special export license. The thorium content remains in a slag which CBMM will stockpile in drums for the account of CNEN.

Because its thorium content presents a radioactive hazard, special licensing for its processing is required in the United States. As a result, the Brazilian concentrate was priced about $0.20 per pound less than Canadian pyrochlore during 1966.

Companhia de Ferro Ligas da Bahia became associated with Thermo-Ligas Metalúrgicas, S.A. (Thermo-Liga), and announced plans for the production of ferrocolumbium and other ferroalloys in northern Brazil.

Canada.—Production of pyrochlore concentrate by St. Lawrence Columbium and Metals Corp. Canada's sole producer, at its mine and mill near Oka, Quebec, decreased during 1967 from the peak reached in 1966. Output, which had been primarily from open pit operations in previous years, was entirely from the underground facilities completed during the year. The company began underground mining early in 1967 at a rate of about 4,000 tons per day. Diamond drilling has indicated that the deposit extends onto property of Oka Columbium & Metals Ltd., a wholly owned subsidiary, and of Main Oka Mining Corporation (N.P.L.). St. Lawrence purchased 42 percent of the outstanding shares of Main Oka during 1966. Columbium Mining Products Ltd., also located in the Oka district near the St. Lawrence mine, announced that it had signed a contract with Continental Ore Corp. of New York to deliver approximately 2.6 million pounds of Cb_2O_5 in pyrochlore concentrate annually over a 10-year period

Table 14.—Free world production of columbium and tantalum concentrates (gross weight) by countries [2] [3]

(Pounds)

Country	1963		1964		1965		1966		1967 [p]	
	Columbium	Tantalum	Columbium	Tantalum	Columbium	Tantalum	Columbium	Tantalum	Columbium	Tantalum
North America: Canada [4]	2,941,303	---	4,150,388	---	4,541,745	---	5,073,000	---	4,244,000	---
South America:										
Argentina	---	[5] 4,520	---	---	---	---	---	[r] 2,013	---	[5] 3,309
Brazil:										
Columbite-tantalite [6]	42,763	231,000	24,643	180,777	88,317	364,466	[r] 130,611	[r] 351,796	225,500	452,991
Pyrochlore	---	---	712,081	---	2,636,686	---	[r] 10,527,000	---	10,177,000	---
French Guiana		5,031		2,000		1,850		[r] 2,000		2,200
Europe:										
Norway	783,000	---	408,000	---	330,689	---	---	---	---	---
Portugal [5]	4,464	72,711	21,526	32,280	---	47,772	27,000	66,998	17,973	99,306
Spain [6]	---	---	14,610	---	---	13,483	10,000	13,000	---	10,950
Africa:										
Burundi		4,000		NA		NA		NA		NA
Congo, (Kinshasa) [5] [7]	163,435	147,255	---	101,159	44,000	160,000	128,000	993,000	66,289	313,307
Malagasy Republic		38,000		7,900		9,000	---	[5] 990	---	[5] 14,909
Mozambique [8]		337,924		415,697		[r] 302,637		[r] 313,700		360,639
Nigeria	4,506,850	33,600	5,239,324	22,400	5,707,486	29,000	4,986,211	26,900	4,309,760	[e] 24,000
Rhodesia, Southern	---	151,016	---	141,318	---	77,000	---	[e] 88,000	---	---
Rwanda		[e] 70,000		64,421		109,239		54,756		69,224
South Africa, Republic of	---	64,000	---	14,000	---	6,000	---	4,000	---	[e] 9,900
South-West Africa, Territory of	419	4,142	448	1,027	1,080	1,135		1,892		NA
Uganda		20,000		12,857		17,924		24,648		61,085
Asia:										
Malaysia	197,100	---	125,400	---	103,000	---	152,400	---	186,006	---
Thailand [7]	---	---	---	---	---	---	---	---		101,412
Oceania: Australia	---	[r] 30,889	---	[r] 33,600	---	25,580	---	10,549	---	51,520
Total		[r] 9,853,422		[r] 11,725,856		[r] 14,618,089		[r] 22,988,464		20,801,280

[e] Estimate. [p] Prelimanary. [r] Revised.

[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. This data excludes columbium- and tantalum-bearing tin slags.

[2] The U.S.S.R. is also known to have produced columbium and tantalum concentrates, but specific data are not available.

[3] Compiled mostly from data available May 1968.

[4] Represents pyrochlore concentrates containing approximately 52 percent Cb_2O_5.

[5] U.S. imports.

[6] Exports.

[7] In addition, tin-columbium-tantalum concentrate (averaging about 10 percent combined Cb_2O_5 and Ta_2O_5 content for the Congo (Kinshasa) and averaging between 19.5 and 22 percent combined Cb_2O_5 and Ta_2O_5 for Thailand) was produced; data not available.

[8] Includes microlite as follows: 1963, 160,000; 1964, 312,200; 1965, 187,350; 1966, 174,500; and 1967, 154,845.

starting in 1968. A 1,000 ton-per-day mill to be built will employ a different process than that used by St. Lawrence. Initially, open pit mining will be used. Ore reportedly contains approximately 0.43 percent Cb_2O_5, about the same as at St. Lawrence. Implementation of this contract did not materialize owing to lack of sufficient financing and the contract lapsed. However, Continental Ore holds an option to reinstate the contract in the event that Columbium Mining is successful in obtaining the required capital.

A major pyrochlore deposit was being explored in the James Bay Area lowlands of Northern Ontario about 50 miles south of Moosohee and 400 miles north of Toronto by a group of companies headed by Imperial Oil Enterprises and including Consolidated Morrison Explorations Ltd., Goldray Mines, and Argor Explorations. Exploratory drillings indicated a deposit containing more than 40 million tons of pyrochlore ore averaging at least 0.52 percent Cb_2O_5 and extending to a depth of 1,000 feet. Additional columbium exploration work was conducted by Consolidated Manitoba Mines on its property in the James Bay lowlands adjoining the Imperial Oil-Consolidated Morrison property.

During 1967, Min-Ores Mines began diamond drilling operations to evaluate the grade and extent of the columbium ore discovered in 1966 beneath Callander Bay, Lake Nippissing, Northern Ontario.

International Bibis Tin Mines optioned the Peg Tantalum property in the Yellowknife area on the north shore of Great Slave Lake, Northwest Territory, and will explore the property jointly with the Rare Metals Division of CIBA Corp.

The complex cesium-tantalum-beryllium-lithium-gallium ore deposits of Chemalloy Minerals Ltd. (Toronto) at Bernic Lake, Manitoba, were explored by a joint venture between Chemalloy and Goldfields Corp. (New York). Preliminary investigations indicated substantial ore deposits averaging 0.39 percent Ta_2O_5. Development work will be conducted by Tantalum Mining Corp. (Ontario) owned 60 percent by Goldfield and 40 percent by Chemalloy. It is anticipated that a milling plant will be constructed adjacent to the Bernic Lake property in 1968.

Congo (Kinshasa).—The production of columbium and tantalum mineral concentrates continued to decrease during the year as GEOMINES, Compagnie Miniére des Grand Lacs Africans (MGL), and Minerga-Congo were troubled with labor relocation problems resulting from political disturbances. The Union Carbide Corp. pyrochlore deposit, which originally was being developed for production in 1967, encountered political problems which prevented the aquisition of a mineral concession from the Congolese Government and little actual development work was conducted during the year. When this property is developed further, the Congo (Kinshasa) will produce columbium concentrate from pyrochlore and tantalum concentrates from tin slag.

France.—A new Péchiney research center to be known as SOFEREC was dedicated in October at Voreppes near Grenoble. This new center will be the largest research complex for nonferrous metals in Europe and will conduct research on columbium and tantalum for use in the nuclear, aeronautical, space, chemical, and electronic industries.

Ivory Coast.—Sté. Anonyme de Recherches et d'Exploitations Miniére de Côte d'Ivoire (SAREMCI) ceased production of columbite-tantalite concentrates from the Bouke deposits.

Kenya.—Two reports on the Mrima Hill pyrochlore deposit were published which described the geology and mineralogy, ore reserves, ore treatment, and columbium recovery operations attempted.[3] Overall reserves exceed 41 million tons containing 0.67 percent Cb_2O_5 and 1.25 million tons containing 1.75 percent Cb_2O_5. Development of the deposit has been hindered by the complex and variable nature of the ore. Studies currently are being made on procedures for recovering the columbium and other constituents by pyrometallurgical methods.

Mozambique.—Production of tantalum-mineral concentrates by three local Portuguese firms, Empresa Mineira do Alto

[3] Binge, F. W., P. Joubert, and J. E. Mason. The Mrima Hill Deposit, Coast Province, Kenya. Ministry of Natural Resources, Mines and Geological Dept., Republic of Kenya, Inf. Circ. 2, 1966, 51 pp.

Harris, P. M., and D. V. Jackson. Investigations Into the Recovery of Niobium From the Mrima Hill Deposit. Trans. Inst. Min. and Met., Sec. C, v. 75, London, 1966, 17 pp.

Ligonha (EMDAL), Sociedade Mineira de Marropino, Lda., and Sociedad Mineira de Mutala, Lda., was almost entirely from the pegmatite mining area of northern Mozambique and was reported to be at a level of about 60 tons of tantalite (60 percent Ta_2O_5) and 70 tons of microlite (75 percent Ta_2O_5) annually. Higher production is anticipated as a result of the scheduled opening of two new mining areas and concentrating plants by the country's chief tantalum producers.

While the largest Mozambique pegmatite, located at Muiane, was worked in 1966 by EMDAL primarily for its beryl content, the sluice plant was believed to have also recovered about 250 grams of tantalum concentrate per ton of which it is estimated that approximately one-third is microlite (60 percent Ta_2O_5) and two-thirds is tantalite-columbite concentrate (40 percent Ta_2O_5 and 30 percent Cb_2O_5). EMDAL is reportedly installing extra concentrating equipment including a screen, jig, and two tables to treat 80 tons of ore per 8-hour day. EMDAL is also working the small Gelo pegmatite deposit about 16 miles from Muiane on the Gilé road. The yield from this working was estimated to be about 500 grams of 40 percent Ta_2O_5 concentrate per metric ton of ore.

Marropino produced microlite concentrate from a pegmatite deposit at Morrua about 23 miles northeast of Mulevala and tantalite concentrate from a second deposit at Marropino, about 18 miles south of Morrua. The average concentrate grade from these two operations was 60 percent Ta_2O_5, and during the first half of 1966 recovery reportedly averaged 500 grams per ton while recovery during the second half of the year was believed to average 1,000 grams per ton as a result of encountering a pocket of higher grade ore. The problem of lack of water, which had previously restricted production at Marropino, was remedied by the construction of three dams to store and provide a constant year-round water supply.

Foreign investment, represented by Derby & Co., a subsidiary of Philipp Brothers Corp. of New York, by Rand Mines of Johannesburg, and by the Johannesburg Consolidated Investment Co., expressed interest in acquiring the tantalite properties of Mutala and of Marropino.

Netherlands.—Capacity was doubled at the aluminum-base columbium and tantalum master alloy facility in Arnhem, operated by N.V. Kawecki-Billiton Matall-industrie, a subsidiary of Kawecki Chemical Co., and N. V. Billiton Maatschappij.

Nigeria.—Columbium continued to be recovered almost exclusively as a co-product of tin mining. All columbite and tantalite mining operations were in the Northern Province of Nigeria. High-grade tantalite (65 percent Ta_2O_5) ore was recovered by hand-sorting primarily during the rainy season when enough water is available. Most of the larger companies were emphasizing mechanization to overcome the labor availability and cost problems involved in hand-sorting operations.

Although several major producers have increased production of columbite and tantalite by the use of modern equipment, internal disturbances within Nigeria have caused several small operations to close.

Juntar Nigeria Co. Ltd., one of the country's largest columbite producers, reportedly has reserves of almost 10 million pounds of columbium concentrate.

Norway.—Mining rights to the low-grade pyrochlore deposit at Sove, near Ulefoss in the Telemark district, were transferred from Norsk Bergverk A/S, the state-owned company which suspended mining operations in the fall of 1965, to a partnership between the West Germany company Metallgesellschaft A. G. and Fangel and Co. A/S of Norway for an initial period of 3 years. The partnership was seeking to develop a method of economically working the large, low-grade deposit.

Rhodesia, Southern.—Kamativi Tin Mines, Ltd., a Dutch-controlled company near Wankie, continued to be the major producer of tantalite which was recovered as a magnetic byproduct from tin concentrates before smelting. Kamativi reportedly increased its total productive capacity to 50,000 tons of ore per month in 1966.

Although official production figures on columbium and tantalum ceased to be reported by Southern Rhodesia following its unilateral declaration of independence (UDI) proclaimed in November of 1965, an indication of the country's continued Cb-Ta production is given by U. S. imports, tables 10 and 11.

South Africa, Republic of.—The newly formed company, Thermometallurgical Corporation (Pty.) Ltd., will be the country's first ferroalloy producer and will produce ferrocolumbium, ferrotantalum, and other ferroalloys from domestic and imported ores.

U.S.S.R.—Trade journals reported that for the first time ferrocolumbium of Soviet origin was being offered for sale on the free world market and that small quantities were purchased in Western Europe for examination during 1966.

United Kingdom.—A new plant was constructed by Kawecki Chemical Co. in Darley Dale, England, early in the year to produce the aluminium-base columbium and tantalum master alloys required by the U. K. ferroalloy industry.

TECHNOLOGY

To develop alloys suitable for use at elevated temperatures, columbium and tantalum were combined with tungsten, hafnium, zirconium, molybdenum, vanadium, and titanium, and the resulting alloys were evaluated with respect to strength at elevated temperatures, oxidation resistance, and fabricability.[4] Of the alloys investigated, the Cb-Hf-W-Ti and the Cb-Hf-Mo series exhibited the optimum combination of high temperature properties.

In another Bureau of Mines study, additions of carbon, aluminum and chromium were made to high-temperature columbium-base alloys to evaluate the effects of solid solution strengthening and precipitation hardening caused by these alloy additions.[5]

The trend toward higher operating temperatures to improve the efficiency of space power and propulsion systems has led to the development of extruded tubing of columbium and tantalum alloys (B–66 and T–111, respectively), which can serve reliably in extremely rigorous high-temperature environments.[6] In addition to their good high-temperature, high-strength properties, these alloys possess the ductility, fabricability, and corrosion resistance that make them suitable for tubing to conduct liquid metal coolants in space reactors.

Studies by U. S. Atomic Energy Commission contractors evaluated the effects of radiation of columbium and tantalum metals and their alloys.[7] Special attention was given to determining the effects of fast neutron irradiation on Cb- and Ta-based alloys being considered for cladding and structural materials in fast "breeder" reactors. Preliminary data indicates that neutron irradiation does not adversely effect the structural and cladding properties of these alloys.

Studies of the compatibility of construction materials with liquid and vapor alkali metals indicated that columbium, columbium-base alloys, tantalum, and tantalum-base alloys, possessed excellent compatibility with sodium, sodium-potassium (NaK), potassium, lithium, and cesium metal coolants and should be suitable for use in nuclear reactors using these coolants.[8] Columbium and tantalum alloys are suitable for application with liquid metals when the oxygen content of the molten metals is kept low to prevent detrimental reaction of the oxygen with columbium and tantalum alloys.

Because they do not readily react with plutonium and plutonium alloy fuels, tantalum and tungsten were both satisfactory materials for fuel containment in the Los Alamos Molten Plutonium Reactor Experiment (LAMPRE), but tantalum was preferred because of its greater ease of fabrication.[9]

[4] Babitzke, H. R., and H. Kato. Columbium and Tantalum Alloy Development. BuMines Rept. of Inv. 6964, 1967, 18 pp.
Babitzke, H. R., R. E. Siemens, and H. Kato. High-Temperature Columbium and Tantalum Alloys. BuMines Rept. of Inv. 6777, 1966, 16 pp.

[5] Yoda, Renpei, H. R. Babitzke, and H. Kato. Study of Columbium-Base Alloys. BuMines Rept. of Inv. 6988, 1967, 34 pp.

[6] Buckman, Jr., R. William, and John L. Godshall. Refractory Alloy Tubing for Space Power Systems. Metal Progress, v. 89, No. 3, September 1966, pp. 105–110.

[7] Norman, Edgar C. (ed.). Summaries of Fast Fuels and Materials Development Programs. U.S. Dept. of Commerce, Clearinghouse for Federal, Scientific, and Technical Information, USAEC–TID–6506, pt. 3, 4th ed., May 1966, 253 pp.

[8] DeMastry, John A. Liquid Metals in Space Power Systems. Battelle Tech. Rev. v. 15, No. 3, March 1966, pp. 17–21.
Stang, J. H., E. M. Simons, J. A. DeMastry, and J. M. Genco. Compatibility of Liquid and Vapor Alkali Metals With Construction Materials. Battelle Memorial Inst., Columbus, Ohio, DMIC Rept. 227, Apr. 15, 1966, 112 pp.

[9] Litton, Felix B., and John C. Biery. Reactor of Tantalum With Molten Cerium—Cobalt Alloys. J. Electrochem. Soc., v. 113, No. 4, April 1966, pp. 371–376.

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