April 1997

INDUSTRY TRADE AND TECHNOLOGY REVIEW

OFFICE OF INDUSTRIES
Publication 3039

UNITED STATES
INTERNATIONAL
TRADE COMMISSION

PREFACE

The *Industry, Trade, and Technology Review* (*ITTR*) is a quarterly staff publication of the Office of Industries, U.S. International Trade Commission. The opinions and conclusions it contains are those of the authors and do not necessarily reflect the views of the Commission or of any individual Commissioner. The report is intended to provide analysis of important issues and insights into the global position of U.S. industries, the technological competitiveness of the United States, and implications of trade and policy developments.

Inquiries or comments on items appearing in this report may be made directly to the author, or to:

Director of Industries
Industry, Trade, and Technology Review
U. S. International Trade Commission
500 E Street, SW
Washington, DC 20436
Fax: 202-205-3161

Requests for copies of the *ITTR*, or to be added to the mailing list, should be address to the Office of the Secretary, U.S. International Trade Commission, 500 E Street SW, Washington, DC 20436, or by fax: 202-205-2104

Quarterly Review Staff

Larry Brookhart
Robert Hughes

assisted by

Zema Tucker
Sharon Greenfield

Contributing Authors

Marie C. Wold
Vincent DeSapio
Patrick Coleman

Robert A. Rogowsky
Director of Operations

Vern Simpson
Director of Industries

Listing of Published Articles

(May 1994 - April 1997)

May 1994

Microprocessor industry: Developments influencing global competition
U.S. bicycle industry creates innovative products using metal matrix composites
Aluminum product development and the automotive industry
Electric utility industry compliance with "acid rain" clean air standards portends favorable U.S. air pollution control equipment market

August 1994

Computer outsourcing services: Telecommunication regulation affects global competitive position of U.S. firms
Systems integration services enhance U.S. global competitiveness
Economics and innovation spur shift from mechanical fasteners to adhesives and sealants in certain automotive applications
R&D consortia in the U.S. and Japanese automobile industry
India and Pakistan resist commitments to greater market access in the textiles and apparel sector

October 1994

Bovine somatotropin (bst): An application of genetic engineering to increase milk production
Impact of environmental disposal laws on packaging worldwide
Titanium industry seeks new markets which could bring competitive benefits to end users
Regulatory environment impacts emerging personal communications industry
Emerging focus on quality systems registration enhances market prospects for the U.S. instruments industry

March 1995

NAFTA update: Steady U.S. bilateral trade growth with Mexico faces mixed prospects in 1995
New manufacturing processes for materials: Government policies and programs towards commercialization
Globalization and growth herald new markets for passenger rail suppliers
Forces behind restructuring in U.S. apparel retailing and its effect on the U.S. apparel industry
Steel in residential construction: A potentially significant developing market

May 1995

Section 22: Uruguay Round Agreement changes U.S. operation of agricultural program
Telecommunication services: Bell companies act to join global network alliances
The information superhighway: Global implications from current test projects
Direct ironmaking: A case study in government and industry cooperation to commercialize new manufacturing processes for materials

Listing of Published Articles--*Continued*

September 1995

Structural changes and competitive strategies of the U.S. footwear industry in the 1990s
U.S./EU toy safety standards and the implications for APEC harmonization
Comparison of production-sharing operations in the Caribbean Basin with those in Mexico and in selected East Asian countries
Free-trade zones: Global overview and future prospects

December 1995

Financial services: An overview of the World Trade Organization's negotiations
Sol-gel: Industry seeks to commercialize energy-saving technology for existing and emerging markets
China's evolving grain trade opens new marketing opportunities for U.S. exporters
NAFTA update: Early signs confirm benefits

April 1996

Approaching the next frontier for trade in services: Liberalization of international investment
The impact of Cubas's new foreign investment law
The development of information technology in the Arab world

July 1996

Computer services: Examination of commitments scheduled under the General Agreement on Trade in Services
The global positioning system advances toward universal acceptance
Reformulated gasoline program achieves smooth transition

October 1996

World textile and apparel trade: A new era
World shipbuilding and the status of the OECD Agreement to eliminate subsidies
Thin-slab casting/flat-rolling: New technology to benefit U.S. steel industry

January 1997

Basic telecommunication service negotiations in the World Trade Organization: Impetus, offers, and prospects
U.S. film industry: How mergers and acquisitions are reshaping distribution patterns worldwide
Global competitiveness and organized labor: The case of Caterpillar Inc. and the United Auto Workers Union
Evolution of the U.S.-Japanese semiconductor trade regime

April 1997

Liberalization of the Mexican telecommunication sector
Use of magnesium castings in automobiles rises, but challenges remain
U.S. trade in intangible intellectual property: Royalties and licensing fees

CONTENTS

Page

CONTENTS--*Continued*

Page

Appendix A: Key performance indicators of selected industries--*Continued*

Liberalization of the Mexican Telecommunication Sector

Marie C. Wold
(202) 205-3450
Mwold@usitc.gov

On January 1, 1997, Mexico fully liberalized its long-distance telecommunication sector, and on February 15, 1997, became 1 of 69 signatories to the World Trade Organization (WTO) agreement on basic telecommunications. Liberalization of basic telecommunication carriers, coupled with the 1994 Telecommunications Annex (Annex) of the North American Free-Trade Agreement (NAFTA), which accords firms from Canada, Mexico, and the United States rights to construct and operate private and value-added networks throughout North America, afford U.S. firms significant new business opportunities. On the basis of the best information available to date, this article assesses the effects of Mexico's liberalization on U.S. investment, trade, and employment in the telecommunication services industry.

Mexico is a principal trading partner of the United States in telecommunication services. The volume of such trade[1] between the the two countries reached $1.2 billion in 1995, reflecting a 32-percent increase from $924 million in 1991.[2] Further, Mexico has an immense potential consumer base, as indicated by its current teledensity ratio of only 9.2[3] lines per 100 people, compared with 55.3 lines[4] in the United States. In addition, one-third of all telephone lines in Mexico is concentrated around Mexico City, which along with Monterrey and Guadalajara accounts for about one-half of the country's total telecommunication network. Low teledensity and uneven distribution of telephone lines, combined with Mexico's population of 88 million,[5] suggest that future growth in cellular and wireline service may be substantial.

U.S. Investment in the Mexican Telecommunication Industry

Most U.S. investment in Mexico's telecommunication industry has resulted from the privatization of *Telefonos de Mexico*, (TELMEX) and the subsequent liberalization of Mexico's long-distance market. TELMEX was a monopoly supplier of basic, local, and long-

[1] Trade volume is defined as imports plus exports.
[2] U.S. Department of Commerce (USDOC), Bureau of Economic Analysis (BEA), "U.S. International Sales and Purchases of Private Services," *Survey of Current Business*, Nov. 1996, pp. 100-101.
[3] USDOC, International Trade Administration (ITA), "Mexico-Telecommunications Market," *A Guide to the Telecommunications Market in Latin American and the Caribbean*" (Washington, DC: National Technical Information Service (NTIS), July 1996.
[4] International Telecommunication Union (ITU), *World Telecommunication Development Report* (Geneva: ITU, 1995), p. A-27.
[5] USDOC, ITA, *A Guide to the Telecommunications Market in Latin America*, July 1996.

distance services until January 1, 1997, when the market for long-distance calling was opened to competition. On January 1, 1991, the Mexican Government sold a 20-percent interest in TELMEX[6] for $1.8 billion to an international conglomerate including Grupo Carso (Mexico), SBC Communications, Inc., (formerly Southwestern Bell, United States), and France Telecommunications.[7] To date, SBC Communications has invested approximately $1 billion in TELMEX, giving it a 10-percent stake in the national telephone company.

Regulatory Incentives to Invest in Mexico

Since SBC's initial investment in TELMEX, the Mexican Government has implemented policies that will likely promote continued investment. As a prelude to introducing competition in the long-distance calling market, the Mexican Government established, on April 26, 1996, fairly low interconnection rates, which are fees paid by carriers to join their transmission lines to Mexico's network.[8] Although these interconnection rates are somewhat higher than the international norm, they are relatively low for a developing country. Such low rates likely encouraged the entry of foreign telecommunication firms into Mexico's long-distance market to compete with TELMEX.[9] Low interconnection fees typically make market entry more profitable and encourage investment projects, which should foster economic growth and job creation as Mexico's long-distance market opens to international competition[10] (table 1). Also, industry analysts believe that Mexico's relatively high accounting rates[11] will provide further incentives for U.S. firms to construct facilities in Mexico, as U.S. carriers will have incentive to bypass the accounting rate system by both originating and terminating telecommunication traffic. For example, Alestra (AT&T partnership) is planning to spend more than $1 billion over the next several years on its own network, aiming to deploy 5,400 miles of fiber optic cable in 24 cities in Mexico by the year 2000. Likewise, Avantel (MCI partnership) has already laid 3,300 miles of fiber-optic cable serving 33 cities, which includes 3 switching centers. Avantel plans to have a network of 12,500 miles of fiber-optic cable nationwide in 10 years.[12]

---

[6] Erik R. Olbeter and Lawrence Chimerine, *Crossed Wires: How Foreign Regulations and U.S. Policies are Holding Back the U.S. Telecommunications Services Industry* (Washington, DC: Economic Strategy Institute (ESI), 1994), p. 69.

[7] USDOC, ITA, *A Guide to the Telecommunications Market in Latin America*, July 1996.

[8] Barry Geldzahler, "Get a Good Partner," *Telephony*, vol. 230, No. 26, June 24, 1996, p. 94.

[9] Industry analysts believe that Mexico set fairly low rates in order to keep local calling rates at only 2.5 cents per minute. Job creation is a vital political issue in light of Mexico's 29-percent unemployment rate. Geldzahler, "Get a Good Partner," and Garcia and Loughran, "Mexico Sets Telmex Fees."

[10] The interconnection rates are: 1997: 5.32 cents/min.; 1998: 4.69 cents/min.; and 1999-2000: 3.15 cents/min. Edwardo Garcia and Tim Loughran, "Mexico Sets Telmex Fees Before Allowing Competition," *Bloomberg Business News*, Aug. 8, 1996.

[11] Accounting rates are mutually agreed fees paid to foreign carriers for terminating inbound international calls. For a discussion on international accounting rates, see the *ITU World Telecommunication Development Report*, 1994, p. 27.

[12] Rangel, "Consumers Hope End of Monopoly Will Bring Cheaper Phone Service," *The Dallas Morning News*, Aug. 6, 1996.

Table 1
Composition of five U.S. - Mexico joint ventures expected to compete with TELMEX

Group[1]	Partners	Origin	Share	Investment 5 to 10 yrs. ($millions)	Objectives
Avantel	MCI Groupo Financiero-Banamex-Accival	U.S. Mexico	45.0% 55.0%	$1,800	Avantel and Alestra plan to compete in the long-distance market and to initially target commercial telephone users and then the residential market by 1997.
Alestra	AT&T Alfa Bancomer-Visa	U.S. Mexico Mexico	49.0% 25.6% 25.4%	$1,900	Both Avantel and Alestra are currently developing their own fiber-optic networks.
Iusatel	Bell Atlantic Corp. Groupo Iusacell (publicly traded)	U.S. Mexico	42.0% 48.0% 10.0%	$1,300	Expects to compete in both the wireless, wireline, and paging markets. It holds cellular licenses covering 70 percent of Mexico.
Marcatel	Westel Inc. IXC Radio Beep	U.S. U.S. Mexico	24.5% 24.5% 51.0%	$650	Anticipates targeting the long-distance market in Monterrey.
Investcom	Nextel Groupo Comunicaci6n San Louis	U.S. Mexico Mexico	NA	$412	Plans to target small and medium sized business, offering integrated data, voice, and video services.

NA = Not available

[1] Cableado y Sistemas, which is owned by the Mexican company Groupo Varo, and Miditel, which is owned by Mexican based Antonio Canahuati, are two other new telecommunication providers that will compete with TELMEX. Neither has any U.S. ownership.

Sources: Enrique Rangel, "Consumers Hope End of Monopoly in Mexico Will Bring Cheaper Phone Service," *The Dallas Morning News*, Aug. 6, 1996; Enrique Rangel, "Texas Connections Help Mexico's Telecom Firms Get Off the Ground," *The Dallas Morning News*, Aug. 6, 1996; interview with Enrique Rangel, Aug. 1996; Eden Zoller, "Mexico gets set for New Year Competition in Long-distance," *Financial Times Telecom Markets*, Dec. 18, 1996; and Osiel Cruz, "Invertirá Invesetcom US 110 millones en Telefonía," *El Universal*, Nov. 13, 1996

United States-Mexico Telecommunications Trade

The trade volume in telecommunication services between Mexico and the United States increased by an annual average rate of 5 percent over the past 5 years, from $994 million in 1991 to $1.2 billion in 1995. For years, however, the United States has posted a substantial and growing trade deficit with Mexico in telecommunication services (table 2). The longstanding deficit exists, in part, because there are more outgoing calls placed to Mexico from the United States than the reverse, and because of the manner in which accounts are settled between

Table 2
U.S. telecommunication services: Imports, exports, and trade balance with Mexico, 1991-95

(*Million dollars*)

Trade	1991	1992	1993	1994	1995
Exports	169	158	180	198	218
Imports	775	818	884	963	1,001
Trade balance	-586	-660	-704	-765	-783

Source: U.S. Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business,* Sept. 1991; Sept. 1994; and Nov. 1996.

countries. For example, when a call is placed from the United States to Mexico, it is considered a U.S. import, because the U.S. carrier must pay a termination fee to the Mexican carrier. On the other hand, when a call is placed from Mexico to the United States, it is considered a U.S. export, because the Mexican carrier must pay the U.S. telephone company a fee. The amount of the settlement is determined by accounting rates that were first negotiated between monopolies belonging to the International Telecommunication Union (ITU) in the late nineteenth century.[13] Where monopolies have persisted, like those found until recently in Mexico, accounting rates have tended to remain high.

The U.S. trade deficit [14] with Mexico has increased by 7.5 percent annually, on average, in recent years, from $586 million in 1991 to $783 million in 1995.[15] In part, the U.S. deficit with Mexico has expanded because U.S. direct investment (table 3) has increased the number of U.S. affiliates in Mexico, thereby raising the volume of outbound telephone calls from parent firms in the United States to those affiliates. Nonetheless, the deficit in telecommunication services trade may be substantially reduced if the United States and Mexico renegotiate their accounting rate, which is currently 67 cents per minute (see Outlook).

Table 3
U.S. direct investment (USDI) position in Mexico, 1990-95

(*Million dollars*)

Item	1990	1991	1992	1993	1994	1995
USDI	10,313	12,501	13,730	15,229	15,714	[1]14,037

[1] The U.S. stock of investment in Mexico decreased as a result of the depreciation of the peso in Dec. 1994, which reduced the value of peso-denominated properties.

Source: U.S. Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business*, Sept. 1991; Sept. 1994; and Nov. 1996.

---

[13] ITU, *World Telecommunication Development Report*, 1995.

[14] U.S. House of Representatives, *Testimony of Ambassador Jeffrey M. Lang Before the Subcommittee on Commerce, Trade, and Hazardous Materials*, May 9, 1996.

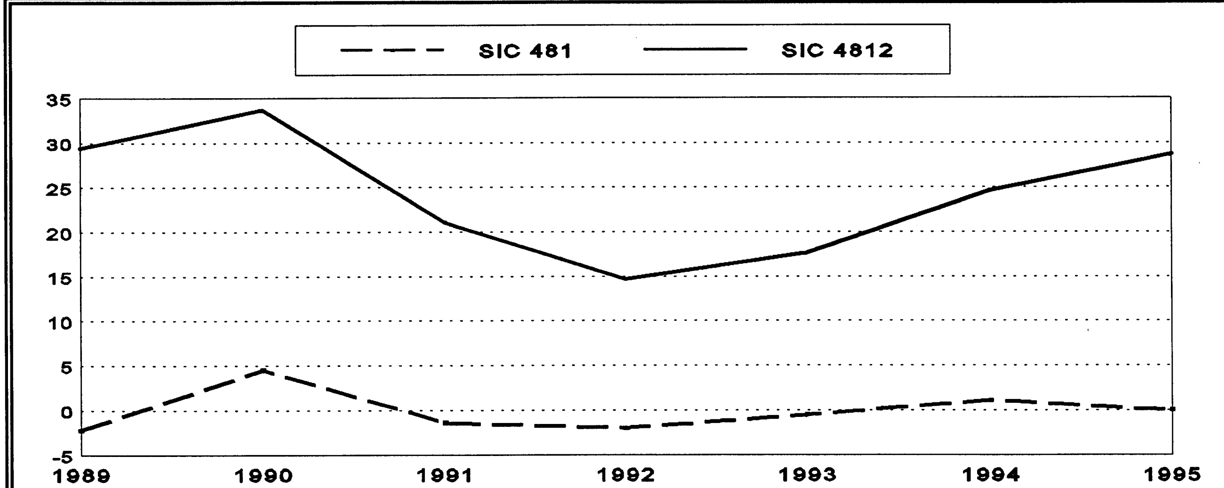
[15] USDOC, BEA, *Survey of Current Business*, Sept. 1994, and Nov. 1996.

U.S. Employment

U.S. employment in the telecommunication services industry declined from a high of 912,000 workers in 1990 to 887,000 workers in 1995, largely due to factors internal to the U.S. market. Principal underlying reasons include greater competition, consolidation, mergers and acquisitions, domestic regulatory reforms, and technological advancements.[16]

The single exception to this declining employment trend is found in the wireless communication sector (SIC 4812),[17] where employment has posted an average 24-percent annual growth from 1989 to 1995 (figure 1).[18] The maintenance of overall employment (SIC 481) among telecommunication service providers is largely the result of these substantial increases in employment among wireless communication providers. For example, despite its employee reduction program instituted at the beginning of 1996, AT&T recently attributed the preservation of its workforce to employment gains in wireless communication and Internet services. AT&T noted that it plans to double its wireless workforce by the year 2000.[19] The increased liberalization of Mexico's long-distance market will likely further increase both U.S. and Mexican employment in the wireless communication sectors, by facilitating U.S. entry into the Mexican cellular market, which is growing as a consequence of poor wireline service and lengthy wireline installation delays.

Figure 1
Percentage change of U.S. employment in telecommunication services, 1989-95



Source: U.S. Department of Labor, Bureau of Labor Statistics, *Employment and Wages*, 1989-1996.

[16] See, for example, Standard and Poors, "Telecommunications: Wireline," *Industry Surveys* (New York: McGraw-Hill) Sept. 12, 1996.
[17] Standard Industrial Classification
[18] U.S. Department of Commerce, Bureau of Labor Statistics, *Employment and Wages*, 1989-1996.
[19] For detailed analysis, see John Keller, "AT&T to End Year with Same Size Work Force," *The Wall Street Journal*, Dec. 30, 1996.

In light of investment opportunities in the Mexican telecommunication industry, employment among U.S. telecommunication service affiliates may grow. During 1986 to 1993, the most recent year of available data, aggregate employment in the services sector among U.S. affiliates in Mexico grew significantly, albeit unevenly, from 19,000 employees in 1986 to nearly 34,000 in 1993 (table 4).[20] Recently, AT&T's joint venture in Mexico (Alestra) announced the creation of 2,000 jobs, with a total of 3,000 expected by 2000.[21] Increasing employment abroad does not necessarily signal a decrease in U.S. employment as service provision in Mexico often requires that additional tasks be performed in the United States.

Table 4
Employment and sales of U.S. affiliates in Mexico, 1986-93

U.S. affiliates	1986	1987	1988	1989	1990	1991	1992	1993
Employment[1]	19.0	12.2	13.0	26.0	28.3	25.9	([2])	33.6
Sales[3]	372	370	417	294	([4])	([4])	([4])	1,071

[1] In thousands.
[2] Actual amount suppressed, but within the range of 25,000 to 49,900.
[3] In millions of U.S. dollars.
[4] Suppressed to avoid disclosure of data of individual companies.

Source: U.S. Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business*, 1986-1994.

Outlook

The fully enforceable WTO agreement on basic telecommunication services,[22] which will go into effect on January 1, 1998, is expected to further liberalize the Mexican market. Although Mexico generally limited foreign investment in telecommunication services providers to 49 percent, Mexico's commitment to the WTO permits 100-percent ownership of firms providing cellular services.[23] This positive outcome in the WTO could also build momentum toward renegotiating international accounting rates. Further, the International Settlement Rates Notice of Proposed Rulemaking (NPRM) issued by the Federal Communications Commission (FCC) on December 19, 1996, may lead to the achievement of cost-based accounting rates. The FCC proposal to reduce the accounting rate applicable to U.S. calls to Mexico, from the current rate of 67 cents per minute to 19 cents per minute,[24] should have the direct effect of reducing

[20] USDOC, BEA, *Survey of Current Business*, Sept. 1994.

[21] Internet http://www.att.com/press/10961022.cia.html, Dec. 27, 1996.

[22] For a general background discussion of the WTO negotiations, see USITC, "Basic Telecommunication Service Negotiations in the WTO: Impetus, Offers, and Prospects," *Industry Trade and Technology Review*, Jan. 1997.

[23] Mexico requires foreign firms to use Mexican infrastructure for the provision of domestic satellites services until 2002.

[24] The proposed FCC benchmarks will be based on an aggregate price calculated from a foreign carrier's tariffed price for the actual domestic transport and termination of a call, the international transmission and switching facilities, and the level of a country's economic development, measured by its gross domestic product. The FCC has proposed 15 cents per minute for high-income countries, 19 cents per minute for middle-income, and 23 cents per minute for low-income countries. U.S. Federal Communications Commission, *Notice of Proposed Rulemaking*, FCC 96-484, Dec. 19, 1996.

settlement payments to Mexico.[25] The FCC has proposed in the NPRM that middle-income countries, such as Mexico, should have 2 years to bring their accounting rates down to the pre-established benchmark rates.

Although Mexico limited its WTO offer on satellite-based, basic telecommunication services, the United States has already negotiated a satellite agreement with Mexico, which went into effect April 28, 1996, in the wake of the May 1995 liberalization of the Mexican satellite sector. It is believed that this agreement will pave the way for cross-border competition between Mexico and the United States.[26] The United States has encouraged adoption of the U.S.-Mexico satellite agreement as the prototype for other such bilateral agreements.■

---

[25] FCC Report, "FCC Settlement Rate Proposal Would Save U.S. Telcos Billions Annually," Jan. 1, 1997, p. 2.

[26] Theresa Foley, "Mexico Deal Sets Blueprint," *Communications Week International*, issue 166, June 3, 1996.

Use of Magnesium Castings in Automobiles Rises, but Challenges Remain

Vincent DeSapio
(202) 205-3435
desapio@usitc.gov

Magnesium has played a significant role in U.S. automakers' successful efforts to manufacture lighter weight, fuel-efficient automobiles. In the United States, the concentration of magnesium in motor vehicles has grown steadily during the past decade. Magnesium properties of high strength and weight ratio as well as machinability have proven their advantages, both on an economic and performance-related basis, in relatively narrow applications for structural components such as steering column systems and instrument panels. Automakers have committed themselves to increased use of magnesium during the next decade in their continuing efforts to achieve weight reductions in automobiles. At the same time, magnesium has yet to significantly enter such major segments of the automotive component markets as the engine and drive train that are exposed to extreme thermal conditions. In the next decade, magnesium producers and automakers, partly assisted by U.S. Government initiatives, will try to improve the quality of magnesium for use in high-temperature automotive applications as well as improving the cost competitiveness of these components. This article examines global automotive uses of magnesium, the structural and economic factors that place limitations on its use in certain applications, as well as developments likely to encourage the industry's greater adoption of magnesium in the future.

Before 1970, nearly all magnesium used by the automotive industry was alloyed with aluminum in quantities that rarely exceeded more than 1 kilogram (kg) per vehicle. However, the energy supply shortages of the 1970s and environmental requirements imposed by Federal and State Governments[1] fostered the increased use of magnesium components in passenger cars. In an effort to improve fuel economy and reduce emissions, automakers achieved reduced vehicle weight partly by substituting aluminum[2] and magnesium for certain steel and cast iron components; magnesium is 36 percent lighter per unit volume than aluminum and 78 percent lighter than steel. Alloyed magnesium, regarded as having the highest strength/weight ratio of

[1] The Environmental Protection Agency (EPA) presently requires automakers to achieve a Corporate Average Fuel Economy (CAFE) standard of 27.5 miles per gallon for cars and 20.6 miles per gallon for light trucks, while also meeting various emission requirements for carbon monoxide and for oxides of nitrogen. There is also legislation in California requiring 2 percent of all cars sold in the state to be zero-emission vehicles by 1998, rising to 10 percent by 2003.

[2] For a more detailed discussion of the use of aluminum in automobiles, see U.S. International Trade Commission, "Aluminum product development and the automotive industry," prepared by Charles Yost, *Industry, Trade, and Technology Review*, May 1994, *p. 17.*

Major Automotive Systems Presently Using Magnesium Alloys Castings

- **Steering Column Systems.** Magnesium has become the material of choice by automotive manufacturers for steering column systems.[1] On average, a magnesium steering wheel reduces the weight of steering wheel systems by 0.6 kilograms, compared to traditional aluminum/steel designs, and also reduces vibration throughout the column due to a reduction in the number of system components. An estimated 80 percent of North American passenger cars and light trucks will be equipped with magnesium steering wheel components by the year 2000.

- **Valve Covers.** Magnesium is gaining wider use in the manufacture of engine valve covers because its damping properties result in reduced engine noise. Magnesium valve covers are lighter than plastic or aluminum valve covers and have superior temperature stability and stiffness, leading to fewer leaks and the elimination of complicated fastening and sealing systems designed to prevent leaks.

- **Instrument Panel Systems.** One-piece magnesium die castings have only recently begun to emerge as the material of choice for use in instrument panel cross car beams. Presently used in new General Motors mid- and full-size vans, these castings offer reductions of between 30 and 50 percent in weight, over 60 percent in the number of parts required for total assembly, and between 60 and 75 percent in the time required for assembly.

[1] Steering column components and their support brackets have been manufactured from magnesium die castings since the 1980s when the introduction of air bags and cruise and radio controls on the steering wheel resulted in additional weight to the steering column system. This added weight increased the potential for vibration and customer dissatisfaction in this vibration-sensitive area.

Source: Scott Fairchild and Lisabeth Riopelle, "Magnesium and Its Future in the Automotive Industry," *Die Casting Engineer*, July/Aug., 1996, p. 20.

all metals, is highly resistant to corrosion, and has high-impact strength.[3] Manufacturers also emphasize that magnesium has high-fatigue strength,[4] is machinable at high speeds and possesses favorable thermal and electrical conductivity. These properties enable design of magnesium die cast components that are both thinner and lighter than traditional components, yet they still meet requisite impact-absorbing specifications.[5]

Magnesium's high strength and superior machinability reportedly also permit complex magnesium components such as instrument panel cross car beams to be cast in one piece, unlike similar steel beams that are typically manufactured as separate components and fastened

[3] *ASM Handbook*: Volume 2: Properties and Selection: Nonferrous Alloys and Special-Purpose Materials, 1990, pp. 1132-1134.

[4] *Fatigue strength* is defined as the ability of a material to resist fracturing under a cyclic, or, repeated stress environment.

[5] Steve Erickson and John Soper, "Magnesium Stands on its Own," *Machine Design*, Oct 12, 1995, p. 106.

together.[6] Multiple components can increase the number of surfaces that rub or vibrate, causing squeaks and rattles that lead to customer dissatisfaction; the use of one-piece magnesium castings within the instrument panel assembly has substantially eliminated such vehicle noise. One-piece castings also have contributed to significantly reduced beam assembly time and processing costs by eliminating the specialized tooling required for the production of individual components associated with steel assembly.[7]

Magnesium is presently used by the automotive industry in two ways. Die-cast components for automotive chassis, bodies, and some power trains account for nearly 90 percent of all magnesium used by the automotive industry (table 1); production of such components rose by an average annual rate of 8 percent between 1985 and 1996 to 2.5 kg/vehicle (table 2). Magnesium is also contained in aluminum alloys for castings used in aluminum wheels, and in sheet and extrusions used to manufacture hoods, deck lids, fenders, and roof racks.

Table 1
Present and near-term (to 1999) committed use of magnesium castings in automotive components

(*Kilograms per vehicle*)

Type of use	Ford	General Motors	Chrysler
Vehicle Interior:			
Bench structures	5.1 - 5.6	0	0
Seat riser	2.3 - 4.3	0	0
Instrument panel components	1.2	6.5 - 10.6	5.0
Brake/clutch/accelerator brackets	2.1 - 2.8	1.6	0.2
Radio housing	0.2 - 0.7	0	0
Window motor housing	0.3	0	0
Mirror bracket and housing	0	0	0.4
Steering column assembly	3.2 - 3.8	1.8 - 1.9	1.7 - 2.6
Engine:			
Oil filter adapter	0	0.7	0
Valve cover	0.6 - 1.1	1.2	2.5 - 2.6
Cam cover	1.2	3.3	0
Alternator/air conditioning bracket	0	0	1.0 - 1.3
Power steering pump bracket	0	0	1.2
Stator	0	0.4 - 0.5	0
Intake manifold	0	4.5	0
Manifold cover	0.2	0	0
Transmission:			
Four wheel drive transfer case cover and assembly	10.1 - 12.2	23.4	0

Source: Gerald S. Cole, Rani Agarwal Finstad, John C. Grebetz, "The Potential for Magnesium in the Automotive Industry," 1995 (presented at the International Magnesium Association Annual Conference, 1955), and USITC staff telephone interview with Gerald Cole, 1996.

[6] Al Wrigley, "Magnesium Gets the Squeaks Out," *American Metal Market*, Apr. 1, 1996, p. 4.
[7] Scott Fairchild and Lisabeth Riopelle, "Magnesium and Its Future in the Automotive Industry," *Die Casting Engineer*, July/Aug. 1996, p. 20.

Table 2
U.S. material use in a typical passenger vehicle

(Kilograms per vehicle)

Material	1978	1985	1990	1995	1996[1]
Steel	967.7	810.3	780.3	803.2	809.5
Iron	232.7	212.7	206.4	181.1	176.8
Plastic and plastic composites	81.8	96.1	104.1	112.0	111.4
Aluminum	51.1	62.7	72.0	85.2	88.9
Copper and brass	16.8	20.0	22.0	19.8	20.5
Powder metal parts	7.0	8.6	10.9	12.7	13.4
Zinc die castings	14.1	8.2	8.4	7.3	7.0
Magnesium castings	0.5	1.1	1.4	2.3	2.5
Fluids, lubricants	90.0	83.6	82.7	86.4	89.8
Rubber	66.4	61.8	61.8	61.8	63.2
Glass	39.3	38.6	39.3	41.6	42.7
Other materials	54.8	45.0	38.0	44.8	45.2
Total	1,622.3	1,448.7	1,427.3	1,458.2	1,470.9

[1] Estimated.

Source: 1996 *Ward's Automotive Yearbook*, p. 24.

Factors Affecting Further Use of Magnesium in Automobiles

Despite the rapid success of magnesium in capturing large segments of the market for certain limited applications, these alloys have yet to be widely used in engine and drive train components, areas in which nearly 80 percent of the entire weight of the automobile is concentrated and which are presently dominated by steel, cast iron, and aluminum (table 2). Magnesium has traditionally been excluded from these high-volume applications because of certain critical structural and economic weaknesses. Possibly the greatest structural impediments to the use of magnesium are susceptibility to weakening in environments that exceed 150^0 C. in temperature, and vulnerability to galvanic corrosion when placed next to dissimilar metals (such as stainless steel and many aluminum alloys) in the presence of an electrolyte, that is, a solution capable of conducting electrical energy from one metal to another metal.[8] In the latter case, methods that include decorative coatings, plating, and finishes have been developed to insulate magnesium from dissimilar metals in corrosion-prone automotive

[8] Erickson and Soper, p. 104.

environments near water, oil, and acids.[9] The more difficult structural problem to solve is that of developing magnesium alloys that offer superior creep[10] resistance at high temperatures.

Of equal concern in the large-scale adoption of magnesium by the automotive industry is the cost of the metal relative to competing materials. At the present listed price of $1.65-1.70 per pound for automotive-grade magnesium alloy ingot, magnesium is $0.95-1.00 per pound more expensive than aluminum alloy AL380, with which it competes most directly. The rise in the price of magnesium ingot (from $1.54-1.62 per pound) in early 1995, led to cancellation of some projects that had anticipated significant use of magnesium.[11]

Despite the apparent cost advantages of aluminum alloy relative to magnesium alloys, industry experts caution that cost is a complex variable to assess when applied to material comparisons. Although material cost is an important consideration in the selection of material for automotive components, the use of a higher cost material may, in certain applications, result in increased operating efficiencies, leading to lower production costs, if the material possesses properties that enable it to be processed more economically. Production costs for producing a magnesium component, such as an instrument panel beam, reportedly are lower than for a similar aluminum beam because magnesium's lower density and greater strength/weight ratio allow less material to be used in the component. Die-casting process cycle times for magnesium are also often shorter because the metal flows more easily and absorbs less heat during the casting process.[12] In addition, finishing costs for magnesium are often lower than for aluminum because magnesium's ease of machining results in faster operations and longer tool and die life. Moreover, closer tolerances can be achieved on magnesium castings, making some finishing operations unnecessary.[13] Magnesium manufacturers anticipate that many of these positive factors associated with magnesium will narrow some of the cost advantage that aluminum alloy now maintains.

Developing New Alloys

An essential element in the increasing importance of magnesium alloys in structural applications has been the development of AM50 and AM60 alloys. Although traditional magnesium alloy AZ91 currently accounts for nearly 70 percent of the magnesium automotive component market, industry experts estimate that newer alloys, AM50 and AM60, will account for nearly 60 percent of this market by the year 2000. The greater ductility and impact-absorbing capability

---

[9] In addition, sealing compounds, rubber grommets, gaskets, vinyl thread tapes, and the use of fastener attachment designs that shed water are used to further isolate dissimilar metals and deter corrosion. Ibid.

[10] *Creep* is defined as the slow deformation by stresses below the normal yield strength of a material, typically occurring at elevated temperatures.

[11] Ford Motor Co. reportedly cited cost increases in magnesium as a reason for its cancellation of plans to use magnesium instrument panel support beams in its luxury Lincoln sports sedan, scheduled for introduction in 1999. This followed its decision to eliminate magnesium components for the seat-back frame from its Windstar minivan. Al Wrigley, "Ford Jettisons Magnesium," *American Metal Market*, Aug. 14, 1996, p. 12 and "Ford Plans to Trim Magnesium Usage," *American Metal Market*, Apr. 16, p. 1.

[12] Erickson and Soper, p. 106.

[13] Ibid.

Table 3
Typical properties of automotive-grade magnesium and aluminum alloys (at 20° C), principal applications, and price

Alloy	Tensile strength (1,000 pascals)	Elongation (Percent in 51 mm)	Impact strength (Joules)	Melting range (Degrees C)	Principal applications	Price (Dollars/ pound)
AZ91	230	3.0	2.2	470 - 595	Valve covers, transfer cases, lock housings, mirror brackets	$1.65 - $1.70
AM60	220	6.0 - 8.0	6.1	540 - 815	Steering wheel systems, instrument panels, support brackets	$1.65 - $1.70
AM50	220	6.0 - 10.0	9.5	543 - 620	Steering wheel systems, instrument panels, support brackets	$1.65 - $1.70
AE42	225	8.0 - 10.0	5.8	565 - 620	Automatic transmission cases	$2.20[1]
AL380	315	3.0 - 3.5	3.0	540 - 595	Steering wheel systems, instrument panels, support brackets, automatic transmission cases, valve covers	$0.76

[1] AE42 is not yet commercially traded and no quoted prices are available. The price listed is a suggested price for the metal.

Source: Compiled by USITC staff from various sources, including American Society of Metals (ASM), *American Metal Market*, and various industry contacts.

of these newer alloys (table 3) make them more suitable for rapidly growing structural applications that are often subjected to high strain during a vehicle collision (for example, steering column components, instrument panel assemblies, and seats).[14]

In an effort to overcome the structural limitations of magnesium alloys and expand the range of automotive applications, magnesium manufacturers are also seeking to develop various new, higher performance alloys as a replacement for existing aluminum, steel, and cast iron. AS21 alloy [15] improves magnesium's performance by adding silicon to the alloy for creep resistance at high temperatures, and manganese and zinc for corrosion resistance; AE42 alloy depends for its corrosion resistance capabilities and for its improved performance at higher temperatures on

[14] Darryl L. Albright, "Current Trends in the Development and Utilization of Magnesium Alloys," 1995, document obtained from Hydro Magnesium Inc., p. 35.

[15] AS21 was first used by Volkswagen AG in the drive train of its Beetle during the 1970s and has been reintroduced only recently in prototype trials.

reducing the amount of aluminum and increasing the percentage of rare earth metals in the alloy.[16] Both AS21 and AE42 alloys remain in their development stages, but indications are they will play an increasing role in automotive applications within the next 5 years, provided their marginally higher cost relative to AZ and AM alloys is reduced and certain problems in casting these alloys are resolved.[17]

Improving the Quality of Recycled Magnesium

The use of recycled (scrap) magnesium by the automotive industry has become an important factor in the magnesium demand-supply relationship since recycled magnesium is currently excluded from use in automotive components because of quality considerations. Growing demand for magnesium alloys and the consequent rise in price have focused attention on the production of automotive-grade metal from scrap.

Magnesium recycling is viewed as one means for bringing additional magnesium supplies into the market, thereby improving the cost competitiveness of magnesium. The United States produced nearly 62,000 metric tons of secondary (recycled) magnesium in 1995, compared to nearly 128,000 metric tons of primary magnesium.[18] Because of the existence of large supplies of recycled magnesium, much industry research has gone into efforts to effectively refine scrap material to perform equally to virgin magnesium alloy.[19] Such a development, by bringing additional magnesium supplies into the market, would make magnesium more cost-competitive relative to steel, cast iron, and aluminum. Quality assurance is the major factor inhibiting the use of recycled magnesium in automotive components, together with associated costs of testing material for impurities that affect a component's mechanical properties (especially fatigue and impact strength) and chemical properties (corrosion resistance).[20] Methods currently used to determine scrap metal quality are effective in analyzing the metallic composition of alloys; however, testing methods to analyze the nonmetallic content of recycled material are often expensive and laborious to perform. A testing method currently being promoted by Dow Chemical Co. promises to provide a relatively inexpensive, simple, and quick means of determining the cleanliness of magnesium alloys AZ91 and AM50.[21]

---

[16] AE42 was developed in 1990 by Dow Magnesium and specifically designed for use in automotive automatic transmission cases where operating temperatures commonly exceed 150^{0}C.

[17] Albright, p. 32.

[18] According to industry sources, limited amounts of class 1 scrap material, defined as clean trimmings and rejected cast parts from existing magnesium production, are beginning to be used by the automotive industry. Annual class 1 scrap production is estimated to equal between 25 and 50 percent of total diecasting production, or between 8,000-16,000 metric tons.

[19] Andrew G. Haerle, Barry A. Micucki, William E. Mercer II, "A New Technique for Quantifying Non-Metallic Inclusion Content in Magnesium," p. 1, 1996. Supplied by Dow Chemical Co.

[20] Ibid.

[21] This method utilizes light reflectance to assure metal cleanliness. Oxide impurities within a recycled magnesium metal sample reflect light differently than the magnesium matrix within the sample. The Dow method has taken advantage of this principal to devise an instrument which can quantify the ratio of refraction to reflection within the sample to assure a relatively inexpensive and quick means of quality control for magnesium metal fabricators. Andrew Haerle, Micucki, Mercer II, "A New Technique," 1996.

New Process Technologies

The magnesium manufacturing industry is also seeking to improve magnesium's product performance in automotive applications and lower production costs by developing newer process technologies for the manufacture of cast magnesium alloys. Among the processes currently being developed are *thixomolding* and *surface modification technologies*.

Thixomolding, a process currently being developed by Thixomat Inc. (Ann Arbor, MI) and Dow Chemical Co. (Midland, MI), combines the features of die casting and injection molding to produce parts having near net shapes[22] and tighter tolerances than can be achieved with conventional die casting. In addition to reducing the cost associated with surplus metal and waste disposal, the thixomolding process also reportedly produces a magnesium component with at least 50-percent reduced porosity, contributing to increased strength and high-temperature performance.[23] Currently in commercial use only in U.S. production of thixomolded components for GM EV1 electric cars (magnesium cases and heat rails), the process is also scheduled to be used for the commercial production of magnesium components in Canada, Japan and Sweden.

Despite its enormous potential, thixomolding faces certain hurdles in its adoption. These include higher raw material processing costs (which make magnesium components produced through this process 10-20 percent more expensive than conventional die-cast components), and the unwillingness of fabricators to switch to a single-use molding process which limits manufacturers to the production of only one metal.[24] Despite these limitations, officials at Thixomat Inc. believe that larger production volume will lead to lower unit costs and that thixomolded components will make a greater contribution to magnesium supply as they become more price competitive with conventional die-cast components.[25]

Surface modification technologies seek to improve the surface properties of the next generation of magnesium alloys by making them more corrosion- and heat-resistant than conventionally coated magnesium components.[26] Research into this technology and limited commercial production of components is presently concentrated in Japan.[27] Techniques currently being developed and applied to magnesium alloys include:

---

[22] Near net manufacturing produces semimanufactured parts which are produced nearly to the shape of the finished part, thereby reducing the need for costly finishing operations.

[23] Al Wrigley, "SSM Forming Gains Popularity," *American Metal Market*, June 3, 1996, p. 4.

[24] In conventional die casting, the cold-chamber molding machines are capable of switching between aluminum and magnesium production, while in the thixomolding process, the machines must be dedicated to production of magnesium components only. USITC staff telephone interview with officials of Thixomat Inc., Oct. 1996.

[25] Ibid.

[26] In current applications, most magnesium castings are protected from mechanical friction and harsh chemical and thermal environments by *anodizing*, a surface finishing technique that offers only limited abrasion resistance. In anodizing, the thinly deposited protective layer is often easily ruptured or peeled off when surface pressure becomes sufficient to cause deformation of the magnesium part.

[27] Isao Nakatsugawa, "Surface Modification Technology for Magnesium Products," presented at International Magnesium Association Conference, Ube City, Japan, May 1996.

- *Ion-implantation* - Certain atoms are embedded in the surface of a component through the use of a beam of ionized particles. This process neutralizes the ions and renders the surface resistant to corrosion.
- *CVD/PVD* - Widely used in the abrasives industry, these processes involve the deposition of a solid on a heated surface via a chemical reaction from the vapor phase, leaving the surface resistant to wear and corrosion.
- *Laser Surface Melting/Alloying* - Lasers either melt the surfaces of metals to create solid solutions that improve corrosion resistance capabilities, or melt a metallic coating and the underlying substrate, causing the metals in the coating and the substrate to alloy and to better resist corrosion.
- *Thermal Spray Coatings* - Certain metals are fed into a torch that heats them to a molten or nearly molten state. The metals are then sprayed in a gas stream against a metal surface. Such processes can be used to spray a wide variety of metal coatings and create the formation of extremely thick coatings.

Projected Growth of Magnesium

According to purchasing agents for Ford, General Motors, and Chrysler, growth of cast magnesium components[28] is projected to nearly double to an average annual rate of 20 percent during the rest of the decade. This compares to an anticipated average annual growth rate of 4 percent for aluminum and less than 1 percent for steel. As a result, the volume of magnesium castings for use in automobiles is projected to grow from 28,400 metric tons (2.5 kg/vehicle) in 1996 to 39,400 metric tons (3.3 kg/vehicle) in 1998, and to 60,000 metric tons (5 kgs/vehicle[29]) by the year 2000.[30]

Ford Motor Co., the pioneer in the use of magnesium die castings in instrument panel beams and steering column assemblies, used nearly 65 percent of all magnesium castings consumed by the automotive industry in 1995.[31] However, General Motors has announced a goal to expand its annual use of magnesium to nearly 16,000 metric tons by 1998 from less than 8,000 metric tons used in 1996,[32] a development that could eventually rank GM with Ford as the largest

[28] Nearly 31 magnesium components were introduced in the 1995 automotive model year. "Current Trends in the Development and Utilization of Magnesium Alloys," Darryl L. Albright, Hydro Magnesium Corp., 1995, p. 33.

[29] Based on a projected annual production volume of 12 million vehicles.

[30] Gerald S. Cole, Rani Agarwal Finstad, John C. Grebetz, "The Potential for Magnesium in the Automotive Industry", p. 2. Presented at the International Magnesium Association Annual Conference, 1995.

[31] Ibid.

[32] For 1997-1999, GM has announced plans to substitute 27-pound magnesium instrument panel cross-vehicle structural beams for standard steel beams in its Chevrolet Express, Chevrolet Van, and GMC Savana models; to convert the transfer cases and cover halves of its four-wheel drive GM

(continued...)

Table 4
Present and projected use of magnesium castings by the automotive industry in North America, 1995-98

Company	1995	1996	1997	1998
General Motors (*Metric tons*)	3,400	7,800	9,600	15,800
Chrysler (*Metric tons*)	3,900	5,400	5,900	5,800
Ford (*Metric tons*)	12,100	15,200	15,800	17,800
Total (*Metric tons*)	19,400	28,400	31,300	39,400
Mass of magnesium per vehicle (in kilograms)	2.3	2.5	2.9	3.3

Source: Gerald S. Cole, Rani Agarwal Finstad and John C. Grebetz, "The Potential for Magnesium in the Automotive Industry," 1995, and USITC staff telephone interview with Gerald Cole, 1996.

automotive users of magnesium[33] (table 4). GM also reportedly will use magnesium in a two-piece molded case and a heat rail to protect battery connections in its EV1 electric cars, introduced commercially in December 1996.[34] As confirmation of their commitment to magnesium use, both Ford and GM have announced long-term arrangements for the purchase of large volumes of magnesium ingot for die castings, reportedly intended to hedge against possible future shortages of magnesium.[35]

U.S. Government's Role

The U.S. magnesium industry is hopeful that a major, sustained commitment by the U.S. Government toward development of new magnesium alloys will provide added interest in the use of magnesium and help to continue to focus the attention of U.S. automakers on magnesium's potential in structural applications. For fiscal year 1997, the U.S. Government is expected to allocate nearly $295 million for projects and research directly and indirectly-

[32] (...continued)
vehicles to magnesium from aluminum; to substitute magnesium steering column supports and support brackets for conventional steel units in its redesigned and new compact-sized cars and in its Chevrolet Blazer, S10, GMC Jimmy and Sonoma sports utility vehicles; to use one-piece magnesium instrument panel pedal bracket supports in its compact-size pickup trucks and standard-size pickup trucks; and plans to convert the driver's side instrument panel supports/pedal bracket supports in its standard-size pickup trucks to magnesium from steel. Ford recently announced that it will use some magnesium castings in its five-speed automatic rear-wheel-drive transmissions for pickup trucks, sports utility vehicles and vans for introduction by the year 2002.

[33] Al Wrigley, "Magnesium Outlook Brighter," *American Metal Market,* Apr. 10, 1996, p. 5.

[34] Al Wrigley, "GM Picks Magnesium for EV1s," *American Metal Market,* Apr. 17, 1996, p. 5. GM is building 2,000-3,000 EV1's in four cities in California and Arizona. Because the lead-acid battery packs used to power the electric car are so massive, GM engineers have specified the use of lightweight materials like magnesium, where possible, to minimize the load placed on the engine.

[35] Al Wrigley, "GM Still Pursues Magnesium," *American Metal Market,* Apr. 22, 1996, p. 6, and "Ford Gives Magnesium a Boost," *American Metal Market,* Feb. 3, 1997, p. 6.

related to the Partnership for a New Generation of Vehicles (PNGV),[36] including nearly $10 million for the development of advanced light-weight materials and structures.

Thus far, there has been one project financed under the PNGV that could potentially accelerate the further adoption of magnesium castings by the automotive industry. The U.S. Department of Energy has entered into a CRADA (Cooperative Research and Development Agreement) with the U.S. automobile industry and the North American Die Casting Association to develop an improved method for producing prototype dies for magnesium and other lightweight metals in metal mold processes such as die casting. The goal of this CRADA is to reduce the development time for the introduction of new metal mold dies from 12 months to 3 months, enabling the more rapid production of a prototype die with performance characteristics similar to those of a production die. Such a development would reduce the cost of die cast tooling, improve the mechanical properties of prototype die castings, and improve the industry's ability to produce complex shapes and sizes.

In another PNGV-related development, Ford Motor Co. recently announced that it will use 200 pounds (91 kg) of magnesium, or approximately 10 percent of the total anticipated weight, in each of the six or seven prototype automobiles it is building under the PNGV. Ford announced that it will make extensive use of magnesium in the engine and drive train of these automobiles.[37]

Use of Magnesium by Foreign Automakers

Like their U.S. counterparts, major foreign automotive manufacturers have been prompted by energy-related and environmental factors to manufacture lighter-weight and low-emission automobiles. However, widespread adoption of magnesium components has lagged behind U.S. levels. In 1995, European manufacturers used less than 0.8 kg/vehicle of magnesium while Japanese and Korean manufacturers combined used less than 0.25 kg/vehicle of magnesium; in contrast, U.S. manufacturers used an average of 2.3 kg/vehicle of magnesium. As in the United States, the principal areas of market growth have occurred in structural components for instrument panels, seat frames, and steering column assemblies. By the year 2000, the use of magnesium by European and Pacific Rim (including Japan and Korea) manufacturers is projected to nearly double from 1997 levels (table 5).[38] Worldwide consumption of magnesium

---

[36] The PNGV was approved in September 1993, by the President and the Chief Executive Officers of the major domestic automakers. The goal of this program is to develop, by 2004, vehicles that will deliver up to three times the fuel efficiency of today's vehicles (up to 80 miles per gallon and a driving range of 380 miles), be 80 percent recyclable, and cost no more than comparable vehicles. As part of its mandate, the PNGV has committed funds to promote the development and use of advanced light-weight materials, such as magnesium, in these vehicles. USITC staff telephone interview with U.S. Department of Energy officials, Washington, DC, Mar. 1997.

[37] Al Wrigley, "Ford Ups Magnesium in PNGV," *American Metal Market*, Mar. 3, 1997, p. 6.

[38] Dwain Magers, "A Global Review of Magnesium Parts in Automobiles," paper presented at Magnesium Automobile Parts Seminar, Tokyo, Japan (May 31, 1996).

Table 5
Present and projected use of magnesium castings by the automotive industry in North America, Europe, Pacific Rim, 1995-2000

(*Thousand metric tons*)

Region/country	1995	1996	1997	1998	1999	2000
North America	23	31	39	44	49	51
Europe	10	12	16	23	30	35
Pacific Rim (Japan and Korea)	2	3	3	4	5	6
All other	7	8	9	9	10	11

Source: Norsk Hydro Corp.

by automakers is expected to rise to nearly 100,000 metric tons by the year 2000, compared to 40,000 metric tons consumed in 1993.[39]

In Japan, Toyota Motor Corp. and Honda Motor Corp. have made the greatest application of magnesium alloy components in their automotive designs. Toyota, following the pioneering example of Ford Motor Co., used magnesium in steering column upper brackets and in the steering wheel cores of various models.[40] Toyota reported that, in addition to weight savings, the use of magnesium in forming a one-piece steering column reduced vehicle noise levels within the passenger compartment, and reduced component costs by eliminating the need for additional machining. In addition to these applications, Honda has applied limited amounts of magnesium alloys to engine valve covers and disc wheel brake rotors.

Three German automakers have had a relatively long history of magnesium use. In the late 1980s, Audi developed a magnesium one-piece die frame for the instrument panels in its V-8 engine automobiles, achieving a 50-percent weight reduction and reductions in vibration and noise levels. During this same period, Mercedes Benz began using AM50 magnesium die castings to form the seat frame for its 500 SEL automobiles. These two firms, together with Volkswagen AG, have also begun to aggressively explore magnesium's potential in engine and drive train components.[41] Volkswagen AG, drawing from its experience during the early 1970s as the world's largest magnesium consumer, recently announced a decision to increase the percentage of magnesium in its cars over the next 10 years.[42] Most of the magnesium will come from Israel's Dead Sea Works Ltd., in which Volkswagen owns a 35-percent interest. The amount of magnesium to be purchased by Volkswagen has not been announced; however, the

---

[39] Dwain Magers, "The Potential of Magnesium for the Automotive Industry," 1995, Press Release, Hydro Magnesium Co.

[40] Ibid., p. 10.

[41] Ibid.

[42] In the 1970s, Volkswagen used as much as 42,000 metric tons of magnesium annually in the engines and transmission train components of its air-cooled engines.

Israeli plant plans to begin annual production of 27,500 metric tons and to eventually double this capacity.[43]

Although the United States presently maintains a competitive lead in the automotive use of magnesium, foreign automotive manufacturers are also making major financial and research commitments to increase their use of magnesium in new, structural applications. If present trends continue, the per/vehicle use of magnesium by some foreign manufacturers could begin to approximate the amounts used in U.S. automobiles by the year 2000. ■

[43] Philip Burgert, "VW Expects to Up Magnesium Use," *American Metal Market*, June 4, 1996, p. 5.

U.S. Trade in Intangible Intellectual Property: Royalties and Licensing Fees

Patrick Coleman
(202)205-3459
pcoleman@usitc.gov

In addition to the growing emphasis on worldwide protection of intellectual property rights,[1] trade in intellectual property generates intense interest in the United States and abroad, in part because leading experts contend that net exports of intellectual property reflect national competitiveness, especially in advanced-technology industries. This article examines the principal components of trade in intangible intellectual property, identifies underlying patterns, and discusses trade barriers in principal export markets.

U.S. firms post a consistent surplus on trade in intangible intellectual property. The U.S. current account reports trade in intangible intellectual property in a line item entitled "royalties and licensing fees." Royalties and licensing fees are collected by those who sell patented industrial processes, techniques, formulas, and designs; copyrights and trademarks; business format franchises;[2] and management services.[3] U.S. royalty and licensing fee receipts measure U.S. exports of intangible intellectual property, whereas U.S. payments of royalties and licensing fees measure U.S. imports of such property.

In 1995, the United States exported intangible intellectual property valued at just under $27 billion, and imported intellectual property valued at $6.3 billion, resulting in a trade surplus of $20.6 billion (figure 1). This surplus represented 31 percent of the total surplus registered in the services trade account.[4] A great deal of this trade occurs between affiliated firms,

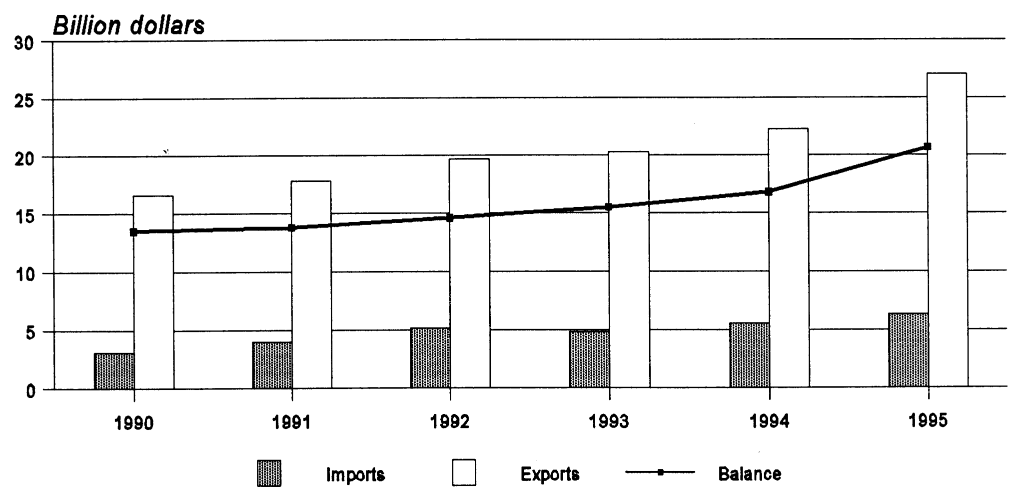
[1] The Trade-Related Intellectual Property Rights (TRIPs) Agreement, which entered into force on January 1, 1995, allows obligations to be phased in slowly according to a country's level of development. As a result of these staggered implementation provisions, the Council for TRIPs monitors implementation of the agreement and provides a forum for World Trade Organization (WTO) members to confer on intellectual property matters. See USTR, *1997 Trade Policy Agenda and 1996 Annual Report of the President of the United States on the Trade Agreements Program*, Mar. 1997, p. 50.

[2] Business format franchising entails a franchisee's acquisition of a franchise's entire business concept, from business plan to training materials.

[3] It is difficult, in some cases, to make the distinction between management fees and intellectual property. As an example, one company that provides blueprints and technical advice to its affiliate may classify the associated charges as a licensing fee for providing know-how, whereas another may classify these changes as management fees. See U.S. Department of Commerce (USDOC), Bureau of Economic Analysis (BEA), "U.S. International Transactions in Royalties and Fees: Their Relationship to the Transfer of Technology," *Survey of Current Business*, Dec. 1973, p. 5.

[4] USDOC, BEA, "U.S. International Sales and Purchases of Private Services," *Survey of Current Business*, Nov. 1996, pp. 82-83.

Figure 1
U.S. trade in intangible intellectual property, exports and imports, 1990-95



Source: U.S. Department of Commerce, Bureau of Economic Analysis, "U.S. International Transactions," July 1996, p. 69.

particularly U.S.-based parent firms and their foreign-based affiliates in the machinery-manufacturing, chemicals-manufacturing, and wholesaling industries. The large share of these intracorporate transactions undertaken by machinery and chemicals manufacturers reflects the globalization of these industries and the high intellectual property content of the industrial processes they sell abroad. In the wholesaling industry, the large share of intracorporate transactions principally reflects the activities of wholesaling affiliates abroad who return royalties and license fees to U.S. parent companies in return for using copyrighted materials, trademarks, and patented processes. Intellectual property trade between unaffiliated firms is relatively smaller, but it reveals that industrial processes developed in the United States are marketed abroad successfully, and it challenges the notion that the U.S. manufacturing sector is a poor innovator of advanced process technologies.

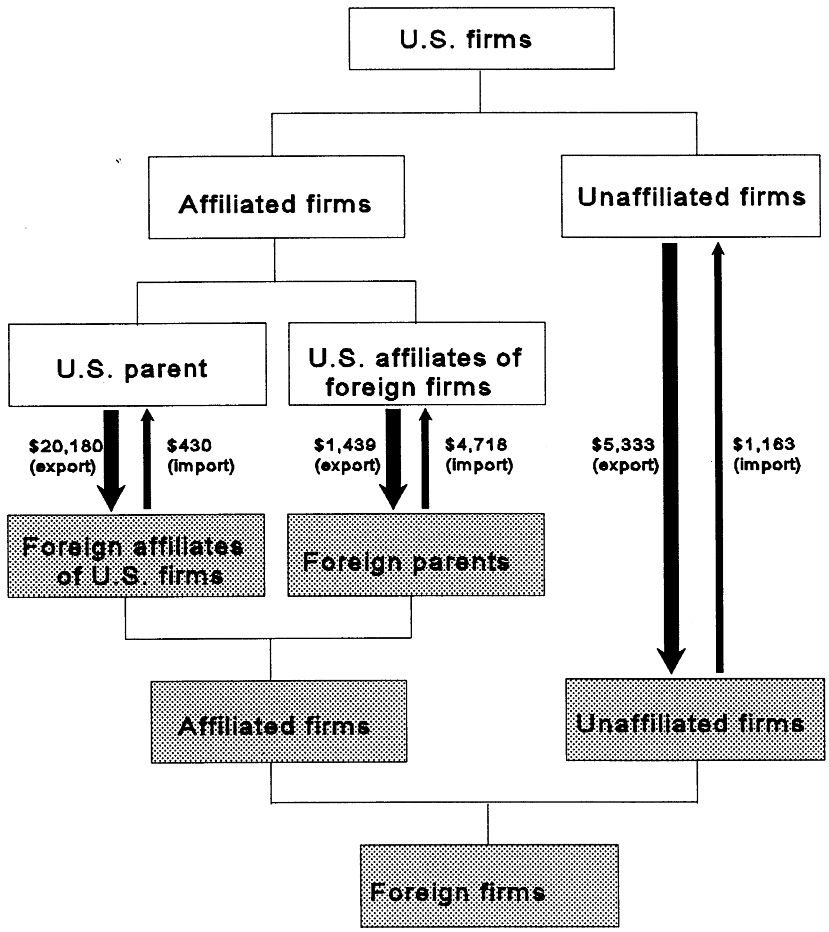
Intracorporate Trade

When analyzing trade in intellectual property, it is necessary to examine intracorporate trade. Intracorporate trade entails transactions between parent companies headquartered in one country and affiliates in another (figure 2).[5] Consistent with historical patterns, intracorporate trade accounted for 80 percent of U.S. trade in intellectual property in 1995.[6] Intracorporate trade predominates because firms with marketable intellectual property prefer to exercise some degree of control over its distribution since such property may be instrumental to the firm's competitive position in the global market.

[5] For the purposes of this discussion, foreign affiliates of U.S. firms are those at least 10-percent owned by U.S. parents. Similarly, U.S. affiliates of foreign firms are those that are at least 10-percent owned by foreign parents.

[6] USDOC, BEA, *Survey of Current Business*, Nov. 1996, pp. 82-83.

Figure 2
U.S. trade in intangible intellectual property, 1995 (*million dollars*)



Source: U.S. Department of Commerce, Bureau of Economic Analysis, "U.S. International Transactions," July 1996, p. 69.

In 1995, U.S.-based firms exported intellectual property valued at $21.6 billion to foreign-based affiliates.[7] U.S. intracorporate exports comprise both U.S. parents' receipts from their foreign-based affiliates ($20.2 billion), and U.S. affiliates' receipts from their foreign parents ($1.4 billion). U.S. intracorporate imports consist of U.S. parents' payments to their foreign affiliates ($430 billion), and U.S. affiliates' payments to their foreign parents ($4.7 billion). In 1995, intracorporate imports of intellectual property reached $5.1 billion, resulting in a surplus of $16.5 billion.[8]

[7] USDOC, BEA, " US International Transactions, First Quarter 1996," *Survey of Current Business*, July 1996, p. 84.
[8] Ibid.

In 1995, the U.S. machinery-manufacturing industry (including industrial and commercial machinery manufacturers and computer equipment manufacturers) apparently accounted for the largest share of intracorporate exports, totaling \$5.7 billion or almost 28 percent of such exports, and generated a surplus of more than \$5.4 billion in trade of intellectual property (table 1).[9] Wholesale traders appeared to account for 22 percent of intracorporate exports, and recorded a \$3.3-billion surplus.[10] Manufacturers of chemicals and allied products appeared to represent the third-largest exporter of intellectual property, accounting for 16 percent of total intracorporate exports, and generated a trade surplus of nearly \$1.2 billion in 1995.

Table 1
U.S. intracorporate receipts and payments of royalties and licensing fees, percentage share, and trade balance, by selected industries, 1995[1]

Industry	Receipts (exports)	Share of receipts	Payments (imports)	Share of imports	Trade balance
	Million dollars	*Percentage*	*Million dollars*	*Percentage*	*Million dollars*
Total of all industries	20,540	100.0	4,896	100.0	15,644
Manufacturing	13,049	63.5	3,087	63.1	9,962
Food and kindred products	1,116	5.4	234	4.8	882
Chemicals and allied products	3,234	15.7	2,066	42.2	1,168
Primary and fabricated metals	165	0.8	103	2.1	62
Machinery	5,700	27.8	296	6.0	5,404
Other manufacturing	2,834	13.8	388	7.9	2,446
Nonmanufacturing	7,491	36.5	1,809	36.9	5,682
Wholesale trade	4,569	22.2	1,314	26.8	3,255
Services	1,768	8.6	302	6.2	1,466
Other nonmanufacturing	1,154	5.6	193	3.9	961

[1] Industry-specific data are based on unpublished figures net of withholding taxes and other deductions. These data differ from published gross aggregate figures used in figure 2 and elsewhere in this article as noted.

Source: U.S. Department of Commerce, Bureau of Economic Analysis.

The prominence of machinery and chemical manufacturers as exporters of intellectual property to overseas affiliates reflects the extent of globalization and technology transfer associated with these industries.[11] Among all manufacturing industries, U.S. direct investment abroad is greatest in the chemicals industry, where the stock of outward investment measured \$50.4

[9] Sales for intracorporate transactions in intellectual property, by industry, are based on unpublished data collected by the U.S. Department of Commerce, Bureau of Economic Analysis. Industry-specific intracorporate receipts of \$20.5 billion and payments of \$4.9 billion reflect certain deductions such as withholding taxes. Consequently, these data are not strictly comparable to published gross aggregate figures presented earlier on intracorporate receipts of \$21.6 billion and payments of \$5.1 billion..

[10] Wholesale trade industries are classified by SIC codes 50 and 51.

[11] For a more complete discussion on the relationship between royalties, licencing fees, and the transfer of technology see, USDOC, BEA, *Survey of Current Business*, Dec. 1973, pp. 4-7; and, Edwin Mansfield, *Intellectual Property Protection, Foreign Direct Investment, and Technology Transfer* (Washington: International Finance Corporation, 1994).

billion in 1995. The stock of U.S. direct investment in the machinery industry measured $29 billion in 1995.[12] The U.S. chemical and machinery industries are also prime developers of technology related to the production of pharmaceuticals, computers, and other machines.

Research and development (R&D) expenditures per employee, a common barometer of technological intensity, are indicative of this trend. Among all U.S. industries, research and development expenditures were highest in the chemicals industry, at $15,047 per employee (table 2). The second-highest level of expenditures was recorded by the machinery industry, which spent $12,895 per employee. By contrast, average R&D expenditures per employee in the U.S. manufacturing sector measured $7,302 per employee in 1995.

Table 2
Research and development expenditures per employee, 1993

Industry	Expenditures for research and development	Number of employees	Research and development expenditures per employee
	Million dollars	*Thousands*	
Total of all industries	74,176	17,682	$ 4,195
Manufacturing	65,977	9,036	7,302
Chemicals and allied products	17,248	1,146	15,047
Machinery, except electrical	13,541	1,050	12,895
Transportation equipment	16,782	1,773	9,467
Electric and electronic equipment	7,572	834	9,079
Other manufacturing	8,933	2,419	3,693
Primary and fabricated metals	743	577	1,288
Food and kindred products	1,159	1,237	937
Petroleum	2,278	512	4,446
Wholesale trade	658	434	1,516
Services	1,447	1,663	870
Other industries	3,655	4,949	739
Finance (banking), insurance, and real estate	161	1,089	148

Note: Figures may not add to totals shown due to rounding.

Source: U.S. Department of Commerce, Bureau of Economic Analysis, U.S. Direct Investment Abroad, June 1995, table II.K.1.

In comparison, the prominence of wholesalers among exporters of intangible intellectual property appears to stem from affiliates' use of trademarks, copyrights, and patented processes owned by their parent firms. Affiliates of U.S. parent firms in the computer industry reportedly account for a large share of intellectual property sales,[13] principally stemming from their provision of software customization and systems integration services. The affiliates' use of trademarked and copyrighted goods and patented processes would ultimately require the affiliates to return royalties and license fees to their U.S.-based parents, transactions that would be counted as exports in the U.S. balance of payments.

---

[12] USDOC, BEA, "U.S. Direct Investment Abroad: Detail for Historical-Cost Position and Related Capital and Income Flows, 1995," *Survey of Current Business*, Sept. 1996, p.107.

[13] USDOC, BEA, *Survey of Current Business*, Nov. 1996, p. 75.

Trade Between Unaffiliated Firms

During 1995, U.S. firms exported intangible intellectual property valued at $5.3 billion to unaffiliated foreign firms (figure 2), and imported intellectual property valued at $1.2 billion, generating a trade surplus of nearly $4.2 billion. Sales of industrial process technologies[14] represented about 60 percent of U.S. exports of intellectual property to unaffiliated firms. Trade in industrial processes also generated an equivalent share of the considerable trade surplus in 1995, which was consistent with historical trends.[15] This surplus in industrial process technology increased from $1.7 billion in 1990 to $2.5 billion in 1995, reflecting average annual growth of 9 percent (table 3). This suggests either a U.S. competitive advantage in developing and marketing industrial process technology, or a greater U.S. proclivity to sell intellectual property to foreign firms. If the surplus is indicative of a competitive advantage, this would challenge the popular notions that the United States is a poor innovator and marketer of process technologies and that it focuses itself inadequately on developing such technology.[16]

Table 3
U.S. trade in industrial process technologies between unaffiliated firms, and trade balance, 1990-95

(Million dollars)

Year	Exports	Imports	Trade balance
1990	2,333	665	1,668
1991	2,434	796	1,638
1992	2,525	818	1,707
1993	2,820	1,054	1,766
1994	3,043	1,056	1,987
1995	3,316	819	2,497

Source: U.S. Department of Commerce, Bureau of Economic Analysis, "U.S. International Transactions," July 1996, p. 84; Sept. 1995 pp. 82-83; and Sept. 1994, p. 111.

Insights regarding the principal suppliers of unaffiliated U.S. trade in intellectual property can be gleaned from examining unpublished industry data on trade in intellectual property (table 4).[17] Electronic and electrical equipment manufacturers, excluding computer

---

[14] Industrial process technologies include license fees, royalties, and other fees received or paid for the use, sale, or purchase of intangible assets, including patents, trade secrets, and other proprietary rights, that are used in connection with, or related to, the production of goods.

[15] USDOC, BEA, "U.S. International Transactions, First Quarter," *Survey of Current Business*, July 1996, p. 84.

[16] See, for example, Lester Thurow, *Head to Head: The Coming Economic Battle Among Japan, Europe, and America* (New York: William Morow and Co., 1992).

[17] Industry-specific data on unaffiliated transactions in intellectual property are based on unpublished data, collected by the ASDIC, BEA, that are expressed net of withholding taxes and other deductions. Unaffiliated net receipts and payments were valued at $5.1 billion and $1.1 billion respectively, of which receipts of $738 million and payments of $114 million could not be classified within a specific industry. Consequently, these data are not strictly comparable to published gross aggregate data presented in figure 2 for unaffiliated receipts of $5.3 billion and payments of $1.2 billion.

Table 4
Unaffiliated trade in intangible intellectual property, by selected industries, 1995 [1]

Industry	Exports	Imports	Trade balance	Total Trade	Share of total unaffiliated trade volume
	(*Million dollars*)				(*Percent*)
Total manufacturing	3,335	916	2,419	4,251	68.9
Apparel and other textile products	144	7	137	151	2.4
Printing and publishing	121	46	75	167	2.7
Chemicals and allied products	479	652	-173	1,131	18.3
Petroleum refining and related industries	110	11	99	121	2.0
Fabricated metal products	47	3	44	50	0.8
Industrial and commercial machinery and computer equipment	210	8	162	258	4.2
Electronic and other electrical equipment components, except computer equipment	1,611	115	1,496	1,726	28.0
Transportation equipment	211	7	204	218	3.5
Measuring, analyzing, and controlling instruments; photo- graphic, medical and optical goods, and watches and clocks	89	13	76	102	1.7
Total non-manufacturing	994	77	917	1,071	17.3
Eating and drinking places	95	0	95	95	1.5
Business and computer related services	156	39	117	195	3.2
Motion pictures	240	(2)	(2)	(2)	(2)
Engineering, accounting, research, management, and related services	295	13	282	308	5.0

[1] Industry-specific data on unaffiliated transactions in intellectual property are based on unpublished data, collected by the U.S. Department of Commerce, Bureau of Economic Analysis, that are expressed net of withholding taxes and other deductions. Unaffiliated net receipts and payments were valued at $5.1 billion and $1.1 billion respectively, of which receipts of $738 million and payments of $114 million could not be classified within a specific industry. Consequently, these data are not strictly comparable to published gross aggregate data presented in figure 2 for unaffiliated receipts of $5.3 billion and payments of $1.2 billion.

[2] Data suppressed to avoid disclosure.

Source: USDOC, BEA, *Survey of Royalties, License Fees, and other Receipts and Payments for Intangible Rights Between U.S. and Unaffiliated Foreign Persons*, unpublished data, 1995.

manufacturers, accounted for the largest portion of unaffiliated U.S. trade in intellectual property, exporting $1.6 billion in 1995. The chemicals-manufacturing industry was the second-largest exporter, with exports of $479 million. Other major exporters represented service industries including the engineering, accounting, research, and management services industries with joint exports of $295 million, and the motion picture industry with exports of $240 million. In 1995, all U.S. industries registered surpluses in trade of intangible intellectual property with unaffiliated firms, except the chemicals-manufacturing industry, which recorded a deficit of $173 million.

Barriers to Trade

The continued growth of U.S. exports of intellectual property requires that U.S. trading partners provide adequate protection of such property, both tangible and intangible. Innovators of intellectual property indicate that they prefer to forego sales in foreign markets where intellectual property protection is inadequate. Consequently, the U.S. Government has, in recent years, implemented policies and undertaken other efforts to encourage its major trading partners to protect intellectual property. Major trading partners include the European Union (EU), Japan, Canada, and Mexico (table 5).

Table 5
U.S. international royalty and licensing fee transactions for intangible intellectual property, by area, 1995

Area	Exports	Imports	Total trade volume	Total royalty and licensing fee trade
	(Million dollars)			*(Percent)*
Canada	1,235	138	1,373	5.1
European Union	13,351	3,555	16,906	62.7
Japan	5,345	1,467	6,812	25.3
Mexico	414	46	460	1.7

Source: U.S. Department of Commerce, Bureau of Economic Analysis, "U.S. International Transactions," July 1996.

The Office of the United States Trade Representative (USTR), under the so-called "special 301" provisions of the Trade Act of 1974, has placed the EU on the "priority watch list" concerning intellectual property rights.[18] The excessively expensive EU patenting process is cited as one reason for this designation. There are also concerns over the implementation of the new EU single trademark system. In addition, certain EU-member states deny U.S. firms national treatment concerning audio and video taxes.[19] The United States has also voiced concerns about the shortfall between certain member states' patent laws and the provisions negotiated under the WTO Agreement on Trade-Related Aspects of Intellectual Property Rights (the TRIPs Agreement). In fact, the United States has initiated WTO dispute settlement procedures against Portugal, because of apparent inconsistencies between their patent laws and the TRIPs

[18] World Wide Web, retrieved Sept. 9, 1996, Office of the United States Trade Representative (USTR), http://www.ustr.gov/reports/special/factsheets.html, Facts Sheets- "Special 301" on Intellectual Property Rights. The designation "priority foreign country," refers to countries that impose policies and practices, which actually or potentially affect sales of U.S. intellectual property in an adverse manner, and that are not engaged in negotiations or making significant progress in negotiations to address these problems.

[19] World Wide Web, retrieved Sept. 9, 1996, Office of the United States Trade Representative (USTR, *Facts Sheets- "Special 301" on Intellectual Property Rights*.

Agreement.[20] In addition, some EU-member states impose economic needs tests,[21] nationality, and residence restrictions that adversely affect foreign participation in wholesale trade. For example, France applies needs tests, residency requirements, equity limits, and price controls on foreign pharmaceutical wholesalers.[22]

Japan, too, is on the USTR "priority watch list." The United States has cited continuing problems with Japanese patent laws, especially the limited interpretation of patent claims by Japanese courts.[23] In addition, it has been alleged that Japan inadequately protects trade secrets and trademarks.[24] The United States has also been engaged in a WTO dispute settlement procedure with Japan, concerning the limited term of protection granted to audio recordings under Japanese law.[25]

U.S. exports of intellectual property to Canada and Mexico are smaller than exports to the EU and Japan, but the U.S. Government is actively encouraging these North American partners to improve protection of U.S. intellectual property. Canada is currently on USTR's "watch list."[26] In particular, the USTR has expressed concern regarding Canadian copyright laws, which allegedly restrict U.S. trade in intellectual property in order to preserve Canadian culture. In Mexico, USTR has noted significant concern regarding the counterfeiting and piracy of U.S. intellectual property. The United States and Mexico are working bilaterally to devise new laws and promote the enforcement of existing laws concerning intellectual property protection in Mexico.[27] ■

---

[20] USTR, "USTR Announces Two Decisions: Title VII and Special 302," press release, Apr. 30, 1996, Washington, DC.

[21] Economic needs tests assess the impact of new market entrants on the indigenous industry. Such assessments may result in negative determinations if market entry is considered likely to have a detrimental effect on market structure, profitability, population density, geographic distribution, or job creation. Thresholds regarding these criteria are subjective and largely nontransparent, allowing regulators to exercise broad discretion with respect to granting market access.

[22] USITC, "Distribution Services," ch. in *General Agreement on Trade in Services: Examination of Major Trading Partners' Schedules of Commitments*, USITC publication 2940, 1995, pp. 3-7 through 3-8.

[23] World Wide Web, retrieved Sept. 9, 1996, Office of the United States Trade Representative (USTR, *Facts Sheets- "Special 301" on Intellectual Property Rights*.

[24] Ibid.

[25] Ibid.

[26] Countries are placed on the "watch list" as a means of monitoring progress in implementing commitments with regard to the protection of intellectual property rights and for providing comparable market access for U.S. intellectual property products.

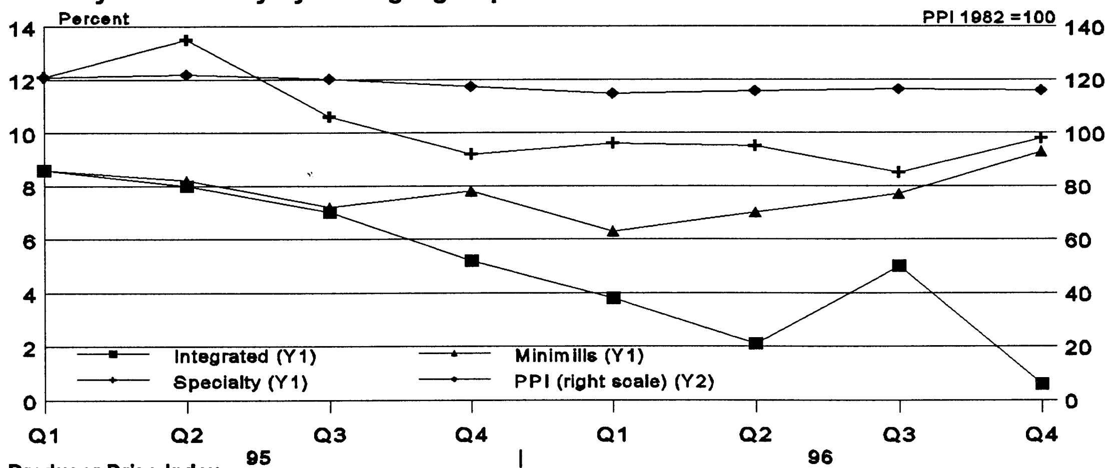
[27] Ibid.

APPENDIX A
KEY PERFORMANCE INDICATORS OF SELECTED INDUSTRIES

- **STEEL** (Felix Bello, 202-205-3120/fbello@usitc.gov)
  (Tracy Quilter, 202-205-3437/tquilter@usitc.gov)
- **AUTOMOBILES** (Deborah McNay, 202-205-3425/mcnay@usitc.gov)
- **ALUMINUM** (Karl S. Tsuji, 202-205-3434/tsuji@usitc.gov)
- **SERVICES** (Christopher Melly, 202-205-3461/melly@usitc.gov)

STEEL

Figure A-1
Steel industry: Profitability by strategic group[1]



PPI = Producer Price Index
[1]Operating profit as a percent of sales.
Source: Individual company financial statements, U.S. Bureau of Labor Statistics.

- Beginning with this issue, to more accurately assess industry performance, profitability is presented for 3 strategic groups within the industry: integrated steelmakers, minimills, and specialty steel producers. The new presentation seeks to demonstrate the variability among these three sectors, which an industry aggregate is unable to disclose. Because the ownership structure of certain mills limits availability of data for certain companies, it is not possible to comprehensively cover each group; however, the aggregate comprising each group as a whole is fairly representative. Specialty steels and integrated steelmakers have experienced the greatest decline in profitability since the peak in 1995.

- In the quarter ending December 1996, the profitability of integrated steelmakers[1] continued to decline from the same period in 1995. However, the steep declines in the second and fourth quarters of 1996 are driven by extraordinary events such as the blast furnace breakout at U.S. Steel in April 1996 and the restructuring costs incurred by Bethlehem Steel in the fourth quarter 1996. Union workers at WHX Corp. undertook a work stoppage beginning October 1, 1996 that had not been resolved as of year end. This overall decline in profitability also relates to a decline in prices while shipments have remained relatively constant. Recent minimill entrants in the flat rolled sector, such as Steel Dynamics, Inc., have reportedly cut prices in order to gain market share.

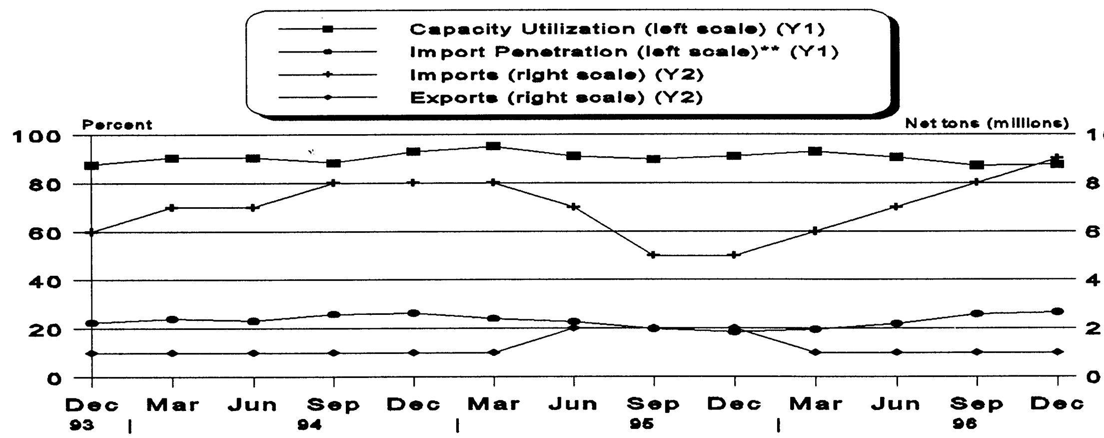
- The profitability of minimills[2] showed continued improvement into the fourth quarter 1996, after a slower start early in the year. While prices remained relatively stable, increased shipments contributed to profitability.

- Specialty steel producers maintain the highest profitability of the three sectors. Profitability rebounded in the fourth quarter after a steady decline from its peak during the second quarter 1995. The industry cites an influx of imports as a reason for the long term decline. Overall, stainless steel imports rose 7 percent from 1995 levels; however there were significant increases in U.S. imports of stainless steel sheet and plate (13 percent and 19 percent, respectively).[4]

[1] Integrated steel producers profitability is based on the financial statements of the following public companies: ACME Metals, Inc., AK Steel, Bethlehem Steel Corp., Geneva Steel Co., Inland Steel, LTV, US Steel Group, Weirton Steel Corp., and WHX Corp.
[2] Minimill profitability is based on the financial statements of the following public companies: ACME Metals, Inc., AmeriSteel Corp., Birmingham Steel, Chaparral Steel Co., Commercial Metals, Nucor Corp., Oregon Steel Mills Inc., and Steel Dynamics, Inc.
[3] Specialty steel producers profitability is based on the financial statements of the following public companies: Allegheny Teledyne Inc., Armco Specialty Flat-Rolled Steels, J&L Specialty Steel, Inc., Lukens Stainless Group, and The Timken Company.
[4] American Iron and Steel Institute.

STEEL

Figure A-2
Steel mill products, all grades: Selected industry conditions



**Import share of apparent open market supply.
Source: American Iron and Steel Institute, U.S. Bureau of Labor Statistics.

- Although domestic shipments increased in 1996 by 2.5 percent to reach 100.1 million tons, a slight decrease of 3 percent occurred in the fourth quarter from third quarter levels. Carbon flat rolled steel consistently outperformed other product categories with shipments up 0.7 percent over 1995 levels. Overall, domestic demand remains strong although the aggregate steel producer price index showed only marginal growth in the second half of 1996; prices are still below 1995 levels.
- Between 1995 and 1996, imports rose 19 percent while exports fell 29 percent. Strong U.S. demand, along with equipment outages and restructuring at domestic plants, contribute to these patterns. However, increased capital investment over the last few years should expand capacity and improve the industry's ability to meet future demand. Exports show a decrease as producers were able to sell more product domestically.
- Inventories rose throughout the second half of 1996, to 6,962,000 tons at the end of December after a steady decline from September 1995 to March 1996. The Steel Service Center Institute reported the number of months of shipments on hand was generally between 3 and 4 months.[1]

[1] Inventories data compiled from the Steel Service Center Institute Business Conditions Report, Jan. 1997.

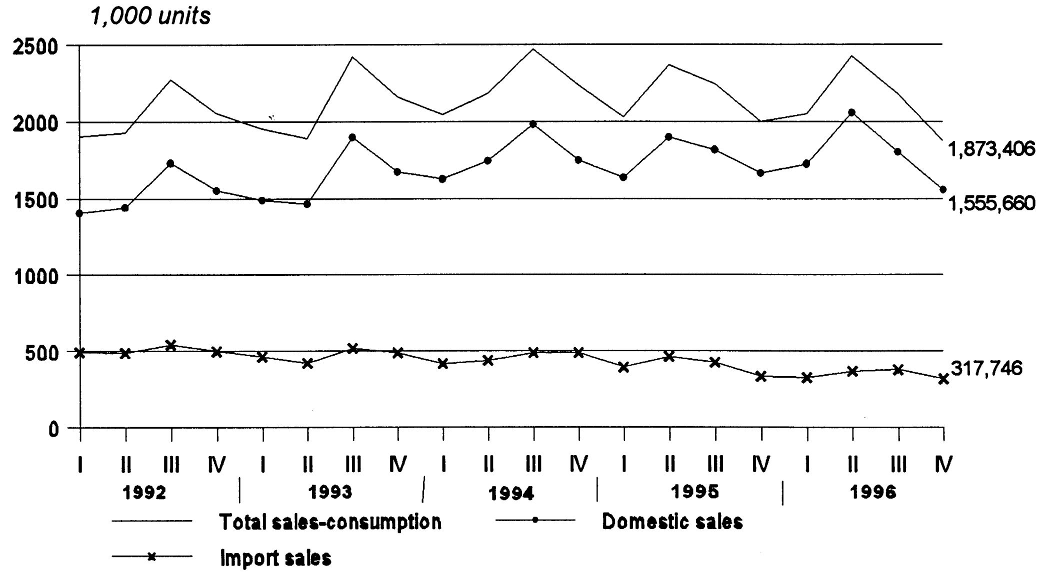
Table A-1
Steel mill products, all grades

Item	December 1996	Percentage change, December 1996 from September 1996[1]	January-December 1996	Percentage change, Jan.-Dec. 1996 from Jan.-Dec. 1995[1]
Producer's shipments (1,000 short tons).....	8,043	-3.2	100,130	2.5
Imports (1,000 short tons)................	2,538	-5.4	29,164	19.0
Exports (1,000 short tons)................	374	2.3	5,031	-28.9
Apparent supply (1,000 short tons).........	10,208	-3.9	124,264	8.0
Ratio of import to apparent supply (percent).............................	24.9	[2] -1.5	47.0	[2]11.0

[1] Based on unrounded numbers.
[2] Percentage point change.
Note.--Because of rounding, figures may not add to the totals shown.
Source: American Iron and Steel Institute.

AUTOMOBILES

Figure A-3
U.S. sales of new passenger automobiles, by quarter



Note.–Domestic sales include all automobiles assembled in Canada and imported into the United States under the United States-Canadian automobile agreement, these same units are not included in import sales.

Source: *Automotive News*; prepared by the Office of Industries.

Table A-2

U.S. sales of new automobiles, domestic and imported, and share of U.S. market accounted for by sales of total imports and Japanese imports, by specified periods, Jan. 1995-Dec. 1996

Item	Oct.-Dec. 1996	Jan.-Dec . 1996	Percentage change-- Oct.-Dec. 1996 from July-Sept.1996	Percentage change-- Jan.-Dec. 1996 from Jan.-Dec. 1995
U.S. sales of domestic autos (*1,000 units*)[1]	1,556	7,139	-13.6	2.8
U.S. sales of imported autos (*1,000 units*)[2]	318	1,390	-15.9	-9.2
Total U.S. sales (*1,000 units*)[1, 2]	1,873	8,529	-14.0	0.6
Ratio of U.S. sales of imported autos to total U.S. sales (*percent*)[1, 2]	17.0	16.3	-2.2	-9.8
U.S. sales of Japanese imports as a share of the total U.S. market (*percent*)[1, 2]	8.8	8.6	-4.1	-22.7

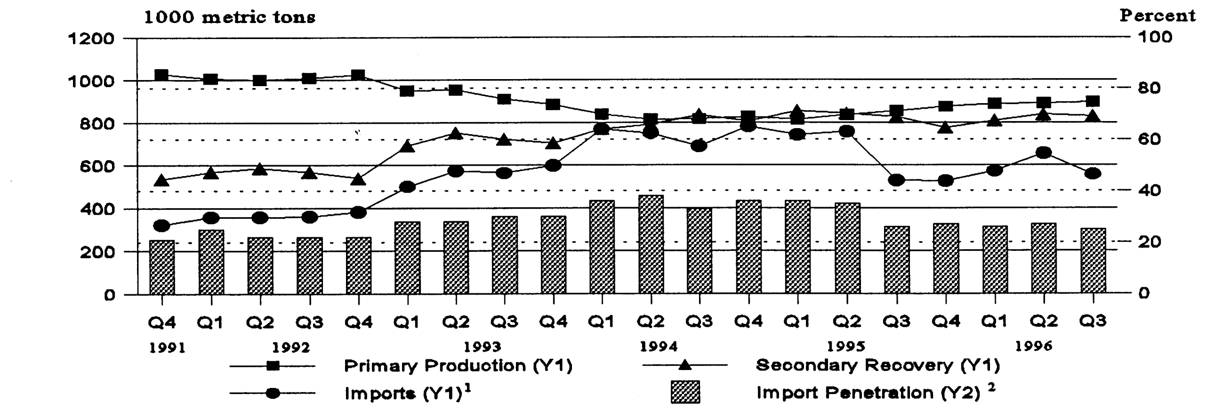
[1] Domestic automobile sales include U.S.-, Canadian-, and Mexican-built automobiles sold in the United States.

[2] Does not include automobiles imported from Canada and Mexico.

Source: Compiled from data obtained from *Automotive News*.

ALUMINUM

Figure A-4
Aluminum: Selected U.S. industry conditions--



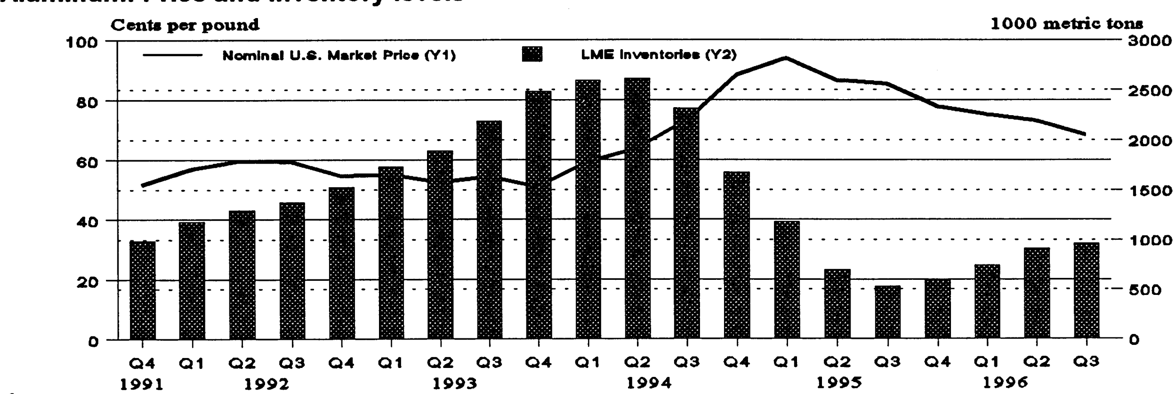
[1]Crude (metals and alloys) and primary (e.g. plates, sheets, and bars) forms for consumption.
[2]Percent share of imports to apparent domestic supply.

Source: U.S. Geological Survey.

- Persistent market weakness, especially in the industrialized countries, and increased global production from smelter restarts and capacity expansions, contributed to continued stockpiling of excess aluminum into LME inventories; the third quarter 1996 level of 962,000 metric tons was 81 percent above the nadir of 531,000 metric tons a year ago. The average U.S. price of primary ingot continued to drop, reaching 68.5 cents per pound, 20 percent below the 85.4 cents per pound level in third quarter 1995; the higher prices a year ago reflected multiple factors (particularly production cutbacks under the 1994 Memorandum of Understanding and extensive drawdown of LME inventories) that created the potential for supply restrictions to U.S. markets.

- U.S. production remained static at 1.7 million metric tons, with a slight increase in primary production being offset by decreased secondary recovery during this third quarter 1996. Demand for mill products remained weak as domestic end-users continued to reduce their inventories of metal and purchased new metal only as needed. Under these conditions, import penetration dropped two percentage point to 25 percent, down nearly 100,000 metric tons from the previous quarter to 557,000 metric tons.

Figure A-5
Aluminum: Price and inventory levels--

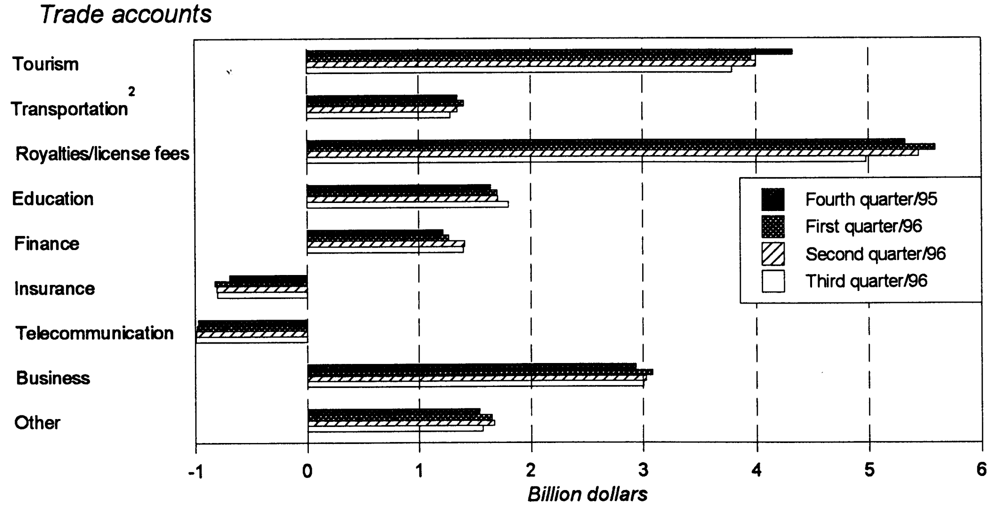


[1]Quarterly average of the monthly U.S. market price of primary aluminum ingots.
[2]End of quarter inventories.

Sources: U.S. Geological Survey, World Bureau of Metal Statistics, Metals Week, and U.S. Bureau of Economic

SERVICES

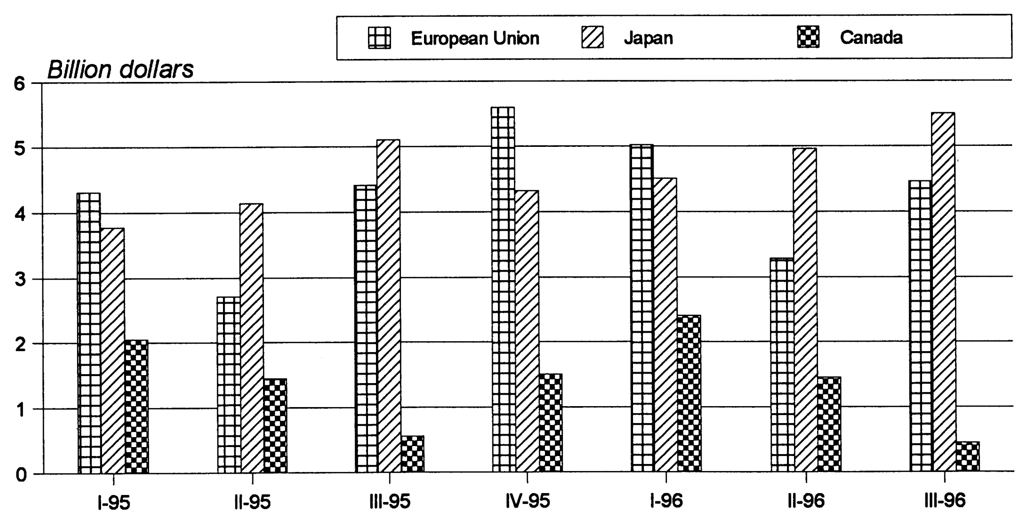
Figure A-6
Balance on U.S. service trade accounts, fourth quarter 1995 through third quarter 1996[1]



[1] Figures reflect trade among unaffiliated firms only.
[2] Includes port fees.

Source: Bureau of Economic Analysis, *Survey of Current Business.*

Figure A-7
Surpluses on cross-border U.S. service transactions with selected trading partners, by quarter, 1995-96[1]



[1] Figures reflect private-sector transactions only; military shipments and other public-sector transactions have been excluded.

Source: Bureau of Economic Analysis, *Survey of Current Business.*