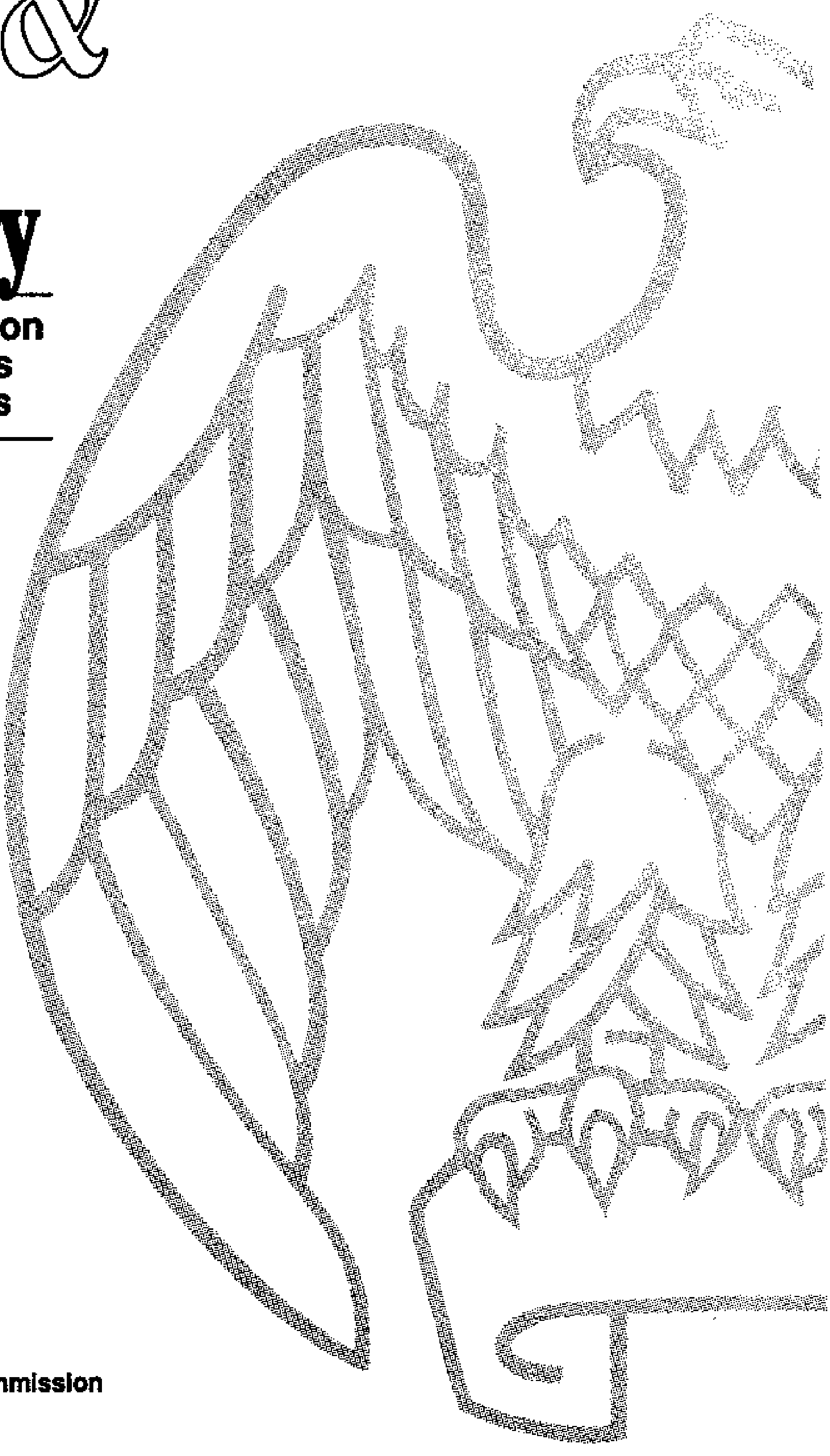
Industry & Trade Summary

Aircraft and Reaction Engines, Other Gas Turbines, and Parts



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UNITED STATES INTERNATIONAL TRADE COMMISSION

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PREFACE

In 1991 the United States International Trade Commission initiated its current *Industry and Trade Summary* series of informational reports on the thousands of products imported into and exported from the United States. Each summary addresses a different commodity/industry area and contains information on product uses, U.S. and foreign producers, and customs treatment. Also included is an analysis of the basic factors affecting trends in consumption, production, and trade of the commodity, as well as those bearing on the competitiveness of U.S. industries in domestic and foreign markets.[1]

This report on aircraft and reaction engines, other gas turbines, and parts covers the period 1988 through 1992 and represents one of approximately 250 to 300 individual reports to be produced in this series during the first half of the 1990s. Listed below are the individual summary reports published to date on the machinery and transportation sector.

USITC publication number	*Publication date*	*Title*
2430	November 1991	Aircraft, Spacecraft, and Related Equipment
2505	April 1992	Construction and Mining Equipment
2546	August 1992	Agricultural and Horticultural Machinery
2570	November 1992	Electric Household Appliances and Certain Heating Equipment
2633	June 1993	Textile Machinery and Parts
2746	March 1994	Aircraft and Reaction Engines, Other Gas Turbines, and Parts

[1] 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 the statutory authority covering the same or similar subject matter.

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INTRODUCTION

This summary will discuss key aspects of the global industry that produced aircraft and reaction (rocket) engines, nonaircraft gas turbines, and parts for these engines during 1988-92. The report is organized into three major sections: U.S. and foreign industry profiles; U.S. and foreign tariffs and nontariff measures; and U.S. performance in domestic and foreign markets. In addition, appendices provide information explaining tariff and trade agreements and highlight trade statistics.

The products covered by this summary include aircraft and nonaircraft gas turbines, piston engines designed for aircraft, reaction engines, and parts for all of these engines.[1] An aircraft engine, which may be either piston-type or gas-turbine, is used to create forward movement in aircraft. The reaction engines covered here include engines other than turbojets designed principally for use in rockets. The nonaircraft gas turbines covered herein are used for stationary power needs, such as the generation of electricity, industrial cogeneration, and mechanical drive applications.

U.S. industry shipments of aircraft and reaction engines, nonaircraft gas turbines, and parts rose during 1988-92, reaching $29.4 billion in 1992.[2] Seventy percent of U.S. shipments were made up of aircraft gas-turbine engines and parts for these engines. U.S. exports of the summary products reached $8.3 billion in 1992, whereas U.S. imports of these goods amounted to $6.2 billion in 1992.[3] Parts of aircraft and nonaircraft gas turbines were the leading HTS subheadings in this product grouping in terms of both U.S. imports and exports. In 1992, U.S. exports of parts amounted to $3.6 billion, or 43 percent of total U.S. exports of all summary products, while U.S. imports of parts accounted for 46 percent of U.S. imports of these products in 1992.

Aircraft gas turbines are nonpiston-type engines that generally are used to power large or high-performance aircraft. They are tubular horizontal containers, open on both ends, and built in several sections to facilitate assembly and disassembly of the engine. All gas-turbine engines generally consist of a compressor, a combustion chamber, a burner section (sometimes referred to as a combustor), drive turbines, and tail pipe or exhaust duct. Gas-turbine engines heat, accelerate, and compress large quantities of air, which is then expelled at high velocity. It is the exhaust of the gas turbine which is utilized to power the airframe or generating unit. Four types of aircraft gas-turbine engines currently are produced: (1) turbojets, which are utilized primarily by military jet aircraft; (2) turbopropellers, which are employed on larger business aircraft and most commuter aircraft; (3) turboshafts, which are used in helicopters; and (4) turbofans, which primarily power business jets and large civil transport aircraft. Stationary turboshaft engines are also mated to generators to produce electricity.

The working cycle of the gas-turbine engine is similar to that of the four-stroke piston engine, which is typically found in small aircraft or automobiles. However, in the gas-turbine engine, combustion occurs at a constant pressure, whereas in the piston engine it occurs at a constant volume. Induction, compression, combustion, and exhaust are intermittent in a piston engine, whereas they occur continuously in a gas turbine. In a four-cycle piston engine, only one stroke is utilized in the production of power, while the others are involved in charging, compressing, and evacuating the air/fuel mixture. In contrast, the turbine engine eliminates the three idle strokes, thus enabling more fuel to be burned in a shorter time, which then produces a greater power output for a given size of engine.[4]

While the operation of all gas-turbine engines is similar, there are two designs for a turbojet engine; these designs are differentiated by the path of the intake air (figure 1). A straight-through flow system is the basic design; it provides for an engine with a high jet-thrust velocity and a relatively small frontal area. This type of engine is preferred for high performance aircraft, such as military fighters, because its small frontal area creates less induced aerodynamic drag than other types of aircraft gas-turbine engines. In contrast, the reverse flow system gives an engine greater frontal area with a reduced overall length. These are typically smaller gas turbines used in turbopropeller applications, where drag is less of a concern due to the lower operating speeds of the aircraft.

Turbofan aircraft engines are the most popular for civil applications. Turbofans are essentially turbojet engines with an enclosed fan attached to the front of the engine. This fan, with both fixed and rotating blades, enables the engine to operate more quietly and burn less fuel for a given thrust than would be the case with a pure turbojet engine.

An important characteristic of the turbofan engine is its utilization of the bypass principle. This principle involves the division of airflow at the front of the engine. The ratio of the volume of cool air that is ducted over the engine to the volume of air passed through the high-pressure system by the fan determines the bypass ratio of the engine. With low bypass ratios (for example, on the order of 1:1, as in a turbojet), the two air streams are usually mixed before being exhausted from the engine. Conventionally, all of the air taken in by the engine is given an initial low compression by the fan. Some of this air is then ducted around the high-pressure sections of the engine, with the balance of the air being delivered to the combustion

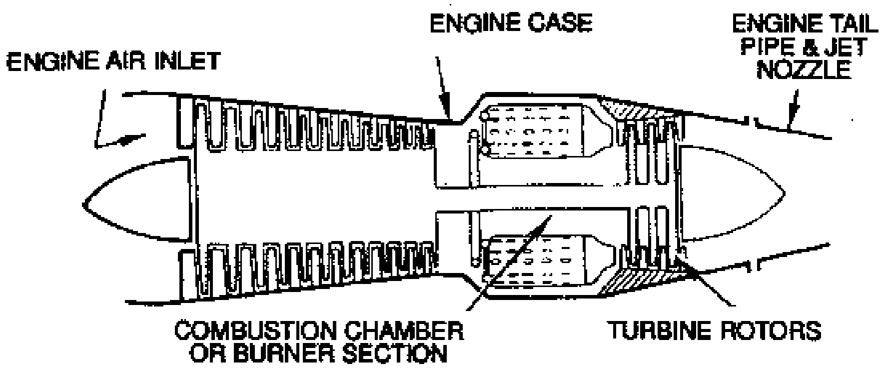
[1] Table B-1. International Trade Administration, *U.S. Industrial Outlook 1993* (Washington, DC: U.S. Department of Commerce, Jan. 1993), pp. 20-10 to 20-13.

[2] Table B-2.

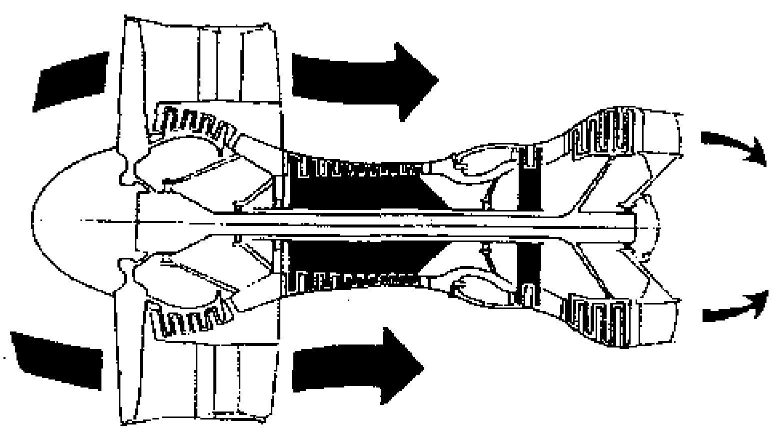
[3] Ibid.

[4] Rolls-Royce, plc., *The Jet Engine* (Derby, England: Rolls-Royce plc, 1986), fourth ed., p. 11.

Figure 1
Single-spool turbojet, high-bypass ratio turbofan



Single-spool turbojet



High-bypass ratio turbofan

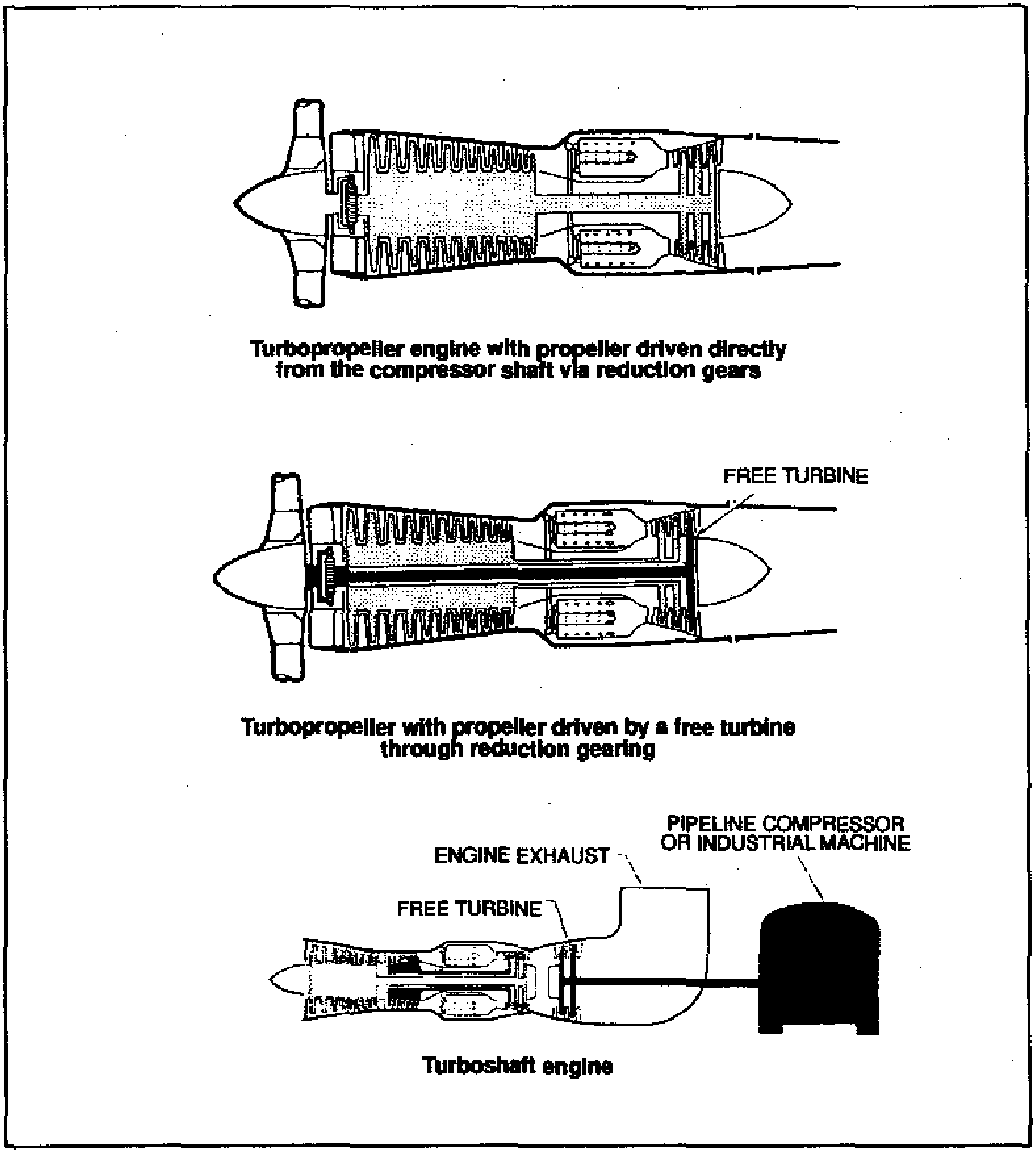
Source: Pratt & Whitney (used with permission).

system (high-pressure, or "hot" section). The air ducted around the engine serves to cool the engine and, when mixed with the exhaust, reduces engine noise. Bypass engines are more fuel efficient than pure turbojet engines, and therefore are favored by aircraft manufacturers. Increasing the bypass ratio usually leads to an increase in fuel efficiency. However, because the size of the fan must be increased to alter the ratio, higher bypass engines typically are fitted to larger airframes, both for aerodynamic reasons and cost considerations. Very-high bypass ratios, in the order of 15:1, are achieved using propfans. These are a variation on the turbopropeller theme but with advanced technology propellers capable of operating with high efficiency at high aircraft speeds.[5]

The major difference between a turbopropeller, or an aircraft turboshaft engine, and a turbojet, or turbofan engine, is the conversion of gas energy into mechanical power, usually via a gearbox, to drive a propeller (airplane), or rotor (helicopter). Only a small amount of jet thrust is available from the exhaust system in a turbopropeller or turboshaft engine (figure 2). The majority of the energy in the gas stream is absorbed by additional turbine stages, which drive

[5] Ibid, p. 17.

Figure 2
Turbopropeller and turboshaft gas turbine engines



Source: Pratt & Whitney (used with permission).

the propeller or rotor through internal shafts.[6] These engines are very efficient for relatively low-speed, low-altitude aircraft.

Piston-type aircraft engines are usually two- or four-cycle spark-ignition devices. Piston-type engines are also referred to as reciprocating engines. They are primarily air-cooled and currently are utilized on lightweight aircraft. These types of engines are found in recreational, agricultural, and executive transport aircraft, and light helicopters.

Rocket engines are either solid- or liquid-fuel type, continuous combustion engines (figure 3). Solid-fuel rockets are typically employed when the launch vehicle is designed for only one mission, as in the case of launching a satellite. In a solid-fuel rocket, a circular or star-shaped channel runs down the center of the propellant, forming a combustion chamber. While solid-fuel rockets can produce great power, they cannot be shut down; they continue to burn until all of their fuel is exhausted. Liquid-fuel reaction engines, on the other hand, are designed for repeated firings and may be used as maneuvering rockets for space vehicles. In a liquid-fuel rocket, two liquids, the fuel and the oxidizer, are mixed and burned in the combustion chamber. Liquid oxygen and liquid hydrogen typically are used as fuel in these rockets.[7]

U.S. INDUSTRY PROFILE

Industry Structure[8]

Over 500 U.S. firms produced aircraft and reaction engines, nonaircraft gas-turbine engines, and parts for these engines during 1992. U.S. production of aircraft engines is concentrated primarily in the Northeast and Midwest, while rocket engines are predominantly manufactured in the West. Parts manufacturers are located throughout the United States. Total employment of production workers in establishments producing these products was estimated to be 87,000 workers in 1988 and 75,000 in 1992. The ratio of production workers to all workers remained relatively stable at about 50 percent during 1988-92.[9] According to USITC estimates, shipments per worker increased from $289,000 to $391,000 during 1988-92. The average hourly wage earned by production workers manufacturing aircraft engines and parts increased from $13.80 in 1988 to $16.28 in 1992, or by 18 percent.[10] Industry sources indicate that the majority of production workers are members of the International Association of Machinists and Aerospace Workers.

U.S. manufacturers of aircraft and reaction engines have a strong reputation for quality, on-time delivery, and worldwide product support. These factors have had a positive effect on the competitiveness of the United States vis-à-vis the rest of the world. Most U.S. engine manufacturers are part of U.S. business conglomerates that have interests in nonaerospace businesses in addition to aeroengine manufacturing.

The United States is the world's largest producer of aircraft engines. The seven major U.S. producers of these products are generally part of larger, publicly-owned companies. These producers are located in the Northeastern, Midwestern, and Western United States. Engines manufactured by these firms powered 70 percent of the world's large civil aircraft as of December 31, 1992.[11] U.S. producers likely will retain their overall dominant market position for the foreseeable future, despite the growing trend toward international joint ventures in aircraft engine design and production. Future partnerships will include both existing Western companies and Russian producers of aircraft gas-turbine engines.[12]

There are 14 U.S. manufacturers of engines for missiles and rockets.[13] Rocket manufacturers are located predominantly in the Western United States, and are supported by hundreds of suppliers established throughout the country.

Pratt & Whitney, a division of United Technologies, Inc., and the aerospace divisions of the General Electric Company (GE) dominate U.S. production of civil and military aircraft turbojet, turbopropeller, turboshaft, and turbofan engines. GE also produces stationary gas turbines. These two companies accounted for the bulk of U.S. aircraft gas turbine shipments during the period. Revenues generated by the United Technologies Power Group, which includes Pratt & Whitney, Pratt & Whitney Canada, and Pratt & Whitney Government Engine Business, increased from $6.3 billion in 1988 to $6.9 billion in 1992, or by 9 percent.[14] Pratt & Whitney engines were installed on 53 percent of the world's

[6] Ibid.

[7] David Macaulay, *The Way Things Work* (Boston: Houghton Mifflin Co., 1988), pp. 170-171.

[8] The Standard Industrial Classification (SIC) categories for products covered in this summary include SIC 3724, Aircraft Engines and Engine Parts; SIC 3764, Guided Missile and Space Vehicle Propulsion Units and Propulsion Unit Parts (part); and SIC 3511, Steam, Gas, and Hydraulic Turbines, and Turbine Generator Sets (part).

[9] Aerospace Industries Association of America, Inc. (AIA), "Employment of Production Workers in the Aerospace Industry," Statistics 93-57, Series 12-04, published Nov. 3, 1993; and USITC estimates.

[10] AIA, "Average Hourly Earnings in the Aerospace Industry," Statistics 93-59, Series 14-04, Nov. 3, 1993.

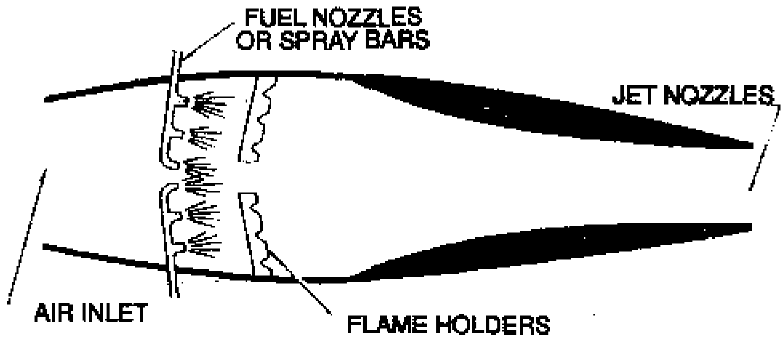
[11] Boeing Commercial Airplane Group, *World Jet Airplane Inventory, Year-End 1992* (Seattle, WA: The Boeing Co., Mar. 1993), p. 22. Market share percentages do not include the participation of Pratt & Whitney or General Electric in cooperative manufacturing programs with international partners. If such programs were included, U.S. market share would amount to approximately 80 percent of the global aircraft engine market for large civil transports.

[12] In 1993, Pratt & Whitney signed a Memorandum of Understanding with Perm Aviadvigatel, setting up a joint venture aimed at modernizing the Russian aeroengine firm.

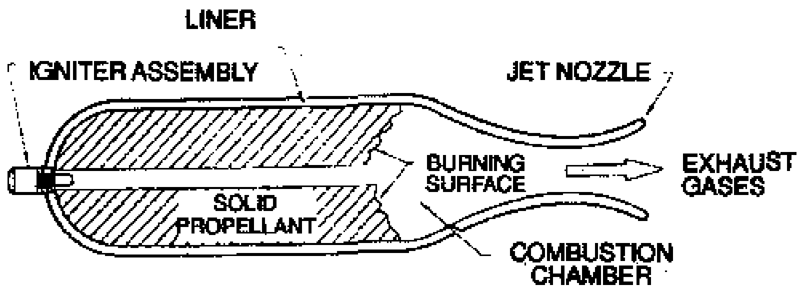
[13] McGraw-Hill Aviation Week Group, *World Aviation Buyer's Guide, Winter 1993* (New York: McGraw-Hill Aviation Week Group, 1993), pp. 243-354, 1115-1116.

[14] *Annual Report, 1989* (Hartford, CT: United Technologies Corp., Feb. 1, 1990), p. 51; and *Annual Report, 1992*, (Hartford, CT: United Technologies Corp., Feb. 12, 1993), p. 20.

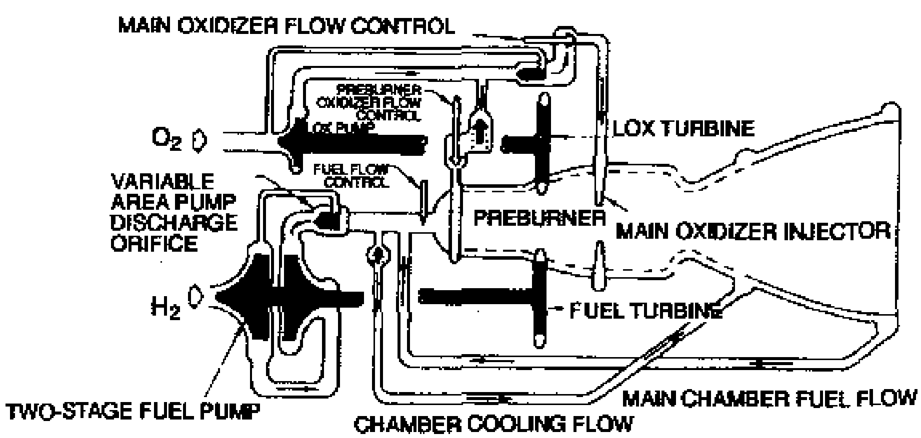
Figure 3
Ramjet engine, solid- and liquid-fuel reaction (rocket) engines



Ramjet engine



Solid-fuel reaction engine



Liquid-fuel reaction engine

Source: Pratt & Whitney (used with permission).

civil turbojet aircraft as of December 31, 1992.[15] United Technologies also manufactures rocket engines in its Space Propulsion and Systems division. Pratt & Whitney teamed with the Allison Gas Turbine Division of General Motors, Inc. during 1986-90 to develop a geared, counter-rotating propfan engine. This engine was designed in response to the civilian aircraft market's concerns over the projected rise in fuel prices. Pratt & Whitney is currently a partner in International Aero Engines (IAE), a multinational joint venture formed in 1983 that also includes Rolls-Royce of the United Kingdom, Japanese Aero Engine Corp. (JAEC - Japan),[16] Motoren- und Turbinen-Union (MTU - Germany), and Fiat Aviazione (Italy).[17] Pratt & Whitney has a 30-percent share in this program, and is part of another five-member international group formed to research the design of a hypersonic engine.

GE aircraft jet engines powered 27 percent of the world's large civil aircraft as of December 31, 1992.[18] Total aeroengine revenues for the corporation amounted to $6.4 billion in 1988, increasing to $7.4 billion in 1992, or by 14 percent.[19] GE teamed with Société Nationale d'Etude et de Construction de Moteurs d'Aviation (SNECMA) of France in 1974 to form a joint engine manufacturing company, CFM International, that produces aircraft engines for the Boeing 737 and Airbus models A320 and A340.[20] CFM engines were installed on 15 percent of all civil turbojet aircraft in 1992.[21] In response to market concerns over the projected rise in cost of jet fuel, during 1986-88, GE designed and tested a fuel-efficient unducted fan engine with a bypass ratio of 36:1.

Other U.S. manufacturers of aircraft gas-turbine engines during this period were: Allison Gas Turbine Division, General Motors, Inc. (turbopropeller, turboshaft, and propfan); Garrett Engine Division, Allied Signal Industries, Inc. (turbopropeller and turbofan); Textron-Lycoming, a division of Textron, Inc. (turboshaft, turbopropeller, and turbofan); and Williams International (turbofan). Piston engines for aircraft were made in the United States primarily by Teledyne-Continental Motors (TCM) and Textron-Lycoming. TCM also produces rotary engines for remotely-piloted vehicles.

There were two cooperative ventures initiated between U.S. companies during the mid-1980s. Garrett Engine Division and GE joined to create CFE Company, whose goal was to design, develop, and produce a 6,000-pound thrust engine, the CFE738. In April 1990, it was chosen by Dassault-Bréguet of France to power their Falcon 2000 business jet. Allison and Garrett joined to form the Light Helicopter Turbine Engine Company to produce the T800, chosen in 1988 by the U.S. Army for its multi-service LHX (Light Helicopter Experimental) program.

Aero-engine manufacturers buy parts from a common pool of vendors, as well as from each other. Areas of proprietary technology found on aircraft gas-turbine engines include the design and composition of the fan blades and the design and metallurgy involved in the hot sections of the engine (those sections where combustion takes place). Parts manufacturers that are granted Parts Manufacturing Authority (PMA) by the Federal Aviation Administration (FAA) are able to sell the parts that they produce both to the original-equipment manufacturers and the aftermarket. PMAs compete with aircraft engine producers for replacement parts in the aftermarket.

Timely delivery of both engines and parts is a critical element in the procurement decisions of engine purchasers. Engine manufacturers have production systems that use multiple sourcing and parallel production in order to minimize production disruptions. Parallel production is the setup of duplicate production lines within the manufacturer's own facility, in order to compensate for a production line disruption. Multiple sourcing is the subcontracting of the same product with a variety of firms in order to ensure on-time delivery; this is not possible with all parts.

In the past, producers of gas-turbine engines for large civil transport aircraft sold their products directly to the airframe manufacturers, who then offered the airframe and engine as a complete package. However, beginning in the mid-1970s, engine manufacturers began selling their engines not only to airframe manufacturers, but also directly to civil or military end-users, a practice which continues today. This development was made possible by changes in airframe design which allow for some interchangeability of engines on some airframes. This added flexibility in engine choice is important in both the original-equipment market and the retrofit market, as it broadens the market for a particular engine, and increases the choices available for the purchaser.

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[15] Boeing, p. 22.

[16] JAEC is made up of Ishikawajima-Harima Heavy Industries, Kawasaki Heavy Industries, and Mitsubishi Heavy Industries.

[17] Member companies have contracted to a 30-year agreement to produce engines capable of producing between 18,000 and 30,000 pounds of thrust. The first engine to be produced, the V2500, entered service on July 28, 1988 on an Airbus A320. This engine is a candidate for re-engining the U.S. Air Force's KC-135 and the McDonnell Douglas MD-90 series of civil transport airplanes. Each member contributes that portion of the engine it specializes in producing; the number of companies participating makes this venture unique. Pratt & Whitney and Rolls-Royce each have a 30-percent share of IAE; JAEC, 23 percent; MTU, 11 percent; and Fiat Aviazione, 6 percent. *Jane's All the World's Aircraft 1989-90* (London: Jane's Information Group, 1989), p. 701.

[18] Boeing, p. 22.

[19] *1988 Annual Report* (Fairfield, CT: General Electric Company, Feb. 10, 1989), p. 65; and *1992 Annual Report*, (Fairfield, CT: General Electric Company, Feb. 12, 1993), p. 43.

[20] GE is responsible for design integration, the high-pressure turbine assembly (engine core), the main engine control, and related components. The engine core is derived from the F101 turbofan, which was developed for the U.S. military. SNECMA is responsible for the low-pressure system, gearbox, accessory integration, and engine installation. This partnership has concentrated on mid-power engines (20,000-35,000 pounds of thrust).

[21] Boeing, p. 22.

Aircraft engine manufacturers compete aggressively in the world market by introducing evolutionary technology, usually in conjunction with the announcement of a new airframe. Retrofitting older airframes with new engines may soon become a larger and more important market for engine manufacturers, due to the enactment of more stringent noise and environmental regulations throughout the world. Producers of aircraft engines for smaller commuter, agricultural, or recreational aircraft continue to sell their product predominantly to the airframe manufacturer, and typically have an exclusive arrangement with that manufacturer for a particular model of aircraft.

For those contracts in which an aircraft purchaser is offered a choice of engines on a particular airframe, the decision typically is based on such factors as the financing package offered, timely delivery, quality, reliability, fleet commonality, ease of service, parts availability, technical support from the manufacturer, and low operating costs. In general, aircraft engine manufacturers present competitive bids for prospective engine contracts. These bids may include financial incentives such as preferential loan rates or spare parts and/or training, to attract prospective purchasers. Coproduction and offset agreements are also used as a common marketing strategy for aircraft engine producers.[22] Such offerings serve to spread the heavy investment burdens and risks among the various producers.

Funding for research and development (R&D) in the aerospace industry ranks eighth among all U.S. industrial sectors.[23] In 1992, United Technologies and GE recorded a combined $4 billion in R&D expenditures, although between 35 and 40 percent of these funds were supplied by the U.S. Government. These expenditures and percentages were approximately the same in 1991.[24]

Aeroengine R&D expenditures are primarily devoted to materials research (composite parts), hydrodynamic research (new engine fan blade design), and physics (thin-air and non-air breathing engines, e.g., ramjet and scramjet).[25] As previously discussed, during the 1980s, some important concerns of airlines were the projected price increase of oil, and therefore, jet fuel; engine noise; and exhaust emissions. As a result of these concerns, engine manufacturers were asked to produce a new generation of engines that were quieter, more fuel-efficient, and less polluting. The cost benefits of these programs were not fully realized, however, as the prices of oil and jet fuel did not rise to the levels projected by aircraft purchasers, averaging $26 a barrel and $0.63 a gallon, respectively, during 1988-92.[26] Engine manufacturers also found they could impact both noise and exhaust concerns within the scope of their current engine programs.

Aircraft gas-turbine engine manufacturing is a highly research intensive industry. Turbine blade and component metallurgy and electronic engine control systems, such as Full Authority Digital Engine Control (FADEC), represent the current state-of-the-art in engine technology. The combination of metals that can sustain extreme temperature changes and the complex electronic systems that control the combustion process have contributed to the safety and durability of the modern aircraft gas-turbine engines that are installed on today's world aircraft fleet. Introduced on new engines produced for the civilian market during 1986-90, FADEC systems monitor and control certain engine performance parameters, such as turbine speed, fuel flow, and engine temperatures. By maintaining a closer tolerance on engine performance parameters, a pilot can operate an aircraft more efficiently and thereby extend the life of the engine.

Industry sources indicate that there were no shortages of labor, raw materials, or capital during 1988-92. Global production overcapacity existed during the period and continues to exist today. The insufficient number of FAA-certified, overseas repair stations is an industry concern that surfaced during the period. In order for a U.S. airline to fly in the United States, all engine repair work must be done at an FAA-certified station. Industry sources indicate that the paucity of certified overseas repair stations has forced airlines to do repair work that may not have been adequately documented in all instances, creating potential safety and legal violations. In response to this situation, the FAA is in the process of increasing the number of certified overseas repair stations.

A major factor adversely affecting the U.S. industry is product liability, which has effectively limited U.S. production of aircraft piston-type engines for small general aviation aircraft registered in the United States. These concerns arose as a result of the January 1963 case of *Greenman vs. Yuba Power Products, Inc.*.[27] In this case, the Supreme Court of California embraced the concept of strict liability, which stated that a manufacturer who produced a product found to be defective or unreasonably

[22] A coproduction agreement is an arrangement wherein the manufacturer agrees to manufacture or assemble a portion of the final product in the purchasing country as a condition for a successful contract bid. An offset agreement is an arrangement wherein the seller agrees to purchase products from the purchasing nation as a condition of sale. U.S. International Trade Commission, *Analysis of Recent Trends in U.S. Countertrade: Report on Investigation No. 332-125*, USITC publication 1237, Mar. 1982, p. 8.

[23] "R&D Scoreboard," *Business Week*, June 29, 1992, p. 107.

[24] Annual reports of United Technologies and the General Electric Co., 1992.

[25] A ramjet is the simplest type of air-breathing engine, having no moving parts. It is a turbojet without compressors, which achieves air/fuel mixture compression via the ram effect of air pressure going into the engine. Supersonic air is slowed to subsonic speeds for combustion by a boundary layer of air formed by the shape of the engine intake. A scramjet is similar in function to a ramjet; the difference is that combustion takes place with the air passing through the engine at supersonic speeds. Both the ramjet and scramjet can only operate efficiently above Mach 1 (the speed of sound, 762 miles per hour at sea level), limiting their application to civil aircraft.

[26] U.S. Department of Energy, *Monthly Energy Review, October 1993* (Washington, DC: publication DOC/EIA-0035(93/10)), p. 115.

[27] 59 Cal. 2d 57, 377 P.2d 897, 27 Cal. Rptr. 697 (1963).

dangerous when put to its intended use, and those who distributed and sold that product, liable for injuries caused by that product, without proof of any negligence or fault on the part of the manufacturer or the vendors.[28] Therefore, U.S. producers of general aviation aircraft and manufacturers of engines for this segment must continue to insure themselves for many aging aircraft and engines that were produced since their company's inception.[29]

Consumer Characteristics and Factors Affecting Demand

The price, quality, technological level, and performance of foreign-made aircraft engines and parts for aircraft engines is similar to that of U.S.-made products. However, worldwide product support by some foreign manufacturers is not equal to that provided by the majority of U.S. engine manufacturers, according to industry sources.

Because airframe manufacturers are building aircraft that generally can accept engines from several manufacturers, producers of large commercial aircraft engines and parts sell their products directly to U.S. and global airlines and aircraft leasing companies whose corporate headquarters are located throughout the world. The U.S. market for military, commuter, and executive aircraft engines and parts is located predominantly in New York, Connecticut, Missouri, Kansas, and Texas, where most of these types of aircraft are assembled.

Demand for aircraft engines and parts is determined principally by the amount of airline traffic and Federal budget expenditures for military aircraft. A number of Federal regulations have also had an impact on the demand for new aircraft engines. For example, proposed Federal regulations on noise have caused airlines to upgrade their planes with newer, quieter, more fuel-efficient engines. Competition among world aeroengine producers has been further stimulated by the aforementioned ability of engine manufacturers to sell directly to the numerous end-users (world airlines, leasing companies, and the U.S. military procurement agencies) instead of the relatively few airframe manufacturers. Though this ability may not have increased the overall demand for engines, it has introduced more instability into the market by allowing a broader range of customers to decide on the choice of final product.

FOREIGN INDUSTRY PROFILE

Rolls-Royce, plc., located in the United Kingdom, and SNECMA of France are the chief foreign competitors of U.S. manufacturers of aircraft gas-turbine engines. Rolls-Royce is the largest producer of aircraft gas turbines in Europe, with aeroengine turnover totaling $3.8 billion in 1992.[30] Rolls-Royce was acquired by the British Government in 1971 and was subsequently privatized in 1987. Rolls-Royce makes gas-turbine engines for both aircraft and nonaircraft applications, as well as other types of turbine engines. The United States represented the largest single market for Rolls-Royce during 1992.[31] As of December 1992, Rolls-Royce gas-turbine aircraft engines were installed on 11 percent of all Western large civil aircraft.[32] SNECMA produces civil engines in conjunction with its joint venture with GE, and military engines for French fighter aircraft.

In addition to these two enterprises, France and Germany have aircraft engine producers that concentrate primarily on the manufacture of aircraft gas-turbine parts and subassemblies, and engines for helicopter applications. Société Turbomeca (Turbomeca) of France has supplied Aérospatiale of France, a multi-line aircraft producer, with the Arriel series of helicopter engines. Turbomeca is also pursuing the U.S. business helicopter market as an original-equipment supplier. MTU of Germany has supplied parts to, and entered into joint ventures with, various U.S. and foreign jet engines for civil aircraft. It has a 21-percent share of the Pratt & Whitney PW2000 engine program; a 13-percent share of the JT8D-200 engine program; an approximate 12-percent share in the manufacture of GE's CF6-50 engine program and in IAE's V2500 engine programs; an 8-percent share of GE's CF6-80A/A1 engine, which powers the Airbus A310 and Boeing's 767; and a 9-percent share of GE's CF6-80C2 engine, found on the Airbus A300-600.[33]

West European engine manufacturers could increase their global market share if their engines become optional on new Airbus aircraft and if a new type of smaller jet transport is built by a European Union (EU) member. Currently, Rolls-Royce is developing engines to power Airbus' newest aircraft, the A330. Rolls-Royce has also formed a joint venture with Bavarian Motor Werke ((BMW) Germany) to develop a new generation of engines for one of the proposed West European 75-120 seat regional jet airliners. MTU has linked up with Pratt & Whitney for the same reasons. A West European production partner responsible for the partial or total production of engines for these aircraft could add to the appeal of these aircraft for certain purchasers.

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[28] *The Liability Maze: The Impact of Liability Law on Safety and Innovation*, Peter W. Huber and Robert E. Litan, eds. (Washington, DC: The Brookings Institution, 1991), p. 480.

[29] See U.S. International Trade Commission, *Industry & Trade Summary: Aircraft, Spacecraft, and Related Equipment*, USITC publication 2430, Nov. 1991, for a more complete discussion of the product liability problem.

[30] *1992 Annual Report* (London: Rolls-Royce plc., Mar. 1993), p. 27. £ = $1.7655, per *International Financial Statistics* (Washington, DC: International Monetary Fund, Nov. 1993), series rh, p. 548.

[31] Industry officials, interview by USITC staff, Dec. 1993.

[32] Boeing, p. 22.

[33] Jane's Information Group, *Jane's All the World's Aircraft, 1992-93* (London: Jane's Information Group, 1992), p. 637.

Canada is the principal source of competition for U.S.-built turbopropeller aircraft engines. Pratt & Whitney Canada, 97-percent owned by Pratt & Whitney U.S.A., is the leading foreign supplier of turbopropeller engines to the world. Pratt & Whitney Canada also produces a line of small turbofan engines for business jet aircraft. As of January 1, 1992, it had delivered 36,000 engines since its inception.[34]

Poland is a supplier of large radial, in-line, and opposed piston engines used on some agricultural and large float-equipped aircraft. Polish manufacturer Zrzeszenie Wytworcow Sprzetu Lotniczego I Silnikowego PZL (PZL), represented the sole global source of new production of large radial engines during 1988-92. In 1975, PZL acquired the rights to manufacture and market the full range of air-cooled piston engines formerly produced by the Franklin Engine Company (Aircooled Motors) of the United States. Franklin engines can still be found on U.S. general aviation aircraft manufactured prior to the mid-1970s.

There are many examples of foreign engine producers entering into joint ventures with each other, in order to compete primarily for European defense-related aircraft programs. Rolls-Royce teamed with Turbomeca to produce the Adour, the engine for the SEPECAT Jaguar fighter aircraft. This engine also was selected for the Mitsubishi T-2 military trainer, and is produced in Japan under license. One version of the engine powers the U.S. Navy's Goshawk training aircraft. Rolls-Royce also joined with MTU and Fiat Aviazione to produce the Turbo-Union RB199 engine that powers the Toronado multi-purpose fighter. Under the 1985 European Small Engines Cooperation Agreement, Rolls-Royce teamed with MTU and Turbomeca to produce the MTR 322 (Rolls-Royce/Turbomeca) and MTR 390 (MTU/Turbomeca/Rolls-Royce), both turboshaft engines designed for helicopter applications. Rolls-Royce again joined with MTU, Fiat, and Sener of Spain to produce the EUROJET, a new motor for the proposed Eurofighter program.

Parts for rocket motors are produced in several West European countries, Russia, China, and Japan. Arianespace is the commercial provider and marketing arm of the European Space Agency, a consortium of thirteen European aerospace companies, which, together, supply parts for the Ariane series of rockets.[35] China and Russia design, develop, and produce reaction engines for rockets. These engines differ technically from U.S. engines in that one set of engine pump and fuel oxidizer is used to fuel up to four combustion chambers, whereas the U.S. practice is to use one pair of pump/oxidizers per combustion chamber. While the Russian design allows the engine to continue to function if a problem arises with one of the combustion chambers, it also makes the engine's mission vulnerable to pump/oxidizer failure, which would disable all of the combustion chambers. Japan has developed a rocket engine to power its space vehicles. Some nonaircraft gas turbines are produced by the same companies which produce aircraft gas turbines, albeit at separate facilities, and by independent firms.

U.S. TRADE MEASURES

Tariff Measures

The provisions of the *Harmonized Tariff Schedule of the United States* applicable to aircraft and reaction engines, other gas turbines, and parts are shown at the 8-digit level in appendix B, table B-1. The column 1 rate of duty[36] for spark-ignition, reciprocating or rotary, internal combustion piston engines for aircraft is zero. It is also zero for parts suitable for use solely or principally with these engines. However, the column 1 rate of duty for gas turbines and rocket engines is 5 percent ad valorem, and the duty rate for parts of these engines is either free, as in the case of cast-iron parts, or 3.7 percent ad valorem for noncast-iron parts, or 3.4 percent ad valorem for parts of reaction engines. The GATT[37] Agreement on Trade in Civil Aircraft (ATCA), which became effective on January 1, 1980, provides for the elimination, on a most-favored-nation (MFN) basis, of all customs duties and similar charges of any kind levied on, or in connection with, the importation of civil aircraft to signatory nations. Parts, components, or subassemblies of civil aircraft are also accorded duty-free treatment under the agreement if they are certified for use in civil aircraft. The United States, the EU, Canada, Japan, Austria, Norway, Romania, Sweden, and Switzerland are signatories to the ATCA.[38] As a result of this agreement, U.S. exports of civil aircraft engines to signatory countries enter duty free; however, GATT member countries that are nonsignatories, such as Brazil, may impose a duty on such imports, but export on a duty-free basis to signatory countries. The GATT Uruguay Round of trade negotiations, completed in December 1993, may result in further reductions in U.S. and foreign duties on the articles covered by this summary. The U.S. Round schedule of concessions was not available at the time that this summary was prepared.

NAFTA, as implemented by the North American Free Trade Agreement Implementation Act (Pub. Law 103-182, approved December 8, 1993), provided for the elimination of U.S. duties, effective January 1, 1994, on summary goods imported from Mexico. Mexico also eliminated its duties on imports of such goods from the United States effective January 1, 1994.

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[34] *Jane's 1992-93*, p. 619.

[35] For a discussion of Arianespace, see USITC, *Aircraft, Spacecraft, and Related Equipment*.

[36] Refer to appendix A for an explanation of tariff and trade agreement terms.

[37] See app. A.

[38] Duty reductions are not limited to the signatories to the agreement, since under the GATT, such reductions apply to all GATT member countries.

Nontariff Measures

There are no known nontariff barriers to U.S. imports of aircraft engines and parts of aircraft engines.

U.S. Government Trade-related Investigations

During 1988-92, there were no statutory investigations concerning aircraft, rocket, or other gas-turbine engines, or parts for these engines. However, the Senate Finance Committee requested the U.S. International Trade Commission to conduct a study of the competitiveness of the U.S. large civil aircraft industry. This study, *Global Competitiveness of U.S. Advanced-Technology Manufacturing Industries: Large Civil Aircraft*, was published in August 1993.

FOREIGN TRADE MEASURES

Tariff Measures

The primary foreign markets for U.S.-produced aircraft and reaction engines, other gas turbines, and parts are France, the United Kingdom, and Canada. All of these nations base their tariff classifications on *Harmonized System Nomenclature* headings 84.07-84.12. The EU and Canada, as signatories to the ATCA, provide for the duty-free entry of civil aircraft engines and parts. Tariffs applicable to other summary products range from 4.3 percent to 6 percent ad valorem for nonaircraft gas turbines.

Brazil and Mexico also base their tariff classifications on HTS headings 84.07-84.12. Brazil, which is not a signatory of the ATCA, nevertheless eliminated import duties on aircraft engines effective January 1, 1991. In 1992, Brazil levied a 20-percent duty on reaction engines, a 10- to 25-percent duty on nonaircraft gas turbines, and a 25-percent duty on parts for nonaircraft gas turbines. An additional tax of 5 percent was levied on all products in this summary.[39] Permission to import aircraft engines and parts must be obtained from the Commisão Técnica de Aeronáutica Civil. Mexico imposed a duty of 10 percent on all summary products during 1988-92. This duty was to have been eliminated as of January 1, 1994.

Nontariff Measures

All civil aircraft engines and parts for these engines, as well as the factories in which they are made, must be certified by the appropriate civil governmental authority that grants airworthiness certificates to each type of aircraft. The United States and the countries of Western Europe demand that any aircraft engine operated in their airspace meet stringent airworthiness standards. In the United States, these standards are promulgated and administered by the FAA. Each West European country currently has comparable civil authorities. Because most aircraft engines consumed worldwide are produced in either the United States or Western Europe, most of the aircraft in the world fleet have been certified by one or all of these agencies. Therefore, individual country standards generally do not inhibit the trade of aircraft engines, as all engines must conform to similar international standards. However, trade in some countries is hindered by certain business practices, which stipulate the use of a foreign national as the agent of the U.S. manufacturer.[40] Other countries, such as Sweden, impose a tax on aircraft flying in their airspace using certain engines that are alleged to produce excess pollutants.

U.S. MARKET

Consumption

U.S. consumption of aircraft and reaction engines, other gas turbines, and parts fluctuated upward by 23 percent during 1988-92, from $22.1 billion to $27.2 billion (figure 4).[41] This rise can be attributed to the increase in demand for aircraft and rocket engines in their primary use industries such as airlines and the military. The period 1988-92 saw a record number of U.S. large civil aircraft orders and deliveries which, in turn, fueled the demand for aircraft engine and engine parts. U.S. airlines increased their fleets by 14 percent during the period, while world airlines increased the size of their large jet aircraft fleets by 27 percent.[42]

Production

Shipments of U.S. aircraft and reaction engines, other gas turbines, and parts rose erratically from $25.2 billion in 1988 to $29.4 billion in 1992, or by 17 percent (figure 4). This was due to conflicting trends in the market for aircraft engines: a decrease in military demand, and an increase in the civilian market. Most U.S. aircraft engine production is destined for U.S. military and civil airframe manufacturers. The major type of aircraft engine shipped was the turbojet and its variants. Sales of larger, more powerful U.S.-built engines are displacing smaller ones because of an increase in the size and performance requirements of new aircraft. Rocket engines and parts represented 15 percent of U.S. shipments in 1988 and in 1992.[43]

U.S. production of aircraft gas-turbine engines has declined somewhat. This is due principally to the decline in new large civil aircraft orders and the continued decline in orders for the military market. However, because the majority of the world's aircraft

[39] This tax, the Imposto sobre Productos Industrializados (tax on industrialized products), was suspended in 1993 on selected items found in this product grouping; see *Tarifa Aduaneira do Brazil* - TAB, NBM-SH, pp. 553-554.

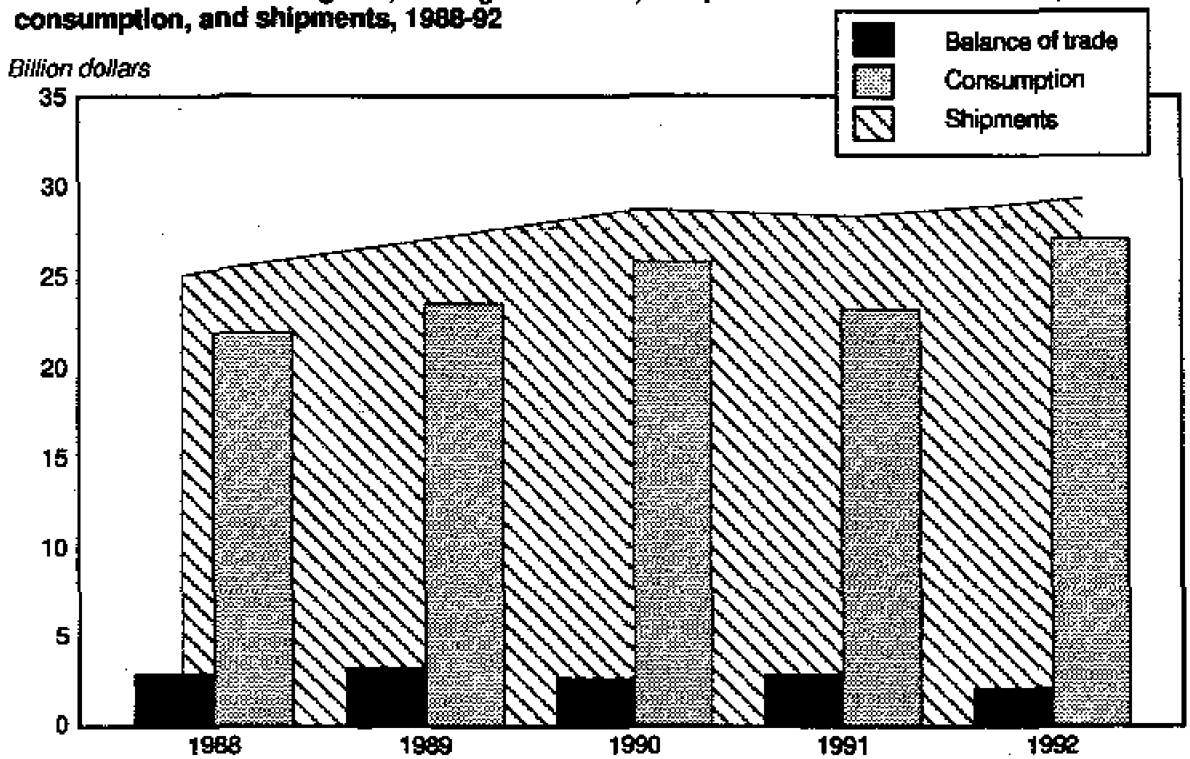
[40] Industry sources indicate that in adhering to local law in the host country, the U.S. manufacturer may be liable for prosecution under the U.S. Foreign Corrupt Practices Act.

[41] Table B-2.

[42] Boeing, pp. 31-32.

[43] Table B-2.

Figure 4
Aircraft and reaction engines, other gas turbines, and parts: U.S. balance of trade, consumption, and shipments, 1988-92



Source: Shipments and consumption estimated by USITC staff. Balance of trade compiled form official statisitcs of the U.S. Department of Commerce.

in service, as well as those on order, have U.S. aircraft engines, the demand for U.S.-made parts should continue to expand.

Imports

Products Imported

Two commodities accounted for 83 percent of total U.S. imports: aircraft and nonaircraft turbojet or turbopropeller engine parts not made of cast-iron and aircraft turbojets of a thrust exceeding 25kN (figure 5).[44] These imports were valued at $5.1 billion in 1992.[45] As previously discussed, overall import totals include the engine components manufactured by SNECMA in France for inclusion in the CFM line of engines,[46] and the engines produced by Rolls-Royce in the United Kingdom, which are typically exported on U.S. airframes. The SNECMA engine components for the CFM engine are used on the Boeing 737; Rolls-Royce engines are used on the Boeing 747, 757, and 767, the McDonnell Douglas DC-10, the Lockheed L-1011, and the Gulfstream Aerospace G-4 business jet.

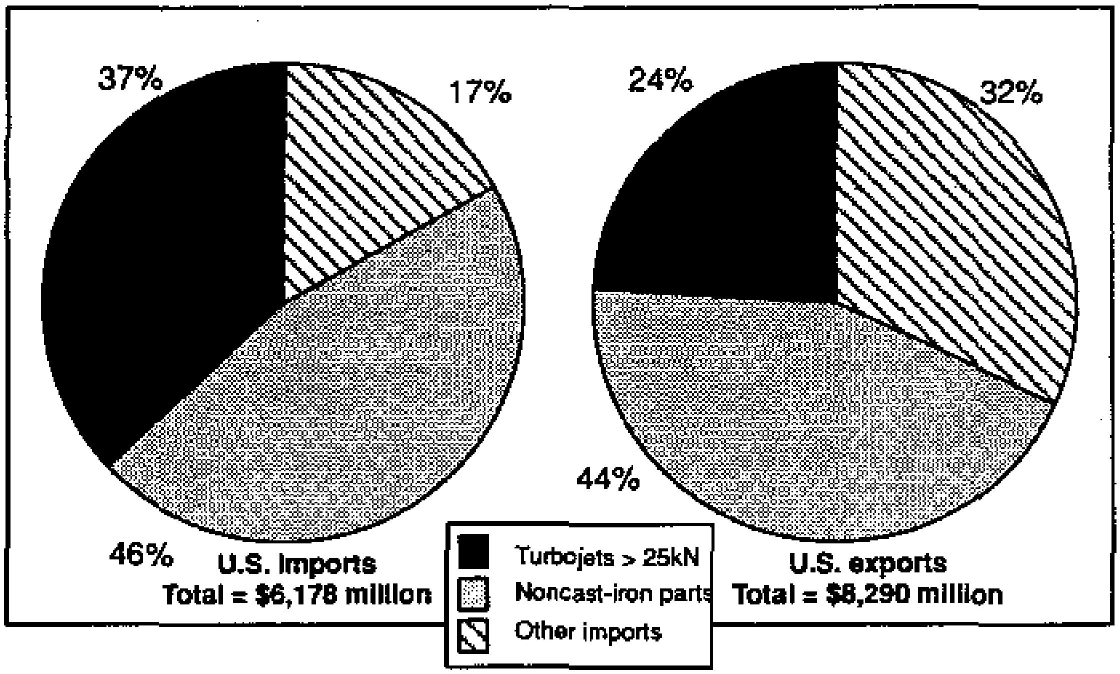
Import Levels and Trends

U.S. imports of aircraft and reaction engines, other gas turbines, and parts rose steadily from $3.0 billion in 1988 to $6.2 billion in 1992, or by 105 percent (figure 6).[47] The bulk ($2.8 billion) of total U.S. imports in 1992 consisted of parts for aircraft and nonaircraft turbopropeller and turbojet engines, which included high-value assemblies and components from France for the CFM joint venture.[48] Imports of these parts typically are exported on a finished airframe. As more than half of all U.S. civil transport aircraft produced during the period were exported,[49] gross calculations of the ratio of U.S. imports to U.S. consumption may be misleading. The import share of the U.S. market, according to official U.S. Department of Commerce trade data, rose significantly

[44] The power of a jet engine is measured in pounds of thrust, or pound/foot. One Newton equals 0.2248 pound/foot of thrust; therefore, 25kN = 5,620 pound/foot of thrust.
[45] Table B-1.
[46] Engine assemblies are exported as needed to each of the companies. GE assembles the complete engine in the United States for the U.S. market, while SNECMA assembles the complete engine in France for the European market.

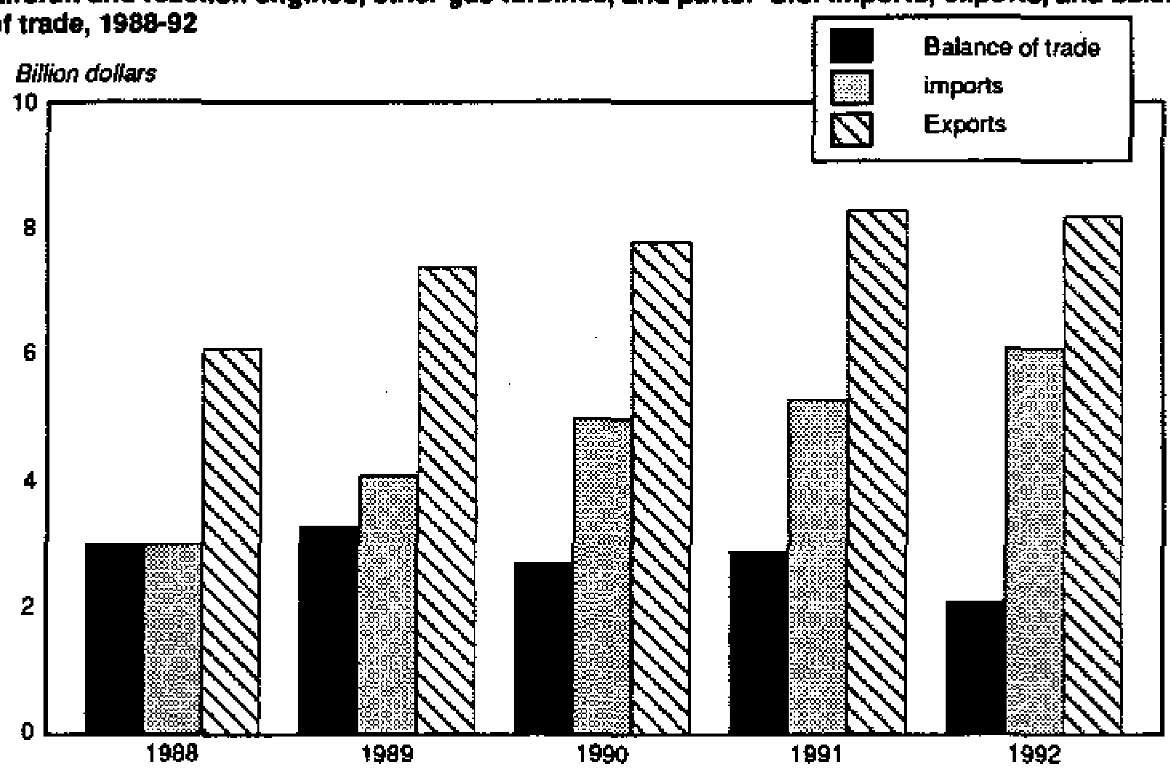
[47] Table B-2.
[48] Compiled from official statistics of the U.S. Department of Commerce for *Harmonized Tariff Schedule* item 8411.91.9080.
[49] Boeing, p. 14.

Figure 5
Aircraft and reaction engines, other gas turbines, and parts: U.S. imports and exports, 1992



Source: Data for noncast-iron parts estimated by USITC staff. Other data compiled from official statistics of the U.S. Department of Commerce.

Figure 6
Aircraft and reaction engines, other gas turbines, and parts: U.S. imports, exports, and balance of trade, 1988-92



Source: Compiled form official statisitcs of the U.S. Department of Commerce.

between 1988 and 1990, from 14 percent to 17 percent to 20 percent, then increased to 23 percent in both 1991 and 1992.

Principal Import Suppliers

The twelve-member nations of the EU remained the principal suppliers of U.S. imports of aircraft and rocket engines, other gas turbines, and parts during 1988-92. Shipments from these countries combined for between 67 and 79 percent of total U.S. imports of these engines and parts during the period.[50] As previously noted, France was the primary source of total U.S. imports of summary products during the period, with the United Kingdom second. Together, these two countries accounted for 56 percent of total U.S. imports of aircraft and reaction engines, nonaircraft gas turbines, and parts for these engines during 1988-92. During the period, total U.S. imports from France increased by 118 percent, to $2.3 billion in 1992, whereas imports from the United Kingdom increased by 187 percent, to $1.8 billion.[51]

The two leading products imported during the period were noncast-iron parts for aircraft turbojet or turbopropeller engines, and aircraft engines exceeding 25kN in thrust.[52] U.S. imports of noncast-iron parts for aircraft turbojet or turbopropeller engines from France grew by 116 percent, from $522 million in 1988 to $1.1 billion in 1992, while U.S. imports from the United Kingdom of such parts increased by 12 percent. U.S. imports of aircraft engines exceeding 25kN from the United Kingdom during 1989-92[53] increased by 103 percent, to $1.2 billion, while those imported from France increased by 28 percent, to $1.1 billion.[54] The increase in imports from the United Kingdom was made possible by the flexible engine options available to customers of airframe manufacturers, which allowed the end-user to choose British-built engines instead of U.S.-built engines. Because the United States exported the majority of its domestic large civil transport aircraft in 1992, it is possible that these engines will be re-exported.

U.S. Importers.

Airframe manufacturers, airline companies, and aircraft leasing companies are the primary importers of aircraft engines. When an airline or aircraft leasing company places an order for aircraft, the airframe manufacturer advises the purchaser what engines are designed to be used on the aircraft. If the aircraft can accept an engine from more than one manufacturer, the purchaser of the aircraft then negotiates with the appropriate aircraft engine producers for the purchase of engines, spare engines, and engine parts needed for routine service. If the engine manufacturer is a non-U.S. producer, then the airframe manufacturer normally becomes the importer of record for those engines that it needs to complete the aircraft. The aircraft customer is typically also the importer of record for spare engines and parts.

FOREIGN MARKETS

Foreign Market Profile

The EU was the leading export market for U.S. aircraft and reaction engines, other gas turbines, and parts during 1988-92.[55] This market accounted for over 49 percent of total U.S. exports of these products during the period. The EU has the largest concentration of aircraft and aircraft engine manufacturing capacity, as well as the largest commercial aircraft fleet outside of the United States and Russia. The majority of these aircraft were equipped with engines manufactured in the United States, and are serviced predominantly with parts manufactured in, or shipped from, the United States. France, the United Kingdom, and Canada were the top three foreign markets for U.S. exports, accounting for 46 percent of total U.S. exports of summary products in 1992. Exports as a percentage of U.S. shipments of aircraft and reaction engines, other gas turbines, and parts increased from 24 to 28 percent during 1988-92. Industry sources indicate that exports of engines are underreported, as official statistics do not account adequately for imported engines that are re-exported on U.S. airframes.

The EU economic integration could adversely affect U.S. engine producers, according to industry sources. More stringent environmental standards, and a proposal to create a more uniform labor policy throughout the EU, could increase the cost to U.S. suppliers of doing business in this market, according to industry sources. These same sources are concerned that with new environmental and labor legislation, higher levels of capital investment will be needed in order to maintain the same level of U.S. industrial participation in the EU.[56]

U.S. Exports

Products Exported

Parts of aircraft and nonaircraft turbojets or turbopropellers were the largest group of U.S. exports of these products during 1992, amounting to $4.9 billion in 1992, representing 59 percent of total U.S. exports of the products covered in this summary.[57] The global airline fleet and the majority

[50] Table B-5.
[51] Ibid.
[52] Table B-1.
[53] Under the *Tariff Schedule of the United States*, which became effective January 1, 1989, aircraft engines were differentiated based on whether they were piston or turbine-type, not as to their power ratings, as found in the *Harmonized Tariff Schedule of the United States*.
[54] Compiled from official statistics of the U.S. Department of Commerce.

[55] Table B-5.
[56] Industry officials, interviews by USITC staff, 1993.
[57] Tables B-1 and B-2.

of military aircraft not built in the former Soviet Union employ U.S.-built engines, which are predominantly made from U.S.-built parts. These parts are not available from foreign manufacturers; therefore, parts must be sourced from the United States.

Export Levels and Trends

U.S. exports of aircraft and reaction engines, nonaircraft turbines, and parts thereof rose from $6.1 billion in 1988 to $8.3 billion in 1992, or by 36 percent.[58] During 1988-89, U.S. exports of aircraft and rocket engines, other gas turbines, and parts thereof rose steeply by 22 percent, to $7.4 billion. U.S. exports rose gradually between 1989-91, to $8.3 billion, before declining by 1 percent in 1992.[59] France and the United Kingdom were the largest single markets for these products.[60] The largest percentage increase in exports to a major country grouping was accounted for by the ASEAN nations, to which U.S. exports increased by 105 percent.[61] Overall demand for U.S.-made aircraft and rocket engines, other gas turbines, and parts was generated largely by the global need for aircraft engines on new airframes (especially in the EU and the Pacific Rim nations), and the need to service engines currently in use in the world fleet.

During the period, exports as a share of shipments rose irregularly from 24 percent to 28 percent, reflecting the increased importance of foreign markets to U.S. suppliers.[62] As foreign purchases of aircraft rise, sales of aircraft engines and parts will also continue to increase. The Commonwealth of Independent States has the potential to become a major market for U.S. aircraft engines if political and national security issues can be resolved. In 1991, the Russian airline Aeroflot ordered a number of U.S. aircraft engines to repower its Ilyushin Il-86 and proposed Il-96M aircraft. An initial shipment of Pratt & Whitney engines has been shipped to Russia for certification on these airframes. The aircraft powered by these engines will be for domestic routes initially, although export versions of these aircraft are planned.[63] U.S. engines are considered more fuel efficient and less maintenance intensive than Russian engines, according to industry sources.

U.S. Exporters

The principal exporters of aircraft engines are the U.S. producers of aircraft engines and U.S. airframe manufacturers.

U.S. TRADE BALANCE

The United States maintained a trade surplus in aircraft and reaction engines, other gas turbines, and parts during 1988-92 that ranged from $3.1 billion in 1988 to a high of $3.3 billion in 1989, before declining irregularly to $2.1 billion in 1992.[64] The largest single-country U.S. trade surplus for these goods is with Japan. In 1992, this surplus amounted to $498 million. Japan relies on the United States for civil transport aircraft because there are no manufacturers currently building this type of aircraft in Japan. The largest U.S. trade deficit during the period was with the United Kingdom; in 1992, this deficit amounted to $935 million. The United Kingdom is the only foreign country that produces a range of aircraft turbine engines for civil transports that compete with U.S.-made engines.

Other significant reversals for the U.S. balance of trade in these products occurred with Germany and France. During the period, the U.S. balance of trade with Germany declined from a surplus of $139 million to a deficit of $9 million, while trade with France declined from a surplus of $213 million to a $125-million deficit.[65] This trend reflects the increased use of foreign parts and assemblies on U.S.-built engines, and will likely continue.

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58 Table B-2.

59 Compiled from official statistics of the U.S. Department of Commerce.

60 Table B-4.

61 Table B-5.

62 Table B-2.

63 For more information on the Russian aircraft industry, see U.S. International Trade Commission, *Global Competitiveness of U.S. Advanced-Technology Manufacturing Industries: Large Civil Aircraft*, USITC publication 2667, August 1993.

64 Table B-5.

65 Ibid

APPENDIX A
EXPLANATION OF TARIFF AND TRADE AGREEMENT TERMS

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 on 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.

Rates of duty in the ***general*** subcolumn of HTS column 1 are most-favored-nation (MFN) rates; for the most part, they represent the final concession rate from the Tokyo Round of Multilateral Trade Negotiations. Column 1-general duty rates are applicable to imported goods from all countries except to those enumerated in general note 3(b) to the HTS, whose products are dutied at the rates set forth in ***column 2***. Goods from the People's Republic of China, Czechoslovakia, Hungary, Poland, and Yugoslavia are among those 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 entry under one or more preferential tariff programs. Such tariff treatment is set forth in the **special** subcolumn of HTS 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 subcolumn of column 1, the GSP provides duty-free entry to eligible articles that are the product of, and are 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, implemented by Presidential Proclamation 5133 of November 30, 1983, and amended by the Customs and Trade Act of 1990, applies to merchandise entered, or withdrawn from warehouse for consumption, on or after January 1, 1984; this tariff preference program has no expiration date. Indicated by the symbol "E" or "E*" in the special subcolumn of column 1, the CBERA provides duty-free entry to eligible articles that are the product of, and are imported directly from, designated countries, as set forth in general note 3(c)(v) to the HTS.

Preferential rates of duty in the special subcolumn of column 1 followed by the symbol "IL" are applicable to products of Israel under the ***United States-Israel Free-Trade Area Implementation Act*** of 1985, as provided in general note 3(c)(vi) of the HTS. When no rate of duty is provided for products of Israel in the special subcolumn for a particular provision, 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) to the HTS.

Other special tariff treatment applies to particular ***products of insular possessions*** (general note 3(a)(iv)), goods covered by the ***Automotive Products Trade Act*** (general note 3(c)(iii)) and the ***Agreement on Trade in Civil Aircraft*** (general note 3(c)(iv)), and ***articles imported from freely associated states*** (general note 3(c)(viii)).

The ***General Agreement on Tariffs and Trade*** (GATT) (61 Stat. (pt. 5) A58; 8 UST (pt. 2) 1786) is the multilateral agreement setting forth 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 scheduled 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. 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.

Officially known as "The Arrangement Regarding International Trade in Textiles," the ***Multifiber Arrangement*** (MFA) provides a framework for the negotiation of bilateral agreements between importing and producing countries, or for unilateral action by importing countries in the absence of an agreement. These bilateral agreements establish quantitative limits on imports of textiles and apparel, of cotton, wool, silk blends, and other vegetable and manmade fibers in order to prevent market disruption in the importing countries—restrictions that would otherwise be a departure from GATT provisions. The United States has bilateral agreements with more than 30 supplying countries, including the four largest suppliers: China, Hong Kong, the Republic of Korea, and Taiwan.

APPENDIX B
STATISTICAL TABLES

Table B-1
Aircraft and reaction engines, other gas turbines, and parts: Harmonized Tariff Schedule subheading; description; U.S. col. 1 rate of duty as of Jan. 1, 1993; U.S. exports, 1992; U.S. imports, 1992

HTS subheading	Description	Col. 1 rate of duty as of Jan. 1, 1993		U.S. exports, 1992	U.S. imports, 1992
		General	Special[1]		
				Million dollars	
8407.10.00	Spark-ignition reciprocating or rotary internal combustion piston engines, for use in aircraft	Free		101	43
8409.10.00	Parts suitable for use solely or principally with the aircraft engines of heading 8407 or 8408	Free		211	57
8411.11.40	Turbojets of a thrust not exceeding 25 kN, for aircraft	5.0%	Free (A,C,CA,E,IL,J)	173	136
8411.11.80	Turbojets of a thrust not exceeding 25 kN, other than for aircraft	5.0%	Free (A,CA,E,IL,J)	9	(2)
8411.12.40	Turbojets of a thrust exceeding 25 kN, for aircraft	5.0%	Free (A,C,CA,E,IL,J)	2,010	2,276
8411.12.80	Turbojets of a thrust exceeding 25 kN, other than for aircraft	5.0%	Free (A,CA,E,IL,J)	12	0
8411.21.40	Turbopropellers of a power not exceeding 1,100 kW, for aircraft	5.0%	Free (A,C,CA,E,IL,J)	50	152
8411.21.80	Turbopropellers of a power not exceeding 1,100 kW, other than for aircraft	5.0%	Free (A,CA,E,IL,J)	2	(2)
8411.22.40	Turbopropellers of a power exceeding 1,100 kW, for aircraft	5.0%	Free (A,C,CA,E,IL,J)	127	40
8411.22.80	Turbopropellers of a power exceeding 1,100 kW, other than for aircraft	5.0%	Free (A,CA,E,IL,J)	2	1
8411.81.40	Other gas turbines of a power not exceeding 5,000 kW, for aircraft	5.0%	Free (A,C,CA,E,IL,J)	56	40
8411.81.80	Other gas turbines of a power not exceeding 5,000 kW, other than for aircraft	5.0%	Free (A,CA,E,IL,J)	80	2
8411.82.40	Other gas turbines of a power exceeding 5,000 kW, for aircraft	5.0%	Free (A,C,CA,E,IL,J)	54	16
8411.82.80	Other gas turbines of a power exceeding 5,000 kW, other than for aircraft	5.0%	Free (A,CA,E,IL,J)	480	63
8411.91.10	Parts of turbojets or turbopropellers: Cast-iron parts, not advanced beyond cleaning, and machined only for the removal of fins, gates, sprues and risers or to permit location in finishing machinery	Free		(3)	37
8411.91.90	Other parts of aircraft and nonaircraft turbojets or turbopropellers	3.7%	Free (A,C,CA,E,IL,J)	(3)	2,841

See footnotes at end of table.

Table B-1—*Continued*

Aircraft and reaction engines, other gas turbines, and parts: Harmonized Tariff Schedule subheading; description; U.S. col. 1 rate of duty as of Jan. 1, 1993; U.S. exports, 1992; U.S. imports, 1992

HTS subheading	Description	Col. 1 rate of duty as of Jan. 1, 1993 General	Special[1]	U.S. exports, 1992	U.S. imports, 1992
				Million dollars	
8411.99.10	Other parts: Cast-iron parts, not advanced beyond cleaning, and machined only for the removal of fins, gates, sprues and risers or to permit location in finishing machinery	Free		(4)	10
8411.99.90	Other parts of aircraft and nonaircraft gas turbines	3.7%	Free (A,C,CA,E,IL,J)	(4)	465
8412.10.00	Other engines and motors, and parts thereof: Reaction engines other than turbojets	5.0%	Free (A,B,C,CA,E,IL,J)	25	1
8412.90.90	Parts of reaction engines other than turbojets	3.4	Free (A,B,C,CA,E,IL,J)	1	3

[1] Programs under which special tariff treatment may be provided, and the corresponding symbols for such programs as they are indicated in the "Special" subcolumn, are as follows: Generalized System of Preferences (A); Automotive Products Trade Act (B); Agreement on Trade in Civil Aircraft (C); United States-Canada Free-Trade Agreement (CA); Caribbean Basin Economic Recovery Act (E); United States-Israel Free Trade Agreement (IL); and Andean Trade Preference Act (J).

[2] Less than $500,000.

[3] No directly comparable Schedule B number exists; total U.S. exports of goods under Schedule B headings 8411.91.4000-8411.91.7050 corresponding to goods imported HTS subheadings 8411.91.10-8411.91.90 amounted to $3,636 million.

[4] No directly comparable Schedule B number exists; total U.S. exports of goods under Schedule B headings 8411.99.4000-8411.99.7050 corresponding to goods imported under HTS subheadings 8411.99.10-8411.99.90 amounted to $1,256 million.

Source: U.S. exports and imports compiled from data of the U.S. Department of Commerce.

Table B-2
Aircraft and reaction engines, other gas turbines, and parts: U.S. shipments, exports of domestic merchandise, imports for consumption, and apparent U.S. consumption, 1988-92

Year	U.S. shipments[1]	U.S. exports	U.S. imports	Apparent U.S. consumption[1]	Ratio of imports to consumption[1]
	Million dollars				*Percent*
1988	25,152	6,100	3,012	22,064	14
1989	26,988	7,445	4,123	23,666	17
1990	28,742	7,870	5,085	25,957	20
1991	28,345	8,345	5,374	23,374	23
1992	29,360	8,290	6,178	27,248	23

[1] Estimated by the staff of the U.S. International Trade Commission.

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

Table B-3
Aircraft and reaction engines, other gas turbines, and parts: U.S. imports for consumption, by principal sources, 1988-92

Source	1988	1989	1990	1991	1992
	Value *(1,000 dollars)*				
France	1,058,918	1,550,164	1,728,864	2,065,636	2,306,628
United Kingdom	615,179	1,069,551	1,426,820	1,357,473	1,764,603
Canada	544,904	579,543	720,880	674,481	690,456
Germany	210,989	249,854	391,381	367,866	503,900
Sweden	165,902	152,748	178,870	180,627	177,404
Italy	81,529	65,009	75,130	139,785	145,413
Japan	67,264	73,984	104,279	129,950	128,534
Singapore	4,232	20,189	38,582	64,963	83,043
Netherlands	20,457	29,153	38,287	34,702	44,173
Korea	10,079	25,622	19,568	35,810	40,903
All other	232,487	307,273	361,933	323,171	292,770
Total	3,011,941	4,123,090	5,084,595	5,374,463	6,177,828

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

Table B-4
Aircraft and reaction engines, other gas turbines, and parts: U.S. exports of domestic merchandise, by principal markets, 1988-92

Market	1988	1989	1990	1991	1992
	Value *(1,000 dollars)*				
France	1,272,599	1,802,911	1,885,137	2,155,830	2,181,897
United Kingdom	805,075	871,695	926,164	822,132	830,434
Canada	503,098	674,580	710,699	722,317	786,987
Japan	548,138	577,638	633,808	644,199	626,946
Germany	350,424	489,409	471,692	618,368	495,326
Korea	75,243	88,069	183,216	480,422	360,238
Netherlands	214,290	346,802	341,889	347,796	244,175
Sweden	112,922	154,218	209,006	212,098	204,886
Singapore	129,788	285,529	258,593	181,235	133,135
Italy	93,394	109,836	121,255	129,781	95,681
All other	1,995,207	2,044,040	2,128,066	2,030,478	2,330,066
Total	6,100,248	7,444,727	7,869,524	8,344,656	8,289,770

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

Table B-5
Aircraft and reaction engines, other gas turbines, and parts: U.S. exports of domestic merchandise, imports for consumption, and merchandise trade balance, by selected countries and country groups, 1988-92[1]

(Million dollars)

Item	1988	1989	1990	1991	1992
U.S. exports of domestic merchandise:					
France	1,272	1,803	1,865	2,156	2,182
United Kingdom	805	872	926	822	830
Canada	503	675	711	722	787
Germany	350	489	472	618	495
Japan	548	578	634	644	627
Korea	75	88	183	480	360
Sweden	112	154	209	212	205
Netherlands	214	347	342	348	244
Italy	93	110	121	130	96
Singapore	130	286	259	181	133
All other	1,995	2,044	2,128	2,030	2,330
Total	6,100	7,445	7,869	8,345	8,290
EU-12	2,970	3,903	4,027	4,346	4,086
OPEC	210	144	199	187	393
ASEAN	245	409	430	326	503
CBERA	31	43	30	34	51
Eastern Europe	2	7	8	3	4
U.S. imports for consumption:					
France	1,059	1,550	1,729	2,066	2,307
United Kingdom	615	1,070	1,427	1,357	1,765
Canada	545	579	721	674	690
Germany	211	250	391	368	504
Japan	67	74	104	130	129
Korea	10	26	20	36	41
Sweden	166	153	179	181	177
Netherlands	20	29	38	35	44
Italy	82	65	75	140	145
Singapore	4	20	39	65	83
All other	232	307	362	323	293
Total	3,012	4,123	5,085	5,374	6,178
EU-12	2,019	3,116	3,817	4,120	4,909
OPEC	(2)	1	1	1	2
ASEAN	(2)	25	41	67	86
CBERA	(2)	(2)	(2)	(2)	(2)
Eastern Europe	(2)	3	4	3	3
U.S. merchandise trade balance:					
France	213	253	156	90	-125
United Kingdom	190	-198	-501	-535	-935
Canada	-42	96	-10	48	97
Germany	139	239	81	250	-9
Japan	481	504	530	514	498
Korea	65	62	163	444	319
Sweden	-54	1	30	31	28
Netherlands	194	318	304	313	200
Italy	11	45	46	-10	-49
Singapore	126	266	220	116	50
All other	1,763	1,737	1,766	1,707	2,037
Total	3,088	3,322	2,784	2,971	2,112
EU-12	951	787	210	226	-823
OPEC	210	143	198	186	391
ASEAN	245	384	389	259	417
CBERA	31	43	30	34	51
Eastern Europe	2	4	4	(2)	1

[1] Import values are based on customs value; export values are based on f.a.s. value, U.S. port of export. U.S. trade with East Germany is included in "Germany" but not "Eastern Europe."

[2] Less than $500,000.

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