COMPETITIVE POSITION OF THE U.S. GEAR INDUSTRY IN U.S. AND GLOBAL MARKETS

Report to the President on
Investigation No. 332–275
Under Section 332(g)
of the Tariff Act of 1930
as amended

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PREFACE

On April 14, 1989, at the request of the United States Trade Representative (USTR), and in accordance with section 332(g) of the Tariff Act of 1930, (19 U.S.C. 1332(g)), the U.S. International Trade Commission instituted investigation No. 332-275, 'Competitive Position of the U.S. Gear Industry in U.S. and Global Markets.' (See app. A for request letter.) The Commission was requested specifically by the USTR to provide, to the extent possible, the following:

- Profiles of the U.S. industry and major foreign industries;
- A descriptive assessment of the global market for gears, to the extent possible, using categories of gear products most useful to the industry;
- A comparison of U.S. and foreign producers' strengths and weaknesses in such areas as (1) raw material, labor, and capital availability; (2) technological capabilities; (3) extent of plant and equipment modernization; (4) end-product quality, pricing, and service support, and government involvement; and,
- U.S. and foreign industry and U.S. consuming industry views on market direction and potential for the U.S. industry.

The study also includes a detailed analysis of selected key products that are important to the U.S. gears and gear products industry and are representative of different segments of the industry in terms of manufacturing process, import competition, marketing, and financial condition.

Notice of the Commission's investigation, including the public hearing, was given by posting copies of the notice in the Office of the Secretary, U.S. International Trade Commission, Washington, DC, and by publishing the notice in the *Federal Register* (54 F.R. 18167) of April 27, 1989 (app. B). The Commission held a public hearing in connection with this investigation on November 1, 1989, at the U.S. International Trade Commission Building, 500 E Street, SW, Washington, DC. All persons had the opportunity to appear in person or by counsel, to present information, and to be heard. (See app. C for list of witnesses.)

Concurrent with the request for the Commission investigation, the USTR informed the Commission that agencies of the U.S. Department of Defense, led by the Department of the Navy, had requested the U.S. Department of Commerce (Commerce) to conduct a study concerning U.S. defense readiness with respect to the U.S. gear industry under section 705 of the Defense Production Act of 1950, as amended (50 U.S.C. App. 2155). In its study, Commerce would be required to collect and analyze certain data from U.S. producers of gears, some of which would be identical to data which the Commission would be required to collect.

The USTR further informed the Commission that, in order to minimize the reporting burden placed on firms in the U.S. gear industry in supplying data to the government, the Office of Management and Budget (OMB), acting pursuant to its authority under the Paperwork Reduction Act, had indicated that information obtained from the U.S. industry should be collected using a single survey. Accordingly, the USTR requested that the Commission coordinate with the appropriate officials at Commerce in developing portions of the questionnaire that would pertain to Commerce's responsibilities. The Commission agreed to the request and submitted on June 19, 1989, for OMB's approval (along with questionnaires for U.S. importers/purchasers and distributors), a U.S. producers' questionnaire that had been jointly developed by the Commission and Commerce. Producers receiving the questionnaire were advised as to which agency or agencies would use the respective data. Accordingly, appropriate data from the producers' questionnaire were shared with Commerce.

In the course of this investigation, the Commission compiled data and information from questionnaires sent to 264 U.S. producers, 69 importers/purchasers, and 49 distributors of gears. The listing was derived from mailing lists in previous Commission investigations, a Trinet Market Share Report, the Customs Net Import File, and individual firms in the gears and gear products industry. U.S. producers responding to the questionnaire accounted for over 85 percent of total industry shipments[1] during 1984-88. In addition, data provided by producers in the four selected gear industry sectors represented an estimated 80 to 90 percent of their respective industry sectors. Finally, information was gathered from various public and private sources, trade associations, overseas posts of the U.S. Department of State, industry conferences, interviews with company executives, importers and purchasers of gears and gear products, and also from public data gathered in other Commission studies. Also, information was gathered from interviews with selected foreign industry officials in Western Europe and Asia.[2]

The information and analysis provided in this report are for the purpose of this report only. Nothing in this report should be construed to indicate how the Commission would find in an investigation conducted under other statutory authority covering the same or similar subject matter.

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[1] Total industry shipments estimated by the staff of the U.S. International Trade Commission.

[2] Staff traveled to Western Europe (West Germany, Italy, United Kingdom, Belgium, and France) and Asia (Japan and Korea) during November December 1989, to interview members of trade associations and industry/government officials.

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EXECUTIVE SUMMARY

In March 1989, the U.S. Trade Representative requested the U.S. International Trade Commission to conduct an investigation and prepare a report on the competitive position of the U.S. gear industry in U.S. and global markets. The USTR request makes the following observation regarding the U.S. gear industry:

> "The U.S. gear manufacturing industry produces components that are essential to most industrial and transportation equipment. The industry, which has experienced a dramatic increase in imports since 1983, is unable to assess properly its trade concerns because U.S. government and private data on the industry's production and trade composition are fragmented and incomplete. The American Gear Manufacturers Association has formally requested assistance providing the industry with a comprehensive set of objective data."

The diversity of the group of companies that comprises the U.S. gear industry complicates the collection and compilation of data on the gears industry. However, through a questionnaire survey of U.S. gear producers, importers, and distributors, as well as domestic and international interviews with industry experts, the Commission was able to develop a considerable database on the U.S. industry and market and provide an assessment of the conditions of competition in the gear industry.

The principal findings of the Commission's assessment of the U.S. gear industry are as follows:

I. Profile of the U.S. gear industry

- *In 1988, the U.S. gear industry consisted of more than 300 firms having shipments of $14.8 billion and production worker employment totaling 84,600 persons.*

Gears and gearing are intermediate products which are essential to a wide range of U.S. finished product industries. The four principal markets for gears and gearing are the motor vehicle, industrial products, aerospace, and marine industries. Approximately 80 percent of gear industry shipments, $11.9 billion, were motor vehicle gearing in 1988 (table A). Shipments of industrial gearing totaled $1.7 billion; aerospace gearing shipments totaled $928.7 million; and marine gearing shipments totaled just $275.6 million. The U.S. gear industry exported a total of $2.4 billion in 1988, or 16 percent of total shipments (p. 4-3). U.S. gear consumers imported $2.7 billion in 1988, resulting in a gear trade deficit of $316 million in 1988, as import penetration rose to over 18 percent of total gear consumption (table A).

- *During 1984-88, Canada, Mexico, the United Kingdom, Japan, Australia, and West Germany were the chief foreign markets for U.S. exports of gears and gearing products.*

These markets accounted for 67 percent of total U.S. exports in 1988. Canada has traditionally been the leading foreign market for U.S. exports of gears and gearing primarily because of the cross border structure of the automobile industry. In total, exports of motor vehicle gears and gearing accounted for 90 percent of U.S. exports to the 6 leading foreign markets, and most exports were sent to foreign subsidiaries or partners of U.S. firms (p. 4-4).

- *Major structural changes took place in the U.S. industry during 1984-88.*

The domestic gear industry has experienced a number of mergers, acquisitions, leveraged buy outs, and joint ventures in recent years, following a period of divestitures prior to 1984. Some U.S. firms have acquired interests overseas to expand their markets, although much of the activity in international acquisitions has been foreign firms investing in new U.S. facilities (pp. 4-1 through 4-2).

Table A
Profile of the U.S. gear industry, 1984-88

Item	1984	1985	1986	1987	1988	Average annual percentage change, 1988 over 1984
Shipments (million dollars):						
For gears used in—						
Motor vehicles	9,589	10,564	10,466	11,068	11,876	5.5
Industrial products	1,639	1,571	1,529	1,536	1,679	0.6
Aerospace products	811	785	895	893	929	3.4
Marine products	254	249	249	265	276	2.1
Total	12,293	13,168	13,139	13,762	14,759	4.7
Operating margin (percent)	([2])	([2])	9.6	9.9	10.9	([2])
Capital expenditures (million dollars)[1]	394.4	437.1	485.8	729.4	646.4	13.1
Ratio of capital expenditures to shipments (percent)[1]	3.5	3.4	4.0	5.8	4.9	8.8
R&D expenditures[1]	53.8	65.3	68.7	71.1	77.7	9.6
Ratio of R&D expenditures to shipments (percent)[1]	0.5	0.5	0.6	0.6	0.6	4.7
Production workers (thousands):						
Motor vehicles	62.9	60.8	61.8	60.2	61.3	-
Industrial products	16.8	14.8	14.3	13.7	14.9	-
Aerospace products	5.3	5.2	6.0	5.6	5.6	1.4
Marine products	2.8	2.6	2.6	2.7	2.8	([3])
Total	87.8	83.4	84.7	82.2	84.6	-
Exports (million dollars):						
For gears used in—						
Motor vehicles	1,737	1,946	1,662	1,684	2,101	4.9
Industrial products	145	148	136	146	167	3.6
Aerospace products	98	119	119	129	144	10.0
Marine products	7	8	9	11	13	16.7
Total	1,987	2,221	1,926	1,970	2,425	5.1
Imports (million dollars):						
For gears used in—						
Motor vehicles	1,444	1,521	1,702	1,944	2,118	10.1
Industrial products	266	329	392	480	561	20.5
Aerospace products	25	31	39	41	50	18.6
Marine products	6	8	9	10	12	18.9
Total	1,741	1,888	2,141	2,474	2,741	12.0
Apparent consumption (million dollars):						
For gears used in—						
Motor vehicles	9,296	10,139	10,507	11,329	11,893	6.4
Industrial products	1,761	1,751	1,785	1,870	2,073	4.2
Aerospace products	738	697	815	804	834	3.1
Marine products	253	249	249	264	275	2.1
Total	12,047	12,836	13,355	14,267	15,075	5.8
Trade balance (million dollars):						
For gears used in—						
Motor vehicles	293.2	425.5	(40.4)	(260.3)	(16.8)	-
Industrial products	(121.7)	(180.7)	(255.1)	(333.8)	(394.4)	34.2
Aerospace products	73.0	87.8	80.2	88.8	94.3	6.6
Marine products	1.0	([4])	([4])	1.0	1.0	([3])
Total	245.5	332.6	(215.4)	(504.4)	(315.9)	-
Exports/shipments (percent):						
For gears used in—						
Motor vehicles	18.1	18.4	15.9	15.2	17.7	-
Industrial products	8.8	9.4	8.9	9.5	9.9	3.0
Aerospace products	12.1	15.1	13.3	14.5	15.5	6.4
Marine products	2.8	3.2	3.6	4.1	4.7	14.4
Total	16.2	16.9	14.7	14.3	16.4	0.4
Import penetration (percent):						
For gears used in—						
Motor vehicles	15.5	15.0	16.2	17.2	17.8	3.5
Industrial products	15.1	18.8	21.9	25.7	27.1	15.7
Aerospace products	3.4	4.4	4.7	5.0	5.9	15.1
Marine products	2.4	3.2	3.6	3.8	4.4	16.5
Total	14.5	14.7	16.0	17.3	18.2	5.9

[1] Compiled from data submitted in response to questionnaires of the U.S. International Trade Commission.
[2] Not available
[3] Less than 0.05 percent.
[4] Less than $50,000.

Source: Estimated by the staff of the U.S. International Trade Commission, except as noted.

- *The U.S. market for gears and gear products grew by nearly 25 percent during 1984-88, and accounted for more than one-third of global consumption.*

The U.S. market for gears and gear products is the largest in the world and during 1984-88 rose 25 percent, from $12.0 billion to $15.1 billion. U.S. imports grew from $1.7 billion to $2.7 billion, or by 57 percent, during 1984-88. Import penetration rose from 15 percent in 1984 to 18 percent in 1988 (p. 6-1, table A). In 1988, the U.S. market accounted for 35 percent of global consumption, which is estimated at $42.6 billion.

- *Increased U.S. gear and gearing imports during 1984-88, principally supplied by Canada, Japan, France, and West Germany, were attributable to three factors.*

U.S. imports increased during 1984-88 principally because of (1) U.S. original equipment manufacturers, as a cost-lowering measure, bought less expensive gearing from foreign sources; (2) major Western European and Japanese producers were successful in their concerted efforts to penetrate the U.S. market; and (3) Japanese parts producers supplied the growing number of Japanese-owned auto manufacturers in the United States (p. 6-1). In the early 1980s, flagging demand in home markets and the strong dollar made the U.S. gear market attractive to foreign producers. Many U.S. gear consumers were facing difficult market conditions and turned to imported gearing which, largely due to the exchange rate, was often less expensive than the comparable U.S. product. A more recent trend is an increase in imports of gearing by foreign-owned U.S. assembly plants, especially automotive, from their parent companies.

- *In the U.S. market, the largest component of consumption is motor vehicle gearing, a market that is strongly influenced by quality considerations.*

In 1988, apparent U.S. consumption of motor vehicle gears and gearing accounted for nearly 80 percent of total consumption of gears and gearing (table A); consumption of motor vehicle gearing increased from $9.3 billion in 1984 to $11.9 billion in 1988. Imports accounted for 16 percent of U.S. apparent consumption of motor vehicle gearing in 1984 and 18 percent in 1988. A large percentage of these imports are from U.S. subsidiaries located in Canada. Imports from Japan are primarily used in Japanese automotive transplant assembly operations in the United States. The motor vehicle industry is characterized by rapid technological change in virtually all major vehicle systems and producers must be somewhat innovative to remain competitive. Product quality is an especially important consideration for vehicle gear producers and the use of cubic boron nitride grinding technology is becoming a critical element in remaining competitive (pp. 6-2 through 6-5).

- *In the U.S. market, industrial gears and gear products, the second most important market sector, grew irregularly during 1984-88, but imports' share of the market more than doubled.*

In 1988, apparent U.S. consumption of industrial gears and gear products accounted for 14 percent of total consumption of gears and gearing; consumption of industrial gears rose from $1.8 billion in 1984 to $2.1 billion in 1988 (table A). Imports accounted for 15 percent of U.S. apparent consumption in 1984, but rose to 27 percent in 1988. The increase in imports resulted from increasing consumer demand for quality products competitively priced, especially by foreign-owned gear assembly operations. The U.S. market for industrial gearing is directly related to the overall investment in new plant and equipment in the manufacturing sector and to expenditures on public works (pp. 6-5 through 6-6).

- *U.S. demand for aerospace gears grew significantly during 1984-88, with imports nearly doubling during this period.*

In 1988, apparent U.S. consumption of aerospace gearing accounted for 6 percent of total consumption of gears and gearing; consumption of aerospace gears increased from $738.0 million in 1984 to $834.0 million in 1988, or by 13 percent (table A). Aerospace gear imports nearly doubled from $25.0 million in 1984 to almost $50.0 million in 1988 and the ratio of imports to consumption rose from 3 to 6 percent during this period. The demand for aerospace gears is heavily influenced by the demand for helicopters. Despite a downturn in demand for helicopters, however, overall demand for aerospace gears increased during 1984-88 because of the unprecedented increase in sales of large civil transport vehicles (pp. 6-6 through 6-9).

- *U.S. demand for marine gearing remained level during 1984-88, but softened toward the end of this period for small marine gearing, as imports obtained a larger share of the market.*

In 1988, apparent U.S. consumption of marine gears accounted for 2 percent of total apparent U.S. consumption of gears and gearing. During 1984-88, U.S. apparent consumption of these gears rose irregularly, ranging from a low of $249 million in 1985-86 to a high of $275 million in 1988, whereas the import-to-consumption ratio rose from 2 percent in 1984 to 4 percent in 1988 (table A). Increased imports of large marine gearing occurred in both the government and commercial markets, due, in part, to lower prices. In late 1988, consumption of small marine gears began to fall as sales of pleasure craft softened due to saturation of the market (pp. 6-9 through 6-11).

- *The overall number of production workers in the U.S. gear industry declined 3.6 percent during 1984-88.*

There were an estimated 84,600 production workers in the U.S. gear industry in 1988, down from 87,800 in 1984 (table A). Employment declined by 6.4 percent between 1984 and 1987 and then increased by 2.9 percent between 1987 and 1988. The overall decrease in employment in the U.S. gear industry reflects increased automation and flat shipment trends of the industrial and marine gear sectors. However, employment showed a slight increase during the last year of the period; this increase can be attributed to an upturn in the market in 1987 which necessitated an increase in employment (p. 4-5).

- *Nominal wages for all U.S. gear production workers rose significantly; however, wages in real terms reflected an increase of only 3 percent.*

Total compensation, including fringe benefits, bonuses, and payments in kind, remained relatively stable for the period, declining by 2 percent in real terms, although in nominal terms, total compensation costs increased by 11 percent. Wages also declined in real terms, by 4 percent, while increasing 8 percent in nominal terms. Annual productivity per worker rose by 17 percent in real terms (p. 4-5).

- *Skilled personnel necessary for U.S. gear manufacturing operations are in short supply.*

Machinists and trainees with the necessary mathematical skills to become machinists are most in demand. Firms attribute the scarcity of workers to generally low unemployment, insufficient numbers of high school graduates with adequate mathematical and verbal skills, and the low status of blue-collar jobs. On-the-job training has a significant cost, as it requires taking otherwise productive skilled workers away from their tasks in order to train new workers. Subsequently, some firms have worked with vocational schools to develop programs covering rudimentary skills, such as blueprint reading and basic machine operations. Many firms report high retention rates among workers recruited from these schools (pp. 4-6 through 4-7).

- *During 1984-88, U.S. gear manufacturing capacity declined an estimated 9 percent.*

The decline in capacity is based upon a number of different indicators such as plant closings and declines in employment; however, partially offsetting such changes were increases in productivity, as well as the rationalization of inefficient operations. For example, a decline of 15 percent for machinery in place was offset by the introduction of newer, more efficient gear-cutting and finishing machine tools which resulted in improved productivity. Decreases in capacity of some firms owned by U.S. producers have partially been offset by new capacity added by foreign-owned gear producers as well as by other U.S. firms (p. 4-9).

- *The level of capacity utilization by U.S. producers varied substantially among firms producing for different markets.*

For the U.S. gear industry as a whole, capacity utilization was 71 percent in 1988, as measured in actual machine hours spent producing gears compared with available machine hours. Many captive producers manufacturing gears and gearing for the automotive and construction equipment industries have been operating at higher levels of capacity utilization, in some instances close to 100 percent. Most producers of gears and gearing for the aerospace and specific industrial and marine products markets have been operating at lower rates of capacity utilization (p. 4-11).

- *The level of profits generated by most U.S. gear producers trended upward.*

The increase in operating margin during 1986-88 was partly attributable to the general improvement in the economy, especially in the automotive and machinery sectors. Net sales rose slightly faster than production related costs. Although the percentage increase in operating income was nearly twice that of sales, net income before taxes rose only 11.4 percent during 1986-88 as a result of a more than doubling of non-production-related expenses, such as interest expense, plant closing losses, and write-offs of assets (p. 4-11, table A).

- *Companies that can convince lenders that they will continue to generate revenues and that they have valuable assets are likely to have an advantage in the capital markets over small job shop operations.*

The ability of gear producing firms to obtain financing and the rates at which they borrow money are determined largely by the financial strength of the individual company. The large proportion of companies in this industry that are small and that do not have a high net asset value or an expected stream of future revenues from long term contracts often find most conventional means of financing unavailable or unaffordable. Gear-producing subsidiaries of large companies, such as captive producers in the automotive market, generally meet their capital needs through their corporate financial centers and thus may obtain capital at lower rates or in different ways than are available to smaller firms. U.S. bank lending rates for short-and medium-term financing needs of the private sector declined from slightly over 12 percent in 1984 to approximately 9 percent in 1988 (p. 4-12).

- *During 1984-88, the trend in capital expenditures for gear-producing machine tools in the United States increased, but continued to lag behind the expenditure levels of foreign producers.*

Total expenditures on gear-producing machine tools by U.S. firms rose 48 percent between 1984 and 1988, although such expenditures fell 11 percent between 1987 and 1988 to an estimated $56 million. In spite of the increase during 1984-88, 1988 U.S. expenditures were substantially below the 1980 level. Expenditures for this type of machinery by West German and Japanese producers were significantly higher than for U.S. firms during 1984-88 and totaled over $130 million in 1988 in each of these two countries (pp. 7-13 through 7–14).

- *R&D expenditures by U.S. gear producers increased during 1984-88.*

R&D expenditures by the U.S. gear industry rose annually during 1984-88, increasing from $53.8 million in 1984 to $77.7 million in 1988, a 44-percent gain, but did not keep pace with such expenditures by broader industry groups (p. 4-13). Gear industry R&D expenditures represented less than 1 percent of shipments during 1984-88 whereas the level of R&D for nonelectrical machinery industries, a similar but broader group, totaled 3.5 percent of sales in 1987. University gear research in the United States has lagged behind that performed in West Germany and Japan. Traditionally, the bulk of gear R&D in the United States is done at the company level and is generally not shared. Several ongoing projects in the United States, especially the work of the ASME Gear Research Institute and the Defense Logistics Agency's newly established Instrumented Factory for Gears (INFAC), are designed to improve the competitive position of the U.S. gear industry (p. 4-14, table A).

II. Profile of major foreign gear industries

- *The Japanese gear industry had shipments of $8.4 billion in 1988 and employed an estimated 39,000 persons.*

Japan's gear industry shipments were predominantly motor vehicle gearing, with the bulk of the remainder accounted for by industrial and marine gearing. Japan's aerospace gearing industry is relatively small, but is growing through licensing agreements for larger components, such as engines, and through co-production of aircraft with U.S. and Western European aerospace producers. In 1988, the Japanese gear industry served a domestic market estimated at $6.0 billion, and its exports totaled an estimated $2.5 billion. Approximately 83 percent of exports were of vehicle gearing. Imports of gearing products totaled just $90 million and consisted mainly of industrial and vehicle gearing. Major foreign suppliers were the United States, France, and West Germany (p. 5-18).

- *The West German gear industry had shipments of $4.8 billion in 1988 and employed an estimated 23,000 persons.*

West Germany is a technological leader in industrial gearing; in contrast with other major producers, shipments of industrial gearing accounted for approximately half of production. West Germany is also a leader in marine gearing, especially for diesel engines, and a significant number of firms produce for this market. The West German gear industry serves a domestic market estimated at $3.2 billion, and exports about half of its production, or $2.2 billion. Imports totaled $521.7 million, accounting for about 17 percent of domestic consumption, about the same percent as in the United States, and were primarily from France, Italy, and other EC countries (p. 5-3).

- *Other important EC suppliers had aggregate shipments of $6.4 billion and employed an estimated 32,500 persons.*

Italy, France, Belgium, and the United Kingdom are all highly industrialized, technologically advanced countries with significant gear producing industries. All four countries are involved in the vehicle and industrial gearing sectors. France, the United Kingdom, and Belgium also produce aerospace and marine gearing. The majority of firms in each country are described as small-to medium-sized firms, operating as subsidiaries of multinational producers, as captive suppliers to the vehicle or aerospace sectors, or as independents operating in niche markets (pp. 5-8 through 5-18).

- *Other suppliers include Canada, Korea, Taiwan, Mexico, and some of the newly industrialized countries.*

The gear and gear products industry in Canada is closely integrated with U.S. vehicle producers; the gear industry in Korea is also highly dependent on vehicle producers, both domestic and Japanese. Taiwan has designated its gear industry as a "strategic industry" permitting it to have preferential treatment. Major gear producers in Mexico and Brazil produce primarily for domestic consumption. China has an almost unlimited supply of low-cost labor and the potential to become a major supplier in the future and Singapore is a focal point for transshipments among other Asian countries (pp. 5-23 through 5-27 and app. J).

III. Assessment of the global market for gears

- *Estimated world consumption of vehicle, industrial, aerospace, and marine gearing, measured in terms of U.S. dollars, rose sharply during 1984-88, but experienced only moderate growth when measured in national currencies.*

During 1984-88, the Commission's estimate of world consumption of vehicle, industrial, aerospace, and marine gearing, in terms of U.S. dollars, increased from $20 billion to $25 billion in 1984 to $40 billion to $45 billion in 1988. However, if these measurements utilized national currencies that have appreciated against the dollar, the change in production and consumption would be considerably smaller. For example, during 1984-88, production of gearing in West Germany increased by 107 percent as measured in U.S. dollars, but production as measured in Deutsche marks rose by 28 percent (p. 3-1).

- *Motor vehicle gearing represents more than 60 percent of world production and consumption of gears and gear products; the remainder is accounted for by industrial, aerospace, and marine gearing. The United States was a principal supplier to all markets, except marine gearing.*

The largest producers and consumers of vehicle gearing are those countries that have the most significant automotive industries, namely the EC countries, the United States, Japan, and Canada. Korea was a significant producer and consumer, although imports account for an important, but decreasing, part of its total needs. West Germany, the United States, and Japan are the world's largest sources and markets for industrial gearing. The United States is not only the single largest producer of aerospace gearing, but the largest individual market as well (p. 3-1).

- *During 1984-88, world capacity in the gear industry grew in most countries.*

The number of facilities and investment in new machinery increased, especially during 1986-88, as the world economic situation improved. This was particularly true in newly industrialized countries; during 1984-88, domestic shipments of Korea and Taiwan, for example, increased nearly 94 percent to $280 million and 153 percent to $124 million, respectively. These and other emerging suppliers are expected to become a greater force in the world market over the next 10 years (pp. 5-23 through 5-25, app. J).

- *During 1984-88, the value of the U.S. dollar changed significantly compared with the currencies of many countries exporting gearing to the United States.*

Western European currencies and the Japanese yen appreciated sharply against the dollar in 1986 and subsequent years. Against these currencies, the real exchange rate index increased by 30 to 50 percent or more during 1984-88 (pp. 3-2 through 3-3). The relative decline of the dollar, all other things being equal, should make U.S. products more price competitive and U.S. imports more expensive.

- *Excluding the non-market economies, 1988 world exports of gearing totaled an estimated $11.2 billion and world imports totaled $8.8 billion.*

In 1988, the largest exporters were Japan and the United States (22 percent each), West Germany (19 percent), and France (10 percent) (p. 3-2). The major importing countries in 1988 were the United States (31 percent), Canada (20 percent), and the United Kingdom (11 percent). The demand for gearing in these countries was principally for automotive gearing. Japanese automobile transplants in the United States and U.S. automobile producers' subsidiaries in Canada dominated the trade flows within, as well as into and out of, North America. Japan's exports as a share of production were 29 percent, compared with almost 45 percent for West Germany, 16 percent for the United States, and 53 percent for France (p. 3-2).

- *The major suppliers and consumers of gearing in the non-market economies of the world are the Soviet Union, Hungary, East Germany, and China.*

Nonmarket economies supplement their own production with some imports, mainly from Western Europe. Production in these nonmarket economies, as well as in South America, Africa, and South Asia, is mostly destined for internal markets, but is insufficient to meet total demand (p. 3-1).

- *Product standards in gear trade are an important marketing tool and the ability to manufacture to a variety of standards is an important asset for gear producers.*

Despite the fact that standards are voluntary, they are often used by private and public procurement officials in tender documents and may attain the status of a de facto requirement in particular countries (p. 3-8). One of the most widely used standards is the DIN of West Germany (p. 3-8). The American Gear Manufacturers Association (AGMA) has become more active in the International Standards Organization (ISO) during the last few years and has had some success in influencing ISO standards drafting (p. 3-7). AGMA standards are receiving wider acceptance because of an emphasis on "serviceability" compared with the more "academic" approach used for developing other countries' standards (p. 3-8).

IV. Comparison of U.S. and foreign producers' strengths and weaknesses

- *Raw material costs are comparable for gear manufacturers worldwide. However, the cost of bearings used in gear products has increased for U.S. producers.*

According to U.S. and foreign industry sources, Japanese, European, and U.S. gear producers face fairly comparable material costs. Since mid-1989, however, U.S. manufacturers have paid a higher price for bearings due to a decline in U.S. production and antidumping tariffs on bearings imported from key foreign suppliers. The costs of the resulting shortages and double-digit bearing price increases have been passed on to customers, reducing U.S. producers' price competitiveness (pp. 7-9 through 7-10).

- *The United States experienced less growth in real hourly compensation costs for production workers in 1984-88 than did most of its Western European competitors.*

When adjusted for inflation, hourly compensation costs for U.S. production workers were unchanged from 1984 to 1988; in West Germany, they increased in real terms by 3.5 percent over the period. In Japan and Canada, however, they fell by 3.1 percent and 0.7 percent, respectively (p. 7-7).

- *The supply of skilled labor worldwide has tightened in recent years, and employers are pursuing a variety of training programs to ease the shortage.*

As the current workforce ages, major world producers are finding it difficult to fill entry-level and skilled manufacturing positions. Geography, labor force mobility, and the economy are all factors; in addition, young people are not entering the skilled manufacturing trades. Employers are assuming a major role in training new hires in a wide range of skills (p. 7-9).

- *During 1984-88, U.S. interest rates were higher on average than those in West Germany and Japan, but lower than those in other major gear producing nations.*

U.S. bank lending rates averaged 9.6 percent during 1984-88, compared with 9 percent for West Germany and 5.8 percent for Japan. In other European countries, the rates ranged, on average, from 10.5 percent in the United Kingdom to 16.9 percent in France (p. 7-12).

- *U.S. gear producers are disadvantaged relative to European and Japanese manufacturers in gaining access to capital.*

Domestic producers believe that competing successfully in the future requires current capital expenditures to upgrade equipment. U.S. and foreign industry officials feel that in the United States, investors typically focus on short-term profitability, unlike foreign investors who generally consider return on investment over the long term (p. 7-12). One of the results of this is that lending rates for research projects with long leadtimes are two to three times higher in the United States than in many other countries. Operating with lower profit margins than their foreign competitors, U.S. firms lack retained earnings, and the majority are not large enough to have easy access to capital markets. In contrast, certain of their foreign competitors have relationships with larger firms and banks which assure more ready availability of capital. In the United States, the integration of financial institutions and industry, that is prevalent in countries such as West Germany and Japan, is prohibited (p. 7-12).

- *University research and development expenditures in Japan and West Germany far exceeded those of the United States, but technology leaders differ by market sector.*

The United States spent less than $1.0 million in university gear research in 1985, as compared with an estimated $3.8 million in West Germany and $5.0 million in Japan in the same year. Both West Germany and Japan have extensive gear research centers in universities, cooperating and sharing information with private corporations and government agencies. In the United States only a few of these centers exist; almost all research is done at the company level and remains proprietary (p. 7-2). While the U.S. is believed to be the leader in aerospace gear technology, it lags behind its competitors in technology for automotive and marine applications, for which West German firms are believed to have an advantage. No clear leader in industrial gearing technology has emerged (p. 7-3).

- *Most U.S. gear manufacturers lag behind their Japanese and Western European counterparts in adopting new machine-tool technology.*

During 1984-88, U.S. expenditures for gear-making machine tools were $264.0 million, compared with $542.8 million for West Germany and $428.4 million for Japan (p. 7-14). The world's leading machine tool manufacturers are located in Japan and Western Europe, particularly in West Germany. As a result, gear producers located in or near those countries can experiment with and integrate the latest in machine-tool technology in their facilities before it arrives in the United States (pp. 7-13 through 7-14 and app. E).

- *The U.S. machine tool industry ranks behind Western European and Japanese machine tool builders for some critical types of machinery.*

Industry sources indicate that the technology and quality of West German, Swiss, and Japanese gear-making machine tools equal or surpass that of U.S. producers. For instance, West German and Swiss machine tool builders excel in bevel gear grinding machine tools and Japanese manufacturers produce excellent hobbing and grinding machines. Foreign machine tool firms are characterized as large, technologically advanced, multi-product firms known for high quality, moderately priced products; some are subsidiaries of much larger firms. U.S. machine tool firms, while technologically advanced, are smaller and more specialized (app. E).

- *On average, the equipment currently in use by U.S. manufacturers is older than that of West German and Japanese producers.*

According to trade surveys, 88 percent of the gear-cutting and finishing machine tools in use in the United States in 1989 were more than 10 years old; in Japan, only 63 percent were of that age. West German sources estimate that the average age of critical manufacturing machines is less than 10 years. Older machinery tends to require more frequent maintenance and repair, which reduces its productive time. Also, technology embodied in new machinery enables manufacturers to maximize their productivity (p. 7-14).

V. U.S. and foreign industry and U.S. consuming industry views

- *U.S. manufacturers claim that some government actions have harmed the competitiveness of the U.S. gear industry in global markets.*

U.S. manufacturers claim that antitrust and product liability laws, tax policy, OSHA and EPA regulations, and other government policies harm their competitiveness (p. 4-14); moreover, according to U.S. producers, incentives to export are practically nonexistent. In contrast, a number of foreign producers receive support from their governments, which allows them to be more competitive. This support includes accelerated depreciation for new machinery, encouragement for mergers and acquisitions, and, in most European countries, government rebating of VATs. The following specific taxation issues concern many U.S. gear manufacturers: (1) the treatment of depreciation under the Modified Accelerated Cost Recovery System; (2) the corporate alternative minimum tax; (3) the elimination of the Investment Tax Credit; (4) the current tax treatment of capital gains; (5) the treatment of "goodwill" under the U.S. tax code; and, (6) changes in the present tax code concerning foreign tax credits (pp. 4-16 through 4-17).

- *U.S. gear producers claim U.S. product liability laws inhibit research and development efforts.*

U.S. producers' insurance costs have risen dramatically in recent years in the face of product-liability lawsuits. As a result, according to industry sources, some firms cannot afford the high insurance premiums and have been forced to curtail or eliminate research and new-product-development efforts. Many U.S. firms feel that, in order to avoid product liability problems, they must produce only proven designs with extra measures incorporated to ensure durability and longevity, and to stress design of products to more stringent standards. This hinders them from competing against foreign companies that can more readily offer new products and designs (pp. 4-17 through 4-18 and 8-4).

U.S. firms maintain that while businesses and manufacturers should be held liable for injuries caused by their products due to their own negligence, liability laws must be uniformly enforced and penalties reasonable. Under the current system, U.S. businesses assert that they can be forced to pay large settlements for injuries that they did not cause; it is not always necessary in the U.S. legal system to show that the target of such a suit was responsible for injuries. U.S. firms maintain that this gives foreign firms a competitive edge over their U.S. counterparts since other industrialized countries have a fault-based standard of liability or other judicial or institutional differences that reduce the uncertainty of liability lawsuits. The fault-based system sets more rigorous standards for the proof of fault and the proof of the absence of contributing fault on the part of the plaintiff (p. 8-4).

- *Certain U.S. Department of Defense policies are eroding the U.S. defense industrial base, according to some U.S. producers.*

Some U.S. producers believe they are harmed by the Defense Department's practice of purchasing on initial bid price rather than the life cycle cost of the product. This policy favors the low-cost producer whether it is the manufacturer that has invested heavily in research and development to produce a superior product or another, perhaps less knowledgeable, producer. Other sources believe that defense weapon systems are increasingly relying on foreign gears and gear products purchased as a result of offset agreements or of contracts awarded to the lowest bidder. Some firms have advocated the strict enforcement of 'Buy America' procurement regulations in order to counter shifts in purchases to foreign goods (pp. 8-1 through 8-2).

- *U.S. distributors cite improved product assortment, price, quality, service, and leadtime as the primary areas U.S. producers need to address in order to remain competitive in the U.S. market.*

Some U.S. distributors criticize U.S. gear manufacturers for not offering a complete assortment of gear products at a competitive price. U.S. distributors believe that if U.S. manufacturers are to retain their market share, they must develop products that are competitive in terms of quality and price, increase communications with customers, shorten lead times, and build export marketing networks. Others feel that cost structure and design factors must be reexamined to reduce prices and R&D must be increased. Foreign producers believe that U.S. production is primarily intended for the domestic market and is therefore not truly competitive with the assortment of products available from foreign sources (p. 8-5).

- *U.S. producers expressed concern over the way gears and gear products are currently classified under U.S. Government statistical programs.*

They are concerned that a large part of current domestic industry activity is not covered by the Standard Industrial Classification system. Similarly, import statistics of products from other countries (especially Canada) to the United States are not collected in categories that are useful to the domestic industry (p. 8-2).

- *U.S. producers expressed concern over the current pattern of foreign investment in the United States.*

U.S. producers are facing increased competition from foreign-owned firms that are locating in the United States in order to increase their market share. Such firms are not investing in existing U.S. operations but are constructing new facilities or are establishing marketing agreements with U.S. distributors. Foreign automobile manufacturers are locating in the United States and are sourcing gears from their home country (p. 8-2).

- *U.S. industry sources allege unfair trade practices by foreign suppliers, citing as an example import prices that are substantially lower than U.S. producers' prices, despite unfavorable exchange rates for the imports.*

Foreign suppliers state that price differences are a result of their different gear production technology and the production of gears for different applications. Domestic firms advocate the implementation of reciprocal trade agreements between the United States and those countries exporting to the United States, and matching U.S. import tariffs with those faced by U.S. exports (pp. 8-3 through 8-4).

- *U.S. firms indicated that trade barriers significantly inhibit the free flow of U.S. exports into major foreign markets.*

Trade barriers named included high tariffs, import licensing requirements, technology transfer requirements, subsidies, local content requirements, exchange and other monetary or financial controls, and discriminatory sourcing. Countries most often cited with significant barriers to trade include Japan, Argentina, Australia, Brazil, the EC member states, India, Mexico, Korea, China, and the Eastern Bloc (p. 4-4).

- *According to U.S. manufacturers, finding and retaining skilled labor is difficult and current training programs are inadequate and outdated.*

A number of countries report a similar lack of skilled workers. Those U.S. firms that offer in-house training report that many employees leave for higher paying jobs with other firms. Unlike the United States, where training programs receive little or no government financing, assistance is provided for training programs in the EC and Japan (p. 7-9).

In some countries, such as West Germany, vocational training and apprenticeship programs are used to train a skilled labor force. In other European countries and in Japan, however, such programs are not widespread and manufacturers express concerns similar to their U.S. counterparts regarding attracting younger employees to these programs (p. 7-9).

Based on comparisons of the U.S. gear industry with the U.S. gross national product (GNP) and broader industry groups, growth in total U.S. gear industry shipments have lagged behind that of the GNP and the motor vehicle sector, kept pace with that of the durable goods sector, and surpassed the growth in all manufacturing (table B). Employment in the U.S. gear industry fell slightly during 1984-88, whereas it rose 3 percent annually in the motor vehicle industry and less than 1 percent in all manufacturing during the same period. Capital expenditures, especially among U.S. vehicle gear producers, increased substantially during 1984-86, as new machinery was required for new generations of automotive transmissions, and then declined. Such expenditures increased at an average annual rate of 4 percent, compared with 7 percent for all manufacturing during the period.

Table B

Comparisons of the U.S. gear industry with other U.S. industries, 1984-88

Item	*1984*	*1985*	*1986*	*1987*	*1988*	*Average annual percentage change, 1988 over 1984*
U.S. gross national product (billion dollars)	3,772.2	4,014.9	4,231.6	4,524.3	4,880.6	6.7
U.S. producers' shipments:						
Durable goods (billion dollars)	1,159.5	1,188.2	1,199.9	1,263.5	1,388.2	4.6
Gear industry (billion dollars)[1]	12.3	13.2	13.2	13.8	14.8	4.7
Motor vehicle and equipment industry[2] (billion dollars)	179.3	188.5	191.6	197.0	219.3	5.2
All manufacturing (billion dollars)	2,254.4	2,280.2	2,260.3	2,390.0	2,611.6	3.7
U.S. trade balance (deficit):						
Gear industry (million dollars)[1]	246	333	(215)	(504)	(316)	-
Motor vehicles and equipment industry[2] (billion dollars)	(27.9)	(37.7)	(48.6)	(49.5)	(45.8)	-
All manufacturing (billion dollars)	(107.9)	(132.1)	(152.7)	(152.1)	(119.8)	-
U.S. employment (production workers):						
Gear industry (thousand persons)[1]	87.8	83.4	84.7	82.2	84.6	-
Motor vehicle and equipment industry[2] (thousand persons)	753	884	865	865	856	3.3
All manufacturing (thousand persons)	20,995	20,878	20,962	20,935	21,320	0.4
U.S. capital expenditures as a share of net sales:						
Gear industry (percent)[3]	3.5	3.4	4.0	5.8	4.9	8.8
Motor vehicle and equipment industry[2] (percent)	3.8	5.5	6.4	4.6	4.4	3.7
All manufacturing (percent)	3.9	4.3	4.1	4.3	5.1	6.9
U.S. import penetration ratio:						
Gear market (percent)[1]	14.5	14.7	16.0	17.3	18.2	5.9
Motor vehicle and equipment industry[2] (percent)	21.9	21.2	27.6	28.5	26.7	5.1
All manufacturing	11.0	11.7	13.1	13.4	13.4	5.1

[1] Estimated by the staff of the U.S. International Trade Commission.
[2] Includes products classified in Standard Industrial Classification industry grouping 371.
[3] Capital expenditures as a percent of shipments based on data reported in Commission questionnaires.

Source: Data are compiled from official statistics of the U.S. Department of Commerce, except as noted.

Chapter 1
Product Description and Uses

Overview

Gears are toothed wheels that are connected in various ways to transmit motion and force in machines. In most cases, one gear wheel turns at a rate different from that of the other and rotates in a different direction. A difference in speed between two gears produces a change in the force transmitted.[1] Gears are joined together with other gears and elements, such as shafts and belts, to transmit motion between input and output shafts at a constant ratio.[2,3] Gears are available in a variety of sizes, shapes, and materials; the choice depends on the application.[4]

Applications

Gears and gear products have applications in most types of powered machinery. They are essential for the operation of vehicles and industrial machinery as well as aircraft and ships. For the purposes of this study, there are four principal applications of gears and gear products that will be discussed: motor vehicle gearing, which includes both on-road and off-road vehicles; industrial gearing for products ranging from steel mills to photocopy machines; aerospace gearing; and marine gearing for military and commercial ships and pleasure craft.

Motor Vehicle Gearing

Motor vehicle, or "vehicle," gearing falls into a number of different SIC codes:[5] vehicle gearing for automobiles, trucks, and buses is classified under SIC 3714; gears for vehicles used in the construction industry are found under SIC 3566; and gearing for agricultural vehicles is included in SIC 3523. Vehicle gearing includes gearing used in drive assemblies, such as transmissions, and in engines, as well as other applications, such as rack-and-pinion steering and windshield-wiper assemblies. Generally, these gears are mass produced.

Industrial Gearing

Industrial gears and gearing fall under SIC 3566. Industrial gearing is used in machinery and equipment of all sizes in a wide range of applications. It is found in heavy industrial equipment—material-handling and material-processing machinery, blowers, compressors, pumps, and all types of mixers—as well as in nonindustrial machines, such as hand-held appliances, power tools, photo-processing machinery, and rotation equipment on radar antennas and microwave, satellite dish, and telescope platforms. End-use applications for industrial gearing are numerous; some of the more prominent include pulp and paper, lumber, mining, steel and aluminum, food processing, printing, textile, and sewage disposal machinery.

Aerospace Gearing

Aerospace gearing is found under a variety of SIC provisions. Aircraft engines, and parts and auxiliary equipment are classified under SIC 3724 and 3728, respectively. Engines and engine parts for guided missiles and space vehicles are found under SIC 3764. Communications satellites are included in SIC 3663. For aerospace applications, the ability to transmit high levels of power with a lightweight, reliable gear assembly is crucial.

Marine Gearing

Marine gearing is classified under SIC 3566 and SIC 3568. Gears in this category include relatively small gears used in pleasure craft, which are typically mass produced; moderate-sized gears for vessels such as barge tugs or fishing boats; and the large, custom-produced gears used for oceangoing diesel or gas-turbine-driven ships. End users of these gears include the commercial and defense shipbuilding industries.

Gears and Gearing

There are basically four main types of gears: spur, helical, bevel, and worm. (For further detail on product categories, see app. D). In addition, there are certain special gears that serve the same function but cannot be classified in conventional groupings. Gear products can be further categorized by the position of their shafts, whether parallel or nonparallel, and, if nonparallel, whether intersecting or nonintersecting.

Spur Gears

When spur gears are used, two gear wheels intermesh in the same plane, regulating the speed or force of motion and reversing its direction.[6] Spur gears are generally the easiest to manufacture and the most commonly used, especially for drives with parallel shafts. They have straight teeth which are cut parallel to the axis of rotation.[7]

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[1] David Macaulay, *The Way Things Work* (Boston, 1988), p. 41.

[2] John C. Lerning, "Basic Gearing," presented at 16th Annual Gear Manufacturing Symposium, Apr. 10–12, 1988, p. 1.

[3] In the nomenclature of the industry, "of two gears that run together, the one with the larger number of teeth is called the gear." The pinion is the gear with the smaller number of teeth. See also American Gear Manufacturers Association, *Gear Nomenclature (Geometry), Terms, Definitions, Symbols, and Abbreviations* (Arlington, VA, 1976), pp. 1–2.

[4] Ibid.

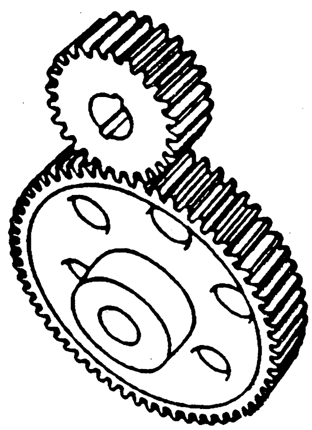
[5] The Standard Industrial Classification (SIC) is the U.S. statistical classification standard underlying all Federal economic statistics classified by industry.

[6] Macaulay, *The Way Things Work*, p. 41.

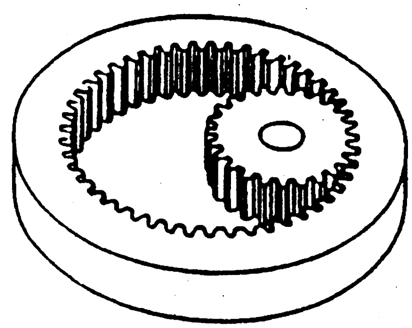
[7] *Power Transmission Design Handbook 1989* (Cleveland), p. A311.

The three main classes of spur gears – external tooth, internal, and rack and pinion – are shown in figure 1-1. External-tooth gears, as the name implies, have teeth cut on the outside edges of the wheels. This is the most common type of spur gear and it is typically used in pump and compressor assemblies and aircraft gear boxes. Internal gears have teeth cut on the inside surface of a ring, and one or more external-tooth spur gears are mounted inside. This type of gear is often used in small gear motors, wind turbines, and marine drives. With rack-and-pinion gears, one wheel, the pinion, meshes with a sliding toothed rack, converting rotary motion to back-and-forth motion, or vice versa. These gears are most commonly found in vehicle steering mechanisms.

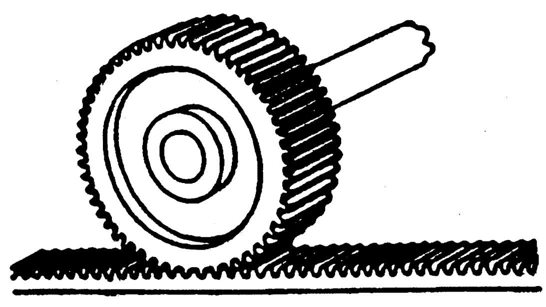
Figure 1-1
Spur gears



External tooth gears



Internal gears



Rack-and -pinion gears

Source: *Manufacturing Technology Research Needs of the Gear Industry*, IIT Research Institute, December 1987.

Helical Gears

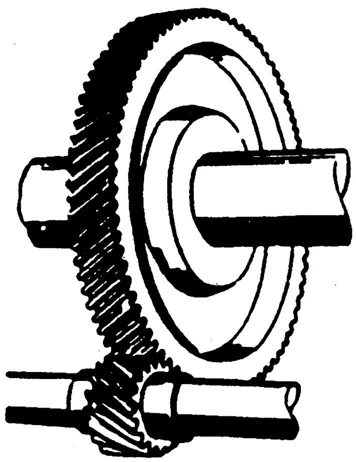
Helical gears are similar to spur gears and can be classified in the same three categories, external, internal, and rack and pinion. These gears differ from spur gears mainly in the shape of the teeth (see fig. 1-2). Helical gear teeth are cut at an angle across the face of the gear, whereas spur gear teeth are cut parallel to the axis on which the gear rotates. The difference in the configuration of the teeth results in less wear and vibration; however, because the gears come together with slightly more of a sliding motion than do spur gears, lubricants that are able to minimize metal-to-metal contact are essential. A common use for helical gears is in automotive transmissions, where such gears are partially replacing spur gears. Herringbone gears are a special form of such gears that contain two helical gears with teeth cut at opposing angles and no space in between. One of the many uses for herringbone gears is in extruding machinery.

Bevel Gears

In bevel gear mechanisms, two wheels intermesh at an angle to change the direction of rotation and, if necessary, the speed and force. The shafts intersect, typically at a 90-degree angle. The two types of bevel gears shown in figure 1-3 are distinguished by their teeth. Straight-tooth bevels have teeth cut straight across the face of the gear, but spiral bevel gears have curved teeth and produce smoother, quieter operation than do straight-tooth bevels. Bevel gears are used in many types of vehicle power transmission systems including aircraft gear boxes, motor vehicle transaxles, and locomotive axles.

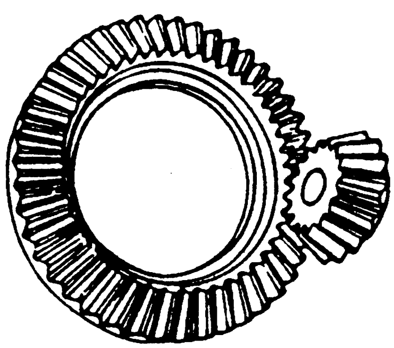
Hypoid gears are a form of spiral-bevels, in that they have curved teeth (see fig. 1-4); however, their shafts do not intersect. They are known for their strength, rigidity, and operating smoothness. They are frequently used in rear axles of automobiles with rear-wheel drives and, increasingly, in industrial machinery.

Figure 1-2
Helical gears

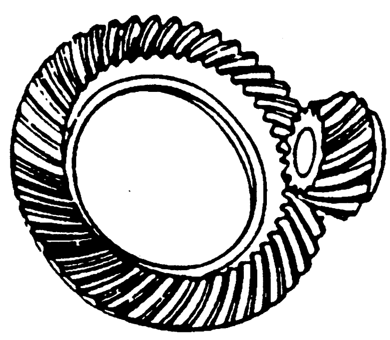


Source: *Manufacturing Technology Research Needs of the Gear Industry*, IIT Research Institute, December 1987.

Figure 1-3
Bevel gears



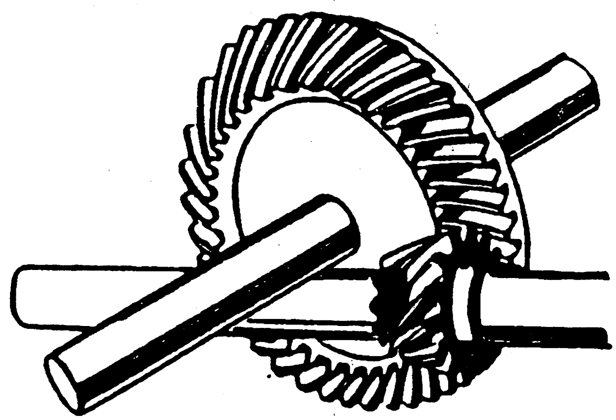
Straight–tooth bevel gears



Spiral bevel gears

Source: *Manufacturing Technology Research Needs of the Gear Industry*, IIT Research Institute, December 1987.

Figure 1-4
Hypoid gears

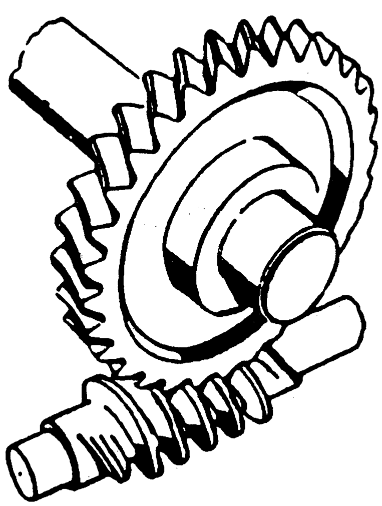


Source: *Manufacturing Technology Research Needs of the Gear Industry,* **IIT Research Institute, December 1987.**

Worm Gears

Worm gear mechanisms consist of a shaft with an involute (screw) thread, or worm, that meshes with a toothed wheel to alter the direction of motion and change the speed and force (see fig. 1-5). Generally, the worm acts as the driver, revolving several times to pull the wheel through a single revolution. The shafts are nonparallel, usually at right angles, and nonintersecting. Compared with other gear types, worm gears are noted for their higher rates of wear and for the higher temperatures resulting from friction between the worm and the gear. Worm gears are frequently used in material-handling machinery such as conveyors, elevators, and cableways.

Figure 1-5
Worm gears



Source: *Manufacturing Technology Research Needs of the Gear Industry,* **IIT Research Institute, December 1987.**

Other Special Gears

Some companies have taken basic gearing concepts and derived special types of gears, which they have patented. These include Gleason Corp.'s patented Zerol™ bevel gears, and ITW Corp.'s patented Spiroid™ gears (see fig. 1-6). These types of gears compete with conventional gears in that they can be used to perform the same functions. These special gears are often used to overcome space constraints or because they offer a combination of features that are not available in conventional gears. However, their use must be designed into the product from its inception; they generally cannot replace conventional gears.

Gear Products

Gears are generally designed and assembled together with appropriate shafting, bearings, and lubrication in a sealed housing that will transmit power (torque and speed) with efficiency, and yet offer a certain product life cycle and reliability. Such configurations are generally called speed reducers, but are known by a variety of names such as gear boxes, speed increasers, enclosed gear drives, and gearmotors.[8]

Moderate speed industrial reducers generally have a maximum speed of 3,600 rpm and are driven at a full load of 1,725 rpm or less. Such reducers account for a significant share of the market. High-speed industrial reducers used, for example, in the petrochemical industry and on turbine-driven compressors have a speed as high as 20,000 rpm, and may, in a few special, limited applications, approach 60,000 rpm. Speed reducers are selected for a particular application depending upon the input and output shaft arrangement, type of gears used, and the ratio[9] and horsepower ranges. Speed reducers, excluding transmissions used in aircraft and motor vehicle transmissions, may be grouped according to their mounting arrangements: base-mounted, gearmotor, and shaft-mounted.

Base-mounted reducers have the feet of the reducer housing bolted to a stationary platform. The prime mover, either a motor or engine, is also mounted to the same platform or onto the reducer itself. Such a reducer generally has a high-speed input shaft connected to the prime mover and a single or double output, or lower speed shaft, connected to the machine element to be driven. A shaft-mounted reducer has a hollow output shaft that slips over a driven shaft, which then supports the reducer. The housing of the reducer may be mounted to a stationary platform.

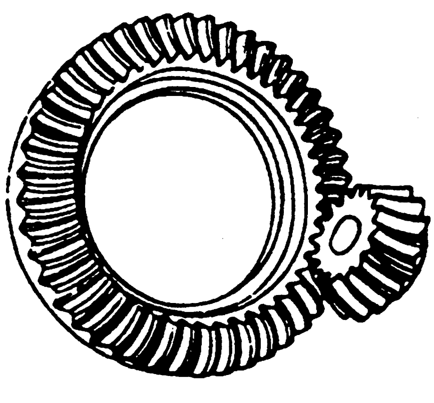
Gearmotors are enclosed gear sets with a prime mover; the motor is attached to the reducer frame or the reducer can be attached to a frame supporting the motor. A gearmotor is a configuration in which the motor is an integral part of the total article, rather than a configuration in which a motor can be easily attached to a reducer with an adaptor-coupling interface. The latter configuration is referred to as a motorized reducer.

Furthermore, there are special applications of gear arrangements, principally defense-related, that perform a number of unique functions. For example, mechanisms that open the bay doors of shuttles, robot arms that deploy cargo for shuttles and satellites, and guidance actuator systems on missiles all have gear assembly components.

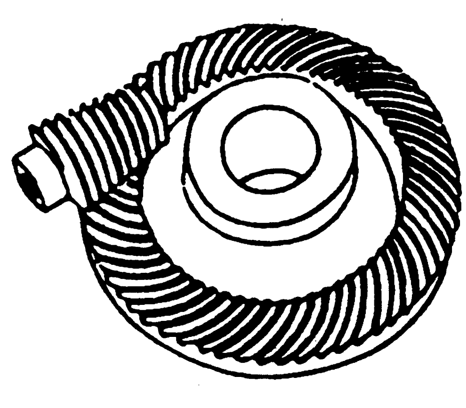
[8] For purposes of this report, these products are also referred to by the generic term "gearing."

[9] "Ratio range" is the number of revolutions required by the pinion to rotate the gear one complete revolution.

Figure 1-6
Certain special gears



Zerol™ bevel gear



Spiroid™ gear

Source: *Manufacturing Technology Research Needs of the Gear Industry*, IIT Research Institute, December 1987.

Chapter 2
Processes and Technology

Production

Gears are manufactured either by machining[1] a gear blank or by a variety of forming processes. The manufacturing process may vary according to the design characteristics of the gear produced, but the basic production method is the same. Machining a gear involves cutting or grinding gear teeth. Forming a gear involves processes such as precision forging, in which the gear is stamped out in a press, or molding, which includes the use of powdered metals. Other forming processes include form grinding, broaching, rolling, and shearing. After the gear teeth are cut, the gear is generally hardened in a heat-treating and/or quenching process. The gear surface is then finished in any one of a number of surface-finishing operations. High-performance gears, because of the precision and durability required, are usually machined, whereas gears that are subject to less stress are formed.

A leading force for change in machining gears is end users' demand for gears with closer tolerances, greater wear resistance, and lower failure rates. This, in turn, drives manufacturers to seek computer-controlled machine tools and cutting tools that can repeatedly produce gears to extremely fine tolerances—in many cases to tolerances less than a quarter of the thickness of a human hair. To ensure quality, computer-controlled measuring equipment is required. Other areas that become more critical as a result of machining to closer tolerances are the selection of materials, surface treatment, and precision metallurgical testing equipment. Attention to such factors ensures that the consistency of the material properties of the gear is maintained during machining and surface treatment operations, including heat treatment and final grinding.

Selection of Gear Materials

Gears are made from a variety of materials according to their characteristics and suitability for the application. Factors in the materials selection process include resistance to wear, integrity over temperature ranges, heat-treating capability, tensile strength, and machinability. A variety of alloy steels, bronzes, and other metals may be used. These materials are then processed into general shapes or gear blank shapes by forging, casting, or rolling.

In some applications, hardness, wear, and fatigue resistance are the most important factors. Hardness is a function of both chemical composition and heat treatment. If extensive heat treatment is necessary, the "memory" of the material through heat treatment is an important quality. Gear steels are generally chosen according to their ability to be either through- or case-hardened. Case-hardened steels allow for a hard exterior, while permitting the center of the gear to remain softer and more ductile so that the bending stresses will not fracture the gear during operation. These steels have a relatively low carbon content. Through-hardened steels result in a gear having uniform hardness throughout, and having a relatively high carbon content. Steels used by the gear industry may be alloyed with metals such as chromium, nickel, molybdenum, and vanadium. Bronze is principally used in worm gearing. Typically, the worm is made out of case-hardened steel and its companion gear is made from bronze. The heat generated in the friction of meshing in worm gearing is readily dissipated by the bronze worm gear. Bronze is also used in many small gears.

Materials research and development is a significant factor in developing a superior gear or gear product. The American Society of Mechanical Engineers (ASME) Gear Research Institute (GRI) is currently conducting research on austempered ductile iron (ADI)[2] as a material from which certain gears could be made.[3] Many benefits of using ADI have been cited, including fatigue resistance, roughness, low cost, light weight, noise and vibration dampening, improved wear and scuffing resistance, and flexibility in design for optimal shape. ADI gears have a relatively low carbon content.[4] ADI castings are also less expensive than forgings and possess similar, if not greater, material strength.[5]

Machine Operations

The manufacture of a gear requires numerous different types of operations. An overview of the major gear-manufacturing processes is presented in figure 2-1. The manufacture of a gear starts with a gear blank, generally a forging, casting, a cold forming, or a piece of bar stock. The blank is worked on a lathe or machining center to do any required finish turning and facing operations prior to cutting the gear teeth. The teeth are cut into the gear blank on a milling machine, shaping machine, hobber, or bevel generator, depending on the type and quality of gear. A slightly oversized gear is generated in order to allow for a layer of surface metal to be removed after heat treatment or during finishing operations.

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[1] "Machining" refers to working metal by removing chips of metal from the workpiece.

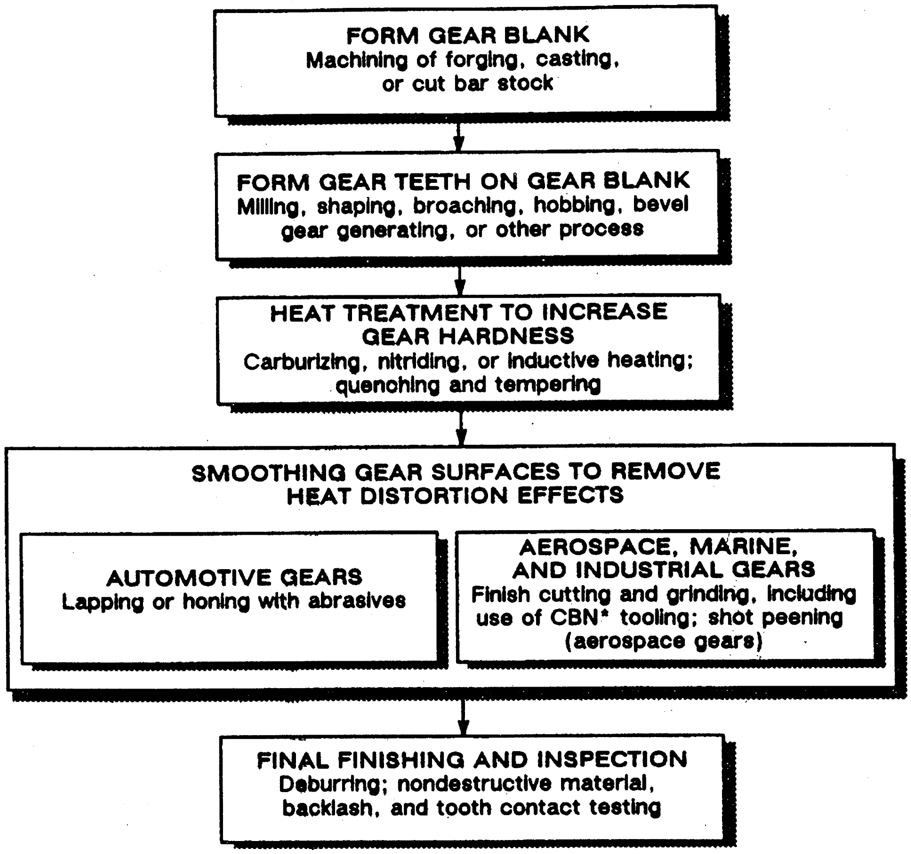
[2] Austempered ductile iron is a stronger, less brittle form of iron that results from the addition of certain alloys in the molten stage and controlled heating and cooling treatment, which alters the form and distribution of the carbon contained in the iron.

[3] USITC staff interview with officials of ASME-GRI, Sept. 21, 1989.

[4] "Austempered Ductile Iron: Technology Base Required for an Emerging Technology," *Gear Technology* (October–November 1984), pp. 31–36.

[5] John A. Vaccari, "Why the Interest in ADI Castings," *American Machinist*, September 1989, p. 58.

Figure 2-1
Gear manufacturing processes



* Cubic boron nitride—an extremely hard abrasive material.

Source: Compiled by the staff of the U.S. International Trade Commission based on information from Illinois Institute of Technology Gear Research Institute, Speco Corp., and Ishikawajima-Harima Heavy Industries Co., Ltd.

Milling machines can be used to rough cut the gear teeth. Further profiling of the gear teeth may be done by hobbers, shapers, or shavers. Hobbers are special machines for cutting gear teeth using a cutting tool called a hob. A hob is cylindrical with multiple rows of teeth following a helical path around the base. The hobber moves the gear blank in tandem with the rotation of the hob, generating a curved gear tooth profile. Shapers generate a tooth form by rotating a workpiece between reciprocating strokes of a cutting tool that resembles a gear. Shavers are used to improve the accuracy and/or uniformity of the gear tooth following gear-cutting operations, but prior to hardening in heat treatment. The shaver uses a serrated-edge cutting tool in the shape of a gear with helical teeth to "shave" small amounts of metal from the gear.

Increasingly, production of spur, helical, and other gears is performed on computer-controlled machine tools that allow the operator to program the gear specifications into the machine that will produce the gear. Because of the drive toward producing gears with closer tolerances, computer-controlled machine tools are becoming standard in the industry. Bevel and hypoid gear teeth are cut on special, multiaxis machine tools. Because of the complexity of the operations they perform, these machine tools have electronic controls. Only recently have these machines incorporated computer controls.

Depending upon the application of the gear, inspection during or after each machining operation may be performed. In high-volume manufacturing of gears, statistical sampling may be used to check that gear teeth are being cut to uniform specifications.

Surface Treatment

Surface treatment includes heat treating, lapping, and grinding. After the gear teeth are cut, the gear may be heat-treated to harden the gear surface and increase both wear and fatigue resistance. Heat treatment also relieves stresses built up in the gear during previous machining operations. Heat treatment involves placing the gear in special furnaces that diffuse carbon or nitrogen atoms into the gear surface. Carburizing is done in gas atmospheres at temperatures ranging from 1,650°F to 1,800°F, and may take up to 24 hours. The gear is then quenched in oil, usually in a quenching press. The interior of the press contains a mold similar to the shape of the gear, so the gear, which may have changed shape slightly while being heated, is forced back to its original shape. Even so, some dimensional distortion may still occur. Nitrating is performed at lower temperatures, approximately 1,000°F. It is a much slower process, and may take up to 10 days. The resulting hardened surface is not as thick as with carburizing. However, nitrating does not require quenching in oil after heat treatment and any dimensional distortions are minimal.

After heat treatment, the gear may be lapped or honed with an abrasive compound. The lapping process polishes the surfaces of the gear, corrects minor distortional errors, and removes nicks and burrs, thus reducing noise, or vibration, when the gear is in operation. Spur, helical, and other parallel axis gears are lapped by running in mesh with a gear-shaped lapping tool. However, lapping is no longer recommended as a finishing method for spur and helical gears because other processes have been developed that produce better results. Bevel gears are lapped by running in mesh with their pinions. In the automotive industry, most gears are finished by lapping with an abrasive compound.

Gears used in high-performance applications, with tolerances of less than .001 inches, must be ground. Grinding removes dimensional distortions resulting from the heat-treatment and quenching processes. However, grinding must be precise because some of the very thin hardened surface that was obtained through heat treatment is being removed. If too much is removed, the effects of heat treatment are negated. Generally, grinding involves using a wheel that is dressed, or contoured, to the desired tooth form. A cubic boron nitride (CBN) wheel, which is harder than many other abrasives, may also be used.[6] Special gear grinders must be used for bevel gears. Grinding to precise tolerances may require special conditions. In some instances, rooms with floors that are physically detached from the rest of the factory floor are constructed in order to prevent vibrations from interfering with the grinding process.

Test and Assembly

Throughout the manufacturing process, gears are inspected for various tolerances. The gear teeth usually are inspected on mechanical testing machines, computer numerically controlled (CNC) coordinate measuring machines, or other gear metrology[7] machines. For aerospace, marine, and some industrial applications, gears are also tested for their metallurgical properties.

[6] Cubic boron nitride will maintain its hardness at temperatures of up to 1,830°F and is chemically inert in the grinding of ferrous materials.

[7] The science that deals with measurement.

Gears are usually assembled into gear boxes, which are generally produced by gear manufacturers. The assembly[8] of gear boxes may involve the purchase of bearings, shafts, gear-box housings, seals, lubricants, and miscellaneous items. Most gear box manufacturers produce their own gears and shafts, but they usually purchase the remaining items needed to produce gear boxes. Frequently, the housings for the gear boxes are produced from purchased castings but subsequent machining of mountings for shafts, bearings, and fasteners is done by the gear box producer. Such machining is done to precise tolerances, because misalignment can result in premature wear or failure. After the gears are assembled into a gear box, the whole assembly is tested for smoothness of operation and alignment.

Technology

Level of Technology

Many U.S. gear industry professionals believe that the U.S. gear industry has fallen behind its competitors in Europe and Japan. According to one industry expert, the decline in the U.S. technological base has been demonstrated by the need for U.S. engineers to go abroad to study gear technology.[9] Some industry experts believe that foreign technology, especially that which increases power density,[10] is at the forefront of technological development. New gear research is carried out primarily in West Germany, Japan, and the Soviet Union.[11] A leading U.S. gear researcher believes that the competitive advantage in gear technology belongs to European and Japanese manufacturers, especially with regard to materials. However, this source reports that the U.S. gear industry leads the world in aerospace gearing technology. The size of the market and the strong demand for advanced aerospace products from the U.S. Government and U.S. aircraft producers have supported research and development efforts.[12] In the mid-1980s, U.S. marine gear experts concluded that European gear producers were ahead of their U.S. counterparts in the production of large hardened and ground marine reduction gears. Such a technological lead was estimated at 4 to 10 years.[13]

Some U.S. gear company officials believe that much of the difference in gear technology is perceived rather than real. One U.S. company

[8] Producing a gearbox may be characterized as strictly an assembly operation in the sense that all of the components and even the design, including research and development efforts, may be purchased by a producer.

[9] Remarks by Dale H. Breen of the American Society of Mechanical Engineers, Gear Research Institute, at the Fall 1986 meeting of the American Gear Manufacturers Association.

[10] The same or greater amount of torque that can be incorporated into a smaller gearbox.

[11] USITC staff telephone interview with Donald R. Houser, Department of Mechanical Engineering, The Ohio State University, Oct. 6, 1989.

[12] Ibid.

[13] Unpublished report of the U.S. Department of the Navy, Mar. 3, 1986.

official described U.S. and foreign technologies as roughly comparable, with products being differentiated by unique national design criteria. For example, U.S. standards require that a cooling device be incorporated in gear boxes above a certain power level whereas West German standards do not. As a result, a West German gear box with a comparable power level is smaller and may be perceived by the consumer as being technologically superior. However, it may also be necessary to add an auxiliary cooling device to the German gear box to prevent overheating.[14]

In the technology of gear production machinery, the lead once held by U.S. manufacturers is eroding. There is only one U.S. manufacturer of state-of-the-art bevel-gear-generating machine tools. Although several U.S. firms produce hobbing machine tools, industry sources indicate the U.S. hobbing machine tool sector is declining. The dominant company in gear grinding machinery is Swiss, and West Germany has leading firms in bevel gear, hobbing, and gear-grinding machine tools. Japan is believed to be competitive in gear hobbers, shapers, and grinders whereas the United States and West Germany have the world's leading gear metrology machine builders (see app. E for additional information).

In the area of process, or manufacturing, technology foreign firms have been quicker in adopting new developments such as factory automation and certain quality control techniques. The U.S. industry and certain research groups are taking steps to improve the U.S. technological standing. One U.S. firm, the Falk Corp., introduced a new employee-training program and management philosophy in 1984. Changes included training employees in statistical process control to boost quality and the introduction of machine clusters or cells to cut material handling and lead time. The firm is also utilizing robotics to load and unload machine tools and has installed two robotic cells to weld housings.[15] Other U.S. firms have introduced similar techniques since 1984 (see app. H for additional information). The gear instrumented factory (INFAC) program of the Defense Logistics Agency (DLA) focuses on improving existing manufacturing techniques. DLA stated that INFAC will be a means of finding out what the needs of industry are, and what level of automation is best for different-sized firms.

[14] USITC staff telephone interview with officials of AGMA, Mar. 3, 1990.
[15] USITC staff interview with officials of the Falk Corp., September 1989.

Patents and Licensing

Although several companies have patented special types of gears derived from general gear shapes, patents for special gears are not a major factor in establishing a competitive advantage.[16] It is the design of the gear product and its integration into power transmission equipment that gives some firms a competitive advantage. Many of the leading producers choose to license their designs to foreign manufacturers rather than export to or produce in foreign countries.

Licensed gear products are manufactured by leading companies in the United States, Europe, and Japan. Although no exact data are available, one official of the U.S. gear industry estimates that there are more gears manufactured in the United States under license from foreign gear producers than there are gears made overseas under license from U.S. firms.[17] West Germany, the United Kingdom, France, and Japan were cited as countries whose gear products were being produced in the United States under license. For example, certain U.S. gear manufacturers produce specialty gear products, such as gears used in marine or power generation applications, under license from West German and U.K. producers.

A few major U.S. producers have granted licenses for the manufacture of gears abroad. According to one U.S. company official, the reason this practice is not more widespread is because U.S. technology is perceived to be behind that of certain competitors in Europe and Japan.[18] According to this U.S. industry source, West German gear manufacturers grant more licenses for foreign production, mainly to countries located in Asia, than manufacturers from any other country. Japanese producers do not license "out," but manufacture in Japan under license from several European gear manufacturers. Licensed products are normally sold in the country in which the license is granted, so that the same product may be licensed in many countries to generate additional revenue.

[16] Ibid., Oct. 5, 1989.
[17] USITC staff telephone interview with Richard B. Norment, Executive Director, American Gear Manufacturers Association, Oct. 6, 1989.
[18] USITC staff telephone interview with officials of the Philadelphia Gear Co., Oct. 5, 1989.

Chapter 3
The Global Market

World Production and Consumption

Estimated world consumption[1] of vehicle, industrial, aerospace, and marine gearing during 1984-88 ranged from $20 billion to $25 billion in 1984 and increased to between $40 billion and $45 billion in 1988. However, a significant portion of the growth was attributable to the effect of exchange rate fluctuations on data converted to U.S. dollars. Measured in national currencies that have appreciated against the dollar, the change in production and consumption would be much smaller.

The major suppliers and consumers of gearing in the market economies of the world are the Western European countries, the United States, and Japan. These countries produce not only for their own needs, but also for export to most other markets worldwide. The Soviet Union, Hungary, East Germany, and China are the major producers and consumers of gearing in the nonmarket economies of the world. These countries supplement their own production with imports, mainly from Western Europe. Production of gearing in South America, Africa, and South Asia is destined mostly for internal markets and is insufficient to meet total demand, thus making imports a necessity.

Motor vehicle gearing represents more than 60 percent of world production and consumption of gears and gear products. The largest producers and consumers of vehicle gearing are those countries that have significant automotive industries—the United States, Japan, West Germany, Italy, France, the United Kingdom, Belgium, and Canada. Korea is a large consumer of vehicle gearing, but it must import a significant portion of its total needs.

The remainder of worldwide gearing production and consumption is divided among industrial, aerospace, and marine gearing. West Germany, the United States, and Japan are the world's largest sources and markets for industrial gearing, largely due to the size of the manufacturing, mining, and processing industries in these countries. The United States is not only the single largest producer of aerospace gearing, but the largest individual market for these gears as well. It accounts for 60 to 70 percent of global production and 30 to 40 percent of global consumption of aerospace gearing. Japan, West Germany, and Korea are the principal producers of marine gearing, as well as the largest shipbuilders. Their main markets are the developed countries.

Estimated gear and gearing production, export, import, and apparent consumption data for the major producing countries for 1988 are shown in table 3-1. The United States is the leading producer and consumer of gearing, principally due to its large vehicle and aerospace industries. Japan is the second largest producer, primarily because of the large volume of vehicle parts production in Japan, much of which is destined for overseas vehicle assembly plants. West Germany is the third largest producer with half of its shipments composed of industrial gearing and over one-third of the total accounted for by vehicle gearing. Canada, Italy, France, and the United Kingdom also have high levels of production principally because of vehicle-gearing manufacturing and assembly operations of major automotive producers located in these countries.

[1] These estimates exclude nonmarket economies and are based on questionnaire data collected by the Commission from the domestic gearing industry, official data published by the U.S. Department of Commerce, European and Japanese official statistical sources, and interviews with foreign industry executives.

Table 3-1
Gears and gearing: Profile of major market-economy producers and world[1] production and trade, 1988

Major producer	Production	Exports	Imports	Apparent consumption	Ratio of imports to consumption
	Million dollars				Percent
United States	14,759.1	2,424.8	2,740.7	15,075.0	18.2
Japan	8,428.2	2,478.8	89.9	6,039.2	1.5
West Germany	4,791.8	2,157.7	521.7	3,155.8	16.5
Canada	1,225.0	769.1	1,802.0	2,257.9	79.8
Italy	2,221.1	567.6	513.3	2,166.9	23.7
France	2,121.6	1,121.1	605.4	1,605.8	37.7
United Kingdom	942.1	412.6	973.4	1,503.0	64.8
Belgium	1,071.4	652.7	437.9	856.6	51.1
Korea	280.0	11.5	278.9	547.4	50.9
All other	9,159.7	604.1	836.8	9,392.4	8.9
Total	45,000.0	11,200.0	8,800.0	42,600.0	20.7

[1] Estimates exclude nonmarket economies.

Source: Estimated by the staff of the U.S. International Trade Commission, based on statistics of Eurotrans, *Eurostatistics*, Japanese Ministry of International Trade and Industry, the Japan Tariff Association, *Statistics Canada*, and the Bureau of the Census, and interviews with foreign industry executives.

During 1984-88, capacity in the gear industry grew in most countries. There were increases in the number of facilities and in investment in new machinery, especially during 1986-88, as the world economic situation improved. This was particularly true in countries such as Korea and Taiwan. These and other emerging suppliers are expected to become a greater force in the world market over the next 10 years.

World Trade Flows

For the market economies, 1988 exports of gearing totaled an estimated $11.2 billion and imports totaled $8.8 billion. The difference between these exports and imports, $2.4 billion, went largely to nonmarket economies. In 1988, the largest exporter was Japan, followed by the United States, West Germany, and France. Japan's exports as a share of its production were 29 percent, compared with 45 percent for West Germany, 16 percent for the United States, and 53 percent for France. The major importing countries in 1988 were the United States, Canada, and the United Kingdom. The demand for imported gearing in these countries was principally for vehicle gearing, in particular, automotive. Japanese automobile transplants in the United States and U.S. automobile producers and their subsidiaries in Canada dominate the trade flows within, as well as into and out of, North America.

Exchange Rates

Table 3-2 presents the nominal and real exchange rates (expressed in U.S. dollars per unit of foreign currency and indexed to 1984), as well as producer price indices, for eight producers and consumers of gears and gearing. An increase in the index represents an appreciation of the foreign currency compared with the dollar and a potential increase in the competitiveness of U.S. products.

A decrease in the value of the dollar relative to foreign currency, all other things held constant, raises the dollar price of imports. Therefore it can result in a decrease in the level of imports. Nevertheless, U.S. imports of gears and gearing continued to increase during 1984-88. A decrease in the value of the dollar lowers the price of U.S. commodities in terms of foreign currency, and can lead to increased exports. However, U.S. exports of gearing remained relatively constant after late 1985, when the U.S. dollar began to depreciate relative to the currencies of major trading partners, and only in 1988 did U.S. exports begin to rise. Industry sources contend that the continued growth in imports is due to a variety of nonprice factors such as quality or customer service. In addition, sources claim that import prices have not risen in proportion to the relative change in the exchange rates. The lack of growth in exports is most often attributed to the inexperience of U.S. firms in foreign markets; few firms export their products outside of North America.

Exchange rate fluctuations have a substantial effect on the trends in data converted from the original currency to U.S. dollars. For all the currencies that have a real exchange rate index greater than 100, the growth rate in shipments, exports, imports, and apparent consumption measured in U.S. dollars will be higher than that measured in the national currency. For example, growth in U.S. imports from West Germany measured in U.S. dollars was nearly 100 percent during 1984-88, whereas the percentage change valued in Deutsche marks was only about 28 percent. Because producers' costs and domestic purchases are usually valued in national currencies, the effect exchange rates have on industry data may distort trends.[2]

Tariffs

U.S. Customs Treatment

The imported gears and gearing included in this study are classified for tariff purposes under the provisions of the Harmonized Tariff Schedule of the United States (HTS)[3] shown in table 3-3 (see app. F for a concordance of HTS and TSUS item numbers). The Most Favored Nation (MFN) rates of duty applicable January 1, 1990, to U.S. imports of gearing range from "Free" to 50 cents each plus 7.7 percent ad valorem, which is estimated to be equivalent to 7.8 percent ad valorem (table 3-3). The current column 1 general duty rate reflects the final concessions granted by the United States in the Tokyo Round of the Multilateral Trade Negotiations under the General Agreement on Tariffs and Trade.

Col. 2[4] rates of duty range from "Free", for gear boxes suitable for agricultural use, to $4.50 each plus 65 percent ad valorem for nonenumerated speed changers. Eligible imports are also dutiable under several special preferential tariff programs.[5] For instance, much of the motor vehicle gearing from Canada enters the United States free of duty under the United States-Canada Automotive Products Trade Act (APTA).

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[2] See profiles of major producing and consuming countries in ch. 5 for a comparison of foreign industry trends measured in both dollars and foreign currencies.

[3] The Harmonized Commodity Description and Coding System, known as the Harmonized System or HS, is intended to serve as the single modern product nomenclature for use in classifying products for customs tariff, statistical, and transport purposes. Legislation passed in 1988 replaced the Tariff Schedules of the United States (TSUS) with an HS-based tariff schedule known as the Harmonized Tariff Schedule of the United States, effective Jan. 1, 1989.

[4] Col. 2 rates of duty apply to products whether imported directly or indirectly, from certain countries pursuant to sec. 401 of the Tariff Classification Act of 1962, to sec. 231 or 257(e)(2) of the Trade Expansion Act of 1962, to sec. 404(a) of the Trade Act of 1974, or to any other applicable section of law, or to action taken by the President thereunder.

[5] Rates of duty for imports from certain countries, preferential tariff programs, tariff nomenclature, and tariff and trade terms are explained in app. F.

Table 3-2

Exchange rates: Indices of the nominal and real exchange rates between the U.S. dollar and currencies of eight specified countries,[1] and indices of producer prices in the foreign countries and the United States,[2] 1984–88

(1984=100.0)

Year	West Germany			Italy			France			United Kingdom			
	Nominal exchange rate index	*Producer price index*	*Real exchange rate index[3]*	*Nominal exchange rate index*	*Producer price index*	*Real exchange rate index[3]*	*Nominal exchange rate index*	*Producer price index*	*Real exchange rate index[3]*	*Nominal exchange rate index*	*Producer price index*	*Real exchange rate index[3]*	*U.S. producer price index*
1984	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1985S	96.7	102.5	99.5	92.0	107.3	99.2	97.3	104.1	101.7	97.0	105.3	102.7	99.5
1986	131.1	99.9	135.5	117.9	106.3	129.7	126.2	([4])	([4])	109.8	109.8	124.6	96.6
1987	158.3	97.4	155.4	135.6	109.1	149.2	145.4	([4])	([4])	122.6	114.0	140.6	99.1
1988	162.0	98.7	154.7	135.0	114.3	149.5	146.7	([4])	([4])	133.3	119.2	153.7	103.1
	Japan			*Canada*			*Belgium*			*Korea*			
	Nominal exchange rate index	*Producer price index*	*Real exchange rate index[3]*	*Nominal exchange rate index*	*Producer price index*	*Real exchange rate index[3]*	*Nominal exchange rate index*	*Producer price index*	*Real exchange rate index[3]*	*Nominal exchange rate index*	*Producer price index*	*Real exchange rate index[3]*	*U.S. producer price index*
1984	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1985	99.6	98.9	99.1	94.8	102.7	97.9	97.3	102.6	100.3	92.6	100.9	93.9	99.5
1986	140.9	89.9	131.1	93.2	103.5	99.9	129.4	90.8	121.5	91.4	99.4	94.1	96.6
1987	164.2	86.6	143.2	97.7	106.3	104.7	154.8	86.3	134.7	98.0	99.9	98.8	99.1
1988	185.3	85.7	153.8	105.2	110.4	112.5	157.2	87.7	133.7	110.2	102.6	109.7	103.1

[1] Based on exchange rates expressed in U.S. dollars per unit of foreign currency.
[2] The producer price indices are aggregate measures of inflation at the wholesale level in the United States and the eight specified foreign countries.
[3] The real values of the foreign currencies are the nominal values adjusted for the difference between inflation rates in the individual foreign countries and the United States, as measured by the prevailing producer price indices in these countries.
[4] Data are not available.

Source: International Monetary Fund, *International Financial Statistics*, April 1989.

Table 3-3

Gears and gearing: Applicable U.S. general (most-favored-nation) rate of duty, by HTS subheading/statistical suffix, effective Jan. 1, 1990

HTS subheading	*Statistical suffix*	*Article description*	*General rate of duty*
			Percent ad valorem
8433.90.50	20-80(pt)	Parts for machinery of heading 8433, n.e.s.i.	Free
8436.99.00	20-90(pt)	Parts for agricultural, horticultural, forestry, poultry-keeping or bee-keeping machinery, n.e.s.i	Free
8483.40.30	40, 80	Fixed, multiple, and variable ratio manually operated speed changers, imported for use with machines for making cellulosic pulp, paper or paperboard	Free
8483.40.50	10, 50	Fixed, multiple, and variable ratio speed changers, other than for use with machines for making cellulosic pulp, paper or paperboard	2.5
8483.40.70	00	Speed changers other than fixed, multiple, and variable ratio manually operated speed changers	7.8[1]
8483.40.90	00(pt)	Gears and gearing, other than toothed wheels, chain sprockets and other elements	2.5
8483.60.80	00	Shaft couplings (other than universal joints)	5.7
8483.90.50	00	Parts of gearing, gear boxes and other speed changers	2.5
8483.90.80	10(pt), 90(pt)	Parts of transmission equipment, n.e.s.i	5.7
8501.40.20	20	Single-phase AC gearmotors, of an output exceeding 37.5 W but not exceeding 74.6 W	4.2
8501.40.40	20	Single-phase AC gearmotors, of an output exceeding 74.6 W but not exceeding 735 W	5
8501.40.50	20	Single-phase AC gearmotors, of an output exceeding 735 W but under 746 W	5
8501.40.60	20	Single-phase AC gearmotors, of 746 W or more	3.7
8501.51.20	20	Multiphase AC gearmotors, of an output exceeding 37.5 W but not exceeding 74.6 W	4.2
8501.51.40	20	Multiphase AC gearmotors, of an output exceeding 74.6 W but not exceeding 735 W	5
8501.51.50	20	Multiphase AC gearmotors, of an output exceeding 735 W but under 746 W	5
8501.51.60	20	Multiphase AC gearmotors, of an output from 746 W to 750 W	3.7
8501.52.40	00(pt)	Multiphase AC motors, of an output exceeding 750 W but not exceeding 14.92 kW	3.7
8501.52.80	20(pt), 40(pt)	Multiphase AC motors, of an output exceeding 14.92 kW but not exceeding 75 kW	Free
8501.53.40	40(pt), 80(pt)	Multiphase AC motors, of an output exceeding 75 kW but under 149.2 kW	Free
8501.53.60	00(pt)	Multiphase AC motors, of an output of 149.2 kW or more but not exceeding 150 kW	4.2
8501.53.80	40(pt), 60(pt)	Multiphase AC motors, of an output greater than 150 kW	4.2
8607.91.00	00(pt)	Parts of railway or tramway locomotives, n.e.s.i	3.9
8607.99.10	00(pt)	Parts for coaches and freight cars of heading 8605 or 8606 n.e.s.i., except brake regulators	5.5
8607.99.50	00(pt)	Parts of railway or tramway rolling stock, n.e.s.i	3.9
8708.40.10	00	Gear boxes for the vehicles of subheading 8701.20 or heading 8702 or 8704	3.1
8708.40.20	00	Gear boxes for the vehicles of heading 8703	3.1
8708.40.30	00	Gear boxes for tractors suitable for agricultural use	Free
8708.40.50	00	Gear boxes for the motor vehicles of heading 8701 (except subheading 8701.20) or 8705	3.1
8708.50.10	00	Drive axles for agricultural tractors	Free
8708.50.30	00	Drive axles for tractors not suitable for agricultural use	2.2
8708.50.50	00	Drive axles for motor cars	3.1
8708.50.80	00	Drive axles for vehicles other than tractors and motor cars	3.1
8708.94.10	00(pt)	Steering wheels, steering columns, and steering boxes for agricultural tractors	Free
8708.94.50	00(pt)	Steering wheels, steering columns, and steering boxes for vehicles other than agricultural tractors	3.1
8709.90.00	00(pt)	Parts of self-propelled works trucks for short distance transport of goods, and tractors of the type used on railway station platforms	Free
8710.00.00	90(pt)	Parts of tanks and other armored fighting vehicles	Free
8714.19.00	00(pt)	Parts and accessories of motorcycles (including mopeds), other than saddles and seats	4.2
8803.30.00	10(pt), 50(pt)	Parts of airplanes or helicopters, except propellers, rotors, and undercarriages	Free
8803.90.30	00(pt)	Parts of communications satellites	Free
8803.90.90	10(pt), 50(pt)	Parts of other aircraft, and spacecraft and spacecraft launch vehicles, except propellers, rotors, and undercarriages	Free

[1] Ad valorem equivalent of 50 cents each + 7.7 percent, based on 1988 U.S. imports.

Source: Office of Tariff Affairs and Trade Agreements, USITC.

Gearing products for most applications are classified under HTS headings 8483.40 and 8483.90. These provisions generally exclude gears and gear boxes "which are designed for use solely or principally with vehicles or aircraft," by virtue of notes 1(l) to section XVI and 2(e) to section XVII, as explained in the nonbinding Explanatory Notes.[6] However, if gears or gear boxes are internal parts of vehicle or aircraft engines, they are classified under HTS subheadings 8483.40 and 8483.90, as is gearing specially designed for ships.[7] AC electric gearmotors of an output exceeding 37.5 W, whether equipped with gears or gear boxes, are included in HTS heading 8501.[8]

Foreign Customs Treatment

Table 3-4 presents data on tariffs applied by selected countries to imported gears and gearing during 1988.[9] Tariffs are generally higher in nations such as Brazil, India, China, and Argentina, that are currently developing or expanding their industries. Tariff rates on gears and gearing and on vehicle gearing in these nations average 33 percent ad valorem and 28 percent ad valorem, respectively. In contrast, tariff rates applied by countries with mature, developed industries generally are about one-fourth of those applied by other countries, with gearing generally assessed tariffs of 3.4 to 7 percent ad valorem and vehicle gearing tariffs of 3.1 to 7 percent ad valorem. Rates of duty in Eastern Europe and the Soviet Union generally fall between the tariff rates of Western developed countries and those of other countries.

Transportation Factors

In response to Commission questionnaires, most U.S. producers and importers reported that transportation costs are not an important factor in selling gear products. However, a few of the respondents, largely those that export limited quantities of gearing, stated that transporting their products over long distances, either across the United States or overseas, adds a significant amount to the price. Estimates of the cost of transportation, as a percent of price, range from 2 to 3 percent for freight alone to 15 to 20 percent for overseas freight and customs costs. The size and weight of the larger products were cited by a few respondents as major factors that made long-distance shipping costs prohibitive.

Most U.S. producers do not export their products and many of those who do concentrate on the nearest foreign market, Canada. Companies that export reported that transportation costs either add to export prices or restrict profit margins. In export markets, U.S. producers report that if the cost of transportation is added to the price, they lose sales to foreign producers. If the cost of transportation is not added to the price, U.S. producers stated that they were not able to make sufficient profits on the sales. Transportation costs may make U.S. products less competitively priced in Eastern Europe, Africa, and Asia. In many instances, foreign producers have lower transportation costs because they are geographically closer to developing country markets; for instance, Western European producers can readily transport to the Middle East, Africa, or East Bloc nations. Japanese producers can readily transport to Pacific Rim markets. In instances where transportation costs are prohibitive, foreign markets are often penetrated by establishing local subsidiaries that produce gearing or by licensing agreements.

Unfair Trade Practices

The Commission is unaware of any petitions or complaints filed in recent years under U.S. or foreign antidumping, countervailing duty, or unfair trade practice statutes regarding gears and gearing.[10]

The Role of Product Standards in Gear Trade

Gear standards function as a common language through which gear manufacturers and users can evaluate various gear products. They provide users with reference points as to the reliability and performance of a product based either on design or application experience. The standards process also provides a forum for scientific discussion of product design, materials, and application, which often leads to better products. In addition, standards are also used as a marketing tool by manufacturers, either in penetrating new markets or protecting established markets.

Standards Systems

Outside of proprietary designs, gears and gearing in international trade are manufactured to the national standards developed by the West German Standards Institute (DIN),[11] the American Gear Manufacturers Association (AGMA), and to a lesser extent by the Japanese Industrial Standards (JIS). A limited number of gear standards have also been developed by the International Standards Organization (ISO). Although not as widely used, gear standards have been established by the national standards bodies in many countries.

For special applications, such as aerospace gearing, individual producers may have their own standards, such as the PW standard for Pratt & Whitney products. National defense organizations

[6] Customs Cooperation Council, *Harmonized Commodity Description and Coding System: Explanatory Notes*, First Edition, 1986.
[7] Ibid.
[8] Ibid.
[9] Some countries have revised their rates since publication of the source materials used.

[10] U.S. Department of State Telegrams, 1989.
[11] Deutsches Institut fur Normung.

Table 3-4

Gears and gearing: Applicable import tariffs, by selected source and product, 1988

(Percent ad valorem or ad valorem equivalent)

Source	Gear boxes and other speed changers	Gears and gearing	Parts of gearing, gear boxes, etc.	Gearmotors	Gear boxes for vehicles HS 8701-8705	Hydraulic power engines—gear type	Screw-type compressors for use in refrigeration	Gear-type hydraulic fluid power pumps
Developed countries:								
Austria	7	7	7	22	4	7	6	8
Canada	7.3	7.3	8.9	8.4-12	8.3[1]	7.4	4-7.4	7.4
Finland	3.8	3.8	16.5	4	7	5.1	5.1	5.1
Japan	Free-3.4	Free-3.4	Free-3.4	Free	Free	Free	Free-4.6	Free
New Zealand	34	34	34	25.5	5	5	5	Free
Norway	6.2	6.2	6.2	3.8	Free-7	6.2	Free	5.1
Sweden	3.8	3.8	3.8	3.8	5.3-6.2	3.8	3	3
United States[2]	3.4	2.5	2.5	5.0	5.1[1]	3.4	3.4	3
EC	4.9	4.9	7	5	4.9	7	4.4	4
Eastern Europe:								
Czechoslovakia	22	22	22	10	24	24	15	12
East Germany	Free	Free	Free	Free	Free	Free	Free	Free
Hungary	([3])	([3])	([3])	30	Free	10.4	11	10.4
Poland	([3])	([3])	([3])	7	45	15	25	25
Soviet Union[4]	Free	Free	Free	Free	Free	Free	Free	Free
Other countries:								
Argentina[5]	5-40	5-40	5-40	5-40	10-40	10-40	40	40
Brazil	57	57	57	50	57	50	50	50
Mexico[6]	10	10	10	10	10	10	20	30
Central America Common Market[7]	5-20	5-20	5-20	5	5-10	5	5	5
China	20	20	20	20	20	20	20	20
Korea	15	15	5	15	15	15	15	15
India[8]	60	60	100	110	100	50	110	50
Taiwan	15	15	30	10-15	17.5-25	10	15	12.5
Venezuela[9]	1	1	1	1-80	1	1-35	1-70	1

[1] Agricultural tractors are free.
[2] Articles are duty free if certified for use in civil aircraft.
[3] Not available.
[4] A tax is assessed on the importer of record.
[5] All imports are assessed an additional 7-percent miscellaneous tax and a 13-percent value added tax.
[6] All imports are assessed an additional 6-percent for handling charges and a 13-percent value added tax.
[7] Guatemala, El Salvador, Nicaragua, and Costa Rica.
[8] Duty rates between 0 and 60 percent are assessed an additional 30 percent of duty; duty rates 60 percent or higher are assessed an additional 40 percent of duty.
[9] All imports are assessed an additional 5 percent service fee.

Source: Douanes International Customs Tariffs Bureau and individual country sources.

will also have specific standards, which vary from commercial standards, depending on the application. For instance, the U.S. military uses a standard called "Mil-spec."

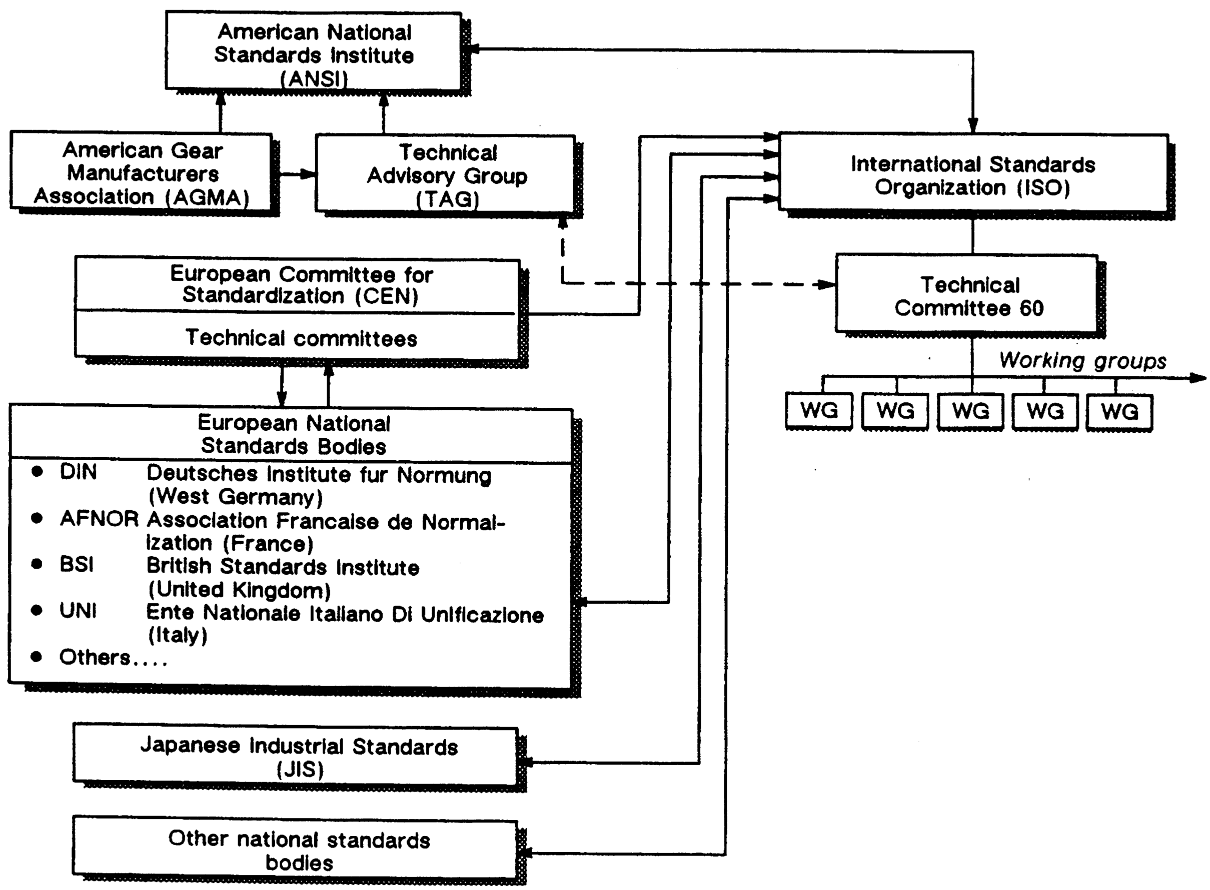
The AGMA rating standards first appeared in 1919, followed by AGMA gear quality standards in the late 1930s. AGMA standards are used primarily in the United States, Canada, Australia, and to a lesser extent in Japan and Taiwan. The first West German gear quality standard was issued in 1951.[12] The DIN standards are widely used in Europe, including the Soviet Union, even though there are national standards systems in most of these countries. Recently, DIN standards have been promoted in China. The JIS standards are widely used in Japan, and are complemented by gear standards developed by the Japan Gear Manufacturers Association (JGMA). JIS gear standards are also widely used in Taiwan and Korea, where the industries have been significantly influenced by trade with Japan.

[12] Donald R. McVittie, "Analyzing Gear Standards," *Power Transmission Design*, August 1987, pp. 27-31.

The ISO and the European Committee for Standardization (CEN) are working on international standard systems. CEN is planning to develop a single set of standards for the European Community (EC) and the European Free Trade Association (EFTA) by the end of 1992, but has not yet put together a body of standards. Industry sources assume that CEN will adopt the most prevalent standard in the EC, which at this time is DIN, as the unified standard. The set of gear standards issued by the ISO, an organization to which most of the major gear producers belong, is not as fully developed as those of AGMA or DIN. To date, this organization has no performance rating standards in force. The 16 ISO standards cover nomenclature, tooling, and geometry.[13] Although most ISO drafts of gear standards use DIN standards, the AGMA, acting through the American National Standards Institute (ANSI), has become more active in the ISO during the last few years and has had some success in influencing ISO standard drafting. The relationship between national standard setting organizations, including CEN and ANSI, and the ISO is illustrated in figure 3-1.

[13] Ibid.

Figure 3-1
Framework for the development of international gear standards



Source: American National Standards Institute and the American Gear Manufacturers Association.

A Comparison of Standards Systems

The principal difference between AGMA and DIN standards is that the former rely heavily on actual experience, whereas DIN standards are based largely on theoretical and laboratory research data. Western European gear producers have indicated that DIN standards are more comprehensive than AGMA's. DIN standards include bearings, steel profiles, and lubrication, whereas AGMA standards relate to gears only and favor "through-hardened" over "case-hardened" gears.[14] Other differences between AGMA and DIN standards relate to material appraisal, quality determination, service factors, gear box components, and thermal capacity.

AGMA standards are conservative in order to decrease the chances that the gears will fail, leading to downtime and/or personal injury. Since product liability is more of an issue and expense in the U.S. market than in any other country, the need for conservative standards is more relevant to the U.S. industry. According to U.S. industry sources, for a number of applications in the United States, purchasers need gears and gear products with more durability and are thus better served by a more conservative standard such as AGMA.[15]

AGMA believes that its approach to developing standards is receiving wider acceptance in Europe, in part because of its emphasis on "serviceability" compared with the more "academic" approach frequently utilized to draft European standards.[16] A similar view was expressed by a major Japanese gear manufacturer, who believes AGMA standards are becoming stronger than DIN standards internationally and will continue to do so in the future because AGMA's are more flexible in matching the customer's needs with the product life cycle.[17]

Manufacturers can, and do, produce gears to any standard, including hybrids of national standards plus their own manufacturing and applications experience. It is important for consumers to understand the various gear standards so that they can benefit from the strengths of a particular system.[18] Each user needs to take into account his special application and equate his requirements with the cost of the various products on the market.

Despite the fact that standards are voluntary, they are often used by private and public procurement officials in tender documents and may attain the status of a de facto requirement in particular countries.[19] All countries with their own national standards view them as a marketing tool and, furthermore, wish that they be replicated in international standards.

The most prevalent standard covering gears and gearing has been the DIN standard which covers a wide range of products, including gears, and is aggressively promoted by West Germany. DIN has assisted standards development agencies, in general, in the less developed countries (LDCs)[20] and, with respect to gears, in such countries as China; Saudi Arabia, which influences other neighboring countries; Brazil;[21] and the Soviet Union.[22] Both the U.S. and Japanese industries, as well as those of 20 other countries, work through the ISO to present their own views on standards, but their budgets for this purpose are believed to be considerably less than such funding in West Germany. The aggressive marketing of the DIN standards has greatly facilitated the acceptance of West German products into foreign markets at the expense of competitors.

Presently, the U.S. gear industry manufactures almost exclusively to AGMA standards. Since AGMA standards are widely accepted in only a few markets, export opportunities have been limited. With respect to gear exports to the EC, the U.S. industry argues that the costs of redesigning and manufacturing gears to other national standards for this market may be prohibitively expensive.[23]

A different point of view on the subject of manufacturing to more than one national/international standard was voiced to the Commission by a major West German gear producer that manufactures in the United States. This company stated that, in general, foreign-owned companies must and do comply with more than one set of standards, as it does by manufacturing all of its gear products sold in the United States to AGMA standards.[24] One French firm indicated that while it prefers to manufacture to DIN standards, it can produce to any standard easily because it uses computer numerically controlled machine tools.[25]

West European and Japanese gear producers reported that the use of the U.S. customary system as opposed to the metric system restricts U.S. export potential but that gear producers need to be able to manufacture to any specifications in order to compete in the world market. To accomplish this, certain adjustments need to be made, sometimes at an additional cost. Some companies that export reported the conversion to inches often only applies to the dimensions of the input and output shafts. However, the availability of replacement parts for the internal gear workings may play a significant

[14] USITC staff interviews with gear industry officials, Western Europe, November-December 1989.
[15] USITC staff telephone interview with officials of the Philadelphia Gear Company, Oct. 5, 1989.
[16] AGMA, *European Economic Report*, 1989 edition.
[17] USITC staff interviews with gear industry officials, Japan, December 1989.
[18] McVittie, "Analyzing Gear Standards," pp. 27-31.
[19] U.S. International Trade Commission, *The Effects of Greater Economic Integration Within the European Community on the United States*, USITC Publication 2204, July 1989, p. 6-9.

[20] AGMA, prehearing submission, Oct. 25, 1989.
[21] USITC staff interviews with officials of the AGMA, Nov. 2, 1989.
[22] VDMA response to USITC staff inquiries, Dec. 12, 1989.
[23] AGMA, posthearing submission, Nov. 15, 1989, p. 26.
[24] SEW-Eurodrive, Inc., posthearing submission, Nov. 15, 1989, pp. 6-7.
[25] USITC staff interviews with gear industry officials, France, November 1989.

role in the purchase decision.[26] It costs firms more to manufacture to a different measuring system partly because designs have to be converted and partly because production runs in different measuring systems are usually smaller. One company estimated a 10 percent increase in costs.[27] Other exporting firms reported that they attempt to switch customers to a metric standard because of the possibility of an error in the conversion.[28]

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[26] USITC staff interviews with gear industry officials, Western Europe, November-December 1989.
[27] Ibid.
[28] USITC staff interviews with gear industry officials, Japan, December 1989.

Chapter 4
The U.S. Industry

Industry Structure

The establishments that produce gears and gearing fall into two groups – those that manufacture for sale to other unrelated firms and those captive establishments producing gearing for their end-product divisions. The majority of noncaptive, or merchant, producers are small firms with fewer than 200 employees. Many are family-owned and operated, and fewer than 10 percent have more than one establishment. Many of these companies are job shop operations producing a wide range of gears to order, and the composition of their production may change substantially from year to year. Captive producers, on the other hand, are generally subsidiaries of larger corporations that have established gear-manufacturing facilities to supply parts and subassemblies for incorporation into the company's finished products. Many of the captive gear producers are in the automotive and aerospace industries and overall are estimated to account for approximately two-thirds of total shipments.

The vehicle sector has a higher proportion of captive establishments producing gears and gearing assemblies than do the industrial, aerospace, and marine gearing sectors. Industry sources indicate that there are approximately 40 establishments engaged primarily in the production of vehicle gearing. The largest establishments, both in number of employees and value of production, are subsidiaries of the Big Three auto makers. The remainder of this industry sector consists of establishments producing specialty vehicle gears and transmissions, such as those used on heavy-duty trucks and off-road vehicles, or smaller suppliers to the major original equipment manufacturers (OEMs) in the industry. Many of the producers of specialty vehicle gearing and nearly all of the subcontractors and job shops are independent producers. Due to strong demand, the number of establishments producing these items has remained relatively constant over the past 5 years. OEMs may purchase gearing, either from other motor vehicle producers or from independent sources. These firms also export motor vehicle transmissions and other motor vehicle gearing to their foreign subsidiaries, primarily in Canada. Likewise, they frequently import motor vehicle transmissions and other motor vehicle gearing into the United States from their overseas subsidiaries and joint-venture partners.

In the industrial segment of the gearing industry,[1] the number of establishments decreased from 309 in 1982 to 272 in 1987.[2] Most of these producers are independent companies, employing fewer than 500 persons and averaging approximately 150 employees. The largest U.S. firms producing industrial gearing employ between 900 and 1,300 persons. The larger U.S. producers tend to have foreign subsidiaries, principally in Canada and Mexico. Recently, several foreign industrial gearing producers have established manufacturing or assembly operations in the United States. Such firms include SEW-Eurodrive and Flender, from West Germany; Sumitomo and Shimpo, from Japan; and Hansen Transmissions, headquartered in Belgium. Several other foreign-based producers have minor assembly and sales operations in the United States.

Aerospace gearing producers are, for the most part, independent producers that manufacture power transmission equipment for a variety of applications in the aerospace and other industries. Some producers are subsidiaries of larger multiproduct corporations, others are independent gearing manufacturers, and a few are captive producers. According to industry sources, 13 firms account for the bulk of aerospace gearing sold in the U.S. market. Helicopter producers, more than other aerospace manufacturers, tend to have captive production facilities, but they often supplement their own production with open market purchases. Foreign firms have not established any new manufacturing of aerospace gearing in the United States; however, Lucas Aerospace of the United Kingdom acquired Western Gear in 1987, thereby becoming one of the largest U.S. aerospace gearing producers.

The number of U.S. companies producing marine gearing has declined significantly over the last decade. According to industry sources, there are less than 10 producers of large marine gearing in the United States, and most of those firms supply gearing for both commercial and defense applications. Currently, nearly all ship gearing is produced by five U.S. producers – General Electric, Westinghouse, Falk, Philadelphia Gear, and Cincinnati Gear. In recent years, U.S. and West German firms have entered into agreements allowing for U.S. production of marine gearing using design and technological input from West German firms. Gearing for pleasure craft is manufactured principally by three U.S. firms, OMC Corp., formerly Outboard Marine Corp., Mercury Marine, a subsidiary of the Brunswick Corp, and Twin Disc. There are some small job shops participating in the marine market, but their activities are usually restricted to repair operations.

Structural Changes

The past decade has brought many changes in the U.S. gear industry. Many gear-consuming industries, such as shipbuilding and agricultural and construction equipment, have experienced significant declines, and others, such as steel, have adopted new manufacturing processes that utilize substantial amounts of imported production

[1] Speed changers, industrial high-speed drives, and gears (SIC 3566).

[2] Data are from the 1982 and 1987 *Census of Manufactures.*

equipment. These factors, combined with increasing imports of finished products containing gears and gear products, and the growing trend for U.S. gear consumers to establish captive shops, have resulted in major changes in the industry. Like many other U.S. industries, the domestic gear industry has been affected by a number of mergers, acquisitions, leveraged buy-outs (LBOs), and joint ventures in recent years, following a period of divestitures prior to mid-1984. According to industry sources, in the early 1980s, there were a number of divestitures of well known gear companies by large multinational corporations, principally because many of these operations generated low returns on investment during and immediately after the 1981-82 recession. Examples of such divestitures include Bucyrus-Erie selling Western Gear, Brad-Foote, and Pittsburgh Gear; FMC Corporation selling PT Components; Dresser Industries selling its Foote Jones division; and Westinghouse selling Nuttall Gear. Since mid-1984 through early 1990, according to data compiled from the Commission's questionnaires and other data sources, there were at least 16 LBOs and 33 acquisitions of gear producers.

The motivation for structural changes in the U.S. gear industry varies considerably. In some instances, firms seek to complement their current product lines in order to offer complete lines of equipment or to enter new markets. For example, in the first half of 1989, Deere & Company purchased Funk Manufacturing, a power transmission and pump drive producer, to improve its ability to offer motor vehicle transmission and engine packages to its off-highway motor vehicle customers. Similarly, in late 1987, Regal-Beloit purchased Household International's Gear Products Division, which included Illinois Gear, Richmond Gear, and Ohio Gear. These firms' custom gearing and enclosed drives complemented the products of Regal-Beloit's own motor vehicle transmission division without duplicating its products.[3] And, in mid-1987, Keystone Carbon, a powdered metal parts (including gears) and bearings producer, purchased Allegheny International's IPM, a high-volume auto parts producer, to increase its output of medium-to-large parts used mostly in automobiles, appliances, lawn and garden equipment, power tools, and business machines.

In other cases, firms seek to make more efficient use of production capacity. GM and Chrysler announced a joint venture in October 1989 to combine the operations of GM's Hydra-matic Division manual transmission plant in Muncie, IN, with that of Chrysler's New Process Gear Division in Syracuse, NY. GM will have 36-percent equity in the venture and Chrysler will have 64 percent. According to press accounts, this is the first time any of the Big Three have collaborated on joint production. Chrysler's New Process Gear Division, which had been operating at full capacity, will concentrate on four-wheel-drive transfer cases.[4] Its production of manual transmissions for passenger cars will be shifted to GM's plant, which has been operating at low capacity rates. The legal basis for this joint venture is found in the Cooperative Research Act of 1984, under which joint ventures, mergers, and acquisitions are registered with the Government, and their antitrust liability is limited.

Some firms use joint ventures and other arrangements as a means of gaining entry into new product markets or into the U.S. market. By forming a joint venture with Koyo Seiko, a Japanese parts producer that is 20-percent owned by Toyota, TRW, a U.S. company, has contracts to supply steering gears to the U.S. operations of Toyota, Mitsubishi, Mazda, and Hyundai. TRW also supplies steering gears to Nissan's Tennessee operations. In order to more quickly penetrate the U.S. market, LeRoy-Somer purchased King Bearing, a large U.S. distributor of mechanical power transmission products, including gearing. Two independent West German producers, ZF Transmissions and Getrag, have established gear/motor vehicle transmission assembly plants in the United States and Honda began assembly of transmissions at its automobile assembly and engine manufacturing plant in Marysville, OH, in late November 1989.

Although much of the activity in international acquisitions has been foreign firms investing in U.S. facilities, some U.S. firms have acquired interests overseas to expand their markets. For example, to improve its strength in international markets and to gain more expertise in transmission and drive components, Cummins Engine acquired Self Changing Gears, a British producer of gear boxes used for military and industrial applications. In January 1990, Emerson Electric announced its proposed acquisition of Leroy-Somer, a French gearmotor producer, for $460 million. Emerson previously purchased McGill Manufacturing, a domestic producer of bearings, for an estimated $135 million.[5]

U.S. Shipments

The United States is the largest producer of gears and gearing. At least 50 to 60 percent of total U.S. shipments is captive; this percentage is even higher for motor vehicle gearing. The estimated value of U.S. shipments of gears and gearing increased by 20 percent in nominal terms during 1984-88, from $12.3 billion to $14.8 billion, and in real terms, the value of gear and gearing shipments rose 16 percent, increasing from $12.3 billion in 1984 to $14.3 billion in 1988. The following

[3] "Regal-Beloit Buying Gear Division from Household Manufacturing," *Metalworking News*, July 27, 1987, pp. 4 and 24.

[4] "GM/Chrysler Coop: What It Could Mean," *American Machinist*, November 1989, p. 51.

[5] Dave Fusano, "Emerson Bid of $93/Share Bags McGill," *Metalworking News*, Dec. 18 & 25, 1989, pp. 44–45.

tabulation shows estimated total shipments in millions of dollars in both nominal and real[6] values:

Year	Nominal	Real
1984	12,293	12,293
1985	13,168	13,234
1986	13,139	13,601
1987	13,762	13,887
1988	14,759	14,315

The estimated value of U.S. shipments increased more rapidly in 1987 than it had earlier in the period. This increase in the growth rate was principally due to the expansion in the U.S. economy that led to greater expenditures for both capital and consumer goods. The bulk of the increase in U.S. shipments can be accounted for by an increase in demand for gears in the motor vehicle area, specifically the automotive sector. As shown in table 4-1, U.S. shipments of gears and gearing during 1984–88 consisted primarily of gears and gearing for motor vehicles. U.S. shipments of motor vehicle gears increased from $9.6 billion in 1984 to $11.9 billion in 1988, an increase of 24 percent. The value of shipments of gears for industrial purposes showed only minimal growth during the 1984–88 period, reflecting lower levels of investment in the U.S. industrial sector. U.S. shipments of gears for aerospace products increased 15 percent during 1984–88 as public demand for air travel increased, necessitating the purchase of new aircraft and replacement parts for refurbishing older aircraft. The demand for marine gears remained relatively low reflecting the depressed status of the shipping industry. U.S. shipments of marine gears consisted mainly of replacement parts for ships and gears for pleasure craft.

According to data compiled from the Commission's questionnaires, U.S. producers' shipments of gears and gearing for defense applications rose from $737.1 million in 1984 to $797.8 million in 1986 and then fell to $730.6 million in 1988. However, these totals are probably understated because vehicle and industrial gearing producers manufacture commercial-type power transmission products that may be sold to OEMs or distributors. Because producers have no contact with the ultimate consumer, they are often unaware of the identity of the end user.

Based on questionnaire data, defense shipments were estimated to account for approximately half of U.S. producers' shipments of aerospace gearing and about one-third of marine gearing shipments. Aerospace gearing was the largest sector, accounting for more than half of reported defense shipments in every year during 1984–88. Marine gearing was the smallest sector throughout the period, accounting for less than 5 percent of the total in each year. Aerospace gearing shipments followed roughly the same trend as total defense shipments, which peaked in 1986 and then declined, whereas marine gearing shipments showed no clear trend during 1984–88. The remainder of defense shipments were of industrial and vehicle gearing which declined from approximately 45 percent to 33 percent of reported defense shipments during the period.

U.S. Exports

U.S. exports of gears and gearing increased from an estimated $2.0 billion in 1984 to $2.4 billion in 1988, or by 22 percent. The real value of U.S. exports of gears and gear products increased nearly as much as the nominal value, representing an increase of 18 percent. The following tabulation shows estimated real[7] and nominal value of U.S. exports, in millions of dollars, during 1984–88:

Year	Nominal	Real
1984	1,987	1,987
1985	2,221	2,232
1986	1,926	1,994
1987	1,970	1,987
1988	2,425	2,351

[6] Computed using the Producer Price Index from International Monetary Fund, *International Financial Statistics*, April 1989.

[7] Ibid.

Table 4-1

Gears and gearing: U.S. producers' shipments, 1984-88

Item	1984	1985	1986	1987	1988	Change, 1988 over 1984
	Million dollars					Percent
Motor vehicle	9,588.8	10,564.1	10,466.1	11,068.4	11,875.9	23.9
Industrial	1,638.8	1,570.5	1,529.4	1,535.8	1,678.9	2.4
Aerospace	810.9	784.6	895.2	893.1	928.7	14.5
Marine	254.1	249.2	248.7	265.1	275.6	8.5
Total	12,292.6	13,168.4	13,139.4	13,762.4	14,759.1	20.1

Source: Estimated by the staff of the U.S. International Trade Commission.

Exports accounted for less than 17 percent of total U.S. shipments in every year during the period. In 1984, the United States experienced a trade surplus in gears and gearing of approximately $245.5 million. By 1988, the growth in imports had outstripped that of exports to such an extent that the trade balance had shifted to a deficit of $315.9 million.

As shown in table 4-2, U.S. exports of gears and gearing for motor vehicles constituted the largest segment of U.S. exports, whereas gears and gear products for marine purposes accounted for the smallest segment. During 1984-88, exports of motor vehicle gearing increased from $1.7 billion to $2.1 billion, representing an increase of 21 percent. Exports of marine gearing had the largest percentage change on the smallest base with a nearly 86 percent increase during 1984-88. Aerospace gearing posted the next largest increase, 47 percent, followed by vehicle gearing with 21 percent and industrial with 15 percent.

During 1984-88, Canada, Mexico, the United Kingdom, Japan, Australia, and West Germany were the principal markets for U.S. exports, accounting for 66 percent of total U.S. exports during 1988 (table 4-3). Canada has traditionally been the leading foreign market for U.S. exports of gears and gearing primarily because of the cross-border structure of the automobile industry. Canada accounted for 53 percent of total U.S. exports in 1988, which consisted principally of gear boxes and parts for motor vehicles. In total, exports of motor vehicle gears and gearing accounted for 90 percent of U.S. exports to the six leading foreign markets, and most exports were sent to foreign subsidiaries or partners of U.S. firms.

U.S. industry sources indicated that the increase in exports can be attributed to three factors: cyclical patterns in the U.S. automotive industry, the weakening of the dollar against most foreign currencies in 1987-88, and the increasing intermingling of U.S. and foreign companies, especially in the automotive industry.

Respondents to the questionnaire indicated that trade barriers exist which have significantly inhibited the free flow of U.S. exports into major foreign markets. The most often mentioned trade barriers included high tariffs, import licensing requirements, technology transfer requirements, local content requirements, exchange rate and other monetary or financial controls, and discriminatory sourcing. Countries most often cited with significant barriers to trade included Japan, Argentina, Australia, Brazil, EC member states, India, Mexico, Korea, and China.

Table 4-2

Gears and gearing: U.S. exports of domestic merchandise, by type of sector, 1984-88

Item	*1984*	*1985*	*1986*	*1987*	*1988*	*Change, 1988 over 1984*
	Million dollars					*Percent*
Motor vehicle	1,737.0	1,946.2	1,661.5	1,683.8	2,101.4	21.0
Industrial	144.6	148.3	136.4	145.8	166.7	15.3
Aerospace	98.0	118.5	118.7	129.3	143.7	46.7
Marine	7.0	8.0	9.0	11.0	13.0	85.7
Total	1,986.6	2,221.0	1,925.6	1,969.9	2,424.8	22.1

Source: Estimated by the staff of the U.S. International Trade Commission.

Table 4-3

Gears and gearing: U.S. exports of domestic merchandise, by principal markets, 1984-88

(In millions of dollars)

Principal market	*1984*	*1985*	*1986*	*1987*	*1988*
Canada	1,021.5	1,154.9	997.2	1,007.9	1,277.2
Mexico	64.4	97.6	59.3	50.6	76.2
United Kingdom	75.3	71.8	62.5	60.3	74.6
Japan	58.3	48.4	46.6	50.7	70.2
Australia	49.0	51.2	38.8	45.6	66.2
West Germany	67.4	66.0	40.0	41.0	45.4
All other	650.7	731.1	681.2	713.8	815.0
Total	1,986.6	2,221.0	1,925.6	1,969.9	2,424.8

Source: Estimated by the staff of the U.S. International Trade Commission.

Employment

The number of production workers employed in the U.S. gear industry fell from an estimated 87,800 in 1984 to a low of 82,200 in 1987, a decline of 6 percent (table 4-4). However, between 1987 and 1988, employment increased by 3 percent, rising to 84,600. The increase was most likely in response to an upturn in the market in 1987–88. Nominal wages and total compensation per hour for employees in this sector rose by 8 percent and 11 percent, respectively, during 1984–88. However, hourly wages and total compensation, including fringe benefits, bonuses, and payments in kind, decreased by 4 and 2 percent, respectively, in real terms.[8] Although neither wages nor compensation in real terms increased, both nominal and real worker productivity figures rose. In real terms, annual productivity per production worker increased by 21 percent and worker productivity per hour, as measured by output per man-hour, climbed by 17 percent.

Unionization

According to AGMA statistics, 54 percent of AGMA members have unions representing their hourly workforce,[9] although the degree of unionization varies by sector. For example, workers in the auto industry are more heavily unionized than are workers in the industrial gearing sector. Data gathered in the Commission's questionnaire indicated that respondents' workers producing gearing were represented by a number of different unions. The International Association of Machinists and Aerospace Workers (IAM) was mentioned most frequently, followed closely by the United Auto Workers (UAW). Other labor organizations representing employees of gear manufacturers included the United Steelworkers of America and the International Union of Electronic, Electrical, Machine and Furniture Workers (IUE), as well as the International Brotherhood of Electrical Workers (IBEW) and the International Brotherhood of the Teamsters.

Questionnaire responses revealed that the majority of unionized firms had union contracts which provided for work rules. These rules cover scheduling (usually by seniority), time and attendance, safety, behavior and ethics, work content, and job classification. Reported effects on productivity were mixed. While some firms reported that the work rules harmed productivity by inhibiting flexibility in assigning workers to jobs, others felt that the rules aided in the efficient control of scheduling and the orderly flow of work from job to job.

[8] Real wages calculated using a wage deflator based on machinists' wages.

[9] AGMA, posthearing submission, Nov. 15, 1989, p. 35.

Table 4-4

Employment and wages in the U.S. gear industry, 1984-88

Item	*1984*	*1985*	*1986*	*1987*	*1988*	*Change, 1988 over 1984*
Production workers (thousands)	87.8	83.4	84.7	82.2	84.6	(3.6)
Annual hours per worker	2,084	2,091	2,125	2,135	2,154	3.4
Wages per hour:						
Nominal	$13.97	$4.73	$14.48	$14.82	$15.10	8.1
Real (1984=100)	$13.97	$14.23	$13.60	$13.55	$13.35	(4.4)
Total compensation per hour:						
Nominal	$18.17	$19.25	$20.16	$19.82	$20.22	11.3
Real (1984=100)	$18.17	$18.59	$18.94	$18.12	$17.87	(1.7)
Annual worker productivity:[1]						
Nominal (1,000 dollars):	140.0	157.9	155.1	167.4	174.5	24.6
Real (1984=100) (1,000 dollars)	140.0	158.7	160.6	168.9	169.3	20.9
Worker productivity per hour:						
Nominal	$67.18	$75.51	$73.00	$78.42	$80.99	20.6
Real (1984=100)	$67.18	$75.89	$75.57	$79.13	$78.55	16.9

[1] Shipments per worker.

Source: Estimated by the staff of the International Trade Commission, based on data from the U.S. Bureau of Labor Statistics, *Supplement to Employment and Earnings*, the International Monetary Fund, *International Financial Statistics Yearbook*, and compiled from Commission questionnaires.

Labor Supply

As in other U.S. industries, the gear industry reports difficulty in finding and attracting the skilled personnel needed for manufacturing operations. Machinists, and trainees with the necessary mathematical skills to become machinists, are most in demand. Computer numerically controlled (CNC) lathe operators, qualified electricians with backgrounds in industrial electronics, gear grinders and cutters, engineers, and inspectors are also in short supply. U.S. gear producers offer several possible reasons for the shortages. Some firms attribute the scarcity of workers to generally low unemployment in their geographic areas or to competition from higher paying shops offering more benefits, overtime, and bonuses. Many complain that there are insufficient numbers of high school graduates with adequate mathematical and verbal skills. Also, they state that it is difficult to attract young people to the manufacturing trades when starting wages are often lower than service industry wages, and work hours are long.

This trend could prove even more troublesome for the industry in the future as the average age of the workforce rises. Researchers projected that the percentage of the population aged 35 to 54 would grow by more than 44 percent between 1987 and 1993, although the 15-to-34 age group from which new employees will come would decline by almost 13 percent.[10] Data gathered in the Commission's questionnaire reflect this projection. As shown in table 4-5, the overall average age of workers in the gear industry ranges from 39 to 41. Although these workers have at least 20 more productive years before retirement age, a pool of younger workers is needed to replace them. However, the 25-to-34 age group currently accounts for a relatively small portion of the workforce in most of the occupations listed. If the average age of the workforce continues to rise – that is, if attracting younger people remains a problem – manufacturers will face an even more severe shortage in the future.

[10] *Wall Street Journal*, Jan. 18, 1988, p. B1.

To combat the labor shortage, some gear manufacturers have recruited trainees from trade and vocational schools and community colleges, and trained them in-house.[11] On-the-job training has a significant cost, as it requires taking otherwise productive skilled workers away from their tasks in order to train new workers. Some firms have minimized this cost by bringing back recent retirees as instructors. Producers also report that training provided in trade schools does not adequately prepare the students for the manufacturing environment; often, the machines used and processes taught are out-of-date. Therefore, some firms have worked with these institutions to develop programs covering rudimentary skills, such as blueprint reading and basic machine operations. Subsequently, many firms report high retention rates among those workers recruited from these schools.

Initial on-the-job training must be followed up by additional training whenever new equipment is installed or different production methods are employed. One firm developed its own library of training videotapes, for use as an introduction to new processes and a refresher course for old skills.[12] According to the manufacturers surveyed, the costs of this type of training are borne almost entirely by the employer.

When asked what difficulties they could foresee in recruiting, training, and retaining skilled workers over the next 5 years, U.S. gear manufacturers' responses were mixed. Most of those currently experiencing difficulties in recruitment expected their problems to continue. The local economic situation was frequently mentioned as a key determinant: one employer noted that layoffs in other industries in his area would ease the shortage of skilled labor and another stated that slower growth in the firm's business would lessen the need for attracting new employees. In some areas, keen competition for skilled labor was expected to continue, although

[11] Transcript of public hearing, Nov. 1, 1989, p. 30.
[12] Ibid., p. 25.

Table 4-5
U.S. gear industry: Overall average age and average age range, by frequency, for certain occupations, 1988

Occupation	*Average age*	*25-34*	*35-44*	*45-54*	*55 and over*
		Percent			
Design engineers	41	17.2	50.5	23.7	8.6
All other engineers	39	24.0	54.8	18.3	2.9
Gear machinists	39	23.1	53.8	22.2	0.9
Tooling personnel	43	13.5	43.8	34.8	7.9
Heat treatment personnel	41	17.2	46.9	32.8	3.1
Gear product assembly	39	32.5	38.9	24.7	3.9
Inspection personnel	39	24.0	47.2	25.9	2.9

Source: Compiled from data submitted in response to questionnaires of the U.S. International Trade Commission.

one employer hoped that a new employee ownership and involvement program would increase the company's retention rate. Several expected the nonavailability and inadequacy of vocational programs to continue and some were planning to increase in-house programs to upgrade the skills of current semi-skilled employees.

Manufacturing Operations of U.S. Producers

The manufacture of gears requires extensive investment in machinery, whereas the assembly of gears can be accomplished from purchased components with comparatively smaller investment. Because of the relatively small size of most gear-manufacturing establishments, with the exception of vehicle gearing producers, certain operations may be contracted out. Contracting out certain operations reduces the overhead of the gear manufacturer.

Few U.S. gear or gear product manufacturers perform all the steps necessary to make a gear from raw steel. Only a small number of firms in the United States perform their own casting or forging of gear blanks, since these are capital-intensive production steps. Some small producers specialize in machining gear blanks or in cutting gear teeth. Operations that are frequently contracted include heat treatment and spiral bevel gear production (generation and grinding). Gear grinding with cubic boron nitride (CBN) wheels is a relatively new technology and is not in widespread use. (See app. G for data on the number of establishments performing certain manu- facturing operations.)

Manufacturing in the U.S. gear industry differs according to the gear quality, its required precision, the size of the gear, and the number produced. Manufacturing efficiencies are frequently derived by reducing the setup time of the machine tools, i.e., the time required to change the cutting or other tools used in the machine tool. If production lot sizes are small, as is frequently the situation with production of aerospace, large marine, and custom industrial gearing, manufacturing inefficiencies arise. Relatively large amounts of time are spent in setting up machinery, rather than producing gears. Data for minimum, average, and maximum production lot sizes, as reported by U.S. producers, are presented in appendix G. The relatively large production lot sizes in custom-type gearing reflect the trend in the U.S. industry toward gear production to OEM specifications and away from large standard gearing product lines, especially in the industrial gearing market. Small production lot sizes in most gear reducer categories reflect the weak demand for gearing in the U.S. market. Vehicle gearing is the exception, with lot sizes averaging in the thousands.

Scrap rates also reflect the U.S. gear industry's manufacturing operations, quality practices, and investment in modern machinery. According to data gathered in the Commission's questionnaires, U.S. producers' scrap rates declined from an average of 3.8 parts per 100 in 1984 to 3.0 parts per 100 in 1988 (table 4-6). During 1984-88, the rework rate also declined. The rate of acceptable production, as viewed by manufacturers, increased steadily from 1984 to 1988. Another indicator, ontime delivery, increased marginally during this period.

Many U.S. gear producers have adopted new manufacturing management techniques since 1984. In general, such techniques are used to raise productivity through improving quality, reducing scrap rates, and reducing production time. (For definitions of these manufacturing management techniques and data on producers adopting these methods, see app. H.) Data from the Commission's questionnaires indicate that U.S. gear producers are adopting flexible manufacturing cells, just-in-time concepts (JIT), Materials Requirements Planning II (MRP II), statistical process control (SPC), total quality commitment (TQC), and batching of work flows. Many gear producers responded that they had adopted several of these management techniques during 1984-88. The following tabulation shows the management techniques most frequently employed by gear producers and the total number of gear producers that reported adopting these techniques during 1984-89:

Management technique	*Producers*
Statistical Process Control	51
Just-in-time	30
Flexible manufacturing cells	29
Total Quality Commitment	26
Materials Requirements Planning II	25
Batching of work flows	21

Table 4-6

Gears and gearing: U.S. producers' scrap rate, rework rate, acceptable production rate, and producer-reported ontime delivery rate, 1984-88

Year	*Scrap rate*	*Rework rate*	*Acceptable production*	*On-time delivery rate*
	Parts per 100			*Percent*
1984	3.8	5.1	76.0	82.4
1985	3.4	4.1	79.2	82.4
1986	3.1	3.9	80.4	82.8
1987	3.2	4.0	83.8	82.5
1988	3.0	4.0	85.0	83.6

Source: Compiled from data submitted in response to questionnaires of the U.S. International Trade Commission.

Other producers indicated they had adopted such measures prior to 1984, while others plan to adopt them in 1990. The benefits derived from the use of these manufacturing management techniques partially explain the decline of scrap rates and the rise in the ratio of acceptable production as shown in table 4-6.

Some U.S. gear producers appear to have moved to flexible manufacturing cells in 1985 and 1986, with other producers just beginning to use them in 1987. Although the use of flexible manufacturing systems (FMSs) is not extensive, they are increasingly being installed by large captive producers of gearing. FMSs are typically used in either the gear box machining or the gear production processes. The adoption of MRP II in 1985 and 1986 coincided with its introduction as a replacement for Materials Requirements Planning (MRP I). Thirty firms implemented JIT concepts and 51 adopted SPC during 1984-89; these actions were significantly influenced by gear producers' customers. Most firms have only begun to adopt TQC since 1987. Other management techniques that companies stated they had adopted were group technology centers, total quality management (TQM), Statistical Quality Control (SQC), continuous improvement, and simultaneous engineering.[13]

The adoption of such techniques has led to significant increases in productivity. Data from the Commission's questionnaire indicate that work-in-process turnover rates have increased, defect rates have decreased, lead times have been reduced, and machine setup times have also been reduced by using these techniques. In many instances, turnovers of work-in-progress have doubled, resulting in products being produced faster with less inventory on the factory floor. Defect rates have fallen by as much as 90 percent and lead times have been cut in half. In other instances, although defect rates or lead times did not change significantly, machine set-up time was reduced significantly, saving the company hours of production time.

Use and Cost of Materials

The raw materials and components used to produce gears and gearing include a variety of steel castings, forgings, and bar stock, as well as bronze castings and bearings. Other miscellaneous components include seals and lubricating oils. Data from the Commission's questionnaires shown in table 4-7 report the share of total delivered cost of certain materials used by U.S. gear producers in 1988, as well as the average share of the delivered cost of materials accounted for by imports.

U.S. producers use more gear blanks made of castings than forgings, and even fewer blanks made of bar stock. This may be due, in part, to long lead time in obtaining forgings and U.S. producers' willingness to substitute castings materials. Bronze is mainly used by worm gear producers, and as the data reflect, this is not a large product segment in the overall U.S. gear market. The average share of delivered cost[14] accounted for by U.S. imports is, for the most part, 2 percent or less, with the exception of other parts. U.S. imports accounted for 13 percent of the delivered cost of other parts, primarily because of the use of foreign bearings. Imported motors, which are used in gearmotors, also account for a significant share of this percentage.

[13] Ford announced that it would use simultaneous engineering for the computerized production testing equipment for its CD4E transmissions to be produced in the early 1990s. See Al Wrigley, "Ford, GM Shift Into Drive on New Transmission Plans," *Metalworking News*, May 8, 1989, pp. 1, 37.

[14] The average is computed from the company average as reported in the Commission's questionnaires and is not necessarily representative of the share of total delivered costs for all companies.

Table 4-7
Cost and use of materials: Share of U.S. gear producers' total delivered cost and costs accounted for by imports, by type of material, 1988

Material	*Share of total delivered cost of material*	*Imports' share of delivered cost of material*
Castings, blanks	19.3	2.0
Forgings, blanks	9.7	1.0
Bar stock	5.4	.3
Bronze	0.3	([1])
Parts, housings	3.8	.5
Other parts	40.8	12.5

[1] Less than 0.05 percent.

Source: Compiled from data submitted in response to questionnaires of the U.S. International Trade Commission.

U.S. gear producers experienced shortages or extended lead times in obtaining materials and components during 1984–88. Shortages and lack of availability have also adversely affected other industries, and were due, in part, to reductions in the capacity of foundries in the mid-1980s and in the limited domestic capacity of bearing producers.[15] Data from the Commission's questionnaires indicate that extended lead times have been encountered since 1986 for bar stock, stainless steel tubing, castings, forgings, and bearings. In an attempt to overcome these problems, firms paid premium prices and purchased from warehouses, double-ordered quantities, and carried larger materials inventories. In some cases, castings were used instead of forgings. In other instances, producers modified production lot sizes or extended delivery dates to customers. The duration for many of the shortages was 6 months to a year, or longer.

Capacity

The capacity of many U.S. producers of gears is difficult to measure, because their production is so varied. Different product mixes, including products other than gears, can be manufactured on the same machines. The characteristics of the gear, such as gear size in inches, pitch diameter (number of teeth per inch), material hardness, precision, and final inspection process, all affect the length of time required to produce a gear, and consequently, the quantity of the gears produced in a given period of time. Changing such variables, as well as varying the production lot size, makes it almost impossible to measure capacity in terms of units. This is especially true for job shops, which have no set product mix.

The capacity of captive motor vehicle gearing producers is easier to measure. These companies tend to produce large production runs and have much less variation in the kinds of products they manufacture. Because of the more uniform nature of the products, these manufacturers tend to measure capacity in terms of units. In order to reconcile the different methods of measuring capacity, Commission and Commerce staff developed a methodology to measure capacity in machine hours (see app. I) to assess machine capacity for the many job shops and other producers manufacturing gears in relatively low volumes, focusing on the production of gears only.

Some firms producing gearmotors and other speed reducers do not produce gears, but assemble them from components purchased from other vendors. Such components include gears, housings, shafts, bearings, seals, lubricating oils, and motors. Capacity of assembly operations is constrained only by available assembly space and the number of skilled assembly workers, which can be increased much more easily and quickly for assembly than for gear production.[16]

Indicators such as plant closings, declines in employment, and machines in use may point to declines in capacity. However, partially offsetting such changes are increases in the productivity of workers and new machinery, as well as the rationalization of inefficient operations. Also, decreases in capacity owned by U.S. producers have been offset somewhat by new capacity added by foreign-owned gear producers.[17]

During 1984–88, U.S. gear-manufacturing capacity declined by an estimated 9 percent, based upon a number of different indicators. First, the number of gear-cutting and finishing machine tools declined from 34,834 in 1983 to 29,509 in 1989 (table 4–8). This decline of 5,325 units, or 15 percent of machinery in place, was partially offset by the introduction of 443 newer numerical-controlled (NC), or CNC gear-cutting and finishing machine tools. Because each NC or CNC machine tool is estimated to be able to replace up to five older machine tools, the decrease in capacity resulting from fewer machine tools in use is substantially less than the 15 percent decline in the number of machines. This substitution was partly responsible for the increase in industry productivity as measured by shipments per production worker because the use of NC or CNC machine tools permits a company to maintain production levels with fewer workers.[18]

Capacity is also affected by the age of machinery. According to industry sources, because of LBOs, U.S. gear producers have not invested in machinery to the same extent as major competitors, such as West Germany and Japan. During 1984–88, U.S. gear producers limited their investment and used existing machinery. About 16 percent of total metal-cutting machine tools in the U.S. industry was less than 5 years old in 1989, as compared with 14 percent in 1983. For gear-cutting and finishing machine tools, the share was smaller, approximately 5 percent in 1989, falling from 7 percent in 1983. A similar difference in age of machine tools in the 5–to–9 year age bracket between total metal-cutting machine tools and gear-cutting and finishing machine tools is apparent. For gear cutting and finishing machine tools, the greatest drop was in the

[15] U.S. International Trade Commission, *Certain Metal Castings*, USITC Publication 1849, June 1986; U.S. International Commission, *Competitive Assessment of the U.S. Foundry Industry*, USITC Publication 1582, September 1984; and U.S. International Trade Commission, *Antifriction Bearings (Other than Tapered Roller Bearings) and Parts Thereof From the Federal Republic of Germany, France, Italy, Japan, Romania, Singapore, Sweden, Thailand, and the United Kingdom*, USITC Publication 2185, May 1989.

[16] Industry sources indicate that new hires can be trained to perform assembly operations in as little as 2 weeks, depending upon the complexity of the product.

[17] See ch. 4, "Structural Change."

[18] The estimate of five machines is used because such machines may not be used in the most efficient manner; however, industry sources indicate that one NC or CNC machine could replace as many as eight old manually operated machine tools.

Table 4-8
Number of U.S. machine tools and gear-cutting and gear-finishing machine tools, by age, 1983 and 1989

Year/Item	Age of machine tools: 0-4 years	5-9 years	10-19 years	20 years and over	Total
	Number				
1983:					
Metal-cutting machine tools	241,877	343,250	571,504	546,202	1,702,833
NC machine tools	45,593	24,872	17,120	5,187	92,772
Gear-cutting/finishing machine tools[1]	2,457	3,829	11,114	17,434	34,834
1989:					
Metal-cutting machine tools	292,163	449,681	640,864	488,045	1,870,753
NC machine tools	79,231	68,628	40,402	8,811	197,072
Gear-cutting/finishing machine tools	1,354	2,092	10,642	15,421	29,509
NC gear-cutting/ finishing machine tools	443	98	89	174	804
	Percent of total[2]				
1983:					
Metal-cutting machine tools	14.2	20.2	33.6	32.1	100.0
NC machine tools	49.1	26.8	18.5	5.6	100.0
Gear-cutting/finishing machine tools	7.1	11.0	31.9	50.0	100.0
1989:					
Metal-cutting machine tools	15.6	24.0	34.3	26.1	100.0
NC machine tools	40.2	34.8	20.5	4.5	100.0
Gear-cutting/finishing machine tools	4.6	7.1	36.1	52.3	100.0
NC gear-cutting/ finishing machine tools	55.1	12.2	11.1	21.6	100.0

[1] Data for NC gear-cutting and gear-finishing machines in 1983 are not available.
[2] Because of rounding, figures may not add to the totals shown.

Source: Estimated by the staff of the U.S. International Trade Commission based on American Machinist, *American Machinist Inventory of Metalworking Equipment, 1983*, November 1983, and "Summary of the 14th Inventory by Machine-Tool Type," *American Machinist*, November 1989, p. 92.

5-to-9 years of age bracket, which fell to 7 percent from 11 percent. Overall, the average age of gear manufacturing machine tools used by U.S. firms is growing older. In 1989, 88 percent of gear-cutting and finishing machinery used by the U.S. industry was over 10 years of age as compared with 82 percent in 1983.[19]

According to the Commission's questionnaire responses, the majority of equipment in use by U.S. gear producers is 10 years old or older. In certain types of machinery, such as spiral bevel gear generators, spiral bevel gear grinders, and grinding/hard finish gear teeth machines, a significant share of the machinery is over 10 years old.[20] U.S. firms appear to have invested more in milling machines, machining centers, and lathes, since a greater percentage of the machinery, as compared with gear cutting and finishing machinery, is less than 10 years old. Also, the data indicate that U.S. firms have made recent investments in carburize and nitride furnaces and in CNC inspection machines.

Other potential indicators of capacity loss are total employment decline and the decline in the number of establishments. According to data collected by the Commission's questionnaires, the total number of production workers declined during 1984-88. However, productivity as measured by shipments per production worker per hour increased by 21 percent in nominal terms and 17 percent in real terms.[21] During 1984-88, the number of plant closings for the U.S. gear industry totaled only one plant, according to data collected

[19] Age of equipment for gear inspection machines is not readily available from the 14th American Machinist Inventory of Metalworking Equipment as published in *American Machinist*, November 1989; however, data from the 13th inventory in 1983 indicates there was a total of 5,321 gear inspection machines, of which 711, or 13 percent, were from 0 to 4 years in age, and 969, or 18 percent, were from 5 to 9 years in age.

[20] See app. G.
[21] See ch. 4, "Employment."

from the Commission's questionnaires. There were also a number of LBOs and consolidations of operations.

Capacity Utilization

The rate of capacity utilization of U.S. producers varies substantially between firms and the markets for which they were producing gears and gearing. According to industry sources, many captive producers manufacturing gears and gearing for the automotive and construction equipment industries have been operating at higher levels of capacity utilization, in some instances close to 100 percent. Producers of gears and gearing for the aerospace and specific industrial and marine products markets have been operating at lower rates of capacity utilization.

According to Census data, fourth quarter capacity utilization for SIC Industry 3566 increased from 62 percent of practical capacity[22] in 1984 to 63 percent in 1987. Utilization remained relatively flat until 1987, principally due to weak demand and general economic conditions. Typically, the first and fourth quarters are the busiest in terms of orders and shipments for high-volume industrial gearing producers. According to industry sources, the low rate of capacity utilization also reflects recessionary economic conditions in some end-user industries, such as the agricultural, petroleum, and electric power generation industries. Other causes for low rates of capacity utilization are the adoption of substitute technologies by consuming industries, increased competition from imported gears and gearing, and indirect import competition in the form of increases in imports of finished products incorporating gears and gearing.

Data gathered in the Commission's questionnaire indicate that for the U.S. gear industry as a whole, average actual machine capacity utilization was about 71 percent in 1988, as measured in actual machine hours spent producing gears compared with total available machine hours.[23] In many instances, a low level of actual capacity indicates substantial downtime, either for machine maintenance or repair or because of inefficient work-flow. However low actual capacity may also occur in companies that have many specialized machines that are used only when needed.

For the manufacturing operations shown in the tabulation below (in percent), capacity utilization, measured as actual hours used as a share of practical capacity, was greatest in the heat-treatment operations:[24]

Machine operation	*Average capacity utilization*
All machines	70.6
Turning operations	76.5
Gear tooth cutting	74.2
Heat treatment	84.8
Finishing	68.8
Gear tooth hard finishing	53.9

The utilization rate in heat treatment operations was almost 85 percent, compared with much lower rates for other gear-manufacturing operations. This high rate of utilization could indicate that the industry faces production constraints due to bottlenecks in heat treatment. However, heat treatment is one of the operations most frequently contracted out both by firms that have no heat treatment capability and by those whose needs temporarily exceed their capacity. Therefore, the capacity utilization rates of the other operations are more indicative of the capacity utilization of the industry as a whole.

The number of shifts varied among U.S. gear producers serving different gear markets. Vehicle gear producers, particularly for automotive, truck, and bus customers, indicate that they have generally been running two shifts. Other producers, however, indicate that they have been operating only one shift. Specific data on the number of shifts employed are not available.

Profitability and Capital Investment

Financial data on the profitability of most gear producers are not publicly available because many producers are subsidiaries of companies producing other products or are privately held. However, data from Commission questionnaires indicated that the level of operating profits generated by these companies was comparable with that of several similar industries and lower than that of many industries. Profitability data, as measured by the operating margin, for these industries for the period 1986–88 are presented in table 4–9. The upward trend in operating margins of some of these industries is attributable, in part, to the general improvement in the economy, especially in the automotive sector, during 1986–88.

The financial performance of gear-producing companies improved during 1986–88 as is shown in table 4–10. Net sales rose slightly faster than related production and operating costs. Although the percentage increase in operating income was nearly twice that of sales and expenses during 1986–88, net income before taxes rose only 11.4 percent. This was a result of a more than tripling of other expenses not directly related to normal production operations. These expenses include interest expense, plant closing losses, and writeoffs of assets.

[22] Practical capacity is the maximum level of production that a firm could expect to obtain using a reasonable employee work schedule and the machinery already in place. Financial factors, such as overtime pay, or added materials costs, should not be considered.
[23] See app. I, table I–1.
[24] Ibid.

Table 4-9

Operating margins for selected industries, 1986-88

(In percent)

Industry	1986	1987	1988	Average
Office equipment	15.1	14.0	13.3	14.1
Electrical equipment	12.8	13.1	12.4	12.8
Steel	10.0	12.1	13.6	11.9
Machinery	11.1	11.8	12.0	11.6
Home appliances	11.0	11.2	10.2	10.8
Auto parts	10.8	10.3	10.3	10.5
Gears and gearing[1]	9.6	9.9	10.9	10.1
Aerospace/defense	9.8	10.0	9.9	9.9
Auto and truck	6.8	8.0	13.6	9.5
Machine tool	9.3	9.2	9.6	9.4

[1] Compiled from data submitted by noncaptive producers in response to questionnaires of the U.S. International Trade Commission.

Source: Compiled from various issues of *Value Line Investment Survey*, except as noted.

Table 4-10

Income and loss experience of noncaptive U.S. gear producers on their companies' overall or divisional operations, accounting years 1986-88

Item	1986	1987	1988	Change, 1988 over 1986
	Million dollars			Percent
Net sales	5,237	5,626	6,257	19.5
Cost of goods sold and general, selling, and administrative expenses	4,733	5,070	5,573	17.7
Operating income	504	557	683	35.5
Other income (expense)	(56)	(101)	(185)	230.4
Net income before taxes	448	456	499	11.4

Source: Compiled from data submitted in response to questionnaires of the U.S. International Trade Commission.

Compared with certain industries, the gear industry has relatively low profit margins. Consequently, many gear producers do not generate sufficient internal funds to finance the purchase of new equipment. In order to finance the large capital outlays for new equipment, these firms have to turn to outside sources such as banks or the securities markets. A large portion of the companies in this industry claim to have difficulty financing the sizable expenditures necessary to acquire modern machinery and equipment. Their ability to obtain financing and the rates at which they borrow money are determined largely by the financial strength of the individual company, which is judged primarily by the value of the company's net assets and profitability. Therefore, companies with valuable assets, such as land or machinery with high resale value, long-term contracts with customers, or a history of profitable performance, are likely to have an advantage in the capital markets over small job shop operations. The large portion of companies in this industry that are small or that do not have an expected stream of future revenues may find most conventional means of financing unavailable or unaffordable.

Gear-producing subsidiaries of large companies such as the captive producers in the automotive market generally meet their capital needs through their corporate financial centers, which obtain capital through the parent's retained earnings, the sale of stock in the equity markets, the issuance of corporate bonds and other notes, and loans from banks and other lenders. Because these companies are likely to have greater assets and more extensive relationships with financial institutions, they may obtain capital at lower rates or in different ways than are available to smaller firms. U.S. bank lending rates for short- and medium-term financing needs of the private sector declined from slightly over 12 percent in 1984 to approximately 9 percent in 1988.[25] The actual lending rate to individual companies would be higher or lower based on the lending institution's evaluation of the investment risk, the length of the loan, and the type of project for which financing is sought.

Capital expenditures on gear-cutting, grinding, and finishing machinery by U.S. gear producers

[25] International Monetary Fund, *International Financial Statistics*, various issues.

declined significantly during 1980–84.[26] It is estimated that total expenditures on gear-producing machine tools rose roughly 48 percent between 1984 and 1988; however, total expenditures in 1988 were less than half the 1980 figure. Such expenditures cover only a portion of capital expenditures required for a modern gear production operation. Total capital expenditures reported in response to the Commission's questionnaire rose from $394.4 million in 1984 to $646.4 million in 1988, as shown in the following tabulation (in millions of dollars):

Year	Capital expenditures
1984	394.4
1985	437.1
1986	485.8
1987	729.4
1988	646.4

The capital expenditures required to enter the gear industry with new machinery and equipment are substantial. However, firms with fully depreciated machinery and with a skilled workforce can be purchased relatively cheaply in an acquisition and several companies have entered the industry in this way. Other companies choose to buy used, rather than new, machines. New machine tool prices range from $100,000 to several million dollars, whereas used machine tools can be bought for a fraction of these prices. In addition, capital expenditures for machinery will vary considerably depending on the precision desired in the finished gear and its size. More precision in the gear requires more costly machinery. Gear manufacturing also requires substantial investment in property and plant. High-precision gear producers, for instance, typically perform final grinding operations in environmentally controlled sections of the factory, because of the close tolerances required. In addition to environmental systems, the factory floor sometimes needs to be physically separated from the rest of the factory so that vibrations in the plant floor are not transmitted to precision grinding machines.

[26] See "Other Comparative Factors", ch. 7.

Research and Development

Research and development (R&D) expenditures by U.S. gear producers increased from $53.8 million in 1984 to $77.7 million in 1988 (table 4–11), a 44-percent gain, but did not keep pace with such expenditures by broader industry groups in the United States.[27] During this same period, total R&D expenditures as a percent of total shipments increased annually from 0.5 percent to 0.6 percent. These ratios for R&D expenditures compared unfavorably with data for broader categories of U.S. manufacturers. For certain nonelectrical machinery industries (SIC industry groups 352–56 and 358–59), U.S. companies' own R&D expenditures, as a percent of net sales, rose from 2.2 percent in 1980 to 3.5 percent in 1987.[28]

Private studies focusing on university research in engineering reported that R&D expenditures and activities in U.S. universities were far below the levels in certain other leading gear-producing countries. Furthermore, university gear research in the United States lagged behind that of West Germany and Japan during 1981–85. In 1988, the number of graduate students, researchers, faculty, and support staff involved in gear research totaled 73 in the United States, compared with 155 in West Germany and 222 in Japan.[29] During 1981–85, this survey reported that 60 master's and doctoral degrees in gears and gearing were conferred in the United States, compared with 102 degrees in Japan and 259 degrees in West Germany. This study indicated that there are currently 23 special purpose gear test facilities and one gear manufacturing facility in U.S. universities. However, these numbers compare unfavorably with West Germany where there are 72 and 10 respectively, and with Japan, 81 and 43 respectively. Another study reported that in 1985, West Germany provided $3.5 million in R&D funds to universities, whereas Japanese research was funded at $5.0 million (used in whole or in part by universities).[30] This source further indicated that U.S. university expenditures totaled only $600,000.

[27] Compiled from data submitted in response to questionnaires of the U.S. International Trade Commission.
[28] Data from the National Science Foundation.
[29] *"A Worldwide Survey of University Research in Gearing,"* Dr. Donald R. Houser, Ohio State University, 1988.
[30] Don Borden, ASME-GRI presentation published in Power Transmission Design, March 1988, pp. 29–32.

Table 4-11
Gears and gearing: Research and development expenditures for gears and gearing, 1984-88

Item	1984	1985	1986	1987	1988
Gears and gear products (1,000 dollars)	53,802	65,315	68,656	71,124	77,663
On materials (1,000 dollars)	6,881	6,977	7,629	7,814	12,075
On processes (1,000 dollars)	9,780	10,121	9,709	13,614	14,684
Total R&D as a share of total shipments (percent)	0.5	0.5	0.6	0.6	0.6

Source: Compiled from data submitted in response to questionnaires of the U.S. International Trade Commission.

Traditionally, the bulk of gear R&D in the United States is done at the company level and the results are generally not shared. A wide variety of R&D projects were identified by producers responding to the Commission's questionnaire. Most frequently cited topics were metallurgy, design, and lubrication. Other projects included gear noise, grinding, testing, new machine design, tooth analysis, and shot peening. Several projects in the United States, especially the work of the ASME Gear Research Institute (GRI) and the Defense Logistics Agency's newly established Instrumented Factory for Gears (INFAC), are responses designed to improve the competitive position of the U.S. gear industry. Cooperative research is sponsored by the GRI, which was founded in 1982 in recognition of increased international competition and greater R&D efforts in other countries. GRI believes in the concept of "Cooperative Pre-competition Research and Development," defined as the pooling of resources and working together to create technologies without jeopardizing domestic competitive position. The institute's method of operation is to identify a need, initiate a project, and enlist support from various companies, research organizations, and local, State, and Federal government. A detailed listing of GRI projects since 1984, including the amount of funding and the number of participants, appears in table 4–12.

Officials of GRI indicated that the needs of the industry are much greater than they have been able to meet. Because of underfunding, this organization states that its activities have not reached the level needed to offer career path type employment to prospective researchers and, therefore, it is not competitive with universities and private industry.[31] Total funding of GRI since 1984, as reported by ASME-GRI, appears in the following tabulation:

Year/period	*Revenue from technical programs*	*Total revenues*
1984	$211,737	$242,042
1985	457,743	490,424
1986	409,522	444,850
1987	427,355	456,494
1988, Jan.-June	192,017	203,737
1988-89, fiscal year . .	280,691	312,555
Total	$1,979,065	$2,150,102

The gear dynamics laboratory at Ohio State University was established in 1980 as a research consortium supported by several firms in the industry. Most of its funding is used to provide financial aid for M.Sc. and Ph.D. students working on thesis projects related to gears and gearing.

INFAC, a major project funded largely by the Federal Government, was begun in October 1989 to advance the manufacturing and process capabilities of the U.S. gear industry as well as the precision machining and manufacturing industries. Its funding, valued at $24.0 million for 3 years with a 2-year option valued at $18.6 million, is being provided by the U.S. Defense Logistics Agency (DLA), with an additional $8.0 million in contributions from State and industry sources. This program consists of construction of a demonstration factory, education and training, industrial extension or technology transfer, and special research and development tasks. The R&D component of this program, funded at $4.0 million for the first 3 years, will select projects by means of a research review board made up of industry and academic representatives. Such projects will be balanced between those that can apply technology at once and those that address long-term basic issues.[32]

Another major Federal research program is centered at NASA's Lewis Research Center, which has had an ongoing research program for aircraft mechanical components since the early 1940s. Although the budget remained at about $500,000 annually during 1984–89, a new project relating to transmissions for helicopters and funded at $13.0 million by the U.S. Army is being conducted during 1989–91. In addition, there are other Federal research centers, as well as universities and nonprofit institutions such as Battelle, performing some proprietary gear research. Furthermore, certain machine tool builders, such as Gleason, conduct such projects, as do companies such as General Motors, United Technologies, Eaton Corporation, and Ford that use gears.

American Pfauter, a U.S. subsidiary of Herman Pfauter GmbH and Co., and Maag Gear Wheel Co., Ltd., opened a Gear Technology Center in Illinois in January 1990. This facility will offer customers and researchers the opportunity to solve problems such as increasing machine speed, improving machine uptime and reliability, and reducing changeover and setup time. This firm will spend $9 million on the construction of a 10,000-square-foot facility which will include a demonstration factory that will hold nine machines and additional offices devoted to software development, project engineering, computer simulation, training, and other off-line technologies.[33]

U.S. Domestic Policies

There are numerous U.S. Government policies and regulations that the domestic gear industry perceives as impediments to its international competitiveness. Primary concerns of this industry include general economic policies that result in high interest rates and tax policies that hinder capital investment; U.S. environmental, health, and

[31] Letter to the Commission from ASME-GRI, Jan. 30, 1990.

[32] IIT/IIRI Gear and Bearing Center, *Gear and Bearing News*, Fall 1989.

[33] Fusaro, David, "Pfauter Assembles Gear Technology Center," *Metalworking News*, Nov. 6 1989, p. 27.

Table 4-12

Gear Research Institute: Major gear research projects, by description, duration, amount of funding, and participants, fiscal years 1984-89

Project description	*Duration*	*Amount of funding*	*Participants*
		1,000 dollars	
Aerospace projects:			
Materials with high temperature properties; influence of coatings on performance; and develop preprocessor for FEA[1] analysis	Undetermined	240/yr.	10 Aerospace companies
Vehicle industry projects:			
Influence of quality and residual stress and predicting and controlling heat-treatment distortion	Undetermined	165/yr.	8 Ground vehicle and supplier companies
Other projects:			
Worm gear technology	Undetermined	150	11 Worm gear manufacturers
Austempered ductile iron	4 years	1,250	33 Major corporations and the U.S. Department of Commerce
Boron alloyed steel	2.5 years	64	7 Major corporations and the Colorado School of Mines
Contact fatigue	2 years	65	National Science Foundation and Northwestern University
Strategic materials	2 years	65	U.S. Bureau of Mines
Plastic gears	3 years	67	Supplier of phenolic matrix gears
Heat treatment	6 months	30	Large speed reducer manufacturer
Cast gears	6 months	20	Foundry companies
Surface finish methods	1 year	50	Large vehicle manufacturer
Lubricants	1 year	22	Large farm equipment manufacturer
Gear durability and noise—Taguchi style experiment	2 years	94	Large auto manufacturer
Gear geometry and materials	1 year	83	Large vehicle manufacturer
Heat treatment	6 months	13	Electric Power Research Institute
Aircraft gears	1 year	25	Supplier of aerospace gear
Evaluate gears of a foreign manufacturer	9 months	36	Large vehicle manufacturer
Failure analysis	3 months	13	Marine equipment manufacturer
Materials	9 months	38	Large farm equipment manufacturer
Conference on austempered ductile iron	(2)	80	Attended by 210 representatives from 8 countries
Consulting and problem solving	Ongoing	20/yr.	Various companies

[1] Finite element analysis.
[2] Not applicable.

Source: ASME, Gear Research Institute, Jan. 30, 1990.

safety regulations; product liability laws; and government contracts that benefit foreign producers of gearing.

Taxation

The ability of domestic gear companies to compete both domestically and internationally is significantly influenced by the way U.S. tax policies affect capital formation. According to industry sources, certain current U.S. tax laws and/or recent changes in particular laws have had a significant negative impact on U.S. gear producers. Specifically, the following issues concern many U.S. gear manufacturers: (1) the treatment of depreciation since 1987 under the Modified Accelerated Cost Recovery System (MACRS); (2) the corporate alternative minimum tax (AMT); (3) the elimination of the Investment Tax Credit (ITC); (4) the current tax treatment of capital gains; (5) the treatment of "goodwill" under the U.S. tax code; and (6) changes in the present tax code concerning foreign tax credits.

U.S. gear manufacturers claim that they have been adversely affected by the extended depreciation schedules applied to machinery and equipment for the gear industry under the MACRS. Faced with 7- to 15-year depreciation schedules, U.S. gear manufacturers allege that the machine is often obsolete long before it can fully be written off. Under Accelerated Cost Recovery System (ACRS), the depreciation system in effect from 1981–86, U.S. gear manufacturers, like other manufacturers, were allowed to take generous depreciation allowances that often exceeded the actual rate at which depreciable assets wore out during the first years of asset life. This provision was designed partially to offset the effects of inflation on depreciation allowances. During periods of high inflation, depreciation allowances based on true economic rates of depreciation were not considered to be sufficient to replace worn-out assets.[34] The previous ACRS compensated for this by letting firms get their depreciation allowances back faster, before they were eroded by inflation.

U.S. gear manufacturers also objected to the AMT, which they believe hinders their competitiveness. The current AMT was designed to ensure that every corporate taxpayer with economic income pays at least some Federal income tax and does not escape tax liability through the use of exclusions, deductions, and credits. According to the National Association of Manufacturers (NAM), the AMT creates the potential for double taxation and further complicates an already complex system. In addition, NAM believes that many AMT components are apt to overstate corporate profits and increase companies' alternative minimum taxable income (AMTI).

The association is concerned over the inclusion of Adjusted Current Earnings (ACE) in the corporate AMT. The Tax Reform Act of 1986 requires that, as of January 1, 1990, the ACE be included in the corporate AMT. ACE, designed to be a tax-based evaluation of economic income, are equal to 75 percent of the amount by which ACE exceed AMTI. The NAM believes that the ACE adjustment will have a severely negative effect on capital-intensive industries, such as the gear industry, because it requires the use of the lower straight-line depreciation method for assets placed in service both before and after the ACE effective date. NAM also is concerned that, as lawmakers seek ways to raise revenue to reduce the budget deficit, the AMT could be targeted for a rate increase from its current 20-percent level.[35]

U.S. gear manufacturers also believe that the recent elimination of the ITC leaves U.S. manufacturers at a disadvantage relative to gear manufacturers in other countries. The ITC provided a credit against current tax liabilities of up to 10 percent of the firm's current investment in new machinery and equipment. It provided an incentive to such investment and often resulted in substantial tax savings to those who took advantage of it.[36] Its elimination was seen by many to be harmful to the gear industry as it discouraged investment and reduced the availability of capital.[37]

The industry is also concerned about the taxation of capital gains as a result of the Tax Reform Act (Act) of 1986. The Act sharply increased the tax rate on long-term capital gains. Previously, taxpayers had been allowed to exclude 60 percent of long-term capital gains from taxation. This effectively reduced the maximum tax rate on such gains to less than 20 percent. The Act taxes capital gains at the same rate as ordinary income. This means that the top rate on capital gains has risen from less than 20 percent to 28 percent, a greater than 40-percent increase. Many argued that this increase caused venture capital investment to fall substantially. The higher tax rate makes it more difficult for manufacturers to obtain the investor capital needed for the purchase of newer, more productive equipment. Instead, investors tended to leave their capital "locked-up" in existing investments in older, long-held assets.[38] In comparison, the long-term capital gains tax rate in Japan is 5 percent; in Germany, South Korea, and Taiwan, it is zero.[39]

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[34] U.S. International Trade Commission, *Effects of Proposed Tax Reforms on the International Competitiveness of U.S. Industries*, USITC Publication 1832, April 1986, p. 3.

[35] Laura Pettey, "Minimum Tax: Reform in Sight?," *Issue Brief*, National Association of Manufacturers, October 1989, pp. 1–2.

[36] USITC, *Effects of Proposed Tax Reforms*, USITC Publication 1832, p. 3.

[37] Testimony of Ilona Hogan, on behalf of the American Gear Manufacturers Association, USITC hearing, Nov. 1, 1989.

[38] Bruce Bartlett, "Taxing and Spending Policies: The Fiscal Foundation for Competitiveness," ch. in *Making America More Competitive* (Washington, DC: The Heritage Foundation, 1987), pp. 26–27.

[39] Laura Pettey and Paul Huard, "The Case for Capital Gains Tax Reduction," *Issue Brief*, National Association of Manufacturers, September 1989, p. 1.

Some U.S. manufacturers also take exception to the manner in which the Act treats foreign tax credits. Before the Act, U.S. companies with overseas subsidiaries could consolidate their foreign income and obtain credit from the U.S. Government for the majority of the taxes that the corporation paid to other governments. Many claim that the Internal Revenue Service now requires elaborate breakdowns from U.S.-owned businesses that have plants in foreign countries based on their sources of income. This makes it more difficult to use foreign tax credits from one country to offset the foreign tax bills accumulated in another country. U.S. manufacturers state that this type of reporting means fewer places to protect foreign income and, as a result, they have to pay higher effective U.S. tax rates. In addition, the U.S. Government taxes U.S. corporations on their worldwide income. Most foreign governments do not. Thus in Europe, for example, firms pay little or no tax to their home governments on any foreign income.

Antitrust

According to the AGMA, U.S. gear firms feel they are disadvantaged by U.S. antitrust and trade regulation laws. They believe that the aggressive trend of mergers and acquisitions of large companies evident in Europe and Asia, leading to economies of scale and lowering manufacturers' production costs, have not been replicated in the United States largely because of domestic antitrust and trade regulation laws. Mergers and acquisitions of gear companies creating near monopolies are not legal in the United States. U.S. gear firms believe that, even though certain laws regarding joint ventures have been relaxed over the last several years, there is much need for improvement.

It should be noted that, to encourage efficiency-enhancing research joint ventures, Congress passed the National Cooperative Research Act of 1984. The act modifies antitrust liability for research joint ventures that register with the U.S. Department of Justice (Justice) and the Federal Trade Commission (FTC). There are two ways that the act changes a joint venture's liability. First, it codifies a rule of reason style approach to analyzing research joint ventures. Under the act, to challenge the reasonableness of a joint venture, enforcement agencies and courts must first establish anticompetitive effects from the joint venture. If effects such as collusion or other anticompetitive activities are found, they must be weighed against procompetitive factors, such as economies of scale in research. Second, the act limits the exposure to private antitrust suits of registered research joint ventures, and the maximum potential antitrust liability of these joint ventures is single (rather than treble) damages in any private antitrust proceeding.[40] According to an official with the FTC, during November 1989, the FTC approved legislation allowing for a joint venture between GM and Chrysler for the purpose of producing manual automotive transmission gears. The joint venture owns the former Chrysler and GM plants and will do joint research and development.

According to Justice officials, hearings have recently been held on the possibility of joint production either between several U.S. companies or between U.S. and foreign companies. In its report, *Making America More Competitive*, the NAM called for the following: (1) modify section 7 of the Clayton Act that prohibits mergers that tend to create monopoly, to ensure that efficiency-enhancing mergers are not blocked; (2) reduce the incentive for private antitrust litigation; (3) loosen restrictions on licensing intellectual property; (4) eliminate restrictions on manufacturer discounts; and (5) prohibit merger suits by competitors.

Product Liability

Many U.S. manufacturers believe that the lack of standards governing product liability is a threat to U.S. competitiveness. They claim that courts in the United States routinely award huge damage settlements without adequate proof that a company's product is responsible for alleged injury. They allege that in some instances, companies have been forced out of business, unable to pay soaring liability insurance premiums. In other cases, firms do not develop, design, and market their own products but produce to customer specifications because of potential liability actions. U.S. producers believe that, while businesses and manufacturers should be held liable for injuries caused by their products due to their own negligence, liability laws must be uniformly enforced and the penalties reasonable. Under the current system, U.S. businesses can be forced to pay huge settlements for injuries that they may not have caused. The current situation fosters nuisance suits, since there is so much to gain monetarily from a successful suit, and since it is not necessary in the U.S. legal system to have objective proof that the target of such a suit was culpable for injuries. U.S. producers maintain that this gives foreign firms a competitive edge since no other industrialized country burdens its own businesses with such crippling laws.[41] Other countries have a fault-based standard of liability that sets rigid requirements for the proof of fault and the proof of the absence of contributing fault on the part of the plaintiff.

The AGMA maintains that since U.S. companies are subject to U.S. product liability laws, whether selling domestically or abroad, their liability costs are based upon liability exposure here. One component of the cost of product liability to the industry is the cost of litigation and damages. The cost of a court case which may last several years and

[40] Langenfield and Scheffman, "Innovation and U.S. Competition," *The Antitrust Bulletin*, vol. 34, No. 1 (Spring 1989), pp. 55–63.

[41] Edward L. Hudgins, "Relaxing Government Regulation," *Making America More Competitive* (Washington, DC: The Heritage Foundation, 1987) p. 31.

the amount of damages awarded is far greater in the United States than in most other countries. There are few limits on the amount of awards and on the duration of the litigation. Foreign manufacturers, on the other hand, do not face such stringent laws on most of their sales. Therefore, they have a large cost advantage. According to the association, there are fewer product liability cases in Japan and Europe and much lower cost awards, which they believe is partly due to the prohibition of contingency fees, the near nonexistence of punitive damages, and the fact that judges, not juries, decide the amount of verdicts. The AGMA believes that the U.S. product liability laws particularly hinder smaller firms whose profit margins are already narrow and for which such a suit could prove fatal.

Another component of the cost of product liability to the industry is the cost of insurance premiums. Generally, the premium is based on the level of coverage and the company's sales volume. The premium, as a percentage of sales, falls as sales rise for a given level of coverage. AGMA estimates that product liability insurance premiums in the United States represent, on average, less than 1 percent of a firm's revenues.[42] Product liability insurance premiums in Europe and Japan are significantly lower, partly because companies' coverage is lower and partly because their risk of litigation is less.

Insurance premiums for exports to the United States can be much higher than those in the country of manufacture. According to the trade association representing leading European gear industries, product liability premiums for European vendors selling in the United States and Canada averaged about 5 percent of the revenues from these sales in 1988, up from 1.4 percent in 1986, and were expected to continue to rise.[43] Recently, one British gear manufacturer increased its product liability insurance coverage by 150 percent to cover liability for products sold in the United States.[44] In another instance, a U.S. manufacturer stated that U.S. insurance companies' premiums were unrealistically high because the faultless record of the firm's products was not considered when premiums were quoted. The manufacturer ultimately chose a foreign insurance vendor that offered a lower premium based on the past performance of the product.[45]

The effects of product liability legislation and litigation have also been felt in the gear industry's end markets. For example, the general aviation sector, which produces aircraft with less than twenty seats, experienced nearly ten-fold growth in liability premium costs between 1979 and 1989, from $24 million to over $200 million annually for the industry.[46] According to a study conducted by the General Aviation Manufacturers Association, the average cost for product liability insurance for these aircraft was more than $100,000 per unit in the mid-1980s and has continued to rise in spite of improvements in the safety record and reliability of the product.[47] According to general aviation industry officials, product liability has been a significant factor in the drastic drop in shipments of these aircraft in the last decade, from over 17,000 a year in 1979 to 1,535 in 1989.[48]

Department of Defense Procurement

Department of Defense (Defense) procurement contracts are of vital concern to many domestic producers of gearing, since many medium- and small-sized producers of gearing rely on defense weapons contracts for a substantial portion of their revenues. Major concerns of U.S. gear producers are Defense's emphasis on lowest cost sourcing, lack of "Buy America" procurement provisions, and the loss of business because of offsets and Memoranda of Understanding, and, therefore, the slow erosion of part of the Nation's defense industrial base. Because of lowest cost sourcing and offsets, U.S. gear producers contend that increasing quantities of gearing used in U.S.-produced weapon systems, for both U.S. and foreign consumption, are being produced by foreign competitors.[49]

In recent years, Defense has shifted the emphasis of its procurement policies from systems life cost or the cost of the system over the duration of its use to lowest cost purchasing from qualified bidders.[50] Domestic gear manufacturers maintain that this has resulted in a decrease in the number of contracts awarded to domestic suppliers. Past policies emphasized maintaining a viable production base capable of meeting U.S. security needs. Such considerations prevented contracts from being awarded solely on a price basis, and permitted domestic manufacturers to win more contracts. U.S. gear producers also believe that Defense's current emphasis on initial low bid prices ignores systems life costs and increases Defense's reliance on foreign sources for gearing.

Defense requirements for free and open price competition for subcontractors and suppliers also keep the supplier base in a state of constant upheaval, making it difficult for defense contractors to build a stable of high-quality, cost-effective vendors. This problem results from the uncertainty

[42] AGMA, posthearing submission, p. 17.
[43] Eurotrans, minutes from the meeting of Economic Commission, March 3, 1988.
[44] USITC staff interviews with gear industry officials, United Kingdom, November 1989.
[45] USITC staff interview with U.S. gear industry official, August 1989.
[46] Statement before the Senate Committee on the Judiciary on the General Aviation Accident Liability Standards Act of 1989, Senator Nancy L. Kassebaum, March 1990.
[47] USITC staff interviews with general aviation industry officials, March 1990.
[48] Statement before the Senate Committee on the Judiciary, M. Stuart Millar, Piper Aircraft Corporation, March 9, 1990.
[49] Statement of Richard Norment, AGMA, before the House Banking Committee, May 1988.
[50] Transcript of public hearing, Nov. 1, 1989, p. 19.

gear producers face when dealing with Defense in bidding on contracts. A U.S. gear manufacturer may purchase a multimillion dollar machine to produce gears with the assurance that there will be a constant demand from Defense for the product. For subsequent contracts for the same product, the prime contractor or subassembly subcontractor, both of whom the gear producer might supply, may decide to purchase from a lower cost source. Therefore, after substantial investment for the initial contract, the gear producer may lose all subsequent contracts for the same product to another manufacturer, either foreign or domestic.

Defense sources indicate that there are no laws that apply "Buy America" restrictions to all gearing purchased through defense acquisitions. However, there is an internal policy which dictates that the U.S. Navy buy marine gearing from U.S. sources. This policy, initiated in 1987, exists in the form of a letter from the Assistant Secretary for Procedures that is included in Navy contracts. No other defense service has similar policies for purchases of gearing.

In sales of defense articles under Memoranda of Understanding (MOUs) or offset arrangements[51] between U.S. exporters and foreign governments and firms, the U.S. Government has the policy of not becoming involved in either specifying the offset arrangements or acting as a guarantor of the arrangement. Offsets are especially common in the aerospace industry, and are increasingly so in other types of weapon systems. Under such sales, component sales can be moved offshore, U.S. subcontractors can lose business, and new competitors for the U.S. subcontractors can be created or their technological capabilities can be enhanced.

[51] A type of countertrade, the offset agreement is mainly used for defense related sales, sales of commercial aircraft, and other "large ticket" items considered a priority by the purchasing organization – usually a government or a state enterprise. Generally, offsets help recover the hard – currency drain resulting from the purchase and, more importantly, provide desired transfer of technology and local employment. The industrial and commercial compensation practices required to offset the purchase of military – related exports generally include five types: coproduction, licensed production, subcontractor production, overseas investment, and technology transfer. Offset arrangements can generally be classified into one of three categories: (1) direct offsets include any business that relates directly to the product being sold (generally, the foreign vendor seeks local contractors to form joint venture or coproduce certain parts); (2) indirect offsets include all business unrelated to the product being sold (generally the vendor is asked to buy a country's goods or invest in an unrelated business); or (3) a combination of direct and indirect offsets. U.S. International Trade Commission, *Assessment of the Effects of Barter and Countertrade Transactions on U.S. Industries*, USITC Publication 1766, October 1985.

Chapter 5
Profiles of Major Foreign Producer Country Markets and Industries

Overview

The principal gear-producing countries of the world are the industrialized nations. This is primarily because these nations have large gear consuming industries, such as automotive and paper, textile, chemical, and food processing machinery industries, which have supported the growth and development of the gear and gearing industries. With the growth of an industrial base in some developing and newly industrialized countries, more nations are emerging which have the potential to become world class producers of gears and gearing.

The major foreign producing countries in 1988 were West Germany, Italy, France, the United Kingdom, Belgium, Japan, Korea, and Canada. Approximately 735 manufacturers, specializing primarily in vehicle gears, accounted for the preponderance of foreign gear production. An overview of the U.S. gear industry and that of its principal competitors can be seen in table 5-1.

The major producing countries in Europe are West Germany, Italy, France, the United Kingdom, and Belgium. The gear industries in these countries support internationally recognized automotive, aerospace, marine, and industrial machinery industries. Although each country in Europe has certain differences in its market and its industry, there are some commonalities that hold true across national boundaries, especially within the European Community (EC) and within the Eastern Bloc.

EC countries are each other's leading trading partners. The 12 EC member states are currently working toward further economic integration and have set the end of 1992 as the completion date for a single integrated market. One of the goals of this effort is the harmonization of certain standards, regulations, and laws. Despite the changes that are expected as a result of further integration, the effects are expected to be minimal throughout the European gear industry mainly because companies in the industry have been operating on a pan-European level rather than a national level for some time. A major advantage of EC integration, cited by European gear producers, is expected to be shorter shipping times between member countries in Europe because trucks will not be stopped at national borders.[1]

A common perception among EC producers is that changes in Eastern Europe will reduce defense spending in Europe as well as in the United States, significantly affecting the gear-producing industry. Military vehicles, ships, and aircraft currently represent a large portion of the gear industry's revenues, and a substantial decline in sales of these articles would cause a restructuring of certain segments of the industry.

Eastern Bloc countries currently have neither the equipment to be a force in the market nor the hard currency to purchase products from Western Europe, the United States, or Japan. Their manufacturing facilities for the most part are antiquated and their ability to acquire equipment and technology has been hampered to some degree by the Coordinating Committee on Multilateral Export Controls (COCOM) regulations. There is a movement in COCOM to lift the restrictions on machine tool exports to East Bloc countries, which would hasten their development as gear producers.[2] East Germany, Czechoslovakia, and Hungary are regarded by EC producers as the most promising countries in the Eastern Bloc[3] and could become significant forces in the market if they were to receive large infusions of equipment, financing, technology, and training from developed countries. Although many European producers felt that Soviet products are inferior in quality, U.S. sources believe that Soviet producers' defense-related products are among the best in the East Bloc. European sources estimate that even if the East Bloc obtained the necessary machinery, it would be at least 20 years before they would be competitors in the world market.[4]

Some U.S. industry officials have cited standards as an impediment to their entry into the EC market. However, industry sources throughout the EC stated that although they manufacture to their own country's standard, they also can manufacture to the West German Standards Institute (DIN),[5] International Standards Organization (ISO), or American Gear Manufacturers Association (AGMA) standards without significant problems. They find that a greater problem exists in converting between the U.S. customary and the metric systems. At the least, this would require that the input and output shafts be converted and that a supply of compatible spare parts be readily available to the consumer. The added cost of this conversion and a reliable source of spare parts may limit some companies' ability to compete.

Defense equipment contracting in Europe differs from that in the United States. In the EC, defense procurement is usually on a multinational basis. Several countries usually plan new projects together and agree on the quantities that each

[1] USITC staff interviews with gear industry officials, Europe, November-December 1989.

[2] "U.S. to Back High-Tech Sales Boost to East Bloc," *The Washington Post*, Jan. 22, 1990, p. 12.

[3] USITC staff interviews with gear industry officials, Europe, November-December 1989.

[4] USITC staff interviews with gear industry officials, West Germany, Nov. 23-28, 1989.

[5] Deutsches Institut fur Normung.

Table 5-1

Profile of U.S. and foreign gear industries, 1988

Item	*United States*	*West Germany*	*Italy*	*France*	*United Kingdom*	*Belgium*	*Japan*	*Korea*	*Canada*
Firms	300	180	100	130	100	60	350	60	65
Employees (thousands)	84.6	23.0	11.0	11.5	4.5	5.5	39.0	3.5	6.0
Predominant gear type	Vehicle	Industrial	Vehicle	Vehicle	Vehicle	Vehicle	Vehicle	Vehicle	Vehicle
Shipments (million dollars)	14,759	4,792	2,221	2,122	942	1,071	8,428	280	1,225
Exports (million dollars)	2,425	2,158	568	1,121	413	653	2,479	12	769
Imports (million dollars)	2,741	522	513	605	973	438	90	279	1,802
Apparent consumption (million dollars)	15,075	3,156	2,167	1,606	1,503	857	6,039	547	2,258
Trade balance (million dollars)	(316)	1,636	54	516	(561)	215	2,389	(267)	(1,033)
Ratio of—									
Imports to consumption (percent)	18.2	16.5	23.7	37.7	64.8	51.1	1.5	50.9	79.8
Exports to shipments (percent)	16.4	45.0	25.7	52.8	43.8	60.9	29.4	4.1	62.8
Hourly compensation costs[1]	$15.01	$18.93	$13.37	$13.52	$10.80	([2])	$14.83	$2.90	$13.96
Apparent consumption of gear-making machine tools (million dollars)	56	135	46	22	([2])	([2])	133	46	[3]3
Interest rate (percent)[4]	9.3	8.3	13.6	15.7	10.3	8.9	4.9	10.1	10.8

[1] Industrial and Commercial Machinery (SIC 35), for 1988.
[2] Not available.
[3] This figure represents Canada's imports of gear-making machinery; there is very little domestic production of these machine tools in Canada.
[4] Bank lending rate as published by the IMF, International Financial Statistics, 1988.

Source: Compiled from data from the U.S. Department of Commerce, the U.S. Bureau of Labor Statistics, and the International Monetary Fund, and staff interviews with gear industry officials.

government will purchase before production begins. Defense contracts are then awarded based not only on the price and quality offered by the producer but also on the share of production purchased by each country. For example, if the United Kingdom were to contract for 20 percent of a helicopter produced for the EC, it would receive 20 percent of the total value of the individual contracts to produce those helicopters.[6]

As part of the EC 1992 integration, all EC countries have passed or are considering new product liability legislation that, in many cases, is more restrictive than the current laws. Implementation is going slowly and it appears that individual countries are making a number of changes in the proposed legislation. The cost of product liability insurance in the EC reportedly is less than 1 percent of sales unless the product is sold in the United States or Canada. For such sales, the premium is increased to approximately 5 percent of sales in that market.[7]

A significant cost factor that applies in the EC, but not the United States, is the value added tax (VAT). Many U.S. exporters believe that the VAT, which is imposed in all EC countries, makes their products sold within the EC more expensive than those sold in countries without a VAT. In the EC, a VAT is levied on imported articles at the time of entry at the same rate as domestically-produced articles. For machinery sold in West Germany, a 14-percent VAT applies; for machine tools purchased in Belgium, the VAT is 19 percent. However, the VAT is rebated on exports.

The production and export of gearing in Asia is dominated by Japan. Japan's gear industry supports many of its internationally recognized industries, such as automobiles, shipbuilding, industrial machinery, and an expanding aerospace industry. Japan's gear industry developed after World War II, in conjunction with its automotive and machinery industries. Initially, the demand for marine gearing resulted from the country's shipbuilding industry, which grew until the late 1970s, when Korea began to displace Japan in the world shipbuilding market.[8] Automotive and other vehicle gearing, as well as industrial gearing, also began to grow as shipbuilding declined. The Japanese gear industry is currently made up of approximately 350 companies, including captive producers. Korea's gear industry has the potential to grow into a major world producer. Korea has several large, gear-consuming industries, such as steel, shipbuilding, and automobiles, and is currently developing its aerospace sector. Gearing used in other Asian countries, such as Malaysia, Indonesia, Thailand, and the Philippines, is generally produced in Japan. Other Asian producers and consumers of gearing, including Taiwan, Singapore, India, and China, are profiled in appendix J, together with Brazil and Mexico.

Country Profiles

West Germany

Industry and trade profile

West Germany ranks third after the United States and Japan as the world's leading gear manufacturer. West German producers dominate many segments of the international gear market, in terms of technology, research, and production. West German gear producers are the principal gear producers in Western Europe and are geographically concentrated mainly around the cities of Aachen, Hanover, Stuttgart, and Munich.[9]

The West German gear industry is composed of approximately 180 firms, including captive gear producers in the automotive industry. Many small firms produce for certain niche markets or are suppliers to other equipment manufacturers; companies with less than 100 employees account for half the total number of companies but less than one-fifth of total production. Less than 5 percent of all companies have more than 1,000 employees. A significant proportion of West German gear makers are family-owned businesses and nearly all companies in the industry are privately held, or are subsidiaries of larger, diversified firms.[10] There have been several acquisitions or mergers of major West German gear producers during the last few years. Flender, a large producer of drive trains, was acquired by Deutsche Babcock, a West German industrial multinational, in September 1988. Automaker Daimler-Benz recently merged with Messerschmitt-Boelkow-Blohm GmbH (MBB), an aerospace manufacturer. Mergers, for the most part, have taken place to broaden product lines, enter new markets, to share costs and risks or increase market share.[11] West German firms have also used licensing agreements, joint ventures, and cooperative arrangements with other West German and foreign firms to expand their markets.

The leading gear producers in West Germany are large multi-product companies that produce for a variety of markets (table 5-2). The largest producers operate internationally with sales and service outlets, assembly centers and manufacturing plants, or licensees in other Western European countries, North and South America, South Africa, India, and the Far East. With the exception of operations in countries such as Brazil and India, large West German firms have tended to

[6] USITC staff interviews with gear manufacturers, Italy and the United Kingdom, November-December 1989.
[7] Eurotrans, Minutes of the Economic Commission, Mar. 3, 1988.
[8] USITC staff telephone interview with officials of NASA, Sept. 22, 1989.

[9] AGMA *European Economic Report*, Washington, DC, 1988 Edition, p. 9.
[10] USITC staff interviews with gear industry officials, West Germany, Nov. 23-28, 1989.
[11] Ibid.

Table 5-2
Leading West German gear producers, by major sectors,[1] 1989

Company	Industrial	Marine	Vehicle
BHS-Voith	X	X	
Daimler-Benz		X	X
Flender	X	X	X
GETRAG	X		X
Getriebebau NORD	X		
Hurth	X	X	
Jahnel-Kestermann	X	X	
Lenze	X		
Lohmann und Stolterfoht	X	X	
P.I.V. Antrieb	X	X	
RENK (Renke Tacke)	X	X	X
SEW-Eurodrive	X		
Thyssen Getriebe und Kupplungswerke	X		
Voith	X	X	X
Volkswagen			X
Zahnradfabrik Friedrichshafen AG	X	X	X

[1] The aerospace gear sector was not included because it is limited in West Germany; two of the companies are Zahnradfabrik Friedrichshafen (ZF) and Motoren- und Turbinen-Union (MTU) which is owned by Daimler-Benz.

Source: Verband Deutscher Maschinen- und Anlagenbau e. V.

rationalize their production worldwide.[12] Because of the difficulty in exporting to Brazil and India, West German producers operating in these countries either produce a full line of products locally or license their products to indigenous producers.

There are large West German firms, such as SEW-Eurodrive, that produce commodity or standard industrial gearing products based on a modular design and others, such as RENK Corp., that produce custom gear products. Vehicle gearing production is dominated by captive automotive producers, such as Daimler-Benz, Volkswagen, subsidiaries of General Motors, and two independent producers, Zahnradfabrik Friedrichshafen (ZF) and Voith Transmissions. Although many companies produce marine gear products, the more significant ones are RENK, Lohmann und Stolterfoht, Hurth, Voith, and ZF.

The West German economy, as measured by Gross National Product (GNP), grew at a real average annual rate of more than 2 percent during 1984-88, a slower rate than many other EC countries.[13] However, West German gear producers are currently operating at or near capacity as a result of the unexpected rapid economic growth in 1988 which continued through 1989. Gear shipments increased from $2.3 billion in 1984 to nearly $4.8 billion in 1988 (table 5-3). Industrial gearing was the largest segment of production and represented approximately half of the total in 1988. The second largest product grouping, which accounted for more than one-third of total shipments, was vehicle gearing.

During 1984-88, West Germany's trade surplus in gears and gearing rose from $728.3 million to $1.6 billion, or by nearly 125 percent (table 5-3). This coincided with a 120-percent increase in exports and a 109-percent increase in imports. West German imports of gearing increased from $250.3 million in 1984 to $521.7 million in 1988. Exports increased from $978.6 million in 1984 to $2.2 billion in 1988. However, data in Deutsche marks show more moderate levels of change. The West German trade surplus for gears and gearing rose from DM2.1 billion to DM2.9 billion, an increase of approximately 38 percent. Exports rose from DM2.8 billion to nearly DM3.8 billion, an increase for the period amounting to 36 percent. Imports also rose, from DM712.4 million to DM916.2 million, an increase of approximately 29 percent.

Exports averaged 43 percent of total West German producers' shipments during 1984-88, whereas imports averaged 16 percent of consumption during the period. The EC countries were West Germany's major trading partners, supplying over half of total imports and receiving over half of total exports. Italy, Japan, and France were the three largest sources of imports during the period and the United Kingdom, France, and Belgium were West Germany's largest export markets.

Research and development

The West German gear industry is believed to be one of the world's leaders in gear research and development (R&D) expenditures. West German companies spend approximately 4 percent of revenues on R&D, the bulk of which is for proprietary research conducted primarily in-house. Some proprietary research and much of the common research is conducted at the Gear Research Institute (FZG)[14] of the Technical University of Munich and, to a lesser extent, at the Laboratory for Machine Tools and Industrial Management

[12] Ibid.

[13] International Monetary Fund, *International Financial Statistics*, 1989.

[14] Forschungsstelle fur Zahnrader und Getriebebau.

Table 5-3
Gears and gearing: West German production, exports, imports, and apparent consumption, 1984-88

Year	Shipments	Exports	Imports	Apparent consumption	Ratio (percent) of imports to consumption
	Value (million dollars)				
1984	2,309.7	978.6	250.3	1,581.4	15.8
1985	2,626.7	1,112.9	284.7	1,798.5	15.8
1986	3,798.7	1,597.6	426.4	2,627.4	16.2
1987	4,349.3	1,939.8	497.2	2,906.8	17.1
1988	4,791.8	2,157.7	521.7	3,155.8	16.5
	Value (million Deutsche marks)				
1984	6,573.1	2,785.0	712.4	4,500.5	15.8
1985	7,733.0	3,276.5	838.2	5,294.7	15.8
1986	8,248.8	3,469.2	925.9	5,705.4	16.2
1987	7,817.4	3,486.6	893.8	5,224.6	17.1
1988	8,415.4	3,789.4	916.2	5,542.2	16.5

Source: Estimated by the staff of the U.S. International Trade Commission.

(WZL)[15] of the Technical University of Aachen. The FZG offers a graduate curriculum in gearing and has a laboratory equipped with state-of-the-art gear production and test equipment.

The Power Transmission Engineering Association of the West German Machinery and Plant Manufacturers Association (VDMA)[16] is the trade association representing West German gear producers. The association, located in Frankfurt, functions as an information clearing house for the industry and purchasers.[17] In addition, the Research Association for Power Transmission (FVA),[18] an arm of the Power Transmission Engineering Association, is a major source of funding for gear research. The FVA has over 70 corporate members that fund research projects; the Federal Government matches these funds.[19] The member companies submit proposals for studies to the FVA, and FVA working groups prioritize the research topics and issue requests for proposals to universities and private laboratories capable of doing the research. The organizations selected to carry out the research report to the FVA periodically and publish the results of the project, usually within 3 years after completion.[20] A summary of the 170 FVA research projects conducted between 1970 and 1987 is shown in table 5-4.

In addition to monetary contributions, the member companies also contribute the time and expertise of some of their engineer managers to the FVA working groups. In return for this investment, the companies are able to follow the progress of the research projects as they are being conducted instead of waiting for their conclusion and eventual publication of findings. Companies may also assign their engineers to teach and conduct research at the technical universities. The company benefits from the employee's exposure to developing technology and gains the opportunity of evaluating students as potential employees over an extended period of time.

[15] Laboratorium fur Werkzeugmaschinen und Betriebslehre.
[16] Verband Deutscher Maschinen- und Anlagenbau e.V.
[17] Professor Dr.-Ing. H. Winter, "Integrating Universities and Industry," *Proceedings of the Institute of Mechanical Engineers*, 1988, vol. 202, No. B1.
[18] Forschungsvereinigung Antriebstechnik.
[19] H. Winter, "Integrating Universities and Industry."
[20] Ibid.

Table 5-4
Research projects of the FVA, 1970-87

FVA working groups	Number of projects	FVA working groups	Number of projects
Materials	22	Freewheel clutches	9
Design problems	20	Load spectra	8
Computer calculations	17	Shaft-hub connections	8
Manufacturing techniques	16	Noise	7
Roller bearings	14	Worm gears	6
Oils and lubricants	13	Cost analysis	4
Couplings	10	Journal bearing	4
Clutches	9	Cardan joints	3
		Total	170

Source: Professor Dr.-Ing. H. Winter, "Integrating Universities and Industry," *Proceedings of the Institute of Mechanical Engineers*, 1988, vol. 202, No. B1, p. 16.

The German Research Society (DFG),[21] a quasi-governmental body, sponsors a wide variety of research, including gear research. The DFG funds the research completely from tax revenues but may request companies to contribute equipment or expertise.[22] All research results are published, but only after a time lag comparable to that of the FVA. A government agency that funds research and promotes cooperation between industry and research organizations is the Federal Ministry for Research and Technology (BMFT).[23] The BMFT contributes 50 percent of the funds for a given project and private companies fund the remainder. If the companies wish to retain proprietary rights to the results, they must reimburse the BMFT; otherwise, all results are published.[24]

Employment and training

Approximately 23,000 persons were employed in West Germany's gear industry during 1988. Hourly compensation costs for production workers in industrial and commercial machinery manufacturing (SIC 35) rose from nearly 28 Deutsche marks in 1984 to more than 33 Deutsche marks in 1988, an increase of 20.5 percent. In U.S. dollar terms, the increase appears much greater because of fluctuating exchange rates. Such costs rose nearly 95 percent, from $9.71 in 1984 to $18.93 in 1988.[25]

West Germany, like most of the other principal gear-producing nations, faces a shortage of skilled industrial labor. Assisted by favorable Federal tax laws, many of the larger West German gear manufacturers have instituted comprehensive labor training programs to train apprentice machinists over periods of 3 to 7 years. These programs were once highly competitive, but are now attracting declining numbers of applicants. This scarcity of skilled laborers has forced some leading West German gear manufacturers to produce more noncustom gear products and to rely more heavily on automation and robotics. Recent events in East Germany, easing border restrictions between East and West Germany, may increase the supply of skilled or trainable industrial workers in West Germany.

The workforce on the shop floor is generally drawn from the immediate geographic area. It is widely perceived as unlikely that workers would move even a short distance if the company were to relocate its facilities. Often many of the workers in a company are related to one another and stay with the company for most if not all their working lives.[26]

[21] Deutsche Forschungsgemeinschaft.
[22] H. Winter, "Integrating Universities and Industry."
[23] Bundesministerium fur Forschung und Technologie.
[24] H. Winter, "Integrating Universities and Industry."
[25] Unpublished data from the U.S. Bureau of Labor Statistics, August 1989.
[26] USITC staff interviews with gear industry officials, West Germany, Nov. 23-28, 1989.

Most production workers have completed a company training program, which consists of classroom and practical training. In the final phase of the program, the trainees receive specific training on the machines that they will be using in the factory. Additional training on new machines or new processes is provided as needed. The engineering staff also benefits from training programs, many of them ongoing. Engineers are often sent to specialized seminars to keep them informed of the latest developments in the field. They also participate in working groups sponsored by the research arm of the German gear association, where they meet with engineers of other companies as well as professors to discuss new technologies and applications.[27]

The Metalworking Union, one of the largest and most powerful unions in West Germany, covers most gear production workers. The length of the work week and wages, including the annual percentage increase, are set by the union contract which is renegotiated every 3 years. The contract expired in March 1990 and is up for renegotiation. The union wants to reduce the work week from 37 to 35 hours and to increase wages by up to 7 percent.

The shorter work week is meeting resistance from employers, trade associations, and the Federal Government because of the growing shortage of skilled workers.[28] These groups have taken the position that shortening the work week would reduce industry output. Employers would like to retain the flexibility of using overtime to meet temporary increases in demand, whereas the union would prefer that employers hire more workers. Further, because of the difficulty in firing or laying off employees, companies are reluctant to increase the workforce when the need may be only temporary. Not only do companies find that laying off workers is difficult and expensive because of union and government regulations, it hurts their reputation and ability to recruit good workers.

The effects of the union's resistance to overtime vary. Generally, matters such as overtime and special shifts are negotiated with the local workers' councils which may be more flexible on these subjects than the national union. Some companies have no difficulty getting approval from these councils for overtime but often have to grant concessions in other areas in return. Other companies find that their ability to increase production temporarily is severely curtailed by the councils' restriction on overtime.

Government policies and programs

The West German Government supports its industries, including the gear industry, through a variety of policies and programs. These include

[27] Ibid.
[28] U.S. Department of State Telegram, November 1989, Bonn, Message Reference No. 36102.

maintaining low interest and inflation rates. In the area of tax policy, machinery is usually depreciated over 5 to 8 years; machines running in three shifts can be depreciated within 2 to 3 years.[29]

The government targets certain industries for development and may give them extraordinary treatment. For example, in the case of the aerospace industry the Economics Ministry reported that a Daimler-Benz/MBB merger would restrict competition. However, it recommended that the merger be approved because the disadvantages "would be outweighed by the economic advantages as a whole."[30] Policies and programs that are more specific to the gear industry involve maintaining strong research centers in mechanical engineering and machine design at certain universities and funding certain research programs.

Other competitive factors

There are various factors which help West German products to compete successfully in world markets. Low product liability and capital costs work to producers' advantage, as do advanced product design, productivity-enhancing machinery, and high product quality.[31]

West German producers generally have not needed as much product liability insurance as U.S. producers. In addition, the industry association has negotiated group rates for its members that are believed to be lower than those that are available to U.S. producers. Therefore, product liability insurance is a much lower addition to product cost in West Germany than in the United States. In West Germany, as in most European countries, product liability disputes are normally settled by negotiation between the parties involved instead of litigation. The negotiated settlement usually is limited to recovery of revenues or business lost because a particular machine is not operating. Few cases are brought on the basis of personal injury. Extensive litigation in liability and workers' compensation suits is rare in West Germany, because workers know in advance exactly what compensation they will receive for specific injuries. Most German producers are of the opinion that the issue of product liability is becoming more important as a result of proposed EC 1992 legislation which is stronger than that which is currently in force, but that it will not be as critical an issue as it is in the United States.[32]

To increase both the quality and the quantity of production, the West German industry has invested heavily in developing technology through significant expenditures for gear-making machinery and for factory automation. The VDMA estimates that investment in plant and equipment averaged about 5 percent of sales for most gear producers.[33] West German consumption of gear-making machine tools increased from $49.1 million in 1984 to $160.0 million in 1987, and declined to $135.3 million in 1988. Most of the expenditures are for machine tools produced by West Germany's machine tool builders, which rank second in the world output behind Japan.[34] In addition, West German gear producers have automated many of their factories with robots and flexible manufacturing systems. RENK[35] and ZF are believed to have some of the most modern gear-making machine tools and automated facilities of all European gear producers.

Wages for production workers in West Germany are higher than in the United States. However, West German companies offset the difference with higher productivity, achieved in part through the use of newer, faster machines and factory automation. According to the VDMA, the average age of key machinery, including cutting, grinding, and milling machinery, measurement devices, and heat-treating equipment, is estimated to be less than 10 years. Higher productivity is also attributed to a better trained, long-term work force.[36]

In some instances, price is not the deciding factor in the purchase decision for gearing. West German engineering and quality have a certain reputation in the market that gives German products an edge with some customers over comparable U.S. products. West German producers state that it is quality, reliability, service, and prompt delivery that sell their products even though they may be more expensive than competing products. In addition, users are often willing to pay a premium to stay with the same manufacturer and for what they regard as a quality product. Purchasers also find advantages in suppliers that offer a complete line of compatible drive train equipment and may choose a product on this basis rather than price.

The cost of capital in West Germany is significantly lower than in some other gear-producing countries. Many industry sources believe that this is so because West German firms have a longer investment horizon and rely more on short-term financing. In addition, financial institutions frequently have investments in the companies to which they provide financing. Low interest rates in West Germany are also attributed to the high savings rate, which averaged 11 percent during 1980-87. Of the major gear producers, only

[29] VDMA written response to questions of USITC staff, Dec. 12, 1989, p. 5.

[30] "Germany Approves Merger of 2 Giant Firms," *The Washington Post*, Sept. 9, 1989, pp. 12-13.

[31] USITC staff interviews with gear industry officials in West Germany, November 1989.

[32] Ibid.

[33] U.S. Department of State Telegram, November 1989, Bonn, Message Reference No. 36102.

[34] Joseph Jablonowski, "World Machine-Tool Output Gains 15%," *American Machinist*, February 1989, p. 61.

[35] "Prunk Hinter Gitten," *HighTech*, Nov. 4, 1989, pp. 35-36.

[36] USITC staff interviews with gear industry officials, West Germany, Nov. 23-28, 1989.

Italy and Japan exceeded that rate.[37] The fluctuation in interest rates is managed by the Bundesbank and is not as subject to political influence as in many countries. Interest rates in West Germany for corporations were approximately 8 percent at the end of 1988.[38]

Investment and merger philosophies in West Germany also have a significant effect on the cost of capital. Most firms seek to finance investments out of earnings rather than borrowings, thus reducing their debt load and interest payments. Mergers and acquisitions in West Germany are rarely hostile. Some have been promoted by the government as a means of strengthening a particular industry. For instance, the Daimler-Benz/MBB merger, mentioned previously, was an effort to strengthen the West German aerospace industry.[39]

Italy

Industry and trade profile

It was not until the early 1980s that Italy became a major international producer of gears and gearing. Italy is ranked fourth behind the United States, Japan, and West Germany as a producer of gears and gearing. Industry experts estimate vehicle gearing production to be approximately 60 percent of Italy's total gear production. Industrial gearing accounts for between 20 and 30 percent of total Italian gear production.

Industry sources estimate that the Italian gear-manufacturing industry is composed of approximately 100 firms, including captive gear suppliers in the automotive and aerospace industries, and is concentrated geographically in the Bologna-Milan region. Fewer than 10 firms have more than 500 employees and account for over half of total production. The majority of firms have less than 100 production workers. Larger gear producers frequently subcontract work to very small "family" unit operations of 5 to 15 people that specialize in gear component manufacture and assembly. These numerous family operations are in addition to the 100 firms in the industry and act as captive suppliers and job shops to the major gear producers. In general, Italian gear producers are privately held, noncaptive suppliers of gears and gear products. Industry sources estimate that there is less than 5 percent foreign ownership in the domestic gear industry. Similarly, few joint ventures exist between Italian and foreign gear producers despite the attraction of the industry's low overhead structure, well-trained workforce, and attention to quality.[40]

The major Italian producers of industrial gears and gear products are international companies with sales, assembly, or manufacturing facilities in a number of countries. Some of the more significant producers and their applicable product sectors are shown in table 5-5. Agusta and Fiat, the two major Italian producers of state-of-the-art precision gearing, are the principal aerospace producers and their main products are helicopter gear boxes and aircraft engines. Fiat and Graziano produce transmissions for the automotive market, as well as for off-road and industrial vehicles. Companies such as Danieli, Costamasnaga, and Innse produce heavy industrial equipment such as steel mills, extruders, and material handling machines. These companies have worldwide distribution and are considered by industry analysts to be technologically advanced.

In Italy, small companies reportedly are able to succeed because of lower overhead and greater flexibility in managing their workforce. Workers can be laid off and paid informally, according to their productivity.[41] In small, nonunion shops

[37] *59th Annual Report of the Bank of International Settlements*, June 1989, Basel, Switzerland, p. 32.

[38] International Monetary Fund, *International Financial Statistics*, various issues.

[39] "Germany Approves Merger of 2 Giant Firms," The Washington Post, Sept. 9, 1989, pp. 12-13.

[40] USITC staff interviews with gear industry officials, Italy, November-December 1989.

[41] Ibid.

Table 5-5
Leading Italian gear producers, by major sectors, 1989

Company	Vehicle	Industrial	Aerospace	Marine
Agusta			X	
Bonfiglioli Riduttori		X		
Co.Me.R	X			
Costamasnaga		X		
Danieli & C		X		
Fiat	X		X	X
Graziano	X			
Gusti O.T.G	X	X	X	X
Innse		X		
Maag Italia	X	X		X
Pal Demm	X			

Source: Compiled by the staff of the U.S. International Trade Commission.

bonuses or incentives can be paid to the best workers without union interference. In part, because of this, concentration in the Italian gear-producing industry may have decreased in recent years as the trend has been for companies to split rather than combine. Workers may start their own company while still holding a secure job at a unionized firm. Many workers have second jobs in small nonunionized firms.

The Italian gear industry continues to show strong long-term growth. Italian shipments of industrial gears and gear products reached $2.2 billion in 1988, up from $949.2 million in 1984, representing an overall increase of 134 percent during 1984-88 (table 5-6). As measured in lira, shipments increased 73 percent over the same period. Industry experts indicate that the industry has continued to operate at an 85- to 90-percent capacity-utilization rate, a higher level than many of the gear industries in other industrialized countries.

During 1984-88, Italy's trade balance for gears and gear products fluctuated widely from a deficit of $74.6 million in 1987 to a surplus of $54.2 million in 1988. During this same period, the trade balance, measured in lira, fluctuated from a negative 96.7 billion lira to 76.0 billion lira. Apparent consumption of gears and gearing increased from an estimated $949.8 million in 1984 to an estimated $2.2 billion in 1988, representing an overall increase of 128 percent. As measured in lira, consumption increased by almost 69 percent over the period. One component of this growth in consumption in the Italian market is for variable-speed transmission parts, which reached $170.2 million in 1988, its highest level ever. Markets for major original equipment parts with applications for the automotive market, such as gear boxes, have also increased dramatically.[42] Industry experts indicate that prevailing economic conditions are the largest determinants of domestic gear consumption. Existing data reveal that 1988 bookings for gears by end users rose nearly 15 percent over 1987 levels, a trend expected to continue throughout 1990.[43]

The bulk of the Italian trade in gear products is with the EC countries, although Italy has traditionally sought to develop Eastern Bloc and Latin American markets. Overall imports of gears and gear products increased 119 percent, from $234.2 million in 1984 to $513.3 million in 1988. As measured in lira, imports grew by 62 percent during the period. Exports of Italian gears increased 143 percent, from $233.6 million in 1984 to $567.6 million in 1988 (table 5-6). As measured in lira, exports increased 81 percent during the period. Exports of Italian gears and gear products have traditionally been aimed at firms in industrialized countries involved in the manufacture of industrial machinery; construction, agricultural, and mining machinery; and material-handling equipment. Their major competitors worldwide are West Germany and Japan.

Research and development

Reportedly, only a limited amount of research and development is done at universities because it is generally not supported by the industry.[44] For the most part, R&D is done on a company basis, in-house. Fiat, however, is supporting some research on pneumatics at the university in Torino.

[42] Frost & Sullivan, Report No. E963, 1989.

[43] AGMA, *European Economic Report*, Washington, DC, 1989.

[44] USITC staff interviews with gear industry officials, Italy, November-December 1989.

Table 5-6
Gears and gearing: Italian shipments, exports, imports, and apparent consumption, 1984-88

Year	Shipments	Exports	Imports	Apparent consumption	Ratio (percent) of imports to consumption
			Value (million dollars)		
1984	949.2	233.6	234.2	949.8	24.7
1985	970.4	238.8	239.5	971.1	24.7
1986	1,462.3	359.8	358.9	1,461.4	24.6
1987	1,691.4	389.8	464.4	1,766.0	26.3
1988	2,221.1	567.6	513.3	2,166.9	23.7
			Value (billion lira)		
1984	1,667.7	410.4	411.5	1,668.8	24.7
1985	1,853.0	456.0	457.2	1,854.2	24.7
1986	2,180.0	536.5	535.1	2,178.6	24.6
1987	2,192.2	505.3	602.0	2,288.9	26.3
1988	2,891.0	743.5	667.5	2,815.1	23.7

Source: Estimated by the staff of the U.S. International Trade Commission.

Employment and training

The Italian gear industry employs roughly 11,000 workers, in firms of varying size. Hourly compensation costs for production workers in industrial and commercial machinery manufacturing (SIC 35) rose during 1984-88 from $7.45 to $13.37, an increase of 80 percent. In terms of lira, the increase appears much smaller because of fluctuating exchange rates; such costs increased by only 33 percent.[45] Italian machinery production workers earn nearly as much per hour as their U.S. counterparts. For example, during 1988, hourly compensation costs for machinery production workers in Italy was $13.37, compared with $15.01 in the United States.[46]

It is becoming increasingly difficult to recruit skilled workers in the industry. Italian gear producers have been forced to adopt extended work hours, already 50 hours a week in some parts of the industry, and rely on automation as an answer to the labor shortage.[47] Unemployment is very low in northern Italy, reportedly less than 5 percent, in the areas where nearly all of the gear producers are located. Because southern Italy has significant unemployment, there has been a slight increase in labor mobility evident as workers move north. However, the flow of workers is not sufficient to meet the needs of the industrial north; thus, there is an overall shortage of skilled labor in Italy's manufacturing sector.

With respect to training needs in the Italian gear industry, experienced workers need only a few months training for specific duties or machines, according to industry officials; the minimum training period for a new worker on a complex machine is about 6 months. Larger companies have formal training programs that train workers in certain skills over a period of 1 to 4 years. There are state schools that teach mechanical skills and provide some work experience to students beginning at age 14 and finishing at about age 18. However, these schools do not attract enough students to satisfy the industrial sector's need for workers.

In 1988, ASSIOT,[48] the association that represents the Italian gear industry, together with a related association formed a training program for factory technicians. Some of the funding for this program comes from the EC's structural funds and the rest is provided by the association and the government.[49] Because of the shortage of mechanical engineering students at the secondary level, the program recruits liberal arts students with mechanical aptitude and teaches them mechanical skills. The program includes about 6 months of theoretical training plus 3 months of practical training in a firm. Although the program is quite small at this time, the association plans to promote it more extensively in the schools.

Italian firms stated that unions in the larger plants are fairly rigid. If a firm has more than 15 workers it must have some union representation and if it has more than 100 workers the union rules are much stricter. Some industry officials suggested that larger companies have difficulty hiring skilled workers because unionized firms cannot pay the market wage. Wages for all unionized firms are set according to a national contract negotiated by the union. Because the union insists on a flat wage rate whereby all workers are compensated equally, rather than for their individual efforts, the result has been a union-negotiated wage that is lower than the market wage plus bonuses. The main attraction of the union shops is job security and stability.

According to representatives of Italian companies, unions are not as strong as they once were, but are still well organized. Although unions may be against overtime, they have allowed it, partly because of the shortage of workers. However, it is very difficult and expensive to dismiss or lay off workers. A firm must first demonstrate to the union and the government the reason that the layoffs are warranted, such as the long-term loss of a market. Usually, layoffs are accomplished by closing an entire facility or department, but companies are much more likely to reduce the number of employees by attrition. Generally, at the larger companies, management will reallocate workers among different divisions rather than lay off workers. Employees who are laid off receive unemployment compensation until they find another job.[50]

Government policies and programs

Italian gear producers reinvest a high degree of sales revenue in capital equipment, and are likely to continue this practice because of the favorable Italian tax laws. Specifically, Italian tax laws make it possible for gear producers to maximize deductions for capital investments. Although the Italian Government sponsors no specific assistance to the gear industry, gear producers can apply for the same programs available to other industries. These programs include the Government's fund for technological innovation, another fund for applied research, and the "Sabatini Law" that provides low-interest loans to certain firms investing in capital goods.[51]

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[45] Unpublished data from the U.S. Bureau of Labor Statistics, August 1989.

[46] Ibid.

[47] AGMA, *European Economic Report*, 1989.

[48] Associazione Italiana Costruttori Organi di Trasmissione e Ingranaggi.

[49] USITC staff interview with ASSIOT officials, November 1989.

[50] USITC interviews with gear industry officials, Italy, November-December 1989.

[51] U.S. Department of State Telegram, November 1989, Milan, Message Reference No. 02811, and Legge 28 November 1965, No. 1329, "Provvedimenti per l'acquisto di nuove macchine utensili," *Gazzetta Ufficiale Della Repubblica Italiana*, No. 311, Dec. 14, 1965, pp. 6255-6258.

Other competitive factors

Interest rates in Italy, as measured by the IMF bank lending rate, were relatively high during 1984-88. The rate in 1988 was 13.6 percent, higher than that experienced by most developed countries during 1984-88, and in 1984, the lending rate was even higher—22.2 percent. In spite of this, the Italian gear industry has made investments in plant and equipment and has increased the level of factory automation. One of the reasons is that many companies use internally generated, rather than borrowed, funds for investment in equipment. Internally generated funds are available because, as in many European companies, the debt load is very low and much of their profits are available for reinvestment.

Product liability insurance, raw materials, and energy costs in Italy are comparable with those of other Western European countries. Product liability insurance is not a significant cost factor in Italy. Few cases ever come to litigation and generally they do not involve personal injury as they do in the United States. In addition, ASSIOT has negotiated group insurance rates for its members. Most of the costs for raw materials and energy in Italy are about the same as those in other Western European countries and do not differ significantly from the costs of the U.S. industry. Italian gear manufacturers indicate that they purchase steel and other materials from EC sources, principally Italy and West Germany.

France

Industry and trade profile

The French gear industry ranks fifth in the world, after those of the United States, Japan, West Germany, and Italy, with shipments estimated at $2.1 billion in 1988. The industry consists of approximately 130 producers manufacturing gears for France's major industrial and manufacturing sectors. France's major gear consuming industries include the steel, automotive, aerospace, electronics, textile, chemical, agriculture, mining, and food processing industries. The majority of French gear producers is located in the Northeast, as is nearly 80 percent of all industrial activity.

The gear industry in France is divided into two types of companies: the small- to medium-sized firms employing less than 150 workers and the large firms such as Leroy-Somer, Renault, and Ford. Most of the smaller firms are privately held and many are family owned, whereas the larger firms are usually publicly held multinational companies in the automotive or industrial gear sector. In France, more than any other European country, the gear industry is dominated by the vehicle sector. The leading gear producers and their principal applicable product sectors are shown in table 5-7. A number of mergers and acquisitions have occurred in France in recent years as companies strove to become more competitive. In addition, U.S. firms increased their presence in the industry. For example, Girard Transmissions, a manufacturer of speed reducers, was acquired by Leroy-Somer in 1987. Leroy-Somer, in turn, was acquired in 1990 by Emerson Electric, a U.S. manufacturer of electric and electronic products as well as gear products. Tourco, a leading French producer of vehicle transmissions, was acquired in 1988 by Dana Corp. of the United States. The acquisition by Dana Corp. was expected to enable Tourco to increase its exports to the U.S. market. Ford has expanded its production facilities in its Bordeaux-Blanquefort plant and Renault Vehicles Industriels entered into an agreement with Rockwell International in 1985 to jointly manufacture automotive gear boxes.

According to French gear industry sources, very little merger activity has occurred among smaller firms. Such firms reportedly are uninterested in merging among themselves or with larger companies because they are generally family-owned firms and are unwilling to surrender their independence and their name.[52] Small firms also have the advantage of fewer regulations by the government and the unions, since companies with less than 50 employees are not required to have union representation. Large companies are interested in merging, but there is little interest on the part of large companies in acquiring small firms.

[52] USITC staff interviews with gear industry officials, France, November 1989.

Table 5-7
Leading French gear producers, by major sectors, 1989

Company	Vehicle	Industrial	Marine	Aerospace
ACB			X	
CATEP		X		X
Citroen Messian Durand	X		X	
Ford	X			
Hispano-Suiza				X
Leroy-Somer		X		
Peugeot	X			
Renault	X			
Tourco	X	X		

Source: Compiled by the staff of the U.S. International Trade Commission.

The demand for gears and gear products is tied directly to conditions prevailing in the major French industries. France had marginal economic growth during 1983-85, posting a two-year increase in real GNP of only 2 percent. Since mid-1986, however, France has experienced a period of relatively strong growth. The demand for gears and gearing has subsequently increased as orders for automobiles, auto parts, and capital goods have expanded. French consumption of gears and gearing rose 111 percent from $761.4 million in 1984 to $1.6 billion in 1988 (table 5-8). Measured in francs, consumption grew by about 44 percent.

The French market may be characterized as fairly open. However, French firms maintain that they depend on export markets because traditional domestic consuming industries such as textile machines, woodworking machines, and machine tools have declined or disappeared. The marine gear market in France has declined significantly; the commercial shipbuilding industry itself produces only fishing boats and a few cargo vessels or passenger ships. The most stable market for industrial gearing is material-handling equipment.

Private companies' access to the defense market is limited. Almost all defense products are manufactured in government-owned plants. The government purchases gears on the open market only when it cannot produce the required part or quantities.[53]

During 1984-88, the trade surplus in gears and gearing increased from $271.4 million to $515.7 million (table 5-8). However, in 4 of the 5 years in this period, imports as a percent of apparent consumption were 38 percent. Imports of gears rose from $290.6 million in 1984 to $605.4 million in 1988, an increase of 108 percent for the period. Measured in francs, imports grew from 2.5 billion francs to 3.6 billion francs, an increase of 42 percent. Imports were mainly from other EC countries, namely, West Germany, Italy, and Belgium. Other sources include Spain, the United Kingdom, the United States, Sweden, and Finland.

Exports of French gears and gearing increased from $562.0 million in 1984 to $1.1 billion in 1988, an increase of 99 percent. The increase as measured in francs was only 36 percent. Major export markets include West Germany, the United Kingdom, Italy, and Spain; exports outside the EC are limited. French producers stated that a major problem in entering the U.S. market is the language barrier. Other problems include the use of inches instead of meters, product liability insurance costs, and the distribution system that is necessary to sell in the United States. Additionally, the U.S. aerospace market has its own manufacturing and quality specifications that are difficult to assimilate.[54]

Research and development

Most French firms are too small to have their own R&D facilities or to fund R&D projects individually. Larger firms and producers of vehicle gearing, however, typically conduct their own proprietary research. As a result, much of the research that is conducted in France is done either in universities or by one of France's leading industrial research institutions, such as the Technical Research Center of the Mechanical Engineering Industry (CETIM).[55] Located in the cities of Senlis, Nantes, and St. Etienne, CETIM was established in 1965 to bolster the international competitiveness of French manufacturers. CETIM monitors and collects scientific and technical information, conducts research and development projects, and strives to transfer new discoveries and its accumulated knowledge to French industry. Areas of recent research activities include machine tools,

[53] Ibid.
[54] Ibid.
[55] Centre Technique des Industries Mecaniques.

Table 5-8
Gears and gearing: French shipments, exports, imports, and apparent consumption, 1984-88

Year	Shipments	Exports	Imports	Apparent consumption	Ratio (percent) of imports to consumption
			Value (million dollars)		
1984	1,032.8	562.0	290.6	761.4	38.2
1985	1,053.0	566.9	303.6	789.7	38.4
1986	1,517.8	817.1	437.6	1,138.3	38.4
1987	1,825.5	1,094.7	563.9	1,294.7	43.6
1988	2,121.5	1,121.1	605.4	1,605.8	37.7
			Value (billion francs)		
1984	9,026.1	4,911.6	2,539.4	6,653.9	38.2
1985	9,461.2	5,093.7	2,728.0	7,095.5	38.4
1986	10,512.4	5,659.6	3,031.1	7,883.9	38.4
1987	10,972.6	6,579.9	3,389.2	7,781.8	43.6
1988	12,638.1	6,678.4	3,606.0	9,565.6	37.7

Source: Estimated by the staff of the U.S. International Trade Commission.

mechanical drives, hydraulic and pneumatic drives, CAD/CAM, metals and alloys, sheet-metal working, and hot and cold forging. The National Syndicate of Gear Manufacturers and Constructors of Transmissions Components (SYNECOT),[56] a French trade association representing the majority of gear producers, establishes gear research agendas and conducts gear research, as well as sets national gear standards. SYNECOT, through its Institute of Gearing and Transmissions (IET),[57] conducts practical courses for gear engineers, technicians, workers, and users. Approximately 70 percent of IET's courses are aimed at users, providing them with the latest in technological developments and applications, especially advances in computer technology.[58]

Employment and training

The availability of skilled labor is a problem for the French gear industry. Some employers try to retrain current employees on CNC machines. Other firms have apprenticeship programs to train new people. Most apprenticeship programs recruit students as they complete their compulsory education at age 16 or 17. Apprenticeship programs, usually lasting about 1 year, consist of classes and practical experience, and after course completion, the apprentices are qualified to work in the factory. However, the government requires all young men to perform compulsory military service at age 18, and many firms find that trainees do not return to work afterward. Generally, labor turnover is high among younger workers who frequently leave after only 2 to 6 months. Those employees that remain with a company for more than a year generally stay with the company for many years.[59]

Employment in the gear industry is about 11,500. Hourly compensation costs for production workers in industrial and commercial machinery manufacturing (SIC 35) increased during 1984-88 from nearly 67 francs per hour to more than 80 francs per hour, or slightly more than 20 percent. In U.S. dollar terms, the increase appears much greater because of the fluctuation in exchange rates. Such costs rose 76 percent, rising from $7.67 per hour in 1984 to $13.52 in 1988.[60]

Government policies and programs

Like its EC counterparts, the Government of France is at least minimally involved in the promotion of its domestic industry. Government support is strongest for the nation's aerospace and defense industries, including such firms as Aerospatiale and SNECMA, which have captive gear- producing establishments.

Other competitive factors

French raw material and product liability insurance costs are roughly comparable to those in all EC countries. Most gear-making firms purchase their steel in the EC from the source offering the lowest price. Both steel and bronze come from the EC, especially Belgium, the Netherlands and West Germany. Steel is usually purchased from distributors that are subsidiaries of steel making companies, but sometimes it is purchased directly from the steel company. As gear manufacturers' organizations elsewhere in the EC, the French gear producers' association has arranged group product liability insurance rates for its members to help control product liability insurance premiums. New EC product liability laws may impose a heavier burden on sellers and could cause these costs to rise significantly.

During 1984-88, bank lending rates in France, as measured by the IMF, were among the highest in Europe and have had an effect on investment in plant and equipment. Funds for short- and medium-term loans were available in France at an average of nearly 16 percent in 1988.[61] Small companies with limited sources of funds have not been able to purchase new equipment as easily as larger companies. One producer has stated that many smaller companies cannot afford to have their own heat treatment facility because of the high capital investment required, and therefore contract this step out to other companies.[62]

Differing product standards do not pose significant problems to most manufacturers. Industry sources state that, with CNC, they can adjust to produce to any standard. They generally use two sets of standards, the French National Standard Association (AFNOR),[63] and DIN, but occasionally they also use AGMA.

United Kingdom

Industry and trade profile

In 1989, there were an estimated 100 gear producers in the United Kingdom, the vast majority of which are small- to medium-sized companies. The economy in the United Kingdom has shown little growth since 1979; industrial production, as measured by the IMF, increased slightly over 3 percent during 1979-86.[64] Because of the poor performance of the economy during this period, many companies, including gear producers, were forced to curtail their operations or close. As a result, the gear industry in the United Kingdom became smaller and more concentrated. In 1987 and 1988, there was a marked improvement in the industrial sector, with industrial production rising

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[56] Syndicat National Des Fabricants D'Engrenages et Constructeurs D'Organes de Transmission.
[57] L'Institut de l'Engrenage et des Transmissions.
[58] USITC staff interviews with gear industry officials, France, November 1989.
[59] Ibid.
[60] Unpublished data from the U.S. Bureau of Labor Statistics, August 1989.
[61] International Monetary Fund, *International Financial Statistics*, various issues.
[62] USITC staff interviews with gear industry officials, France, November 1989.
[63] Association Francaise de Normalization.
[64] International Monetary Fund, *International Financial Statistics*, 1989.

over 3 percent per year. This upswing in the economy was reflected in increased gear shipments in 1988.

During 1984-88, several prominent British manufacturers entered into various arrangements with gear producers in order to expand their markets, reduce their dependency on certain market sectors, or broaden their product lines. The U.K. firm Leyland Bus and ZF of West Germany entered into an agreement in 1987 to jointly manufacture gear boxes for Leyland-produced buses. Leyland Bus was to supply ZF with various gear box components and in return would purchase 66 percent of its bus transmissions from ZF during 1987-88. Leyland Bus intends to build between 3,000 and 4,000 buses and coaches by the end of 1990.[65] Control Techniques, a U.K. producer of variable speed transmissions, acquired a controlling interest in three smaller British gear producers in 1987: Euro Controls, Lightwood Engineering, and Q-Power Transmission.[66] Allen Gears, a U.K. company, has licensed Philadelphia Gear Corporation to produce gear boxes for hydro-turbine generators.[67]

The leading producers in the United Kingdom are a mixture of foreign- and domestic-owned firms. The leading producers and their principal applicable product sectors are shown in table 5-9. Westland and Lucas are the major aerospace gearing producers in the United Kingdom. The vehicle sector is dominated by Eaton, the largest vehicle gearing producer in the United Kingdom. J.H. Fenner produces commodity type gear products, and gears for marine applications are produced by GEC-Alsthom and Allen Gears.

During 1984-88, demand for gears and gearing increased. As shown in table 5-10, shipments of gears and gearing increased by 89 percent from $498.7 million in 1984 to $942.1 million in 1988. In British pounds, the increase in value of shipments was a moderate 42 percent, from £373.2 million to £528.9 million. The increase in demand for gears also caused a significant increase in gear imports. Imports of gears and gearing rose from $339.0 million in 1984 to $973.4 million in 1988, an increase of 187 percent. In British pounds, imports grew from £253.7 million to £546.4 million, an increase of 115 percent. Imports as a percentage of domestic consumption rose from 47 percent in 1984 to 65 percent in 1988. The United States and West Germany are principal sources of U.K. imports. During 1984-88, the United Kingdom's trade deficit for gearing grew from $220.4 million to $560.8 million.

The EC is the major export market for U.K. gear manufacturers.[68] Other important export markets are the Commonwealth countries. Exports to the United States from U.K. firms range from none for some companies to as much as 20 percent of exports for other firms. Exports of gears and gear products increased 248 percent during 1984-88, rising to $412.6 million in 1988 from $118.5 million in 1984. In pounds, the rise from £88.7 million to £231.6 million amounted to an increase of 161 percent over the period 1984-88. The difference in percentage increases is attributable to exchange rate fluctuations that have increased the value of the U.K. pound relative to the U.S. dollar.

Research and development

According to industry sources, there was a general cutback in R&D during the early 1980s as a result of the downturn in the U.K. economy. During this time, many companies viewed cuts in R&D as a means of improving profits in the short term. Government spending on research has followed the same pattern as private financing. Neither source of funds has returned to prerecession levels.

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[65] "Gearbox Accord for ZF, Leyland," *Automotive News*, June 22, 1987, p. 31.
[66] "Control Acquires," *Control & Instrumentation*, December 1987, p. 7.
[67] British Gear Association, *Drives and Controls*, 1989.
[68] United Kingdom Department of Trade and Industry, *Overseas Trade Statistics of the United Kingdom*, December 1988.

Table 5-9
Leading British gear producers, by major sectors, 1989

Company	Industrial	Vehicle	Marine	Aerospace
David Brown	X	X	X	
Eaton Ltd		X		
J.H. Fenner	X			
GKN		X		
GEC-Alsthom Gears Ltd	X		X	
Leyland Daf		X		
Lucas Aerospace Ltd				X
NEI Allen Ltd	X		X	X
Reliance Gear	X	X	X	X
Renold Gear	X			
Westland Helicopters Ltd		X	X	X

Source: *Drives and Controls*, British Gear Association.

Table 5-10
Gears and gearing: United Kingdom shipments, exports, imports, and apparent consumption, 1984-88

Year	Shipments	Exports	Imports	Apparent consumption	Ratio (percent) of imports to consumption
			Value (million dollars)		
1984	498.7	118.5	339.0	719.1	47.1
1985	559.1	164.3	383.5	778.4	49.3
1986	663.1	190.9	458.8	931.0	49.3
1987	763.6	229.3	665.3	1,199.5	55.5
1988	942.1	412.6	973.4	1,503.0	64.8
			Value (million pounds)		
1984	373.2	88.7	253.7	538.1	47.1
1985	431.3	126.7	295.9	600.5	49.3
1986	452.0	130.2	312.8	634.6	49.3
1987	465.9	139.9	405.9	731.9	55.5
1988	528.9	231.6	546.4	843.7	64.8

Source: Estimated by the staff of the U.S. International Trade Commission.

The U.K. Government funds some defense-related research, and companies in high-technology fields, such as aerospace, have continued R&D activities, albeit at lower levels. One firm currently has 12 ongoing projects on gears and lubricants, some of which are partially government funded, and has had as many as 20 projects at one time.

Many industry experts believe that the U.K. industry needs to increase its R&D spending significantly in order to strengthen its competitive position. The University of Newcastle upon Tyne has established a gear research center to provide engineering consulting services in design, development, and applied research to firms in the industry that would not otherwise have access to the equipment and expertise that the center offers.

Employment and training

There were approximately 4,000 to 5,000 persons employed in the U.K. gear industry in 1988; both employment and production are rising. In 1989, most firms in the United Kingdom were working two shifts plus overtime for a total of approximately 90 hours per week.[69] Hourly compensation costs for production workers in industrial and commercial machinery manufacturing (SIC 35) rose from £4.6 to £6.0, an increase of 33 percent. In dollar terms, the increase appears much greater because of fluctuating exchange rates. Such costs rose over 77 percent, from $6.09 to $10.80.[70] According to several U.K. firms, there is a shortage of machinists and engineers. It is becoming increasingly difficult to fill vacancies and attract applicants to apprenticeship programs. Industry sources attribute the decline in the availability of workers in large part to the common perception that these are low-status occupations. Students, especially the mechanically inclined, are not encouraged to study mechanical engineering or mechanical trades in school. Industry sources state that schools have stopped teaching mechanical courses, such as metal working or machine repair. As a result, the labor pool lacks the types of skills that are needed by industry. In addition, workers are generally unwilling to relocate even if unemployed. This makes it difficult for companies in the industry to relocate or open new facilities in other locations.[71] The lack of mobility of the workforce has resulted in a geographical concentration of the industry in the north of England.

Nearly all of the workers in the U.K. gear industry are union members. Industry sources indicate that unions are not opposed to overtime but are attempting to reduce the work week from 39 to 35 hours. According to U.K. gear producers, reducing employment except by attrition is difficult and expensive. Firing employees is difficult to justify without significant cause, and layoffs are expensive because of the cost of unemployment payments. Therefore, firms are conservative in hiring and will only add employees if a long-term increase is justified. They are then better able to continue to carry all employees if orders decline.

Most production workers enter training or apprenticeship programs as soon as they have finished their compulsory education, usually at age 16. Because of the geographic concentration of the industry, local associations of companies and trade schools are able to provide training for several companies. Training programs usually last from 1 to

[69] USITC staff interviews with gear industry officials, United Kingdom, November 1989.
[70] Unpublished data from the U.S. Bureau of Labor Statistics, August 1989.
[71] USITC staff interviews with gear industry officials, United Kingdom, November 1989.

4 years, depending on the complexity of the job and the aptitude of the trainee, and include classroom and machine shop training. Most training is privately funded; however, some government assistance is provided. For large firms, training may be handled in-house.

Government policies and programs

The British Government actively promotes investment by qualified foreign firms. The government uses grants, low-interest loans, tax incentives, accelerated depreciation, and the availability of ready-built factories and warehouses to encourage investment, employment, R&D, and industrial development.

The major incentive for capital investment is accelerated depreciation; equipment purchased after March 1972 can be totally depreciated in 1 year. If a company's profits are too low to permit taking full advantage of this provision, the deduction may be taken against income in any of the 3 previous years or in a future year. This provision applies equally to all industries.[72]

The British Government also has certain tax provisions that encourage R&D.[73] Firms may fully depreciate all assets used in R&D in 1 year, including buildings and land. In addition, firms may charge all payments to research associations to current expenses. If the Department of Trade and Industry (DTI) approves, the research associations' profits are tax exempt. Research associations make little profit, however, and the DTI requires them to put their profits back into research to keep their tax exemption.[74]

Other competitive factors

Many of the costs of production in the United Kingdom are reported to be higher than those in the United States. U.K. sources opined that costs such as energy and labor are lower in the United States and that steel produced in the United Kingdom is approximately 15 percent lower in cost than that available elsewhere in the EC. Most firms are located near Sheffield, a major steel-producing area, and purchase some, if not all, steel locally.

The cost of product liability insurance in the United Kingdom is comparable to that in other European countries and lower than that in the United States. Lower rates are due to differences in product liability laws and litigation and the fact that the British Gear Association has negotiated a lower group rate for its members. British firms say that proposed product liability legislation, a result of the planned EC 92 integration, is more stringent than current law. Currently, liability is based on contract particulars or negligence. The proposed legislation broadens the scope of product liability, although not to the extent that is found in the United States.

Bank lending rates in the United Kingdom, as measured by the IMF, rose irregularly from 9.7 percent to 10.3 percent during 1984-88. In late 1989, industry sources indicated that the base lending rate had been pushed up to more than 15 percent by Government fiscal policies. These sources state that the level of interest rates was an obstacle to obtaining funds for investment in capital equipment.[75]

In part because of the high cost of capital and also because of the downturn in demand, U.K. companies have not invested as heavily as some other gear producers. U.K. firms have followed very conservative capital expenditure policies which mainly involve replacing equipment that is no longer serviceable or reconditioning older equipment. Some firms state that the most difficult investment to justify is new machinery that would result in product improvement or that would be used to produce an entirely new product, because these investments would not improve short-term financial performance. Although the policy at certain firms is to invest annually in new machinery, most investment is either to increase capacity to meet orders or to replace worn-out machines.[76]

As low investment levels have slowed improvements in productivity, some U.K. firms have begun implementing management techniques that can reduce costs. Several firms are moving toward smaller lot sizes. This would limit the amount of work-in-process at any one time. In this way, they are trying to reduce their inventory of raw materials and finished products to the minimum needed to service their customers.

Belgium

Industry and trade profile

The Belgian gear industry consists of approximately 60 producers manufacturing gears for major industrial and manufacturing sectors. The industry is dominated by subsidiaries of foreign multinational vehicle producers that account for the majority of production and employment in the industry. Producers of industrial gearing make up the second-largest group and producers of aerospace gearing and marine gearing account for the smallest portion. These producers are medium- to small-sized firms employing an average of 200 persons, with the largest having more than 800 and the smallest having 25 persons.[77]

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[72] OECD, *International Investment and Multinational Enterprises*, 1988, p. 229.

[73] Ibid.

[74] U.S. International Trade Commission, *Foreign Industrial Targeting and Its Effect on U.S. Industries, Phase II: The European Community and Member States*, USITC Publication 1517, April 1984, p. 100.

[75] USITC staff interviews with gear industry officials, the United Kingdom, November 1989.

[76] Ibid.

[77] Comments prepared for the USITC by Fabrimetal, Brussels, Belgium, January 1990.

Leading Belgian gear manufacturers include Hansen Transmissions, Clark International Components, Ford Tractor, and Twin Disc (table 5-11). Hansen, owned by British Tire and Rubber (BTR), is the largest industrial gear manufacturer in Belgium, serving the metal, mining, chemical, petroleum, and power-generating industries. Clark, a U.S. subsidiary located in both Antwerp and Bruges, and Ford Tractor produce industrial vehicle transmissions for the European market. Twin Disc, producing marine transmissions in Nivelles, is also a U.S. subsidiary.[78]

Belgium's major gear-consuming industries include steel, automotive, textile, chemical, agriculture, and food processing. Demand for gears has increased as Belgium experienced its best economic growth in the past decade. In 1988, the Belgian economy grew at a rate of almost 4 percent. Belgium's central location and highly developed transportation infrastructure have helped make it one of the largest exporters in Europe. It is a European manufacturing base for many multinational firms.[79] Much of Belgium's growth is attributable to its automotive gear-producing sector, which accounts for approximately 70 percent of total gear production. The automotive sector has experienced massive investment in the latter part of 1984-88. Auto assembly plants now include Ford, GM, Renault, Volkswagen, and Volvo. The remaining 30 percent of production is primarily industrial gearing.

During 1984-88, the Belgian trade surplus for gears increased significantly from $173.7 million to $214.8 million, and imports as a percent of apparent consumption declined from 64 percent to 51 percent. Imports of gears and gearing increased almost 120 percent, from $199.2 million in 1984 to $437.9 million in 1988 (table 5-12). The increase, as measured in Belgian francs, was not as substantial. Imports grew from 11.8 billion Belgian francs to 16.1 billion Belgian francs, an increase of 36 percent. Other EC countries, particularly France, West Germany, and the United Kingdom, were the principal sources of imports.

Exports of gears and gearing increased almost 75 percent during 1984-88, from $373.9 million in 1984 to $652.7 million in 1988. As measured in Belgian francs, exports grew from 22.1 billion Belgian francs to 24.0 billion Belgian francs, or only 8 percent. Major foreign markets include the EC and Scandinavian countries.

Research and development

R&D is done mainly on a cooperative basis, although gear production benefits from proprietary research conducted by large multinational firms in their home countries. Topics include different manufacturing technologies, such as machining, foundry, and robotics. This cooperative research is funded on a 50/50 basis by the industry association, Fabrimetal, and the Belgian Government.[80]

Employment and training

The Belgian gear industry employs approximately 5,500 people, most of whom are in the automotive sector. Hourly compensation costs for production workers in industrial and commercial machinery manufacturing (SIC 35) rose 13 percent during 1984-87, from 520.5 Belgian francs in 1984 to 588.3 Belgian francs in 1987. In dollars, hourly compensation costs grew nearly 75 percent, from $9.01 in 1984 to $15.75 in 1987.[81] Most workers in the gear industry are unionized. According to industry officials, the union restricts employers' flexibility in the areas of layoffs and the number of hours worked.

[78] Ibid.

[79] U.S. Department of Commerce, International Trade Administration, "Foreign Economic Trends and Their Implications for the United States: Belgium" ([Washington, DC]: U.S. Department of Commerce, International Trade Administration, July 1989).

[80] USITC staff interviews with gear industry officials, Belgium, November 1989.

[81] Data for 1988 not yet available. Unpublished data from the U.S. Bureau of Labor Statistics, August 1989.

Table 5-11
Leading Belgian gear producers, by major sectors, 1989

Company	Vehicle	Industrial	Marine	Aerospace
ABT		X		
Asco				X
Clark Components	X			
CMI Transmissions		X		
David Brown Sadi		X		
Defawes		X		
Esco Transmissions		X		
Ford Tractor	X			
Hansen Transmissions Int'l		X		
Twin Disc			X	
Volvo Cars	X			
Watteeuw		X		X

Source: Fabrimetal.

Table 5-12
Gears and gearing: Belgian shipments, exports, imports, and apparent consumption, 1984-88

Year	Shipments	Exports	Imports	Apparent consumption	Ratio (percent) of imports to consumption
			Value (million dollars)		
1984	483.7	372.9	199.2	310.0	64.3
1985	569.1	466.2	234.3	337.2	69.5
1986	743.8	618.2	319.8	445.5	71.8
1987	874.9	738.0	392.5	529.5	74.1
1988	1,071.4	652.7	437.9	856.6	51.1
			Value (million francs)		
1984	28,722.6	22,145.1	11,827.9	18,405.5	64.3
1985	33,789.8	27,679.8	13,914.2	20,024.2	69.5
1986	33,228.5	27,614.3	14,286.0	19,900.2	71.8
1987	32,664.7	27,551.3	14,653.6	19,766.9	74.1
1988	39,394.3	23,998.0	16,099.2	31,495.5	51.1

Source: Estimated by the staff of the U.S. International Trade Commission.

The industry association, Fabrimetal, has stated that a lack of skilled workers is a critical issue in the gearing industry. Employees are also reportedly changing companies more frequently. Many gear producers' employees come from publicly-funded technical schools where they receive basic workshop training on older machines. This vocational training is mainly oriented toward gear production. Several companies then train apprentices in-house for an additional 6 to 12 months per machine.[82]

Government policies and programs

The Belgian Government supports industrial growth by encouraging the development of industrial areas with specific advantages, such as access to transportation networks. Investment incentives offered by national and regional governments have also spurred industrial development.[83] Special educational programs include funding for technical and vocational schools, cooperative research programs, and a secondary educational system which encourages the development of more skilled workers necessary for the gear industry.

Other competitive factors

Two costs that are relevant to the competitiveness of Belgian gear producers are the expense of producing products measured in inches, in order to meet U.S. standards, and materials and labor costs. Several Belgian gear manufacturers stated that most of their materials are purchased in the EC. Material costs make up about one-third of total costs and that percentage is rising. Labor also accounts for one-third of costs, but that share is declining. Plant, equipment, and overhead account for the remainder. Bank lending rates, which were relatively high at the beginning of the period, fell to approximately 9 percent in 1988.[84] With respect to standards, products designed in inches are more expensive for non-U.S. companies to produce because the companies do not have the volume of orders that would make it possible to lower the price.[85]

Japan

Industry and trade profile

Japan's gear industry consists of about 350 firms and, in terms of production, is dominated by the captive gear operations of its automotive industry which accounted for over two-thirds of the value of the total in 1988. In addition to the large captive producers of automotive gearing, there are four major independent producers of transmissions—Aisin-Warner Ltd., Japan Automatic Transmission Co., Ltd., Fuji Tekko Co., Ltd., and Aisin Seiki Co., Ltd.—and another 26 firms producing automotive transmission parts.[86]

Captive production operations also produce gearing for large industrial corporations, such as Ishikawajima-Harima Heavy Industries (IHI), Mitsubishi, Komatsu, and Sumitomo. In Japan's growing aerospace industry, IHI, Mitsubishi, Kawasaki, and Fuji Heavy Industries produce most of the gears. Leading Japanese producers of gears and gear products are shown in table 5-13, according to their applicable product sectors.

[82] Comments prepared for the USITC by Fabrimetal, Brussels, Belgium, January 1990.

[83] U.S. Department of Commerce, "Foreign Economic Trends and Their Implications for the United States: Belgium," July 1989.

[84] International Monetary Fund, *International Financial Statistics*, various issues.

[85] USITC staff interviews with gear industry officials, Belgium, November 1989.

[86] U.S. International Trade Commission, *U.S. Global Competitiveness: The U.S. Automotive Parts Industry*, USITC Publication 2037, December 1987, pp.12-101, and Dodwell Marketing Consultants, *The Structure of the Japanese Auto Parts Industry*, 3rd ed., October 1986.

Table 5-13
Leading Japanese gear producers, by major sectors, 1989

Company	Industrial	Vehicle	Marine	Aerospace
Asano Gear		X		
Aisin Seiki Co		X		
Fuji Heavy Industries	X	X		X
Fujikoshi ("Nachi")	X			
Fuji Tekko Co. Ltd		X		
Hasegawa	X			
Hitachi	X			
Honda		X		
IHI	X	X	X	X
Japan Automatic Transmission Co., Ltd		X		
Kawasaki	X	X	X	X
Maschinko	X			
Mitsubishi	X	X	X	X
Nissan		X		
Nissei Industrial	X			
Nippon Gear	X		X	
Osaka Seisa	X		X	
Sumitomo	X		X	
Toyota		X		
Yanmar Diesel	X	X	X	

Source: Compiled by the staff of the U.S. International Trade Commission.

About 95 percent of Japan's independent gear producers are small- to medium-sized firms, working as subcontractors to the automotive and machinery industries, especially the machine tool industry.[87] The major producers, including captive producers, are situated near the customers they support, and therefore are concentrated in and around Tokyo, Nagoya, Osaka, and Hiroshima.[88]

Japanese industrial gear manufacturers sell about 30 percent of their gearing through large wholesalers, who in turn sell to subagents, who then sell to end users. Another 40 percent is sold directly to subagents, and the remaining 30 percent is sold directly to the end user by the manufacturer. Foreign investment in Japan's gear industry is minimal, although some foreign firms, such as Flender and SEW-Eurodrive of West Germany and Twin Disc of the United States, have recently invested in manufacturing facilities there. Japanese firms have technical tieups or original equipment manufacturer (OEM) supply arrangements with a number of leading U.S. and European producers. For example, IHI produces gear boxes for GE's turbo-prop engines, and Kawasaki is producing helicopter transmissions in a joint venture with MBB of West Germany. By licensing production in aerospace products, commodity-type industrial gearing and marine gearing, Japanese producers utilize production and design technology and also generate revenues from these products. Overall R&D efforts can then be concentrated on other products or minimized. Industrial gear producers tend to sell in foreign markets through joint ventures, distributors, or through large Japanese trading companies.

[87] *Comline Industrial Machinery & Mechanical Engineering*, Jan. 10, 1989, p. 6.

[88] USITC staff telephone interview with NASA official, September 1989.

Japanese shipments of gears and gearing increased from $2.9 billion in 1984 to $8.4 billion in 1988, a gain of 189 percent (table 5-14). The growth, expressed in yen, was not as substantial. Shipments rose from ¥693.2 billion in 1984 to ¥1,080.1 billion in 1988, an increase of 56 percent. Production rose largely in response to increased exports, as well as greater domestic consumption of automobiles, trucks. and buses.[89]

Japanese imports of gears and gearing grew from $58.0 million in 1984 to $89.9 million in 1988, an increase of 55 percent. Measured in yen, however, imports declined from ¥13.8 billion in 1984 to a low of ¥9.4 billion in 1987, before recovering to ¥11.5 billion in 1988; overall, imports declined 16 percent over the period. The United States accounted for 37 percent of the total, followed by France at 23 percent and West Germany at 18 percent. Vehicle gearing, principally transmissions and transaxles, accounted for 43 percent of total imports. Japanese exports of gears and gearing increased from $789.1 million in 1984 to almost $2.5 billion in 1988, a gain of 214 percent. Measured in yen, exports grew 69 percent during the period, from ¥187.6 billion in 1984 to ¥317.7 billion in 1988. Major markets included the United States, Korea, and Belgium. Automotive, truck, and bus transmissions accounted for 83 percent of total exports. Korea is an important market, especially for automotive gearing, because the major Korean automotive producers have licensing and supply arrangements with Japanese automobile producers.

[89] Japan's production of automobiles, trucks, and buses increased from approximately 11.5 million units in 1984 to 12.7 million units in 1988. Motor Vehicle Manufacturers Association, *Facts & Figures '89*, p. 30.

Table 5-14
Gears and gearing: Japanese shipments, exports, imports, and apparent consumption, 1984-88

Year	Shipments	Exports	Imports	Apparent consumption	Ratio (percent) of imports to consumption
			Value (million dollars)		
1984	2,916.2	789.1	58.0	2,185.1	2.7
1985	3,245.5	900.6	49.1	2,393.9	2.0
1986	5,024.3	1,426.6	61.9	3,659.5	1.7
1987	6,412.0	1,784.5	64.7	4,692.2	1.4
1988	8,428.2	2,478.8	89.9	6,039.2	1.5
			Value (billion yen)		
1984	693.2	187.6	13.8	519.4	2.7
1985	774.2	214.8	11.7	571.1	2.0
1986	846.7	240.4	10.4	616.7	1.7
1987	927.3	258.1	9.4	678.6	1.4
1988	1,080.1	317.7	11.5	773.9	1.5

Source: Estimated by the staff of the U.S. International Trade Commission based on Machinery Statistics, Ministry of Industry and International Trade statistics from the Japan Tariff Association.

Japanese apparent consumption of gears and gearing grew from $2.2 billion in 1984 to $6.0 billion in 1988, an increase of over 176 percent. Measured in yen, the increase was less sizeable but still significant. Consumption rose from ¥519.4 billion in 1984 to ¥773.9 billion in 1988, an increase of 49 percent (table 5-14). This increase was driven principally by continued growth in the automotive and machinery industries, as well as in domestic construction.

Research and development

Japan is among the world leaders in gear R&D. The Ministry of International Trade and Industry (MITI) Agency of Industrial Science and Technology (AIST) has an active Mechanical Engineering Laboratory. However, MITI and the Japanese Government have not requested any gear research recently.[90] The Japanese Gear Manufacturers Association (JGMA) does not fund or sponsor any gear research, except as might be required in developing product standards.[91]

The government funds research at several university gear research centers including the University of Tokyo, the Laboratory of Precision Machinery and Electronics of the Tokyo Institute of Technology, Kyoto University, and Kyushu University, which has a gear-making machine tool research laboratory. University research centers are usually very small, with teams of researchers dedicated to narrow research topics, such as noise or fatigue in gears. The universities typically do not perform direct research for companies, as they do not want to develop close corporate associations.

Professors frequently conduct basic research, rather than application- specific research, and they are generally free to decide upon their own topics. They can apply to the Ministry of Education for funding. The typical award is $39,000 to $62,000 per year for three years, with a maximum of about $234,000 for a three-year project, although an additional $15,000-$16,000 per year may also be granted. Since such funding is relatively small, professors typically ask for donations of machinery from gear companies, such as test gears or testing equipment.[92] If companies want to adopt research results of professors, they usually ask permission and pay a nominal sum to the professor.[93]

The results of university research are generally published in the Journal of the Japan Society of Mechanical Engineers (JSME) and the Journal of the Japan Society of Precision Engineering, as well as being presented at international conferences. The JSME sponsors gear research projects for which it solicits funds from companies. Typically, funding from companies for JSME projects totals $100,000 to $125,000. The JSME also sponsors a conference every 4 years on mechanical power transmission machinery.[94]

Proprietary research on gears is performed by larger companies, such as Toyota, Honda, Nissan, Mitsubishi, IHI, and Kawasaki. Mitsubishi and IHI are noted for marine gear research, but also conduct research on machinery and aerospace gearing. Industrial gearing research is minimal, since technology is frequently obtained through licensing arrangements with foreign companies. Industrial gear manufacturers are focusing their research on reducing noise, increasing gear reducer efficiency, and producing more compact and lighter gear boxes. For automotive producers, research has

[90] USITC staff interview with MITI officials, Dec. 4, 1989.
[91] USITC staff interview with JGMA officials, Dec. 4, 1989.

[92] USITC staff interviews with Prof. K. Umezawa, Research Laboratory of Precision Machinery and Electronics, Tokyo Institute of Technology, Dec. 6, 1989.
[93] Ibid.
[94] Ibid.

focused on gears and production methods and productivity. Recent developments in Japanese automobile gearing include a reduced pressure angle on the gear, which allows for quieter gears that are also easier to manufacture, and ribbing on transmissions to reduce weight and decrease noise. Other research has focused on hard finishing methods, various cutting methods, and productivity improvements.[95]

Employment and training

Total employment for the Japanese gear industry, including automotive and other vehicle gearing, is estimated at 39,000 persons. Many Japanese gear producers, as well as other heavy industry manufacturers, are having difficulty recruiting university graduates, especially engineers, and other types of skilled workers.[96] In contrast, Japanese automotive producers report that they have not encountered problems recruiting production workers or engineers, possibly because they are large corporations that can offer lifetime employment.[97] As in other industrialized countries, production workers in Japan's metalworking industries, including the gear industry, tend to be older, as recent graduates have shown a preference for the service sector over the manufacturing sector.[98] In the gear industry, the average age of production workers is about 40 to 43 years and increasing.[99] Because of the current age of the workforce, there is some concern that the gear industry will eventually lose some of its skills.

Worker training in the Japanese gear industry is left up to the individual companies, as the national apprenticeship program was eliminated in the 1970s. Large Japanese companies with captive gear operations are able to train employees, including cross-training in different aspects of the firm. Some companies rotate workers to different production assignments every 2 or 3 years. Automobile companies have extended the concept of cross-training to their gear design engineers, requiring them to learn to produce and test prototype gears, as well as design them.[100]

[95] USITC staff interviews with gear industry officials, Japan, Dec. 4-11, 1989.

[96] According to Japanese gear producers, attitudes prevailing among young workers include less tolerance to the management structure in Japanese companies, and a willingness to change jobs and to engage in part-time work. This attitude is exemplified in a saying among young workers that they should avoid "dangerous [kiken], dirty [kitanai], and dark and dull [kurani]" jobs. USITC staff interviews with Japanese gear producers, Dec. 4-11, 1989.

[97] USITC staff interviews with officials from Honda Motor Co. and Toyota Motor Co., Dec. 7 and 8, 1989.

[98] Information obtained by USITC Commissioner Alfred E. Eckes through interviews during visit to Japan, July 1989.

[99] USITC staff interviews with gear industry officials, Japan, Dec. 4-11, 1989.

[100] USITC staff interviews with automotive manufacturers, Japan, Dec. 7-8, 1989.

Hourly compensation costs for Japanese production workers in the industrial and commercial machinery manufacturing industries (SIC 35) rose 101.5 percent from $7.36 in 1984 to $14.83 in 1988.[101] Measured in yen, they rose from ¥1,747 in 1984 to ¥1,902 in 1988, an increase of only 8.9 percent.[102] Discussions with Japanese gear producers indicate that the typical factory worker with several years' experience earns about $27,000 to $29,000 per year, including bonuses. Such bonuses are given to workers twice a year, and are generally based on encomic conditions and individual capabilities. Bonuses may account for 5 months' salary, or between 30 to 40 percent of a worker's annual salary. In order to contain labor costs, Japanese gear producers use part-time workers in operations that require minimal training. Such areas include gear product assembly operations and selected office support services.

Even the smaller gear producers offer their employees many benefits, including health insurance, welfare pension insurance, labor insurance, and loan programs. Frequently, the company provides housing, either in company-owned dormitories usually for single male workers, or in company apartment buildings. Many firms sponsor club activities, including sports and English language groups, or informal groups outside of work that use company resources for product innovation.[103]

Government policies and programs

According to Japanese industry officials, there were no policies that benefit gear producers specifically. However, there are tax incentives which encourage investment in plant and equipment. Depreciation of assets for the gear industry, including automotive gearing producers, is 10 years.[104] Certain machinery, however, is eligible to be depreciated more quickly, using either "increased initial depreciation" or "additional depreciation" allowances. Increased initial depreciation allows a portion of the acquisition cost of an asset to be deducted in the first accounting period in which the asset is used, in addition to the ordinary depreciation. Additional depreciation permits the deduction of a certain percentage of the ordinary depreciation allowance in addition to ordinary depreciation. Both supplemental and ordinary depreciation allowances together may not exceed the value of the asset. The increased initial allowance of the acquisition cost for machinery and equipment ranges from 8 to 50 percent.

The Japanese tax system also provides an investment tax credit for the acquisition of certain

[101] Unpublished data from the U.S. Bureau of Labor Statistics, August 1989.

[102] See ch. 7, table 7-6.

[103] USITC staff interviews with gear industry officials, Japan, Dec. 5-11, 1989.

[104] USITC staff interviews with gear industry officials, Japan, Dec. 5-11, 1989, and Ministry of Finance, Tax Bureau, *The Japanese Tax System*, 1988.

equipment, particularly "mechatronics"—industrial robots and NC manufacturing machinery—which will enable small- and medium-sized companies to become more efficient. The company has the choice of special initial depreciation of 30 percent of the acquisition cost or a tax credit of 7 percent of the acquisition cost. The maximum amount of tax credit allowed is 20 percent of the corporation's tax liability in the tax year. Other tax incentive provisions exist for R&D expenditures and for investing in energy efficient and pollution control equipment.

Most gears are imported duty-free. For most marine reduction gears, the import duty is 3.4 percent ad valorem, although MITI has asked the Government to eliminate this tariff altogether.[105] This action coincides with the Government's announced plan to increase imports through tax incentives, government loans and import credits.[106]

Other competitive factors

Japanese gear producers are competitive worldwide in most types of gearing. In the vehicle gearing area, especially automotive, Japanese transmission design and manufacturing expertise are used in providing products with a competitive edge, such as cars with smoother and quieter transmissions. In industrial gearing, Japanese producers have enhanced existing products, but have not developed "modular" standardized products as have the Europeans. Japanese gear producers lag behind the Europeans in aerospace product design primarily because they have only recently begun to develop an aerospace industry. Expertise in aerospace gearing is growing largely through licensing agreements with U.S. and European producers.

The issue of product liability is virtually unknown in the Japanese gear industry. Many small, independent gear producers manufacture gears to the customer's specification, and therefore product liability is not passed down to the gear producer.[107] For products manufactured under license, the product liability rests, for the most part, with the product designer—generally a foreign company.

The cost of capital in Japan is perhaps the lowest of all the major gear-producing countries. Industry sources believe that capital costs are low because of the high Japanese saving rate and investors' relatively long investment horizon.[108] Other reasons that were cited were the integration of financial institutions and industry and the greater reliance on short-term rather than long-term financing.[109] Bank lending rates as measured by the IMF fell from 6.7 percent in 1984 to 4.9 percent in 1988.

The age of Japanese gear machinery varies, depending on the market for which the gears and gear products are produced. Establishments producing for the shipbuilding industry have slowed their purchases of new machinery as the demand for their products has declined. Manufacturers supporting auto producers and other active industries have newer machinery.[110] The transmission and assembly plants of the large automobile manufacturers, such as Honda, Toyota, Nissan, and Mazda, have highly automated gear hobbing, shaving, and heat-treating processes, as well as computerized quality control for gear production throughout the manufacturing process.[111]

The Japanese gear industry has made significant investment in plant and equipment. For gear-cutting and finishing machine tools alone, expenditures totaled $428.4 million during 1984-88. In 1987, approximately 16 percent of total gear-cutting and finishing machines in Japan was 4 years old or less and 22 percent was between 5 and 9 years old.[112] Japan has a number of gear-making machine tool builders that support their gear industry, such as Mitsubishi Heavy Industries, Ltd.; Yutaka Seimitsu, a subsidiary of Toyota; Kanzaki Kokyukoki Mfg. Co., Ltd.; Kashifuji Works Ltd; and Okamoto Machine Tool Works, Ltd. Japanese gear producers, however, have also sought state-of-the-art gear cutting and gear grinding machine tools, especially for bevel gears, from machine tool builders in the United States, West Germany, Switzerland, and East Germany.[113]

The Japanese employ a combination of domestically produced and imported technology. Gear producers sometimes modify or develop machine tools in instances where the available machinery is inadequate.[114] They also adopt the latest technology quickly, regardless of its origin. For example, Japanese firms were quick to implement CBN grinding, which increases output and reduces losses due to tooth burning during the

[105] USITC staff interview with MITI officials, Dec. 4, 1989.
[106] Stuart Auerbach, "Japanese Announce Trade Plan," *The Washington Post*, Dec. 29, 1989, p. F1.
[107] Ibid.
[108] USITC staff interviews with industry officials, West Germany, United Kingdom, France, and Italy, November-December, 1989.

[109] *Federal Reserve Bank of New York Quarterly Review*, "Explaining International Differences in the Cost of Capital," Summer 1989, p. 20.
[110] USITC staff telephone interview with Dennis Townsend, NASA, October 1989.
[111] Dennis Townsend, *Summary of Japanese Gear Technology*, 1987.
[112] Based on data from MITI's statistical survey of Japan's machine tool inventory undertaken in September 1987, and summarized in "Trends in Machine Tool Inventory Over Past Seven Surveys," *Metalworking Engineering and Marketing*, November 1988, pp. 128-135.
[113] USITC staff visits to Japanese gear plants indicated a great use of CNC machine tools, especially in general machining and gear hobbing and honing operations. However, many bevel gear cutting machines were still manually controlled.
[114] USITC staff telephone interview with Dennis Townsend, NASA, October 1989; interviews with U.S. and Japanese gear producers; and USITC staff visits to Japanese gear plants, Dec. 5-11, 1989.

finishing process. Although production is still highly labor intensive in smaller establishments that have not employed the latest technologies, many automotive, aerospace, and industrial gear manufacturers have automated the material handling of workpieces between machining, heat treatment, and assembly stations whenever possible. This is particularly true where there are high production volumes, such as at automotive plants. In general, such material-handling devices reduce production time, the number of required workers, and factory floor space. In most instances, such automated material handling is developed and produced in-house by the company's mechanics, or with the assistance of robot vendors. Some firms, though, purchase standard material-handling robots or material-handling machine tool accessories, such as palletizers. Multiple workpieces can be automatically loaded, machined, and unloaded, resulting in machine tools that can operate virtually unattended for as much as 40 hours, if not longer, depending upon the part being cut.

Many industries have instituted quality control procedures originally developed in the United States and later improved upon in their factories. Japan's reputation for manufacturing quality products is widely-known. Japanese producers have successfully implemented measures that have increased quality and decreased the number of products ultimately rejected. Such quality procedures include not only company philosophy, but also just-in-time methods, kitting, operator attention to detail, statistical process control (SPC), and Total Productive Maintenance (TPM). TPM results in substantial increases in productivity through decreases in rejects and machine downtime, along with reduced plant machinery maintenance costs, inventories, worker injuries, and pollution.

The JGMA has taken the lead in developing Japanese gear standards.[115] Japanese manufacturers and customers generally use the Japan Industrial Standards (JIS), established by the Japan Standards Association, a government agency, or standards published by JGMA. Many of the JIS were adopted from JGMA standards. Also widely used are the AGMA standards, and to a lesser extent the West German DIN standards. ISO standards, which are still developing, are also followed. JIS and JGMA standards are similar to AGMA standards, and licensed products are generally made to either the AGMA or DIN standards, or some proprietary rating system based on published standards and company experience. One Japanese manufacturer noted that in Japan, AGMA standards cannot be followed exactly, because Japanese steel differs from U.S. steel.[116] Also, the production of gear boxes with nonmetric shafts and bearings marginally raises production cost and requires additional quality control efforts.

In developing standards, the JGMA membership fees and company donations of personnel and other resources cover most of the standards development expenditures. A small amount is funded by the Japan Standards Association.[117] Annual direct expenditures by the JGMA on standards development are estimated at $20,000, excluding company expenses or transportation costs.

Korea

Industry and trade profile

The Korean gear industry developed in the late 1970s and has grown rapidly. The development of the industry was heavily influenced by the influx of Japanese and European manufacturers of vehicle and industrial gearing. There are an estimated 50 mostly small- to medium-sized gearing producers in Korea today, with a few large producers as well, mostly in the vehicle and industrial gearing sectors (table 5-15). Imports still account for roughly one-half of domestic demand and exports are low. The unusually low amount of exports is in large part due to the use of Korean production as parts of finished products, such as automobiles.

Motor vehicle gears and gearing are an important segment of this industry and are accounted for largely by captive shops of automobile manufacturers. Some of the gearing requirements for these firms are met by independent Korean producers. The largest of these is Korea-Spicer Corp., a joint venture of the Dana Corporation and Sung Shin. Vehicle gearing is also imported from West Germany. Industrial gears are manufactured by about 30 firms that are small to medium sized and average 120 employees.[118] Firms such as Korea Heavy Machinery Industries (KHMI), Hyosung Industries Co., Ltd. (HICO), and Hyundai Heavy Industries (HHI) produce large gears for applications such as power plants, while marine gears are manufactured by HHI, KHMI, and Ssangyong Heavy Industries Co., Ltd. In addition, both tanks and helicopters are made in Korea, and it is believed that gears for these products are made domestically. As in Japan, there are a number of small firms in Korea that cut only gears for the above mentioned producers; because of their specialized activities, these small firms are very price-competitive.

[115] The JGMA represents a total of 135 members: 121 gear producing establishments and 14 suppliers to the gear industry. The 121 members account for approximately 70 to 80 percent of industrial gearing production, excluding most captive production for automotive, marine, and aerospace industries.

[116] USITC staff interviews with gear industry officials, Japan, Dec. 11, 1989.

[117] USITC staff interview with JGMA officials, Dec. 4, 1989.

[118] U.S. Department of State Telegram, 1989, Seoul, Message Reference No. 12934, and USITC staff interviews with gear industry officials, Korea, December 1989.

Table 5-15
Leading Korean gear producers, by major sectors, 1989

Company	Vehicle	Industrial	Aerospace	Marine
Bon Sin Machinery Works	X			
Daewoo Motor Co	X			X
Hyosung Industries Co		X		
Hyundai	X	X		X
Jeil Machinery		X		
Kia-Machine Tool Co	X	X		
Korea Heavy Machinery Industries		X		X
Korea-Spicer Corp	X			
Samsung		X	X	
Ssangyong Heavy Industries		X		X
Tong-Il Co	X	X		

Source: Compiled by the staff of the U.S. International Trade Commission.

There is considerable gear production in Korea under license from, and in collaboration with, European, Japanese, and U.S. companies. For example, HICO currently manufactures gears under license from RENK of West Germany, and Daewoo produces gears under license from Opel of West Germany. Also, transmission assemblies are manufactured in technical cooperation with Clark Equipment Company, Dana Corporation, and Zahnradfabrik Friedrichshafen of West Germany. Axle assemblies are produced in cooperation with Guest-Keene and Nettlefords of the United Kingdom and Rockwell International of the United States.[119] Korea-Spicer receives technical assistance from Isuzu of Japan. Hyundai and Mitsubishi collaborate on gear products in the truck market.

The Korean market for gears and gearing grew from an estimated $235.6 million in 1984 to $547.4 million in 1988 (table 5-16), with a sudden jump in growth beginning in 1986. Sharp increases are expected in 1989, based on Commission staff discussions with Korean industry officials.[120] Shipments of gears and gearing rose 94 percent from $144.0 million in 1984 to $280.0 million in 1988 (table 5-16). The industry trade deficit rose from $91.6 million in 1984 to $267.4 million in 1988. Much of this deficit, however, is due to the use of imported parts in other finished articles which may then be exported.

Of major concern to Korean gear producers is the health of the shipbuilding industry. New shipbuilding orders declined in 1988, and the industry suffered from labor unrest. New low-interest export financing available to Japanese shipbuilders created a competitive disadvantage for Korean shipbuilders, since no similar assistance is available to them.

Korean imports of gears and gearing rose from an estimated $100.9 million in 1984 to $278.9 million in 1988. The principal sources of imports are Japan, which accounted for 76 percent of the total, or $211.8 million, followed by the United States, which accounted for 12 percent, or $33.9 million. The large increases in imports reflect the demand for automotive gearing both for vehicles consumed domestically and for export. In 1989, Korean producers began to significantly develop their vehicle gearing production capacity.[121] In 1988, approximately 79 percent of imports were of

[119] *Korea Trade Post*, Mar. 25, 1988.
[120] USITC staff interviews with gear industry officials, Korea, December 1989.
[121] Ibid.

Table 5-16
Gears and gearing: Korean shipments, exports, imports, and apparent consumption, 1984-88

Year	Shipments	Exports	Imports	Apparent consumption	Ratio (percent) of imports to consumption
	Value (million dollars)				
1984	144.0	9.3	100.9	235.6	42.8
1985	148.0	9.8	113.2	251.4	45.0
1986	168.0	10.3	157.4	315.1	50.0
1987	216.0	10.9	226.9	432.0	52.5
1988	280.0	11.5	278.9	547.4	50.9
	Value (billion won)				
1984	116.1	7.5	81.3	189.9	42.8
1985	128.8	8.5	98.5	218.7	45.0
1986	148.1	9.1	138.7	277.7	50.0
1987	177.7	9.0	186.6	355.4	52.5
1988	204.8	8.4	204.0	400.4	50.9

Source: Estimated by the staff of the U.S. International Trade Commission.

vehicle gearing, with industrial gearing imports accounting for the remainder. Korean duty rates on gears dropped from 15 percent ad valorem in 1988 to 13 percent in 1989, and are expected to fall to between 7 and 8 percent in 1993. Exports totaled only $11.5 million in 1988, and were evenly split between vehicle and industrial gearing.

Research and development

At present, limited gear R&D in Korea is being performed primarily by motor vehicle companies. Additionally, Korean producers are benefiting from research conducted by captive suppliers outside of Korea, mainly through licensing and collaborative agreements. Officials of Korea-Spicer indicated that it plans to begin R&D on gears and gear production in the near future. Limited gear research is done at the University of Inchon.

Employment and training

The Korean gear industry employs an estimated 3,500 persons. According to unpublished data from the U.S. Bureau of Labor Statistics, hourly compensation costs for production workers in industrial and commercial machinery manufacturing (SIC 35) in 1988 were $2.90. Wage increases were granted in 1989, however, and staff conversations with gear industry officials in Korea indicated that average hourly wages at the end of 1989 were about $5.00.[122] Since late 1988, Korean industry overall has been adversely affected by labor unrest. Certain smaller family-owned gear companies have had fewer labor disturbances, as have companies in geographic regions where strikes have not been prevalent. One major gear producer, Korea-Spicer, reported little labor unrest at their facility during the last 3 years, when wages were increased 15 to 20 percent annually. Another industry source, however, reported considerable apprehension about upcoming nationwide labor negotiations in April-June 1990 and expects plant closings.[123]

Government policies and programs

Several programs available from the Korean Government are designed to assist small- and medium-sized companies. One such program, provided by the Ministry of Trade and Industry (MTI) and administered by the Korea Association of Machinery (KOAMI), evaluates plans for new plants and makes low-interest loans to further develop the plans as well as to purchase machinery. In late 1989, MTI announced a new program, designed for economic development in the 1990s. This program would make $3.3 billion in soft loans available to small-and medium-sized companies for the purpose of developing manufacturing technology.[124]

Canada

Industry and trade profile

Canadian gearing manufacturers are generally categorized as either independent domestically-owned, independent foreign-owned, or captive suppliers of certain manufacturing industries. The Canadian gear industry is dominated by the automotive industry, especially by subsidiaries of major U.S. automobile producers. In the motor vehicle gear industry, approximately 80 percent of the products are made for OEMs. In general, the Canadian industrial gear manufacturing industry is made up of niche market producers specializing in gear products for specific industries. Currently, there are approximately 65 firms manufacturing industrial gears and gearing products in Canada. Most are small- to medium-sized, closely held firms, concentrated in the manufacturing centers of Southern Quebec, Ontario, and British Columbia.

Less than 20 percent of Canadian producers of industrial gears and gear products are foreign owned, whereas about 90 percent of makers or assemblers of automotive transmissions are foreign owned.[125] David Brown, a U.K. industrial gearing manufacturer, opened a distribution and service center in Ontario in mid-1989, and claims this is the largest inventory of gearing in Canada.[126] Foreign manufacturers established facilities in Canada because of proximity to the United States, the largest market in the world, and to take advantage of lower average labor costs in Canada, as compared with those in the United States, together with duty-free entry into the U.S. market for Canadian-produced automotive products under the Automotive Products Trade Act. These factors give Canadian producers, including Canadian subsidiaries of U.S. firms, a competitive advantage in the U.S. market.

Spar Aerospace, Ltd., possibly the largest gear producer in Canada, is the only known Canadian producer of aerospace gears and gear products. With sales of gear products averaging $30 million annually during 1984-88, this firm accounts for over 70 percent of gear production for the Canadian aerospace industry.[127]

Canadian apparent consumption of industrial gears and gear products increased from an estimated $1.9 billion in 1984 to an estimated $2.3 billion in 1988, an overall increase of 19 percent; consumption increased 13 percent in Canadian dollars from CAN$2.5 billion to CAN$2.8 billion (table 5-17). The increase in gear consumption

[122] Ibid.

[123] USITC interview with Mr. Pak, Director, Korea Auto Industry Association, Dec. 15, 1989, Seoul, Korea.

[124] USITC staff interviews with gear industry officials, Korea, December 1989.

[125] USITC staff telephone interview with AGMA executive, September 1989.

[126] "David Brown Opens Distribution Centre," *Canadian Machinery and Metalworking*, July 1989, p. 9.

[127] USITC staff telephone interview with AGMA executive, September 1989.

Table 5-17
Gears and gearing: Canadian shipments, exports, imports, and apparent consumption, 1984-88

Year	Shipments	Exports[1]	Imports[1]	Apparent consumption	Ratio (percent) of imports to consumption
			Value (million dollars)		
1984	1,160.0	936.5	1,674.0	1,897.5	88.2
1985	1,150.0	911.1	1,711.0	1,949.9	87.7
1986	1,160.0	805.8	1,722.0	2,076.2	82.9
1987	1,200.0	788.3	1,730.0	2,141.7	80.8
1988	1,225.0	769.1	1,802.0	2,257.9	79.8
			Value (million Canadian dollars)		
1984	1,502.3	1,212.8	2,168.0	2,457.5	88.2
1985	1,570.3	1,244.1	2,336.4	2,662.6	87.7
1986	1,611.8	1,119.7	2,392.7	2,884.9	82.9
1987	1,591.2	1,045.2	2,294.0	2,840.0	80.8
1988	1,507.6	946.6	2,217.7	2,778.8	79.8

[1] Compiled from *Statistics Canada* data.

Source: Estimated by the staff of the U.S. International Trade Commission, except as noted.

reflected Canada's overall economic growth during this period. Canada experienced high rates of capacity utilization, while investment in machinery and equipment soared by 24 percent during 1988.[128]

The demand for gears and gear products in Canada, as in most industrialized nations, is influenced by the demand for capital goods and transportation equipment. The industry groups that are the major customers of the Canadian gear industry are similar to those of the U.S. industry. The major end-user industries of industrial gears include construction and mining machinery and material-handling equipment, turbine and mechanical power transmission equipment, and other machinery and equipment. Automotive transmission end-users are included in the transportation equipment industries.

Despite the fact that the United States is the largest importer of Canadian industrial gears, gear products, and automotive transmissions, Canada had a trade deficit with the United States annually since 1984. Imports as a share of Canadian apparent consumption have fallen steadily in recent years. In 1988, imports accounted for 80 percent of Canadian consumption of industrial gears and gearing products (see table 5-17).

The Canadian industry relies heavily on imports of gearing products for the assembly of automotive and industrial products. In 1988, the United States was the principal source of imports. Imports of vehicle gears and gearing products in 1988, the bulk of which were of U.S.-origin, accounted for the majority of imports. Imports of all other gears in the same year accounted for less than 20 percent of the total. Seventy percent of U.S. exports of industrial gears and gearing products and 90 percent of U.S. exports of automotive transmissions to Canada entered duty free in 1988, indicating how extensively the Automotive Products Trade Act (APTA) is used in the gear industry. Industry sources estimate that subsidiaries of U.S. companies have over 60 percent of the automotive transmission market in Canada.

Canada's exports of gears and gearing fell 18 percent from $936.5 million in 1984 to $769.1 million in 1988 (table 5-17). Over 95 percent of Canada's exports of vehicle gears and gearing in 1988 was shipped to OEMs in the U.S. market. Virtually all of the products originated from Canadian subsidiaries of U.S. automotive OEM firms. Although Chrysler, Ford, and GM maintain major in-house parts manufacturing facilities in Canada, the bulk of the Canadian automotive transmissions are assembled from gear parts imported from the United States for captive production and the auto aftermarket. Canadian gear exports were adversely affected in 1989 by an increase in value of the Canadian dollar vis-a-vis the U.S. dollar. The Canadian dollar value increased from $.75 in 1988 to $.85 in 1989. This increase effectively made Canadian exports more expensive in the U.S. market.

Research and development

The bulk of Canadian R&D in the gear industry is conducted by companies in the automotive industry. In addition, several small- to medium-sized Canadian-owned firms have internal R&D departments for both process and product technology. However, their research is primarily aimed at improving their existing products and cutting production costs. Most of the large Canadian firms support the American Society of Mechanical Engineers' Gear Research Institute which is one of the principal gear R&D organizations in the United States.

[128] Country Marketing Plan, Post Commercial Action Plan, Canada 1988, p. 3.

Employment and training

The estimated total number of employees throughout the Canadian gear manufacturing industry is 6,000 workers. The vast majority of these employees are involved in the manufacture and assembly of vehicle gearing. A partial list of non-vehicle gear producers, with an estimated number of production workers, is shown in the following tabulation:

Company	Number of employees[1]
Spar Aerospace	325
Ampscot Equipment Ltd	50
Continental Conveyer & Machine Works	50
Hansen Transmission Ltd	32
Cambridge Gear Manufacturing Ltd	30
Olympic Gear & Manufacture, Inc.	25

[1] Production workers based on man years.

Hourly compensation costs for production workers in industrial and commercial machinery manufacturing (SIC 35) rose 20 percent overall during 1984-88, from $11.63 in 1984 to $13.96 in 1988. Measured in Canadian dollars, the increase was only 14.1 percent, from CAN$15.06 in 1984 to CAN$17.19 in 1988.[129] However, when adjusted for wage inflation, hourly compensation costs in Canadian dollars actually declined slightly overall.[130]

Government policies and programs

The Canadian Government offers a wide range of industrial incentive programs which can be of substantial benefit to the Canadian gear industry. The assistance offered by these programs can take many forms: cash grants, loans, cost sharing, technical assistance, and equity participation. Most of these programs are available to all industries, although some special incentives are available only to certain industries and projects. For example, the Canadian Government provides aid to the Canadian automotive industry to develop process technology through the Center for Automotive Parts Technology. Manufacturers of automotive gears are eligible for loans with partial deferral of principal and interest payments for up to 3 years.[131]

The APTA provides for duty-free trade between the United States and Canada in original-equipment auto parts. Preferential duty treatment for most products is also granted to the United Kingdom under the United Kingdom and Ireland Tariff. There have been changes in Canada's trade policies with the advent of the United States-Canada Free Trade Agreement (FTA), which became effective January 1, 1989. Under the FTA, nearly all duties will be eliminated by 1998. Automotive products imports, including vehicle gearing, under the APTA will remain duty free, and tariffs on aftermarket automotive products will be phased out by 1993.

Recent investment policy changes have made it easier for foreign producers of gears and gearing to invest in Canada. Investment Canada, a Federal Government agency, now exempts from review foreign investments in new businesses, as well as direct and indirect acquisitions of companies with assets below a certain threshold. In addition, under the FTA, U.S. investments in Canada will be granted national treatment, which eliminates discrimination based on nationality of ownership and the imposition of performance requirements on U.S. investors.

Other competitive factors

Gear and gear products manufacturers in Canada are not a major force in the world market due to their relatively small overall size and their integration with the U.S. industry. With the exception of one firm currently striving to increase its share of the North American gear market, most of the firms are niche producers specializing in limited products for certain markets. As a measure of Canadian competitiveness in markets other than the United States, market share of Canadian exports is insignificant.

[129] Unpublished data from the U.S. Bureau of Labor Statistics, August 1989.

[130] See ch. 7, table 7-6.

[131] USITC, *U.S. Global Competitiveness: The U.S. Automotive Parts Industry*, USITC Publication 2037.

Chapter 6
U.S. Market

Overview

The U.S. market for gears and gear products is the largest in the world and accounts for more than one-third of total global consumption. Apparent U.S. consumption of gearing rose by nearly 25 percent from $12.0 billion in 1984 to $15.1 billion in 1988. U.S. imports increased faster than consumption during 1984-88, ending the period at $2.7 billion, or 18 percent of total consumption, as shown in the following tabulation:

Year	Imports	Apparent consumption	Ratio of imports to consumption
	— Million dollars —		Percent
1984	1,741.1	12,047.1	14.5
1985	1,888.4	12,835.8	14.7
1986	2,141.0	13,354.8	16.0
1987	2,474.3	14,266.8	17.3
1988	2,740.7	15,075.0	18.2

The largest component of consumption is motor vehicle gearing, followed by industrial, aerospace, and marine gearing. Each of the four segments of the market for gears and gearing is influenced by different factors, and serves separate groups of customers.

Increased U.S. imports can be attributed principally to three factors: major Western European and Japanese producers making a concerted effort to penetrate the U.S. market, U.S. original equipment manufacturers (OEMs) buying less expensive gear products from foreign sources, and Japanese parts producers supplying Japanese-owned auto manufacturers in the United States. In the early 1980s, flagging demand in home markets and the strong dollar made the U.S. gear market attractive to European and Japanese producers. Many U.S. gear consumers were, at that time, facing difficult market conditions and trying to lower their costs to remain profitable. These consumers turned to imported gears and gear products which, largely due to the exchange rate, were often less expensive than the comparable U.S. product. Once supplier relationships and familiarity with foreign products were established, many U.S. consumers continued to purchase foreign gearing even after the exchange rate advantage disappeared. A more recent trend is an increase in imports of gearing by foreign-owned U.S. assembly plants from their parent companies. The increase in imports of automotive parts is most notable, although at least one firm has begun replacing imports with U.S. production.

During 1984-88, Canada, Japan, France, and West Germany were the principal foreign suppliers of gears and gearing (table 6-1). These four nations accounted for approximately 76 percent of total U.S. imports in 1988. During 1984-88, Canada's dominance declined from 52 percent to 25 percent primarily because U.S. producers are scaling back their Canadian operations and increasing their ties with Europe and Japan. In 1988, Japan became the leading foreign supplier of gears and gear products, accounting for 27 percent of total U.S. imports. U.S. imports from Japan and Canada consisted principally of motor vehicle gearing.

Data gathered from U.S. producers and U.S. importers in response to the Commission's questionnaires indicated that U.S. imports of gear products as the result of offset agreements were minimal;[1] only one firm reported direct imports. However, data gathered from the Commission's questionnaires, showing lost sales reported by 10 U.S. gear producers as the result of offset obligations undertaken by U.S. prime contractors during

[1] See p. 4-19 for a discussion of offset agreements.

Table 6-1
Gears and gearing: U.S. imports, by principal sources, 1984-88

Item	1984	1985	1986	1987	1988	Change, 1988 over 1984
	Million dollars					Percent
Japan	361.1	381.1	484.2	626.1	753.2	108.6
Canada	911.3	885.1	781.3	759.2	698.1	-23.4
France	75.4	111.0	231.4	279.0	334.3	343.4
West Germany	91.3	120.3	162.0	225.3	287.1	214.5
United Kingdom	107.0	116.2	138.2	156.1	188.0	75.7
All other	195.0	274.7	343.9	428.6	480.0	146.2
Total	1,741.1	1,888.4	2,141.0	2,474.3	2,740.7	57.4

Source: Compiled from official statistics of the U.S. Department of Commerce

1984-89, are presented in the following tabulation (in millions of dollars):

Year	Lost sales
1984	6.6
1985	7.6
1986	9.1
1987	10.1
1988	10.2
1989	22.4
Total	66.0

Commission staff interviews with aerospace gearing producers indicate that even if a U.S. firm has the lowest cost, it may not be allowed to bid for the contract because of the offset obligation of the prime contractor.[2] Sales to prime contractors typically are fulfilled over several years, so a gear producer that won a contract would receive revenue over a period of years. When a sale is foregone as a result of an offset agreement, a stream of revenues is lost. For some firms, such as those in specialized aerospace gearing, such a loss can be a significant portion of their total revenues.

Vehicle Gearing

Factors Influencing the Market

Motor vehicle, or "vehicle", gearing is used in a number of different applications, both civil and military. These applications can be divided into on-road and off-road sectors. Vehicle gearing includes gearing used in internal engine drives, transmissions and other drivetrain components, and other miscellaneous vehicle components.

The motor vehicle industry is characterized by rapid technological change in virtually all major vehicle systems. Substantial changes in vehicle drivetrains are affecting vehicle gear producers, and like the vehicle parts industry in general, vehicle gear producers must be somewhat innovative to remain competitive. The most important force behind drivetrain modifications is the need to comply with laws that require improved vehicle fuel economy,[3] reduced engine emissions, and reduced vehicle noise.

There are four major trends within the on-road vehicle industry that are presently affecting the vehicle gear industry. These trends are: (1) the use of continuously-variable transmissions (CVTs) on automobiles; (2) the increased number of speeds available on automatic transmissions used onautomobiles, trucks, and buses; (3) the use of all-wheel drive systems on automobiles; (4) and the use of cubic boron nitride (CBN) grinding technology in gear production.

[2] USITC staff interviews with U.S. aerospace gear producers, May, August, and November 1989.

[3] Corporate Average Fuel Economy (CAFE) laws are greatly affecting vehicle drivetrain configurations. For example, Ford Motor Co. recently suspended plans to build a new transmission at its Livonia, MI, plant until the schedule for CAFE requirements was finalized. "CAFE Leaves Ford-Van Dyke Waiting," *Wards Automotive Reports*, Oct. 16, 1989, p. 331.

The CVT represents a fundamental design departure from conventional vehicle transmissions. The CVT is an automatic transmission which has an infinite number of speeds within a given range, rather than the 3 to 5 speeds found on conventional transmissions; it also lacks a torque converter.[4] Because CVTs increase vehicle performance and fuel economy, their use is expected to broaden as firms develop CVTs that can be used with larger engines. Current CVTs are suitable only for vehicles with small (under 2- liter) engines.[5] Because CVTs function primarily by the use of steel bands and pulleys rather than gears,[6] the main effect of widespread use of CVTs would be reduced demand for gears.

Other changes in drivetrain technology, however, may offset the effect of CVTs on the demand for vehicle gears. The introduction of 4-, 5-, and 6-speed automatic transmissions has increased the demand for vehicle gears. Additional gear speeds produce improved fuel economy, which is necessitated by Corporate Average Fuel Economy (CAFE) laws. Such transmissions are rapidly replacing the once common 3-speed automatics. In general, each additional speed requires the addition of another set of 5 to 6 gears in the transmission. Additional transmission speeds complicate the variables that must be considered when the gears are designed.[7]

A growing number of automobiles are equipped with all-wheel drive systems. These systems transfer engine power to all four wheels of the vehicle rather than to only 2 wheels, improving traction during acceleration. There are two types of all-wheel-drive systems: chain-driven and gear-driven. Gear-driven systems require an additional differential unit that uses approximately seven gears. Industry officials indicate that all-wheel-drive systems will contribute to the demand for gears, but are unlikely to force substantial changes in gear design.[8]

Vehicle gear producers, like vehicle parts manufacturers in general, are facing increased demands for improved product quality.[9] Given the critical nature of the components in which gears are used, product quality is an especially important consideration for vehicle gear producers. Producer sare responding with new production techniques

[4] U.S. International Trade Commission, *U.S. Global Competitiveness: The U.S. Automotive Parts Industry*, USITC Publication 2037, December 1987, p. 12-97.

[5] "FHI to Increase CVT Production Capacity," *Comline Transportation*, April 20, 1989, p. 4.

[6] USITC staff interviews with U.S. motor vehicle transmission producers, January 1990.

[7] USITC staff telephone interview with official of Ford Motor Co., Oct. 12, 1989.

[8] USITC staff telephone interviews with U.S. motor vehicle transmission producers, October 1989.

[9] USITC staff telephone interviews with U.S. producers of vehicle gears and motor vehicle transmissions, October 1989.

and sophisticated manufacturing systems.[10] Of notable importance is the application of CBN grinding technology to the production of drivetrain gears for construction vehicles, heavy trucks, and buses.[11] Use of CBN cutting and grinding tools, made of an abrasive carbon material, allows the production of very-high-quality gears. More importantly, the use of high-quality gears results in quieter operation of heavy vehicles, many of which must comply with increasingly stringent noise reduction requirements. Furthermore, quiet gears reduce vehicle noise in truck cabs, and firms frequently use low cab noise as a marketing tool.[12]

Market Size

Apparent consumption, as seen in the following tabulation, was low in 1984 and 1985, as a result of a general economic decline and hard times in the automotive industry. Consumption then rose markedly in 1987 and 1988. The steady increase in imports over the period can be explained by a number of factors, including the presence of foreign-owned vehicle assembly plants in the United States. These plants generally import vehicle gearing from their parent companies in other countries. Also, some large multinational vehicle producers have begun rationalizing their operations, concentrating production of certain products in each plant. The firms' assembly plants worldwide then import the parts needed.

Year	Imports	Apparent consumption	Ratio of imports to consumption
	— Million dollars —		Percent
1984	1,443.8	9,295.6	15.5
1985	1,520.7	10,138.6	15.0
1986	1,701.9	10,506.5	16.2
1987	1,944.1	11,328.7	17.2
1988	2,118.2	11,892.7	17.8

[10] USITC staff telephone interviews with U.S. motor vehicle gear producers, October 1989. "Ooka Forge Develops Monoblock Forging for FWD Transmission Gears," *Comline Transportation*, Feb. 4, 1988, p. 1; "Interest Seen Growing in 'Limited' FMS for Gears," *Metalworking News*, Sept. 12, 1988, p. 12; "Liebherr Offers Auto Gear Grinding Machine," *Metalworking News*, Sept. 19, 1988, p. 10.

[11] USITC staff interviews with U.S. motor vehicle gear producers indicated that CBN technology is not being widely used in the U.S. or foreign automobile and light truck industry.

[12] USITC staff telephone interview with official, Eaton Corp., Oct. 17, 1989.

Suppliers to the Market

End-use markets for motor vehicle gearing include applications in both the on-road and off-road sectors. The on-road sector accounts for the vast majority of vehicle sales and includes gearing for cars, light-, medium-, and heavy-duty trucks, buses, motorcycles, and recreational vehicles. The off-road gearing sector supplies products for construction, agricultural, and industrial works vehicles. Military applications include tanks, personnel carriers, trucks, automobiles such as jeeps, and mobile weapons systems, as well as other vehicles and are included in both sectors. Table 6-2 shows major suppliers of gearing to these sectors of the U.S. market.

Most gears used in vehicles are found in transmissions. The majority of transmissions used in passenger automobiles and light trucks are produced by General Motors Corp., Ford Motor Co.,

Table 6-2
Major suppliers of vehicle gearing to the U.S. market, by sectors, 1989

Supplier	On-road	Off-road	Military
Caterpillar	X	X	
Chrysler	X	X	
Comer (Terrell Gear)		X	
Dana	X		
Deere		X	
Eaton	X		
Fairfield		X	
Ford	X	X	
General Electric			X
General Motors	X		X
Harley Davidson	X		
Mack Truck	X		
Omni		X	
Patterson		X	
Rockwell	X	X	X
TRW	X	X	
Twin Disc			X
Voith	X		
Yale		X	
ZF	X	X	

Source: Compiled by the staff of the U.S. International Trade Commission.

and Chrysler Corp.[13] The Big Three automakers each purchase between 10 and 25 percent of the transmissions used in their vehicles from independent producers and other automakers. Purchases from other automakers consist mainly of purchases from foreign-owned companies with which U.S. automakers have joint ventures. The Big Three automakers sell a small portion of the transmissions they produce to specialty vehicle manufacturers, such as recreational vehicle producers and military vehicle producers. Independent producers supply approximately 15 percent of the passenger automobile and light truck transmissions to the U.S. market. Most transmissions are sold as original equipment components. Aftermarket transmission sales represent approximately 5 percent of the total market, and are primarily to automobile dealers as replacement parts.[14]

Most transmissions used on medium- and heavy-duty trucks and buses are produced by five independent companies that specialize in transmissions. The Big Three automakers produce only a minor (less than 10 percent) share of medium- and heavy-duty transmissions for the U.S. market. Over 95 percent of all medium- and heavy-duty transmissions produced for the U.S. market are sold to vehicle producers as original equipment. The remainder are usually sold to vehicle manufacturers as replacement parts.[15]

Off-road vehicle transmissions, mainly those transmissions used in construction vehicles, are primarily produced by the three largest manufacturers of construction vehicles. These large firms purchase from 10 to 30 percent of their transmissions from independent suppliers.[16] Smaller construction vehicle firms purchase a substantially greater portion of transmissions from independent suppliers. The U.S. market for construction vehicles has increased by approximately 10 percent per year since 1984, providing a growing market for producers of construction vehicle transmission gears. Aftermarket transmissions are generally sold to distributors.

Three U.S. firms, General Motors, General Electric, and Twin Disc, produce transmissions for military vehicles, which consist mainly of tanks and armored personnel carriers. These transmissions are often highly sophisticated components that may perform braking and steering functions, in addition to normal transmission functions. Other military vehicle transmissions operate in a manner similar to automatic transmissions. The market for these types of transmissions is dependent upon U.S. Government orders of military vehicles. During the last 5 years, the U.S. market for military vehicle transmissions has fluctuated, showing no clear trend.[17]

Market Segments

The demand for vehicle gears in the various market segments depends on trends in the end-use industries, which, in turn, are affected by a number of factors. In the automotive industry, demand is determined largely by cost considerations and consumer preferences. Inflation, interest rates, and incentives such as rebates or low-cost financing are important. The influence of rebates and financing on sales was strong a few years ago but has declined somewhat in recent years, as consumers began to take these offers for granted. A combination of these factors resulted in an increase and then a decline in the retail sales of cars; the growing popularity of light trucks is evidenced by the steady rise in the number of units sold, as its shown in the following tabulation:

Year	Cars	Trucks: Light	Trucks: Medium and heavy
1984	10,391	4,093	277
1985	11,042	4,682	284
1986	11,460	4,863	264
1987	10,277	4,912	288
1988	10,626	5,149	334

Sales of medium- and heavy-duty trucks move counter to trends in inflation and interest rates. The variation in medium- and heavy-duty truck sales can also be explained, in part, by the continuing realignment of the U.S. freight transportation industry, which was deregulated in the early 1980s.[18]

Changes in consumers' preferences boosted the demand for 5-speed manual transmissions, a trend that increased automakers' consumption of gears. The following tabulation shows the increasing popularity of 5-speed manual transmissions during 1985-88 over 4-speed manual transmissions, measured in the number of units sold:

Year	4-speed	5-speed
1985	452	709
1986	319	883
1987	130	848
1988	59	1,024

[13] USITC staff telephone interviews with U.S. motor vehicle transmission producers, October 1989.
[14] USITC staff telephone interviews with representatives of General Motors Corp., Ford Motor Co., and Chrysler Corp., November 1989.
[15] USITC staff telephone interviews with U.S. motor vehicle transmission producers, October 1989.
[16] USITC staff telephone interviews with U.S. construction vehicle producers, November 1989. Certain construction vehicles use hydrostatic transmissions, which use a relatively small number of gears compared with other types of transmissions. Construction vehicle producers frequently purchase hydrostatic transmissions from independent suppliers with expertise in hydrostatic transmission technology.
[17] USITC staff telephone interview with official of Allison Div., General Motors Corp., Oct. 5, 1989.
[18] *1987 Ward's Automotive Yearbook*, p. 257.

The U.S. market for buses is unpredictable, relying almost entirely on the availability of public funding. In recent years, several foreign and domestic bus producers have abandoned the U.S. market because of its unpredictability.

Sales of off-road vehicles for construction and agricultural applications are also heavily dependent on economic factors. Demand for construction vehicles lagged during the economic recession of the first half of the 1980s. High interest rates made financing equipment purchases difficult and curtailed housing starts. However, by the mid 1980s, equipment sales began to recover, growing by 1 percent in 1987 and nearly 6 percent in 1988.[19] Sales of these vehicles also depend heavily on Federal, State, and local government spending. Sales of agricultural equipment are affected by the strength of the farm economy, which was depressed for most of the 1980s. Big crop yields led to low domestic prices, and low farm exports led to stockpiling and less planting by U.S. farmers. Many farmers were heavily indebted and could not afford to purchase new equipment. The farm economy began to recover in late 1987, although droughts in 1988 hindered the recovery's progress. Technological developments in agriculture can also have an impact on equipment sales. Recently, the practice of "no till conservation" has become popular. It involves planting seeds directly into the residue from past crops, weeds, grass, and cover crops without retilling, thus decreasing the frequency of agricultural equipment use. It is estimated that 75 to 90 percent of U.S. farmland could be treated in this manner by 2010.

Industrial Gearing

Factors Influencing the Market

The U.S. market for industrial gearing is directly related to the overall investment in new plant and equipment by the U.S. manufacturing sector and expenditures on public works. During the mid-1980s, purchasing decisions were more strongly influenced by price considerations, compared with a greater emphasis on product quality in the later 1980s. The major consumers of industrial gearing are OEMs, end users, and distributors, in a variety of gearing application market segments.

Market Size

The industrial gearing market is the second-largest sector of the gear market in the United States in total dollar volume and quantity of product consumed. During 1984-88, U.S. apparent consumption of industrial gearing, as shown in the following tabulation, rose from $1.8 billion to $2.1 billion. However, in 1985, consumption fell to below the 1984 level, and then rose through 1988 by 18 percent. During this period, imports as a share of consumption nearly doubled, reflecting aggressive marketing of imported products, both directly to consumers and, to a lesser extent, through distributors.

Year	Imports	Apparent consumption	Ratio of imports to consumption
	— Million dollars —		Percent
1984	266.3	1,760.5	15.1
1985	329.0	1,751.2	18.7
1986	391.5	1,784.5	21.9
1987	479.6	1,869.6	25.6
1988	561.1	2,073.3	27.0

U.S. production of industrial gearing remained stagnant while imports met the increase in U.S. demand for industrial gearing during 1984-88. Structural changes in the U.S. gear industry affected its performance and involved intense price competition. Import market share rose from 15 percent to nearly 27 percent as U.S. industrial gear users purchased more imported gearing.

Suppliers to the Market

Approximately 60 percent of the U.S. industrial gearing market, including distributors, is supplied by 11 firms. The leading suppliers generally produce commodity products, as well as custom orders for OEM customers (table 6-3). Typically, the

[19] *Ward's Automotive Yearbook*, various editions.

Table 6-3
Major suppliers of industrial gearing, by gearing type, 1989

Supplier	Commodity gearing	Custom gearing
Emerson Electric	X	
Falk	X	X
Flender	X	
Horsburgh & Scott	X	X
IMO Delaval	X	X
Lufkin	X	X
Philadelphia Gear	X	X
Peerless Winsmith	X	
Regal-Beloit	X	X
Reliance Electric	X	
SEW-Eurodrive	X	
Sumitomo	X	

Source: Compiled by the staff of the U.S. International Trade Commission.

OEM supplies the gear specifications to the gear producer. Most of the major suppliers specialize in producing both commodity- and custom-type gearing but only for certain end markets, because of the finished product engineering expertise required. The rest of the market is supplied by about 300 smaller producers which operate mainly as job shops or custom producers of small production runs.

Market Segments

The U.S. market for industrial gearing is comprised of a wide variety of application segments, but can be categorized into certain industrial machinery, material handling and mining, and metals processing industries.

Although gears and gearing are used in almost all machines, certain types of industrial machinery use a greater proportion of gearing. The gearing used in these machines is usually custom designed to the machinery builders' specifications. U.S. consumption of certain industrial machinery increased by 13 percent during 1984-88, but shipments grew only by 2 percent during the period. The bulk of the increase in demand was supplied by imported machinery. As a result, overall demand for domestically produced gearing for certain industrial machines showed little change during 1984-88.

During 1984-88, some markets for certain industrial machinery including textile machinery, food and beverage processing machinery, and paper and printing machinery were strong. U.S. demand for such machinery rose more than 36 percent during the period. However, imports accounted for over half the growth in demand. Weaker markets for industrial gearing were compressors, pumps, and oil field machinery. Overall consumption in these markets increased less than 5 percent during 1984-88, whereas imports doubled and the ratio of imports to consumption rose from under 10 percent to over 16 percent. This has adversely affected some specialized industrial gearing producers. For example, U.S. consumption of oil field machinery declined from $2.1 billion to $772 million during 1984-88 largely because domestic oil drilling decreased dramatically as a result of uncertainty over prices and supply. Fluctuating prices led to conservative investment policies by the oil companies in the United States. Many operators have moved their oil-drilling operations abroad, believing that foreign sites hold greater promise than U.S. locations since some foreign countries are offering improved drilling incentives.

The general material handling market segment covers many diverse applications, from conveyors used on farms and in mining to those used in processing plants and factories, as well as all types of elevators and cranes. Much of this market is for replacement units or upgrades of existing material handling lines, as establishments rearrange their flow of materials in the plant to gain efficiencies. The products used in material handling are relatively standard, but custom-designed units are required for unusual applications or for extreme operating environments. Demand for mining machinery rose toward the end of the 1984-88 period. Higher prices for most mine products, combined with reduced consumer stocks, led to greater mining activity. As a result, many U.S. mines made investments in machinery and equipment, such as in-pit crushing equipment and high capacity conveyor systems.

The metals processing machinery industries in the United States, which include the metal processing machinery and machine tool industries, were weak markets for U.S. gear producers during 1984-88. U.S. consumption of metal cutting and forming machine tools grew by nearly 24 percent but shipments showed only a 7-percent increase during the period. U.S. imports supplied an increasing share of consumption, rising from 33 percent in 1983 to 44 percent in 1988. Another machinery market with reduced demand for domestic industrial gearing was primary metals processing, including steel. Since 1984, U.S. steel producers have invested heavily in modern foreign technology and machinery. U.S. gear producers have stated that they often have not been able to bid on gear boxes for new machinery because U.S. steel producers have purchased entire steel-making systems from foreign vendors. Consequently, U.S. gear producers are relegated to supplying repair and replacement units for the older steel mills.

Aerospace Gearing

Factors Influencing the Market

The aerospace industry consumes a variety of gears for use in engines, differential transmissions, auxiliary power units, flap actuators, and gear- type fuel and hydraulic pumps. Aerospace gears are lightweight high precision gears, used as part of components and subassemblies in fixed-wing aircraft, helicopters, spacecraft, missiles, and satellites.

According to the Manufacturing Technology Information Analysis Center, aerospace gears can be grouped into three different-sized categories. Large heavy gears, which convey very high torque forces, are usually found in turbo-prop drive-line gear boxes of helicopters or tilt-wing aircraft. Medium-sized gears are used in undercarriage gear retraction mechanisms, flap or control surface actuators, and aircraft accessory gear boxes. Small gears are required to run at varying speeds for use in fuel, lubrication, and scavenge pumps, in different types of actuators, and in various control functions and instrumentation.[20]

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[20] Manufacturing Technology Information Analysis Center, Defense Logistics Agency, *Manufacturing Technology Research Needs of the Gear Industry*, IITRI Project P06066, Dec. 31, 1987, p. 13.

The demand for aerospace gears is heavily influenced by the demand for helicopters, the primary end user of these gears. Gears account for approximately 10 percent of the value of helicopters, while accounting for less than 2 percent in all other aircraft. Demand for helicopters declined during 1984-88, but demand for large civil transports grew significantly. Therefore, while the primary end users' demand for gears has declined, the unprecedented demand for large civil transports has increased the overall consumption of aerospace gears.

Market Size

The U.S. aerospace industry accounted for approximately 5 percent of total U.S. gear consumption during 1984-88. International agreements for the production of gears, as shown in the following tabulation, contributed to a near doubling in imports, from $25 million to $50 million during 1984-88. However, imports have not been a significant factor in the U.S. market. They accounted for only 3 to 6 percent of consumption during 1984-88. The United States remains the preeminent supplier of aerospace gears due to its lead in manufacturing technology and the existence of a large U.S. market for these gears.

Year	Imports	Apparent consumption	Ratio of imports to consumption
	— Million dollars —		Percent
1984	25.0	737.9	3.4
1985	30.6	696.8	4.4
1986	38.5	815.0	4.7
1987	40.6	804.3	5.0
1988	49.5	834.4	5.9

Suppliers to the Market

The U.S. aerospace gear market is dominated by 13 manufacturers. These companies account for nearly 95 percent of all aerospace gearing sold in the United States and are identified in table 6-4. Nine of these firms are subsidiaries of Fortune 500 companies. Others, like U.K.-based Lucas-Western and the Canadian firms of Pratt & Whitney Canada and Spar, are either foreign owned or do not have domestic U.S. production facilities.

These gear manufacturers are either prime contractors or subcontractors. Prime contractors sell both defense and commercial products to a variety of end users including the U.S. Government, corporations, individuals, and airlines. Prime contractors customarily place large, long-term purchase orders with subcontractors. In many instances, these orders constitute an important share of the gear manufacturers' total sales. Subcontractors, such as Arrow and Litton, rely on prime contractors as their principal customers for aerospace gears. Aerospace producers, except most helicopter producers, purchase most of their gearing or subassemblies containing gearing from subcontractors. Many of the small gear producers manufacture loose gears for the replacement market.

Market Segments

The U.S. aerospace market consists of civil and military sectors. Both sectors include helicopters, general aviation aircraft, large transports, special purpose aircraft, missiles, and space vehicles. The trends in sales of large transports and special purpose aircraft have moved in opposite directions, with sales of military special-use aircraft declining in the late 1980s as sales of large civil transports increased. Sales of helicopters and general aviation aircraft accounted for less than 5 percent of total sales in the aerospace market in 1988.

Military demand for aerospace gears has been driven by the buildup and maintenance of the U.S. Armed Forces. The value of industry sales to the Department of Defense (Defense) surpassed civilian expenditures each year until 1988, when civil aerospace accounted for a greater share of total U.S. aerospace sales. Defense outlays for military aircraft, missiles, and spacecraft, as shown table 6-5, increased from $24.4 billion in 1984 to $29.3 billion in

Table 6-4
Leading aircraft gear suppliers, by sectors, 1989

Supplier	Fixed-wing	Helicopter	Other
Aircraft Gear Corporation	X	X	X
Allison Gas Turbine (General Motors)		X	
Arrow Gear		X	X
Bell Helicopter (Textron)		X	
Garrett Aerospace (Allied-Signal)	X		
International Gear Corporation		X	
Litton Precision Gear (Litton)	X	X	X
Lucas-Western		X	
Pratt & Whitney (United Technologies)	X		
Sikorsky Aircraft		X	
Spar Aerospace (Canada)	X		
Speco	X	X	
Textron-Lycoming (Textron)	X		

Source: Compiled by the staff of the U.S. International Trade Commission.

Table 6-5

Aerospace products: U.S. Government and civilian expenditures, total and by product 1984-88

(In millions of dollars)

Sector and year	Total	Aircraft and parts	Engines and parts	Missiles and space vehicles
U.S. Government:				
1984	24,351.9	15,136.2	5,080.3	4,135.5
1985	27,396.4	17,783.1	4,116.2	5,497.1
1986	29,113.0	18,788.3	3,967.4	6,357.3
1987	30,658.5	18,131.4	5,638.6	6,888.5
1988	29,337.1	15,278.3	6,038.8	8,020.0
Civilian:				
1984	20,459.5	13,121.4	3,948.8	3,389.3
1985	25,312.1	16,466.8	5,575.6	3,269.7
1986	27,945.2	19,177.1	5,825.6	2,942.5
1987	29,144.7	18,899.1	6,394.3	3,851.3
1988	33,436.0	20,433.0	8,993.2	4,009.8

Source: Compiled by the staff of the U.S. International Trade Commission from Aerospace Industries Association *Facts and Figures*, various editions, and data from the U.S. Bureau of the Census.

1988. Aircraft accounted for 52 percent of total military expenditures on aerospace products in 1988.[21]

In the civil aerospace sector, the commercial transport market boomed during the mid- to late-1980s. Total sales of civilian aircraft rose steadily from $20.5 billion in 1984 to $33.4 billion in 1988. The backlog of unfilled domestic orders for civil transport aircraft grew from 213 units at the end of 1983 to 532 units at the end of 1988.[22] This increase in demand can be attributed to many factors, including increased passenger traffic and greater airline profits, which enabled the airlines to finance purchases of new aircraft. Increased traffic also strained the airlines' capacities, necessitating the purchase of larger, more modern aircraft. The traveling public's perception of older planes as unreliable provided a marketing justification for these purchases. The trend towards stricter noise standards at airports has led to a choice between installing hush-kits on existing engines, replacement (where possible) of older engines with newer ones, or replacement of the aircraft. The last decade has also seen growth in the number of aircraft-leasing companies which have accounted for a growing percentage of the new aircraft orders. Finally, the increase in demand for airfreight services has resulted in greater-than-normal orders for cargo planes.

Other segments of the civil aerospace market have been weak. The demand for nonmilitary helicopters and general aviation aircraft has declined significantly since 1979, primarily as a result of product liability issues and a lack of demand in helicopter services. During the 1970s, the offshore gas and oil industries were the largest consumers of civil helicopters. Falling oil prices and a subsequent decline in offshore oil activities caused the idling of a significant number of aircraft, thereby increasing the availability of used helicopters. Other reasons for the decline in demand for new helicopters included high purchase prices and operating expenses, and the inability of helicopter airlines to enter the passenger market.

The emergence of previously unexploited commercial markets, such as emergency medical services, law enforcement, and commercial sightseeing, has helped to partially offset the decline in demand for helicopters for offshore gas and oil industries. Domestic civil helicopter deliveries increased marginally from 376 units in 1984 to 383 units in 1988. During the same period, the value of helicopter shipments increased by 1 percent, from $330 million to $334 million. However, the trend was sharply downward from 1984 to 1986 before regaining its former level in 1988. Data for domestic civil helicopter deliveries for 1984-88 are shown in the following tabulation:[23]

Year	Quantity (Units)	Value (Million dollars)
1984	376	330.3
1985	376	505.7
1986	326	287.1
1987	358	277.1
1988	383	334.4

The fixed-wing portion of the general aviation market also fared poorly during this period. Between 1984 and 1987, U.S. shipments of fixed-wing general aviation aircraft fell 55 percent, from 2,438 units to 1,085 units. In 1988, shipments

[21] Ibid.

[22] *World Aviation Directory*, 1989, p. x-32.

[23] *Aerospace, Facts and Figures 89-90*, Aerospace Industries Association of America, Inc., 1989, p. 32.

rose 5 percent to 1,143 units, valued at $1.9 billion, as shown in the following tabulation:[24]

Year	Quantity (Units)	Value (Million dollars)
1984	2,438	1,698.7
1985	2,029	1,431.3
1986	1,495	1,262.7
1987	1,085	1,364.0
1988	1,143	1,918.4

Demand declined primarily because of import competition, the increasing price of aircraft, and the shrinking demand for recreational aircraft.

Firms such as McDonnell-Douglas, General Dynamics, Boeing, and General Electric purchase most of the gearing for their products. Other producers like Sikorsky and Bell manufacture gears in their own divisions, contract with other producers for some products, and, on occasion, because of price or time constraints, rely on small job shops and imports. Because gearing producers for the aerospace market are in some cases 3 to 4 tiers below the prime contractor or aerospace producer, the nationality of the gear producer may not be known to the ultimate consumer of the finished product.

Defense acquires gears from manufacturers, weapons systems producers, or subcontractors. As subcontractors, Rockwell, McDonnell-Douglas, Sikorsky, and Boeing have traditionally satisfied most of Defense's aerospace gear requirements. Subcontractors purchase gears from either domestic or foreign sources for inclusion in their defense-related projects.

Marine Gearing

Although the United States is no longer a major producer of large ships except for defense purposes, the U.S. market for marine gearing is still significant. There are two primary types of gears produced for marine applications: custom-produced gears for large ships and smaller marine gears produced in large volumes for work boats, fishing boats, and pleasure craft.

Factors Influencing the Market

Large marine gears are primarily reduction gears for diesel or gas turbine-driven ships. The requirements for the two drives are significantly different. Gears for gas-turbine engines have a very large diameter, with a big reduction ratio because of the speed at which the gas turbine operates. These gears, therefore, require greater accuracy than do diesel units with respect to specifications. Recently, diesel propulsion has gained a considerable advantage over the gas turbine, partially because of rising fuel costs and improved power-to-volume and power-to-weight ratios.[25] In modern naval vessels with displacements of up to 1,000 tons, diesel engines have been established as an almost exclusive power source. Gas turbines are still used in larger combat ships over 3,000 tons. The advantage with respect to specific weight makes them the prime choice for higher power applications. The gas turbine and diesel propulsion shares are about the same in ships between 1,000 and 3,500 tons.

The development and use of high horsepower diesel engines took place in Europe before it did in the United States. As a result, European marine gear research and development concentrated on the production of hardened and ground gears. The U.S. marine gear industry has lagged behind European firms in the design and manufacture of such gears because its main customers, the United States Navy and merchant marine, used turbine propulsion for both merchant and naval vessels until the early 1980s, when diesel power systems increasingly were adopted.

Market Size

During 1984-88, the U.S. market for marine gearing ranged from an estimated $253.1 to $274.6 million, as presented in the following tabulation. In 1988, large marine gears accounted for about 10 percent, or $27 million of the total marine gearing market, and smaller marine gears for the remaining 90 percent, or $248 million. The United States is the largest market for smaller marine gears in the world. Approximately $153 million in marine gearing was used in captive consumption and $122 million was sold as marine transmissions or replacement gearing in the open market in 1988. In addition to separate market segments for large and small marine gears, the market is further segmented into gears produced for defense and commercial applications.

Year	Imports	Apparent consumption	Ratio of imports to consumption
	— Million dollars —		Percent
1984	6.0	253.1	2.3
1985	8.0	249.2	3.2
1986	9.0	248.7	3.6
1987	10.0	264.1	3.8
1988	12.0	274.6	4.4

Suppliers to the Market

Major suppliers of marine gearing to the U.S. market are shown, by market segment, in table 6-6. The production of large gears for defense applications is concentrated in three companies: General Electric, Westinghouse, and Cincinnati Gear. Another three companies, Falk, a subsidiary of Sundstrand, Westech, and the Philadelphia Gear Co., have had experience producing large marine

[24] Ibid.

[25] Dr.-Ing. W.F. Schaefer and Z.J. Karaszewski, *Marine Diesel Propulsion Plants for the United States Navy*, January 1989.

Table 6-6
Leading marine gear suppliers, by primary sector, 1989

Supplier	Large marine gears/gearing	Smaller marine gears/gearing
BHS-Voith		X
Borg-Warner		X
Cincinnati Gear	X	
Falk	X	
General Electric	X	
Lohmann und Stolterfoht	X	
Marine Gear	X	
Mercury Marine		X
Outboard Marine		X
Philadelphia Gear	X	
Reintjes	X	
RENK	X	X
Twin Disc		X
Westech	X	
Westinghouse	X	
Yamaha		X
ZF		X

Source: Compiled by the staff of the U.S. International Trade Commission.

gears for defense applications. However, their primary customers include U.S. merchant shipping companies and operators of fishing vessels, harbor vessels, and inland waterway vessels.[26]

The U.S. market for smaller marine gears is dominated by a few high- volume U.S. producers, including Twin Disc, OMC Corp. (formerly Outboard Marine), and Mercury Marine (a subsidiary of Brunswick Co.). West Germany and Italy are major competitors in the market for smaller marine applications. For example, the Trinity Marine Group, a U.S. firm, is currently building a German-designed yacht using ZF reverse reduction gears.[27]

Market Segments

Very few large marine gears are produced for commercial applications, since U.S. production of large commercial vessels is nearly at a standstill.[28] The U.S. gear industry has experienced a significant decline in incoming orders that the industry attributes to price competition from imported products in both government and commercial markets. West German firms in particular have employed this advantage to gain a foothold in the U.S. market.

The U.S. market for extremely large marine gears is highly dependent on U.S. Navy contracts. In fact, 20 percent of domestic gear manufacturers' products go to defense prime contractors. The U.S. Navy contracts for shipbuilding through the prime contractor, a shipbuilder, that in turn purchases the necessary gearing from a number of manufacturers that may include some foreign sources.

During the early 1980s, Navy ship design, cost, and operational requirements changed, necessitating the use of hardened and groundreduction gears as opposed to the through-hardened gearing used in older vessels. Hardened and ground gearing facilitates transmission of higher shaft horsepower through smaller, lighter gear boxes, which last longer and run quieter. The noise pattern of ship engines is important to naval sonar detection and identification. During the mid-1980s, U.S. large marine gear producers did not have the necessary technology, experience, and production machinery and facilities to produce such gears. Consequently, the U.S. Navy purchased some foreign marine gears from major West German gear manufacturers such as RENK, ZF, and Lohmann und Stolterfoht GmbH for incorporation in U.S.-built vessels.

U.S. marine gear producers subsequently have made the investments in machinery necessary to produce hardened and ground marine gears. Agreements have been established between U.S. and West German marine gear producers that allow for design and technological input from the West German firms, if necessary, on U.S. Navy gearing contracts. For production of marine gears, Falk and GE are licensed by RENK and Cincinnati Gear is licensed by BHS. Falk is also cooperating with RENK in a U.S. Navy program. RENK designed the gearing which Falk is manufacturing.

The U.S. Navy has always had a requirement limiting nuclear propulsion business to U.S. citizens and U.S.-owner companies. In late 1986, the Navy required that naval gearing also have substantial

[26] USITC staff conversations with U.S. Department of Transportation official, September 1989.
[27] *Diesel Progress*, August 1989, p. 4.
[28] There were no new merchant-type vessel contracts with U.S. private shipyards during 1985-89. In early 1990, an order for a $129 million container vessel was placed with a San Diego, CA shipyard. However, industry sources report that the design minimizes the use of marine gearing. The countries having the largest merchant orderbooks are South Korea and Japan, with 32 and 25 percent of the world by deadweight tonnage (DWT), respectively. Asia as a whole had 367 ships on order for over 22 million DWT in 1988, whereas Europe had 408 ships on order for just over 9 million DWT in 1988.

U.S. content. This policy was established in the form of a letter from the Assistant Secretary for Procedures that is included in Navy contracts. However, producers say that although some procurement policies enhance their competitiveness, others are not favorable.[29] Firms believe the costs of compliance with regulations for companies doing business with the U.S. Government are verging on prohibitive. Offshore manufacturers do not have to comply with the rules, and so do not have to absorb these same costs.[30]

[29] Compiled from data submitted in response to questionnaires of the U.S. International Trade Commission.
[30] Ibid.

U.S. consumption of small marine gearing continued to increase through most of 1988, and the U.S. share of the market remained stable. However, in late 1988, sales of pleasure craft softened due to saturation of the market. After 6 years of solid growth, sales of new boats dropped off, due, in part, to rising interest rates and uncertainty about the economy. A tapering off in sales of recreational boats generally results in a corresponding drop in demand for smaller marine gearing.

Chapter 7
Comparisons of International Competitiveness Between U.S. and Foreign Industries

Factors affecting the competitiveness of the U.S. gear industry are numerous. They include pricing, research and development, access to distribution and supply networks, labor cost and availability, raw materials, government involvement and regulation, access to capital markets, and product liability. Other factors affecting the ability of companies to compete are the level of investment in modern equipment and the adoption of advanced technologies. When these factors are considered in the aggregate, it appears that U.S. gear producers lag behind the major foreign producers in terms of overall international competitiveness.

Pricing Relationships

The average price of all domestically produced gears and gear products rose faster than the Producer Price Index (PPI) in the United States during 1984–88, but less than the overall price level, as measured by the Gross National Product (GNP) deflator.[1] During 1984–87, prices for gears and gear products included in SIC Industry 3566 increased by 6 percent and by an additional 8 percent in 1988. The PPI for motor-vehicle transmissions rose by 6 percent during 1984–87 but declined to the 1986 level in 1988. The following tabulation shows the average annual U.S. PPI, as reported by the U.S. Bureau of Labor Statistics, for gears and gearing classified in SIC industry 3566, and motor vehicle transmissions, classified in SIC industry 3714(pt), during 1984–88 (1984 = 100.0):

Year	*PPI for gears and gear products (except motor-vehicle transmissions)*	*PPI for motor-vehicle transmissions*
1984	100.0	100.0
1985	103.2	99.6
1986	104.8	104.6
1987	105.9	105.5
1988	114.4	104.5

During 1986–88, the price of U.S. gears rose more quickly than those produced in West Germany, France, and Belgium, but at a slower rate than gears and gearing manufactured in Italy and the United Kingdom.[2] However, the lack of detailed price data makes the comparison of U.S.-produced gears and gearing with U.S. imports difficult. Gears are often differentiated by technical specifications that have a large effect on the price of the final product. Other factors such as guaranteed delivery time, availability, product reliability, and service are also of considerable importance to customers.[3] According to U.S. gear distributors' responses to Commission questionnaires, these four factors are regarded as crucial by the majority of their original equipment manufacturer (OEM) and maintenance repair operations (MRO) customers, and account for some price differentials. Finally, gears and gearing are often sold jointly with other products, and it is difficult to separate their prices from those of the other components.

Changes in supply and demand considerations affect the relative prices of domestic and foreign gears and, consequently, the competitiveness of the U.S. gear industry. The major determinants affecting the supply of gears include the cost of labor, capital, intermediate inputs, regulatory compliance, and the choice of production technology. The long-term demand for gears by the automobile, marine, aerospace, and other industries will significantly affect world prices for gears. Relative shifts in demand among the various gear-consuming industries are also likely to significantly affect prices. Moreover, the substitutability of domestic and foreign gears influences the price of U.S.-produced gears in both domestic and foreign markets.

Certain costs of production and the competitiveness of any national gear industry are affected by currency exchange rates. Changes in exchange rates over the period of the investigation have benefited U.S. producers. The real value of the dollar reached its peak, relative to the currencies of the major world producers, during 1984–85. The real value of the Canadian dollar has since appreciated 12.5 percent against the U.S. dollar. The Korean won has risen 9.7 percent, the Belgian franc appreciated 33.7 percent, and the currencies of Italy, West Germany, the United Kingdom, and Japan have appreciated approximately 50 percent. While exchange rate changes generally do not correspond to equal changes in import prices, they do affect the relative competitiveness of domestic and foreign producers. In particular, the depreciation of the real value of the dollar increases the competitiveness of U.S. manufacturers in the domestic market. While individual firms have no control over the level of the exchange rate, they can make certain decisions that will control the foreign currency price of their product. If a foreign currency appreciates relative to the U.S. dollar, foreign firms are sometimes faced with the alternatives of raising the dollar price of their products to keep current profit margins or lowering their profit margins to protect market share.

Long-term trends in gear usage suggest that the demand-side determinants of price follow the cycles

[1] Yearly wholesale prices in the United States increased slightly over 3 percent during 1984–88. The GNP deflator increased about 13 percent in the same period. See International Monetary Fund, *International Financial Statistics*.

[2] According to statistics from Eurotrans, prices of West German, French, and Belgian nonautomotive gears grew between 1 and 2 percent more slowly than did U.S. gear prices. Prices for Italian and British nonautomotive gears increased 10 percent faster than did U.S. prices. All prices were measured in home currency.

[3] VDMA written response to questions of the USITC, Dec. 12, 1989, p. 5.

of the automotive, aerospace, marine, and industrial equipment industries. Chapter 6 examines the trends in these industries. It should be noted that the automotive cycle has recently peaked whereas demand in the commercial aerospace market is increasing. There does not appear to be a major substitute for gears and gear products in development. Consequently, future demand can be expected to follow the demand for the final products in which gears are a component.

Research and Development, Technology, and Product Quality

Because of changes in end-user applications and materials, and hence, performance criteria, attention to research and development (R&D), technology, and product quality is essential to a firm's competitiveness. R&D primarily focuses on design, materials, and manufacturing technology. Much of the R&D that results in new or improved products is performed overseas, particularly in West Germany and Japan.

The U.S., West German, and Japanese gear industries rely heavily on proprietary R&D efforts. Data from the U.S. industry and estimates provided by the West German Machinery and Plant Manufacturers Association (VDMA)[4] for West Germany indicate a marked disparity between countries. The West German gear industry spent about 4 percent of its sales on R&D during 1984–88, compared with less than 1 percent of shipments spent by the U.S. gear industry. The percent spent by the U.S. industry increased over the period; however, total expenditures reported in Commission questionnaires were only $77.7 million in 1988. In 1985, U.S. universities spent less than an estimated $1.0 million on gear research, compared with an estimated $3.8 million for West Germany and $5.0 million for Japan. Both West Germany and Japan have universities with gear research centers, which include laboratories capable of conducting state-of-the-art research on gears. Universities in the United States have little private or government funding for gear research and laboratories.[5]

The West German gear industry has traditionally worked closely with excellent university, association, and private research centers. This coordination leads to considerable exchange of ideas and personnel. In Japan, in addition to significant R&D expenditures by some of the largest companies, especially motor vehicle and large multi-product firms, there are many small but excellent university research and testing centers, several of which are staffed by world leaders in their field of expertise.[6]

[4] Verband Deutscher Maschinen- und Anlagenbau e. V.

[5] USITC staff interview with Dr. Don Houser, Ohio State University, August 1989.

[6] USITC staff interviews with Dennis Townsend, Senior Research Engineer, Lewis Research Center, National Aeronautics and Space Administration, June 1989 and January 1990.

In the mid–1980s, a U.S. gear industry expert spent 4 months studying the Japanese gear industry and Japanese developments in gear dynamics, gear deflection strengths, thermal analysis, gear lubrication studies, and high-speed gears. He commented that Japan surpassed the United States in gear-manufacturing techniques and gear cutting-materials and methods. In comparing the U.S. and Japanese industries, he noted that the United States still lags behind.[7] Another industry expert believes that there is potential for improvement in the U.S. industry through the programs of the American Society of Mechanical Engineers (ASME) Gear Research Institute (GRI), which he feels are significantly underfunded, and through the Instrumented Factory for Gears (INFAC) program.[8]

Activities sponsored by the ASME-GRI, and the even more recent INFAC program for gears, are major efforts to improve U.S. competitiveness. In addition, a $13 million project on military helicopter transmission development financed by the U.S. Army is being conducted during 1989–91 at the National Aeronautics and Space Administration Lewis Research Center. This helicopter research is in addition to the approximately $500,000 allocated annually for gear research by the Lewis Research Center.

Technology relates to both the design of the gear or gear product, as well as the manufacturing process and quality characteristics. If a market is technology-driven, such as aerospace, the technological resources of the producing firm and the engineering incorporated into the product are determining factors in purchasing decisions. In high-volume, production-cost-sensitive markets, such as vehicle gearing, the technology of manufacturing is applied to reduce costs by lowering the labor or material inputs. Some industry sources estimate that the use of the most modern gear-making machinery can lead to a 20–percent decrease in manufacturing times.[9] If such increases in productivity can be realized, then modern machinery is extremely important in developing manufacturing technology and increasing competitiveness.

A variety of industry sources and press reports indicates that leading Western European firms are using modern machinery and automation in the production of gears.[10] Trade sources indicate that the U.S. industry has not invested significantly in gear-grinding machines and automation compared with its major foreign competitors. Western European firms have developed and implemented

[7] Ibid.

[8] USITC staff telephone interview with Dale Breen, GRI, Jan. 30, 1990.

[9] Dr. G. Sulzer, "Economics of CNC Gear Hobbing," *Gear Technology*, March–April 1987, pp. 42–46.

[10] USITC staff interviews with gear industry officials, West Germany, November 1989.

grinding technology and automation to reduce input costs and to improve their competitive position in the world market. European firms developed cost-cutting technologies such as case hardening and grinding, that can reduce the amount of steel required by as much as 40 percent.[11] Labor costs outside the United States are far more difficult to reduce in the short term because union and government regulations make laying off workers difficult and expensive. Therefore, European companies adopted automation to contain employee numbers and keep costs at a minimum. Since the U.S. industry was not faced with these problems to the same degree, there has been less need to change products or processes.

In certain markets, the U.S. gear industry is believed to be the leader in technology, whereas in others, the U.S. industry has fallen behind its major competitors. U.S. producers are the world leaders in aerospace technology at this time. However, through competitive price bidding for gear production, technology developed by U.S. gear producers in the aerospace industry is being transferred offshore. R&D on "master gears" and other gear prototyping is performed in the United States by the prime contractor, but because of price and other considerations, in many instances, production contracts are awarded to foreign suppliers.[12] In many industrial applications, the U.S. industry has technology comparable with that of its foreign competitors. However, in passenger automobile gearing, U.S. industry sources believe the United States is generally lagging behind both in application and in manufacturing technology. In marine applications, especially for large gears associated with diesel engine propulsion systems, West German firms are believed to have the competitive advantage in both design and manufacturing technology.[13]

The product quality differences between U.S.- and foreign-produced gearing vary widely, depending upon the market and application. Various gearing standards, such as AGMA, DIN,[14] and ISO,[15] among others, are used to assist in marketing and differentiating the products of competing manufacturers. Some U.S. industry sources, especially in the industrial gearing market, believe that quality distinctions between U.S.- and foreign-produced gears and gear products are more perceived than real.[16]

Respondents to the Commission's producers', importers/purchasers', and distributors'question-naires reported the frequency of customers' requests for gears manufactured to various standards (table 7-1). These results illustrate the importance of AGMA and U.S. military specifications in the U.S. market, as well as the need to manufacture to a variety of specifications in order to increase market opportunities.

[11] USITC staff interviews with U.S. gear industry officials, March 1990.

[12] Statement before the U.S. House of Representatives, Committee on Banking, Finance, and Urban Affairs, Subcommittee on Economic Stabilization, by the American Gear Manufacturers Association, May 17, 1989, p. 11.

[13] USITC staff interviews with officials of the U.S. Department of Transportation, October 1989.

[14] Deutsches Institut fur Normung, the standards body of West Germany.

[15] International Standards Organization.

[16] USITC staff interviews with U.S. producers, October 1989.

Table 7-1

U.S. producers, importers/purchasers, and distributors: Frequency of customers' specification of a particular gearing standard when purchasing

Standard	*Always*	*Often*	*Occasionally*	*Never*
U.S. producers:				
AGMA	10	40	2	30
DIN	0	1	26	32
Mil-spec[1]	7	12	32	19
ISO	0	0	15	40
Other[2]	7	9	9	12
U.S. importers/purchasers:				
AGMA	5	7	4	0
DIN	1	0	4	3
Mil-spec[1]	2	1	5	3
ISO	1	0	5	2
Other[2]	1	2	1	1
U.S. distributors:				
AGMA	3	9	11	1
DIN	0	0	9	6
Mil-spec[1]	1	0	12	4
ISO	0	0	2	0
Other[2]	0	0	0	0

[1] U.S. military specifications.

[2] Includes customers' own specifications.

Source: Compiled from data submitted in response to questionnaires of the U.S. International Trade Commission.

Distribution, Supply, and Servicing Aspects

The competitiveness of gear producers worldwide depends not only on producing a technologically advanced low-cost product, but also marketing that product to the customer. For the gear producer, leadtimes, access to distribution networks, and servicing of product are important areas that, if neglected, will mean poor performance in the market. Globally, vehicle, aerospace, and marine gearing is generally sold directly by the manufacturer to the customer, because of either the large volume of product sold or the high level of engineering and technical after-sales support required. Some replacement units are sold through service or repair companies for the product which incorporates the gear components. Industrial gears and gear products are sold directly to the customer, either OEMs or end users, or through distributors. As described in this section, distribution patterns vary among countries and affect the degree of market penetration by foreign producers.

Vehicle Gearing

In the United States most vehicle gearing is sold directly to vehicle- producing OEMs or to dealers or independent service companies for after-sales service and replacement. The same distribution pattern exists in Canada, due principally to the relationship between the U.S. and Canadian industries. European firms generally sell to U.S. OEMs or through distributors. Most imports from Europe are from subsidiaries of U.S. OEMs that are located there for reasons of lower costs, global rationalization of production operations, or penetration of the European market. For instance, during 1984–88, several U.S. agricultural and construction equipment producers, such as Ford and J.I. Case, located their transmission and drive axle production operations in Europe. In 1988, Ford subsequently moved most of its tractor production to Europe. Recently, several European noncaptive market producers of transmissions and other vehicle gearing have established assembly operations in the United States in order to compete in the high-volume product area.

In contrast, Japanese vehicle gearing producers either sell directly to U.S. OEMs, generally through large trading companies, or export directly to Japanese automotive transplants assembling in the United States. In November 1989, Honda became the first Japanese-owned automotive gearing assembler in the United States when it began to assemble transmissions for its own vehicles at its Marysville, OH plant.

U.S. gearing producers have established foreign subsidiaries either to support foreign assembly operations or penetrate foreign OEM markets. Ford, GM, Dana Corp., Eaton Corp., and Rockwell International Co., for instance, have established gear-producing subsidiaries in European and South American markets. Brazil, India, and Korea require all foreign vehicle producers to form joint ventures or license production to enter the market.

Industrial Gearing

Industrial gearing is generally distributed by the manufacturer directly to the OEM customer or the end-user. By selling directly, manufacturers may increase their control over their customers and their profitability because they do not have to support distributors through training, product literature, and engineering assistance. On the other hand, use of distributors allows manufacturers to contact more customers and shift some costs to distributors.

There are differences between U.S. and foreign gear producers in the degree to which they use distributors. Respondents to the Commission's questionnaires indicated that sales through distributors accounted for about 40 percent of U.S. shipments in 1988. In Europe, with the exception of the United Kingdom,[17] less than one-third of sales is made by through distributors. In other European countries, such as West Germany, only 20 percent or less of sales is made through distributors.[18] The principal exception to this practice is the Japanese gear industry, which sells the bulk of its products through distributors.

Western European gear producers do not use distributors to the extent that U.S. producers do because of differing distribution systems and approaches to the market. Unlike their U.S. counterparts, most Western European distributors do not carry competing brands. This practice encourages manufacturers to develop their own distribution systems. In addition, because of the technical nature of their products, many European gear manufacturers believe they can offer better service through their own sales and technical staffs than through distributors.

In Japan, approximately 70 percent of sales is made through distributors and 30 percent is made directly to the customer. Many of the sales made to large wholesalers are, in turn, sold to smaller distributors. Japanese export sales are generally made through foreign agents, distributors, or trading companies. An exception to this is Sumitomo, which has established foreign subsidiaries in order to penetrate U.S. and Brazilian markets and purchased a West German industrial gearing firm.[19]

U.S. industrial gearing manufacturers that produce a standard line of gear products sell through distributors and, therefore, do not have an extensive sales and technical support staff.

[17] USITC staff interviews with BGA and gear industry officials, the United Kingdom, November 1989.

[18] VDMA written response to USITC staff questions, Dec. 12, 1989, p. 2.

[19] USITC staff interviews with gear industry officials, Japan and Korea, December 1989.

Generally, U.S. producers require that the distributors purchase and maintain a product inventory. In contrast, major foreign industrial gearing producers serve the North American market primarily through direct sales forces that focus on OEM customers. Distributors are sometimes used, but the modular product offered by some European producers requires a significant level of technical expertise in the seller and does not make a suitable stock product.[20] Producers such as Hansen International, Flender, Leroy-Somer,[21] and SEW-Eurodrive have established manufacturing and assembly centers across the United States and Canada to supply these markets and offer better customer service. Sumitomo established a large assembly center and has subassembly and service centers across the United States for its gear and cycloidal speed reducer products.[22] Sumitomo uses both distributors and a direct sales force in the U.S. market.

U.S. distributors responding to the Commission's questionnaire indicated that the main reasons for selling U.S.-assembled foreign brand products included filling out the distributors' product line, price, and customer preferences. The principal reasons given for selling U.S.-produced industrial gearing were product availability, customer preference, and quality, whereas the main reasons for carrying imported finished gearing were price and completion of the product line (table 7-2).

[20] SEW-Eurodrive, Inc., posthearing brief, Nov. 15, 1989, p. 4.

[21] Acquired by Emerson Electric in January 1990.

[22] USITC staff interview with Sumitomo officials, Nov. 27, 1989.

U.S. distributors indicated, in response to Commission questionnaires, that the profit margins for U.S.– and foreign-produced gearing did not vary significantly. The average profit margin for gear products from three of the largest suppliers to the U.S. market is shown in the following tabulation (in percent):

Origin of gearing product	*Average profit margins as a share of sales*
United States	23.7
Japan	22.5
West Germany	23.2

U.S. distributors also indicated that U.S. producers offer financing arrangements– inventory financing, consignment, and buy plans – while U.S. assemblers of foreign brand products and importers rarely do.

The distributor differentiates himself from the manufacturer by providing services that are not performed by the manufacturer. The main services distributors offered their customers for U.S.–produced, U.S.–assembled, and imported finished products were assistance in product selection, after-sales support, value-added services, and design/engineering services (table 7-3). These are services that many small companies or end users lacking technical expertise are looking for and often do not get from manufacturers.

Table 7-2

U.S. distributors of gearing: Frequency of reasons cited for having sold or marketed U.S.-produced, imported finished, and U.S.-assembled foreign-brand gearing, October 1989

Reason	*U.S.-produced*	*Imported finished*	*U.S.-assembled foreign-brand*
Fill out product line	24	10	16
Delivery times	28	3	8
Price	14	12	14
Availability of product	37	5	11
Quality	30	6	11
Higher profitability	8	5	3
Customer preference	35	7	14
Other	6	4	2

Source: Compiled from data submitted in response to questionnaires of the U.S. International Trade Commission.

Table 7-3

U.S. distributors: Frequency of services provided to customers purchasing U.S.-produced, imported finished, and U.S.-assembled foreign-brand gearing, October 1989

Service	*U.S.-produced*	*Imported finished*	*U.S.-assembled foreign-brand*
Design/engineering	24	14	15
Training	19	6	11
Product selection support	31	16	20
Procurement plans/systems contracts	14	5	10
Value-added services	27	11	18
After-sales support	29	13	18
Marketing support	14	8	9
Other	4	1	1

Source: Compiled from data submitted in response to questionnaires of the U.S. International Trade Commission.

Distributors responding to the Commission's questionnaire indicate that leadtimes are important in their sourcing decisions. The data further indicate that foreign producers have been able to reduce their delivery times to U.S. distributors, and hence to customers, and that this is one reason for their success in the U.S. market (table 7-4). According to distributors, leadtimes for imported finished products decreased substantially, from an average of 41 days in 1986 to 29 days in 1987-88. The leadtimes of U.S.-produced and U.S.-assembled foreign brand industrial gearing were roughly the same during 1987-88.

Responses from U.S. distributors to the Commission's questionnaire indicate foreign producers of industrial gearing sell to anyone in the U.S. market, including end users and small OEMs, whereas U.S. producers have more selective distribution practices. Generally, U.S. producers sell to end users, including MRO purchasers, and to small OEMs through distributors. U.S. producers try to build loyalty with distributors, whereas U.S.-assemblers of foreign brand products often sign distributors without stock requirements and emphasize cost or selling price. The emphasis on cost or selling price is also supported by the pattern of selling directly and avoiding distribution levels. European gear producers believe that U.S. distributors have been instrumental in keeping foreign products out of the U.S. market, stifling innovation, and keeping U.S. prices high compared with foreign prices.[23]

U.S. assemblers of foreign brand products tend to promote quality and delivery. According to U.S. distributors, U.S. assemblers and importers enter new market segments by selling directly to the customer and concentrating on target markets, such as food processing, packaging, and printing machinery. U.S. producers stress quality, ease of maintenance, and availability of spare parts and tend to have a broader focus than U.S. assemblers and importers. Because of their broader approach, U.S. producers fail to meet the customers' specific application requirements more frequently. U.S. distributors, according to their responses to the Commission's questionnaire, believe that U.S.-assembled foreign brand products have a slight edge with respect to quality over U.S-produced products.

[23] USITC staff interviews with European gear industry officials, November 1989.

Both U.S. producers and U.S. assemblers of foreign-brand products maintain large inventories and product literature. However, U.S. distributors indicate that U.S. producers are better at managing inventories than U.S. assemblers and importers and that the latter two may change distribution policies in response to foreign currency fluctuations.

Marine Gearing

Marine gearing is generally sold directly by the marine gearing manufacturer to OEMs, that integrate the gearing into engines and other power train components. In many instances, the OEM purchasing large marine gears also contracts for engineering consulting services. For smaller marine gearing, such as that used on pleasure craft, marine gear products are produced in high volumes, and are sold directly to the OEM.

The major U.S. and European marine gearing producers are independent of the shipbuilders. Some U.S. marine gearing producers, such as Westinghouse and GE, are divisions of large multinational corporations. Other major U.S. producers—Falk and Cincinnati Gear—are much smaller companies. In West Germany, France, the United Kingdom, and Spain, marine gearing companies are independent small- or medium-sized firms. West German companies have invested heavily in R&D and manufacturing operations and have become an important source of licensed technology for foreign producers. West German licensees for marine gearing include GE, Falk, and Cincinnati Gear.

In Japan and Korea, most shipbuilders have in-house marine gearing manufacturing operations. For instance, Mitsubishi, IHI, and Sumitomo of Japan and Hyundai and Daewoo in Korea, produce ships as well as gears. The captive gear operations of such companies can tie into the entire corporation's resources, both technical and financial, providing them with a significant competitive advantage over smaller, independent producers.

Table 7-4
U.S. distributors: Average leadtime, in days, and frequency of response for U.S.-produced, imported, and U.S.-assembled foreign-brand gearing, 1986-88

Type of gearing	1986 Lead-time (days)	1986 Number of responses	1987 Lead-time (days)	1987 Number of responses	1988 Lead-time (days)	1988 Number of responses
U.S.-produced	20	39	20	12	23	15
Imported finished	41	39	29	12	29	17
U.S.-assembled	23	40	24	12	22	18

Source: Compiled from data submitted in response to questionnaires of the U.S. International Trade Commission.

Aerospace Gearing

Aerospace gearing, because of its specific proprietary design requirements, is either produced by vertically-integrated users or is sold directly by independent producers to higher level component manufacturers. In the United States and Western Europe, aerospace gearing is produced by both in-house gear-manufacturing establishments and by outside contractors. However, in Japan and in some instances in Western Europe, the aircraft producer manufactures the major subassembly components and the gearing in the subassembly.

Labor Factors

Direct labor costs, degree of unionization, and current and future labor availability are the principal labor factors affecting the competitiveness of gear manufacturers.

Costs

Hourly compensation costs for production workers in industrial and commercial manufacturing industries (SIC 35) for eight major gear producing nations for 1984–88, in dollars, are shown in table 7–5. These costs increased by 10.7 percent for the United States, compared with 101.5 percent for Japan, nearly 95 percent for West Germany, and nearly 80 percent for Italy during the period. However, comparing annual hourly compensation costs in a currency other than the countries' own can be deceiving, because the magnitude of changes in hourly compensation costs is affected by exchange rate fluctuations, which generally do not affect a producer's actual labor costs.

Another factor to be accounted for is wage cost inflation. By eliminating the effects of wage cost inflation, changes in the real hourly cost of labor to the producer can be examined. Table 7–6 shows hourly compensation costs in nominal foreign currencies and in real, or inflation-adjusted, foreign currencies. In nominal terms, these costs increased by less that 15 percent over the period for the United States, Japan, Belgium, and Canada, and by more than 20 percent for West Germany, Italy, France, and the United Kingdom. When adjusted for wage inflation, the percentage changes in these costs are quite different. The changes, in real terms, were significantly less or even negative for most countries.

Unionization

The presence of unions in the gear industry's labor force varies worldwide. U.S. gear industry workers are represented by large national unions, such as the United Auto Workers (UAW) and the International Association of Machinists (IAM). Just over one-half of the members of the AGMA reported that their gear production workers were unionized.[24] Among AGMA members, the likelihood of union representation increases with the size of the firm. While one-third of firms with 50 or fewer workers were unionized, one-half of those with 51 to 100 manufacturing employees were organized, and three-fourths of those with more than 100 employees were union shops.[25]

Unions have exerted some influence in the U.S. gear industry. Unions have brought about key work rules covering a broad range of issues, including seniority and job assignments, ethics, and scheduling. In addition, total compensation is higher at unionized firms, and union shops are more likely to provide pension plans. Nevertheless, in other areas, such as profit sharing and the average years required to earn vacation, workers at nonunion firms have fared better.[26] In general, union-management relations have been fairly smooth, with few protracted conflicts reported.[27]

[24] AGMA, posthearing submission, Nov. 15, 1989.
[25] AGMA, *Wage & Benefit Survey 1988.*
[26] Ibid.
[27] USITC staff interview with official of the AGMA, Jan. 29, 1990.

Table 7-5

Wages: Hourly compensation costs for production workers in industrial and commercial machinery manufacturing industries (SIC 35), for major gear and gearing producing nations, measured in U.S. currency, 1984-88

Country	*1984*	*1985*	*1986*	*1987*	*1988*	*Percent change*
	Dollars per hour					
United States	13.56	13.99	14.36	14.54	15.01	10.7
West Germany	9.71	10.00	13.89	17.57	18.93	95.0
Japan	7.36	7.48	10.82	12.69	14.83	101.5
Italy	7.45	7.60	10.21	12.59	13.37	79.5
France	7.67	7.87	10.70	12.99	13.52	76.3
United Kingdom	6.09	6.37	7.71	9.11	10.80	77.3
Belgium	9.01	9.30	12.92	15.75	(1)	274.8
Canada	11.63	11.04	11.25	12.47	13.96	20.0

1 Not available.
2 Percentage change based on 1984-87.

Source: Unpublished data from the U.S. Bureau of Labor Statistics, August 1989.

Table 7-6

Wages: Nominal and real[1] hourly compensation costs per worker for production workers in industrial and commercial machinery manufacturing industries (SIC 35), for major producing nations of gearing, measured in national currencies, 1984-88

Item	United States	West Germany	Japan	Italy	France	United Kingdom	Belgium	Canada
	US$	Deutsche-marks	Yen	Lira	French francs	Pounds	Belgian francs	Can$
				Nominal costs				
1984	13.56	27.61	1,747	13,088	66.99	4.56	520.54	15.06
1985	13.99	29.41	1,785	14,503	70.69	4.91	551.57	15.07
1986	14.36	30.15	1,821	15,219	74.09	5.25	557.15	15.63
1987	14.54	31.60	1,835	16,327	78.07	5.55	588.27	16.54
1988	15.01	33.26	1,902	17,410	80.56	6.07	(2)	17.19
Percentage change	10.7	20.5	8.9	33.0	20.3	33.1	[3]13.0	14.1
				Real costs				
1984	13.56	27.61	1,747	13,088	66.99	4.56	520.54	15.06
1985	13.49	28.33	1,730	13,054	66.69	4.85	532.40	14.52
1986	13.56	28.05	1,716	13,075	66.87	5.27	523.15	14.59
1987	13.48	28.29	1,693	13,167	67.30	5.36	541.69	15.05
1988	13.56	28.57	1,692	13,229	67.36	5.69	(2)	14.95
Percentage change	0	3.5	(3.1)	1.1	0.6	24.8	[3]4.1	(0.7)

[1] Real costs calculated using 1984 as a base year.
[2] Not available.
[3] Percentage change based on 1984-87.

Source: Unpublished data from the U.S. Bureau of Labor Statistics, August 1989.

In Europe, unionized firms are common and union rules have been much more burdensome to the employers than in the United States. Key issues in recent years have been the use of overtime, length of the workweek, and wage increases. U.S. capacity is restricted by equipment, whereas in Europe capacity is more likely to be constrained by labor. Employers wanting to increase capacity temporarily by increasing hours generally meet with resistance from unions, which would prefer to see the employer hire more workers. At the same time, some European manufacturers mentioned that they met with less resistance to overtime when they dealt with the union at the local level. Related to resisting overtime is the demand for a shorter work week; for example, British gear unions are trying to reduce weekly hours from 39 to 35 and, in West German unions, from 37 to 35.[28] European unions have won provisions that make it very difficult to fire workers. The firm may have to demonstrate an economic need, such as the loss of a market, and even then, reductions in force may best be accomplished through attrition. Another factor discouraging layoffs is unemployment compensation that the employers must often provide.[29] Some European gear workers are fighting for wage increases as high as 6 or 7 percent.

[28] USITC staff interviews with gear industry officials, the United Kingdom and West Germany, November-December 1989.
[29] Ibid.

In Japan, the portion of the entire workforce that was unionized declined to 28 percent by mid-1987, compared with 55 percent 40 years earlier.[30] This was due in part to the increased use of part-time workers in manufacturing. One Japanese gear industry official reported that his part-time employees might only work for one-half of the year and would refuse offers of permanent employment from either large or small firms.[31] Union membership is not attractive to this segment of the workforce. The labor organizations in the Japanese gear industry negotiate with employers concerning annual work schedules, such as weekends and holidays to be worked. In general, relations between unions and management are much less tense than in other countries. For example, a representative of a large Japanese firm indicated that if a grievance from the in-house union is presented but not resolved satisfactorily, the union approaches management and asks for permission to strike for one-half hour at midday. In return, the workers arrive one-half hour earlier in the morning and increase their productivity throughout the day. The manufacturer pointed out, however, that management does make concessions as a result of these actions. Management sees the strike as an embarrassing indication that they cannot reconcile problems with the workers.[32]

[30] *Japan Economic Almanac 1988*, p. 46.
[31] USITC staff interviews with gear industry officials, Japan, December 1989.
[32] USITC staff interview with U.S. representative of a major Japanese producer, Jan. 26, 1990.

Labor Supply

Manufacturers in most industrialized countries are facing labor shortages of skilled and unskilled workers, and, to some extent, engineers. The world's gear industry is no exception, and small producers are especially affected. In some cases, geography is a factor. Employers in some locations face greater shortages than those elsewhere. Lack of mobility of the labor force is an important issue worldwide. Workers tend to stay in one location throughout their lives regardless of their employment situation and in spite of the attraction of higher income opportunities elsewhere.

The greatest concern expressed by gear manufacturers throughout the world is the shortage of applicants with an aptitude for, and an interest in, entry- level positions in the gear industry. Young people, they claim, are not entering the skilled manufacturing trades as much as they used to; apparently, they are looking for clean, quiet work environments. For instance, in West Germany, increasing numbers of young workers are choosing education and white collar jobs over blue collar work.[33] In Japan, young people speak of work in industry in terms of the three K's: kiken (dangerous), kitanai (dirty), and kurani (dark and dull).[34] Similarly, U.S. manufacturers report that it is hard to entice young people to enter these trades, particularly when starting wages are comparable to those in service industries and the hours are long. Firms in most industrialized countries are aware that their pool of skilled workers is growing older and they realize that their labor shortage will worsen before it improves.

Training alternatives utilized by gear manufacturers range from the informal, on-the-job training which is most common in smaller firms to structured programs involving classroom instruction as well as hands-on experience. In Europe, trainees are recruited from high schools and technical schools and are usually between the ages of 15 and 18. The programs range in length from 1 to 4 years and combine classroom and factory work. The amount of government funding provided for these programs varies. Sometimes firms pay the trainees a modest wage, about $100 to $150 per week. Some European producers reported fairly high turnover rates, some as high as 30 percent, among trainees within a few years of completing the programs. In France, for example, most high school graduates must complete compulsory military service, and they frequently do not return to the firm afterwards. In other cases, workers leave to take jobs with other firms.[35]

Large Japanese gearmakers also offer their own training programs, since the industrial training/apprenticeship system was abandoned a few years ago. These programs consist mainly of rotational assignments on various production steps. According to one industry representative, larger companies find it much easier to attract university students than do smaller firms. While the universities are one source of trainees, others recruit from local commercial, industrial, and regular high schools. At one large firm, new gear production workers are cross-trained on each step of the production process because of the belief that cross-trained employees allow the employers greater flexibility in future job assignments. Meanwhile, new gear design engineers make and test gears in the company's prototype plant for 3 to 6 months. The employers think that the engineers must fully understand the tools and processes before they can design the product.[36]

U.S. firms also offer on-the-job training for their new hires, and more formal apprenticeship programs are common among the largest unionized firms. As in Europe and Japan, new hires are frequently recruited from local trade schools, high school vocational programs, and community colleges. However, in the United States more and more employers are assuming responsibility for teaching basic reading and math, as well as job-specific skills. In Europe and Japan, employers choose from applicants who, frequently, having chosen a vocational education track at an earlier age, may have interned with manufacturers, and are thus better prepared. The returns on training costs are not as certain for U.S. manufacturers, since the U.S. workforce is more likely to change employers than is that of Europe and Japan. As a result, small firms that provide entry-level training frequently lose workers to higher paying large firms.[37]

Raw Materials

The raw materials and components used in producing gearing include a variety of steel castings, forgings, and bar stock, as well as bronze castings and bearings. Other miscellaneous components include seals and lubrication oils. According to a number of industry sources, material costs among the world's major producers of gearing—the United States, Western Europe, and Japan—do not vary significantly.

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[33] Terrence Roth, "German Industrial Boom is Threatened by a Dearth of New Skilled Apprentices," *Wall Street Journal*, Aug. 11, 1989, p. A10.

[34] USITC staff interviews with gear industry officials, Japan, December 1989.

[35] USITC staff interviews with Union Nationale des Industries des Transmissions Mecaniques (UNITRAM),

[35]—*Continued*
Verband Deutscher Maschinen- und Anlagenbau e.V. (VDMA), Associazione Italiana Costruttori Organi di Trasmissione e Ingranaggi (ASSIOT), British Gear Association (BGA), and European industry officials in the United Kingdom, France, West Germany, and Italy, November–December 1989.

[36] USITC staff interview with major Japanese producer, December 1989.

[37] USITC staff interview with representative of the AGMA, Jan. 26, 1990.

In Europe, most gear producers purchase steel and bronze locally in the United Kingdom, West Germany, Belgium, and the Netherlands, from the least expensive source available. In many instances, steel is purchased from distributors, usually subsidiaries of steel producers. West German and U.S. gear producers use different mixes of steel alloys in their products. Thus, it is difficult to compare steel prices.[38] Japanese gear industry sources also indicate that the steel they purchase is not directly comparable to that in the United States.

Two major constraints on production are the availability of forgings and bearings.[39] Forgings are typically used in input and output shafts and in blanks for some gears, such as pinions. According to data gathered by the Commission's questionnaires, some U.S. producers substituted castings for forgings when leadtimes and availability of forgings became tight in the U.S. market.

Since mid-1989, U.S. gear producers have faced higher prices for bearings and availability problems. This is mainly the result of an estimated one-third decline in U.S. bearing production capacity during the 1980s and antidumping duties imposed on imports of bearings from West Germany, Japan, and other countries in mid-1989. Delivery times have lengthened and double-digit price increases have been common.[40] The U.S. Producer Price Index for bearings rose 15 percent from January 1988 to June 1989, and the International Producer Price Index for U.S. imports of bearings increased by 10 percent during the corresponding period. U.S. bearing producers have raised prices, in part to keep up with imported bearing price increases.

Bearings account for between 5 and 30 percent of the manufactured cost of a gear product, and gear companies have indicated that bearing price increases have either been absorbed by the company or passed on to the consumer. For some companies, absorption of such costs has translated into reduced earnings. Industry sources indicate that because of these increased costs U.S. gear producers have become less competitive with foreign gear producers in both U.S. and foreign markets. The bearings embedded in U.S. imports of gear products are not subject to antidumping duties, and bearing shortages have not been reported in either Western Europe or Japan.

Government Involvement

Programs and policies of national and local governments play a major role in a country's competitiveness, both in its own and in foreign markets. Such programs may include special loans to firms in developing industries, more favorable depreciation schedules for new equipment purchases and other special tax incentives to stimulate economic growth, and product liability regulations, as well as a number of other programs.

According to industry sources, some programs and policies are major disincentives for U.S. gear manufacturers. Such U.S. Government policies include the U.S. export control system, the Foreign Corrupt Practices Act, antiboycott statutes, the taxation of export income, lack of funding of the Export-Import Bank and other export financing/promotion programs, and the policies of such regulatory bodies as the Environmental Protection Agency and the Occupational Safety and Health Administration.[41] In many instances, government programs do not specifically target the gear and gear products industries; rather, they are directed at manufacturing in general or at an industry as a whole.

U.S. gear and gear products producers were asked to report actions the government—Federal, State, and local—has taken to enhance their competitiveness. According to questionnaire responses, the most common actions included: (1) some form of business loan, generally at a low rate of interest; (2) low interest or tax-free revenue bonds; (3) State or local tax abatement programs; (4) State funding for manpower training; and (5) tax incentives (including depreciation and credits) for investment, employee stock option plans, and research.

Export Financing

Export sales may depend on the seller's ability to provide financial assistance or favorable payment terms to the purchaser. In the United States, companies look to the Export-Import Bank or commercial banks for assistance. This has become a more important alternative since commercial banks, in attempting to reduce lending risk, have curtailed many such loans. However, the Export-Import Bank has had severe cutbacks in its direct loan budget. In 1988 and 1989, the Export-Import Bank was able to operate its new direct loan program for only part of the year before funds were exhausted.[42]

In addition to direct loans, exports are often financed as part of a foreign aid package. Most industrialized nations provide assistance to their exporting industries in this way. Manufacturers in the donor country provide goods for capital projects in developing areas. These projects, which generally incorporate a high percentage of imported capital goods, are important for the development of the recipient countries and provide a market for the donor's products. However, the percentage of total bilateral foreign aid accounted for by these capital projects varies widely for

[38] VDMA written response to questions of USITC staff, Dec. 12, 1989, p. 5.

[39] USITC staff interviews with gear industry officials, West Germany, November 1989.

[40] Dave Fusaro, "Bearing Output Rises to Cover U.S. Shortages," *Metalworking News*, Aug. 14, 1989, pp. 1 and 52.

[41] AGMA, posthearing submission, Nov. 15, 1989, pp. 1-20.

[42] AGMA, posthearing submission, p. 6.

industrialized nations. In the mid-1980s, capital projects constituted between 60 and 70 percent of Japan's foreign aid and nearly 46 percent of all foreign aid for capital projects. West Germany's assistance accounted for just over 20 percent whereas, U.S. foreign aid totaled only between 2 and 3 percent of aid for such projects.[43] The U.S. has, typically, concentrated its assistance on providing for basic human needs, through rural health delivery systems, education, small-scale agriculture, and the like.[44] U.S. gear manufacturers are concerned that this emphasis places them at a disadvantage, relative to their foreign competitors.

Taxes

European Community (EC) producers use an accelerated depreciation schedule of 3 to 5 years for their machinery, which results in lower tax costs earlier in the life of the machines. This allows these companies to recover their investment in new machinery more quickly. In West Germany, more specifically, machines are normally depreciated over 5 to 8 years, but, if operated during three shifts, may be depreciated within 2 to 3 years.[45] Japanese firms normally use 10-year depreciation schedules, but are allowed to take up to 30 percent in the first year for certain machinery.[46] Depending on their operations, U.S. firms use either a 7- or 15-year depreciation period, which can result in the obsolescence of their machinery long before it is written off.

Industry sources state that certain foreign tax treatments are disadvantageous to U.S. companies that export or invest overseas. U.S. producers believe that the imposition of foreign value added taxes (VATs) on U.S. exports hampers U.S. competitiveness. When a U.S.-produced product is imported into most Western European countries, a VAT is imposed in addition to the customs duty. However, the VAT is rebated on exports from countries with a VAT. In West Germany, for example, the 14-percent VAT on most exported goods is rebated.

The United States is also at a significant disadvantage with respect to goodwill, the amount paid in excess of a company's book value in a takeover. Goodwill is not tax-deductible in the United States, but is everywhere in Western Europe except the United Kingdom. Western European firms can outbid U.S. companies in acquisitions because of this added tax break.

[43] Ernest R. Preeg, "Trade, Aid, and Capital Projects," *The Washington Quarterly*, Winter 1989, p. 176.
[44] Ibid., p. 173.
[45] VDMA written response to questions of USITC staff, Dec. 12, 1989, p. 5.
[46] USITC staff interviews with gear industry officials, Japan, Dec. 5-11, 1989, and Ministry of Finance, Tax Bureau, *The Japanese Tax System*, 1988.

Other Policies

Unlike their counterparts in other countries, U.S. firms report that the Federal Government actually creates disincentives for both U.S. production and exports. Both OSHA standards and EPA regulations, while resulting in estimated costs of only 1 to 2 percent of revenues for producers, are restrictive in nature and, along with the Foreign Corrupt Practices Act, create additional record keeping and accounting requirements. And, while many foreign firms are encouraged by their governments to increase competitiveness through mergers and acquisitions, any U.S. business activities that may restrain trade are subject to antitrust laws. Export licensing requirements also sometimes hinder industry's competitiveness. According to AGMA, a recent sale of high-speed gear increasers to the Soviet Union was lost to another Coordinating Committee on Multilateral Export Controls (COCOM) member because the U.S. Department of Defense denied the U.S. firm the necessary license for export.[47]

Industry Development Areas

Many countries, including the United States, have established some form of industry development areas where such development is encouraged through financial incentives, primarily at the local or State level. In the United States, U.S. or foreign gear producers may receive tax holidays for locating new facilities in certain States or enterprise zones, while other U.S. producers that cannot relocate are at a disadvantage because they cannot receive such tax abatement or other financial benefits. In the United Kingdom, areas of traditionally high unemployment are designated as "development areas," wherein individuals or small firms with less than 25 employees are eligible for investment project grants for up to 15 percent of fixed asset expenditures.[48] In Spain, subsidies are provided for firms locating in regions qualifying for development incentives.[49]

Financial Aspects

Capital Availability

Industry sources have frequently cited high U.S. interest rates as the principal financial competitive disadvantage facing the U.S. gear industry. The interest rates at which a firm can borrow money for such things as capital investments and research have a significant impact on its strategic focus and actions. Table 7-7 compares the bank lending rates[50] of major gear

[47] AGMA, posthearing submission, Nov. 15, 1989, p. 4.
[48] U.S. Department of State Telegram, 1989, London, Message Reference No. 24525.
[49] U.S. Department of State Telegram, 1989, Madrid, Message Reference No. 16011.
[50] The bank lending rate is defined as the rate at which the private sector borrows to meet short and medium term financing needs.

producing nations. During 1984–88, bank lending rates for West Germany and Japan were, on average, below those of the United States. Bank lending rates in the United States were lower than those in Canada and in some European countries, including Italy, France, the United Kingdom, and Belgium. However, in order to compare the rates offered in different countries, the costs of capital should be adjusted for inflation. Inflation rates are also shown in table 7-7.

The cost of capital available to the individual firm varies depending on many factors including the credit worthiness or risk associated with the borrower. The term of the loan affects the cost because long-term, fixed-rate debts is more expensive in the long run than short-term, floating-rate debt. However, U.S. firms generally choose long term debt to protect themselves from inflation risk whereas firms in Japan and West Germany, where inflation has been lower and less volatile, rely more heavily on short term debt. During 1977–88, the ratio of short term to long term debt was 93 percent in Japan, 88 percent in West Germany, and 28 percent in the United States.[51]

The company's relationship with the lender can have an effect on the cost of capital. In the United States, the relationship between banks and industry is limited by law and regulation. In countries other than the United States, there is greater integration of financial institutions and industry. In West Germany banks control 60 percent of market equity value and in Japan the share of industry controlled by banks is estimated at the same or higher level. This relationship in West Germany and Japan allows companies to share the risk of ownership with their lenders and makes it more likely that companies in trouble will be able to get the funds that they need.[52] Without the existence of these connections between U.S. industry and financial institutions, some highly leveraged or financially troubled U.S. firms are unable to obtain needed funds.

The type of project financed is another factor that can affect the cost of capital. Generally, costs are higher for items with an uncertain return, such as research and development, or for items with a short useful life. Land and plant have the longest expected lives and, consequently, the lowest cost of capital. In 1988, the Federal Reserve Bank of New York estimated research and development costs of capital in the United States at more than 20 percent and that of land, plant, and equipment to be between 10 and 12 percent. The same costs in Japan were estimated at 9 percent and between 5 and 7 percent, respectively. West German companies' costs were somewhat higher than those of Japan but significantly lower than those of the United States.[53]

Investment Policy

Firms can choose between internal and external sources of capital for their financing needs. Smaller companies tend to rely more heavily on outside sources. The U.S. gear industry is made up largely of small- to medium-size firms which lack the resources needed for internal financing and access to large external pools of capital. During the 1980s, the U.S. gear industry had low profit margins, leading to relatively small pools of retained earnings.[54] As a result, many U.S. gear producers

[51] *Federal Reserve Bank of New York Quarterly Review*, "Explaining International Differences in the Cost of Capital," Summer 1989, p. 20.

[52] Ibid., pp. 20–22.
[53] Ibid., p. 16.
[54] AGMA, posthearing submission, Nov. 15, 1989, p. 33.

Table 7-7
Interest rates: Bank lending rates and inflation rates (as measured by the GNP deflator) for major producing nations of gearing, 1984–88

(In percent)

Item	*United States*	*West Germany*	*Japan*	*Italy*	*France*	*United Kingdom*	*Belgium*	*Canada*
				Banking lending rate				
1984	12.0	9.8	6.7	22.2	18.9	9.7	14.0	12.1
1985	9.9	9.5	6.5	18.2	17.8	12.3	12.5	10.6
1986	8.4	8.8	5.9	14.6	16.4	10.8	10.4	10.5
1987	8.2	8.4	5.0	13.6	15.8	9.6	9.3	9.5
1988	9.3	8.3	4.9	13.6	15.7	10.3	8.9	10.8
Average	9.6	9.0	5.8	16.4	16.9	10.5	11.0	10.7
				Inflation rate				
1984	4.0	2.0	1.2	8.9	7.4	4.6	5.2	3.1
1985	2.8	2.2	1.5	8.7	5.8	5.7	5.8	3.0
1986	2.7	3.1	1.7	7.5	5.1	3.5	3.4	2.5
1987	3.3	2.0	-0.2	6.1	2.9	4.7	1.9	4.4
1988	3.4	1.5	0.4	6.0	3.1	6.6	1.2	4.2
Average	3.2	2.2	0.9	7.4	4.9	5.0	3.5	3.4

Source: International Monetary Fund, *International Financial Statistics*, various issues.

cannot rely on internally generated funds to finance equipment purchases and must resort to borrowing from regional U.S. banks often at several percentage points above the prevailing prime rate or issuing securities. However, European producers generally rely on internal funds or borrow from larger European banks that can obtain capital in the European financial markets. Japanese firms have had strong relationships with the large banks that are prominent in Japan's large industrial groupings, and capital may be loaned at preferential rates.

Major gear-producing nations also differ in their planning horizon for return on investment. This is influenced by a number of factors, including the savings rate and government policies. In the United States and the United Kingdom, investors focus on short-term profit and therefore are less willing to wait for long-term returns on investments. At the other extreme are Japan and West Germany, where investors accept longer horizons for returns.[55,56]

Other Comparative Factors

Other factors that affect the competitiveness of U.S. producers are product liability, investment in new machinery, and manufacturing methods. These factors affect a company's cost structure, and therefore its ability to compete in the marketplace.

Product Liability

EC gear producers have a comparative advantage over U.S. firms in the area of product liability insurance. EC rates are negotiated on an industry-wide basis, generally resulting in more favorable rates to producers. Product liability disputes are usually settled by negotiation rather than litigation, and judges, not juries, decide compensation amounts. In the United States, manufacturers must purchase expensive product liability insurance policies which offer relatively little protection against large jury awards. According to industry sources,[57] these differences help explain why U.S. firms, especially smaller-sized producers, are not able to compete favorably in global markets.

New Machinery Investment

The U.S. industry is lagging in competitiveness with respect to the application of new and technologically advanced machinery. The use of such machinery boosts productivity, but since 1986, tax incentives for purchasing new equipment have been reduced and equipment prices have increased.[58] The advantages of using new machinery, both machine tools and automated material-handling devices, are numerous. Benefits resulting from investing in modern machine tools include: (1) reduced maintenance; (2) shorter cycle times, i.e., workpieces can be machined more quickly;[59] (3) better accuracy resulting in less scrap; (4) quicker setup times due to computer-controlled or pre-programmed machining sequences; and (5) computer-controlled or preprogrammed machine maintenance and operation diagnostics.

Because new machinery has such time-saving and quality control features, other benefits are forthcoming to the user. Productivity is increased and, according to industry sources, such increases range from 35 to 100 percent.[60] Officials of the VDMA report that using CBN cutting and/or grinding can reduce cycle times by 20 percent or more.[61] In another instance, one respondent to the Commission's producers' questionnaire reported a drop in part defects from 15 to 5 parts per 100 by using computer controlled machine tools.

Sales promotion and worker relations are also enhanced by the firm's commitment to invest in modern machinery. Potential customers' confidence in the gear producer is enhanced by such investments. The new equipment will allow the gear producer to solicit and attempt higher paying jobs that other gear producers may not be equipped to pursue, and also allow the gear producer to meet customers' ever-increasing demands for zero defects and just-in-time supply deliveries. Workers exposed to new machinery increase their skills, and a strong reinvestment plan shows that management is committed to business.

In order to remain competitive, firms in the gear industry must also invest in other types of modern machinery used in gear production. Aside from machine tools, up-to-date heat treatment machinery, furnaces, and material-handling devices and robots are becoming common. Trends in consumption of certain key gear-cutting and -finishing machine tools for selected gearing-producing countries during 1980–88 are presented in table 7–8.[62] In terms of value, apparent consumption in West Germany almost doubled between 1985 and 1986 and rose by 24 percent between 1986 and 1987. In Japan, the value of consumption rose by more than 40 percent between 1985 and 1986. U.S. industry sources indicate that U.S. gear producers have been investing in lathes and machining centers, rather than the expensive specialized gear-making machine tools. Other industry sources indicate that the upward trend in consumption of gear-making tools is continuing in

[55] USITC staff interviews with gear industry officials, the United Kingdom and West Germany, November 1989.
[56] Transcript of public hearing, Nov. 1, 1989, p. 70.
[57] Data submitted in response to questionnaires of the U.S. International Trade Commission.
[58] USITC staff interviews with gear making machine tool manufacturers and purchasers, August 1989.

[59] Shorter cycle times are the result of higher machining speeds, faster cutting tool feed rates into the workpiece material, and faster machine tool setup times.
[60] USITC interviews with U.S., European, and Japanese gear producers and machine tool builders, November–December 1989.
[61] VDMA written response to USITC staff questions, Dec. 12, 1989, p. 3. See also Dr. G. Sulzer, "Economics of CNC Gear Hobbing," *Gear Technology*, March–April 1987, pp. 42–46.
[62] Because of the long machine life, particularly for those used in the United States, this time series begins in 1980.

Table 7-8

Gear-making machine tools: Apparent consumption[1] for selected gearing producing countries, 1980-88

Year	United States	West Germany	Japan	Italy	France[2]
	Quantity (units)				
1980	918	421	1,178	438	52
1981	644	584	1,376	368	99
1982	505	499	892	424	30
1983	117	328	616	496	23
1984	379	161	875	548	121
1985	(3)	459	1,028	754	(3)
1986	617	654	861	780	66
1987	725	533	429	1,273	-33
1988	627	343	728	499	[4]256
	Value (million dollars)				
1980	113.2	74.8	86.1	44.7	9.4
1981	94.4	69.2	110.2	39.4	17.4
1982	76.1	61.6	75.1	26.0	6.7
1983	18.3	55.9	40.7	19.4	3.3
1984	37.9	49.1	53.2	19.2	3.4
1985	52.5	69.5	74.0	16.5	2.2
1986	54.5	128.9	106.8	33.2	8.8
1987	63.1	160.0	61.3	50.0	11.1
1988	56.0	135.3	133.1	46.4	22.3

[1] Apparent consumption data understate the value of gear-making machine tools, because trade figures exclude cost, insurance, freight, and also parts that may be shipped separately.
[2] France has no domestic gear-making machine tool production; therefore, imports minus exports are assumed to equal comsumption.
[3] Official statistics appear to be in error and make such a calaulation unreliable.
[4] Because France adopted the Harmonized System for trade statistics in 1988, consumption data may be based on a broader category than in prior years.

Source: Estimated by the staff of the U.S. International Trade Commission, based on data from various editions of the *Economic Handbook of the Machine Tool Industry*, National Machine Tool Builders Association; *Eurostat*; and machine tool industry sources.

West Germany, Japan, Italy, and France. In 1988, gear-making machine tool consumption in Korea totaled $45.8 million, nearly equal to that of Italy. The level of consumption in Taiwan, an emerging producer of gearing, was only $6.4 million in 1988.

Age of Machinery

Compared with Japanese and West German producers, U.S. gear producers have a much lower percentage of gear-making machine tools that are less than 10 years old. The following tabulation compares the share of gear cutting and finishing machine tools by age for the United States and Japan (in percent):[63]

Age	Country/survey year: United States 1989	Japan 1987
0 to 4 years	4.6	15.9
5 to 9 years	7.1	21.6
over 10 years	88.3	62.5

[63] Based on data from Ministry of International Trade and Industry's (MITI's) statistical survey of Japan's machine tool inventory undertaken in September 1987, and summarized in "Trends in Machine Tool Inventory Over Past Seven Surveys," *Metalworking Engineering and Marketing*, November 1988, pp. 128–135.

According to officials of VDMA, it is not the average age of the total machinery that is important, "but the age of the *key* machinery in gear manufacturing—cutting, grinding, milling machinery; measurement devices, heat treatment equipment."[64] The VDMA estimates that the average age of these key machines in the West German gear industry is less than 10 years old. Key gear-making machinery in Korea and Taiwan is much newer than that in the United States. In Taiwan, most machinery is less than 10 years old,[65] and in Korea, less than 4 years old.[66] Investment by U.K. and French gear producers is not as great as that of West Germany or Italy. Gear producers tend to use older machines for dedicated operations, thereby reducing the need for substantial new investment. However, new machines are used as much as possible in order to maximize the return on investment.[67]

[64] VDMA written response to USITC staff questions, Dec. 12, 1989, p. 3.
[65] American Institute in Taiwan Airgram, 1989, Taipei, Message Reference No. 08035.
[66] USITC staff plant visits in Korea, Dec. 14, 1989. See also appendix E.
[67] USITC staff interviews with gear industry officials, the United Kingdom, Nov. 1989

Trends

U.S. and foreign gear-making machine tool builders selling in the U.S. market indicate that the U.S. industry is slow to adopt leading edge technology machinery. These sources cite as an explanation the short-term management outlook, lack of tax incentives, high debt loads, and pressure for frequent cost reductions common among U.S. producers. Even when machine tool builders have presented justified return on investment (ROI) scenarios to potential U.S. customers, they have resisted investment.

Trends in the adoption and utilization of machinery are apparent in West Germany, Japan, and other countries. In West Germany and Italy, the trend among gear producers is toward further automation in the manufacturing processes, including use of computer-aided-design (CAD), computer-integrated-manufacturing (CIM), upgrades to numerically controlled (NC) and computer-numerically controlled (CNC) machinery, and flexible manufacturing technology.[68]

Japanese producers are increasing investments in heat treatment furnaces, CNC and NC milling, hobbing, and grinding machinery, and inspection machinery and equipment. Japanese producers are also expanding the use of automated material handling between workstations in the machining, heat treatment, and assembly areas. Many of the machine tools have automatic loading and unloading devices and pallets so the machine tool can be loaded for practically unattended continuous operation. The capability of Japanese producers to develop machinery and machine tools varies among companies. Japanese automotive gear producers work with their material-handling machinery and robot suppliers to develop systems that perform dangerous jobs or that can reduce labor costs.[69]

In Korea, the leading firms are influenced in their manufacturing operations by their Japanese or U.S. partners in either licensing or original-equipment-manufacturer supplier relationships.[70] The leading Korean firms are also developing the capability to produce machinery, either for gear cutting or transmission assembly in-house. For instance, Tong Il, a transmission supplier, and Jeil Machine Co. Ltd. not only produce gears, but also produce CNC gear hobbing machine tools for sale on the open market. Also, Kia Machine Tool Co., Ltd. produces not only transmissions, drive axles, and steering gear for Kia Motors—the second-largest automotive producer in Korea—but produces machine tools used in its factories[71]

Manufacturing Methods

The use of certain manufacturing methods frequently improves the efficiency of manufacturing operations and the resulting quality of a product. The design of a product, both from an applications and manufacturability standpoint, can significantly influence unit costs. Many European gear manufacturers produce modular type products that come in a variety of sizes and can easily be customized to the user's application. In comparison, European producers characterize the U.S. standardized product as a catalog product; customers must choose the appropriate model. Some European producers, U.S. producers, and U.S. distributors claim that U.S. product design is one reason why U.S. producers have not successfully met customers' needs. For both the modular and standard product, producers must be able to carry significant inventories in order to offer timely delivery to customers.[72]

Most gear producers, both U.S. and foreign, are moving toward smaller lot sizes to reduce work-in-process inventories and hence reduce manufacturing costs. U.S. and foreign gear manufacturers are adopting a variety of manufacturing management techniques to reduce production time, manage work-in-process inventories, and raise quality. These techniques include Just-In-Time (JIT), Material Requirements Planning II (MRP II), Statistical Process Control (SPC), and Total Quality Commitment (TQC).[73]

U.S. Producers' Strategies in Response to Market Competition

A number of U.S. gear producers have taken steps to enhance their international competitiveness. According to data gathered by the Commission's questionnaires, U.S. producers pursued a variety of market strategies (table 7-9). The most frequent responses focused on developing niche markets, lowering or suppressing

[68] USITC staff interviews with gear industry officials, West Germany and Italy, November 1989.
[69] USITC staff interviews with gear industry officials, Japan, Dec. 4-11, 1989.
[70] USITC staff interviews with gear industry officials, Korea, Dec. 13-15, 1989.
[71] Kia Machine Tool Automobile Division brochure, 1989.
[72] USITC staff interviews with officials of Sumitomo Corp., November and December 1989, and SEW-Eurodrive, August 1989.
[73] See app. H.

Table 7-9

Gears and gearing: Responses from 132 U.S. establishments producing gears and gearing regarding their strategies for responding to competition in the U.S. market for imported and U.S.-assembled foreign-brand gearing, 1984-89

Nature of response	*Gears and gearing*
Took no or few actions because the firm—	
Had already shifted production to more advanced types of related products	16
Had already shifted production to other product lines	4
Lacked capital funds to counter foreign competition	26
Other reasons	26
Took the following actions:	
Lowered or suppressed prices to maintain market share	68
Reduced or dropped plans to expand capacity	28
Cut back production	22
Closed production lines or manufacturing plants	12
Shifted to more advanced types of related products	28
Reduced leadtimes	65
Increased dealer/distributor network	33
Focused on niche markets	80
Imported product	10
Opened a plant to manufacture abroad	3
Other action	22

Source: Compiled from data submitted in response to questionnaires of the U.S. International Trade Commission.

prices to maintain market share, and reducing leadtimes for deliveries. Other frequently mentioned efforts included increasing their dealer/distributor networks, reducing or dropping plans to expand capacity, shifting to more advanced types of related products, and cutting back production. Firms that took few or no actions did so principally because they lacked capital funds to counter foreign competition and/or had already shifted production to other lines of related products.

Chapter 8
U.S. and Foreign Industry and U.S. Consuming Industry Views on Market Direction and Potential for the U.S. Industry

In the course of this investigation, the Commission staff gathered views and opinions of U.S. and foreign gear producers, distributors, trade association representatives, and government officials concerning U.S. market direction and potential. The information has been obtained from responses to questionnaires, public hearings, and interviews.

Financing

It has been observed that the future of the U.S. gear industry lies in access to the capital required to upgrade equipment and facilities.[1] Domestic gear producers acknowledge that the installation of automated manufacturing methods is one in a series of steps required to improve industrial productivity in an industry where labor inputs are relatively expensive. They frequently cite foreign firms' lower costs of capital as a chief source of competitive advantage. They believe that capital costs are lower, in part, because of the relationships, so-called "interlocking directorates," foreign companies have with their banks. These are common in West Germany and Japan, but are prohibited by U.S. law and regulation. As a result, competitors have access to capital at a fraction of the cost available to U.S. companies.[2] Foreign banks, they feel, demonstrate greater support for their countries' industrial base. According to gear producers, this industry suffers from a scarcity of capital at a reasonable cost because returns on investment in this industry are achieved over the longer term, and investors in the United States generally focus on short-term profitability.[3] In contrast, foreign manufacturers are willing to wait longer for returns on investment.[4]

Government policies are often blamed for inhibiting U.S. firms' ability to invest in machinery and equipment. One industry representative cited the United States' poor showing in the results of a National Association of Manufacturers study comparing capital formation policies here and abroad. Some producers support government intervention to lower interest rates, whereas others favor government assistance in machinery and equipment purchases. Others in the U.S. industry have alleged that subsidies are available to foreign manufacturers from their governments. For example, one U.S. manufacturer testified that the purchase of a machine by a Taiwanese firm was subsidized 50 percent by its government.[5]

[1] Transcript of public hearing, Nov. 1, 1989, p. 70.
[2] Ibid., p. 28.
[3] Ibid., p. 70.
[4] Ibid., p. 57.
[5] Ibid., p. 24.

Many producers support revision of current tax laws. The enactment of more accelerated depreciation schedules and reinstatement of investment tax credits were frequently mentioned by gear producers surveyed, as was lowering the capital gains tax.[6] According to industry officials, European manufacturers could depreciate large machinery purchases over just a few years, whereas machines bought by U.S. manufacturers were outdated before they were fully depreciated.

Since 1982, there has been a pattern of divestiture by large companies of marginal or unprofitable gear operations. These operations have been left thinly capitalized.[7] Frequently, leveraged buy-outs have been led by individuals or small groups of managers and have been financed by borrowing against company assets. Although there are no statistics on the performance of these endeavors, industry representatives point to the potential danger for these firms of carrying huge debt loads in the event of an economic downturn, when required cash flows could be limited.[8]

Foreign Outsourcing

U.S. gear manufacturers claim that they have been harmed by private firm and the Department of Defense (Defense) decisions to purchase foreign components. In some cases, U.S. gear consumers may decide to become worldwide purchasers; they might believe they are getting a technologically better product, or may buy from foreign sources as a result of reciprocating agreements.[9] Industry sources are more distressed by current Defense policies which allow increased sourcing from foreign firms. Many have voiced support for implementation and strict enforcement of "Buy America" programs in defense procurement. One gear manufacturer surveyed suggested that the government consider prohibiting prime contractors from purchasing gears from foreign sources. The American Gear Manufacturers Association (AGMA) estimates that approximately 25 percent of Defense's entire sourcing for gearing is foreign.[10]

Some U.S. producers believe that Defense's practice of purchasing on the basis of initial bid price, as opposed to life cycle cost of the product, is eroding the U.S. defense industrial base.[11] These same sources also believe that U.S. defense weapons systems are increasingly dependent upon foreign gears and gear products. U.S. gear manufacturers state that they have seen examples of defense prime contractors buying gear products from foreign sources, sometimes as the result of offset agreements and other times because of price, even

[6] Ibid., p. 58.
[7] Ibid., p. 54.
[8] Ibid., p. 75.
[9] Ibid., p. 73.
[10] Ibid., p. 93.
[11] Statement before the U.S. House of Representatives, Committee on Banking, Finance and Urban Affairs, Subcommittee on Economic Stabilization by the American Gear Manufacturers Association, May 17, 1989, p. 3.

with the decrease in the value of the dollar relative to currencies of major U.S. trading partners.[12] In the case of offset agreements, U.S. producers are not even given a chance to bid in the competition. Without that business, they claim, they cannot make the profits that allow them to invest in the hardware or the skilled labor necessary to compete in the commercial defense markets.[13]

U.S. producers claim that they frequently purchase modern machinery in anticipation of winning a contract, in order to qualify for the bid, or during the initial contract for prototype work, only to see the contract awarded to a foreign firm. The investment in machinery then becomes a financial burden.[14] Another harmful practice, according to industry sources, has been Defense's practice of sending staff to tour West German gear manufacturers and universities to get the "latest word" on gear technology—technology that, U.S. manufacturers claim, is available in the United States.[15]

Product Classification

Gear industry officials and analysts frequently cite the difficulty they encounter in determining the level of imports of gears and gear products under the current classification systems. Activity in the industry, they claim, is not clearly defined by the Standard Industrial Code (SIC) and the Harmonized System codes that include many other products in the categories in which gears are classified.[16], [17] Another major shortfall is in the coverage of captive gear production in the automobile and other industries, a huge part of the gear industry not adequately covered by current classification systems.

Further, the differences between United States and Canadian trade classification codes is a source of confusion. U.S. gear manufacturers hope that this can be resolved; Canadian producers apparently share their concern about accurately measuring imports from, and transshipments through, Canada into the United States.[18]

Foreign Investment in the United States

Foreign gear manufacturers have developed a presence in the United States, but, generally, it has not been by investment in existing U.S. production facilities. According to U.S. industry sources, foreign producers have instead chosen either to "greenfield," building new facilities employing machinery and equipment to which they are accustomed, or they have entered the market by working through distributors, intending to establish manufacturing capabilities later.[19] Some industry sources believe that foreign firms do not want to buy U.S. manufacturers' "old" equipment, and therefore have not taken advantage of opportunities to purchase financially troubled U.S. manufacturers.[20] Foreign automobile manufacturers have also set up production facilities in the United States. However, these manufacturers generally purchase gears from sources in their home country.[21]

U.S. Gear Producers' Foreign Activities

U.S. gear manufacturers have entered into licensing agreements with foreign firms to sell imports in the United States and to sell U.S. products overseas. A limited number of these companies export directly or sell to original equipment manufacturers (OEMs), who in turn export. Many U.S. gear producers feel they lack the financial strength to become involved in partnerships or to establish wholly owned foreign subsidiaries.[22] Producers report that profit margins on exports, less transportation costs, are about equal to those in the United States. Some have felt compelled to export in recent years to maintain their production levels, in light of the decrease in the domestic market due to defense cutbacks.[23] They believe that some foreign markets have opened to them because of favorable exchange rate movements.[24] Others have suggested that tax incentives for exporting, such as reducing the taxes on export profits, would increase their chances of success in competing in the global market.

Firm Size

U.S. gear producers claim that foreign competitors are generally much larger and better capitalized. Consequently, such firms base their marketing strategies on market share, not short-term profits.[25] Industry representatives cannot readily explain why, if greater size would confer advantages, small U.S. firms have not merged. Diversity of end markets was offered as one possible reason.[26] Industry representatives are encouraged by recent changes in anti-trust laws[27] that will allow collaboration among rival domestic manufacturers by permitting them to merge their assets in order to work together to develop new technologies without endangering their domestic competitive stances.

When asked about the optimal size for a firm capable of competing against larger foreign firms and achieving economies of scale, one

[12] Ibid., p. 3.
[13] Transcript, p. 25.
[14] Statement, May 17, 1989, p. 9.
[15] Transcript, p. 35.
[16] Ibid., p. 18.
[17] A listing of Harmonized System headings and subheadings that include gears is in app. F.
[18] Transcript, p. 87.

[19] Ibid., p. 39.
[20] Ibid., p. 73.
[21] Ibid., p. 90.
[22] Ibid., p. 40.
[23] Ibid., p. 76.
[24] Ibid., p. 95.
[25] Ibid., p. 19.
[26] Ibid., p. 52.
[27] Borden, Donald, "An Invitation To Be A Champion," *Gear Technology*, November/December 1988, p. 7.

industry representative estimated that a firm would need to achieve between $200 million and $500 million in sales—substantially larger than the average U.S. gear manufacturer—to finance the needed capital equipment and marketing expenditures.[28] This representative also stated that the U.S. gear industry currently has no defense surge capability and that the time required to develop this capacity in the event of a national emergency would be much longer than would be acceptable.[29]

Labor

U.S. gear manufacturers report difficulties in finding and retaining skilled laborers. Existing training programs are described as inadequate and outdated. Some firms hire graduates of local technical high schools or community colleges and train them in-house. Small- and medium-sized firms have indicated that frequently they train new entrants to the work force, only to see those employees leave for higher paying jobs at larger firms.[30] Many firms have developed their own training programs, some of which are quite extensive, but without financial support from the U.S. Government. On the other hand, their European and Japanese competitors' receive financial or other assistance for training programs from their governments.[31] Some U.S. firms have stated that tax incentives or direct government funding would lessen the burden of providing training programs.

Further, U.S. sources cite foreign educational systems as an advantage for their competitors and support increased U.S. government funding for vocational education. In West Germany, for example, the early choice of vocational career paths and subsequent apprenticeship programs create a broad base of skilled machinists. However, while training and vocational education programs may receive more government support abroad, foreign gear manufacturers report labor shortages similar to those encountered by U.S. producers. Western European sources state that the machinist and engineering trades are considered low-status occupations, and young people who are mechanically inclined are not encouraged to enter those fields.[32] In Japan, gear manufacturers claim that university graduates do not want to work in engineering positions in the factories, and this makes it especially difficult for relatively small industries, like the gear sector, to attract essential employees.[33] Other young Japanese perceive factories as dirty work environments and alternatively look to the service sector for employment.

Comparisons are frequently made between the productivity of U.S. workers and those in other countries. One visitor to a small, family-owned Japanese gear maker was impressed by the skill and dedication of its workforce. The workers were making production-related calculations at their workstations, and had apparently been working extra hours to help the firm catch up with its order backlog.[34] In response to that account, one U.S. producer reported that he would gladly match his operators against any seen in the Japanese plant, adding that his most dedicated operators were first-generation Europeans. Another mentioned that about one-half of his workers demonstrate a strong work ethic, desiring to improve skills through regular refresher training sessions. Further, he noted lower dedication from workers in plants near major cities. Finally, another producer suggested that his firm's relationship with its union prevented the assignment of greater responsibilities to current workers.[35]

International Competition

U.S. gear producers frequently cite examples of foreign firms' extremely low prices as evidence of possible unfair competition. Manufacturers responding to the Commission's questionnaire came out heavily in favor of government intervention to insure a "level field" for global competition, mainly through strict policing of suspected dumping activities. Although U.S. gear manufacturers put forth no verifiable evidence, they cite examples of enormous price disparities between U.S.- and foreign-produced gear products; price differences which, they say, cannot be explained by disparities in the level of technology.[36] Examples are drawn from a wide range of end markets, including steel processing, material handling, power generation, and water treatment.[37] U.S. producers claim that foreign competitors somehow maintain low prices and large market share, even in the face of unfavorable exchange rates. One manufacturer cited less restrictive government regulations as a source of competitive advantage for his foreign competitors. In particular, he mentioned the harmful effect on his business of export restrictions to the Soviet Union and the existence of interlocking directorates between foreign firms and their banks, a relationship that could not exist in the U.S. regulatory framework.[38] Some U.S. gear manufacturers surveyed favored reciprocal trade agreements, allowing countries to export their

[28] Transcript, p. 100.
[29] Ibid., p. 101.
[30] USITC staff interviews with U.S. gear producers, August-September 1989.
[31] Transcript, p. 25
[32] USITC staff interviews with gear industry officials, the United Kingdom, France, West Germany, and Italy, November-December 1989.
[33] USITC staff interviews with gear industry officials, Japan, December 1989.

[34] Transcript, p. 62.
[35] Ibid., pp. 62-64.
[36] Ibid., p. 60.
[37] Ibid., pp. 21-23.
[38] Ibid., p. 28.

goods to the United States only if U.S. exports were allowed into their markets. Others supported matching foreign countries' tariffs on imports of gear products.

Product Liability and Standards

The costs associated with product liability have been suggested as a possible source of the difference in return on investment between U.S. and foreign manufacturers, and many U.S. manufacturers are in favor of government intervention to reduce the burden of product liability laws. One gear industry official stated that, in the United States, if a product fails because of flaws in design or manufacture, very often the case ends up in court. U.S. manufacturers buy product liability insurance to protect themselves against this. However, these policies, while expensive, provide only partial coverage of the costs of legal defense. In contrast, he said, the members of the European Community (EC) are debating the necessity of having any product liability laws. Those currently in place are weaker than those in the United States and are rarely implemented.[39]

According to an industry official, U.S. gear producers manufacture their products to heavier design standards to protect themselves against potential product liability problems that might result from a break down of lighter weight parts.[40] In the opinion of one industry official, U.S. gear standards result in a heavier and more durable product, while European standards result in a lighter, smaller, and less expensive product. Lighter products perform well in stationary applications; however, in higher stress applications, such as helicopters, windmills, and coal mining, heavier products are required.

Presently, there is concern over the future direction of international and European gear standards. A number of U.S. and European gear producers have expressed concern regarding the establishment of standards for the European Committee on Standardization (CEN). Gear industry officials noted that West Germans are chairmen of many of the CEN engineering committees and thus have strong influence over committee decisions.[41] However, a Belgian has been designated as chairman for CEN's gearing committee. The AGMA is concerned that the EC may include in its gear standards certain material or certification requirements, such as European gear body analysis testing, which favor European goods.[42]

In mid-1989, the EC and the U.S. Secretary of Commerce issued a Joint Communique that announced a commitment to the work of the international standardization bodies and to the principle of transparency in standardization.[43] In July 1989, a delegation of the American National Standards Institute (ANSI) met with counterpart private sector European organizations of CEN to discuss a number of standards issues, including the need for ANSI and CEN to exchange, on a continuous basis, the best available information on work plans for standards developers.[44]

Technology

It is claimed that the U.S. gear industry is disadvantaged in two ways with regard to technology. First, most of the world's machine tool producers are either European or Japanese. Gear manufacturers in those countries have been able to experiment with and implement the latest in machine tool technology more readily than manufacturers in other countries. As a result, many new developments in gear manufacturing have historically come into widespread use in Europe and Japan before being adopted in the United States. This lag in the placement of the latest machine tool technology has hurt U.S. gear manufacturers, industry sources say. Second, foreign governments' support of research and development efforts, particularly at the university level, far outpaces that of the U.S. Government. As a result, producers maintain, most of the research conducted in the United States is proprietary and oriented toward internal applications, whereas European manufacturers share the benefits of government-sponsored research.[45] The profit base in the U.S. gear industry, they claim, does not provide the financial backing necessary for basic research and development efforts and most companies are too small to conduct research on their own.[46] Many of those surveyed favored either tax credits or direct Government funding of research and development efforts.

The U.S. Government, through the Defense Logistics Agency, recently awarded funding for the establishment of an instrumented factory (INFAC) that will conduct research on gear-manufacturing techniques and processes. But, according to one industry official, the funding for this project is only a fraction of that available to foreign research centers engaging in basic research.[47] While some are optimistic that the INFAC research will focus on the practical needs of the U.S. gear industry, others fear that the solutions generated will require state-of-the-art manufacturing equipment that is too expensive for most domestic producers.[48]

[39] Ibid., p. 79.
[40] Ibid., pp. 87–88.
[41] USITC staff interviews with gear industry officials, the United Kingdom and West Germany, November–December 1989.
[42] AGMA, post-hearing submission, Nov. 15, 1989, p. 26.

[43] Joint Communique, May 31, 1989.
[44] *ANSI Global Standardization News*, September 1989, p. 7.
[45] Transcript, p. 33.
[46] Ibid., pp. 37–38.
[47] Ibid., p. 38.
[48] Ibid., p. 98.

Government Regulation

While requesting government aid and intervention on some issues, there are also several areas in which U.S. gear manufacturers feel burdened by government involvement. Indeed, some felt that the government should stay out of business entirely. Problem areas mentioned include workmen's compensation and mandatory disability benefits, as well as product liability laws and environmental regulations. Some manufacturers supplying Defense suggested that the procurement process and its extensive regulations tend to discourage attempts to participate in that market. One firm complained that the military's acquisition of rights to data constrains the incentive to pursue military contracts.

EC 1992

According to U.S. gear industry officials, European gear manufacturers predict that the number of European gear companies may decline by as much as 50 percent by the beginning of 1993 without a corresponding decline in production capacity. Mergers and acquisitions have already begun in Europe, and large firms have been created. These firms have the capacity to satisfy not only the European market, but also Third World markets.[49] European gear manufacturers interviewed by Commission staff downplayed the role of EC 1992 as a cause of recent mergers in the European gear industry. They stated that these transactions were part of a larger restructuring of industry to adapt to current economic conditions and took place largely because they made good business sense.[50]

According to U.S. industry representatives, some Europeans are concerned about entering unstable Third World markets, fearing that they will be left with excess capacity if these markets collapse. U.S. gear producers worry that European producers' attention may then turn to the United States, the world's single largest market. U.S. representatives are also concerned about the domestic content and defense procurement procedures that are coming out of the EC 1992 directives. They fear that access to the EC market will be closed to those U.S. firms that do not already have a presence there.[51]

Distributors' Comments

When asked what actions U.S. gear producers should take to improve their competitive position, distributors made suggestions covering a wide range of areas. The greatest number of comments were related to quality improvement. Employee training, just-in-time scheduling, and statistical process control techniques were suggested, as was the importance of a demonstrated commitment to quality concepts. In connection with this, manufacturers were urged to continually update their equipment, developing high tech manufacturing capacity to improve efficiency and reduce costs. Delivery time and product availability demand attention. According to distributors, current lead times are unacceptable; complete product lines, they stated, should be available with shorter delivery lead times.[52]

Major foreign manufacturers have supplanted domestic producers in some gear categories by supplying technologically advanced gear products at a lower cost. Independent U.S. gear distributors indicated that imports were able to gain a foothold in the U.S. market because of the appearance of multibranch national distributor chains that purchase gears in bulk at prices well below those available to independent distributors. In order to remain competitive with the multinational chains, independents began to import price-competitive gears from Western Europe and Japan. With the advent of the chains, according to the independent distributors, the bond of loyalty between domestic producers and independents was also lessened because of U.S. producers' fears of increased import competition.[53]

U.S. distributors believe that if U.S. gear manufacturers are going to retain their market share, they must develop products that are competitive in terms of technology and price, must increase communication with domestic customers, and must develop export marketing networks. Distributors suggested that manufacturers should also take steps, such as evaluating production costs and design factors, to reduce prices. Increased research and product development were recommended, focusing in particular on improved horsepower and torque ratings per unit and innovative gear design technologies. Distributors urged U.S. producers to compete more aggressively in the world market and to fight "for equal import/export duties and against subsidizers." They advised U.S. producers to stress their products' dependability when competing with low priced imports, and to explore export opportunities.[54]

Original Equipment Manufacturers' Views

U.S. OEM consumers of gearing have differing perspectives on the U.S. market. OEMs, with the exception of aerospace producers, tend to be cost driven in producing or purchasing gearing. These consumers, many with captive establishments,

[49] Ibid., pp. 48–49.
[50] USITC staff interviews with gear industry officials, West Germany and Italy, November–December 1989.
[51] Transcript, pp. 48–49.
[52] Data submitted in response to USITC questionnaires.
[53] USITC staff telephone interviews with U.S. distributors, July 1989.
[54] Data submitted in response to USITC questionnaires.

produce or purchase gears and gear products depending on factors such as cost, the development of international joint ventures, or global rationalization of production. Aerospace gear consumers place more emphasis on the technology and reliability of the gears and gear products they consume, since any failure of these products could cost the firm millions of dollars in possible lawsuits and lost future sales. However, given equal technology, aerospace producers will also make a purchase decision based on price or as the result of offset obligations linked to foreign sales.[55]

[55] USITC staff interviews with U.S. aerospace gear producers, August and November, 1989.

APPENDIX A
LETTER TO ACTING CHAIRMAN BRUNSDALE FROM THE UNITED STATES TRADE REPRESENTATIVE

THE UNITED STATES TRADE REPRESENTATIVE
Executive Office of the President
Washington, D.C. 20506

March 22, 1989

The Honorable Anne Brunsdale
Acting Chairman
U.S. International Trade Commission
500 E Street, S.W.
Washington, D.C. 20436

Dear Madame Chairman:

The U.S. gear manufacturing industry produces components that are essential to most industrial and transportation equipment. The industry, which has experienced a dramatic increase in imports since 1983, is unable to assess properly its trade concerns because U.S. government and private data on the industry's production and trade composition are fragmented and incomplete. The American Gear Manufacturers Association has formally requested assistance providing the industry with a comprehensive set of objective data.

Pursuant to Section 332(g) of the Tariff Act of 1930, I request that the U.S. International Trade Commission conduct an investigation and prepare a report on the competitive position of the U.S. gear industry in U.S. and global markets.

Specifically, the Commission report should provide to the extent possible the following:

- Profiles of the U.S. industry and major foreign industries;

- A descriptive assessment of the global market for gears, to the extent possible, using categories of gear products most useful to the industry;

- A comparison of U.S. and foreign producers' strengths and weaknesses in such areas as: (1) raw material, labor, and capital availability; (2) technological capabilities; (3) extent of plant and equipment modernization; (4) end-product quality, pricing, and service support; and government involvement.

- U.S. and foreign industry and U.S. consuming industry views on market direction and potential for the U.S. industry.

The Commission should provide its completed report no later than 12 months from receipt of this request.

I understand that Defense Department agencies, led by the Navy, have asked the U.S. Department of Commerce to conduct a study with respect to the gear industry under section 705 of the Defense Production Act of 1950, as amended (50 U.S.C. App. 2155). In this study, Commerce will be required to collect and analyze certain data identical to that which the Commission will be required to collect in the section 332 study as well as certain additional data.

To minimize the burden placed on industry in supplying data to the Government, the Office of Management and Budget, acting pursuant to its authority under the Paperwork Reduction Act, has indicated that the information should be requested of industry respondents through a single survey. Since the Commerce study requires that questionnaires be sent only to U.S. gearmakers, whereas the section 332 study has a broader scope and will query other groups in addition to the U.S. gearmakers, the section 332 questionnaire should be designed to gather what additional information is needed for the Commerce study.

Accordingly, we ask that your office work with appropriate officials of the Department of Commerce in the development of portions of the questionnaire that will pertain to Commerce's responsibilities. When you have assembled this data it should be transmitted directly to Commerce in a mutually agreeable form along with whatever data gathered in response to our section 332 request is appropriate.

In accordance with USTR policy as set forth in my letter to you on February 16, I direct you to mark as "confidential" such portions of the Commission's report and its working papers as my Office will identify in a classification guide. Information Security Oversight Office Directive No. 1, (sections 2001.2 and 21, implementing Executive Order 12356, sections 2.1 and 2.2.) requires that the classification guides identify or categorize the elements of information which require protection. Accordingly, I request that you provide my Office with an outline of this report as soon as possible. Based on this outline and my Office's knowledge of the information to be covered in the report, a USTR official with original classification authority will provide detailed instructions. The Commission's assistance in this matter is greatly appreciated.

Sincerely,

Carla A. Hills

CAH:mjd
cc: U.S. Department of Commerce

APPENDIX B
NOTICE OF INSTITUTION OF INVESTIGATION NO. 332–275

DATE: The subject DOCD was deemed submitted on April 14, 1989. Comments must be received within 15 days of the publication date of this Notice or 15 days after the Coastal Management Section receives a copy of the plan from the Minerals Management Service.

ADDRESSES: A copy of the subject DOCD is available for public review at the Public Information Office, Gulf of Mexico OCS Region, Minerals Management Service, 1201 Elmwood Park Boulevard, Room 114, New Orleans, Louisiana (Office Hours: 8 a.m. to 4:30 p.m. Monday through Friday). A copy of the DOCD and the accompanying Consistency Certification are also available for public review at the Coastal Management Section Office located on the 10th Floor of the State Lands and Natural Resources Building, 625 North 4th Street, Baton Rouge, Louisiana (Office Hours: 8 a.m. to 4:30 p.m. Monday through Friday). The public may submit comments to the Coastal Management Section, Attention OCS Plans, Post Office Box 44487, Baton Rouge, Louisiana 70805.

FOR FURTHER INFORMATION CONTACT: Michael J. Tolbert: Minerals Management Service, Gulf of Mexico OCS Region, Field Operations, Plans, Platform and Pipeline Section, Exploration/Development Plans Unit; Telephone (504) 736-2867.

SUPPLEMENTARY INFORMATION: The purpose of this Notice is to inform the public, pursuant to Sec. 25 of the OCS Lands Act Amendments of 1978, that the Minerals Management Service is considering approval of the DOCD and that it is available for public review. Additionally, this Notice is to inform the public, pursuant to Section 930.61 of Title 15 of the CFR, that the Coastal Management Section/Louisiana Department of Natural Resources is reviewing the DOCD for consistency with the Louisiana Coastal Resources Program.

Revised rules governing practices and procedures under which the Minerals Management Service makes information contained in DOCDs available to affected States, executives of affected local governments, and other interested parties became effective May 31, 1988 (53 FR 10595).

Those practices and procedures are set out in revised Section 250.34 of Title 30 of the CFR.

Dated: April 17, 1989.

J. Rogers Pearcy,

Regional Director, Gulf of Mexico OCS Region.

[FR Doc. 89-10060 Filed 4-26-89; 8:45 am]

BILLING CODE 4310-MR-M

National Park Service

National Capital Memorial Commission; Meeting

Notice is hereby given in accordance with the Federal Advisory Committee Act that a meeting of the National Capital Memorial Commission will be held on Tuesday, May 2, at 1:30 p.m., in the Executive Conference Room at the National Capital Planning Commission, 1325 G Street, NW., Washington, DC.

The Commission was established by Pub. L. 99-652, for the purpose of advising the Secretary of the Interior or the Administrator of the General Services Administration, depending on which agency has jurisdiction over the lands involved in the matter, on policy and procedures for establishment of (and proposals to establish) commemorative works in the District of Columbia or its environs, as well as such other matters concerning commemorative works in the Nation's Capital as it may deem appropriate. The Commission evaluates each memorial proposal and makes recommendations to the Secretary or the Administrator with respect to appropriateness, site location and design, and serves as an information focal point for those seeking to erect memorials on Federal land in Washington, DC, or its environs.

The members of the Commission are as follows:

James Ridenour, Chairman, Director, National Park Service, Washington, DC.
George M. White, Architect of the Capital, Washington, DC.
Honorable Andrew J. Goodpaster, Chairman, American Battle Monuments Commission, Washington, DC.
J. Carter Brown, Chairman, Commission of Fine Arts, Washington, DC.
Glen Urquhart, Chairman, National Capitol Planning Commission, Washington, DC.
Honorable Marion S. Barry, Jr., Mayor of the District of Columbia, Washington, DC.
John Alderson, Administrator, General Services Administration, Washington, DC.
Honorable Frank Carlucci, Secretary of Defense, Washington, DC.

The purpose of the meeting will be to review and take action on the following:

I. Review of new memorial proposals introduced into the Congress:

S. 618—A bill to authorize a memorial to Mahatma Gandhi
S. 160—A bill to require the construction of a memorial to honor members of the Armed Forces who served in World War II
H.R. 537—Memorial and museum to honor members of the Armed Forces who served in World War II, and to commemorate that conflict
S. 619 and H.R. 937—Monument to honor Martin Luther King, Jr., by the Alpha Phi Alpha Fraternity
S.J. Res 18 and H.J. Res. 156—Monument to General Draza Mihailovich
H.R. Res. 21—Memorial to members of the American press killed while covering a war or other armed conflict
H.R. 810—Monument in honor of the American Flag, and to display the world's largest American flag at Oxon Cove Park
H.R. 441—A bill to establish a mechanism to provide for nonprofit organizations for merchant marine memorials
H.R. 1310—A bill to redesignate a certain portion of the George Washington Memorial Parkway as the "Clara Barton Parkway"
H.R. 850—To direct the Secretary of the Interior to display the flag of the United States of America at the apex of the Vietnam Veterans Memorial

II. Consideration of a policy governing delegation of responsibilities below those participating members of the National Capital Memorial Commission.

Date: April 19, 1989.

Robert Stanton,

Regional Director, National Capital Region.

[FR Doc. 89-10037 Filed 4-26-89; 8:45 am]

BILLING CODE 4310-70-M

INTERNATIONAL TRADE COMMISSION

[Investigation No. 332-275]

Competitive Position of the U.S. Gear Industry in U.S. and Global Markets

AGENCY: United States International Trade Commission.

ACTION: Institution of investigation and scheduling of public hearing.

SUMMARY: At the request of the U.S. Trade Representative (USTR), the Commissison instituted investigation No. 332-275 under section 332(g) of the Tariff Act of 1930 (19 U.S.C. 1332(g)), for the purpose of assessing the competitive position of the U.S. gear industry in U.S. and global markets. The USTR asked that the commission provide its completed report no later than 12 months from receipt of the request.

EFFECTIVE DATE: April 14, 1989.

FOR FURTHER INFORMATION CONTACT: Dennis Fravel (telephone 202-252-1404) or Sylvia McDonough (202-252-1393), Machinery and Equipment Division, Office of Industries, U.S. International Trade Commission, 500 E Street SW., Washington, DC 20436. Hearing-impaired individuals are advised that information on this matter can be obtained by contacting the Commission's TDD terminal on 202-252-1810. Persons with mobility impairments who need special assistance in gaining access to the Commission should contact the Office of the Secretary at 202-252-1000.

Background and Scope of Investigation: On March 27, 1989, the Commission recieved a request from the USTR to "conduct an investigation and prepare a report on the competitive position of the U.S. gear industry in U.S. and global markets". As requested by the USTR, the Commission's report will provide, to the extent possible, the following:

—Profiles of the U.S. industry and major foreign industries;

—A descriptive assessment of the global market for gears, to the extent possible, using categories of gear products most useful to the industry;

—A comparison of U.S. and foreign producers' strengths and weaknesses in such areas as: (1) Raw material, labor, and capital availability; (2) technological capabilities; (3) extent of plant and equipment modernization; (4) end-product quality, pricing, and service support; and government involvement.

—U.S. and foreign industry and U.S. consuming industry views on market direction and potential for the U.S. industry.

Public Hearing: The Commission will hold a public hearing in connection with this investigation beginning at 9:30 a.m. on November 1, 1989, at the U.S. International Trade Commission Building, 500 E Street SW., Washington, DC. All persons will have the opportunity to appear by counsel or in person, to present information, and to be heard.

Requests to appear at the public hearing should be filed with the Secretary, U.S. International Trade Commission, 500 E Street SW., Washington, DC, 20436, not later than the close of business (5:15 p.m.) on October 18, 1989. To be assured of consideration by the Commission, a prehearing statement should be submitted not later than the close of business on October 25, 1989. Posthearing statements must be submitted not later than the close of business on November 15, 1989.

If the number of persons requesting an opportunity to appear by counsel or in person is large, limitation of time for presentation of oral testimony is in the public interest to ensure that all viewpoints are aired. Accordingly, in scheduling appearances at the hearing, the time to be allotted to witnesses for the presentation of oral testimony may be limited. The Commission will determine appropriate allocations of time based on the number of persons requesting an opportunity to appear. Questioning of witnesses will be limited to members of the Commission and its staff and witnesses should be prepared to provide additional information in response to such questioning.

Any written materials containing confidential business information presented at the hearing must be submitted in accordance with the requirements of § 201.6 of the Commission's *Rules of Practice and Procedure* (19 CFR 201.6).

Written Submissions: Interested persons are invited to submit written statements concerning the investigation, in lieu of, or in addition to, appearances at the public hearing. To be assured of consideration by the Commission, such submissions must be received in the Office of the Secretary to the Commission not later than the close of business (5:15 p.m.) on November 15, 1989. Commercial or financial information which a submitter desires the Commission to treat as confidential must be submitted on separate sheets of paper, each clearly marked "Confidential Business Information" at the top. All submissions requesting confidential treatment must conform with the requirements of section 201.6 of the Commission's *Rules of Practice and Procedure* (19 CFR 201.6).

A signed original and fourteen (14) copies of each written statement must be submitted to the Commission in accordance with § 201.8(d) of the Commission's rules (19 CFR 201.8(d)). All written submissions, except for confidential business information, will be made available for inspection by the public during regular business hours (8:45 a.m. to 5:15 p.m.) in the Office of the Secretary to the Commission.

By order of the Commission.

Kenneth R. Mason,

Secretary.

Issued: April 18, 1989.

[FR Doc. 89-10061 Filed 4-26-89; 8:45 am]

BILLING CODE 7020-02-M

[Investigations Nos. 701-TA-297 (Final) and 731-TA-422 (Final)]

New Steel Rails From Canada

AGENCY: United States International Trade Commission.

ACTION: Institution of final countervailing duty and antidumping investigations and scheduling of a hearing to be held in connection with the investigations.

SUMMARY: The Commission hereby gives notice of the institution of final countervailing duty investigation No. 701-TA-297 (Final) under section 705(b) of the Tariff Act of 1930 (19 U.S.C. 1671d(b)) (the Act) to determine whether an industry in the United States is materially injured, or is threatened with material injury, or the establishment of an industry in the United States is materially retarded, by reason of imports from Canada of new steel rails,[1] that have been found by the Department of Commerce, in a preliminary determination, to be subsidized by the Government of Canada. Commerce will make its final subsidy determination in this investigation on or before July 26, 1989.

The Commission hereby gives notice of the institution of final antidumping investigation No. 731-TA-422 (Final) under section 735(b) of the Act (19 U.S.C. 1673d(b)) to determine whether an industry in the United States is materially injured, or is threatened with material injury, or the establishment of an industry in the United States is materially retarded, by reason of imports from Canada of new steel rails, that have been found by the Department of Commerce, in a preliminary determination, to be sold in the United States at less than fair value (LTFV). Commerce will make its final LTFV determination on or before July 26, 1989.

As provided in sections 705(b) and 735(b) of the Act, the Commission must complete final countervailing duty and antidumping investigations before the later of 120 days after the date of Commerce's affirmative preliminary

[1] For the purposes of these investigations, "new steel rails" include rails, whether or not of alloy steel, provided for in subheadings 7302.10.10, 7302.10.50, and 8548.00.00 of the Harmonized Tariff Schedule of the United States (previously classified in items 610.20, 610.21, and 688.42 of the Tariff Schedules of the United States). Specifically excluded from the scope of these investigations are imports of "light rails," which are 60 pounds or less per yard, such as are used in amusement park rides. "Relay rails," which are used rails that have been taken up from a primary railroad track and are suitable to be reused as rails (such as on a secondary rail line or in a rail yard), are also excluded.

APPENDIX C
CALENDAR OF WITNESSES FOR THE COMMISSION'S PUBLIC HEARING

Calendar of Public Hearing

Those listed below appeared as witnesses at the United States International Trade Commission's hearing:

Subject:	Competitive Position of the U.S. Gear Industry in U.S. and Global Markets
Inv. No:	332-275
Date and Time:	November 1, 1989 - 9:30 a.m.

Sessions were held in connection with the investigation in the Main Hearing Room 101 of the United States International Trade Commission, 500 E Street, S.W., in Washington.

On behalf of Congressman Harris W. Fawell, 13th District, State of Illinois, Alan Mertz, Chief of Staff

Venable, Baetjer, Howard & Civiletti—Counsel
Washington, D.C.

on behalf of

American Gear Manufacturers Association

Daniel E. Bailey, President
Rochester Gear, Inc.

Thomas R. Kling, Vice President
Philadelphia Gear Corp.

Richard B. Norment, Executive Director
American Gear Manufacturers Association

Stewart R. Ward, President
Brad Foote Gear Works, Inc.

James J. Cervinka, Chairman of the Board
Arrow Gear Co.

Ilona M. Hogan)—OF COUNSEL

APPENDIX D
DETAILED PRODUCT DEFINITIONS OF GEARS AND GEARING

Gears

This appendix delineates the principal types of gears and gearing used by the motor vehicle, industrial, aerospace, and marine sectors of the U.S. industry. Gears are shipped from the manufacturer as loose machine elements. They are not, at the time of shipment, assembled into a completed gear drive. Synonymous terms used most commonly in the industry are "open gears" or "loose gears."

Gears That Operate on Parallel Shafts

Spur gears

Spur gears are cylindrical in shape, with straight teeth cut parallel to the axis, and rotate on parallel axes. Spur gears typically have a tooth form based on the involute curve developed from the cylindrical shape of the gear. Most other types of gears also use an involute gear tooth form. The involute form of the gear tooth allows gear teeth to roll, for the most part, during contact, rather than slide. This results in less noise and vibration, less wear, lower levels of dynamic loads on the teeth, and less heat generated by friction. Spur gear configurations include external tooth gears, internal or "ring" gears, and rack-and pinion gears.

Helical gears

Helical gears are cylindrical gears in which teeth are cut at an angle across the face of the gear, rather than parallel to the axis. This configuration results in added tooth overlap which generates less noise and vibration than with that of spur gears. Thus, the same-sized gear can transmit more power than a similar arrangement of spur gears. Wear may also be less than that of spur gears since, during the meshing between helical gears, more teeth are in contact, resulting in less load or a more gradual load on the teeth. However, during meshing of helical gears compared with spur gears, there is more sliding and less rolling as the teeth make contact. Lubricants which minimize metal-to-metal contact and premature gear failure are required. The sliding action of the contacting teeth generates a thrust load along each gear shaft, requiring thrust bearings to maintain shaft alignment and to absorb the load on the shaft.

Helical gears may be in the following configurations: single helical, double helical, herringbone, and internal. Double helical gears are a set of helical gears, with tooth angles opposed to each other and a space between the opposing gears. This configuration allows the thrust generated by the angular contact of the teeth of one gear to be offset by the thrust motion generated from the partner gear. Herringbone gears have a tooth configuration similar to that of double helical gears with opposing helical teeth combined into v-shaped teeth, usually meeting at a 30-degree angle (fig. D-1).

Internal gears

Internal gears are cylindrical in form, but have either spur or helical teeth cut from the interior of the gear. Internal gears are frequently found in split train drive arrangements. A split drive arrangement divides the torque from a single input, generally a shaft with a gear, into two or more paths through to the output. Epicyclic gear drives are a space saving type of split train gear drive arrangement (fig. D-2). An epicyclic gear drive has smaller gears traveling around the internal circumference of an internal gear.

Gears That Operate on Nonparallel, Intersecting Shafts

Bevel gears are the principal type of gears that operate on nonparallel, intersecting shafts. Bevel gears have teeth cut on a conical surface, and are constructed so that the input and output shaft centerlines intersect. The two major types of bevel gears are straight bevel and spiral bevel gears. Straight bevel gears have teeth cut straight across the face of the gear, resulting in greater efficiency, but greater noise. Spiral bevel gears have teeth cut across the face of the gear at an angle, similar to helical gears, except that the tooth spirals cut across the face and have one convex and one concave side. Spiral bevel gears produce smoother, less noisy operations than straight bevel gears. A weakness of bevel gears is that they produce thrust loads that tend to separate the gears.[1]

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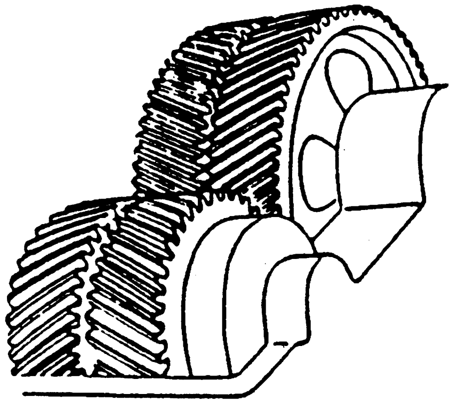
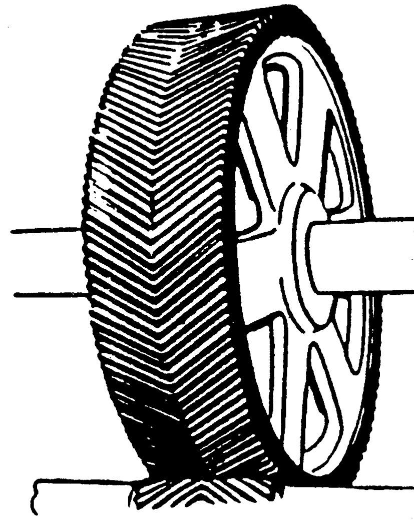
[1] *Power Transmission Design Handbook*, 1988, p. A326.

Figure D-1
Certain helical gears



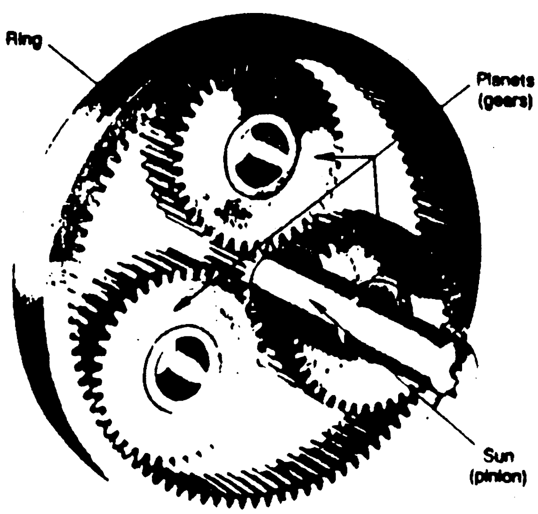
Double helical gears



Herringbone gear

Source: *Manufacturing Technology Research Needs of the Gear Industry*, IIT Research Institute, December 1987.

Figure D-2
Epicyclic gears



Source: *Manufacturing Technology Research Needs of the Gear Industry*, IIT Research Institute, December 1987.

Gears That Operate on Nonparallel, Nonintersecting Shafts

Crossed axes helical gears

These are specially shaped helical gears, with different helical angles, that transmit motion between nonparallel, nonintersecting shafts. Because of the arrangement structure of the gear teeth, the area of contact is only a point or a very small portion of the surface area of the tooth. This limits their ability to transmit power. As a result, these gears are only used in applications to transmit motion without much load.

Hypoid gears

Hypoid gears resemble bevel gears. However, the pinion gear engages the gear on a non-intersecting axis. The teeth are usually formed in a spiral and have one convex side and one concave side.

Worm gearing

Worm gearing consists of a worm and a worm gear. The axes of the worm and worm gear usually are at right angles. The worm has teeth in the form of screw threads, with different variants on the design and arrangement of the teeth or thread. The worm gear is the mate to the worm and is usually cylindrical in form. The teeth on the worm gear may be shaped as grooves in the face of the gear in order to accomodate the threadlike teeth of the worm.

Gears That Operate With Straight Line Motion

Rack–and–pinion gears are the principal type of gears that operate with a straight line of motion. A rack is a gear with teeth in a straight line that is used in conjunction with a pinion, often a spur or helical gear, to convert rotary motion to linear motion. The most common application for a rack–and–pinion is in the automotive industry for steering mechanisms. A rack can have straight teeth, called a spur rack, or helical teeth, called a helical rack.

Gear Products

Gear products are assemblies of gears in certain ratio configurations that either reduce or increase input speed to a given output device, typically a shaft. Such assemblies usually include gears on shafts, bearings, lubrication systems, and seals. Gear products are shipped from the manufacturer as an assembly or as a machine for the purpose of power and/or motion transmission between driver(s) and driven equipment. Synonymous terms used in the industry for "gear drive" are "gear box," "gear unit," "transmission," "speed changer," and "reducer."

Gearmotors or Motoreducers

These products are gear drives that include a motor(s) which can be integrally, flange, or scoop mounted and coupled to the gear set(s) assembly.

Worm Speed Reducers and Gearmotors

These products are gear drives that have worm gearing as their principal means (highest torque or cost set) of power and/or motion transmission. Gear drives with helical or other gearing as nonprincipal attachments or sets within the gear drive are still considered worm speed reducers.

Concentric Gearmotors/Motoreducers

These products are concentric (driven/driving shafts) or in-line gear drives, including epicyclic drives, and concentric shaft gearmotors in which the principal means of power and/or motion transmission is spur, helical, herringbone, or bevel gearing.

Mounted Speed Reducers

These products are gear drives which are supported on a drive shaft, flange, or "stub" mounting. The shaft mounted type generally has a hollow driving (output) shaft mounted on a shaft extension of the driven equipment without other support except a torque reaction arm or flange. Flange mounted reducers consist of a housing with a flange that is mounted to the driven housing, generally without a hollow shaft. Stub mounted reducers include gear drives that are mounted on a stub of the driven shaft, with the housing independently supported.

High Speed Units

These products are gear drives containing a gear which either rotates at more than 3,600 revolutions per minute, or which has teeth with pitchline velocities of 5,000 feet per minute and higher.

Mechanical Adjustable Speed Drives

These products (including belt- and traction-type drives) are gear drives provided with a means of engaging one or more separate gear sets within the drive, in order to provide more than one ratio of rotational speed between driven and driving shafts. These are primarily industrial drives where more than one fixed rotation or range of speeds is required for the application. Vehicle gearing (automotive transmissions, etc.) is not included in this definition.

Flexible Couplings

These products are metallic mechanical connectors, including gear-type flexible couplings, designed to transmit torque without slip, and to accommodate misalignment and sometimes axial travel between driving and driven machine members. Typical misalignment compensating elements are chain, disc, membrane, diaphragm, geared sleeve, grid, and slider block. Flexible couplings do not include flexible shafts, universal joints, and couplings designed for torsional resilience with damping.

Vehicle Gearing

Vehicle gearing includes all unassembled gears, gear drives, or assemblies of or with gears, used on vehicles, either "on road" or "offroad".

APPENDIX E
THE GEAR-MAKING METALWORKING MACHINE TOOL AND MACHINERY INDUSTRY

Overview

This appendix describes the U.S. gear-making machine tool industry, its production and trade, and its principal competitors. Currently, U.S. gear producers are dependent to a large degree on foreign sources for certain types of gear-making machine tools. A variety of other machine tools and equipment used by U.S. gear producers, including machining centers, milling machines, lathes, boring machines, drilling machines,[1] heat treatment equipment such as carbide and nitride furnaces and quenching presses, and inspection equipment used to determine metallurgical soundness, are readily available at competitive prices in the U.S. market.

The continued existence of a U.S. gear-making machine tool and gear metrology machine industry is critical to national security and to the competitiveness of the U.S. defense industrial base. An autonomous domestic industry capable of producing state-of-the-art gear production machinery is also important to national security. In many machinery categories, U.S. machine tool builders cannot provide the most up-to-date equipment, or "they are unable to do so within acceptable price/delivery limits."[2] Foreign gear producers such as West Germany and Japan have ready access to a strong machine tool industry and therefore maintain a competitive edge, whereas U.S. gear manufacturers are dependent on foreign machinery lag behind their foreign competition.[3]

The production of gear-making machine tools and metrology machinery is concentrated in a few firms worldwide most of which are located outside the United States. U.S. gear-making machine tool builders reportedly face several competitive disadvantages, many of which are identical or similar to those faced by U.S. gear manufacturers. These include extended tax depreciation schedules for machinery, lack of an investment tax credit, and high capital costs. Other factors adversely affecting U.S. gear-making machine tool builders are a dependency on foreign components. According to U.S. industry sources, high-quality precision linear bearings, linear guides, ball screws, and motors are no longer produced in the United States.[4] The U.S. gear-making machine tool industry is also adversely impacted by dependency on a strong foreign customer base, the lack of government research support, and restrictive U.S. export regulations.

U.S. Industry Profile

The U.S. industry is comprised of 8 gear-making machine tool firms and approximately 5 gear metrology machinery producers. The United States has two firms that are world leaders in gear-making machine tools: Gleason Corporation, which specializes in producing bevel-gear-generating machine tools and computer numerically controlled (CNC) hobbing machine tools, and National Broach which produces broaching machine tools for the manufacture of internal gears, CNC hobbing machine tools, and gear-shaving and -grinding machine tools. Fellows Corp. and Fayscott Co. also produce gear hobbing machine tools.

CIMA-USA, an affiliate of CIMA of Italy, and American Pfauter, a U.S.-based subsidiary of Pfauter of West Germany, consider themselves U.S. producers of CNC hobbing machines. Although the machine tool chassis and mechanical parts are generally imported, the electronics and hydraulic systems are purchased from U.S. manufacturers. M&M Precision Systems Co. produces certain types of state-of-the-art CNC gear inspection equipment and dominates the U.S. market for these machines. However, other types of gear inspection machinery are also required by the U.S. gear industry, and are generally imported from West Germany.

Most U.S. firms producing gear-making machine tools and inspection machinery are small in size; however, The Gleason Works, a division of the Gleason Corp., employs 900 persons. In 1988, Gleason Corp. reported sales of $210.7 million, of which $115.2 million, or 55 percent, primarily consisted of gear-making machine tools and tooling. National Broach and Fellows have approximately 400 and 250 employees, respectively.

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[1] In December 1986, the U.S. Government announced Voluntary Restraint Agreements (VRAs) with Japan and Taiwan establishing import levels of machining centers, milling machines, lathes, and punching and shearing machines. The U.S. Government attempted to negotiate similar agreements with West Germany and Switzerland. The agreements with Japan and Taiwan expire at the end of 1991.

[2] *The U.S. Machine Tool Industry and Its Foreign Competitors: Working Papers of the MIT Commission on Industrial Productivity, Vol. 2,* MIT Commission on Industrial Productivity, 1989, p. 3.

[3] USITC staff interviews with officials of Klingelnberg and Gleason Corp., August 1989.

[4] USITC staff interviews with officials of Gleason Corp. and National Broach, August and November 1989.

Production and Consumption

During 1980-88, the value of shipments of gear-making machine tools declined by 63 percent and apparent U.S. consumption declined 50 percent (table E-1).[5] The decline in shipments is due, in part, to (1) technological advances, including computer controls, that have more than doubled machine productivity, resulting in the need for fewer machines, or reduced U.S. demand; (2) increased import competition; and (3) the departure of several firms from the industry. U.S. imports as a share of apparent consumption rose irregularly from 39 percent in 1980 to 81 percent in 1987, before decreasing to 75 percent in 1988. U.S. imports of gear-making machine tools were valued at $42.2 million in 1988. Imports from West Germany accounted for 51 percent of the total, Switzerland 24 percent, and Japan 12 percent.

In 1988, U.S. exports of gear-making machine tools (excluding used and rebuilt products and parts)[6] were valued at $34.5 million, down from a peak of $80.1 million in 1981. Exports of parts were valued at $40.5 million in 1988. The relative strength of U.S. exports results from strong demand from West German and Japanese gear producers for state-of-the-art gear-making machinery. Gleason exports approximately 60 percent of its production of gear-making machine tools in response to such demand.[7] Similarly, National Broach and Fellows also depend heavily on foreign sales. The major foreign markets for U.S. gear-making machine tools have varied from year to year, but the largest purchasers of U.S.-produced gear-making machine tools during 1980-88 were Japan, Canada, and West Germany. Exports of gear-making machine tools to major foreign markets, cumulative for 1980-88, and the share

[5] Data were compiled from 1980, since machine tools are used over a long period of time.
[6] For comparison with foreign industries, U.S. export statistics as compiled herein exclude data for used machine tools and parts because foreign trade and production statistics, as well as U.S. shipments data, are not available for used machinery or parts.
[7] USITC staff interview with Gleason officials, August 1989.

Table E-1

Gear-making machine tools, excluding parts: U.S. producers' shipments, exports, imports, and apparent consumption, 1980-88

(Quantity in units; value in thousands of dollars)

Year	Shipments[1]	Exports[1]	Imports[2]	Apparent consumption	Ratio (percent) of imports to consumption
			Quantity		
1980	931	519	506	918	55.1
1981	837	698	505	644	78.4
1982	445	369	429	505	85.0
1983	158	226	185	117	158.1
1984	199	172	352	379	92.9
1985	243	(3)	331	(3)	(3)
1986	253	235	599	617	97.1
1987	204	195	716	725	98.9
1988	161	236	702	627	112.0
			Value		
1980	130,289	61,212	44,095	113,172	39.0
1981	133,132	80,141	41,364	94,355	43.8
1982	86,531	37,388	26,936	76,079	35.4
1983	35,767	31,587	14,105	18,285	77.1
1984	42,362	24,154	19,718	37,926	52.0
1985	51,791	20,432	21,176	52,535	40.3
1986	57,313	35,626	32,818	54,505	60.2
1987	52,608	40,653	51,173	63,128	81.1
1988	48,357	34,488	42,174	56,043	75.3

[1] Data excludes used and rebuilt/refurbished machine tools.
[2] Data includes used and rebuilt/refurbished machine tools. Rebuilt/ refurbished machine tools are believed to account for less than 5 percent of total imports.
[3] Official statistics appear to be in error and are believed to be unreliable.

Source: Compiled from official statistics of the U.S. Department of Commerce, except as noted.

of total exports accounted for by each of those markets, compiled from official statistics of the U.S. Department of Commerce, are shown in the following tabulation:

Principal Market	U.S. exports (Million dollars)	Share of total (Percent)
Japan	60.7	16.6
Canada	50.9	13.9
West Germany	46.1	12.6
China	30.2	8.3
Soviet Union	24.4	6.7
Korea	23.3	6.4
Mexico	11.0	3.0
All other	119.1	32.6
Total	365.7	[1]100.0

[1] Due to rounding, data may not add to the total shown.

Exports to the Soviet Union were significant in 1980 and 1981, but have declined in recent years. This decline can be attributed, in part, to strict enforcement of COCOM[8] export regulations which limit U.S. exports of gear-making machine tools to nonmarket countries. Consequently, the Soviet Union, seeking to acquire the latest technology, has turned to other sources. The lack of hard currency for purchasing machinery from market economies is another factor that has reduced the Soviet Union's purchases of U.S. machine tools.

Competitiveness

Major foreign competitors of U.S. gear-making machine tools and gear metrology industries include West Germany, Japan, Switzerland, and Italy. Shipments of gear-making machine tools from these countries during 1980-88 are shown in table E-2; 1980-87 production and trade data for Switzerland are not available. In 1988, Swiss exports of 654 gear-making machine tools were valued at $88.7 million, and imports of 75 units were valued at $4.9 million.[9]

During 1980-88, U.S. shipments declined steadily, as compared with those of West Germany and Japan. Since 1981, West Germany and Japan have dominated the global production of gear-making machine tools. The value of Japanese shipments were low, relative to those of West Germany, because Japanese machinery was not as technologically advanced as that from West Germany.

The Soviet Union and China have a number of state enterprises producing gear-making machinery for their domestic industries. East Germany's state enterprises that produce gear-making machine tools have developed an international reputation for good gear-grinding technology for a low price, even though they lack advanced computer controls. Such machines have been exported to Japan and the United States. Hungary's Csepel, a machine tool builder, is also marketing a gear grinder in the United States, incorporating U.S.-made electronic controls.

In recent years, there has been significant corporate restructuring in the U.S., West German, and Swiss gear-making machine tool industries. In early 1989, Gleason was the target of a takeover attempt by the Boston-based Goldman Group, the holding company that owns Fellows. In June 1989, Gleason sold 90 percent of its Gleason Power Systems division, which makes differentials, to a Japanese firm and, in November 1989, announced that it was planning to sell its Components Group, the last group outside its core machine tool business.

West European competitors with an increasing presence in the United States include Klingelnberg, Pfauter and its U.S. subsidiary American Pfauter, and Liebherr, all of West Germany; Oerlikon of Switzerland; and CIMA of Italy. In May 1989, Klingelnberg purchased Dr. Wiener of West Germany, which gave the firm a product line of CNC automatic spiral bevel gear-making machine tools that could produce certain bevel gears faster than U.S. or Swiss methods. Klingelnberg also purchased a part of MAAG of Switzerland, as did Oerlikon and American Pfauter. Barber-Coleman of the United States was purchased by American Pfauter in July 1987.

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[8] COCOM is the Coordinating Committee on Multilateral Export Controls, made up of Australia, Belgium, Canada, Denmark, France, West Germany, Greece, Italy, Japan, Luxembourg, the Netherlands, Norway, Portugal, Spain, Turkey, the United Kingdom, and the United States. The group's purpose is to withhold defense technology from nonmarket countries.

[9] *Statistique Annuelle du Commerce Exterieur de la Suisse, 1988 Tome Premier,* Publie Par La Direction Generale Des Douanes, Berne, Switzerland.

Table E-2

Gear-making machine tools: Shipments by selected major producing countries, 1980-88

(Quantity in units; value in millions of dollars)

Year	United States	West Germany	Japan	Italy
		Quantity		
1980	931	1,240	1,178	308
1981	837	1,337	1,315	343
1982	445	1,043	863	434
1983	158	785	718	616
1984	199	690	930	717
1985	243	923	999	687
1986	253	1,133	949	728
1987	204	1,040	746	([1])
1988	161	964	1,001	531
		Value		
1980	130.3	159.1	67.3	15.0
1981	133.1	142.6	90.2	17.0
1982	86.5	121.1	48.3	19.0
1983	35.8	97.3	40.4	20.5
1984	42.4	83.6	48.9	23.0
1985	51.8	106.3	68.6	21.0
1986	57.3	185.7	97.2	22.0
1987	52.6	233.2	88.8	25.0
1988	48.4	230.8	129.7	35.0

[1] Data as published by *Eurostatistics* 1987 appears to be unreliable.

Source: Compiled by the staff of the U.S. International Trade Commission based on data from the National Machine Tool Builders' Association, *Economic Handbook of the Machine Tool Industry*, various editions, *Eurostatistics*, and interviews with U.S. and foreign machine tool builders, August and November 1989.

The major U.S. competitor from Japan is Mitsubishi Heavy Industries, which, in addition to gear-making machine tools, produces a wide variety of machine tools ranging from machining centers, lathes and flexible manufacturing systems to precision cutting tools. Other Japanese competitors include Okamoto Machine Tool Works Ltd., Kanzaki Kokyukoki Manufacturing Co., Ltd., and Kashifuji Works Ltd.

Other nations, such as Korea, Taiwan, and India, are developing domestic gear-making machine tool industries. As in West Germany and Japan, these machine tool industries are supported by their governments, both directly and indirectly, particularly through government sponsored-research at state-run universities.

APPENDIX F
GEARS AND GEARING: CONCORDANCE OF HARMONIZED TARIFF SCHEDULE OF THE UNITED STATES NUMBERS AND TARIFF SCHEDULES OF THE UNITED STATES ANNOTATED NUMBERS, CONCORDANCE OF SCHEDULE B NUMBERS, APPLICABLE U.S. IMPORT DUTIES, AND TARIFF AND TRADE AGREEMENT TERMS

Concordance of U.S. Imports under HTS and TSUS(A) Numbers

HTS heading/ subheading	*TSUS(A) item*
8433.90.50.20 (pt)	666.0070 (pt)
	666.0075 (pt)
8433.90.50.40 (pt)	666.0070 (pt)
	666.0075 (pt)
8433.90.50.60 (pt)	666.0070 (pt)
	666.0075 (pt)
8433.90.50.80 (pt)	666.0070 (pt)
	666.0075 (pt)
8436.99.00.20 (pt)	666.0075 (pt)
8436.99.00.30 (pt)	666.0075 (pt)
8436.99.00.35 (pt)	666.0075 (pt)
8436.99.00.40 (pt)	666.0075 (pt)
8436.99.00.70 (pt)	666.0075 (pt)
8436.99.00.90 (pt)	666.0075 (pt)
8483.40.30.40	680.4600 (pt)
8483.40.30.80	680.4600 (pt)
8483.40.50.10	680.4910 (pt)
	680.4940 (pt)
8483.40.50.50	680.4910 (pt)
	680.4940 (pt)
8483.40.70.00	680.5900
	680.6100
8483.40.90.00 (pt)	680.4960 (pt)
	680.6200 (pt)
	680.6300 (pt)
8483.60.80.00	680.9530 (pt)
	681.0100 (pt)
8483.90.50.00	680.4600 (pt)
	680.4960 (pt)
	680.6200 (pt)
	680.6300 (pt)
8483.90.80.10 (pt)	680.9515 (pt)
	680.9530 (pt)
	681.0100 (pt)
8483.90.80.90 (pt)	680.9515 (pt)
	680.9530 (pt)
	681.0100 (pt)
8501.40.20.20	678.5097 (pt)
8501.40.40.20	678.5097 (pt)
8501.40.50.20	678.5097 (pt)
8501.40.60.20	678.5097 (pt)
8501.51.20.20	678.5097 (pt)
8501.51.40.20	678.5097 (pt)
8501.51.50.20	678.5097 (pt)
8501.51.60.20	678.5097 (pt)
8501.52.40.00 (pt)	678.5097 (pt)
8501.52.80.20 (pt)	678.5097 (pt)
8501.52.80.40 (pt)	678.5097 (pt)
8501.53.40.40 (pt)	678.5097 (pt)
8501.53.40.80 (pt)	678.5097 (pt)
8501.53.60.00 (pt)	678.5097 (pt)
8501.53.80.40 (pt)	678.5097 (pt)
8501.53.80.60 (pt)	678.5097 (pt)
8607.91.00.00 (pt)	690.4000 (pt)
8607.99.10.00 (pt)	690.3560 (pt)
8607.99.50.00 (pt)	690.4000 (pt)
8708.40.10.00	692.3274
	692.3374
8708.40.20.00	692.3276
	692.3376
8708.40.30.00	692.3460 (pt)
8708.40.50.00	692.3278
	692.3378
	692.3534 (pt)
8708.50.10.00	692.3460 (pt)
8708.50.30.00	692.3534 (pt)
8708.50.50.00	692.3288 (pt)
	692.3290 (pt)
	692.3295 (pt)
	692.3390 (pt)
8708.50.80.00	692.3288 (pt)
	692.3290 (pt)
	692.3295 (pt)
	692.3390
8708.94.10.00 (pt)	692.3460 (pt)
8708.94.50.00 (pt)	692.3390 (pt)
	692.3534 (pt)
8709.90.00.00 (pt)	692.4070 (pt)
8710.00.00.90 (pt)	692.4510 (pt)
	692.4520 (pt)
8714.19.00.00 (pt)	692.5500 (pt)
8803.30.00.10 (pt)	694.6110 (pt)
	694.6200 (pt)
8803.30.00.50 (pt)	694.6100 (pt)
	694.6120 (pt)
8803.90.30.00 (pt)	684.8000 (pt)
8803.90.90.10 (pt)	694.3100 (pt)
	694.6100 (pt)
	694.6110 (pt)
	694.6120 (pt)
	694.6200 (pt)
	694.6500 (pt)
	694.6700 (pt)
8803.90.90.50 (pt)	694.3100 (pt)
	694.6100 (pt)
	694.6110 (pt)
	694.6120 (pt)
	694.6200 (pt)
	694.6500 (pt)
	694.6700 (pt)

Concordance of U.S. exports under Schedule B[1]

Sch. B heading/ subheading as of Jan. 1, 1990	*Sch. B item as of Dec. 31, 1988*
8433.90.1000 (pt)	666.1062 (pt)
8433.90.5020 (pt)	666.0068 (pt)
8433.90.5040 (pt)	666.0072 (pt)
8433.90.5060 (pt)	666.1120 (pt)
8433.90.5080 (pt)	666.0077 (pt)
8436.99.0020 (pt)	666.0090 (pt)
8436.99.0040 (pt)	666.0086 (pt)
8436.99.0060 (pt)	666.0088 (pt)
8436.99.0080 (pt)	666.0090 (pt)
8483.40.4010	680.4910
8483.40.4050	680.4920
8483.40.7000	680.4930
8483.40.9000	680.4940 (pt)
8483.60.8000	680.5060 (pt)
8483.90.5000	680.4940 (pt)
8483.90.8010	680.5060 (pt)
8383.90.9500 (pt)	680.5400 (pt)
8501.40.2020	678.5080 (pt)
8501.40.3020	678.5080 (pt)
8501.40.6020	678.5080 (pt)
	678.5080 (pt)
8501.51.2020	678.5080 (pt)
8501.51.3020	678.5080 (pt)
8501.51.6020	690.3310 (pt)
8501.52.4000 (pt)	682.4530 (pt)
8501.52.8020 (pt)	682.4545 (pt)
8501.52.8040 (pt)	682.4545 (pt)
8501.53.4040 (pt)	682.4545 (pt)
8501.53.4080 (pt)	682.4545 (pt)
8501.53.6000 (pt)	682.4545 (pt)
8501.53.8040 (pt)	682.5155 (pt)
8501.53.8060 (pt)	682.5170 (pt)
8607.91.0000 (pt)	690.3710 (pt)
8607.99.1010 (pt)	690.3310 (pt)
	690.3710 (pt)
8607.99.5000 (pt)	692.2400 (pt)
8708.40.1000	692.2932 (pt)
	692.2400 (pt)
8708.40.2000	692.2936
	692.2400 (pt)
8708.40.6000	692.2940 (pt)
	692.3820 (pt)
8708.50.0010	692.3840 (pt)
	692.2400 (pt)
8708.50.0050	692.2903 (pt)
	692.4520 (pt)
8708.94.1010 (pt)	692.3820 (pt)
	692.3840 (pt)
8708.94.5000 (pt)	692.2985 (pt)
8709.90.0000 (pt)	692.4020 (pt)
8710.90.0090 (pt)	692.5500 (pt)
8714.19.0000 (pt)	694.6507 (pt)
8803.30.0010 (pt)	694.6507 (pt)
8803.30.0050 (pt)	694.6517 (pt)
8803.90.9010 (pt)	694.6507 (pt)
8803.90.9050 (pt)	694.6517 (pt)

[1] Schedule B is the U.S. classification system of U.S. merchandise exports.

Table F-1
Gears and gear products: Applicable U.S. rates of duty, by HTS provision

Heading/ subheading	Stat. suf.[1]	Article description	Rates of duty Col. 1	Special[2]	Col. 2
			Percent ad valorem		
8433		Harvesting or threshing machinery, including straw or fodder balers; grass or hay mowers; machines for cleaning, sorting or grading eggs, fruit or other agricultural produce, other than machinery of heading 8437; parts thereof:			
8433.90		Parts:			
8433.90.50		Other	Free		Free
		Of other mowers, harvesting machines and threshing machines:			
	20	Of haying machines and balers	Free		Free
	40	Other	Free		Free
	60	Of machines for cleaning, sorting or grading eggs			
	80	Of machines for cleaning, sorting or grading fruit or other agricultural produce	Free		Free
8436		Other agricultural, horticultural, forestry, poultry-keeping or bee-keeping machinery, including germination plant fitted with mechanical or thermal equipment; poultry incubators and brooders; parts thereof:			
		Parts:			
8436.99.00		Other	Free		Free
	20	Of forestry machinery	Free		Free
	30	Of bee-keeping machinery	Free		Free
	35	Of machinery for preparing animal feeds	Free		Free
		Other:			
	40	Of barn or barnyard machines	Free		Free
	70	Of machines for preparing crops for market or for use	Free		Free
	90	Other	Free		Free
8483		Transmission shafts (including camshafts and crankshafts) and cranks; bearing housings, housed bearings and plain shaft bearings; gears and gearing; ball screws; gear boxes and other speed changers, including torque converters; flywheels and pulleys, including pulley blocks; clutches and shaft couplings (including universal joints); parts thereof:			
8483.40		Gears and gearing, other than toothed wheels, chain sprockets and other transmission elements entered separately; ball screws; gear boxes and other speed changers, including torque converters:			
		Gear boxes and other speed changers:			
		Fixed ratio speed changers, multiple and variable ratio speed changers each ratio of which is selected by manual manipulation:			

See footnotes at end of table.

Table F-1—*Continued*

Gears and gear products: Applicable U.S. rates of duty, by HTS provision

Heading/ subheading	*Stat. suf.*[1]	*Article description*	*Rates of duty Col. 1*	*Special*[2]	*Col. 2*
			Percent ad valorem		
8483.40.30		Imported for use with machines for making cellulosic pulp, paper or paperboard			
	40	Fixed ratio speed changers	Free		27.5%
	80	Other	Free		27.5%
		(cellulosic pulp, paper or paperboard)	Free		27.5%
8483.40.50		Other	2.5%	Free (A,C, E, IL) 1.5% (CA)	27.5%
	10	Fixed ratio speed changers	2.5%		27.5%
	50	Other	2.5%		27.5%
8483.40.70	00	Other speed changers	50¢ each + 7.7%	Free (A,C, E,IL) 30¢ each + 4.6% (CA)	$4.50 each + 65%
8483.40.90	00	Gears and gearing, other than toothed wheels, chain sprockets and other transmission elements entered separately	2.5%	Free (A,C, E, IL) 1.5% (CA)	27.5%
8483.60		Clutches and shaft couplings (including universal joints):			
8483.60.80	00	Other	5.7%	Free (C,E, IL) 3.4% (CA)	45%
8483.90		Parts:			
8483.90.50	00	Parts of gearing, gear boxes and other speed changers	2.5%	Free (A,C, E, IL) 1.5% (CA)	27.5%
		Other:			
8483.90.80		Other	5.7%	Free (C,E, IL) 3.4% (CA)	45%
	10	Parts of articles of subheading 8483.60.80	5.7%		45%
	90	Other	5.7%		45%

See footnotes at end of table.

Table F-1—*Continued*

Gears and gear products: Applicable U.S. rates of duty, by HTS provision

Heading/ subheading	*Stat. suf.*[1]	*Article description*	*Rates of duty* Col. 1	Special[2]	Col. 2
			Percent ad valorem		
8501		Electric motors and generators (excluding generating sets):			
8501.40		Other AC motors, single-phase:			
8501.40.20		Of an output exceeding 37.5 W but not exceeding 74.6 W	4.2%	Free (A,B,E, IL) 3.3% (CA)	35%
	20	Gearmotors	4.2%		35%
8501.40.40		Of an output exceeding 74.6 W but not exceeding 735 W	5%	Free (A*,B,E, IL) 4% (CA)	35%
	20	Gearmotors	5%		35%
8501.40.50		Of an output exceeding 735 W but under 746 W:			
	20	Gearmotors	5%	Free (A*,B,C,E, IL) 4% (CA)	35%
8501.40.60		Other:			
		Gearmotors	3.7%	Free (A,B,C,E, IL) 2.9% (CA)	35%
		Other AC motors, multi-phase:			
8501.51		Of an output not exceeding 750 W:			
8501.51.20		Exceeding 37.5 W but not exceeding 74.6 W	4.2%	Free (A,B,E, IL) 3.3% (CA)	35%
	20	Gearmotors	4.2%		35%
8501.51.40		Exceeding 74.6 W but not exceeding 735 W	5%	Free (A*,B,E, IL) 4% (CA)	35%
	20	Gearmotors	5%		35%
8501.51.50		Exceeding 735 W but under 746 W	5%	Free (A*,B,C,E, IL) 4% (CA)	35%
	20	Gearmotors	5%		35%
8501.51.60		Other	3.7%	Free (A,B,C,E, IL) 2.9% (CA)	35%
	20	Gearmotors	3.7%		35%
8501.52		Of an output exceeding 750 W but not exceeding 75 kW:			
8501.52.40	00	Exceeding 750 W but not exceeding 14.92 kW	3.7%	Free (A,B,C,E, IL) 2.9% (CA)	35%
8501.52.80		Other	Free		35%
	20	For use in civil aircraft	Free		35%
	40	Other	Free		35%

See footnotes at end of table.

Table F-1—*Continued*

Gears and gear products: Applicable U.S. rates of duty, by HTS provision

Heading/ subheading	*Stat. suf.*[1]	*Article description*	*Rates of duty* *Col. 1*	*Special*[2]	*Col. 2*
			Percent ad valorem		
8501.53		Of an output exceeding 75 kW:			
8501.53.40		Exceeding 75 kW but under 149.2 kW	Free		35%
	40	For use in civil aircraft	Free		35%
	80	Other	Free		35%
8501.53.60		149.2 kW or more but not exceeding 150 kW	4.2%	Free (A,C,E,IL) 2.5% (CA)	35%
8501.53.80		Other	4.2%	Free (A,E,IL) 2.5% (CA)	35%
	40	Not exceeding 373 kW	4.2%		35%
	60	Other	4.2%		35%
8607		Parts of railway or tramway locomotives or rolling stock:			
		Other:			
8607.91.00		Of locomotives	3.9%	Free (A,E,IL) 2.3% (CA)	35%
		Other:			
8607.99					
8607.99.10	00	For vehicles of heading 8605 or 8606, except brake regulators	5.5%	Free (A,E,IL) 3.3% (CA)	45%
8607.99.50	00	Other	3.9%	Free (A,E,IL) 2.3% (CA)	35%
8708		Parts and accessories of the motor vehicles of heading 8701 to 8705:			
8708.40		Gear boxes:			
8708.40.10	00	For the vehicles of subheading 8701.20, or heading 8702 or 8704	3.1%	Free (A*,B, E,IL) 2.4% (CA)[3]	25%
8708.40.20	00	For the vehicles of heading 8703	3.1%	Free (A*,B, E,IL) 2.4% (CA)[3]	25%
8708.40.30	00	For tractors suitable for agricultural use	Free		Free
8708.40.50	00	For other vehicles	3.1%	Free (A*,E, IL) 2.4% (CA)[3]	25%
8708.50		Drive axles with differential, whether or not provided with other transmission components:			
		For tractors (except road tractors):			
8708.50.10	00	For tractors suitable for agricultural use	Free		Free
8708.50.30	00	For other tractors	2.2%	Free (A,E,IL) 1.7% (CA)[3]	27.5%
8708.50.50	00	For vehicles of heading 8703	3.1%	Free (A*,B,E, IL) 2% (CA)[3]	25%
8708.50.80	00	For other vehicles	3.1%	Free (A*,B,E, IL) 2% (CA)[3]	25%

See footnotes at end of table.

Table F-1—*Continued*

Gears and gear products: Applicable U.S. rates of duty, by HTS provision

Heading/ subheading	Stat. suf.[1]	Article description	Rates of duty Col. 1	Special[2]	Col. 2
			— Percent ad valorem —		
		Other parts and accessories:			
8708.94		Steering wheels, steering columns and steering boxes:			
8708.94.10	00	For tractors suitable for agricultural use	Free		Free
8708.94.50	00	For other vehicles	3.1%	Free (A,B,E, IL) 2.4% (CA)[3]	25%
8709		Work trucks, self-propelled, not fitted with lifting or handling equipment, of the type used in factories, warehouses, dock areas or airports for short distance transport of goods; tractors of the type used on railway station platforms; parts of the foregoing vehicles:			
8709.90.00	00	Parts	Free		35%
8710.00.00		Tanks and other armored fighting vehicles, motorized, whether or not fitted with weapons, and parts of such vehicles	Free		35%
	90	Parts	Free		35%
8714		Parts and accessories of vehicles of headings 8711 to 8713:			
		Of motorcycles (including mopeds):			
8714.19.00	00	Other	4.2%	Free (A,CA,E, IL)	25%
8803		Parts of goods of heading 8801 or 8802:			
8803.30.00		Other parts of airplanes or helicopters	Free		27.5%
	10	For use in civil aircraft	Free		27.5%
	50	Other	Free		27.5%
		Other:			
8803.90					
8803.90.30	00	Parts of communications satellites	Free		Free
8803.90.90		Other	Free		27.5%
	10	For use in civil aircraft	Free		27.5%
	50	Other	Free		27.5%

[1] Statistical suffix is for statistical purposes only.

[2] The designation "A" or "A*" indicates that the item is currently designated as an eligible article for duty-free treatment under the U.S. Generalized System of Preferences and that all beneficiary developing countries are eligible for the GSP. The designation "B" indicates eligibility for duty-free treatment under the Automotive Products Trade Act between the United States and Canada. The designation "C" indicates eligibility for duty-free treatment under the Agreement on Trade in Civil Aircraft. The designation "E" or "E*" indicates that the item is currently designated as an eligible article for duty-free treatment under the Caribbean Basin Economic Recovery Act (CBERA) and that all beneficiary developing countries are eligible for the preferential duty treatment under the CBERA. The designation "IL" indicates the article is eligible for duty-free treatment under the United States-Israel Free Trade Area Implementation Act of 1985. The designation "CA" prefaced by a duty-rate indicates that the article is eligible for that duty-rate under the United States-Canada Free Trade Agreement Implementation Act of 1988.

[3] Equipment, originating in the territory of Canada, intended for use in the repair or maintenance of certain motor vehicles subject to accelerated staged rate reductions.

Source: United States International Trade Commission: *Harmonized Tariff Schedule of the United States*, USITC Pub. 2030.

Tariff and Trade Agreement Terms

The Harmonized Tariff Schedule of the United States (HTS) replaced the *Tariff Schedules of the United States* (TSUS) effective January 1, 1989. Chapters 1 through 97 are based upon the internationally adopted Harmonized Commodity Description and Coding System through the 6–digit level of product description, with additional U.S. product subdivisions at the 8–digit level. Chapters 98 and 99 contain special U.S. classification provisions and temporary rate provisions, respectively.

The rates of duty in rate *column 1–general* of the HTS are most–favored–nation (MFN) rates and, in general, represent the final stage of the reductions granted in the Tokyo Round of the Multilateral Trade negotiations. Column 1–general duty rates are applicable to imported products from all countries except those Communist countries and areas enumerated in general note 3(b) to the HTS, whose products are dutied at the rates set forth in *column 2;* the People's Republic of China, Hungary, Poland, and Yugoslavia are the only Communist countries eligible for MFN treatment. Among articles dutiable at column 1–general rates, particular products of enumerated countries may be eligible for reduced rates of duty or for duty free treatment under one or more preferential tariff programs. Such tariff treatment is set forth in the *special rates of duty subcolumn* of column 1.

The *Generalized System of Preferences* (GSP) affords nonreciprocal tariff preferences to developing countries to aid their economic development and to diversify and expand their production and exports. The U.S. GSP, enacted in title V of the Trade Act of 1974 and renewed in the Trade and Tariff Act of 1984, applies to merchandise imported on or after January 1, 1976 and before July 4, 1993. Indicated by the symbol "A" or "A*" in the special duty rates subcolumn of column 1, the GSP provides duty–free entry to eligible articles the product of, and imported directly from, designated beneficiary developing countries, as set forth in general note 3(c)(ii) to the HTS.

The *Caribbean Basin Economic Recovery Act* (CBERA) affords nonreciprocal tariff preferences to developing countries in the Caribbean Basin area to aid their economic development and to diversify and expand their production and exports. The CBERA, enacted in title II of Public Law 98–67 and implemented by Presidential Proclamation 5133 of November 30, 1983, applies to merchandise entered, or withdrawn from warehouse for consumption, on or after January 1, 1984; it is scheduled to remain in effect until September 30, 1995. Indicated by the symbol "E" or "E*" in the special duty rates subcolumn 1, the CBERA provides duty–free entry to eligible articles the product of, and imported directly from, designated Basin countries, as set forth in general note 3(c)(v) to the HTS.

Preferential rates of duty in the special duty rates subcolumn of column 1 followed by the symbol "IL" are applicable to products of Israel under the *United States–Israel Free Trade Implementation Act* of 1985, as provided in general note 3(c)(vi) of the HTS. Where no rate of duty is provided for products of Israel in the special rates subcolumn for a particular subheading the rate of duty in the general subcolumn of column 1 applies.

Preferential rates of duty in the special duty rates subcolumn of column 1 followed by the symbol "CA" are applicable to eligible goods originating in the territory of Canada under the *United States–Canada Free–Trade Agreement,* as provided in general note 3(c)(vii) of the HTS.

The *General Agreement on Tariffs and Trade* (GATT) (61 Stat. (pt. 5) A58; 8 UST (pt. 2) 1786) is the multilateral agreement which sets forth the basic principles governing international trade among its more than 90 signatories. The GATT's main obligations relate to most–favored–nation treatment, the maintenance of schedule concession rates of duty, and national (nondiscriminatory) treatment for imported products; the GATT also provides the legal framework for customs valuation standards, "escape clause" (emergency)actions, antidumping and countervailing duties, and other measures. The results of GATT–sponsored multilateral tariff negotiations are set forth by way of separate schedules of concessions for each participating contracting party, with the U.S. schedule designated as Schedule XX.

Automotive products and motor vehicles are eligible for special tariff treatment, if entered under the *Automotive Products Trade Act* (APTA), subject to the following provisions: motor vehicles and original motor–vehicle equipment which are Canadian articles and which fall in provisions for which the rate of duty "Free (B)" appears in the "Special" subcolumn, as outlined in General Note 3(c)(iii)(A), may be entered duty free.

APPENDIX G
DATA ON U.S. PRODUCERS' MANUFACTURING OPERATIONS

Table G-1

U.S. gear producers: Number of U.S. establishments performing certain manufacturing operations, 1989

Operation	*Gears and gearing*
Forging	11
Casting	18
Purchase of raw materials	123
Inspection of incoming materials	159
Gear blank forming (forging or cut bar)	102
Machine of blank (lathe or machining center)	146
Form teeth:	
Milling	69
Broaching	103
Hobbing	154
Shaping	128
Shaving	74
Spiral bevel generator	51
Straight/helical bevel generator	57
Heat treatment:	
Carburize	81
Nitride	41
Finishing:	
Grinding	111
Hard finish	66
Spiral bevel grinding	24
Straight/helical bevel grinding	22
Grinding with cubic boron nitride (CBN) wheel	30
Inspection	134
Assembly	114

Source: Compiled from data submitted in response to questionnaires of the U.S. International Trade Commission.

Table G-2

U.S. gear producers: U.S. producers' production lot size[1] and product diversity, by gear and gear product, 1988

Product	*Product lot size*						*Different types produced*
	Smallest			*Largest*			
	Minimum	*Average*	*Maximum*	*Minimum*	*Average*	*Maximum*	*average size*
Coarse pitch gears:							
Custom-type	1	35	(2)	2	3,409	(2)	(3)
Commodity-type	1	71	(2)	1	6,552	(2)	14,435
Fine pitch gears:							
Custom-type	1	12	(2)	2	8,388	(2)	(3)
Commodity-type	1	9	(2)	1	5,249	(2)	29,486
Worm speed reducers and gearmotors:							
Custom-type	1	23	(2)	2	718	(2)	(3)
Commodity-type	1	11	(2)	1	459	(2)	4,670
Gearmotors and motoreducers:							
Custom-type	1	15	(2)	5	580	(2)	(3)
Commodity-type	1	32	(2)	1	533	(2)	473
Concentric gearmotors/ motor-reducers							
Custom-type	1	3	(2)	5	96	(2)	(3)
Commodity-type	1	5	(2)	1	285	(2)	899
Shaft mounted speed reducers:							
Custom-type	1	7	(2)	1	185	(2)	(3)
Commodity-type	1	4		2	103	(2)	318
High speed units:							
Custom-type	1	5	(2)	5	71	(2)	(3)
Commodity-type	1	1	(2)	3	87	(2)	138
Offset, parallel shaft, and right angle speed reducers:							
Custom-type	1	3	(2)	3	125	(2)	(3)
Commodity-type	1	11	(2)	1	110	(2)	899
Mechanical adjustable speed drives:							
Custom-type	1	1	(2)	2	61	(2)	(3)
Commodity-type	1	1	(2)	2	122	(2)	9
Flexible couplings:							
Custom-type	1	12	(2)	2	113	(2)	(3)
Commodity-type	1	16	(2)	20	674	(2)	17,055
Vehicle gearing:[4]							
Custom-type	1	5,287	(2)	5	10,910	(2)	(3)
Commodity-type	1	40	(2)	5	4,902	(2)	2,882

[1] Custom-type gear and gearing production lot size may be greater than commodity-type lot size because custom-type gearing may be designed specifically for an OEM application, and may not fit open market applications.

[2] Data has been suppressed to prevent the disclosure of Confidential Business Information.

[3] Not applicable.

[4] Some producers did not report data because their production runs are continuous, sometimes over a period of several years.

Source: Compiled from data submitted in response to questionnaires of the U.S. International Trade Commission.

Table G-3

Age of equipment of U.S. gear producers, 1989

Machine type	0-4 years Col. 1	Number foreign Col. 2	5-9 years Col. 3	Number foreign Col. 4	10-19 years Col. 5	Number foreign Col. 6	20 yrs. and over Col. 7	Number foreign Col. 8
Gear shapers	139	42	314	61	542	25	924	86
CNC gear shapers	84	27	42	42	0	0	2	0
NC gear shapers	7	6	19	0	28	0	37	0
Gear shavers	64	8	114	18	356	38	558	0
CNC gear shavers	26	8	4	1	46	1	125	0
NC gear shavers	2	0	9	0	26	0	50	0
Gear hobbers	231	162	415	214	1,278	475	1,618	218
CNC gear hobbers	168	118	65	42	4	1	0	0
NC gear hobbers	16	1	46	29	38	3	38	4
Spiral bevel gear generators	45	6	75	18	354	5	854	1
CNC generators	30	0	6	0	25	0	3	0
NC generators	0	0	8	3	15	0	17	0
Straight/helical bevel generators	8	0	13	0	99	0	263	6
CNC generators	0	0	0	0	0	0	0	0
NC generators	0	0	0	0	3	0	0	0
Milling machines	133	47	249	50	417	41	767	23
CNC milling machines	71	43	85	35	29	6	12	1
NC milling machines	9	3	23	4	39	2	25	0
Machining centers	187	96	148	63	129	12	22	5
Lathes	744	373	843	234	1,356	183	1,823	93
CNC lathes	626	342	471	177	267	49	12	4
NC lathes	67	9	143	18	257	10	57	2
Broaching machines	57	5	116	5	227	4	415	4
CNC broaching machines	4	4	2	2	0	0	0	0
NC broaching machines	2	0	1	0	2	1	18	0
Grinding/hard finish gear teeth machines	94	53	143	55	271	104	595	73
CNC machines	50	33	16	8	3	3	1	0
NC machines	10	6	8	8	0	0	6	1
Spiral bevel gear grinding machines	9	2	26	1	60	0	108	0
CNC machines	3	2	1	1	0	0	0	0
NC machines	6	0	7	0	10	0	4	0
Straight/helical bevel gear grinding machines	28	16	19	9	32	2	64	0
CNC machines	22	16	6	6	0	0	0	0
NC machines	0	0	9	2	3	0	2	0
Heat treatment machines	182	2	210	4	442	2	1,008	4
Carburize furnaces	41	0	37	0	100	0	232	0
Nitride furnaces	9	1	3	0	28	0	50	0
Inspection machines	217	35	290	34	391	26	638	14
CNC coordinate measuring machines	106	24	52	21	15	4	5	4

Source: Compiled from data submitted in response to questionnaires of the U.S. International Trade Commission.

APPENDIX H
DETAILED MANUFACTURING MANAGEMENT TECHNIQUE DESCRIPTIONS

Since the late 1950s, a variety of quality and factory management techniques has been developed and refined, principally in the United States and Japan, to improve manufacturing efficiencies. They have tended to focus on reducing manufacturing costs—inventory costs, labor costs, machine downtime costs, scrap costs—and on reducing the time required to manufacture a product on the factory floor. Quality has also been one of the main focuses, since high-quality products are desired in the marketplace and quality assurance on the factory floor can prevent defects and result in reduced costs. The principal manufacturing management techniques are described below. Gear manufacturers, especially vehicle gearing manufacturers, are using the following techniques to make their manufacturing more efficient. The frequency of the adoption of these techniques by U.S. gear producers during 1984-89 is shown in table H-1.

Flexible Manufacturing Cell

A flexible manufacturing cell (FMC) is a group of related machines which perform a particular process or step in a larger manufacturing process. A cell may be segregated due to noise, chemical requirements, raw material needs, operator requirements, or manufacturing cycle times. The cell is not restricted to one type of part or product, but can readily accommodate different parts or products.

Flexible Manufacturing System

A flexible manufacturing system (FMS) is one manufacturing machine, or multiple machines that are integrated by a computer-controlled automated material handling system. An FMS can be reconfigured by computer control to manufacture various products.

Materials Requirements Planning I

Materials Requirements Planning I (MRP I) is an approach to calculating the raw material or components required to manufacture a production lot of a product. MRP I provides build schedules, manages inventory, and maintains procurement operations.

Materials Requirements Planning II

Materials Requirements Planning II (MRP II) is a system that translates the broad objectives of business strategy into the detailed activities of manufacturing. MRP II includes high-level planning, operations planning, operations execution, and operations reporting.

Just-In-Time

Just-in-time (JIT) is an operating philosophy that has as its basic objective the elimination of waste. Waste is defined as anything other than the minimum amount of equipment, materials, parts, space, and workers' time necessary to add value to the product. JIT identifies activities and resources not adding value and eliminates them.

Statistical Process Control

Statistical Process Control (SPC) is a system allowing for economically sound decision making about a process. In making the decision, risks of taking an unnecessary action when it is not needed are balanced against failing to take an action when necessary. The decisions regarding these risks are made in the context of the concept of variation, specifically with respect to the two sources of process variation: chronic problems or common causes and sporadic problems or special causes.

Total Quality Commitment

Total Quality Commitment (TQC) is complete commitment to quality in all aspects of a manufacturing environment or a business. TQC includes traditional aspects of quality assurance, quality control, and critical business success factors, such as long-range planning, continuing cost reductions, and quality improvements. JIT is an important part of TQC.

Table H-1

Manufacturing operations and quality measures: Frequency of U.S. gear producing establishments' adoption of certain manufacturing management techniques, and the frequency of customer influence on such adoptions, 1984-89

Technique	*1984*	*1985*	*1986*	*1987*	*1988*	*1989*	*Total 1984-89*
Flexible manufacturing cells	7	4	3	6	5	4	29
Customer influenced	1	0	0	1	1	1	4
Batching of work flows	13	2	1	2	1	2	21
Customer influenced	2	0	1	0	0	0	3
Flexible Manufacturing Systems (FMS)	2	0	0	3	1	1	7
Customer influenced	0	0	0	1	0	0	1
Computer simulation	5	1	3	1	4	0	14
Customer influenced	2	0	0	0	1	0	3
Materials Requirements Planning I (MRP I)	7	1	5	0	2	1	16
Customer influenced	2	1	0	0	0	1	4
Materials Requirements Planning II (MRP II)	5	6	3	4	1	6	25
Customer influenced	0	4	2	1	0	3	10
Just-in-time (JIT)	5	8	3	2	5	7	30
Customer influenced	4	7	2	2	2	3	20
Statistical Process Control (SPC)	9	11	7	5	9	10	51
Customer influenced	6	10	5	1	6	7	35
Total Quality Commitment (TQC)	4	2	2	4	8	6	26
Customer influenced	4	0	1	3	4	6	18
Other[1]	1	1	0	3	1	1	7
Customer influenced	0	1	0	1	1	1	4

[1] Includes Continuous Improvement Group Technology.

Source: Compiled from data submitted in response to questionnaires of the U.S. International Trade Commission.

APPENDIX I
METHODOLOGY FOR CAPACITY UTILIZATION

Capacity Utilization Methodology

U.S. producers of gears and gear products were asked to report the practical capacity and actual capacity for their firms in 1988 (table I-1), as measured in machine hours for the operations specified below.

Definitions of terms

Machine hours. Machine hours are defined as machine time used on a workpiece (e.g., run time) plus machine set-up time.

Theoretical capacity. Theoretical capacity assumes running a machine 24 hours a day, 5 days a week, or 120 hours. Respondents were asked to use a percentage of theoretical capacity (such as 70 percent) that best characterizes their establishment's operations to calculate practical capacity.

Practical capacity. Practical capacity is the maximum level of machine utilization that an establishment could reasonably expect to attain using a realistic employee work schedule and the machinery and equipment in place. Practical capacity is run time plus set-up time. Practical capacity, for example, can be assumed to be 70 percent of theoretical capacity (120 hours per week times 70 percent equals 84 hours per week of practical capacity) because of the time required for machine maintenance, movement of materials, and other allowances. This factor (70 percent) may vary for manufacturing operations depending upon machine age, machine capability (numerically controlled or computer numerically controlled, etc.), work flow, the repetitive nature of manufacturing a part or family of parts, etc.

Actual capacity. Actual capacity is the number of machine hours (run time and set-up time) that machines are used.

Hard finishing. Hard finishing is finish grinding or hard skiving of the gear teeth after the heat treatment operation.

Table I-1

Capacity utilization: Practical and actual capacity of U.S. gear producers, in hours, for 1988

Machine operation	*Practical capacity*	*Actual capacity*	*Ratio of actual to practical capacity*
	Hours		*Percent*
All machines	99,539,925	70,286,856	70.6
Turning operations	20,770,137	15,893,132	76.5
Gear tooth cutting (total)	30,852,631	22,882,522	74.2
Hobbing	14,203,009	10,387,678	73.1
Shaping	8,153,248	5,670,062	69.5
Spiral bevel	5,867,670	3,999,983	68.2
Straight bevel	1,195,871	752,357	62.9
Heat treatment (total)	9,607,645	8,145,622	84.8
Carburize	3,525,215	3,289,031	93.3
Nitride	496,674	312,306	62.9
Other	5,585,756	4,544,285	81.4
Finishing	26,696,634	18,357,073	68.8
Gear tooth hard finishing (total)	4,164,025	2,244,666	53.9
For spur and helical gears	2,326,655	1,384,390	59.5
For spiral bevel gears	705,924	379,479	53.8
For straight/helical bevel gears	156,401	106,299	68.0
For herringbone gears	67,568	30,600	45.3
For worm gears	235,875	150,615	63.9
For rack and pinion gears	26,393	21,312	80.7
For other gears	645,209	171,971	26.7

Source: Compiled from data submitted in response to questionnaires of the U.S. International Trade Commission.

APPENDIX J
EMERGING PRODUCING COUNTRIES

General

The developing and newly industrialized countries have the potential to become major forces in the world gear market in the next few years. As these countries move to become self-sufficient and develop their industrial sectors, and as their interest in consumer goods and automobiles increases, the demand for gears and gear products will rise significantly. Those countries with the most advanced industries and with the most potential to increase are Taiwan, China, Singapore, India, Brazil, and Mexico.

Taiwan

Industry and Trade Profile

The gear industry in Taiwan is small and still developing. According to one industry observer, the industry was started about 25 years ago when Shinko, a Japanese manufacturer, built a factory there. Shinko left after only 1 year, however, and the employees started small companies, using the gear drawings from Shinko's facility.[1] Today, the Taiwan gear industry is made up of about 150 small, independent producers. About 40 of these firms produce gears exclusively, and account for 70 percent of Taiwan's total gear production.[2] The largest gear manufacturers in Taiwan have 30 to 40 employees and are no bigger than small U.S. producers. The one exception is Formosa Plastics, a multi-product firm that produces gears and gearing. This firm, medium-sized by U.S. standards, is the largest producer in Taiwan. About half of Taiwan's gear firms are located in northern Taiwan, with the remainder scattered through the central and southern part of the country. The leading gear producers in Taiwan are listed in table J-1.

Taiwan's gear producers have concentrated production in worm gear speed reducers, gear speed reducers, and gears used in machine tools and motorcycles. Production of gears for the automotive industry is minimal and is supplied, for the most part, through imports. The independent producers concentrate mainly on gears for industrial applications.

During 1984-88, the domestic market for gears in Taiwan was strong. Demand was great for gears used in downstream products due, in part, to the rise in machine tool exports from Taiwan to the United States. Also stimulating demand has been the increasing number of Japanese automobile and machine tool makers entering the market in Taiwan. In 1987, Hamada Koki Company, a Japanese firm, took advantage of this growing demand by beginning local production of gears and parts for automobiles and machine

[1] USITC staff interviews with U.S. gear industry officials, September 1989.
[2] American Institute in Taiwan Airgram, December 1989, Taipei, Message Reference No. 08035.

Table J-1
Leading Taiwan gear producers, by sector, 1989

	Industrial gearing	
Firm	*Non-worm gearing*	*Worm gearing*
China Fei Machinery Works Co	X	
Ching Nen Gear Machinery Co	X	
Formosa Plastics Corp	X	
Jen Wu Machinery Co., Ltd	X	X
Jou Da Gear Industry Co., Ltd	X	
Jury Gear Industrial Co., Ltd	X	
Li Hui Electric Factory Co., Ltd	X	
Shin Herng Gear Manufacturing Co	X	
Six Star Machinery Industrial Co	X	
Ta Tung Gear Co., Ltd	X	
Taiwan Gong Ji Chang Co., Ltd	X	X
Taiwan Sun Long Co., Ltd	X	X
Yang Gear Industry Co., Ltd	X	

Source: Compiled by the staff of the U.S. International Trade Commission.

tools. Hamada Koki set up a joint venture with Taichyu Precision Industries Company, a leading Taiwan machine tool manufacturer.[3]

In 1988, apparent consumption of gearing in Taiwan is estimated to have been $258.3 million, with shipments of $124.1 million (table J-2). Most of the domestic production is used in machinery. In 1988, Taiwan imports accounted for about 57 percent of apparent consumption. With the exception of the automotive industry, locally produced gears currently meet an estimated 70 to 80 percent of local market demands, with about 90 percent of Taiwan's gear production being sold to domestic customers. In the automobile industry, 7 of Taiwan's 8 producers use imported gears in car assembly.[4]

Taiwan imports of various gear products rose from an estimated $36.0 million in 1984 to $146.6 million in 1988, and were primarily from Japan, as well as from Canada and West Germany.[5] Automotive gearing accounted for approximately 75 to 80 percent of total imports during 1984-88. Imports of industrial gearing represented nearly all of the remainder; imports of aerospace and marine gearing were negligible during 1984-88. Demand for gears by Taiwan's machine tool industry has been fairly strong since 1985, as that is a major export industry. During 1984-86, exports of gear products from Taiwan, especially of worm gear speed reducers, increased, principally to the United States and Hong Kong. The sudden rise in exports in 1987, to $23.7 million, was accounted for by shipments of automotive gearing. This was probably a one-time export shipment, as exports of automotive gearing in 1988 were negligible.

In late 1989, Taiwan's gear industry was estimated to have a capacity utilization rate of over 100 percent, based on an 8-hour workday and 25-day work months. On certain types of machinery, such as gear-grinding machinery, the utilization rate is over 200 percent.[6]

Most of the technology for the gear and gear-type couplings products has come from Japan and West Germany. During the 1960s and 1970s, Taiwan's gear market was dominated by Japanese products, and currently its automotive industry is dominated by Japanese producers. For example, West German presence in Taiwan has often been through liscensing agreements. Formosa Plastics has recently entered into a licensing agreement with RENK, a West German company, to manufacture parallel and right angle speed reducers.[7]

[3] *Comline Industrial Machinery & Mechanical Engineering*, Sept. 14, 1987, p. 5.
[4] American Institute in Taiwan Airgram, December 1989, Taipei, Message Reference No. 08035.
[5] China External Trade Development Council, *Customs Exports of R.O.C. 1986-88* and *Customs Imports of R.O.C. 1986-88*.
[6] American Institute in Taiwan Airgram, December 1989, Taipei, Message Reference No. 08035.
[7] USITC staff interview with industry official stationed in the Far East, October 1989.

Table J-2

Gears and gearing: Taiwan shipments, exports, imports, and apparent consumption, 1984-88

Year	Shipments	Exports	Imports	Apparent consumption	Ratio (percent) of imports to consumption
			Value (thousand dollars)		
1984	49,000	4,900	35,995	80,095	44.9
1985	54,000	5,400	38,445	87,045	44.2
1986	[2]63,700	6,400	[2]51,500	108,800	47.3
1987	[2]82,000	23,707	[2]96,800	155,093	62.4
1988	[2]124,100	12,400	[2]146,600	258,300	56.8
			Value (million New Taiwan dollars)		
1984	1,938.9	193.9	1,424.3	3,169.3	44.9
1985	2,143.3	214.3	1,525.9	3,454.9	44.2
1986	2,415.5	242.7	1,952.9	4,125.7	47.3
1987	2,625.1	758.9	3,156.5	5,022.7	62.8
1988	3,553.0	355.0	4,197.2	7,395.2	56.8

[1] Compiled from statistics of the China External Trade Development Council and *Monthly Statistics of Trade, The Republic of China*, Statistical Department, Inspectorate General of Customs, The Republic of China.
[2] American Institute in Taiwan Airgram, December 1989, Taipei, Message Reference No. 08035.

Source: Estimated by the staff of the U.S. International Trade Commission, except as noted.

Research and Development

The Government of Taiwan supports gear research, especially gear production technology, at its Mechanical Industry Research Laboratory (MIRL). Firms in the gear industry tend to have their own engineering staffs. Spending on research and development is limited to the leading firms of the gear industry. Such expenditures generally account for only 1 to 2 percent of a firm's total revenues.

Employment and Training

Total employment in the Taiwan gear industry is estimated at less than 2,000 persons. In 1988, hourly compensation costs for production workers in industrial and commercial machinery (SIC 35) in Taiwan were estimated at $3.04.[8] U.S. industry sources familiar with the gear industry in Taiwan estimate these costs for the gear industry to have been between $3.50 and $4.50 per hour in recent years.[9]

Government Policies and Programs

In 1982, the Taiwan Government implemented the "Precision Gear Plan" in order to develop a high-quality gear industry.[10] Under this plan, the gear industry was designated as a "strategic industry" and could receive preferential treatment. This includes receiving loans for the purchase of gear production equipment at a rate of 1.75 points below the country's prime interest rate. Gear producers are exempt from business income taxes, and gear-making machinery can be imported duty-free. The MIRL assists gear manufacturers in the use of computer-aided design and computer-assisted manufacturing (CAD/CAM) equipment and conducts training on some of the latest gear-making machine tools.

Government actions have strongly affected the economic environment in Taiwan in recent years. First, in reaction to requests from the U.S. Government to help reduce the U.S. trade deficit, the Government in Taipei has let the New Taiwan dollar appreciate by more than 40 percent since mid-1986. The Government has also relaxed some import barriers, and has urged domestic business to purchase U.S. products. Finally, the Government has encouraged overseas investment, hoping that profits earned in untapped markets overseas will be reinvested in domestic operations.[11]

Other Competitive Factors

Taiwan does not have its own standards for gearing. Both the Japanese Industrial Standards (JIS) and the American Gear Manufacturers Association (AGMA) gearing standards are commonly used in Taiwan. However, Taiwan's gear producers complain that lack of uniform standards have complicated communication with customers, as well as made machinery purchases more difficult.[12]

Taiwan's gear producers have not been reluctant to invest in machinery and equipment during the recent period of economic prosperity. Some manufacturers have updated their machinery in the last 5 or 6 years, purchasing computer numerically controlled machines from the United States and West Germany. In 1988, Taiwan imports of gear-cutting machine tools totaled $6.4 million. According to Taiwan industry sources, about 50 to 60 percent of Taiwan's gear production machinery is less than 10 years old.[13] Automation is generally limited because of the small size of customers' orders received by the industry. The number of gear grinding machines, which are important in manufacturing precision gears, rose from 18 in 1982 to 40 in 1988. Gear manufacturers have also been purchasing more machinery for automatic worm gear grinding and gear hobbing, as well as CAD/CAM systems, advanced heat treatment machinery, and precision testing and measurement equipment. Production is fairly capital intensive, and productivity, backed by a strong work ethic, is high. Because of their investment in modern

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[8] Unpublished data from the U.S. Bureau of Labor Statistics, August 1989.
[9] USITC staff interview with industry official stationed in the Far East, October 1989.
[10] American Institute in Taiwan Airgram, December 1989, Taipei, Message Reference No. 08035.
[11] "Taiwan Firms Head Overseas as Costs Increase at Home," *The Asian Wall Street Journal Weekly*, Aug. 14, 1989, p. 1.
[12] American Institute in Taiwan Airgram, December 1989, Taipei, Message Reference No. 08035.
[13] Ibid.

machinery, some of Taiwan's gear producers can produce to JIS level "zero," which is equivalent to AGMA class 14, or the quality of gears used in aerospace applications. Taiwan's gear industry's major weaknesses are in design, testing and measurement, and heat treatment.[14]

In Taiwan's gear industry, 80 to 85 percent of the selling price is added value. Labor, including engineering and skilled labor, is estimated to account for a third of the added value; depreciation and interest costs account for another third; and management, miscellaneous costs, and markup account for the remaining third.[15]

Five years ago, the gear industry in Taiwan was prospering, due in part to a favorable exchange rate. Recent foreign exchange fluctuations of the New Taiwan dollar have made products from Taiwan less price-competitive, and, according to industry sources, could further reduce gearing exports in the near future. In addition to the rise of the foreign exchange value of the New Taiwan dollar, local wage increases fed by a severe labor shortage and a more vocal labor force, and high property costs, have helped to drive up manufacturing costs in Taiwan.[16]

China

Industry and Trade Profile

The Chinese gear industry consists of approximately 20 primary and 30 secondary gear manufacturers. Primary gear manufacturers produce gears for automobiles, trucks, tractors, mining machines, locomotives, agricultural machines, ships, and boats. Secondary producers manufacture a wide variety of commodities, including gears, but do not rely on gears for the bulk of their production. The most active gear producing centers are located in the cities of Harbin, Beijing, Shanghai, Xi'an, Wuhan, Zhengzhou, and Shenyang.[17]

All of China's principal gear manufacturers are state-owned entities. Leading Chinese gear manufacturers include: Hangzhou Gearbox Plant, a marine gear producer; Qijiang Gears Plant, Shaanxi Auto Gears Plant, Datong Gears Plant, and Zhuzhou Auto Gears Plant, all major automotive gear producers; and Sichuan Gears Plant, a producer of gears for lifting and handling machinery.

Equity and contractual joint ventures are China's favored manner of foreign investment. These types of joint ventures have become increasingly popular because they commit foreign investors for a minimum of 5 years and because they provide China with foreign capital and the latest technology. In these ventures, the Chinese company usually provides the land, labor, factory, and infrastructure, while the foreign investors provide the technology, machinery and equipment, and technical expertise.

During 1985-88, several prominent foreign companies entered into a variety of agreements with Chinese firms to manufacture gears in China. Renke Tacke of West Germany operates a gear-manufacturing and distribution facility in China under a licensing agreement. In 1985, Eaton Ltd. of the United Kingdom entered into an accord with Chinese automotive manufacturers to license the production of its heavy-duty Fuller Roadranger twin countershaft truck transmissions. The agreement called for Eaton to supply transmissions for assembly until China's truck industry acquired the capability to manufacture its own transmissions.[18] Japanese companies such as Daihatsu Motor Company, Nippondenso Co., Fuji Heavy Industries, Isuzu Motor Co., Honda Motor Co., Suzuki Motor Co. and Yamaha Motor Co. have entered into an agreement to produce light commercial vans, motorcycles, trucks, and subcompact passenger cars on a knock-down basis in China.[19]

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[14] Ibid.
[15] Ibid.
[16] "Taiwan Firms Head Overseas as Costs Increase at Home," *The Asian Wall Street Journal Weekly*, Aug. 14, 1989, p. 1.
[17] Faure, Louis, "L'Industria Cinese degli Ingranaggi e delle Trasmissioni di Potenza: Riflessioni su un Viaggio," *Organi di Trasmissioni*, November 1987, pp. 26-31.
[18] "Eaton signs truck transmission pact with China," *Automotive News*, Feb. 11, 1985, p. 53.
[19] "Torrential Rush to Tap Teeming China Market," *The Oriental Economist*, March 1985, pp. 4-10.

In 1988, Daimler-Benz of West Germany announced a licensing agreement with North Industries (Norinco) of China to produce heavy trucks during the first half of 1990. North will assemble Daimler-Benz trucks from semi-knock-down kits at its Inner Mongolia plant. These trucks will be equipped with gearboxes manufactured by Zahnradfabrik Friedrichshafen (ZF) of West Germany. Eventually, North Industries hopes to source 90 percent of its truck components locally.[20] Assembly and production agreements have also been reached with Chrysler, Peugeot, and Volkswagen. A large proportion of the parts and components used by Volkswagen are Chinese made.

China's seventh 5-year plan, covering 1986-90, calls for an increase in the level of state investment in the development of industrial areas such as transportation, energy, technology, telecommunications, and the production of raw materials. The plan mandates that China obtain advanced technology through cooperative arrangements with foreign firms, rather than relying solely on direct purchases, licensing agreements, barter, or countertrade.

During 1984-88, demand for high-technology products and capital goods grew tremendously. Industrial production grew by 15 percent in 1987. Consequently, the demand for gears and gear products also increased. Because of the shortage of foreign exchange, direct sales to Chinese firms and government agencies for hard currency are limited. Countertrade, compensation trade (payment in goods), counter-purchase (payment in unrelated goods), offset purchases, leasing, and technology licensing arrangements are frequently used instead of cash.[21]

Research and Development

Gear research in China is conducted by 61 universities and institutes and by the Zhengzhou Research Institute of Mechanical Engineering (ZRIME) of the Ministry of Machinery in Beijing. Overall, ZRIME employs about 900 persons, and approximately 45 percent are engineers. The portion of ZRIME that deals with gears has 180 employees, 130 of which are engineers or technicians.[22] The National Center for Quality Control of Gears is also located at ZRIME and performs quality inspections of gears in factories. ZRIME also has responsibility for technical assistance, developing national standards and interpreting foreign standards for gears, as well as promoting the advancement of gear technology in China. ZRIME is conducting research in the areas of longevity and durability testing, lubrication and tribology, design optimization, gear grinding and hardening, quality control, and noise testing.[23] Industrial gear research activities are concentrated in the following sectors: mining and manufacturing; steel; trains; marine; aerospace; and automotive and agricultural equipment.[24]

The Chinese gear industry is also supported by a growing machine tool industry. Gear-making machine tools and metrology machinery are specifically produced at 14 different establishments. Machines built in China today are modern and in some instances comparable to those available from the world's leading producers. The majority of Chinese production is intended for internal domestic consumption. Chinese machine tool machinery factories produce a complete line of gear-making machine tools and inspection equipment, including spiral bevel gear generators, hobbers, shapers, and shavers. Foreign machine tool producers active in China are predominately from West Germany, Switzerland, the United States, and Austria.[25]

Employment and Training

China's gear industry is located in 16 different provinces and employs roughly 40,000 workers. Factories in China are usually quite large, employing thousands of workers. Employees are trained on the job rather than in vocational schools.

[20] "China-Daimler to Produce Heavy Trucks," *Financial Times*, Oct. 28, 1988, p. 5.
[21] U.S. Department of Commerce, Overseas Business Reports, *Doing Business with China*, OBR 88-13, December 1988.
[22] Favre, p. 31.
[23] ASME Gear Research Institute, "Gear Research In China," *Transmissions*, May 1989, pp. 3 and 7.
[24] Ibid.
[25] *China's Machine Tools and Tools*, China Machine Tool & Tool Builders' Association, 1st ed., 1987.

Government Policies and Programs

China's new open-door policies have precipitated significant organizational changes in its political and economic structure which are intended to promote industrial growth and development. In China's drive to modernize, significant strides have been made towards the formation of a market-oriented economy and a greater commitment to economic and trade reforms. China's system of foreign trade has been decentralized and made more efficient. Chinese development policies stress import substitution, with particular importance placed on the development of transportation, energy, technology, telecommunications, and the production of raw materials. Present government policy encourages foreign investment along China's coastal regions in an attempt to boost export-oriented labor-intensive production. China's new customs laws provide for a reduction or an exemption in custom duties on goods imported into, or exported from, special economic zones.

In 1986, special provisions were introduced by the State Council to promote the use of foreign capital by export-oriented high-tech entities. Those provisions included lowering service fees; lowering or eliminating labor insurance, medical care, welfare benefits and housing subsidies; a reduction in site-use fees; priority for services and supplies given to export oriented high-tech companies; priority given by the Bank of China for loans; exemptions for taxes on profits sent abroad; a 50-percent reduction in income taxes; a reduction or extension of enterprise income tax waivers; remittance of income taxes already paid on reinvested profits; and exemption from commercial and industrial taxes.[26]

Besides tariffs, the Chinese government uses other means of regulating or restricting trade. Programs such as import regulatory taxes, import and export licenses, limits on importing luxury goods, and import inspection regulations are used to control trade.

India

Industry and Trade Profile

There are approximately 60 companies manufacturing gears and gear products as their primary product in India. The majority of these companies is Indian owned and operated. Indian gear manufacturers produce gears primarily to meet domestic needs, for inclusion in a variety of products including automobiles, trucks and buses, industrial machinery, ships, household appliances, material-handling and construction machinery, mining machinery, and machine tools.

Leading Indian gear manufacturers are among India's largest 50 companies and India's leading sources of automobiles, trucks, agricultural machinery, and aircraft. The leading producers include Primer Auto Ltd., Hindustan Motors Ltd., and Mahindra & Mahindra, producing gears for passenger cars; Telco-Tata Engineering, Ashok-Leyland, Bajaj-Tempo, and Standard Motors, producing truck gears; and Hindustan Aeronautics, producing gears for aircraft.[27]

The demand for gears and gear products in India is linked directly to circumstances which dominate in India's major industrial sectors. Overall, India's industrial sector grew by 9.5 percent in 1988 over 1987.[28] Sales by the Indian automobile industry, a major consumer of gears, grew by 14 percent in 1988 over 1987.[29] India's domestic markets have traditionally been closed to outside competition. Through high tariffs, import licensing restrictions, and severe constraints on foreign investment, the Indian government successfully impeded the flow of imports and ensured a veritable monopoly for Indian manufacturers. The average tariff rate for finished goods ranges between 100 and 200 percent.

Due to the difficulty of importing gears into the Indian market, major foreign manufacturers have established production and distribution facilities in India. Most produce a wide variety of gears for that market. In recent years, Indian companies have entered into production agreements with major international gear manufacturers. Some of the

[26] "Foreign Investment: Problems and Goals Identified by MOFERT," *China's Foreign Trade*, Issue 1, 1987, pp. 8-11.
[27] *Kothari's Industrial Directory of India*, Kothari Enterprises, 36th ed., 1988-89.
[28] U.S. Department of Commerce, *Business America*, Vol. 110, No. 7, Apr. 10, 1989, p. 47.
[29] Manchanda, Rita, "India Steps on the Gas," *South*, June 1988, p. 76.

collaborative agreements that now exist are with the following foreign gear manufacturing companies: Leyland Vehicles Ltd. of the United Kingdom, Zahnradfabrik Friedrichshafen AG (ZF) of West Germany, Eaton Ltd. of the United Kingdom, David Brown Gear Ltd. of the United Kingdom, Flender of West Germany, and Renke Tacke of West Germany.

On May 25, 1989, India was specifically targeted as a priority country by the U.S. Government for action under Section 301 of the Omnibus Trade and Competitiveness Act of 1988, also known as "Super 301." Super 301 is the U.S. Government's latest act to target specific countries that have erected unfair barriers to U.S. exports and investments. The most often cited barriers to U.S. exports include domestic content requirements, exclusion of foreign insurance companies, export obligations on foreign firms, inadequate intellectual property and patent protection, limits on foreign ownership of businesses, and limitations on the importation of machinery and merchandise by established foreign firms.

Employment and Training

India possesses an adequate supply of skilled and unskilled workers and graduates nearly 1,200 students from its five premier institutes of technology each year.[30] Nearly 30 percent of these graduates emigrate to the West in search of better job opportunities.

Government Policies and Programs

Historically, government policies have effectively protected many of India's manufacturing sectors from import competition. Severe constraints on foreign investment and restrictive import/export licensing regulations were used by the Indian Government as a means of conserving foreign capital and effectively limiting imports to those goods deemed necessary for India's economic development. Imports may also be subject to an auxiliary duty and an excise duty levied on imports competing with domestically produced products.

In 1984, India initiated a new program to selectively liberalize some of its trade policies. The policy changes were aimed at attracting additional foreign investment, improving the quality of domestic production, increasing India's international competitiveness, and quickening the pace of India's economic development. Cooperative agreements such as joint ventures and licensing agreements became the predominant means of acquiring advanced technology and know-how. Indian automotive manufacturers have entered into production agreements with a number of Japanese automakers and currently enjoy a dominant position in the domestic Indian automotive market.

India's new 5-year plan will likely call for increased investment in all major sectors. In order to foster further economic growth, India will further liberalize its licensing regulations, initiate more flexible import policies, and privatize a limited number of state-owned companies. During January-August 1988, India approved 642 new joint venture agreements valued at $113 million between Indian and foreign manufacturers.[31] The United States is one of India's leading trade partners and its second-largest collaborator in joint ventures and technical agreements. As of 1988, U.S. companies had entered into 212 collaborations with Indian manufacturers.[32] At present, foreign participants in joint venture agreements are limited by law to a 40- percent standard restriction for foreign equity.

Singapore

Industry and Trade Profile

The gear industry in Singapore consists of Ordnance Development and Engineering Co. of Singapore Pte Ltd., part of the Government of Singapore Defense Group, and Sundstrand Pacific Pte Ltd. and Garrett Singapore Pte Ltd., both subsidiaries of U.S.

[30] "A Scientific Brain Drain," *South*, November 1989, p. 78.
[31] "Home Thoughts From Abroad," *South*, February 1989, p. 28.
[32] U.S. Department of Commerce, *Business America*, "India is Luring More American Companies," Vol. 109, No. 21, Oct. 10, 1988, p. 14.

aerospace corporations.[33] A signficant portion of production in Singapore consists of semi-finished products imported mainly from a U.S. manufacturer for heat treatment, hard finishing, and inspection. Singapore is also a transshipment point for gear products, and as shown in the tabulation below, re-exports totaled $50.8 million in 1988, rising from $33.8 million in 1986. Tsubakimoto Chain Co. of Japan, a producer of conveyor chains and variable speed drive units, also has a facility in Singapore. Companies that are suppliers to gear manufacturers with operations in Singapore include subsidiaries of Azumi Mfg. Co. Ltd. and Nachi-Fuijikoshi Corp., both of Japan, which produce gear-cutting tools.

The domestic market for gears and gear products is driven by real estate construction, public works, and material-handling applications in factories and other end-user sites. To a smaller extent, Singapore's defense industry also consumes gears. Data for production are not available; virtually all consumption is supplied by imports. Singapore's imports, exports, and re-exports of gears and gearing (excluding vehicle and aerospace gearing) compiled from Singapore's *Trade Statistics*[34] for 1986-88, are shown in the following tabulation (in millions of dollars):

Year	*Imports*	*Exports*	*Re-exports*
1986	80.2	27.1	31.8
1987	111.2	19.0	37.8
1988	150.9	33.4	50.8

The major sources of imports for gears and gearing have been Japan, the United States, and West Germany. Imports from these sources for 1986-88 are shown in the following tabulation (in millions of dollars):

Country	*1986*	*1987*	*1988*
Japan	22.5	32.5	42.0
United States	21.4	29.4	34.5
West Germany	9.9	11.8	20.0

Exports from Singapore have principally been shipped to the United States. Exports to the United States totaled $24.6 million in 1986, $16.6 million in 1987, and $26.9 million in 1988. According to U.S. trade statistics, U.S. imports from Singapore rose from approximately $1.5 million annually during 1984-86 to $38.6 million in 1987 and to $41.2 million in 1988. Approximately 71 and 88 percent of U.S. imports from Singapore in 1987 and 1988, respectively, were parts of gearing for use in civil aircraft.

Research and Development

Data on research and development in the Singapore gear and gear products industry are not available. However, the level of development efforts for Sundstrand Pacific and Garrett Singapore is estimated to be relatively low, since both firms are able to source technology from their U.S. parent firms.

Employment and Training

Data for employment in Singapore's gear industry are not available. In 1988, however, average hourly compensation costs for production workers in the industrial and commercial machinery industries (SIC 35) totaled $3.23.[35]

Government Policies and Programs

Although the Government of Singapore has various programs to assist manufacturers in exporting, none are for the gear industry. Also, no preferential loans have been given to the gear industry by the Government of Singapore. Sundstrand has "pioneer" status, as part of a tax incentive program, until mid-1993.

[33] U.S. Department of State Telegram, December 1989, Singapore, Message Reference No. 13271.
[34] Ibid.
[35] Unpublished data, U.S. Bureau of Labor Statistics, August 1989.

Brazil

Industry and Trade Profile

The Brazilian gear industry consists of approximately 100 producers manufacturing gears primarily for the petrochemical, shipbuilding, steel, automobile, and mining industries. Brazil's gear industry is located predominately in the Sao Paulo region, Brazil's most developed commercial and manufacturing center. Brazil's gear industry has grown into Latin America's largest and most sophisticated, primarily because of Brazil's preoccupation with reducing its dependency on imports while promoting domestic production and exports. The vast majority of Brazil's gear manufacturers are small- to medium-sized firms operated by Brazilian nationals or by subsidiaries of major foreign gear manufacturers. Foreign producers active in Brazil include Flender, SEW-Eurodrive, Zahnradfabrik Friedrichshafen (ZF do Brasil), Cestari, RENK-Zentrale, Sundstrand (Sundstrand do Brazil Equipmentos), and Transmotionica.

The demand for gears and gear products is tied directly to Brazil's major industrial sectors. Growth in overall industrial output in Brazil slowed abruptly in 1987, when output grew by less than one percent, significantly lower than the 8.3 percent and 10.3 percent increases recorded in 1985 and 1986, respectively. This decline resulted from government-enforced price controls and the failure of Brazil's official plan, the Cruzado Plan, to control inflation. Total domestic sales of industrial gears and gear products in Brazil in 1988 was approximately $50 million.[36]

Because of the difficulty associated with importing products into Brazil, major foreign gear producers have established production and distribution facilities there, with many of these firms producing a wide range of products for that market. Industry officials indicate that the machinery and equipment employed by Brazilian gear manufacturers is built under license from foreign firms. The machinery, however, is reportedly comparable with that used in the United States in terms of age and level of sophistication.

In 1988, the Brazilian industry continued to encounter annual inflation rates greater than 1,000 percent and low domestic demand.[37] The low level of economic growth associated with Brazil's numerous investment restrictions contributed to a decline in foreign investments in 1987-88. Total foreign investment in Brazil dropped from approximately $27.7 billion in 1987 to only $300 million in 1988. Major investors were the United States, West Germany, Japan, and Switzerland.

The automotive and capital goods sectors of Brazil's economy both registered declines in 1987-88 due to a deterioration in domestic demand, high interest rates on borrowed money, and government price controls. Domestic auto sales declined by as much as 33 percent in 1987, to the lowest level since 1972. Auto companies were compelled to sell cars at a loss due to a government-imposed price freeze. Domestic declines were offset in part by exports which increased by nearly 60 percent during this period. The capital goods market suffered significantly from Brazil's recent economic problems. The production of capital goods fell by 1.8 percent in 1987 as compared with 1986. Declines in domestic investment in capital goods since 1981 produced a dramatic drop in orders. In 1987, idle capacity stood at nearly 50 percent; production of capital goods increased slightly but overall sales declined by 7 percent.

Employment and Training

Workers employed in manufacturing totaled 8.9 million persons, or 16 percent of the nation's work force. Less than 1 percent of manufacturing workers was employed in the gear industry. A sufficient labor force exists and unskilled labor can be easily acquired; skilled workers, however, are in very short supply. In February 1987, a legal minimum wage was established at Cz$804 per month. Brazilian workers typically work a 48-hour, 6-day work week. ZF Brazil employs approximately 3,800 workers to produce automotive brackets, steering units and pumps, transmissions, and axles.

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[36] USITC interview with representatives of Falk Corporation, Milwaukee, WI., Sept. 29, 1989. Sundstrand do Brazil Equipmentos is a wholly owned subsidiary of Falk.

[37] U.S. International Trade Commission, *Operation of the Trade Agreements Program, 39th Report, 1987*, USITC pub. 2095, p. 4-50.

Remunerations include a monthly salary or wage, commissions, bonuses, traveling expenses, special family supplements for all children under 14, and overtime. Optional fringe benefits, offered by many of the larger companies, may include a pension plan administered by the government, governmental medical and dental care, meals, accident insurance, termination pay, sick pay, maternity leave, yearly vacations, uniforms, and transportation.

Government Policies and Programs

In recent years, Brazil's official policy has been to reduce its reliance on imports while developing domestic industries, thereby conserving foreign exchange reserves. Import restrictions are placed on all nonessential imports. In order to protect local industries, the government often levies tariffs as high as 200 percent. Tariffs for the automotive industry, for example, range between 8 and 205 percent ad valorem.

The government also requires mandatory import licenses for all imported goods and employs domestic content laws as another means of curbing imports. Licenses, issued by the Foreign Trade Department of the Banco do Brazil, are subject to the Brazilian 'Law of Similars' before issuance. This law requires that a likeness test be conducted to determine if a similar product is being produced in Brazil before an import license is granted.[38]

Brazil is a member of the Latin American Integration Agreement (LAIA), which grants special tariff treatment to goods imported from member states. Brazil also signed an economic integration pact with Argentina in July 1986, which reduces trade and tariff restrictions between the two countries. In November 1988, Argentina and Brazil signed a new agreement assigning a 10-year deadline for the total integration of their two economies.

In May 1989, the Government of Brazil announced a new industrial policy terminating programs shielding its industries from import competition.[39] The intention of the new policy is to gradually introduce more imported goods into Brazil, thereby forcing the domestic industry to become more competitive. The policy abolishes 40 laws and nearly 100 regulations and will lead to a reduction of import duties on a variety of products.

Foreign investment in Brazil is encouraged, as long as it constitutes a long-term commitment to Brazil's economic development, especially in those areas designated as priority development areas. Such areas are agriculture, technology, manufactured goods that are presently being imported, and goods which will increase Brazil's export revenues. Joint ventures, especially those under Brazilian control, have become the Government's preferred vehicle for foreign investment.

Investment incentives are offered to priority industries considered to be of importance for Brazil's future development. Such industries include capital goods, fishing, tourism, shipbuilding, metallurgical, cellulose, chemical and petrochemical, automotive, aerospace, and consumer goods. Investment incentives include subsidized loans for buyers of Brazilian-produced equipment, accelerated depreciation, financing at lower-than-market rates using government development funds, low-cost financing for exports, and exemptions from excise taxes and value-added sales taxes on exported manufactured goods.

Other Competitive Factors

Brazil is the most competitive gear and gear products manufacturer in South America. Its domestic industry is large, technologically advanced, and currently capable of supplying other markets. In recent years, its competitiveness was enhanced by stringent government control on imports and industry support through investment programs. Brazil's share of the U.S. market for gears and gear products has risen steadily in recent years and, with the expected increases in domestic production for export, will probably capture a larger market share in a number of other countries as well.

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[38] Ibid., p. 1.
[39] "New Policy for Industry," *Brazil Trade and Industry*, English Edition-No. 118, 1989, pp. 16-19.

Mexico

Industry and Trade Profile

There are approximately eight large firms producing various gearing products in Mexico; five producers are affiliated with U.S. firms, one with a Swedish corporation, and two with majority-owned Mexican companies.[40] The vast majority of Mexico's gear producers, however, are small- to medium-sized firms. In addition, there are numerous other captive medium-and small-sized producers affiliated with the capital equipment and consumer-durable industries that are not accounted for in official gear industry statistics.

Major Mexican gear producers are largely concentrated within 150 miles of Mexico City. The demand for gears and gearing in Mexico revolves around its major industries, including the automotive, mining, agricultural, steel and petrochemical sectors. Secondary sources of demand include producers of compressors, pumps, automotive power transmission equipment, and home appliances.[41]

Although Mexico has one of the most advanced manufacturing sectors in the developing world, the Mexican gear and gearing industry is considerably less developed than that of nations in South America, such as Brazil. Several factors have contributed to the relatively low level of development of this industrial sector. Until recent years, government policies offered a low level of import protection to the capital equipment industry. It was advantageous for both state-owned enterprises and private firms to import gears and gear products rather than develop a competitive domestic industry.[42] In addition, the domestic market was not able to support the development of a significant gear industry, and problems with the economy have hindered companies' ability to raise capital for investment.

Prior to 1986, the largest users of gears and gear products were the 49 industrial entities owned by the Government of Mexico, which accounted for the bulk of total consumption of gears and gear products in Mexico. As a result of the severe economic recession and cutbacks in government procurement between 1982 and 1986, industry experts indicate that capacity utilization for nearly all major Mexican industrial sectors, except the Border Industrialization Program, has fallen below 50 percent.[43]

The market for gears and gear products in Mexico is dependent on the recovery of the national economy. Since 1982, Mexico's economy has experienced virtually no growth as a result of a $103 billion foreign debt and annual inflation rates as high as 160 percent during 1987. The economy was also burdened with domestic interest rates hovering near 100 percent during 1984-88.

Mexican shipments of gears and gear products decreased steadily from approximately $79.0 million in 1984 to $40.0 million in 1988 (table J-3). Mexican domestic consumption, increasing significantly from $87.0 million in 1984 to $112.2 million in 1985, returned to the 1982 level throughout 1986-88. The increase in 1985 can be attributed to a one time rise in imports from the United States.

In fact, the bulk of all gear consumption in Mexico during 1984-88 consisted of imports. During 1984-88, Mexican imports of such products grew by an estimated 48 percent, from $43.0 million in 1984 to $63.5 million in 1988 (table J-3). While these imports came primarily from the United States, industry sources indicate that several foreign firms such as Flender of West Germany, Hansen Transmissions of Belgium, and Sumitomo of Japan have also recently increased their exports of gears and gearing to Mexico. The recent liberalization of the foreign investment laws in Mexico is likely to result in future establishment of manufacturing facilities by some or all of these firms to serve select niche market segments. Major Japanese producers, such as Nissan, Honda, and Sanyo, have all indicated that they intend to increase production capacity in Mexico. Also, a portion of such imports is attributable to gear products being assembled in

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[40] American Chamber of Commerce of Mexico, A.C., *Directory of American Companies Operating in Mexico*, April 1989, pp. 234, 298, 355, and 378.

[41] The American University, *Mexico-A Country Study*, 1985, pp.163-164.

[42] The World Bank, *Mexico's Manufacturing Sector: Situation, Prospects and Policies*, March 1989, p. 93.

[43] U.S. Embassy, Mexico City, Mexico, "Foreign Economic Trends and Their Implications for the United States," February 1989, pp. 5-16.

Table J-3
Gears and gearing: Mexican shipments, exports, imports, and apparent consumption, 1984-88

Year	Shipments	Exports	Imports	Apparent consumption	Ratio (percent) of imports to consumption
	1,000 dollars				
1984	78,967	35,000	43,000	86,967	49.4
1985	68,744	22,500	66,000	112,244	58.8
1986	61,984	22,000	47,000	86,984	54.0
1987	59,600	23,000	49,300	85,900	57.4
1988	40,000	16,000	63,500	87,500	72.6

Source: Estimated by the staff of the U.S. International Trade Commission.

Mexico from parts and subassemblies that were produced in the United States. This is done to take advantage of the lower labor costs in Mexico and the duty-free provisions under HTS heading 9802.00.80 (formerly Tariff Schedules of the United States item 807.00).

Exports of gears and gearing from Mexico decreased during 1984-88, from $35 million in 1984 to $16 million in 1988. In 1988, nearly 67 percent of these products exported from Mexico to the United States entered duty-free under HTS heading 9802.00.80.

Employment and Training

Data on the exact number of employees in the gear and gear products industry are not available, but the number of production workers is estimated to have been between 1,000 and 3,000 in 1988. In an effort to halt spiraling inflation rates, Mexico instituted the Economic Solidarity Pact (ESP), a plan designed to freeze wages and to postpone further depreciation of the Mexican peso. The maximum workweek is six 8-hour shifts; in practice, a 40 to 44 hour week is often in effect, particularly in industrial firms such as gear companies.

There are numerous fringe benefits provided by nearly all large firms. Furthermore, collective labor contracts often provide for benefits in excess of those stipulated by the federal labor law and other legislation in the areas of early retirement, number of holidays, and length of vacations. Many companies also provide major medical and group life insurance, particularly for white collar employees and executives.

Government Policies and Programs

During 1984-88, Mexico embarked on a program to modernize and revive its economy by opening its markets to limited foreign investment and imports. In an effort to accelerate the in-depth industrial structural reforms required to diversify its export base, Mexico further liberalized its foreign investment laws in 1989 to permit 100-percent foreign ownership of Mexican enterprises up to $100 million. These foreign investment regulations were designed to increase new investment in previously restricted sectors of the Mexican economy such as auto parts, iron and steel, and glass production.[44]

These new foreign investment reforms are likely to accelerate the amount of direct foreign investment, which totaled $2.3 billion in 1988. According to Government estimates, nearly 70 percent of total investment will be in manufacturing, 28 percent in service industries and commerce, and the remainder in the mining industries.[45]

Other emerging areas of foreign investment include Mexico's maquiladora program, also known as the Border Industrialization Program, or BIP. Instituted in 1965 to provide permanent employment for Mexico's rapidly growing population, the maquiladora program has expanded rapidly in recent years as a result of a series of devaluations of the Mexican peso, which has effectively decreased wages to below $1 an hour. The

[44] U.S. International Trade Commission, *Operation of The Trade Agreements Program*, July 1989, pp. 113-118.
[45] "A Brief Outline Of New Foreign Investment Rules In Mexico," *Twin Plant News*, pp. 18-23.

maquiladora program sought to attract an infusion of foreign capital and technology that would help to develop a modern industrial base along the United States-Mexican border. Consequently, numerous U.S. and Japanese firms have shifted labor-intensive production to Mexico. In particular, Japanese investment has been growing rapidly; presently there are 46 Japanese maquiladoras in Mexico, and that number will probably increase to approximately 300 operations by 1992. These estimates are based on both U.S. industry and Government of Mexico official projections.[46]

[46] U.S. International Trade Commission, *The Use And Economic Impact of TSUS Items 806.30 and 807.00*, January 1988, pp. 8-12 and 8-13.

APPENDIX K
U.S. DISTRIBUTORS OF INDUSTRIAL GEARING

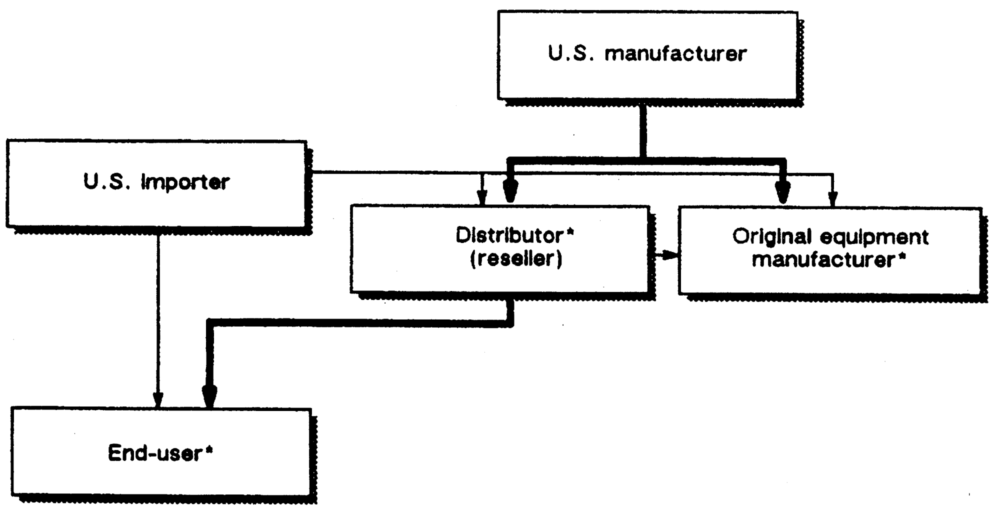
Description of the U.S. Market

The Commission surveyed 49 U.S. distributors of gears and gearing products. Forty five, or 92 percent, of the surveyed firms responded to the Commission's questionnaire. The responding firms operated 537 establishments in 43 different States and Puerto Rico during 1988. Establishments operated by distributors were concentrated primarily in the South and Southwestern states, accounting for 43 percent of the survey total. The remaining establishments were almost evenly distributed between the Northeastern, Western, and the Midwestern states. Over 84 percent of the surveyed firms indicated that they were not owned, in whole or in part, by any other company. The seven firms which were part of other companies operated 64 establishments during 1988. Only one of the respondents reported being owned by a foreign company.

Channels of Distribution

Domestic producers and importers generally sell industrial gearing in the United States directly to unrelated original equipment manufacturers (OEMs) and to certain end-users. Industrial gearing is also sold to distributors, who, in turn, sell to small OEMs and end users. Certain large end users may also import directly. The maintenance, operations, and repair gearing requirements of OEMs and end-users are usually serviced by distributors, directly by U.S. assemblers of foreign-brand gearing, or other importers, but typically not directly by U.S. gear producers with the exception of custom gearing. Figure K-1 shows the channels of distribution for industrial gearing in the U.S. market.

Figure K-1
Principal channels of distribution for industrial gearing



* U.S. OEMs, distributors, and end-users may also import directly.

Source: Compiled by the staff of the U.S. International Trade Commission.

U.S. producers and importers also use a direct sales force, or manufacturer's representatives or agents. The direct sales agent is paid a salary and receives other benefits from the manufacturer or importer. The manufacturer's representative or agent works on a commission basis. Both the direct sales force and the manufacturer's representatives and agents represent the gearing producer. The distributor, however, purchases and takes title to the product and resells it to the customer, and therefore represents the distributor's own business.

Most imported gearing is either large-volume orders of gearing meeting the custom design of OEMs, or a standard type product sold direct to OEMs, end-users, and distributors that can be used in many types of applications. Gearing is also imported as replacement units for foreign machinery. Custom-designed large gearing is less frequently imported. A major difference in the channels of distribution between U.S. and imported product is that importers tend to sell to anyone in the market, whereas U.S. gear producers generally do not sell to small

OEMs and end-users except through distributors.[1] U.S. subsidiaries of foreign companies assembling gear products made up of foreign components tend to sell direct to anyone, but will also use distributors. However, such distributors may not be required to maintain a stock of product, as might be required by the U.S. gear producer.

During 1984-88, there were no major shifts in the channels of distribution of industrial gearing overall. The majority of U.S. producers' and U.S. importers' shipments was to OEMs (44 percent), distributors (36 percent), and to end users (20 percent). Approximately 30 percent of total shipments to distributors was made to related parties, and the remaining 70 percent was to unrelated distributorships.

Changes in Operations

Distributors were asked to indicate on the Commission's questionnaire whether they had experienced any changes in their operations which affected sales or varied the makeup of their firms. Thirteen of the surveyed firms indicated that the makeup of their businesses had been altered through acquisitions, closures, and expansions. According to distributors, acquisitions and expansions enabled them to provide local service in new markets where service had formerly been furnished from distant areas. Changes experienced by distributors in the character of their establishments' operations that affected sales or marketing during 1984-88 are shown in the following tabulation:

Type of change	*Number of occurrences*
Acquisitions	21
Expansions	17
Closures	9

U.S. Distributors' Sales

Total sales of all products reported by distributors increased annually from $462.9 million in 1984 to $728.7 million in 1988 (table K-1). Ten distributors accounted for $533.6 million or 73 percent of total sales in 1988. The ten leading distributors' annual sales for 1988 ranged from $20.0 million to slightly less than $200.0 million. As gear products became less important to distributors, the proportion of total sales of all products accounted for by gears and gearing, including couplings, declined from 13 percent of the total during 1984 to almost 10 percent in 1988.

Sales of domestically produced open and enclosed gearing and parts dominated distributors' gearing sales, accounting for more than 96 percent of total gearing sales in 1984 and 91 percent in 1988. Enclosed gearing and parts constituted the largest single segment of sales during the period surveyed. Sales of domestically produced enclosed gearing and parts declined from $44.3 million in 1984 to $31.0 million in 1985, before rising to $41.6 million in 1988. The proportion of total gearing sales accounted for by domestically produced enclosed gearing and parts declined from 75 percent in 1984 to 60 percent in 1988. Sales of domestically produced open gearing and flexible couplings, together, increased from $12.0 million in 1984 to $21.3 million in 1988.

Distributors' sales of imported gearing and parts, including U.S.-assembled foreign gearing and parts, increased 167 percent from $2.4 million in 1984 to $6.5 million in 1988 (table K-1). Enclosed gearing and parts also dominated distributor sales of imports, accounting for approximately 99 percent of distributors' import sales during 1984-88. Japan, the United Kingdom, West Germany, Italy, and Taiwan were the principal sources of imported gears. Companies such as Sumitomo, SEW-Eurodrive, Renold, David Brown, Leroy-Somer, Nord, and Graham-Shimpo were the sources most frequently mentioned by distributors. Many of these foreign gear manufacturers employed domestic distributors as their means of entering the U.S. gear market. After taking title to the goods, distributors generally provide an experienced sales force and the producer furnishes an established line of gears and gear products. The distributor is also often obliged to buy and preserve a base stock from the manufacturer.[2]

[1] Data submitted in response to questionnaires of the U.S. International Trade Commission by U.S. distributors.

[2] SEW-Eurodrive, Inc., posthearing submission, Nov. 15, 1989.

Table K-1

U.S. distributors: Sales of all products, open gearing, enclosed gearing and parts, and flexible couplings, 1984-88

(In thousands of dollars)

	Latest completed accounting year ending—				
Sales	*1984*	*1985*	*1986*	*1987*	*1988*
All products	462,913	513,466	575,814	632,407	728,673
Open gearing:					
U.S.-produced	4,107	4,853	5,232	6,026	6,673
Imported	36	37	37	35	53
Subtotal	4,143	4,890	5,269	6,061	6,726
Enclosed gearing and parts:					
U.S.-produced	44,304	31,016	32,643	37,013	41,589
U.S.-assembled foreign	2,192	2,568	3,776	4,631	5,263
Imported	200	247	387	672	1,149
Subtotal	46,696	33,831	36,806	42,316	48,001
Total gear sales	50,839	38,721	42,075	48,377	54,727
Flexible couplings:					
U.S.-produced	7,900	11,563	12,466	13,198	14,633
U.S.-assembled foreign	3	2	2	3	5
Imported	0	1	6	9	11
Subtotal	7,903	11,566	12,474	13,210	14,649
Total gear and flexible coupling sales	58,742	50,287	54,549	61,687	69,376

Source: Compiled from data submitted in response to questionnaires of the U.S. International Trade Commission.

Sales by Market

In order to better highlight the differences in firms marketing gears and gear products, distributors were asked to indicate the types of power transmission and motion control products they sold and whether they were domestic or foreign made. As shown in table K-2, distributors marketed a wide variety of complementary power transmission products and electronic motion controls.[3]

Table K-2

U.S. distributors: Frequency of types of motion control products sold and marketed by U.S. distributors, by brand, as of October 1989

	Brand	
Product line	*U.S.*	*Foreign*
Actuators and complex motion control components	23	4
Adjustable-speed drives	37	22
Bearings	36	25
Belt drives	38	10
Chain drives	37	33
Clutches and brakes	34	4
Controls and sensors	29	11
Couplings, flexible shafts, and U-joints	40	3
Cycloidal speed reducers	4	17
Fluid power drives	14	2
Gear drives (except worm gear)	37	20
Gearmotors and motoreducers	35	21
Metallic flexible couplings (including gear-type)	35	2
Motors	35	24
Open gearing	34	1
Power transmission accessories	38	16
Programmable controllers/peripherals/software	15	10
Traction drives	8	15
Worm gear drives (including worm gearmotors)	39	14

Source: Compiled from data submitted in response to questionnaires of the U.S. International Trade Commission.

[3] Edward L. Reid, Jr., *The Increasing Importance of PT Distributors,* Power Transmission Distributors Association, January 1989.

Based on questionnaire responses, most distributors rely primarily on domestic brands. Domestic brands dominated distributors' responses in all product categories except cycloidal speed reducers and traction drives, which are important because they can be used as substitutes for gear boxes.

Market Segments and Demand

U.S. distributors of gears and gear products were requested to furnish a listing of their top 5 customers, by type of industry, for the following categories: OEMs, maintenance repair, and operations (MRO), and other end-user markets. Distributors were also asked to supply estimated sales to those markets. Conveying equipment, chemical processing, and food processing were the most important industries within the OEM, MRO, and other end-user markets, respectively. The following tabulation shows the top end-user markets reported by distributors, as an estimated percent of the total value of sales, during 1988:

Market	*Average*
OEM end-user markets:	
Conveying equipment	21.3
Food and beverage processing	18.3
General machinery	16.3
Printing machinery	13.9
Textile machinery	11.7
MRO end-user markets:	
Chemical processing	15.6
Food and beverage processing	12.5
Mining	11.9
Packaging	11.5
Textile	10.5
Other end-user markets:	
Food processing	24.2
Chemical and refineries	11.5
Steel industry	8.0
Agricultural machinery	7.0
Heating and ventilation	5.0

Factors Affecting U.S. Market Demand

Distributors of gears and gear products were asked to assess those factors which most influence OEM and MRO customers' decisions in purchasing gearing. Distributors indicated that, among other factors, price was the predominant factor affecting OEM customers' decisions to purchase gearing (table K-3). MRO customers, however, placed more importance on reliability, availability, and delivery times. Other important factors influencing OEM customers' decisions were product availability, delivery times, reliability, and service. Additional factors affecting MRO customers' decisions included service, price, life-cycle costs, warranties, and delivery times.

Table K-3
U.S. distributors: Perceptions of the importance of certain factors in OEM and MRO customers' purchase decisions for gearing, by frequency, October 1989

Factor	*Importance to customer—*							
	Extremely		*Very*		*Not Very*		*Not at all*	
	OEM	*MRO*	*OEM*	*MRO*	*OEM*	*MRO*	*OEM*	*MRO*
Price	27	6	17	25	0	9	0	0
Life-cycle cost	3	5	8	20	23	12	3	1
Delivery times	10	17	26	21	2	1	0	0
Product availability	12	19	24	21	3	0	0	0
Brand name	2	1	9	17	27	21	1	1
Country of origin	1	1	6	10	27	27	4	1
Service	5	12	23	23	9	4	1	1
Reliability	9	20	23	18	7	1	0	0
Engineering/design	2	2	18	20	14	15	4	2
Training	1	1	4	11	23	22	11	5
Warranties	2	2	14	24	17	8	3	4
Other	0	0	1	0	0	0	0	0

Source: Compiled from data submitted in response to questionnaires of the U.S. International Trade Commission.

Competitive Assessment by U.S. Distributors of the Quality of U.S.-Produced Gears and Gear Products

The Commission's questionnaire asked distributors to compare the competitiveness of U.S.-produced gears with U.S.-assembled foreign-brand gearing and U.S. imports in the U.S. market. According to questionnaire responses, Japan, the United Kingdom, West Germany, Italy, and Taiwan were the principal sources of imports. As shown by distributors responses in tables K-4 and K-5, domestically-produced gears and gear products were reported to be equal to, or slightly better than, imports. Approximately 77 percent of the responding distributors indicated that U.S.-produced products were equal to, or slightly better than, U.S.-assembled foreign products. Distributors indicated that domestic gear producers enjoyed a slight advantage over producers of U.S.-assembled foreign gears and imports of finished products in all areas except the ability to supply metric sizing.

Table K-4

U.S. distributors: Degree of comparison between U.S.-produced and U.S.-assembled foreign gearing product

Item	*Significantly better*	*Slightly better*	*Equal*	*Slightly worse*	*Significantly worse*	*Do not know*
Overall competitive assessment	5	14	5	2	2	5
Price factors:						
Purchase price (delivered)	5	6	11	4	1	0
Terms of sale	2	21	1	1	3	0
Inventory financing/buy plans	2	17	3	1	4	0
Nonprice factors:						
Delivery time	4	8	9	3	1	0
Service	4	15	4	1	2	0
Warranties (overall)	3	21	1	0	2	0
Duration of warranties	1	22	2	0	2	0
Terms of warranties	2	22	1	0	2	0
Risk for product liability	5	15	1	0	5	0
Quality (overall)	5	15	4	2	0	0
Quality of materials used	2	18	4	0	2	0
Design for application	5	15	3	1	3	0
Reliability	6	13	7	1	2	0
Product innovation	8	8	9	3	2	0
Engineering/design/technical assistance	6	12	3	2	1	0
Training of distributor/customer personnel	5	15	2	2	1	0
Product availability	7	12	4	3	0	0
Ability to supply metric sizing	2	3	6	14	3	0
Other	0	1	0	0	0	0

Source: Compiled from data submitted in response to questionnaires of the U.S. International Trade Commission.

Table K-5

U.S. distributors: Degree of comparison between U.S.-produced and imported gearing product

Item	*Significantly better*	*Slightly better*	*Equal*	*Slightly worse*	*Significantly worse*	*Do not know*
Overall competitive assessment	7	6	3	1	2	0
Price factors:						
Purchase price (delivered)	3	6	4	1	2	0
Terms of sale	1	12	1	0	6	0
Inventory financing/buy plans	2	10	3	0	5	0
Nonprice factors:						
Delivery time	8	5	4	0	1	0
Service	6	10	2	0	1	0
Warranties (overall)	0	15	3	0	2	0
Duration of warranties	1	14	2	1	2	0
Terms of warranties	1	15	2	0	2	0
Risk for product liability	8	8	1	0	3	0
Quality (overall)	5	10	4	0	1	0
Quality of materials used	3	11	5	0	2	0
Design for application	3	8	5	1	2	0
Reliability	2	8	7	0	2	0
Product innovation	4	6	8	0	1	0
Engineering/design/technical assistance	7	7	3	0	1	0
Training of distributor/customer personnel	8	8	1	0	1	0
Product availability	9	3	5	0	1	0
Ability to supply metric sizing	0	2	7	4	4	0
Other	1	1	0	1	1	0

Source: Compiled from data submitted in response to questionnaires of the U.S. International Trade Commission.