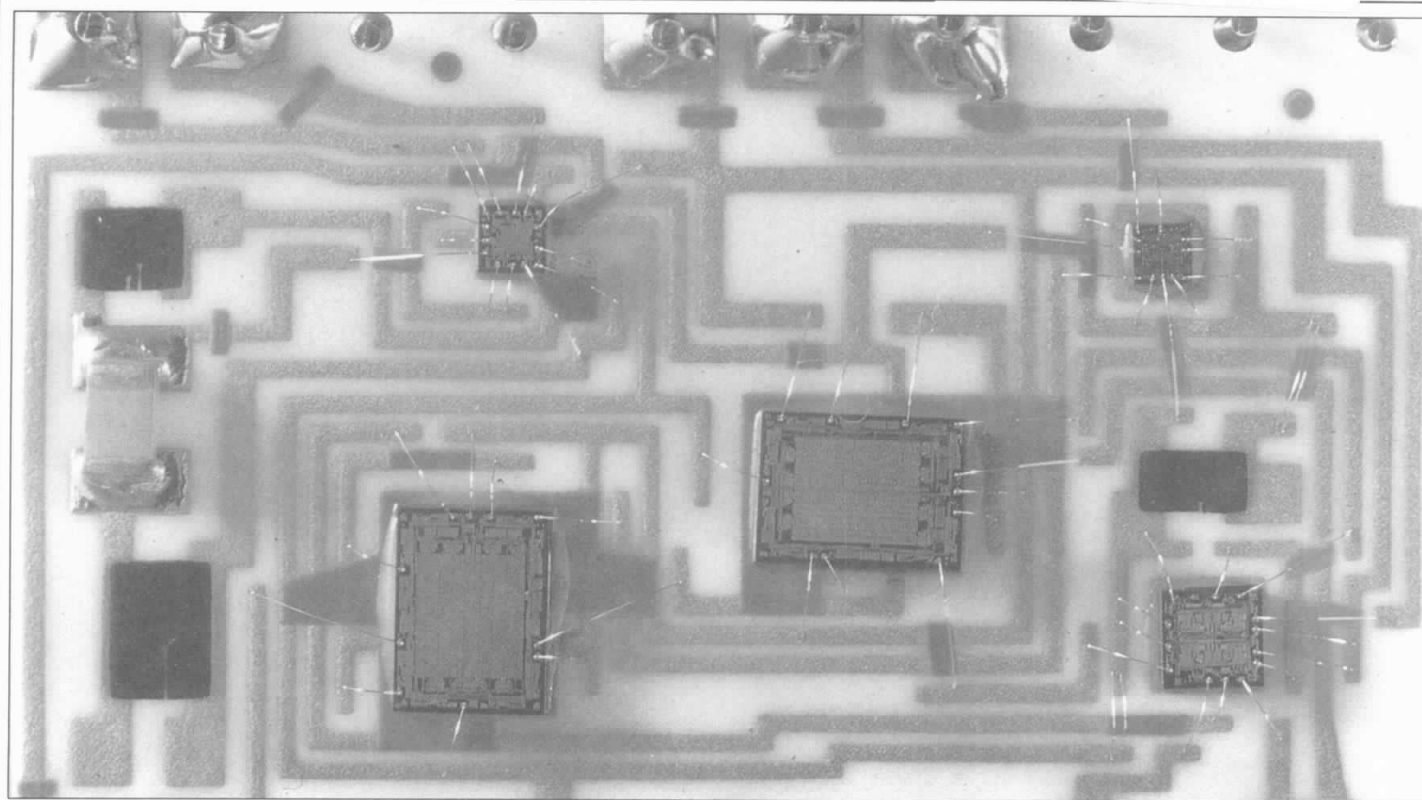




PLATINUM-GROUP METALS

By J. Roger Loebenstein

1993

U.S. DEPARTMENT OF THE INTERIOR

BUREAU OF MINES

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PLATINUM-GROUP METALS



U.S.
DEPARTMENT
OF THE
INTERIOR

Bruce Babbitt
Secretary



BUREAU
OF
MINES

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COVER PHOTO:

*Thick-film pastes containing palladium
or ruthenium are used to print the
conductor and resistor tracks of hybrid
circuits. (Photo provided by Johnson
Matthey, PLC and published in the 1987
issue of Platinum, published by Johnson
Matthey).*

PLATINUM-GROUP METALS

By J. Roger Loebenstein

Mr. Loebenstein, a physical scientist with 19 years of industry and U.S. Bureau of Mines experience, has been the commodity specialist for platinum-group metals for 13 years. Domestic survey data were prepared by Evangeline Hemphill, statistical assistant; and international data tables were prepared by Harold Willis, international data coordinator.

Ore containing the platinum-group metals (PGM) was mined, concentrated, and smelted in Montana, and the resultant PGM matte was exported to Belgium for refining and separation of the individual PGM. In addition, PGM were recovered as byproducts of copper refining by two companies in Texas and Utah. Domestic mine production of PGM was valued at \$47 million in 1993.

Secondary metal was refined by about 20 firms, mostly on the east and west coasts. About 4,800 kilograms (kg) of PGM was refined from scrap on a nontoll basis. The quantity of toll-refined secondary was 13 times larger, amounting to about 61,000 kg.

PGM were sold by at least 90 processors and dealers, largely in the northeast, and were used primarily in the automotive, electrical/electronic, dental/medical, chemical, jewelry, and petroleum refining industries. The automotive, chemical, and petroleum-refining industries used PGM mainly as catalysts. The other industries used them in a variety of ways that took advantage of their chemical inertness and refractory properties.

Dealer prices for iridium, rhodium, and ruthenium continued to decline in 1993, while prices for palladium and platinum increased somewhat. The annual average price for rhodium, \$1,066 per troy ounce, was the lowest since 1989.

PGM were mined in at least 10 countries in 1993; production was dominated by the Republic of South Africa, which accounted for 60% of the world total, and Russia, which accounted for 30%. Platinum and palladium

amounted to 49% and 42%, respectively, of all PGM mined, and the other four metals—iridium, osmium, rhodium, and ruthenium—together amounted to 9%.

Identified world PGM resources at yearend 1993 were estimated jointly by the U.S. Geological Survey and U.S. Bureau of Mines (USBM) at 100 million kg. The reserve base was estimated by the USBM at 66 million kg and reserves at 56 million kg. Of the reserve base and the reserves, the Republic of South Africa had nearly 90% of each; Russia had 9 and 11%, respectively; and the United States had 1% and 0.4%, respectively.

DOMESTIC DATA COVERAGE

Domestic production data for PGM are developed by the USBM from a voluntary survey of U.S. refiners. Of the 13 refiners to which a survey request was sent, 8 responded. These respondents represent 62% of the total refined metal production shown in tables 1 and 2. Production for nonrespondents was estimated using prior-year levels adjusted for general industry trends. (See tables 1 and 2.)

ANNUAL REVIEW

Strategic Considerations

Although some platinum and palladium were produced at the only PGM mine in the United States, the Stillwater Mine, the great majority of PGM consumed in the United States was imported.

Inventories of platinum, palladium, and iridium in the National Defense Stockpile remained unchanged in 1993, as

shown in table 1. No purchases of rhodium or ruthenium were made, even though there are unmet stockpile goals for these two metals.

Consumption and Uses

Reported sales of PGM by refiners is shown in table 3. For comparison, the calculated apparent consumption of the individual PGM also is shown. (See table 3.)

Automotive demand for platinum, palladium, and rhodium was estimated on the basis of 10.4 million automobiles and light trucks produced in 1993, the quantities and proportions of the three metals differing from model to model. While the trend toward palladium-only autocatalysts—reportedly suitable only for smaller vehicles—continued, most autocatalysts still contained all three metals or a combination of platinum and rhodium.

Federal standards require that medium-duty trucks, beginning with model year 1994, be fitted with catalysts. International Catalyst Technology Inc., a joint subsidiary of Degussa (Germany) and Nippon Shokubai (Japan), started production of diesel catalysts for the North American market in Calvert City, KY, at a rate of 3 million catalyst units per year. Engelhard Corp., in Huntsville, AL, and Johnson Matthey PLC, in Wayne, PA, also produced diesel catalysts. (See table 4.)

Markets and Prices

There was some tightness in the world palladium market because of greater

demand by the automotive and electronics industries. The average annual dealer price for palladium rose \$33, to \$120 per troy ounce. In contrast, average monthly dealer prices for rhodium declined substantially, dropping below \$1,000 per ounce for 7 months of the year.¹ The average annual dealer price was \$1,066, thus remaining more than \$1,000 per ounce for the eighth consecutive year. The world supply of rhodium exceeded demand significantly for the second consecutive year despite a 16% increase in world autocatalyst demand.²

Foreign Trade

U.S. imports of palladium rose 29% in 1993. U.S. exports of palladium rose 48%, spurred by higher demand for palladium for use in automobile catalysts in Europe and for dental and electrical uses in Japan. (See tables 5 and 6.)

World Review

North American Palladium Ltd. (formerly Madeline Mines) started up its open pit PGM mine, 81 kilometers north of Thunder Bay, Ontario, Canada. At full production in 1994, the mine was expected to yield 3,100 kg of palladium and 230 kg of platinum annually.³

In the Republic of South Africa, Rustenburg Platinum Mines Ltd., in response to weak platinum demand, closed its Boschfontein shaft, a move that reduced its platinum production by about 8,000 kg. The mine reportedly was a high-cost producer. Also, Rustenburg brought the open pit Potgietersrust Mine on-stream. The mine reportedly is one of the lowest cost producers in the industry. Initial annual production was projected at 5,300 kg of platinum, 5,100 kg of palladium, and 400 kg of rhodium, along with subsidiary copper, gold, and nickel. (See table 7.)

Current Research

A new alloy of palladium, ruthenium, and zirconium having extraordinary wear characteristics was developed at the Paffenbarger Research Center, National

Institute of Standards and Technology, in Gaithersburg, MD.⁴ The patent for the new alloy is held by the American Dental Association Health Foundation, sponsor of the research. The alloy has no known toxic reactions with human tissue and is strong enough to be used surgically for tooth, hip, and knee implants. It also could be used as an industrial coating for high-performance bearings and mechanical joints.

OUTLOOK

Future demand for PGM is expected to continue to grow worldwide, given the strong demand for a cleaner environment. Catalytic converters for controlling emissions from gasoline-powered automobiles are currently used in Australia, Canada, Japan, Mexico, the Republic of Korea, Taiwan, the United States, and several Western European nations. Brazil, Hong Kong, Indonesia, Malaysia, Singapore, and Thailand are expected to start using catalytic converters in the very near future. The potential market for the catalytic converter is huge—there are 500 million motor vehicles worldwide. The use of palladium is growing because the wider use of cleaner, lead-free fuels permits its use as a substitute for more expensive platinum. However, platinum will probably continue to remain the dominant metal in catalytic converters for some time in the future. The advantage in price that palladium has over platinum is somewhat negated by the necessity of using as much as three times more palladium than platinum to achieve the desired reduction in emissions.

The world market for diesel catalysts, now \$30 million to \$40 million per year, is expected to double by 1998.

In the United States, California has for years had the most stringent automobile emission regulations, setting the tone for Federal standards. California will require that 2% of new vehicles sold in the State in 1998 be "zero-emission" vehicles. The percentage is scheduled to increase to 5% in 2001, and to 10% in 2003. Electric vehicles are being studied as a way to meet the zero-emissions requirement.

¹U.S. Bureau of Mines. *Platinum-Group Metals in the Fourth Quarter 1993*. 7 pp.

²Cowley, A. *Platinum 1994*. Johnson Matthey PLC, London, England, p. 47.

³Skilling's Mining Review. *North American Palladium Now Starting up Its Lac Des Iles Mine After Lengthy Delay*. Sept. 11, 1993, pp. 4-6.

⁴American Society of Metals (ASM) News. *New Dental/Medical Alloy Shows Unexpected Wear Potential*. Oct. 1993, p. 5.

OTHER SOURCES OF INFORMATION

Bureau of Mines Publication

Platinum-Group Metals. Ch. in *Mineral Commodity Summaries*, annual.

Other Sources

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Cowley, A. *Platinum 1994*. Publ. by Johnson Matthey PLC, London, England. 52 pp.; available from Donley Communications, New York, NY; Telephone: (212) 751-6126. *Metals Week*.

TABLE 1
SALIENT PLATINUM-GROUP METALS¹ STATISTICS

(Kilograms)

	1989	1990	1991	1992	1993
United States:					
Mine production: ²					
Platinum	1,430	1,810	1,730	1,840	1,800
Palladium	4,850	5,930	6,050	6,470	6,500
Value ³ thousands	\$45,764	\$48,911	\$37,558	\$39,157	\$46,699
Refinery production:					
Primary refined	339	64	216	W	W
Secondary:					
Nontoll-refined	3,933	5,819	4,806	5,327	4,837
Toll-refined	46,253	65,429	67,543	58,982	60,955
Total refined metal	50,525	71,312	72,564	64,309	65,792
Stocks, yearend:					
Industry (refined)	32,543	30,324	24,313	26,946	20,199
National Defense Stockpile:					
Platinum	14,079	14,079	14,079	14,079	14,079
Palladium	39,334	39,334	39,334	39,334	39,334
Iridium	920	920	920	920	920
Exports:					
Refined ⁵	23,082	20,148	27,401	31,060	43,798
Total	38,301	55,044	39,624	57,830	78,521
Imports for consumption: ⁶					
Refined ⁵	111,107	120,631	121,741	129,419	148,790
Total	113,278	125,354	125,661	132,006	153,165
Consumption (reported sales to industry)	78,483	77,487	62,597	66,801	60,272
Consumption, apparent ⁷	101,209	117,043	111,798	109,469	123,273
Net import reliance ⁸ as a percent of apparent consumption	90	88	90	87	91
Price, dealer, average, per ounce:					
Platinum	\$507	\$467	\$371	\$356	\$370
Palladium	\$144	\$114	\$87	\$87	\$120
Iridium	\$303	\$307	\$283	\$158	\$47
Osmium	\$549	\$416	\$400	\$400	\$400
Rhodium	\$1,300	\$3,565	\$3,739	\$2,365	\$1,066
Ruthenium	\$62	\$61	\$55	\$29	\$13
World: Mine production	281,629	291,015	288,343	281,438	250,718

¹Estimated. ²Revised. W Withheld to avoid disclosing company proprietary data.

³The platinum group comprises six metals: platinum, palladium, iridium, osmium, rhodium, and ruthenium.

²Estimates for the Stillwater Mine are from published sources. A very small quantity of byproduct platinum and palladium produced from gold-copper ores was excluded.

³Value based on dealer prices.

⁴Data do not add to total shown because of independent rounding.

⁵Excludes ores and scrap.

⁶Quantities for general imports and imports for consumption are identical.

⁷Includes mine production plus nontoll-refined production plus refined imports for consumption minus refined exports plus or minus changes in Government and industry stocks.

⁸Refined imports for consumption minus refined exports plus or minus changes in Government and industry stocks.

TABLE 2
PLATINUM-GROUP METALS REFINED IN THE UNITED STATES

(Kilograms)

	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total ¹
PRIMARY METAL							
Nontoll-refined:							
1989	47	289	2	—	—	2	339
1990	2	62	—	—	—	—	64
1991	11	205	—	—	—	—	216
1992	W	W	—	—	—	—	W
1993	W	W	—	—	—	—	W
SECONDARY METAL							
Nontoll-refined:							
1989	1,134	2,664	6	—	94	35	3,933
1990	1,928	3,672	7	—	178	34	5,819
1991	2,200	2,297	81	—	215	13	4,806
1992	² 2,133	² 2,903	(³)	—	(³)	(³)	³ 5,327
1993	2,521	2,184	(³)	—	(³)	(³)	4,837
Toll-refined:							
1989	24,058	20,037	219	1	1,565	373	46,253
1990	38,475	23,297	130	—	3,094	433	65,429
1991	39,394	24,045	128	4	3,080	891	67,543
1992	² 27,001	² 27,547	(³)	(³)	(³)	³ 1,325	³ 58,982
1993	<u>30,553</u>	<u>26,053</u>	<u>(³)</u>	<u>(³)</u>	<u>(³)</u>	<u>1,109</u>	<u>60,955</u>
1992 TOTALS¹							
Total primary	W	W	—	—	—	—	W
Total secondary	<u>²29,134</u>	<u>²30,449</u>	<u>(³)</u>	<u>(³)</u>	<u>³3,218</u>	<u>³1,325</u>	<u>³64,309</u>
Total refined metal	<u>²29,134</u>	<u>²30,449</u>	<u>(³)</u>	<u>(³)</u>	<u>³3,218</u>	<u>³1,325</u>	<u>³64,309</u>
1993 TOTALS¹							
Total primary	W	W	—	—	—	—	W
Total secondary	<u>33,074</u>	<u>28,237</u>	<u>(³)</u>	<u>(³)</u>	<u>3,167</u>	<u>1,109</u>	<u>65,792</u>
Total refined metal	<u>33,074</u>	<u>28,237</u>	<u>(³)</u>	<u>(³)</u>	<u>3,167</u>	<u>1,109</u>	<u>65,792</u>

¹Revised. W Withheld to avoid disclosing company proprietary data.

²Data may not add to totals shown because of independent rounding.

³Withheld to avoid disclosing company proprietary data; included in "Total."

⁴Withheld to avoid disclosing company proprietary data; included in "Total" and "Total refined metal."

TABLE 3
PLATINUM-GROUP METALS¹ SOLD TO CONSUMING INDUSTRIES IN THE UNITED STATES

(Kilograms)

Year and industry	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total ²
1989:							
Reported	33,698	39,273	400	57	3,019	2,037	78,483
Apparent consumption ³	47,035	45,299	604	30	6,112	2,129	101,209
1990:							
Reported	36,055	35,116	448	40	4,187	1,641	77,487
Apparent consumption ³	49,875	51,464	649	56	12,314	2,685	117,043
1991:							
Reported	31,112	25,747	359	30	3,778	1,571	62,597
Apparent consumption ³	44,385	57,521	600	44	6,964	2,285	111,798
1992:							
Automotive ⁴	20,503	2,930	—	—	2,930	—	26,363
Chemical	1,716	1,916	44	—	157	181	4,015
Dental and medical	635	5,085	111	40	1	11	5,883
Electrical	2,865	13,318	258	—	73	2,344	18,858
Glass	360	126	—	—	15	8	509
Jewelry and decorative	905	798	25	—	196	27	1,951
Petroleum	1,036	750	—	—	—	42	1,828
Miscellaneous	3,225	3,600	5	1	558	4	7,394
Total ²	31,245	28,523	444	41	3,930	2,617	66,801
Apparent consumption ³	45,606	54,485	207	-19	6,873	2,317	109,469
1993:							
Automotive ⁴	19,446	5,001	—	—	5,123	—	29,570
Chemical	(⁵)	(⁵)	(⁵)	—	(⁵)	W	(⁵)
Dental and medical	(⁵)	5,147	(⁵)	W	(⁵)	W	5,978
Electrical	(⁵)	9,454	(⁵)	—	(⁵)	W	11,962
Glass	(⁵)	(⁵)	(⁵)	—	(⁵)		(⁵)
Jewelry and decorative	1,179	914	(⁵)	—	160	W	2,338
Petroleum	(⁵)	(⁵)	(⁵)	—	(⁵)	W	(⁵)
Miscellaneous	2,675	880	W	—	578	W	4,133
Total	29,801	23,837	528	W	6,106	W	60,272
Apparent consumption ³	47,023	64,815	955	219	(⁵)	(⁵)	123,273

²Revised. W Withheld to avoid disclosing company proprietary data.

³Comprises primary and nontoll-refined secondary metals.

⁴Data may not add to totals shown because of independent rounding.

⁵Defined as mine production plus nontoll production of secondary metal plus refined imports minus refined exports plus beginning stocks minus ending stocks. Export data for iridium, osmium, and ruthenium are not available separately; in this calculation, the collective export figure was assigned to ruthenium.

⁶1989-93 platinum, palladium, and rhodium sales to the automotive industry are estimated based on U.S. light truck sales and U.S. automobile production.

⁷Withheld to avoid disclosing company proprietary data; included in "Total."

TABLE 4
REFINER, IMPORTER, AND DEALER STOCKS OF REFINED PLATINUM-GROUP
METALS¹ IN THE UNITED STATES, DECEMBER 31

(Kilograms)

Year	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1989	14,791	15,182	522	36	1,096	916	32,543
1990	13,421	14,425	483	55	1,089	851	30,324
1991	10,349	12,263	483	46	318	854	24,313
1992	14,187	10,641	W	122	364	W	26,946
1993	10,263	8,324	W	42	134	W	20,199

W Withheld to avoid disclosing proprietary data; included in "Total."

¹Includes metal in depositories of the New York Mercantile Exchange (NYMEX); on Dec. 31, 1993; this comprised 3,524 kilograms of platinum and 1,148 kilograms of palladium.

TABLE 5
U.S. EXPORTS OF PLATINUM-GROUP METALS, BY YEAR AND COUNTRY

Year and country	Platinum (kilo- grams)	Palladium (kilo- grams)	Rhodium (kilo- grams)	Iridium, osmium, ruthenium (kilo- grams)	Ores and concentrates (kilo- grams)	Waste and scrap (kilo- grams)	Total ¹	
							Quantity (kilograms)	Value (thousands)
1992	12,103	17,701	836	420	488	26,279	57,830	\$382,016
1993:								
Australia	79	99	—	—	—	1	179	1,017
Belgium	2,066	5,744	—	—	—	11,999	19,808	60,888
Brazil	3	3	—	—	—	3	10	92
Canada	569	1,260	14	18	—	4,144	6,005	27,243
China	—	—	22	—	—	16	38	1,109
France	227	304	2	1	32	298	864	7,996
Germany	625	296	—	62	—	1,788	2,770	13,687
Hong Kong	131	20	20	8	—	14	193	2,400
Italy	51	677	—	—	4	804	1,536	9,038
Japan	5,555	4,907	313	424	—	3,204	14,403	130,861
Korea, Republic of	888	217	1	3	5	—	1,114	10,925
Netherlands	44	2,776	319	—	47	6	3,191	19,606
Russia	—	—	—	23	—	—	23	231
Singapore	7	898	—	7	—	—	912	2,736
Sweden	59	104	—	—	—	369	532	2,388
Switzerland	3,213	4,352	—	66	—	1	7,632	68,006
Taiwan	8	1,944	—	2	6	—	1,960	6,091
United Kingdom	1,948	2,063	16	26	—	11,974	16,026	66,711
Other	673	578	60	3	4	7	1,325	10,028
Total	16,146	26,242	767	643	98	34,628	78,521	441,053

¹Revised.

¹Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF PLATINUM-GROUP METALS, BY YEAR AND COUNTRY

Year and country	Platinum (kilo-grams)	Palladium (kilo-grams)	Rhodium (kilo-grams)	Ruthenium (kilo-grams)	Iridium (kilo-grams)	Osmium (kilo-grams)	Waste and scrap (kilo-grams)	Ores (kilo-grams)	Total	
									Quantity (kilograms)	Value (thousands)
1992	¹ 57,573	61,093	7,753	2,736	207	57	2,587	—	¹ 132,006	\$1,483,680
1993:										
Australia	577	—	—	—	—	—	308	—	885	9,641
Belgium	3,054	11,096	246	—	—	—	—	—	14,396	88,798
Canada	631	2,242	—	7	2	—	278	41	3,201	20,510
Columbia	2,335	(²)	—	—	—	—	—	—	2,335	19,186
France	(²)	(²)	23	—	—	—	585	—	608	2,884
Germany	1,726	3,424	170	374	109	1	(²)	1	5,805	40,919
Hong Kong	(²)	—	—	—	—	—	369	—	369	2,562
Italy	551	109	36	—	—	—	74	—	770	9,084
Japan	583	2,813	34	—	—	—	28	—	3,458	19,325
Mexico	14	20	3	—	—	—	1,109	—	1,146	12,276
Netherlands	(²)	63	199	—	—	—	12	—	274	9,003
Norway	440	627	43	—	—	—	11	—	1,121	7,952
Russia	4,428	21,367	2,033	16	(²)	—	4	—	27,848	205,175
South Africa, Republic of	31,836	22,906	3,784	3,591	675	126	—	—	62,918	629,500
Switzerland	3,781	1,080	377	84	17	—	—	—	5,339	64,445
Taiwan	(²)	509	—	—	—	—	212	—	721	5,570
United Kingdom	6,693	12,139	228	416	93	3	1,172	—	20,744	154,280
Other	547	480	29	—	—	—	171	—	1,227	9,785
Total	³ 57,196	78,875	7,205	4,488	896	130	4,333	42	³ 153,165	1,310,895

¹Of this amount, 2,544 kilograms was in the form of platinum coins.

²Less than 1/2 unit.

³Of this amount, 967 kilograms was in the form of platinum coins.

Sources: Bureau of the Census and U.S. Bureau of Mines.

TABLE 7
PLATINUM-GROUP METALS: WORLD PRODUCTION, BY COUNTRY¹

(Kilograms)

Country ²	1989	1990	1991	1992	1993*
Australia, metal content, from domestic nickel ore:³					
Platinum	100	100	100	100	100
Palladium	400	400	400	400	400
Canada:⁴					
Platinum*	4,467	5,044	4,683	¹ 4,800	5,500
Palladium*	4,676	5,269	6,439	¹ 5,800	6,900
Other*	1,246	1,396	586	¹ 1,307	1,407
Total	10,389	11,709	11,708	¹ 11,907	¹ 13,807
Colombia: Placer platinum	973	1,316	1,603	¹ 1,956	2,000
Ethiopia: Placer platinum* ⁶	2	2	1	1	1
Finland:⁸					
Platinum	60	60	60	60	60
Palladium	100	100	100	100	100
Japan, metal recovered from nickel-copper ores:⁷					
Platinum	1,031	1,425	988	¹ 629	660
Palladium	821	1,047	1,053	¹ 986	1,200
Russia: Placer platinum and platinum-group metals recovered from nickel-copper ores:⁹					
Platinum	—	—	—	28,000	20,000
Palladium	—	—	—	¹ 70,000	50,000
Other	—	—	—	¹ 6,000	4,000
Serbia and Montenegro:⁹					
Platinum	—	—	—	¹ 10	10
Palladium	—	—	—	¹ 60	50
South Africa, Republic of: Platinum-group metals from platinum ore:⁴ ¹⁰					
Platinum*	82,884	87,813	88,861	¹ 94,891	92,000
Palladium*	35,800	38,300	38,000	¹ 41,000	41,000
Other*	15,000	15,800	16,000	17,000	17,000
Total	133,684	141,913	142,861	¹ 152,891	150,000
U.S.S.R.: Placer platinum and platinum-group metals recovered from nickel-copper ores:⁹ ¹¹					
Platinum	32,000	31,000	30,000	—	—
Palladium	85,000	84,000	82,000	—	—
Other	10,500	10,000	9,500	—	—
United States: Platinum-group metals from palladium ores:⁹ ¹²					
Platinum	1,430	1,810	1,730	1,840	1,800
Palladium	4,850	5,930	6,050	6,470	6,500
Yugoslavia:⁹ ¹³					
Platinum	23	21	¹ 22	—	—
Palladium	199	130	¹ 120	—	—
Zimbabwe:					
Platinum	25	21	19	¹ 9	10
Palladium	43	31	30	¹ 19	20
Grand total ¹⁴	281,629	291,015	¹ 288,343	¹ 281,438	250,718

See footnotes at end of table.

TABLE 7—Continued
PLATINUM-GROUP METALS: WORLD PRODUCTION, BY COUNTRY¹

(Kilograms)

Country ²	1989	1990	1991	1992	1993 ³
Grand total ¹⁴ —continued:					
Of which:					
Platinum	122,994	128,611	¹ 128,065	¹ 132,296	122,141
Palladium	131,889	135,207	134,192	¹ 124,835	106,170
Other	26,746	27,196	26,086	² 24,307	22,407

¹Estimated. ²Revised.

³Table includes data available through May 25, 1994. Platinum-group metal production by Germany (Western states), Norway, and the United Kingdom is not included in this table because the production is derived wholly from imported metallurgical products and to include it would result in double counting.

⁴In addition to the countries listed, China, Indonesia, Papua New Guinea, and the Philippines are believed to produce platinum-group metals, and several other countries may also do so, but output is not reported quantitatively, and there is no reliable basis for the formulation of estimates of output levels. However, a part of this output not specifically reported by country is presumably included in this table credited to Japan. (See footnote 7).

⁵Partial figure; excludes platinum-group metals recovered in other countries from nickel ore of Australian origin; however, a part of this output may be credited to Japan. (See footnote 7).

⁶Unless otherwise indicated, data show estimated proportions of platinum, palladium, and other platinum-group metals within the reported total.

⁷Reported preliminary estimate.

⁸Data are for years ending July 7 of the years listed.

⁹Japanese figures do not refer to Japanese mine production, but rather represent Japanese smelter-refinery recovery from ores originating in a number of countries; this output cannot be credited to the country of origin because of a lack of data. Countries producing and exporting such ores to Japan include (but are not necessarily limited to) Australia, Canada, Indonesia, Papua New Guinea, and the Philippines. Output from ores of Australian, Indonesian, Papua New Guinean, and Philippine origin are not duplicative, but output from Canadian material might duplicate a part of reported Canadian production.

¹⁰All production in the U. S. S. R. from 1989-91 came from Russia.

¹¹All production in Yugoslavia from 1989-91 came from Serbia and Montenegro.

¹²Includes osmiridium produced in gold mines.

¹³Dissolved in Dec. 1991.

¹⁴Estimates for the Stillwater Mine, from published sources. A very small quantity of byproduct platinum and palladium produced from gold-copper ores was excluded.

¹⁵Dissolved in Apr. 1992.

¹⁶Data may not add to totals shown because of independent rounding.

