DIAMOND, INDUSTRIAL

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Diamond is best known for its gem qualities, but some of its unique properties make it ideal for many industrial and research applications as well. Current information on gem-grade diamond can be found in the U.S. Geological Survey minerals yearbook chapter on gemstones. Diamond is the hardest known material and has the highest thermal conductivity of any material at room temperature (May, 1995). Diamond is more than twice as hard as cubic boron nitride or silicon nitride, which are the nearest competitors (Ravi, 1994, p. 537). Because it is the hardest substance known, diamond has been used for centuries as an abrasive in grinding, drilling, cutting, and polishing, and industrial-grade diamond continues to be used as an abrasive for many applications. Diamond that does not meet gem-quality standards for clarity, color, shape, or size is used as industrial-grade diamond. Even though it has higher unit cost, diamond has proven to be more cost effective in many industrial processes because it cuts faster and lasts longer than its rival abrasive materials (Boucher, 1997, p. 26.6). Diamond also has chemical, electrical, optical, and thermal characteristics that make it the best material available to industry for wear- and corrosion-resistant coatings, special lenses, heat sinks in electrical circuits, wire drawing, and advanced technologies.

Both synthetic and natural diamonds have industrial uses, but synthetic industrial diamond is superior to its natural counterpart because it can be produced in large quantities. In many cases, its properties can be tailored to specific applications (Boucher, 1996). It is for these reasons that manufactured diamond accounts for more than 90% of the industrial diamond used in the United States and the world.

Legislation and Government Programs

Congress has authorized the sale of all the diamonds in the National Defense Stockpile (NDS), which is managed by the Department of Defense (DOD). The NDS 2000 annual plan allowed for the sale of a portion of the stockpiled diamond stones. During 2000, the Defense National Stockpile Center (DNSC) sold 989,140 carats of diamond stone (valued at $33.44 million). At yearend 2000, the DNSC reported an NDS remaining inventory of about 1.508 million carats of industrial diamond stone valued at $15.08 million (Defense National Stockpile Center, 2000a, 2000b). The DOD plans to conduct additional future sales until all NDS diamond stone stocks are exhausted. Further NDS information is available in the “Prices” section of this report.

Production

The U.S. Geological Survey conducts an annual survey of domestic industrial diamond producers and U.S. firms that recover diamond wastes. Although most of these companies responded to the 2000 survey, a few significant firms withheld certain data that they deemed confidential. Thus, only estimates of U.S. primary and secondary output are provided in this review.

Industrial Diamond in the 20th Century

The utilitarian role of diamond was confined to lapidary products until industrialization created the first demand for diamond as an industrial tool for precision cutting and as abrasive material set in saw blades and drill bits. Few statistical data are available on abrasive diamond prior to 1911, when the United States imported $110,434 in diamond dust and bort, primarily from South Africa. After World War I, with the development of cemented carbide cutting tools, diamond was found to be the most effective medium for finishing and grinding the new ultrahard metal. This discovery rapidly increased the demand for industrial diamond. There was almost no U.S. diamond production until the early 1930s, when a relatively small diamond deposit near Murfreesboro, AR, was developed. By 1937, about two-thirds, by weight, of all diamond sold each year was used for abrasive purposes, and U.S. imports of abrasive diamond, primarily from South Africa and Brazil, were valued at just under $7 million. World War II, with its increased use of hard-metal tools in the munitions industry, further increased the demand for industrial diamond.

In 2000, synthetic diamond accounted for more than 90% of the industrial diamond market. The United States was the world’s largest market for industrial diamond, as well as the largest producer of synthetic industrial diamond, with estimated production of 248 million carats. In 2000, U.S. imports of an estimated 293 million carats of industrial diamond stone, bort, grit, dust, and powder, primarily from Belgium, Ireland, Switzerland, and the United Kingdom, were valued at about $125 million. In 1955, General Electric Co. announced that its laboratories had succeeded in manufacturing synthetic diamond from carbonaceous material. Economic commercial production of synthetic industrial diamond was achieved by the early 1960s. The manufacture and use of synthetic diamond steadily increased. By the end of the 1960s, domestic production of synthetic industrial diamond had increased to 13 million carats per year, and by the early 1980s, production had reached 57 million carats per year. In 2000, synthetic industrial diamond could be made in a relatively short time, and its performance in specific end-use applications exceeded that of natural diamond.

As one of the world's leading producers of synthetic industrial diamond, the United States accounted for an estimated output of 248 million carats in 2000. Only two U.S. companies produced synthetic industrial diamond during the year—Mypodiamond, Inc., Gibbstown, NJ, and GE Superabrasives, Worthington, OH. General Electric Co., Fairfield, CT, which owns GE Superabrasives and other diamond manufacturing plants abroad, is one of the world's largest producers of industrial diamond.

In 2000, nine firms also manufactured polycrystalline diamond (PCD) from synthetic diamond grit and powder. These companies were the Dennis Tool Co., Houston, TX; GE Superabrasives, Worthington, OH; Novatek Inc., Provo, UT; Phoenix Crystal Corp., Ann Arbor, MI; Precorp Inc., Provo, UT; SII Megadiamond Industries Inc., Provo, UT; Tempo Technology Corp., Somerset, NJ; U.S. Synthetic Corp., Orem, UT; and Western Diamond Products, Salt Lake City, UT.

It is estimated that more than 10.1 million carats of used industrial diamond were recycled in the United States during 2000. Most of this material was recovered by recycling firms from used diamond drill bits, diamond tools, and other diamond-containing wastes. Additional diamond was recovered during the year from residues generated in the manufacture of PCD; most of this material was recovered for PCD from within the production operations of the PCD producing companies (Wilson Born, National Research Company, oral commun., 2001).

The recovery and sale of industrial diamond was the principal business of four U.S. companies in 2000: Industrial Diamond Laboratory Inc., Bronx, NY; Industrial Diamond Powders Co., Pittsburgh, PA; International Diamond Services Inc., Houston, TX; and National Research Company, Fraser, MI. In addition to these companies, other domestic firms may have recovered industrial diamond in smaller secondary operations.

Consumption

The United States remained the world's largest market for industrial diamond in 2000. Based on production estimates and trade data, the apparent U.S. consumption of industrial diamond during the year increased to an estimated 484 million carats, which was a record high. This growth primarily reflects expanded output in many domestic industries where diamond is used. The major consuming industries of industrial diamond in the United States during 2000 were construction, machinery manufacturing, mining services (drilling), stone cutting/polishing, and transportation systems (infrastructure and vehicles). Within these sectors, stone cutting and highway building/repair together made up the largest demand for industrial diamond. The manufacture of every automobile made in the United States consumes 1.5 carats of industrial diamond. Research and high technology uses included close-tolerance machining of ceramic parts for the aerospace industry, heat sinks for electronic circuits, lenses for laser radiation equipment, and polishing silicon wafers and disk drives in the computer industry (Bailey and Bex, 1995).

Diamond tools have myriad industrial functions. Diamond drilling bits and reaming shells are used principally for gas, mineral, and oil exploration. Other applications of diamond bits and reaming shells include foundation testing, masonry drilling, and inspecting concrete in various structures. The primary uses of point diamond tools are for dressing and truing grinding wheels and for cutting, machining, boring, and finishing; beveling glass for automobile windows is another application. Cutting dimension stone and cutting/grooving concrete in highway reconditioning are the major uses of diamond saws; other applications include cutting composites and forming refractory shapes for furnace linings. Very fine diamond saws are used to slice brittle metals and crystals into thin wafers for electronic and electrical devices. Diamond wire dies are essential for high-speed drawing of fine wire, especially from hard, high-strength metals and alloys. The primary uses of diamond grinding wheels include edging plate glass, grinding dies, grinding parts for optical instruments, and sharpening and shaping carbide machine tool tips.

Two types of natural diamond are used by industry: diamond stone (generally larger than 60 mesh/800 microns) and diamond bort (smaller, fragmented material). Diamond stone is employed primarily in drilling bits and reaming shells used by mining companies; it also is incorporated in single- or multiple-point diamond tools, diamond saws, diamond wheels, and diamond wire dies. Diamond bort is used for drilling bits and as a loose grain abrasive for polishing. Other tools that incorporate natural diamond include engraving points, glass cutters, bearings, and surgical instruments.

Synthetic diamond grit and powder are used in diamond grinding wheels, saws, impregnated bits and tools, and as loose abrasive compounds for polishing. Diamond grinding wheels can be as much as 1 meter in diameter.

Loose powders and compounds made of synthetic diamond for polishing are used primarily to finish optical surfaces, jewel bearings, gemstones, wiredrawing dies, cutting tools, and silicon wafers for computer chips. Hundreds of other products made from metals, ceramics, plastics, and glass also are finished with diamond powders and compounds.

The use of polycrystalline diamond shapes (PDS) and polycrystalline diamond compacts (PDC) continues to increase for many of the applications cited above, including some of those that employ natural diamond. The use of PDS, PDC, and matrix-set synthetic diamond grit for drilling bits and reaming shells has increased in recent years. PDS and PDC are used in the manufacture of single- and multiple-point tools, and PDC is used in a majority of the diamond wire-drawing dies.

Prices

Natural and synthetic industrial diamonds differ significantly in price (Boucher, 1997, p. 26.6). Natural industrial diamond normally has a more limited range of values. Its price varies from about $0.45 per carat for bort-size material to about $7 to $25 per carat for most stone. Synthetic industrial diamond has a much larger range of prices than natural diamond. Prices of synthetic diamond vary according to size, shape, crystallinity, and the absence or presence of metal coatings. In general, synthetic diamond prices for grinding and polishing range from as low as $0.10 per carat to $0.95 per carat. Strong and blocky material for sawing and drilling sells for $1.50 to $4.75 per carat. Large synthetic crystals with excellent structure for specific applications sell for several hundred dollars per carat.

In 2000, the DNSC had awarded bids that ranged from $1.44 to $151.00 per carat for NDS diamond stone sold, with the average awarded bid being $33.80 per carat (Defense National Stockpile Center, 2000a, b).

Foreign Trade

The United States continued to lead the world in industrial diamond trade during 2000; imports came from 36 countries (tables 1, 2), and exports/reexports went to 55 countries (tables 3, 4). Although the United States has been a major producer of synthetic diamond for decades, its growing domestic markets have become more reliant on foreign sources of industrial diamond in recent years. U.S. markets for natural industrial diamond always have been dependent on imports and secondary recovery operations, because domestic production of natural diamond was unable to meet demand.

During 2000, U.S. imports of industrial quality diamond stones (natural and synthetic) decreased by 20% from 1999 imports to 2.52 million carats valued at $13.4 million (table 1). Imports of diamond powder, dust, and grit (natural and synthetic) increased by 39% from 1999 imports to 291 million carats valued at $111 million (table 2).

During 2000, U.S. exports and reexports of industrial diamond stone decreased by approximately 9% from 1999 exports and reexports to 3.62 million carats valued at $34.6 million (table 3). Additionally, U.S. exports and reexports of industrial diamond powder, dust, and grit decreased slightly from 1999 exports and reexports to 100 million carats valued at $71.8 million (table 4). Reexports can account for a significant portion of total exports/reexports; therefore, exports and reexports are listed separately in tables 3 and 4 so that U.S. trade and consumption can be calculated more accurately.

World Review

Total industrial diamond output worldwide during 2000 was estimated to be well above 800 million carats; analyst reports estimated that global output, which was valued between $600 million and $1 billion, was at least 600 million carats (Norman Rohr, Warren Diamond Powder Co., Inc., oral commun., 1999; Wilson Born, National Research Company, oral commun., 2000). World demand for industrial diamond in the 1990s had been growing at rates of more than 10% per year (Boucher, 1997, p. 26.6).

Industrial diamond was produced in 30 countries during 2000 (tables 5, 6). In addition to the countries listed in table 6, Germany and the Republic of Korea produced synthetic diamond (Norman Rohr, Warren Diamond Powder Co., Inc., oral commun., 1999), but specific data on their output could not be confirmed. China may have produced much more than the output shown in the table (Owers, 2000; Wilson Born, National Research Company, oral commun., 2001).

In 2000, approximately 70% of the total global natural and synthetic industrial diamond output was produced in Ireland, Russia, and the United States. The dominance of synthetic diamond was even more pronounced, accounting for more than 90% of global production and consumption.

The Ekati Mine, Canada's first commercial diamond mine, completed its second full year of production. The Ekati Mine, located in the Northwest Territories, was a joint venture between BHP Diamonds Inc. (BHP) and Dia Met Minerals Ltd., but in June 2001, BHP purchased Dia Met Minerals Ltd. (BHP Diamonds Inc., 2001). Ekati has estimated reserves of 60.3 million metric tons (Mt) of ore in kimberlite pipes, containing 54.3 million carats of diamonds, and the mine life is projected to be 25 years. In 2000, Ekati produced 2.63 million carats (Luc Rombouts, Terraconsult bvba, May 2, 2001, Diamond annual review—2000, accessed June 19, 2001, at URL http://www.terraconsult.be/overview.htm). Approximately one-third of the Ekati diamond production is industrial-grade material (Darren Dyck, Senior Project Geologist, BHP Diamonds Inc., oral commun., May 27, 2001).

Two other Canadian commercial diamond mines located in the Northwest Territories are expected to commence diamond production in the first half of 2003. They are the Diavik diamonds project and the Snap Lake diamond project. Diavik has estimated reserves of 25.6 Mt of ore in kimberlite pipes, containing 102 million carats of diamonds, and the mine life is projected to be 20 years. Diavik is expected to produce about 102 million carats of diamond at a rate of 6 million carats per year worth about $63 per carat (Diavik Diamond Mines Inc., 2000, p. 10-12). The Snap Lake diamond project was acquired by De Beers Canada Mining Inc. from Winspear Diamonds Inc. and Aber Diamond Corporation in 2000. Snap Lake will be De Beers' first mine outside of southern Africa and the first underground diamond mine in Canada. Snap Lake has estimated reserves of 22.8 Mt of ore in a kimberlite dike, containing 38.8 million carats of diamonds, and the mine life is projected to be 20 years or more (De Beers Canada Mining Inc., 2000, Snap Lake diamond project fact sheet, accessed June 13, 2001, at URL http://www.debeerscanada.com/files_new/snap/infrastruct.html).

Diamond exploration is continuing in Canada, and many new deposits are being found. There have been additional discoveries in both the core and buffer zones of the Ekati lease. At least 35 kimberlites have been discovered in north-central Alberta, and 70 large kimberlites have been found in Saskatchewan. Additional discoveries have been made in Ontario and Quebec (Luc Rombouts, Terraconsult bvba, May 2, 2001, Diamond annual review—2000, accessed June 19, 2001, at URL http://www.terraconsult.be/overview.htm). When the Diavik and Snap Lake mines begin production, Canada will be producing at least 15% to 20% of the total world natural diamond production. This will make Canada a significant producer of natural industrial diamond, as well as of gem-quality diamond.

Outlook

The United States will continue to be the world's largest market for industrial diamond well into the next decade, and it will remain a significant producer and exporter of industrial diamond.

The strength of U.S. demand will depend on the vitality of the Nation's industrial base and on how well the life cycle cost effectiveness of diamond compares with competing materials that initially are less expensive. The many advantages that diamond offers for precision machining and longer tool life, which compensate for increases in other production line costs, seem certain to spur demand for diamond tools. In fact, even the use of wear-resistant diamond coatings to increase the life of materials that compete with diamond promises to be a rapidly growing application (May, 1995). Increased tool life not only leads to lower costs per unit of output but also means fewer tool changes and longer unattended production runs (Advanced Materials & Processes, 1998). In view of the many advantages that come from increased tool life and reports that diamond film surfaces can increase durability by a factor of 50 (Advanced Materials & Processes, 1998), much wider use of diamond as an engineering material is expected.

The most dramatic increase in U.S. demand for industrial diamond is likely to occur in the construction sector as the $200 billion Transportation Equity Act for the 21st Century (Public Law 105-178, enacted June 9, 1998) is further implemented. The act provides funding for building and repair of the Nation's highway system through 2003. Demand for saw-grade diamond alone is expected to increase by more than $1 billion during the coming year to fulfill goals mandated by the act for the repair and replacement of roads, bridges, and other components in the transportation infrastructure of the country (Wilson Born, National Research Company, oral commun., 2001).

According to industry sources, PCD for abrasive tools and wear parts will continue to replace competing materials in many industrial applications by providing closer tolerances, as well as extending tool life. For example, PDC and PDS will continue to displace natural diamond stone and tungsten carbide products used in the drilling and tooling industries (Wilson Born, National Research Company, written commun., 1998).

Truing and dressing applications will remain a major domestic end use for natural industrial diamond stone. The stone cannot be manufactured commercially. No shortage of the stone is anticipated, however, because new mines and more producers selling in the rough diamond market will maintain ample supplies. More competition introduced by the additional sources also may temper price increases.

World demand for industrial diamond will continue to increase during the next few years. Constant-dollar prices of synthetic diamond products, including chemical-vapor-deposition diamond films, will decline as production technologies become more cost-effective and competition increases from low-cost producers in China and Russia.

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TABLE 1

U.S. IMPORTS FOR CONSUMPTION OF INDUSTRIAL DIAMOND STONES, BY COUNTRY 1/

(Thousand carats and thousand dollars)

	Natural industrial diamond stones 2/				Miners' diamond, natural and synthetic 3/			
	1999		2000		1999		2000	
Country	Quantity	Value 4/	Quantity	Value 4/	Quantity	Value 4/	Quantity	Value 4/
Belgium	144	2,980	111	334	53	846	41	567
China	2	14	2	7	1	13	9	10
Congo (Kinshasa)	25	30	1	10	--	--	1	22
Ghana	159	672	67	292	49	772	57	352
India	4	27	33	46	--	--	(5/)	5
Ireland	203	594	322	757	1	23	31	94
South Africa	36	51	8	36	(5/)	10	1	71
Switzerland	3	48	5	76	676	1,170	691	940
United Kingdom	398	517	489	330	215	4,900	338	8,390
Other	835	1,300	117	499	328	343	198	521
Total	1,810	6,230	1,150	2,390	1,320	8,090	1,370	11,000

-- Zero.

1/ Data are rounded to no more than three significant digits; may not add to totals shown.

2/ Includes glazers' and engravers' diamond unset, Harmonized Tariff Schedule of the United States (HTS) codes 7102.21.3000 and 7102.21.4000.

3/ HTS codes 7102.21.1010 and 7102.21.1020.

4/ Customs value.

5/ Less than 1/2 unit.

Source: U.S. Census Bureau.

TABLE 2

U.S. IMPORTS FOR CONSUMPTION OF DIAMOND POWDER, DUST AND GRIT, BY COUNTRY 1/

(Thousand carats and thousand dollars)

	Synthetic 2/				Natural 2/			
	1999		2000		1999		2000	
Country	Quantity	Value 3/	Quantity	Value 3/	Quantity	Value 3/	Quantity	Value 3/
Belgium	2,130	1,580	1,890	946	4,500	3,730	6,400	4,440
China	33,500	6,040	37,700	5,220	227	173	3,140	281
France	--	--	20	27	--	--	--	--
Germany	75	58	2,390	3,320	78	81	144	69
Ghana	87	53	93	31	257	194	69	117
Hong Kong	217	121	1,550	161	--	--	--	--
India	1,820	519	2,240	585	1,350	393	1,150	394
Ireland	97,000	56,400	140,000	69,900	2,250	1,670	2,070	984
Japan	4,420	2,800	6,540	3,040	401	588	913	1,640
Korea, Republic of	9,860	6,460	11,000	6,640	11	6	--	--
Russia	5,220	1,180	6,230	1,330	23	4	62	16
Switzerland	3,570	3,020	3,300	1,780	1,520	1,090	1,840	1,250
United Kingdom	2,070	950	4,150	1,140	1,440	412	815	293
Other	34,300	4,450	56,900	7,420	2,230	293	390	403
Total	194,000	83,700	274,000	102,000	14,300	8,630	17,000	9,890

-- Zero.

1/ Data are rounded to no more than three significant digits; may not add to totals shown.

2/ Harmonized Tariff Schedule of the United States codes: synthetic, 7105.10.0020, 7105.10.0030, and 7105.10.0050; natural, 7105.10.0011 and 7105.10.0045.

3/ Customs value.

Source: U.S. Census Bureau.

TABLE 3
U.S. EXPORTS AND REEXPORTS OF INDUSTRIAL
DIAMOND STONES, BY COUNTRY 1/

(Thousand carats and thousand dollars)

	Industrial unworked diamonds 2/			
	1999		2000	
Country	Quantity	Value 3/	Quantity	Value 3/
Exports:				
Belgium	17	141	320	3,940
Canada	117	410	237	845
Germany	79	473	52	366
Hong Kong	5	41	50	504
Ireland	7	47	3	32
Israel	--	--	42	419
Italy	--	--	9	13
Japan	351	3,480	446	4,220
Korea, Republic of	80	713	64	649
Netherlands	1	12	1	14
Switzerland	12	118	10	100
United Kingdom	16	157	6	50
Other	61	491	320	2,150
Total	746	6,080	1,560	13,300
Reexports:				
Belgium	2,700	25,400	1,180	13,100
Canada	64	278	66	214
Germany	15	150	89	504
Hong Kong	12	123	10	48
Ireland	10	99	33	237
Israel	129	1,630	190	2,020
Japan	110	1,150	124	1,270
Korea, Republic of	92	833	75	787
Netherlands	4	43	2	23
Switzerland	1	7	256	2,700
United Kingdom	27	257	12	119
Other	57	580	26	240
Total	3,220	30,600	2,060	21,300
Grand total	3,970	36,700	3,620	34,600

-- Zero.
1/ Data are rounded to no more than three significant digits; may not add to totals shown.
2/ Harmonized Tariff Schedule of the United States code 7102.21.0000.
3/ Customs value.

Source: U.S. Census Bureau.

TABLE 4
U.S. EXPORTS AND REEXPORTS OF INDUSTRIAL DIAMOND POWDER, DUST, AND GRIT, BY COUNTRY 1/

(Thousand carats and thousand dollars)

	Synthetic 2/				Natural 2/			
	1999		2000		1999		2000	
Country	Quantity	Value 3/	Quantity	Value 3/	Quantity	Value 3/	Quantity	Value 3/
Exports:								
Australia	50	53	73	81	--	--	7	10
Austria	2,670	1,480	2,150	1,420	312	138	426	315
Belgium	1,430	827	1,690	841	237	157	273	284
Brazil	1,890	1,010	2,050	1,070	--	--	--	--
Canada	1,370	1,420	1,470	1,950	89	180	163	248
China	185	59	2	3	183	31	49	11
France	153	57	586	135	51	114	183	57
Germany	4,790	2,530	4,460	2,720	199	104	384	144
Hong Kong	482	395	882	540	147	52	102	125
India	3,230	1,180	1,400	564	104	56	11	3
Ireland	27,400	25,400	28,700	26,300	258	69	68	52
Israel	481	192	819	318	142	29	157	52
Italy	1,860	842	1,450	546	188	108	200	219
Japan	19,100	10,800	23,300	13,200	414	590	905	1,990
Korea, Republic of	12,100	5,920	13,100	6,630	969	445	262	165
Luxembourg	35	13	20	7	119	79	117	92
Macao	30	17	6	7	22	7	--	--
Malaysia	447	173	653	481	--	--	2	6
Mexico	1,020	840	429	218	66	73	133	78
Singapore	1,210	287	124	70	3	10	5	9
Switzerland	1,920	1,230	1,490	1,260	787	1,190	2,820	3,590
Taiwan	5,840	2,930	1,700	1,540	355	95	94	193
Thailand	368	210	133	96	24	23	2	4
United Kingdom	2,250	1,460	2,870	1,040	2,110	1,500	496	284
Other	1,180	693	979	804	137	125	509	437
Total	91,500	60,000	90,600	61,800	6,920	5,180	7,370	8,370
Reexports:								
Austria	--	--	156	29	--	--	55	11
Belgium	189	255	9	13	2	7	9	25
Bermuda	--	--	--	--	--	--	2	5
Canada	361	755	539	755	50	101	41	50
China	23	29	--	--	--	--	--	--
France	--	--	--	--	--	--	7	5
Germany	--	--	31	20	--	--	1	3
Hong Kong	337	347	130	49	--	--	35	14
India	--	--	34	6	1,350	1,190	89	223
Ireland	2	9	125	99	--	--	44	32
Israel	--	--	10	3	--	--	--	--
Italy	--	--	19	5	--	--	--	--
Japan	212	114	130	53	--	--	16	40
Korea, Republic of	25	18	249	70	--	--	--	--
Luxembourg	--	--	--	--	--	--	13	12
Malaysia	121	27	38	9	--	--	--	--
Mexico	23	47	35	17	1	5	24	13
Poland	--	--	4	3	--	--	2	4
Switzerland	3	4	--	--	--	--	--	--
Taiwan	--	--	19	14	--	--	7	5
Thailand	16	9	37	20	4	13	--	--
United Kingdom	88	24	21	27	9	11	71	18
Total	1,400	1,640	1,590	1,190	1,410	1,320	416	459
Grand total	92,900	61,600	92,200	63,000	8,330	6,500	7,790	8,830

-- Zero.

1/ Data are rounded to no more than three significant digits; may not add to totals shown.

2/ Harmonized Tariff Schedule of the United States codes: synthetic, 7105.10.0025; natural, 7105.10.0010.

3/ Customs value.

Source: U.S. Census Bureau.

TABLE 5
NATURAL DIAMOND: ESTIMATED WORLD PRODUCTION, BY TYPE AND COUNTRY 1/ 2/

(Thousand carats)

Country	1996	1997	1998	1999	2000
Gemstones: 3/					
Angola	2,250	1,110	2,400	3,700 r/	5,400
Australia	18,897 4/	18,100	18,400	13,403 4/	12,014 4/
Botswana	12,388 r/ 4/	15,111 r/ 4/	14,772 r/ 4/	16,000 r/	19,700
Brazil	200	300	300	300	300
Canada	--	--	300	2,000	2,000
Central African Republic	350	400	330	400	400
China	230	230	230	230	230
Congo (Kinshasa)	3,300 r/	3,300 r/	5,080 r/	4,120 r/	3,500
Cote d' Ivoire	202	207	210	210	200
Ghana	142	664	649	518 r/	178
Guinea	165	165	300	410 r/	410
Liberia	60	80	150	120 r/	120
Namibia	1,402 4/	1,350 r/	1,390 r/	1,550 r/	1,520
Russia	10,500	11,200 r/	11,500	11,500	11,600
Sierra Leone	162 4/	300	200	450 r/	450
South Africa	4,400	4,500	4,300	4,000	4,300
Venezuela	99	158	80 r/	59 r/	60
Zimbabwe	300	321	10	15 r/	7
Other	165	124 r/	106	207 r/	258
Total	55,200 r/	57,600 r/	60,800 r/	59,200 r/	62,600
Industrial:					
Angola	250	124	364	400 r/	600
Australia	23,096 4/	22,100	22,500	16,381 4/	14,684 4/
Botswana	5,000	5,000	5,000	5,350 r/	4,950
Brazil	600	600	600	600	600
Central African Republic	120	100	200	150	150
China	900	900	900	920	920
Congo (Kinshasa)	18,940 r/ 4/	18,677 r/ 4/	21,000 r/	16,000 r/	14,200
Cote d' Ivoire	100	100	100	100	100
Ghana	573	166	160	128 r/	712
Guinea	40	40	100	140 r/	140
Liberia	90	120	150	80 r/	80
Namibia	--	71	73	89 r/	80
Russia	10,500	11,200 r/	11,600	11,500	11,600
Sierra Leone	108	100	50	150 r/	150
South Africa	5,550	5,540	6,460	6,020 r/	6,480
Venezuela	73	90	17 r/	36 r/	40
Zimbabwe	137	100	19	30 r/	13
Other	120	105	97	141 r/	143
Total	66,200 r/	65,100 r/	69,300 r/	58,200 r/	55,600
Grand total	121,000 r/	123,000 r/	130,000 r/	117,000 r/	118,000

r/ Revised. -- Zero.
1/ World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.
2/ Table includes data available through May 25, 2001.
3/ Includes near- and cheap-gem qualities.
4/ Reported figure.

TABLE 6
SYNTHETIC DIAMOND: ESTIMATED WORLD PRODUCTION,
BY COUNTRY 1/ 2/ 3/

(Thousand carats)

Country	1996	1997	1998	1999	2000
Belarus	25,000	25,000	25,000	25,000	25,000
China	15,500	16,000	16,500	16,500	16,800
Czech Republic	5,000	5,000	5,000	3,000	--
France	3,000	3,500	3,000	3,000	3,000
Greece	750	750	750	750	750
Ireland	60,000	60,000	60,000	60,000	60,000
Japan	32,000	32,000	32,000	32,000	33,000
Poland	250 4/	260	210	200	--
Romania	5,000	5,000	3,000	3,000	--
Russia	80,000	80,000	80,000	80,000	80,000
Slovakia	5,000	5,000	5,000	3,000	--
South Africa	60,000	60,000	60,000	--	--
Sweden	25,000	25,000	25,000	25,000	20,000
Ukraine	8,000	8,000	8,000	8,000	8,000
United States	114,000	125,000	140,000	208,000	248,000
Total	439,000	451,000	463,000	467,000	495,000

-- Zero.
1/ World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.
2/ Table includes data available through May 25, 2001.
3/ In addition to the countries listed, the Republic of Korea also produced significant amounts of synthetic diamond, but output was not officially reported, and available information is inadequate to formulate reliable estimates of output levels.
4/ Reported figure.