VANADIUM

By Henry E. Hilliard

Vanadium, when present in small amounts in certain ferrous alloys, can significantly improve their properties. Manufacturers of automobiles and machinery recognized the toughness and fatigue resistance of vanadium alloys as far back as the early 1900's, incorporating the alloys in axles, crankshafts, gears, and other critical components. Vanadium has been used together with aluminum to give the required strength in titanium alloys used in jet engines and high-speed airframes. Vanadium improves the properties of alloys by reacting with carbon and nitrogen to form refractory carbides and carbonitrides, which act as precipitation strengtheners and grain refiners.

In addition to its metallurgical uses, vanadium has a wide range of uses that include catalytic, ceramic, and electronic applications. The first use of vanadium as a catalyst was in the production of sulfuric acid by the contact process. This type of catalyst was introduced into the United States in 1926 and gradually replaced platinum. Vanadium replaced platinum because it is more resistant to poisoning, is inexpensive, and is relatively abundant when compared to platinum. Sulfuric acid, known since the Middle Ages, has been an important item of commerce for more than 200 years. The catalytic activity of vanadium oxides enables the controlled oxidation of naphthalene and oxylene to phthalic anhydride, and of butane and benzene to maleic anhydride. Both compounds are essential monomers in the production of polyesters and plastics.

Few U.S. vanadium producers would call it an outstanding year, but most were satisfied with the results of 1994. Prices began to rise in the fourth quarter, and most other indicators of industry health, such as sales and shipments, began to move upwards as well. After more than 4 years of decline during which the price of vanadium pentoxide and ferrovanadium fell more than 50% from their 1989 peak, the change was welcome by U.S. vanadium producers.

The gains came, for the most part not from stronger demand, but through cutting costs, increased productivity, and production curtailments in a market that had been in oversupply for more than 4 years. There were signs that the most recent recession was over and that the newly trim vanadium industry might find 1995 a better year than 1994.

Legislation and Government Programs

Importers of Russian ferrovanadium and nitrided vanadium into the United States faced preliminary antidumping duties following a U.S. Department of Commerce preliminary determination, announced on December 28, 1994. In accordance with the preliminary determination, the U.S. Customs Service was directed to suspend liquidation of all entries of ferrovanadium and nitrided vanadium from the Russian Federation that had entered, or been withdrawn from warehouses for consumption on or after January 4, 1995, the date the notice was published in the Federal Register. The Customs Service would require a cash deposit or posting of a bond equal to the amount by which the fair market value exceeds the U.S. price. A final determination was postponed until the 135th day after the publication of the notice in the Federal Register.[1]

The Defense Logistics Agency was authorized to sell vanadium pentoxide (V_2O_5) in fiscal year 1995. The Pentagon decided that V_2O_5 was no longer needed in the National Defense Stockpile (NDS) and approved the sale of the entire stock. This will be the first vanadium sales from NDS since 1972. At yearend, the NDS contained 651 metric tons of V_2O_5.

Production

Vanadium pentoxide is the starting material for the production of most useful vanadium products. An exception is the direct production of ferrovanadium from vanadium-bearing iron slag by Shieldalloy Metallurgical Corp., at its plant in Cambridge, OH. In 1994 there were four active vanadium pentoxide mills in the United States: AMAX Metals Recovery Corp., Braithwaite, LA; Gulf Chemical and Metallurgical Corp., Freeport, TX; Kerr McGee Chemical Corp., Soda Springs, ID; and U.S. Vanadium Corp., Hot Springs, AR. U.S. Vanadium is a subsidiary of Strategic Minerals Corp., Danbury, CT, a totaly integrated vanadium producer. A fifth mill, Energy Fuels Nuclear, Inc. (formerly Umetco Minerals Corp.) Blanding, UT, was idle the entire year.

Domestic production data for vanadium were developed by the U.S. Bureau of Mines (USBM) from a voluntary survey of all U.S. operations. All five U.S. producers responded to the survey. In addition to the vanadium pentoxide mills, the Bureau canvassed three other companies which produce ferrovanadium, vanadium metal, vanadium chemicals, and other specialty vanadium alloys, e.g. aluminum-vanadium master alloys. These three companies also responded to the voluntary survey.

Production of vanadium pentoxide grew by 3% in 1994. Production grew by 9% in 1993 as well, after declining by about 18% in 1992. Production of downstream vanadium products varied widely, however. Production of ferrovanadium grew by 8%, whereas that for aluminum-vanadium master alloys increased by more than 20%. Preliminary data for the production of vanadium chemicals and catalysts indicate a moderate decrease in production. There was no domestic production of vanadium from primary ores in 1994. Raw materials included ferrophosphorous slag, spent catalyst, fly ash, and petroleum residues.

Consumption

Consumption data for vanadium were developed by the USBM from a voluntary survey of all known domestic consumers. There were 61 respondents to the 1994 survey, down from 83 in 1993. The 61 respondents represented 77% of the total canvassed and were estimated to have accounted for 90% of total consumption, or about 3,860 tons. The consumption of nonrespondents was estimated based on past consumption relationships, trends, and data from nonsurvey sources to be about 430 tons. The USBM estimate of total U.S. consumption of vanadium in 1994 was 4,290 tons as shown in table 1.

Metallurgical applications continued to dominate vanadium usage in 1994, accounting for more than 95% of total consumption. Nonmetallurgical applications included catalysts, ceramics, and vanadium chemicals. The USBM did not publish consumption figures for the nonmetallurgical end-use categories for 1994. However, the dominant nonmetallurgical use was in catalysts. Much less was consumed in ceramics and electronics. *(See table 4.)*

Prices

At yearend 1994, world vanadium supply and demand were in balance for the first time in more than 3 years. One large producer estimated world production of V_2O_5 in 1994 at 44,000 tons. The Republic of South Africa's (RSA) Minerals Bureau reported that about 52,600 tons of V_2O_5 were produced in 1993. The approximately 16% decrease in production mainly represented curtailments by producers in RSA and China, which effectively removed more than 5,000 tons of V_2O_5 from the world market. At the same time, steel production in the United States and the European Union increased in 1994; the price of molybdenum, for which vanadium may be substituted in some application, soared. As a result, vanadium prices firmed in the fourth quarter of 1994 and actually began to rise after more than 3 years of steady decline.

The domestic price, in first quarter 1994, of V_2O_5 was $1.35 to $1.40 per pound. By the end of December, the range was $4.25 to $5.00 per pound; the spot market price at the end of December 1994 ranged from $3.90 to $5.10 per pound. Ferrovanadium prices in 1994 were as follows (pounds/vanadium content): first quarter, $3.50 to $4.00; second quarter, $3.90 to $4.15; third quarter, $3.90 to $4.15; and fourth quarter, $4.15 to $7.95. Part of the price increase of ferrovanadium was caused by an increase in the price of aluminum, which increased from $0.50 per pound in January to $0.90 per pound in December. Aluminum is used as a reducing agent in the production of ferrovanadium. Another factor was the imposition of antidumping duties, ranging from 40.46 to 108 weighted average margin percent, on imports of low cost Russian ferrovanadium and nitrided vanadium into the United States.

Current Research and Technology

A family of oxides that contracts uniformly when heated near room temperature reportedly has been discovered. The new materials, discovered by researchers at Oregon State University, are the first that shrink in all three dimensions when heated at or above room temperature. Most materials expand when heated, though a few are known to expand in some dimensions and contract in others. Some glasses are known to contract uniformly in all directions, but only at temperatures below room temperature. The materials contain zirconium, vanadium, phosphorus, and oxygen, with a typical composition being $ZrVPO_7$. Contraction occurs because the bond angle in certain linkages, such as P-O-P and V-O-V, diminishes as the temperature increases. This behavior was seen from room temperature to 900° C. Such contracting materials could be combined with expanding materials to form a composite whose dimensions do not change on heating or cooling. This type of composite would be of interest as a structural material in optical and electronic devices, whose performance can be affected by thermal contraction and expansion.[2]

An experimental ferritic steel, under development at Mintek in the RSA, was said to have properties that are equal to or superior to the austenitic grades. The new iron-base alloy contains 18% chromium and up to 4% vanadium. According to Mintek, the alloy had superior resistance to corrosion induced pitting in chloride solutions. This feature, combined with a ductile-to-brittle temperature of less than -40° C, gave the new alloy the potential to capture part of the market for type 304 and type 316 stainless steel.[3]

Outlook

World steel production, which consumes more than 90% of total vanadium demand, was expected to continue to recover in 1995. Relatively vigorous growth in all markets in 1995 was expected to lead to an increase of about 3.5% in global apparent steel consumption, equal to an increase of more than 21 million tons of finished products. Reflecting the recovery in apparent steel consumption, production of crude steel at the world level was expected to increase by about 3.2% to 746 million tons.[4] At that level, world demand for vanadium was expected to be 61,000 tons of V_2O_5 equivalents. The U.S. steel industry forecasted strong demand for 1995. Estimates for 1995 U.S. mill shipments ranged from 90 to 95 million tons.[5] At that level, U.S. demand for vanadium was expected to be 7,770 tons V_2O_5 equivalents. Whatever the short to medium-term prospects of the steel industry, stability in the vanadium industry will depend on the possibility of further new vanadium capacity and the reopening of mothballed plants. Vanadium supply and demand should remain in balance through 1995, provided there is no new capacity and the mothballed plants remain closed.

[1]Federal Register, v. 60, No. 2, Wed., Jan. 4, 1995, pp. 438-441.

[2]Chemical and Engineering News, Sept. 5, 1994, p. 35.

[3]MINTEK Bulletin, No. 78, Nov. 1994.

[4]Steel Times International, v. 19, No. 1, Jan. 1995, p. 4.

[5]Iron Age-New Steel, v. 11, No. 1, Jan. 1995, p. 10.

OTHER SOURCES OF INFORMATION

U.S. Bureau of Mines Publications

Iron and Steel. Ch. in Minerals Yearbook, annual.

Vanadium. Ch. in Mineral Commodity Summaries.

Vanadium. Reported monthly in Mineral Industry Surveys.

Other Sources

Chemical and Engineering News.

Engineering and Mining Journal.

Metal Bulletin Monthly (London).

Metal Price Support (London).

Metalworking News.

Roskill Reports (London).

TABLE 1
SALIENT VANADIUM STATISTICS 1/

(Metric tons of contained vanadium unless otherwise specified)

	1990	1991	1992	1993	1994
United States:					
Production:					
Ore and concentrate:					
Recoverable vanadium 2/	W	W	W	W	W
Value thousands	W	W	W	W	W
Vanadium oxide recovered from ore 3/	W	W	W	W	W
Vanadium recovered from petroleum residues 4/	2,310	2,250	1,350	2,870	2,740 e/
Consumption	4,080	3,290	4,080	3,970	4,290
Exports:					
Ferrovanadium	271	94	213	219	374
Vanadium pentoxide (anhydride)	819	700	26	126	335
Other oxides and hydroxides of vanadium	976	1,110	1,110	895	1,050
Imports for consumption:					
Ferrovanadium	244	420	592	1,630	1,910
Vanadium pentoxide (anhydride)	83	133	206	70	294
Other oxides and hydroxides of vanadium	271	110	103	19	3
Ore, slag, ash, and residues	3,830	882	838	1,450	1,900
World: Production from ore, concentrate, slag 5/	36,900 r/	34,300 r/	31,500 r/	33,400 r/	33,900 e/

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data.
1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.
2/ Recoverable vanadium contained in uranium and vanadium ores and concentrates received at mill, plus vanadium recovered from ferrophosphorus derived from domestic phosphate rock.
3/ Produced directly from all domestic ores and ferrophosphorus slag; includes metavanadates.
4/ Includes vanadium recovered from fly ash, residues, and spent catalysts.
5/ Excludes U.S. production.

TABLE 2
U.S. VANADIUM PENTOXIDE PRODUCERS

Producer	Plant location	Capacity (metric tons pentoxide per year)
AMAX Metals Recovery Inc.	Braithwaite, LA	1,800
Energy Fuels Nuclear, Inc.	Blanding, UT	6,800
Gulf Chemical & Metallurgical Corp.	Freeport, TX	1,400
Kerr-McGee Chemical Corp.	Soda Springs, ID	2,000
U.S. Vanadium Corp.	Hot Springs, AR	6,800

TABLE 3
U.S. CONSUMPTION AND CONSUMER STOCKS OF VANADIUM MATERIALS 1/

(Kilograms of contained vanadium)

Form	1993		1994	
	Consumption	Ending stocks	Consumption	Ending stocks
Ferrovanadium 2/	3,600,000 r/	297,000	3,890,000	446,000
Oxide	15,100	9,200	18,700	9,970
Ammonium metavanadate	2,170	1,900	W	W
Other 3/	348,000 r/	20,700	382,000	17,500
Total	3,970,000	329,000	4,290,000	473,000

r/ Revised. W Withheld to avoid disclosing company proprietary data; included with "Other."
1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ Includes other vanadium-iron-carbon alloys as well as vanadium oxides added directly to steel.
3/ Consists principally of vanadium-aluminum alloy and small quantities of other vanadium alloys and vanadium metal.

TABLE 4
U.S. CONSUMPTION OF VANADIUM IN 1994, BY END USE 1/

(Kilograms of contained vanadium)

End use	Quantity
Steel:	
Carbon	1,680,000
Stainless and heat-resisting	26,000
Full alloy	777,000
High-strength low-alloy	979,000
Tool	424,000
Unspecified	10,500
Total	3,890,000
Cast irons	31,400
Superalloys	15,600
Alloys (excluding steels and superalloys):	
Cutting and wear-resistant materials	311
Welding and alloy hard-facing rods and materials	2,750
Magnetic alloys	W
Other alloys	323,000
Chemical and ceramic uses:	
Catalysts	W
Pigments	W
Miscellaneous and unspecified	22,800
Grand total	4,290,000

W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous and unspecified."
1/ Data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to total shown.

TABLE 5
U. S. EXPORTS OF ALUMINUM-VANADIUM MASTER ALLOY, FERROVANADIUM, OXIDES AND HYDROXIDES OF VANADIUM, AND VANADIUM METAL 1/

(Kilograms, vanadium content unless otherwise specified)

Material and country	1993		1994	
	Quantity	Value	Quantity	Value
Aluminum-vanadium master alloy: 2/ (gross weight)				
Australia	3,560	$67,500	274	$3,570
Brazil	2,170	29,300	20,900	30,700
Canada	153,000	2,000,000	127,000	1,680,000
Egypt	1,440	20,100	--	--
France	752	12,700	172	18,500
Germany	85	13,900	8,520	107,000
Hong Kong	248	3,230	1,990	25,900
India	--	--	1,590	20,700
Indonesia	--	--	1,540	20,000
Israel	323	4,190	--	--
Italy	--	--	130	3,610
Japan	13,200	166,000	27,300	488,000
Korea, Republic of	6,180	83,700	256	29,100
Malaysia	195	2,530	2,160	28,000
Mexico	589,000	7,660,000	758,000	9,860,000
Netherlands	8,550	313,000	--	--
Norway	--	--	362	4,710
Romania	3,410	44,300	--	--
Saudi Arabia	--	--	233	3,410
Singapore	--	--	3,200	41,500
South Africa, Republic of	78,900	273,000	--	--
Spain	--	--	10,300	7,940
Taiwan	1,860	20,900	7,960	96,900
United Kingdom	2,320	46,200	41,800	233,000
Venezuela	568	7,380	11,600	151,000
Total	866,000 r/	10,800,000	1,030,000	12,900,000
Ferrovanadium:				
Canada	163,000	1,870,000	319,000	3,420,000
Colombia	--	--	375	9,600
Japan	--	--	4,100	137,000
Mexico	45,300	551,000	38,700	552,000
South Africa, Republic of	--	--	593	19,800
Sweden	10,800	359,000	2,970	99,000
Taiwan	--	--	4,260	44,000
United Kingdom	--	--	3,750	125,000
Total	219,000	2,780,000	374,000	4,410,000
Vanadium pentoxide (anhydride): 3/				
Australia	--	--	300	2,850
Belgium	5,230	49,700	207,000	1,160,000
Brazil	--	--	34,800	214,000
Chile	1,280	12,200	302	2,870
Finland	1,070	12,100	--	--
Germany	92,400	380,000	18,200	90,200
Italy	--	--	5,020	37,100
Japan	--	--	13,700	87,400
Kuwait	3,270	24,500	--	--
Mexico	820	16,800	16,900	137,000
Netherlands	--	--	15,900	87,800
Netherlands Antilles	--	--	363	3,450
Pakistan	5,090	79,700	3,970	50,800
South Africa, Republic of	16,800	136,000	60	2,700
Spain	--	--	418	3,970
Switzerland	--	--	15,900	83,400
Trinidad and Tobago	--	--	2,500	38,500
Total	126,000	710,000	335,000	2,000,000

See footnotes at end of table.

TABLE 5 -- Continued
U. S. EXPORTS OF ALUMINUM-VANADIUM MASTER ALLOY, FERROVANADIUM, OXIDES AND HYDROXIDES OF VANADIUM, AND VANADIUM METAL 1/

(Kilograms, vanadium content unless otherwise specified)

Material and country	1993		1994	
	Quantity	Value	Quantity	Value
Other oxides and hydroxides of vanadium:				
Austria	--	--	589	$32,600
Belgium	19,500	$81,300	--	--
Brazil	--	--	12,200	250,000
Canada	627,000	2,920,000	679,000	3,230,000
Chile	--	--	9,740	51,700
France	3,250	265,000	69,200	571,000
Germany	--	--	1,870	9,560
Hong Kong	--	--	17	2,920
Japan	36,300	143,000	14,500	71,600
Mexico	13,300	38,500	2,910	11,900
Netherlands	16,000	115,000	7,770	88,900
Nicaragua	--	--	5,340	36,100
Russia	--	--	2,600	274,000
South Africa, Republic of	64,500	288,000	156,000	630,000
Sweden	89,800	535,000	--	--
United Kingdom	--	--	4,970	36,700
Venezuela	25,200	158,000	84,400	575,000
Total	895,000	4,540,000	1,050,000	5,870,000

r/ Revised.
1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ Includes vanadium metal.
3/ May include catalysts containing vanadium pentoxide.

Source: Bureau of the Census.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF ALUMINUM-VANADIUM MASTER ALLOY, FERROVANADIUM, OXIDES AND HYDROXIDES OF VANADIUM, AND VANADIUM METAL 1/

(Kilograms, vanadium content unless otherwise specified)

Material and country	1993		1994	
	Quantity	Value	Quantity	Value
Aluminum-vanadium master alloy: (gross weight)				
Germany	19,100	$499,000	38,400	$948,000
Ferrovanadium:				
Austria	160,000	1,520,000	78,400	628,000
Belgium	46,100	328,000	--	--
Canada	387,000	3,560,000	639,000	5,270,000
France	8,610	81,700	--	--
Germany	179,000	1,120,000	31,000	181,000
Japan	30,600	235,000	--	--
Russia	688,000	4,380,000	1,110,000	6,480,000
Switzerland	39,500	308,000	--	--
Ukraine	40,800	304,000	9,480	53,100
United Kingdom	48,900	394,000	37,300	238,000
Total	1,630,000	12,200,000	1,910,000	12,900,000
Vanadium pentoxide (anhydride): 2/				
Canada	1,050	17,500	138	2,300
France	--	--	851	152,000
Germany	580	13,000	848	24,300
Russia	--	--	80,700	250,000
South Africa, Republic of	68,200	350,000	211,000	1,290,000
United Kingdom	--	--	14	47,700
Total	69,800	381,000	294,000	1,770,000
Other oxides and hydroxides of vanadium:				
Canada	32	2,930	238	4,020
China	--	--	3,230	35,700
France	8,270	140,000	--	--
Germany	647	12,500	2	1,630
Russia	740	4,470	--	--
South Africa, Republic of	2,140	8,720	--	--
United Kingdom	6,850	124,000	--	--
Total	18,700	292,000	3,470	41,300
Vanadium metal, including waste and scrap: (gross weight)				
Canada	--	--	73	9,260
Germany	11,400	287,000	41,200	1,420,000
Japan	1	1,280	--	--
Russia	--	--	880	41,200
South Africa, Republic of	618,000	5,210,000	528,000	4,400,000
United Kingdom	199	22,900	151	10,600
Total	630,000	5,520,000	570,000	5,880,000

1/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ May include catalysts containing vanadium pentoxide.

Source: Bureau of the Census.

TABLE 7
U.S. IMPORTS FOR CONSUMPTION OF VANADIUM-BEARING ASH, RESIDUES AND SLAG 1/

(Kilograms, vanadium pentoxide content)

Material and country	1993		1994	
	Quantity	Value	Quantity	Value
Ash and residues:				
Barbados	18,000	$7,940	--	--
Canada	439,000	533,000	295,000	$187,000
Dominican Republic	80,000	60,000	--	--
Germany	202,000	142,000	392,000	50,100
Israel	77,300	104,000	--	--
Italy	250,000	180,000	--	--
Jamaica	7,130	17,900	--	--
Korea, Republic of	--	--	16,100	3,220
Mexico	1,010,000	461,000	1,390,000	523,000
Netherlands	12,700	8,320	6,730	9,300
Netherlands Antilles	9,180	5,420	170,000	58,900
Portugal	16,000	84,900	--	--
South Africa, Republic of	--	--	11,000	1,730
United Kingdom	56,000	42,500	--	--
Venezuela	60,300	63,200	108,000	121,000
Total	2,240,000	1,710,000	2,380,000	954,000
Slag, from the manufacture of iron and steel: 2/				
South Africa, Republic of	316,000	1,530,000	1,000,000	1,110,000
Other residues: (not advanced in value)				
Argentina	7,660	5,120	--	--
Canada	15,900	20,500	6,760	4,390
France	14,200	54,200	--	--
Total	37,800	79,800	6,760	4,390

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ As adjusted by the U.S. Bureau of Mines.

Source: Bureau of the Census.

TABLE 8
U.S. IMPORTS FOR CONSUMPTION OF MISCELLANEOUS VANADIUM CHEMICALS 1/ 2/

(Kilograms, vanadium content)

Material and country	1993		1994	
	Quantity	Value	Quantity	Value
Vanadates:				
Canada	84	$3,250	--	--
France	562	255,000	76	$159,000
Germany	36,800	286,000	7,490	71,300
Japan	--	--	4,230	13,000
Netherlands	--	--	4	19,200
South Africa, Republic of	23,400	181,000	17,900	96,700
United Kingdom	1,510	48,900	80	89,900
Total	62,400	774,000	29,700	449,000
Hydrides and nitrides:				
Canada	4,360	5,130	--	--
Sweden	--	--	3	5,090
Total	4,360	5,130	3	5,090

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ Comprises vanadium ore and miscellaneous vanadium chemicals received for immediate consumption plus material withdrawn from bonded warehouses.

Source: Bureau of the Census.

TABLE 9
WORLD VANADIUM PENTOXIDE ANNUAL PRODUCTION
CAPACITY, DECEMBER 31, 1994 1/ 2/

(Metric tons of contained vanadium)

Country	Rated capacity 3/
Austria	1,500
Canada	770
Chile	2,300
China	8,200
South Africa, Republic of	27,200
Russia	9,500
United States	11,000
Venezuela	2,500
Other	550
Total	63,500

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; . may not add to total shown.
2/ Includes vanadium pentoxide in vanadiferous iron slags and petroleum refinery residues.
3/ Includes capacity of operating plants as well as plants on standby status.

TABLE 10
VANADIUM: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons of contained vanadium)

Country	1990	1991	1992	1993	1994e/
Production from ores, concentrates, slag: 3/					
China (in vanadiferous slag product) e/	4,500	4,500	4,700	5,000	5,000
Hungary e/	300	200	200	200	200
Russia e/ 4/	XX	XX	11,000 r/	10,000 r/	10,000
South Africa, Republic of: 5/					
Content of pentoxide and vanadate products e/	7,100	6,500	6,300	8,400 r/	8,600
Content of vanadiferous slag product e/ 6/	10,000	8,460	7,730	6,650 r/	7,100
Total	17,100	15,000	14,000	15,100 r/	15,700 7/
U.S.S.R. e/ 3/ 8/	12,000 r/	12,000 r/	XX	XX	XX
United States (recoverable vanadium)	W	W	W	W	W
Total	33,900 r/	31,700 r/	29,900 r/	30,300 r/	30,900
Production from petroleum residues, ash, spent catalysts: 9/					
Japan e/	700	404 r/	245 r/	252 r/	300
United States	2,310	2,250	1,350	2,870	2,740 7/
Total	3,010	2,650 r/	1,590 r/	3,120 r/	3,040
Grand total	36,900 r/	34,300 r/	31,500 r/	33,400 r/	33,900

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data; not included in "Total." XX Not applicable.
1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ In addition to the countries listed, vanadium is also recovered from petroleum residues in Germany, and several other European countries, but available information is insufficient to make reliable estimates. Table includes data available through June 16, 1995.
3/ Production in this section is credited to the country that was the origin of the vanadiferous raw material.
4/ All production in the U.S.S.R. from 1990-91 came from Russia.
5/ Includes production for Bophuthatswana.
6/ Data on vanadium content of vanadium slag are estimated on the basis of a reported tonnage of vanadium-bearing slag (gross weight) multiplied by an assumed grade of 14.1% vanadium.
7/ Reported figure.
8/ Dissolved in Dec. 1991.
9/ Production in this section credited to the country where the vanadiferous product is extracted; available information is inadequate to permit crediting this output back to the country of origin of the vanadiferous raw material.