National Security Assessment of the U.S. Forging Industry

A Report for the U.S. Department of Defense

Prepared by

U.S. Department of Commerce
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EXECUTIVE SUMMARY

The U.S. Department of Commerce, Bureau of Export Administration, Office of Industrial Resource Administration undertook this national security assessment of the forging industry at the request of the Office of the Assistant Secretary of Defense (Acquisitions and Logistics) to assist the Department of Defense in determining if a restriction limiting military procurement of certain forgings to domestic and Canadian sources was still necessary after 8 years. The Department of Commerce performed the assessment under authority of the Defense Production Act of 1950, as amended, and related Executive Order 12656. Nine major forging companies were sent a survey questionnaire to gather information for this assessment. They represented about one-quarter of the industry in 1990.

<u>The forging procurement restriction was initiated in 1984</u> and is found in the Defense Federal Acquisition Regulations (DFAR) in sections 208.7802 and 208.7803 (48 C.F.R.). The restriction was instituted to respond to the serious deterioration of the domestic forging sector in the early 1980's, and rapidly rising imports.

<u>About 20 percent of defense procurement of forgings (excluding foreign military sales) are covered by the restriction</u>. In 1991, an estimated $943 million of forgings were purchased for all military purposes ($107 million FMS), of which about $180 million were covered by the restriction. Forgings under the restriction include various tank and automotive forgings (for combat vehicles), small caliber weapons forgings, 60mm and 81mm mortar forgings, guntube and guntube preforms and associated forged parts, and shipboard anchor chain, shipboard propulsion shafts, periscope tubes and ring forgings for bull gears over 10 feet in diameter. The restriction has been targeted at those forgings with the highest import penetration levels - primarily ferrous forgings used in Army and Navy applications. The Air Force declined to participate in the restriction, citing competitive strength and technical leadership in the largely nonferrous aerospace forgings sector.

<u>Forgings are an intermediate product used by original equipment manufacturers in high performance, strength, and reliability applications where tension, stress, load and human safety are critical considerations</u>. They are the product of the plastic deformation of virtually any metal or alloy, usually at elevated temperatures. Forgings are made by hammering on or squeezing a metal workpiece so that it approaches its maximum theoretical density and the upper limits of the material's strength. Forgings range from less than an ounce to over 100 tons. Since forgings normally outlast their applications, only a very small aftermarket exists.

Due to their high strength and other properties, and the lack of alternative products or processes, forgings are essential components found in virtually all modern military weapon systems and supporting equipment. The M-60 battle tank contains at least 600 separate forgings. Forgings are the enabling technology that makes a modern aircraft possible. For example, the Boeing 747 (like the Lockheed C5 series or the older B-52s) has about 18,600 forgings. Forgings are used extensively in the landing gear, structural parts in the fuselage, tail assembly, wing spar, wing and engine attachments, and the engines.

Most U.S. forging end-markets, including defense, have declined and are the major cause of the industry's problems. The Forging Industry Association reports that U.S. forging demand has decreased about 20 percent since the 1970's. Aerospace markets began their decline late in the period and plunged 16 percent in 1991. While automotive markets remained stable, industrial markets declined 47 percent, off-road vehicles plunged 63 percent, railroads fell 54 percent and all others contracted 45 percent.

Shipments, employment and investment in the ferrous forgings industry were at their highest levels in the early 1970's. Between 1974 and 1983, shipments fell almost 53 percent from $5.53 billion to $2.61 billion. Employment peaked in 1978 at 41.2 thousand, and then fell to only 25 thousand in 1983. Investment reached its highest level in 1977 at $242.8 million, but dropped to $87.9 million in 1983, and only $82.1 million in 1986. Since the late 1970's, more than 110 forging plants have shutdown.

The two major markets for forgings are automotive and aerospace. In 1991, these two markets accounted for about two-thirds of forgings made by the hot impression die process (equal to roughly 75 percent of all forgings). In 1974, these two markets accounted for less than half the total because of the then greater size of industrial, off-road vehicles, railroad and other markets.

The forging industry has also fragmented into smaller firms. The implications (unless the market greatly expands) are reductions in R&D, increased market volatility, less investment, and a gradual deterioration in competitiveness. In 1979, 47 plants in the ferrous forging sector had more than 250 employees. In 1984, when the DFAR was introduced, 23 such plants existed. By 1989, only 18 such plants remained, a drop of over 60 percent. Further declines in the number of large plants are expected.

The concentration ratios of the industry have also dropped, despite the major contraction of the overall business. The market share in terms of shipments made by the largest four firms fell from 29 percent in 1972, to 22 percent in 1987. Market share for the eight largest companies slipped from 40 to 32 percent; and for the top 20 companies, it dropped from 57 to 47 percent during the period. The average shipments of the top four firms in 1987 was only $179.2 million, down 54 percent from the average in 1972.

The age of equipment in the forging industry has never been greater, and for the most part is fully amortized. The industry supports a large second hand equipment market. Labor productivity rates are almost unchanged in 20 years. For lack of adequate investment, the relative total cost of labor has risen in both the ferrous and nonferrous sectors as a portion of value added. This is opposite in direction to the trend in overall U.S. manufacturing. The forging industry in its present fragmented state is financially unable to undertake needed major investment projects, and incur higher fixed costs.

Between 1986-1990, the cost of labor, materials and energy averaged about 90 percent of dollars shipped for both the ferrous and nonferrous forging industries. This is significantly above the 79 percent average for overall U.S. manufacturers. The 90 percent rate leaves little for overhead and other costs, and implies the forging sector as a whole operated at a loss for the past several years. Moreover, these costs have consistently trended upward since 1974. Depressed end-markets, overcapacity, intense competition, and import pressures have created a protracted buyer's market.

Surveyed forging companies operated at 51 percent of capacity in 1991. Shipments were down 14 percent from 1990. Ramp-up time (i.e., time it takes to reach capacity production) averaged 7.6 months. The major bottleneck to reaching capacity production levels is labor. However, in an improved market situation, labor constraints may not be the concern shown here, as other areas such as die making or materials availability become more pronounced. Forging lead times for new orders averaged 39.3 weeks, and for repeat business, 15.4 weeks. These would both expand sharply at higher rates of capacity utilization. In times of high demand, queue time (i.e., waiting in line for processing) has been known to extend over a year at some forging plants. Employment at the surveyed companies dropped 14 percent between 1987-1991.

Profitability for the surveyed firms has been low since 1987, and in 1991 the group suffered over $100 million in losses. Before-tax profits were highest in 1990, at $43.2 million. However, they plummeted to a loss of $107.2 million in 1991, as sales fell by over 15 percent. All nine firms showed a drop in profits in 1991, and four of those reporting showed losses. Two firms showed losses for the 5-year period, and a third barely finished on the plus side.

The financial balances of the surveyed firms improved as they reduced outstanding debt. This is not surprising, since rising long term debt commonly occurs in rapidly growing sectors where additions to capacity are needed to keep pace with an expanding market. In forgings, however, overcapacity is forcing firms to retrench. As a portion of total assets, debt dropped from 35 to 25 percent. Long-term assets, (down 23 percent), and equity, (down 6.4 percent), also dropped.

Capital expenditures for the surveyed companies held steady, but R&D budgets declined. Capital expenditures were 3.35 percent of shipments in 1990, and 4.02 percent in 1991. The companies forecast that expenditures will remain stable through 1995. R&D expenditures declined from a high of $15.5 million in 1988 to $12.7 million in 1991, a drop of more than 18 percent.

Most of the surveyed companies are using (and the rest considering) Total Quality Management, Concurrent Engineering, Statistical Process Control and CAD/CAM. Some firms are using (and others looking into) near-net shape forging, faster die changing, robotics, non-destructive testing and flexible cell manufacturing. Several companies reported benefits for both their companies and the Defense Department from Industrial Modernization Incentives Program (IMIP) projects which reduce weapon system acquisition cost through the implementation of modern manufacturing processes and increased or accelerated capital investments.

Four of the surveyed firms expect that their competitiveness will improve in the next 5 years, two see it remaining the same, and two others report competitiveness will decline. Those that see improvement noted that the industry is consolidating, which should further strengthen the strongest firms, and that export opportunities are improving. Those that see their prospects remaining the same indicated competition will stay intense worldwide because of global overcapacity and decreasing demand, especially for large custom forgings. In this environment, customers have been driven by price reductions without regard for the forging industry's longer-term survival. The two firms that see a decline noted that expected drops in defense expenditures will create additional surplus capacity, and financially weaken forging companies. Further, third world countries with lower energy and labor costs and newer equipment present a new and increasing challenge in both U.S. and foreign markets.

BACKGROUND

Introduction

The U.S. Department of Commerce, Bureau of Export Administration (BXA) performed this national security assessment of the U.S. forging industry under authority of the Defense Production Act of 1950, as amended (DPA), and related Executive Order 12656. The Office of Industrial Resource Administration (OIRA), Strategic Analysis Division is the BXA organization responsible under this authority for conducting assessments of this nature. OIRA identifies critical defense industries; assesses their capabilities to meet national security needs; evaluates current and potential production constraints; and proposes remedial action when necessary.

In the course of an industry assessment, particular consideration is given to such factors as: industry structure, investment, research and development, competitiveness, foreign sourcing, labor and material cost, productivity, technological factors, and market trends. Data are collected by the Strategic Analysis Division from the private sector under authority of Section 705 of the DPA. OIRA has completed a number of national security assessments, the most recent including studies of: the semiconductor manufacturing equipment, robotics and gear industries. OIRA also, with the Navy, completed a major review of foreign sourcing and dependencies for three naval weapon systems.

In June 1991, OIRA was requested by letter (Appendix A) from the Office of the Assistant Secretary of Defense (Acquisitions and Logistics) to assist the Department of Defense (DOD) in determining if a restriction limiting military procurement of certain forgings to domestic and Canadian sources was still necessary after 8 years.[1] The Department of Commerce accepted the request from Defense by return letter (Appendix B) in July 1991.

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[1] The procurement restriction on forgings was established in 1984 by DOD to preserve a domestic forging defense base that was in serious decline. (The ferrous forging market experienced a severe market contraction (over 40 percent down) combined with a rapid increase in imports in the early 1980's). The U.S. Navy and Army, both heavily dependent on forgings, endorsed the restriction for many of their weapon systems. The Air Force declined, citing competitive strength and technical leadership in the aerospace forging sector.

Methodology and Scope

An industry survey questionnaire (Appendix C) was distributed by OIRA in February 1992 to nine firms in the forging industry under mandatory collection authority provided under Section 705 of the DPA. It was determined that a survey of the entire forging sector was unnecessary to obtain the information needed for this assessment. The nine firm sample included a cross section of the industry, representing both ferrous and nonferrous forgings, and impression die and open die forgers. All nine firms responded to the survey. Collectively, they accounted for about 26 percent of forging production in the United States in 1990. The survey was supplemented with a review of the available literature, and conversations with industry experts at the Forging Industry Association and forging companies, forging users and DOD. Reports reviewed for this assessment included:

A Study for the Forging Industry Association to Determine the Most Important Reasons (ranked and weighted) for Shrinking Forging Demand in Each of the Following Areas: Technical Reasons; Economic Reasons; Other Reasons, November 1991, by Maurice L. Smith, MBS Group for the Forging Industry Association.

Aerospace Forging Industry Study, January 1990, by Universal Technology Corporation for the Air Force Systems Command, Aerospace Industrial Modernization Office, Wright-Patterson AFB, OH.

The Impact of Buy American Restrictions Affecting Defense Procurement, May 1989, by the Logistics Management Institute under Contract for the Director, Foreign Contracting, Office of the Deputy Assistant Secretary of Defense for Procurement, Department of Defense.

Forging Industry Leadtimes: An Analysis of Causes for and Solutions to Long Leadtimes for Aerospace Forgings, September 1986, by Stephen F. O'Neill, USAF; thesis presented at the School of Systems and Logistics of the Air Force Institute of Technology, Wright-Patterson AFB, OH.

The Decreasing Capability of the Forging Industry to Meet Future Mobilization Requirements, May 1986, by Charles H. Smith, Jr. of SIFCO Industries, Inc. for Industrial College of the Armed Forces 5th Annual Mobilization Conference.

Competitive Assessment of the U.S. Forging Industry, March 1986, Investigation 332-216, International Trade Commission.

Industrial Capability Analysis of the Aluminum Forgings and Aluminum Extrusions Industries, September 1984, Resource Assessment Division, Office of Industrial Resource Administration, International Trade Administration, Department of Commerce, Washington, D.C.

This national security assessment has five major parts:

Part I provides an overview of the forging industry. Included in Part I is a section describing the publicly available statistical information on forgings collected by the Commerce Department's Bureau of the Census. This is followed by a description of the manufacturing process for forgings. Next is a review of forging operations existent in other industries such as automotive, aircraft engines and hand tools. The forging industry is then compared in size, energy use and other factors with other manufacturing industries. Part I concludes with a discussion regarding encroaching technologies that could threaten to displace forgings in certain applications.

Part II reviews the importance of forgings to defense applications, provides a description of the origin and scope of the 1984 Defense Federal Acquisition Regulation (DFAR) on certain forgings, and provides a forecast of defense expenditures on forgings to 1997.

Part III traces historical trends for the forging industry from 1972-1990. This Part examines the structural changes that occurred in the forging industry in the last decade. Part III also reviews business cycles, shipments, employment, investment, markets and more, relying largely on statistics collected and published by the Department of Commerce's Bureau of the Census.

Part IV summarizes the responses to the OIRA industry survey questionnaire. Included is aggregated information on capacity, production, lead times, employment, investment, research and development, financial performance, and competitiveness.

Part V presents this assessment's findings and recommendations.

PART I - OVERVIEW OF THE FORGING INDUSTRY

Forgings are an intermediate product used widely by original equipment manufacturers (the durable goods sector). Forgings are produced by the plastic deformation (i.e. altered without rupture) of virtually any metal or metal alloy, usually at elevated temperatures. The process occurs by hammering on or squeezing a metal workpiece so that it approaches its maximum theoretical density and the upper limits of the material's potential strength. Forgings are used in high performance, high strength and high reliability applications, where tension, stress, load and human safety are critical considerations. They range in size from less than an ounce to over 100 tons and are found in the machines, vehicles and equipment used to generate our industrial economy. They are also employed in a wide range of demanding environments, including highly corrosive and extreme temperatures and pressures.

Commonly forged products include axles, wheels, crankshafts, connecting rods, flywheels, differentials, shafts, anchor chain, tools and valves. These products and many other forgings are used in passenger cars, trucks, off-highway vehicles, railroads, aircraft and ships. Forgings are also used extensively in power generators, cranes, pumps, material handling equipment, and industrial machinery such as machine tools, and textile, printing, sawing and chemical processing machinery. Very large and heavy forgings include crankshafts and connecting rods used in large marine, locomotive, ordnance, and industrial internal-combustion engines, and in power generating and nuclear facilities. While forgings are most commonly of iron or steel, many aerospace applications use nonferrous metals such as aluminum and titanium for their strength and light weight.

Forgings common in aerospace applications include the structural beams, or 'bones' of the fuselage and tail assembly, wing spar, wing and engine attachments, major elements of the landing gear, and load bearing hinges, such as those on the landing gear doors. In addition, the gas turbine engines utilize forged compressor blades, rings, discs, rotors, shafts, bearings, fuel nozzles, and hot gas manifolds. Forgings also make up numerous parts for helicopters, missiles, expendable and reusable launch vehicles, and the space shuttle. Forgings, while hidden from the public view, make a modern aircraft possible.

The U.S. International Trade Commission's 1986 forging assessment divided the forging market into three principal areas: (1) small to medium sized, low-value forgings produced primarily for the motor vehicle, construction, agricultural, and manufacturing markets; (2)

large, relatively low-value forgings produced for the shipbuilding, rail, and heavy industrial markets; and (3) high-value forgings manufactured for the aerospace and power generating equipment sector. Although there is some overlap in these three sectors as well as additional products/markets that the forging industry supplies, these three market segments represent the majority of the uses for forged products. The principal raw material utilized to produce small to large low-value forgings is steel; whereas aerospace and power-generating equipment forgings use mostly aluminum, titanium, or other lightweight, more exotic metals in the manufacturing process. There is a very small aftermarket, because forgings rarely fail.

A large percentage of total shipments of forged products are used by the motor vehicle and aerospace industries[2]. The trends in forging production, shipments, sales, and profitability tend to follow the economic performance in these two industries. Since some forgers specialize in only one market segment (e.g., automotive, construction, or aerospace), each may follow a somewhat different pattern. For example, forgers that specialized in automotive forgings in the early 1980's were affected by the decrease in demand for autos, trucks, and buses; but forgers that produced primarily for the aerospace industry were able to capitalize on the rapid defense build-up in the early 1980's and on commercial aircraft sale increases in the late 1980's.

INDUSTRY CLASSIFICATION - The forging industry is divided into two sectors under the Standard Industrial Classification System - SIC 3462 Iron and Steel Forgings, and SIC 3463 Nonferrous Forgings[3]. These specific codes were established in 1972, and replaced old SIC codes 3391 (Ferrous Forgings), and 3392 (Nonferrous Forgings). While the old and the new codes encompass the exact same industries, the revision was made to include forgings with other metal forming industries found in the more broadly defined (two digit)

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[2] The majority of automotive forgings are actually classified as automotive parts and difficult to identify as forgings. Similarly, many aerospace forgings are counted statistically as aircraft engine parts, and have lost their identity as forgings.

[3] The Standard Industrial Classification (SIC) is the statistical classification standard for all establishment-based (or plant-based) Federal economic statistics classified by industry. The classification covers the entire range of economic activities and defines industries in accordance with the composition and structure of the economy. It is revised periodically, last in 1987, to reflect the economy's changing industrial organization. The SIC system divides the economy into about 850 industries, of which 459 are in the manufacturing sector.

group, SIC 34 Fabricated Metal Products, that now encompasses 38 four-digit SIC industries[4].

Two basic indicators provided by SIC classification codes are an industry's specialization and coverage ratio (reported every five years in the Census of Manufactures). Specialization refers to an industry's shipments of "primary" products in relation to total shipments of all products by the industry. Thus, the primary (forgings) and secondary (non-forgings) product shipments are the components of total shipments from which a specialization ratio is computed. To be classified in a particular SIC code, an establishment's major product must be the primary product of that SIC industry. The specialization ratio for most industries is over 90 percent.

The specialization ratio of the ferrous forging industry has ranged from 89 to 92 percent since 1972. The nonferrous forging industry's specialization ratio is somewhat lower, ranging from 84 to 87 percent since 1972. (In 1967, under the old SIC it was only 67 percent). If the two industries were combined, their specialization ratio would rise to well above 90 percent because much of their secondary production is the other's primary production.

Coverage represents the primary product shipments made by an industry compared to the total shipments of that primary product by all industries. The coverage ratio for ferrous forgings ranged from only 68 percent in 1972, to 92 percent in 1987. Until the early 1980's, several steel mills had major forging divisions that represented secondary product shipments. These reduced the coverage ratio of the ferrous forging industry in the earlier period. After these operations closed for economic reasons in the late 1970's and early 1980's, the

[4]The Commerce Department's Bureau of the Census collects statistical information under the SIC system annually. Manufacturing information is collected on employment, shipments, wages, production worker hours, value added, investment, inventories, energy use and more. Each five years ending in either a '2' or '7', the Bureau surveys all known producers (over 20 employees) in each industry, and publishes the information in the 'Census of Manufactures'. In the intermittent years, a sample of about 55,000 mostly larger firms is surveyed, who typically represent over 95 percent of an industry's statistical compliment. The intermittent years are published in the 'Survey of Manufactures'. Census information is collected and assembled on an establishment basis. An establishment is an economic unit, generally at a single physical location, where business is conducted or where services or industrial operations are performed, such as a factory, mill, hotel, mine, farm or warehouse.

coverage ratio of ferrous forgings rose. The ratio for nonferrous forgings was only 63 percent in 1972, but rose to 76 percent by 1987. Most of the difference was produced as secondary products by the ferrous forging industry.

FORGING MANUFACTURING PROCESS - The production processes used to produce low value forgings where steel is the primary raw material, and high-value products that use more expensive metals are quite similar, although not totally identical. Aerospace turbines, automotive crankshafts, and many other components may be produced in the same forging facility, utilizing the same hammers or presses. However, while the production processes are similar in many respects, in practice many forging companies specialize in low or high-value forgings. This tendency promotes production efficiency, and supports the very different engineering requirements of the two markets. Moreover, the heat treatments and machining characteristics of the different metals encourage specialization.

The manufacture of forged products is a process whereby metal is shaped under impact or pressure to produce a desired shape with improved mechanical properties. This process is carried out by several basic forging methods (all of which are fundamentally related to hammering and pressing); the choice of method is determined by the quantity of parts to be produced, the characteristics of the material, and the configuration to be formed.

After forging stock (typically bars and billets) arrives at the forge plant, a sample is often sent to the laboratory for examination to ensure proper grain structure, fiber formation, and cleanliness. Stock is then typically cut to lengths of six to eight feet by either shearing or sawing.

Although there have been new developments in cold forging, materials to be forged are typically heated to temperature ranges conducive to plastic deformation. Principal methods of heating stock include electric or fuel-fired furnaces, electrical induction or resistance processes, or special gas burning techniques. The choice of method is often determined by factors such as the forging temperature required for a particular material and the availability of various fuels.

A new set of dies is typically released after die proofs of the final impression have been approved by the customer and the forging engineer. An operations sheet is then issued which describes the sequence of forging operations to be used, recommended stock size, number of pieces on the initial order, and target dates for production. The dies are then installed, heated, and forged with a sample piece of stock. The piece is inspected and checked for defects; if no corrections are necessary, production begins.

In a typical sequence, stock is delivered from the furnace where preliminary hot working proportions the metal. Using the operation of the hammer as an illustration, the stock is hot worked in successive blows, thus forcing the workpiece to flow into and fill the blocking impressions in the dies. Flash is produced and appears as flat, unformed metal around the edge of the product. The exact shape of each product is obtained by the impact of several additional blows of the hammer that force the stock to completely fill every part of the finishing impression. Finally, the flash is removed from the forging with trim dies in a mechanical press or by sawing and grinding.

Depending on customer requirements, many impression die forgings produced by hot forging methods are heat treated after completion of final forging operations and before machining and end use. The range of heat treating facilities includes equipment for normalizing, annealing, hardening with either water or oil quench, and tempering. As a result of the high temperatures required for forging and heat treating, forgings produced from most materials acquire a thin coating of scale; it is generally necessary to remove scale before further processing is performed. Cleaning is typically accomplished by blast cleaning, tumbling, and/or pickling.

After heat treating and cleaning, finishing operations (e.g., coining, and straightening) are performed cold and consist primarily of minor dimensional corrections. Coining is performed in a press whereby extremely close tolerances can be met; manual or mechanized straightening corrects the warping that can occur during trimming, heat treating, cleaning, or handling. Finally, the forging is given a final inspection and prepared for shipment.

Hammer and press forging

Forging hammers have been the most widely used type of equipment for impression die forging. The three basic types of forging hammers operate on the same basic principle- a heavy ram containing the upper die is raised and is driven or allowed to fall on the workpiece which is placed on the bottom die. These hammers are classified by the method used to raise the ram, (e.g., board hammers, air-lift hammers, and steam hammers). Other types include counterblow hammers and helve and trip hammers.

Forging presses comprise the second type of basic forging equipment employed in impression die forging and are classified according to the means used to deliver energy to the workpiece. Mechanical forging presses provide a fixed stroke; hydraulic presses have a variable stroke that can be adjusted to selected speeds, pressures, and dwell times. In contrast to the hammer, the material is typically struck only once in a die impression, thus the design of each impression is critical, and operator skill is less important.

Impression die forging

Impression die forging accounts for the bulk of commercial forging production. In a simple illustration of impression die forging, a round or rectangular workpiece is placed in a lower die, where it is formed into the desired shape as the top and bottom dies are brought together. At the same time, a small portion of material begins to flow outside the die impressions, forming flash. The flash cools quickly and presents resistance to the forming process, thus aiding the flow of the material into parts of the impressions previously unfilled.

Although the terms are often used interchangeably, the method known as closed die forging is a special form of impression die forging that does not depend on the formation of flash to fill the die completely. In closed die forging, the material is shaped in a cavity with virtually no escape of excess material. Closed die forging is very demanding with respect to die design. Since pressing is typically completed in one stroke, careful control of workpiece volume is necessary to achieve complete filling without creating abnormal pressures in the dies from overfilling. In addition, another potential problem is the trapping of gas and lubricant, thus die vents are often necessary to prevent excessive pressure buildup.

Open die forging

Open die forging is differentiated from impression die and closed die forging in that the material is never completely confined as it is being formed by the dies. The open die process is typically associated with large parts such as shafts, sleeves, and disks; however, weights of parts can range from five to 100,000 pounds.

Open die forgings are produced on flat dies, round swaging dies, and V dies; materials range from carbon, alloy, stainless, and tool steels to aluminum, titanium, and nickel-based alloys. As the workpiece is hammered or pressed, it is manipulated between the lower and upper dies until hot working forces the metal to final forged dimensions. Because this is not a precise process, the skill of the forging master in changing the positioning of the workpiece is very important. Furthermore, the workpiece often cools below its hot-working temperature and must be reheated several times before final forged dimensions are achieved.

The workpiece then moves to heat treating and rough machining. At this time, it is important to establish accurate centers for mounting large items in the lathe; i.e., the as-forged shape is never perfectly round nor entirely straight, hence, precise lathe centers aid in achieving accurate, final, rough-machined dimensions.

Precision forging

Precision die forgings are distinguished from other forgings principally by their more detailed geometric features and closer dimensional tolerances. These types of products are most commonly manufactured from light metals, such as aluminum and titanium for aerospace applications in which weight, strength, and special design are important factors as well as price and delivery.

Precision forging produces a finished part that requires little or no preheating, descaling, lubrication, or machining. These advantages must be evaluated with respect to the relative economies of additional operations and tooling, thus precision forging is typically limited to high-quality applications.

Cold forging

Cold forging involves either impression die forging or closed die forging with lubricant and circular dies at room temperature. Carbon and standard alloy steels are most frequently used; parts are generally symmetrical and typically under 25 pounds in weight. Cold forging efficiently uses raw materials by producing precision shapes that require few finishing operations. Closed die impressions and extrusion-type metal flow yield close-tolerance components; furthermore, production rates are very high with long die life.

Ring rolling

Seamless rolled rings are forged in numerous cross-sectional shapes, ranging from several inches to over 20 feet in diameter. Rings can range in weight from one pound to over 20,000 pounds. Rolled rings are typically used in gears, bearings, couplings, rotor spacers, and components for pressure vessels and valves. Seamless rolled rings are produced on different equipment, which is often modified by individual producers to meet customer specifications. Manufacture of a rolled ring requires the production by means of a press or hammer of a doughnut-shaped forging from a cut-to-shape billet. The pancaked stock is then prepunched and preformed, punched and restruck, then placed over the idler roll of the rolling mill. By applying pressure to the wall as the ring rotates, the outside diameter and inside diameter are gradually expanded.

SHIPMENTS BY MANUFACTURING PROCESS - As noted above, forgings can be made by several different methods. Since 1987, the Bureau of the Census has collected and published statistics on an expanded basis that distinguishes between forgings produced by these various methods. This information is displayed on the table on the following page. Note that hot impression die impact forgings are by far the dominant type. This category has ranged from just over 69 percent of total ferrous forging shipments in 1987, to 62.6 percent in 1990. In the nonferrous forging sector, hot impression die forgings exceeded 80 percent each year. In the ferrous forging sector, the second most popular production method is the open die, or 'smith' forging process. In 1990, open die forgings accounted for about 12 percent of total forging shipments. The open die method is often used for large pieces such as ship shafting or large discs used as covers on nuclear reactors. Cold impression die forgings are generally made from softer (low carbon) steels and steel alloys in large volumes and small sizes. Industrial fasteners are commonly cold forged, although they are not statistically included in the forging sector. Cold forgings are heat treated to relieve stresses. Seamless rolled ring forgings account for six to seven percent of the value of forgings.

PRODUCT SHIPMENTS BY FORGING PROCESS, 1987-1990

Forging Process	Value of Product Shipments (million dollars)			
	1987	1988	1989	1990
Ferrous Forgings: Total	2,903.2	3,209.8	3,695.4	3,765.1
Hot impression die impact, press and upset forgings	2,004.7	2,105.4	2,372.2	2,357.4
% hot impression die impact, etc. of Total	69.1	65.6	64.2	62.6
Cold impression die impact, press and upset forgings	189.8	243.0	301.0	293.7
Seamless rolled ring forgings	181.2	228.3	238.6	270.6
Open die or smith forgings	271.2	346.0	397.3	442.1
Other, not specified	255.7	287.1	386.3	401.3
Nonferrous Forgings: Total	1,061.4	1,128.7	1,222.7	1,236.6
Hot impression die impact, press and upset forgings	884.7	949.3	1,031.8	1,001.1
% hot impression die impact, etc. of Total	83.4	84.1	84.4	81.0
Other nonferrous forgings	124.4	125.8	141.3	187.7
Other, not specified	52.3	53.6	49.7	47.9

Source: Bureau of the Census, 1990 Annual Survey of Manufactures, "Value of Product Shipments"

FORGING OPERATIONS IN OTHER INDUSTRIES - Most SIC industry codes are product-based, rather than process-based. Forgings, however, are process based. The forging process, like drilling, milling, boring, or punching, is a generic process used in many metalworking industries, and in some cases - hand tools, valves or auto axles - is a dominant or critical process. Therefore, this can make the forging industry coverage ratios cited above very misleading. Until 1982, the Census Bureau published a special subject series titled 'Selected Metalworking Operations' (MC82-S-8). This report included information on forging (and other) operations in metalworking industries other than the forging industry.

FORGING OPERATIONS IN VARIOUS METALWORKING SECTORS (1982)

SIC Code and Industry	Number of Forging Operations		
	Total	Over 20 employees	Production Workers
3421-Cutlery	20	2	149
3423-Hand and Edge Tools, nec	92	24	1,357
3425-Handsaws, nec	6	1	67
3429-Hardware, nec	22	1	190
3441-Fabricated Structural Metal	21	2	187
3442-Metal Doors, Sash and Trim	11	2	156
3443-Fabricated Plate Work (Boiler Shops)	22	6	339
3446-Architectural Metal Work	78	1	43
3448-Prefabricated Metal Buildings	4	none	12
3449-Miscellaneous Metal Work	2	none	10
3451-Screw Machine Products	3	none	6
3452-Bolts, Nuts, Rivets, and Washers	40	6	505
3494-Values and Pipe Fittings	36	5	565
3498-Fabricated Pipe and Fittings	23	5	290
3499-Fabricated Metal Products, nec	14	4	225
3523-Farm Machinery and Equipment	49	11	686
3524-Lawn and Garden Equipment	89	1	84
3531-Construction Machinery	20	2	230
3532-Mining Machinery	11	none	54
3533-Oil Field Machinery	23	8	1,450
3592-Carburetors, Pistons, Rings, Valves	9	4	233
3599-Machinery, Except Electrical, nec	13	none	30
3714-Motor Vehicle Parts and Accessories	34	11	1,308
3721-Aircraft	5	5	427
3724-Aircraft Engines and Engine Parts	8	4	511
3728-Aircraft Equipment, nec	10	none	58
3731-Ship Building and Repairing	12	2	161
3743-Railroad Equipment	12	3	311
3764-Space Propulsion Units and Parts	1	none	15
Totals:	538	110	9,659

Source: U.S. Department of Commerce, Bureau of the Census, "Selected Metalworking Operations", 1982

The table on the previous page shows that forging operations exist across many metalworking industries as part of the production process[5]. The biggest of these is General Motors' high-volume Saginaw, Michigan axle division, with annual production in the billions of dollars (although not all is forged). In 1987, shipments of 'axles and axle parts' by SIC 3714 Motor Vehicle Parts and Accessories totalled $4.5 billion (not all forged). This is one and a half times that year's total ferrous forgings industry shipments of $3.0 billion.

Other industries' forging operations range from very modest to fully operational forging plants. Taken as a whole, they constitute a shadow industry of the forging sector. The larger operations are often dedicated to a single product line or family of products, in many cases for prompt use by an affiliate or parent firm. In addition to General Motors' facility, other well-known companies that have major forging operations include Ford's Vulcan Forge division in Detroit; Masco's several auto part forging plants between Detroit and Cleveland making piston pins, gear blanks, and other parts; and Caterpillar's track link plant in Peoria, Illinois. In the aerospace area, General Electric has a blade plant for gas turbine engines in Rutland, Vermont, and Pratt and Whitney a blade plant for the same purpose in Columbus, Georgia. These and other companies with major forging operations are able to keep them busy and efficient, and thereby can justify maintaining them on an economic basis.

The existence of these rather narrowly focused, high-volume forging production houses arose out of the unique circumstances of the huge American market, which provided the largest industrial companies the volume to justify making their own forgings. Many of these captive producers have little interest in selling forged products in the custom or merchant markets, or in international trade, although they may sell small amounts to one another, where the buyer requires essentially the same product[6].

Under different circumstances, these large and profitable forging businesses could have provided business opportunities for custom forgers. Instead, captive operations inhibited the emergence of any large dominant custom forging firms that could have developed a global

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[5]1982 data are used here because the publication was discontinued. They are provided to illustrate the importance of the forging process in the making of high performance metal parts throughout metalworking industries. This survey information represents a sample of about half of 1982 forging activity in these sectors.

[6]For example, General Motors sells axles to Ford and others from its Saginaw operations.

perspective. The European and Japanese economies evolved in small national markets with different traditions, where captive operations could not be justified economically and reliance on custom forgers was much greater than in the United States. Today, this historical trend has created a competitive edge for our foreign rivals, because of their greater size and longer term experience in international trade.

INDUSTRY PROFILE - One can also assess the economic condition of the forging industry by comparing it with all other U.S. manufacturing industries. In 1988, a total of 459 manufacturing industries existed at the four-digit SIC level. In terms of industry shipments, ferrous forgings ranked 206 with $3.3 billion among the 459 industries. Nonferrous forgings, with only $1.0 billion in shipments, ranked 379. (Motor vehicles, SIC 3714, ranked first with shipments of $142 billion.) The ranking of shipments is a base from which to compare and measure other parameters. For example, social security, health and other socially related payments for the workforce were $236.5 million for ferrous forgings, and ranked 113 among all industries. This would appear to be in contrast with the shipment rank of 206. When one considers that the industry is heavily unionized and the average age of the workforce is well above average, higher social costs can be expected.

Both the ferrous and nonferrous forging industries are energy intensive by this analysis. Measured as a percent of value added, ferrous forgings energy consumption ranks 45 - in the top ten percent of all manufacturing industries. Nonferrous forgings rank 57. Both industries also have a very low work-in-process (WIP) turnover rate (shipments/work-in-process inventory). The ferrous forging industry turned over its WIP only 9.41 times (once about every 39 days) and ranked 430. Nonferrous forgings WIP turnover was only 4.93 (once every 75 days) and ranked 451. Only eight industries were lower, and these were mostly major defense systems such as aircraft, tanks, missiles, and turbines. The forging industries also ranked high in average wages, payroll to value added, and investment to value added.

One comparison of particular interest is capital intensity where the ferrous forging sector ranked 189 and the nonferrous sector 133. This measure is based on: 1) shipments per employee, 2) investment per employee, 3) investment per value added, 4) value added to shipments, and 5) wages per value added. If the first three parameters are high, and the last two are low, the industry is considered capital intensive, rather than labor intensive.

COMPARATIVE RANKING AMONG 459 INDUSTRIES, 1988

Parameter	Ferrous Forgings		Nonferrous Forgings	
	($000,000s)	Rank	($000,000s)	Rank
Industry Shipments	3,284.6	206	1,029.5	379
Value Added	1,587.8	197	404.0	396
Cost of Materials	1,757.9	196	664.2	341
Social Costs of Workforce	236.5	113	68.4	317
Inventory	711.9	137	323.2	274
Fuel Cost	82.3	43	18.4	185
Electric Cost	84.4	84	19.1	292
Plant Investment	21.5	151	5.8	325
Machinery Investment	83.8	176	27.7	322
Shipments/Employee ($000s)	124.4	205	147.1	146
Investment/Employee ($000s)	4.0	167	4.8	134
	Value	Rank	Value	Rank
Employees (000s)	26.4	193	7.0	406
Production Workers (000s)	19.6	186	5.3	399
Average Wage (dollars/hour)	$12.42	91	13.10	71
Inventory Turnover/to Shipments	4.61	388	3.19	442
Work-in-Process Turnover	9.41	430	4.93	451
Capital Intensity	54.90	189	62.31	133
	Percentage	Rank	Percentage	Rank
% Value Added/Industry Shipments	48.34	282	39.24	377
% Production Workers/Employees	74.24	252	75.71	211
% Payroll to Value Added	47.32	113	55.15	18
% Wages to Value Added	31.67	106	37.62	30
% Fuel to Value Added	5.18	44	4.55	52
% Energy to Value Added	10.50	45	9.28	57
% Investment to Value Added	6.63	131	8.29	72

Source: Bureau of the Census, 1988 Annual Survey of Manufactures, AS-1, 2 and 3

A formula was devised to get a single number between 1-100 for quick comparison. Petroleum refining was found to be the most capital intensive at 97.34, while bookbinding was the lowest at 4.97. The ferrous forging sector was 54.90, and the nonferrous sector 62.31. Many industries have increased in relative capital intensity in recent decades as equipment and machinery improved and capital was substituted for labor. Many passed the forging sectors in the process. Thirty years ago, the forging sectors would have ranked higher on this scale.

ENCROACHING TECHNOLOGIES - An important factor affecting both domestic and foreign forgers is the growth in competition from the casting (or foundry) industry[7]. In marginal applications, a historical tension between the use of castings and forgings has been a very important engineering as well as competitive consideration. Many mechanical components such as certain crank shafts[8] and transmission parts were formerly forged, but are now cast due to lower costs and improvements in casting technology[9]. Ford Motor Company has begun using connecting rods made by the powdered metal forging process Ford began to use powder metal components a few years ago to achieve weight savings and to reduce machining operations. Chrysler plans to use powder metal forged copper-steel connecting rods weighing about 1.5 pounds apiece in its next generation four-cylinder engines due out in 1994. While powder metal is technically classed as a forging process, it cannot achieve the same strength characteristics of conventional forgings. Connecting rods, however, deal with compressive forces (rather than tensile forces) in which the differences are very minor. Thus far, powdered metal applications have been limited to smaller parts made in very large volumes.

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[7]Care must be taken to not overstate this trend. A representative from a major auto parts supplier, said that car companies are just as likely to switch back to forgings in some applications, induced by competitive pressures to improve the reliability and safety of cars.

[8]General Motors elected to cast crankshafts for its passenger cars in the late 1950's. Castings are much less expensive than forgings, and can be strengthened to an extent with the proper use of alloying agents. However, castings still fall far short of the strength and reliability of forgings. Car companies are now switching back to forged crankshafts for newer more powerful small engines that exert greater torque. Larger crankshafts for pick up-trucks and larger vehicles have always been forged.

[9]The ITC reported, for example, that a large Italian forging operation stated lost a major contract in 1984 for a six-cylinder forged crank shaft, and expected shortly thereafter to lose the contract for a large forged eight-cylinder crankshaft to a competing casting foundry.

The drive to reduce weight in motor vehicles and other industrial equipment is increasing. The average use of aluminum in passenger car has increased from about 120 pounds in 1980 to about 150 pounds today. In his aforementioned study, Maurice L. Smith of the MBS Group forecasts that aluminum use will double by 1996, and triple by 1998. This will cause a switch from some ferrous to aluminum forgings, for parts such as wheel spindles and suspension parts. The use of plastics and composites in body and roof panels, fenders, and other areas such as rear leaf springs, have not as yet had a significant impact on forgings.

In aerospace applications, composites have made some inroads into structural parts and the blades in gas turbine engines, although they are considerably more expensive. Currently, light weight, high strength titanium is the metal of choice for the large air compressor blades found in gas turbine engines. These are the first candidates for replacement by carbon fiber composites, which are both stronger and lighter than titanium, and would further reduce the centrifugal forces. In addition, fiber reinforced ceramics and plastics may displace some forgings in the future[10].

In summary, we concur with the MBS Group finding that the displacement of forgings by castings, powder metal parts, stampings and composites will continue on a part-by-part basis as volume requirements shift, price relationships change, and technology advances. The reverse is also occurring in some instances as companies take advantage of the recognized benefits of forgings, replacing, for example, a two piece welded assembly with a single forging.

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[10]The ITC report cited representatives of the largest crankshaft manufacturer in West Germany predicting that ceramics and plastics would make inroads into markets now served by forgings over the next 10 to 20 years.

PART II - DEFENSE IMPORTANCE

FORGING APPLICATIONS IN MILITARY SYSTEMS - Forgings are used extensively in nearly all military weapon systems. Their use is particularly extensive in aircraft of all types. To illustrate this point, the typical Boeing 747 airframe requires 8,400 individual forgings[11]. Each of the four Pratt & Whitney JT9D engines which power the 747 requires approximately 2,500 individual forgings, or another 10,000 forgings in the engines. The landing gear is made up of four individual main struts, and contains 192 forgings for a grand total of about 18,600 forgings to build one operable 747.

Some of these forgings are huge, requiring the largest presses in the United States to produce, while others are tiny (small compressor blades as an example). Some are made from aluminum alloys and some from titanium. Some, of necessity, require substantial machining operations to conform to the final dimensions of the part while others are forged to final shape (precision forged), thus requiring very special skills on the part of the forging producer. Many forgings are produced from steel alloys while the heat resistant super-alloys are essential for others. In other words, the forging facilities necessary to produce the forgings for an aircraft like the Boeing 747 are extremely varied. No one forging facility has the equipment or expertise to produce the many different types of forgings required to build a modern aircraft.

For smaller aircraft, these numbers are less, but are still impressive. A Boeing 727 requires about 10,000 individual forgings, while the smaller 737 requires about 7,000 forgings. The F-15 has approximately 1,700 forgings in the airframe and its components, another 78 in its landing gear, and about 2,500 in each of its two F-100 engines. The typical military helicopter has approximately 350 forgings in the airframe alone.

In short, a strong forging industry is essential to building aircraft. Generally speaking, the larger the aircraft and the more demanding its operational conditions, the more critical the use of forgings. This is because in most instances, the forging process provides components that are stronger and tougher than components produced by other production processes.

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[11]The information on the number of forgings for aircraft and several other weapons systems comes from the aforementioned SIFCO Industries paper by Charles H. Smith, Jr.

The ability of forgings to impart to metals strength and toughness superior to other means of fabrication has made forgings critical to almost every form of military equipment. Among other examples:

1. The M-60 battle tank depends on at least 585 separate forgings at critical points of shock and stress.
2. The M-113 Personnel Carrier depends on at least 250 forgings.
3. The 2-1/2-ton and 5-ton military trucks have 50 and 75 forged components each.
4. 250-pound and 500-pound bombs each contain seven forgings.
5. The majority of 155mm, 75mm, and 3-inch shells and mortar projectiles contain at least two forgings each.

While most forgings are produced by the hot impression die process, the open die process is essential to the production of such items as the huge shafts used in the drive mechanism of various naval vessels, turbine rotors for power plants, gun barrels, breech rings for large artillery, and pressure vessels for nuclear power plants.

THE BIG PRESSES - Another indication of the defense importance of forgings was the construction of the large presses by the U.S. Air Force in 1953. These presses included two 50,000 ton, and two 35,000 ton models that were erected (one of each) at North Grafton, Massachusetts and Cleveland, Ohio. These presses enabled the forging of larger parts that eliminated joints and fasteners, better utilized material, and decreased aircraft weight, all at lower cost. These presses continue today to be the foundation of our commercial and military aerospace forging capabilities.

The North Grafton plant was leased to and operated by Wyman-Gordon, and the Cleveland plant to Alcoa. The companies supplied both commercial and government accounts from the facilities, enabling them to spread fixed costs more widely and reduce prices to the military. Although the Air Force directed rental payments back into facilities maintenance, this amount was insufficient. The plants deteriorated somewhat because of difficulties in appropriating additional funds from the Congress to properly maintain them. When the Reagan Administration came into office, many other government-owned, company-operated facilities were retired or sold to private concerns as a matter of policy. The North Grafton facility was sold to Wyman-Gordon in June 1982 for about $34 million. The Cleveland facility was sold for $15 million to Alcoa.

Both companies continue operating the facilities, and remain major suppliers of defense forgings. The presses are, however, currently underutilized due to diminishing defense markets and difficulties in exporting. The presses are also nearly 40 years old, and require large yearly outlays to maintain. In 1989, one of the lower crossbeams on the 50,000 ton press at Wyman-Gordon cracked, but was back in operation by Spring 1990. The aforementioned Universal Technology Corporation study noted that prior to 1989, when a major component failed on a large press, it was inoperable for over two years and cost $13 million to repair. In today's diminished market, the operating companies are not generating sufficient cash flow to maintain the presses, and it is very possible one or more may be retired.

The two largest hydraulic forging presses in the world are located in Russia. Both are over 80,000 tons. The French company Fortech has the third largest press rated at about 72,000 tons - purchased from the Russian Government around 1977. Ladish company has the world's largest hammer, equivalent to 50,000 tons located in Wisconsin.

THE WATERVLIET ARSENAL - Nearly all large caliber cannon/gun tubes and mortars for DOD are produced by the Army's Watervliet Arsenal in New York state. The arsenal relies on outside suppliers for preforms from which it produces guntube forgings that are then machined into final form. Watervliet purchases 8-inch guntube forgings from outside contractors because its rotary forge cannot handle that size. It also purchases some smaller size guntubes to maintain a "warm" industrial base.

The Watervliet facility was modernized starting in the mid-1970s. The Army's Manufacturing Technology (ManTech) program funded the acquisition and installation at the arsenal of a large rotary forge from the Steyr Company, located in Steyr, Austria for forging guntubes. This enabled higher qualities and lower costs than obtainable from the private sector. Watervliet's modernization continued with Project REARM in the early 1980's, designed to modernize plant and equipment in Army arsenals and ammunition plants. At a cost of $306 million, the Army now possesses a fully modernized guntube facility capable of meeting all the Army's peacetime needs and a large portion of projected wartime requirements. Watervliet became a sole source for large-caliber cannons as the private sector exited the business.

Watervliet proceeded to develop unique manufacturing methods and techniques to produce guntube forgings more efficiently. In fact, the facility became a show piece for foreign visitors, and on several occasions was directed to share some of its technology with allied nations including the United Kingdom, Israel, and South Korea. Management at the arsenal considered the technology transfers against the national interest since, for example, Korea declared its intent to market U.S. designed weapons to other countries. The Congress, also concerned with the idea of transferring this technology, added the Stratton Amendment to the FY82 DOD Appropriations Act (PL 97-114) which stated that:

> Section 782(b). No funds appropriated by this Act may be used for the transfer of a technical data package from any Government-owned and operated defense plant manufacturing large caliber cannons to any foreign government, nor for assisting any such government in producing and defense item currently being manufactured or developed in a United States Government-owned, Government-operated, defense plant manufacturing large caliber cannons.

This restriction has been renewed in subsequent DOD Appropriations Acts.

ESTABLISHMENT OF FORGING BUY AMERICAN POLICY - Forgings have long been recognized as critical to the military capabilities of the United States. It is not surprising the serious deterioration of the ferrous forging sector, along with several other key sectors, in the early 1980's was viewed with concern by the Department of Defense[12]. This was at a time when the United States was rapidly building up its military capabilities in reaction to the Soviet invasion of Afghanistan and the general build-up of Soviet military capabilities that took place in the previous decade. Concern for the defense industrial base resulted in the Office of the Secretary of Defense issuing a policy statement designed to revitalize DOD's Industrial Preparedness Planning program in March 1982. Later that year in July, the President signed National Security Decision Directive 47, which declared that:

> It is the policy of the United States to have a capability to mobilize industry in order to achieve timely and sufficient production of military and essential civilian material needed to prosecute successfully a major military conflict, to lend credibility to national strategic policy, and to respond to national security emergencies.

This directive revitalized the Services' annual production base analyses programs in which the condition of support industries, such as forgings, were reviewed on a regular basis.

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[12]Most of this section is derived from pages B3-1 to B3-19 of the previously mentioned Logistics Management Institute study.

These analyses alerted DOD of the deterioration of the forging industry.

In April 1983, the Deputy Under Secretary of Defense for Research and Engineering (Acquisition Management) made a list of candidate forging items for possible protection under Buy American rules on grounds of mobilization requirements. The list, developed in consultation with industry representatives, focused particularly on forgings being purchased in increasing volumes from foreign sources. The Services reviewed the list and the Army added several additional items. On April 24, 1984 the Under Secretary of Defense for Research and Engineering announced:

> ...(1) that there is a need for immediate action to assure that the attached list of forging items used by defense be procured from U.S. sources, (2) when adequate U.S. supplies of these forgings are not available to meet DOD needs on a timely basis this restriction may be waived (until such supplies become available from U.S. sources) by the contracting officer, (3) that procurements made under this determination are subject to periodic audit by the Defense Contract Audit Agency to avoid possible excessive cost to DOD, and (4) the need to continue or expand these restrictive provisions will be reviewed periodically by the Deputy Under Secretary of Defense (Acquisition Management).

He directed the Services to implement this policy within 30 days[13]. This restriction first came into effect on May 24, 1984 by direction of the Deputy Under Secretary of Defense for Research and Engineering (Acquisition Management)[14]. The U.S. Air Force, while a close observer of the industry, resolved not to include aerospace forgings in the DFARS because this segment of the industry was competitive and technically superior to its foreign rivals, and at the time showed no signs of weakening.

The original list did not include anchor chain, although it was added October 1, 1984. Ship propulsion shafts were initially restricted only if their length was greater than 50 feet. Restricted cannon forgings included breech block forgings, and the restricted tank/automotive

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[13]Soon after, Canada protested exclusion of the Canadian industrial base. The policy was revised by exempting Canadian firms agreeing to become planned producers under the Industrial Preparedness Planning program. Another revision allowed qualifying countries to compete for procurements where they exceeded those required to maintain a mobilization base.

[14]Memorandum for Secretaries of the Military Departments, Subject: "Retention of Critical U.S. Forging Capability Required to Meet National Defense Needs in an Emergency," April 24, 1984.

forgings included sprockets. The length qualification for ship propulsion shafts was removed February 25, 1985, making the restriction apply to all propulsion shafts other than those for service and landing craft. These changes were consolidated in the 1986 edition of the DFARS with a correction notice on August 18, 1986. The wording of the actual DFARS follow below:

Provisions of the Forging DFARS

208.7802 Policy. It has been determined that defense requirements for the forging and welded shipboard anchor chain items listed in 208.7802-1 below must be acquired from domestic sources (United States and Canada) to the maximum extent practical. Accordingly, all acquisitions of these forging items and all acquisitions of items containing these forging and shipboard anchor chain items shall include, except as provided in 208.7803 below, a requirement that such items and forging items incorporated in end items delivered under the contract be of domestic manufacture only. This restriction does not include forgings used for commercial vehicles (such as commercial cars and trucks) or to noncombat support military vehicles.

208.7802-1 List of DOD Forging and Welded Shipboard Anchor Chain Items That Must be Acquired from Domestic Sources (United States and Canada).

Shipboard Forged DiLok and Welded Anchor Chain (smaller than four inches in diameter)
Ship propulsion shafts (excluding service and landing craft shafts)
Periscope tubes
Ring forgings for bull gears greater than 120 inches (ten feet) in diameter
Large caliber, thick walled cannon, 105mm through 8-inch forgings listed below:
Preform forgings
Gun tube forgings
Muzzle brake forgings
Breach ring forgings

60mm and 81mm mortar forgings listed below:
Bipod forgings
Base plate forgings
Body yoke forgings

Small caliber weapons forgings listed below:
Barrel extensions
Bolts
Receivers
Sights/handles, etc.

Tank and automotive forgings listed below:
Turret rings
Road arms
Final drive gears
Shafts
Track shoes
Axle shafts
Flywheels
Connecting rods
Crankshafts
Roadwheels
Spindles
Torsion Bars

PROCEDURES

208.7803 Procedures

(a) The clause set forth at 252.208-7005, Required Sources for Forging and Welded Shipboard Anchor Chain Items, shall be inserted in all contracts except:

(1) when the contracting officer knows that the item being acquired does not contain forging items listed in 208.7802-1;

(2) when purchases are made overseas for overseas use;

(3) if the quantity being acquired is determined to be greater than that required to maintain the U.S. defense mobilization base (provided the quantity above mobilization base needs constitutes an economical buy quantity), such greater quantities will not be subject to the U.S., Canadian restriction and shall be awarded competitively to the maximum practical extent. NATO and other qualifying countries may compete for the excess quantities consistent with Part 225 of this Supplement.

(b) A Canadian firm may bid on and supply any of the restricted items if: (1) it normally produces similar items or it is currently producing the item in support of DOD contracts (as prime or subcontractor); and (2) it agrees to become (upon receiving a contract/order) a planned producer under DOD's Industrial Preparedness Planning (IPP) Program, if it is not already a planned producer for the item.

(c) Subsequent to the award of a contract, the contracting officer may waive the requirements set forth at 252.208-7005, Required Sources for Forging and Welded Shipboard Anchor Chain items. Such waiver may be granted on a case-by-case basis when adequate domestic supplies of listed forging items are not available to meet DOD needs on a timely basis. Also, these waivers will only be granted to the extent and for the period of time necessary to permit the contractor to acquire and use listed forging items of domestic manufacture.

Source: 48 Code of Federal Regulations section 208.7802, 1990

PROJECTED DEFENSE PROCUREMENT OF FORGINGS, 1991-1997 - Future defense demands for forgings are projected by the Defense Economic Impact Modelling System (DEIMS), using the most recent projections of defense outlays. DEIMS is an input-output model of the U.S. economy that traces the flow of materials and intermediate products through several tiers of the supply chain that come together to satisfy defense demands for weapon systems. DEIMS quantifies defense demand at the lower-tier (subcontractor) levels,

Ferrous Forgings: Projected Defense Procurement

Procurement Category	(in millions of dollars)							% Change 1991-1997
	1991	1992	1993	1994	1995	1996	1997	
Total	571	507	452	403	374	360	356	-37.65
Direct	120	116	109	101	94	91	92	-23.33
Indirect	387	331	285	259	247	241	236	-39.22
Foreign Military Sales	64	60	58	43	33	28	28	-34.85
Indirect (by major system):								
Missiles	13	12	12	11	10	10	9	-30.77
Ammunition	7	6	6	5	5	5	4	-42.86
Tanks and Tank Components	23	17	12	9	8	7	6	-73.91
Other Ordnance	10	9	8	8	7	7	7	-30.00
Communication Equipment	18	16	15	14	14	13	13	-27.78
Other Electrical Equipment	5	4	4	4	4	4	4	-20.00
Motor Vehicles	24	21	18	16	16	15	14	-41.67
Aircraft and Parts	68	59	53	50	48	47	47	-30.88
Aircraft Engines and Parts	107	89	75	68	65	65	65	-39.25
Shipbuilding	11	9	8	7	6	6	6	-45.45
Other	101	89	74	67	64	62	61	-39.60

Source: U.S. Department of Defense

and therefore, is used here as an estimate of projected defense related procurement of forgings. While DEIMS is not a perfect replica of the U.S. economy, it is mathematically consistent and provides a degree of objectivity that is not achieved elsewhere. These projections, like any other, are subject to frequent revision.

Between FY1991-FY1997, DEIMS projects a 37.7 percent decline in defense demands for ferrous forgings. The decline is from $571 million in 1991 to $356 million in 1997. Most of this decline is expected to be in indirect demand - shipments by forging companies to prime or major defense subcontractors. Indirect shipments are projected to decline 39.2 percent. Almost half of indirect forging shipments are aerospace related, for missiles, aircraft and parts, and aircraft engines and parts. Tanks and tank components are expected to decline almost 74 percent, while shipbuilding, ammunition and motor vehicles projects declines of over 40 percent.

About 20 percent of defense demands were direct purchases in 1991. This will rise to 25 percent as direct purchases decline at a slower rate (23.3 percent) than the total. Ship shafting and anchor chain are, for example, purchased directly from the forging companies by the U.S. Navy. Foreign military sales (both direct and indirect) are projected to fall almost 35 percent by 1997.

For the nonferrous forging sector, DEIMS predicts a 21.8 percent drop in defense business from $372 million in 1991 to $291 million in 1997. No direct purchases are reported, which means all nonferrous forging procurement is indirect through prime contractors. Almost 60 percent of indirect non-ferrous forging purchases are reported in the major aerospace categories. Ordnance, ammunition and communications equipment constitute another 15 percent. Other (unspecified) is another 20 percent. Shipbuilding, other electrical equipment and motor vehicles are insignificant. Foreign military sales are close to 12 percent of the total. Most of the decline takes place by 1994. Significant declines are projected for aircraft engines and parts (down 28.6 percent), and aircraft and parts (down 19.8 percent).

Only an estimated 22 percent (or $180 million) of total defense demand for forgings (excluding FMS) is actually covered by the DFAR restriction. The DFAR covered the indirect purchase of forgings for tank and tank components, other ordnance, motor vehicles and shipbuilding; and an estimated three-fourths of the direct Defense forging procurement for ship shafting, periscopes, anchor chain, and the Watervliet Arsenal output, among other uses. By 1997, Defense forgings covered by the DFAR are estimated to fall to $144 million (down 20 percent), but to rise to slightly over 24 percent of total procurement.

Nonferrous Forgings: Projected Defense Procurement

Procurement Category	(in millions of dollars)							% Change 1991-1997
	1991	1992	1993	1994	1995	1996	1997	
Total	372	350	327	303	294	290	291	-21.77
Direct	n/a	n/a	n/a	n/a	n/a	n/a	n/a	-
Indirect	329	300	277	267	264	264	267	-18.84
Foreign Military Sales	43	50	50	36	30	26	24	-44.19
Indirect (by major system):								
Missiles	16	16	16	16	15	14	13	-18.75
Ammunition	19	18	16	15	14	14	14	-26.32
Tanks and Tank Components	1	1	1	1	0	0	0	-100
Other Ordnance	17	16	15	15	15	15	16	-5.88
Communication Equipment	18	17	16	15	15	15	15	-16.67
Other Electrical Equipment	2	2	2	2	2	2	2	-
Motor Vehicles	2	2	2	2	2	2	2	-
Aircraft and Parts	106	97	90	87	86	85	85	-19.81
Aircraft Engines and Parts	70	61	53	49	48	49	50	-28.57
Shipbuilding	2	2	2	1	1	1	1	-50.00
Other	76	68	64	64	66	67	69	-9.21

Source: U.S. Department of Defense

U.S. NAVY CONCERNS - The NAVSEA Shipbuilding Support Office in Philadelphia monitors the Navy's interests in the DFAR. The office reports that one U.S. and one Canadian firm supply anchor chain, and two U.S. firms supply most of the ship shafting. Several additional suppliers round out the entire vendor list. The capabilities of each supplier differ to the extent that no single firm could supply all the Navy's requirements. While, no forging supplier has left the defense business during the past five years, much of the business would go to offshore if the restriction were lifted, thereby placing some of the domestic vendors at risk. Many nations subsidize commercial ship construction, as did the United States until 1984, which helped sustain a domestic forging base. Since then the domestic commercial market for these types of forgings has declined sharply and almost become non-existent. At least one of the affected firms has increased exports, but exports may not be a viable option for all firms.

The following table is based on latest budget projections of new ship construction starts from FY1992 to FY1997.

PROJECTED NEW SHIP CONSTRUCTION

New Construction	FY-92	FY-93	FY-94	FY-95	FY-96	FY-97	Total
Aircraft Carrier, Nuclear	-	-	-	1	-	-	1
Guided Missile Destroyer	5	4	3	4	4	4	24
Amphibious Assault Ship, Multi-purpose	-	-	-	-	1	-	1
Amphibious Assault Ship, Dock Landing	-	-	-	1	-	1	2
Mine Hunter, Coastal	3	2	-	-	-	-	5
Mine Hunter, Coastal Variant	-	-	-	1	-	2	3
Repair Ship,Experimental	-	-	-	-	1	-	1
Ocean Surveillance	1	-	1	2	-	1	5
Fast Combat Support Ship	1	-	-	-	-	-	1
Oceanographic Survey	2	-	2	-	-	-	4
Landing Craft, Air Cushion	*12	-	-	-	-	-	*12
Total	12	6	6	9	6	8	47

* Proposed, not confirmed

Source: NAVSEA Shipbuilding Support Office

U.S. ARMY CONCERNS - The U.S. Army, Tank and Automotive Command (TACOM) monitors the forging restriction for tank and other combat vehicle forgings. TACOM reports that a number of forging companies have left the defense market, in some cases because the firm went out of business. The command also notes that several restricted items have a single supplier, and at least one of these is having financial difficulties. The commercial markets for the restricted items are dominated by foreign sourced forgings. Inquiries from prime contractors interested in using foreign firms, and from foreign firms directly are received on an occasional basis. TACOM anticipates that if the restriction were lifted, foreign sourced forgings would gradually displace many domestic suppliers, primarily due to lower prices. At least one supplier to TACOM that purchases rough forgings and then machine finishes them in-house would solicit bids from foreign forging suppliers if given the opportunity. A second supplier would shift some purchases of rough forgings to a foreign affiliate if the restriction were lifted. A third major supplier said that it is a buyer's market, and that U.S. prices are competitive. This supplier added that removal of the restriction would not force his firm to use foreign sourced forgings at this time.

PART III - HISTORICAL TRENDS

This section traces major economic trends in the ferrous and nonferrous forging industries for the period 1972-1990. The section begins by examining changes in the structure of the forging industry since 1978, by looking at the number and size of operating establishments in the industry, and industry concentration ratios from 1972-1987. This is followed by a review of business cycles, shipments, employment, investment, productivity, major end-markets, inventory turnover, and energy, labor and material costs[15].

[1]FORGING ESTABLISHMENTS - The number of establishments that comprise the two forging industries is tallied yearly in the Census publication, "County Business Patterns". The information in the publication is computed from Internal Revenue Service source data on employment and SIC classifications (theoretically) available for every establishment in the country. The number of establishments are displayed for each of several employment size groups ranging from '1-4' through 'over 1000', and are available at the county, state and national level. The total number of employees and annual payroll are also provided.

Based on the 'County Business Patterns' information from 1978 through 1989, the number of ferrous forging establishments (20 and over employees)[16] peaked at 255 in 1980, dropped sharply to 208 by 1983, rallied back to 227 in 1985, and than fell to 202 in 1987, down over 20 percent from 1980. By 1989, the count rose modestly to 214. Although this data is not yet available for 1990 or 1991, we expect a modest drop in ferrous forging establishments based on employment declines reported by the Department of Labor (see Appendix E). The

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[15]Shipments and investment for both ferrous and nonferrous forgings were converted to constant 1990 dollars using the price index developed by the Department of Commerce's Bureau of Economic Analysis.

[16]In some years more than half the number of establishments listed under forgings have fewer than 20 employees. Typically, data for over 80 percent of these small establishments are estimates. Many are misclassified, and over time can give a very misleading trend. However, while these small establishments may represent a very high percentage of the total establishment count, their shipment total is only two to four percent of total shipments. For purposes of this assessment, the under 20 employee establishments are omitted.

FORGING PLANTS, 20 AND MORE EMPLOYEES (1978-1989)

Year	Forging Metal	Number of Plants	Number of Plants by Employment Range					
			20-49	50-99	100-249	250-499	500-999	1000 or more
1978	Ferrous	234	74	61	60	26	9	4
	Nonferrous	39	11	10	12	2	2	2
1979	Ferrous	250	78	68	57	32	12	3
	Nonferrous	32	11	3	13	2	1	2
1980	Ferrous	255	92	56	69	25	10	3
	Nonferrous	36	12	5	13	3	1	2
1981	Ferrous	250	93	59	63	23	11	1
	Nonferrous	35	11	4	13	4	1	2
1982	Ferrous	229	76	57	66	25	4	1
	Nonferrous	43	12	7	15	4	3	2
1983	Ferrous	208	86	53	50	14	4	1
	Nonferrous	48	20	8	11	5	3	1
1984	Ferrous	217	92	49	53	19	3	1
	Nonferrous	45	14	11	12	4	3	1
1985	Ferrous	227	96	55	55	17	1	3
	Nonferrous	42	11	10	13	5	2	1
1986	Ferrous	210	87	46	54	19	3	1
	Nonferrous	40	9	11	13	4	2	1
1987	Ferrous	202	79	52	54	11	5	1
	Nonferrous	43	11	11	16	2	2	1
1988	Ferrous	202	72	50	60	15	3	2
	Nonferrous	42	12	11	14	3	1	1
1989	Ferrous	214	80	49	67	13	3	2
	Nonferrous	45	13	13	13	4	-	2

Source: U.S. Department of Commerce, Bureau of the Census, County Business Patterns, U.S. Summaries, 1978-1989 nonferrous forging sector peaked in 1983 at 48 establishments in conjunction with the defense buildup, a 50 percent increase over 1979. This number fell to 40 in 1986, and then rose to 45 by 1989. As in ferrous forgings, we expect to find that the total number of non-ferrous forging establishments has dropped since 1989.

The number of plants over 250 employees in the ferrous forging sector dropped sharply since the late 1970s. In 1979, 47 plants were recorded with over 250 employees. By 1989, only 18 plants in this category remained. This decline illustrates the fragmentation of the industry, as well as the loss of market share in high volume forging applications to imports which are normally supplied by larger plants.

In other defense critical metalworking industries, such as bearings, gears, and fasteners' this same phenomenon has been observed, and the underlying causes here again are the same. The deep recession of the early 1980s greatly shrank forging end-user markets, especially in the durable goods sector where output for some industries dropped over 50 percent. This weakened many firms as evidenced by lower profitability and employment, and many companies have not yet fully recovered. This was combined with an over-valued dollar in the early 1980s that limited export opportunities, while making imports more attractive.

Forging imports have 'cherry picked' (i.e., concentrated thus far on the most lucrative market niches). This strategy weakens the competitiveness of an industry beyond what import penetration numbers alone indicate, by focusing on the largest customers, highest volumes, and most profitable orders. Second and third level customers cannot be supplied as efficiently either by domestic or foreign firms because they lack the purchase volumes of first level customers. It is also more difficult to supply these accounts from overseas because transportation, insurance, and transaction costs are spread over fewer units. However, the threat of switching to a foreign supplier by second and third level forging end-users drives down prices for domestic producers. Some domestic forging firms are reportedly specializing in narrow product lines to reduce their costs and maintain profitability.

The situation in the nonferrous forgings area is very different, although this may not hold in the future. The market for nonferrous forgings has in some years been more than half defense related, and is almost totally a high value-low volume business. Larger establishments, such as Cameron, Alcoa and Wyman-Gordon have survived, and are internationally competitive. The number of establishments with over 250 employee in the nonferrous forging sector peaked in 1982 and 1983 at nine, decreased to only five in 1987 and 1988, and than rose to six in 1989. The continued existence of these firms in the face of declining defense expenditures and the increasing size of the foreign aerospace market, depends on boosting exports, as many firms are attempting.

CONCENTRATION RATIOS - As further evidence of the fragmentation of the industry, the market concentration of companies in the ferrous forging area has declined rather dramatically. The market share in terms of shipments made by the largest four firms in the ferrous forging industry fell from 29 percent in 1972, to 22 percent in 1987. At the eight largest company level, the share slipped from 40 to 32 percent, and for the top 20 companies, it dropped from 57 to 47 percent during the same period.

CONCENTRATION RATIOS IN THE FORGING SECTOR, 1972-1987

Year		Total Shipments (in millions of constant 1990 $)	Percent of Shipments Accounted for by			
			4 largest companies	8 largest companies	20 largest companies	50 largest companies
1987	ferrous	$3,258.9	22	32	47	70
	nonferrous	1,191.4	60	73	91	99+
1982	ferrous	$3,444.1	24	31	47	70
	nonferrous	1,319.2	58	75	91	99+
1977	ferrous	$5,279.9	25	34	51	74
	nonferrous	961.8	77	85	97	100
1972	ferrous	$5,361.9	29	40	57	79
	nonferrous	957.4	71	81	96	100

Source: U.S. Department of Commerce, Bureau of the Census, "Concentration Ratios in Manufacturing"

However, an important qualification makes the decline in these numbers far more extreme than they appear. The shipment total (in constant 1990 dollars) declined by over 39 percent from 1972 to 1987, which means the latest ratios are measured against a much smaller base. The average shipments of the top four firms in 1987 was only $179.2 million in constant

1990 dollars, less than half the 1972 figure of $388.7 million. Further, this concentration excludes imports which held a significantly higher share of the U.S. market in 1987, than in 1972.

Another measure of the concentration in an industry is the Herfindahl-Hirshmann Index[17] (HHI). This indicator, while only available for 1982 and 1987, also shows a decline. The HHI was 227 in 1982, and 193 in 1987, indicating that the largest company probably has less than ten percent of the market.

The nonferrous forging industry's concentration ratio has also declined, although the shipment base on which it is measured has increased. From 1972 to 1987, the top 4-firm ratio fell from 71 to 60 percent, reaching a high of 77 percent in 1977. The eight and 20 company levels also declined, from 81 to 73 percent, and from 97 to 91 percent. The average shipment size of the four largest firms was $178.7 million, about the same as ferrous forgings. The HHI index was 1503 in 1987, up from 1291 in 1982 over a shipment base only a third that of ferrous forgings.

Some firms in both the ferrous and nonferrous sectors are trying to increase efficiency and reduce costs by focusing on a narrower product range. This could also narrow their market opportunities and customer base, and likely increase the volatility of year-to-year sales. However, in the longer run, their smaller size and greater market volatility may reduce both investment, and research and development spending, and gradually undermine overall competitiveness.

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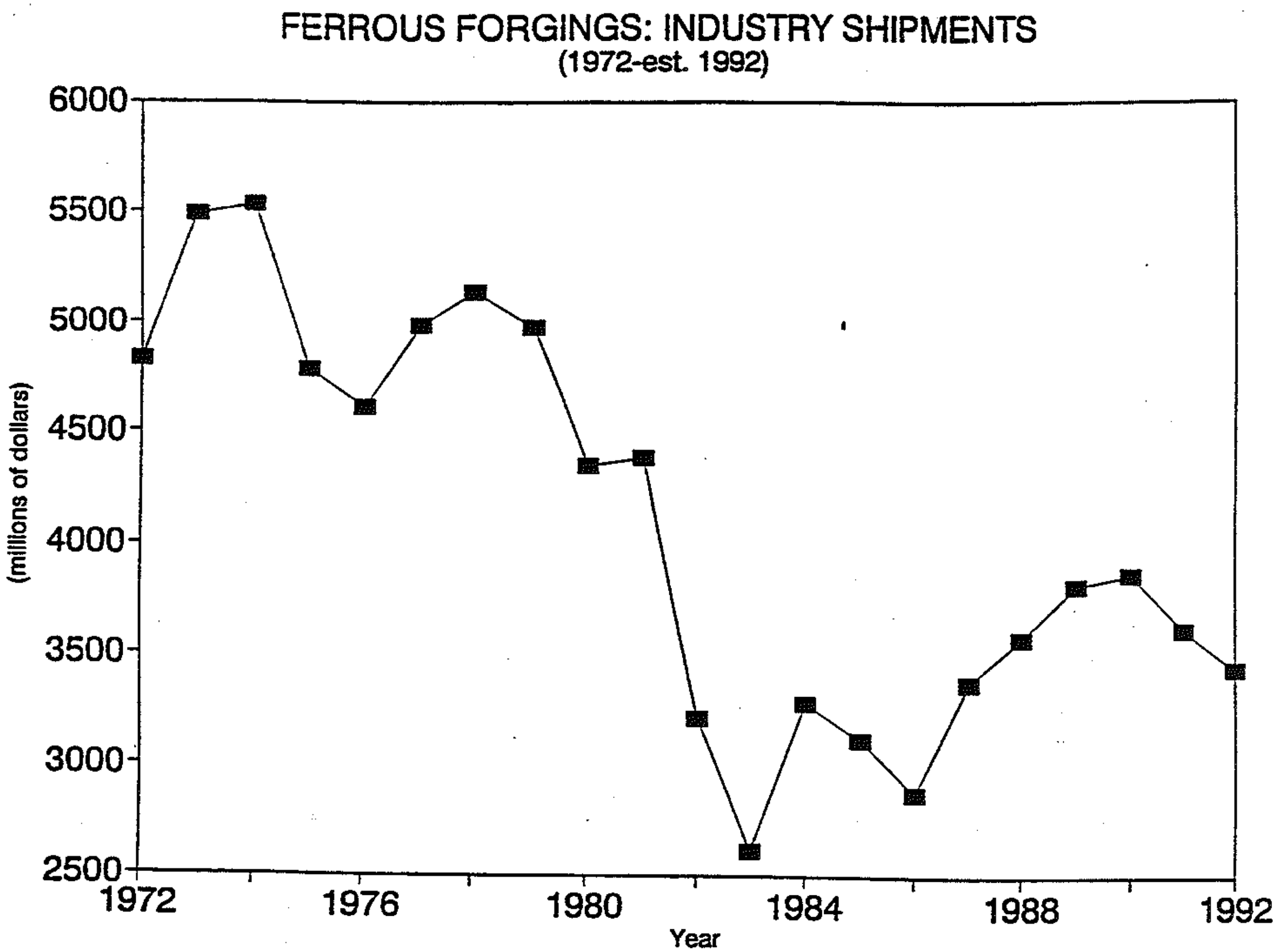
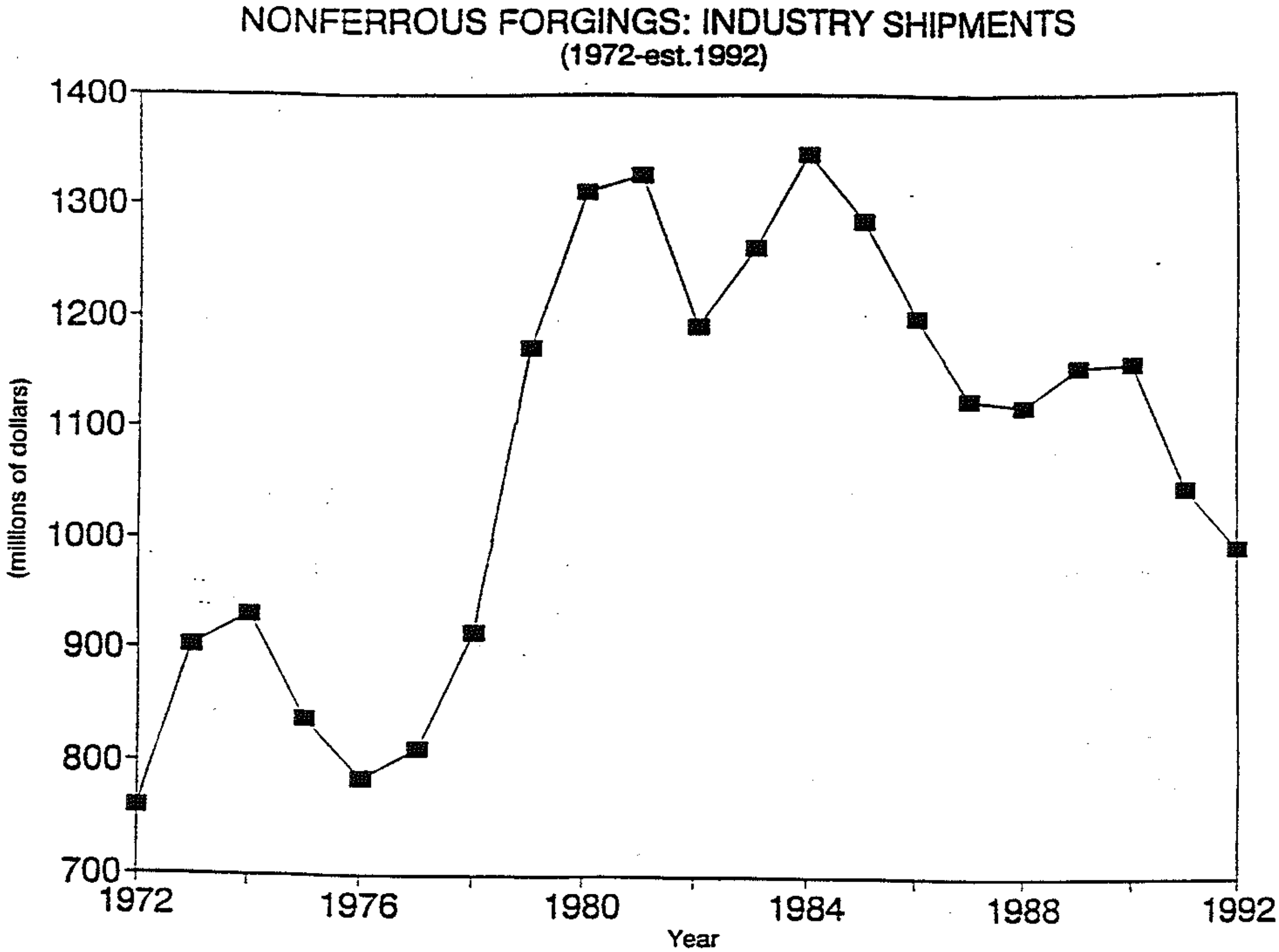
[17]The Herfindahl-Hirschman Index (HHI) provides additional insight into the degree of concentration in an industry. The HHI is calculated by squaring the market shares of the top 50 companies, and summing the total. If each of the top 50 companies accounted for 2 percentage points of the 100 percent, the index would be 200 (2 x 2 x 50). If the top company accounted for 100 percent, than the index would be 10,000 (100 x 100 x 1).



Source: Bureau of the Census, Census and Annual Surveys of Manufactures.

BUSINESS CYCLES - Business cycles are the ups and downs of total shipments over time. A complete cycle is measured from a shipment peak to peak, or trough to trough. The ferrous forging industry experienced five such business cycles during the 1972-1990 period,



Source: Bureau of the Census, Census and Annual Surveys of Manufacturers

or about one every four years on average[18]. The industry reached shipment peaks in 1974, 1978, 1981, 1984, and 1990. Each successive peak was lower than the previous one until

[18]The ferrous forging market is also very volatile on an annual basis, mirroring the movements of the durable goods sector. The observed year-to-year changes in ferrous forging shipment totals averaged 9.68 percent (plus or minus) from each previous year. This included eight down years, and 10 up years. Four consecutive up years came at the end of the period. The maximum yearly change came in 1982 when shipments fell 26.9 percent from 1981 shipments. The highest yearly gain occurred in 1984, when shipments rose 25.6 percent.

1976, 1980, 1983, and 1986. The first three bottoms were also successively lower, before the 1986 total showed a 10 percent improvement. The severest contraction occurred between the 1981 peak and 1983 trough, when shipments fell more than 40 percent. This contraction was made worse by the influx of cheaper imported product at a time when the dollar was overvalued on international exchange markets. Available data from the Forging Industry Association indicate 1991 shipments (in nominal dollars) will decline 6.47 percent, and based on the first 4 months of 1992, Department of Labor's employment numbers indicate the slump may deepen by another 5.0 percent in 1992.

The nonferrous forging industry, reflecting movements in the aerospace and defense markets, experienced four business cycles during this period with shipment peaks in 1974, 1981, 1984, and 1990, or about one every 5 years. Each successive peak was higher until 1984. The 1990 peak was down almost 14 percent. The bottoms of these cycles were reached in 1976, 1982, and 1988. The second trough of 1982 was higher than both the first and the last one of 1988. The 1988 low was down only six percent from the 1982 low. A fairly sharp downturn is estimated for 1991 and 1992.[19]

SHIPMENTS, EMPLOYMENT, PRODUCTIVITY AND INVESTMENT

<u>Ferrous Forgings</u> - Ferrous forging shipments showed a downward trend through most of the 1972-1990 period, although 1990 was the culmination of 4 straight years of rather sluggish growth. Like the rest of the economy, the forging industry experienced several major external shocks during this period beginning with the energy crisis of 1973-74; soaring price inflation in the late 1970's accompanied by extraordinarily high interest rates; a second energy shock and redoubling of energy prices in 1979-1980; and a severely depressed economy in the early 1980's, especially in the durable goods sector. The anti-inflation battle

[19]The yearly volatility of the market for nonferrous forging shipment totals has been somewhat less than for ferrous forgings. For the 18 available observations, the magnitude averaged 7.94 percent. This included 7 down years, and 11 up years. Two consecutive up years ended in 1990 the period, driven by an increase in commercial aircraft orders, and working down backlogs of defense orders. The most extreme yearly change came in 1982 when shipments fell 23 percent. The greatest yearly gain occurred in 1984, when shipments rose 20 percent.

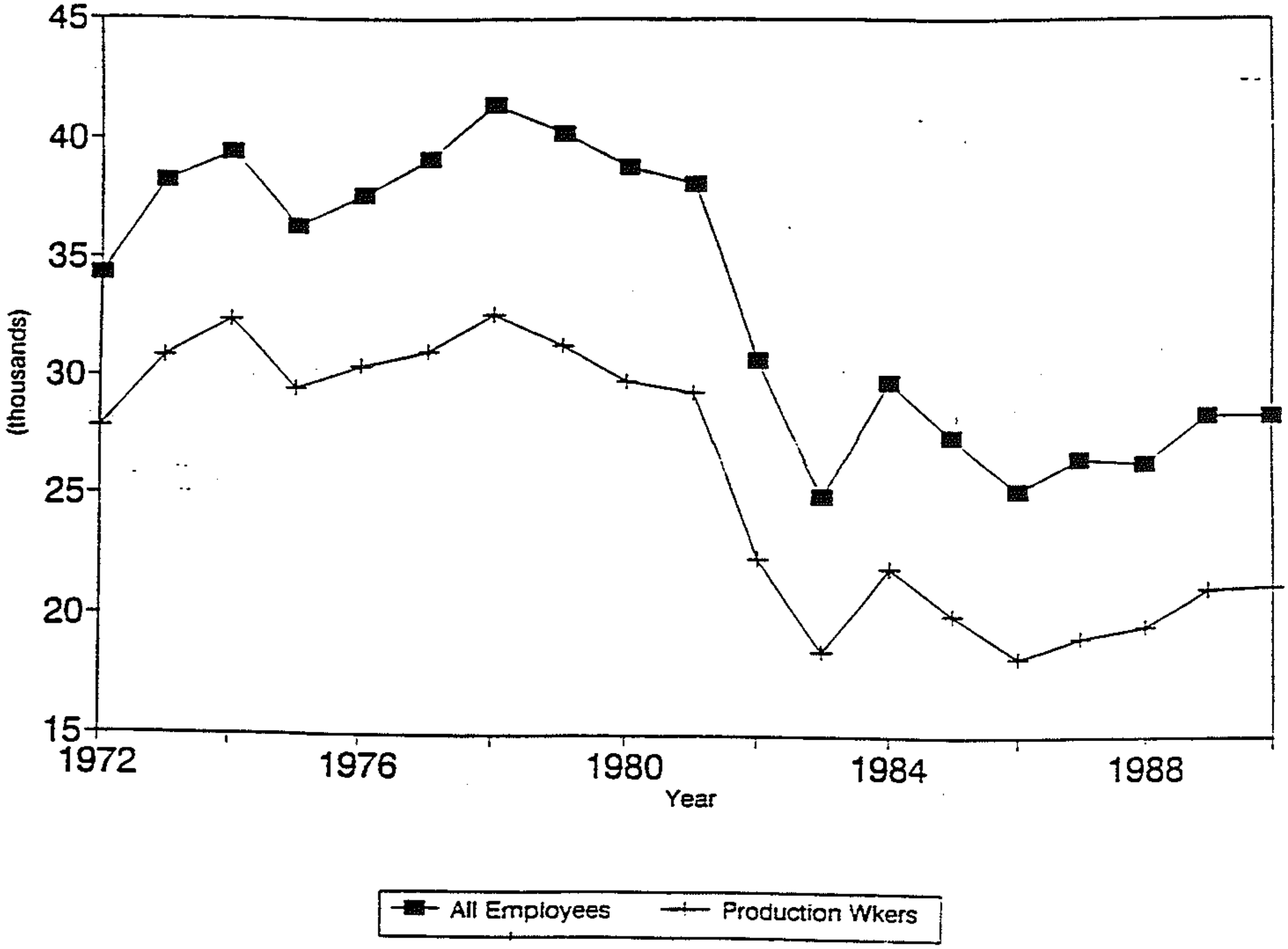
staged by the Federal Reserve beginning in 1979, precipitated the economic downturn and the overvalued dollar that led to an influx of imports of a wide range of products. Imports affected both forgings and forging end-markets. To add to these economic problems, the forging sector also saw more stringent requirements implemented under environmental protection laws and by the Office of Safety and Health Administration.

In this business climate, shipments of ferrous forgings attained their highest level of $5.5 billion (in constant 1990 dollars) in 1974, and recorded their lowest of only $2.6 billion in 1983. Taken in five year increments, shipments averaged $5.0 billion from 1972-1976, then dropped by 5.6 percent during the next five years. In the 1982-1986 period, shipments fell a dramatic 36.7 percent to an average of only $3.0 billion. More than 50 plants closed during this contraction, and almost 13,000 jobs were lost. During the final four years, 1987-1990, average shipments rose 21.1 percent. However, this average remained nearly 28 percent below the average for the 1972-76 period.

In 1991 and the first half of 1992, conditions worsened as shipments fell to an estimated $3.6 billion in 1991, and an annualized rate of $3.4 billion in 1992. Further, at least 110 firms have closed since the late 1970s. In 1992, additional firms such as Edgewater Steel in Oakmont, Pennsylvania (a producer of railroad wheels and seamless rolled rings for motors and antifriction bearings), and Pittsburgh Forgings Company (an employee owned forgings and parts maker in Coraopolis, Pennsylvania) filed for Chapter 11 bankruptcy.

Employment in the ferrous forging industry has also experienced a down trend. During the first five years (1972-1976), employment averaged 37.2 thousand, than rose over 6 percent to 39.5 thousand in the second period. Between 1982-1986, average employment fell by 30.1 percent to only 27.6 thousand. In the last four year period, despite the 21 percent increase in shipments, average employment dropped very slightly to 27.5 thousand. The highest level of total employment was 41.4 thousand in 1978. Production workers rose slightly from an average of 30.2 thousand in the first period to 30.8 in the second, but than fell to 20.3 thousand during the latter two periods, off by 34.2 percent. Peak employment of production workers was also attained in 1978, at 32.6 thousand.

FERROUS FORGINGS: EMPLOYMENT
(1972-1990)



Source: Bureau of the Census, Census and Annual Surveys of Manufactures

Investment in new plant and capital equipment by the ferrous forging industry as measured in constant dollars has also declined. New investment ranged from a high of $242.8 million in 1977, to only $82.1 million in 1986. Between 1972-1976, investment averaged $152.5 million, which was 3.0 percent of shipments. Investment then climbed an average 37 percent during the next five-year period, as average investment reached $208.7 million or four percent of shipments. Then, as the forging market rapidly contracted, investment decreased by half during the five years ending in 1986, to an average of only $110.4 million, or 3.7 percent of shipments. Investment rose modestly to an average of $128 million during the latest four years. However, investment as a percentage of shipments dropped slightly to

PART IV- SURVEY RESULTS

Nine forging companies were sent a survey questionnaire to gather information for this assessment. The firms included representatives of both the ferrous and nonferrous forging sectors, and each surveyed firm had more than 150 employees. In 1990, the surveyed group reported shipments of $1.2 billion. This represented about one fourth of total ferrous and nonferrous industry shipments of $4.8 billion reported by the Bureau of the Census. The nine firms reported 8.8 thousand employees compared with 35.6 thousand for the entire industry in 1990, also about one-fourth of the industry's total.

All information presented in this section is taken from the surveys unless noted otherwise, and is presented in aggregate form to protect business proprietary information of individual firms. A copy of the survey instrument is contained in Appendix C.

FORGING CAPACITY - As shown on the following table, the surveyed firms operated at only 50.8 percent of their practical capacity in 1991, with reported shipments of $1.1 billion. Shipments were down almost 14 percent from 1990. Defense shipments totalled $283.4 million, or slightly more than a quarter of total 1991 shipments. For individual firms,

Forging Shipments (in $000s)		Practical Capacity (in $000s)	% Capacity Utilization		Ramp-Up Time (in months)		Workforce Required at Capacity	
1990	1991		Avg.	Range	Avg.	Range	Number	% Increase
$1,241,571	$1,068,637	$2,101,600	50.8	37-71	7.6	3-18	10,065	79.4
to Defense	$283,380							

Source: U.S. Dept. of Commerce, OIRA Industry Survey

defense shipments ranged from 4.25 to 60 percent of total forging business. Reported "ramp-up" time (i.e., the time it takes to reach capacity production levels) averaged 7.6 months, although this estimate varied widely among firms; the shortest period being only 3 months and the longest a year and a half. The two firms with the smallest defense shares also had the shortest ramp-up periods. The firms reported that 10,065 production workers would be required to operate at capacity production levels, an increase of 4,456 (80) above the firms' 1991 employment.

PRODUCTION EXPANSION BOTTLENECKS - As a result of today's depressed business climate, expected difficulties in reaching capacity production levels are mostly associated with labor (ie. most firms have unused capacity). In an improved market situation, labor constraints may not be the pacing concern, as potential shortages in other areas such as die making or materials availability become more pronounced. However, as shown on the table below, the need for more people was cited 13 times by the companies in identifying their three major constraints or bottlenecks to expanding production. The low rate of capacity utilization, and the continued decline in employment in 1991, have aggravated this problem and left many companies lacking sufficient skilled labor.

AREAS REPORTED AS BOTTLENECKS TO ACHIEVING CAPACITY PRODUCTION LEVEL

Bottleneck Area	Ranked Bottlenecks to Ramping Up to Practical Capacity: Number of times mentioned as...		
	bottleneck #1	bottleneck #2	bottleneck #3
Forging Metals	none	none	none
Design/Engineering	2	none	2
Dies	3	none	1
Heat Treatments	1	1	2
Forging Equipment	none	none	none
Testing	none	1	none
Labor	4	7	2
Other*	1	1	none

* Other includes an electric furnace in need of repair and the reactivation of a large machine tool

Source: U.S. Dept. of Commerce, OIRA Industry Survey

The occupation titles that some of the firms reported they would need to reach capacity production included the following:

Bottleneck #1	Bottleneck #2	Bottleneck #3
Press Operators	Inspectors	Sonic Technicians
Forgers	Die Sinkers	Supervisors
Machinists	Forgers	
Skilled Labor	Heat Treaters	
	Machinists	

The previously mentioned report on forging industry leadtimes by Air Force Captain O'Neill stated that the average age of the labor force was increasing as a result of the major shrinkage in employment in the early 1980's. This came about as younger, less senior workers are normally laid-off first. The situation has not improved. It takes six months to a year to train new workers to a level of proficiency in less skilled jobs, and years of on the job training and experience to become proficient at some of the more demanding forging industry jobs. The aging of the workforce could easily hinder the industry's ability to respond to future surge situations.

In addition to the labor constraints, the forging operations of die making, heat treatments, and design and engineering were each mentioned four times, and testing was cited once. One company that identified heat treatments as a bottleneck, added the detail that a large furnace required certification. In the category of "Other Bottlenecks", one firm reported that a large electric furnace was in need of repair, and another stated that a large machine tool would require reactivation. In addition, with respect to labor concerns, a firm reported that a strike by the blacksmith's union interrupted operations several years ago.

LEAD TIMES - Lead times for the forging group were reported for new (first time) business, and for repeat business. It should be noted that these lead times are realistic under present conditions, but would increase, in some cases dramatically, if business were better. In a surge situation, as in the past, forgings would be pacing items for many weapon systems.

For new forging business, the average reported lead time was 39.3 weeks, with a range of nine to 52 weeks. This is in contrast to an average of 15.4 weeks for repeat business, and a range of seven to 34 weeks. Lead times for new business are longer because front-end operations - design and engineering of the part, selection and purchase of materials, and tool and die preparation - must be done from scratch and these operations can consume a great deal of time. However, once these tasks are accomplished, repeat business can be handled on a faster cycle, although some firms reported otherwise, primarily in the materials purchasing area or tool making, or when repeat business is more than anticipated.

The design and engineering operations for new business can take from two weeks to six months, depending on the complexity of the shape, the forging material, the die design and material, and the determination of cost and producibility of the forging. Materials purchasing usually comes near the end of the design and engineering cycle. Material lead times depend very much on availability of the metal and on the capacity and scheduling of the specialty metal producer from whom the metal is purchased. For some very important metals such as chromium and cobalt, there has been a well-documented history of problems. One firm reported shortages of nickel and chromium during the late 1980s. With no adequate substitute, nothing could be done except waiting for the situation to improve. Another firm reported a shortage of cobalt because of instability in Zaire, the metal's major source. This affected production of Waspaloy, a cobalt derived superalloy. The firm remelted machining chips to make its own Waspaloy until the situation improved.

Tool preparation involves die making and obtaining other cutting tools and fixtures used in the forging process. The design of forging dies and selection of die materials involves considerable experience and can be very costly if done incorrectly. Dies must possess both static and impact strength, and be resistant to abrasion and heat cracks. They must also be wear resistent and economical. Open die forging is done with a flat or slightly curved die, which while meeting the above criteria, is simpler to make than impression dies. Thus, open dies do not present as many problems as impression dies. Open die forgings represent about ten percent of iron and steel forgings, and less than five percent of nonferrous forgings. Larger dies, whether impression or open, take longer to obtain than smaller dies. Surveyed firms report it takes an average of 10.3 weeks to prepare tooling for new business, with a range of one to 14 weeks. Some of this time overlaps with the purchasing of materials. Tool preparation is considerably shorter for repeat orders, averaging only 1.8 weeks, with a maximum reported period of one month. Forging dies would quickly become a problem should demand exceed available capacity.

Production scheduling and queue time (i.e., waiting in line for processing) are very minor contributors to lead time. The average queue time was reported as only 2.8 weeks for new business, and 2.5 weeks for repeat business. Queue time, however, will rise rapidly with increases in business, and has been known to extend over a year at some forging plants. This is because the forging process has a "speed limit", or capacity constraint in the work-in-process area.

FORGING LEAD TIMES; ITEMIZED

Forging Operations	New Business (in weeks)			Repeat Business (in weeks)		
	Itemized		Cumulative Average	Itemized		Cumulative Average
	Average	Range		Average	Range	
Design and Engineering	12.3	2-24	12.3			
Materials and Purchasing	10.9	2-16	20.4			
Tool Preparation	10.3	1-14	25.9	1.8	0-4	2.38
Production Scheduling	3.9	0-8	26.9	.9	0-3	3.11
Queue Time	2.8	0-4	29.2	2.5	0-10	6.0
In-Process Time	9.0	1-24	38.1	8.3	1-24	14.2
Packaging and Delivery	1.2	0-2	39.3	1.2	0-2	15.4

Source: U.S. Dept. of Commerce, OIRA Industry Survey

The "in-process" operations at forging plants involve varying amounts of heat treating, machining, and forging, and usually are a major contributor to long lead times. In-process time is difficult to shorten because of technical aspects of the production process, although efforts are being made to do so with CNC machines, improved systems integration and other technologies. In-process time is similar for both new and repeat business, at about eight or nine weeks on average. Importantly, larger forgings take longer than smaller forgings, and low production volumes (because of more frequent equipment change overs and other variations) take longer than high production volume forgings (of a like weight and material). For some larger forged parts the finish machining alone may take 200 or more hours. The in-process lead time varied from one week for a high volume single product line producer to almost half a year for a very large forging producer.

EMPLOYMENT - The surveyed companies reported total employment of 7,804 employees in 1991, 14 percent below their 1987 total. Most of the decline occurred between 1990 and

EMPLOYMENT
(1987-1991)

Job Category	1987	1988	1989	1990	1991
Scientists and Engineers	343	354	367	354	338
Production Workers	6,747	6,746	6,733	6,514	5,609
Administrative and Other	1,984	1,937	1,957	1,924	1,857
Total Employment	9,074	9,027	9,057	8,792	7,804
# of firms reporting employment declines from previous year	-	4	3	6	7
Persons engaged in R&D included in above figures	70	69	69	65	58

Source: U.S. Dept. of Commerce, OIRA Industry Survey

1991, when employment dropped over 11 percent. However, two of the nine companies reported gains in employment over the five year period. The number of production workers declined almost 17 percent over the period to 5,609 in 1991. Again, most of this occurred between 1990 and 1991, when the number of production workers tumbled almost 14 percent. Scientists and engineers reached a peak in 1989 at 367 before falling back to 338 in 1991. The number of people engaged in research and development fell from 70 to 58, down slightly more than 17 percent for the five-year period.

As a percent of total employment, production workers ranged from a high of 74.6 percent in 1988, to a low of 71.9 percent in 1991. For specific firms the range was from a low of 57.5 percent to a high of 87.7 percent in 1991. Firms with the greatest number of employees tended to be near the high end of the range, indicative of economies of scale. Scientists and engineers represented about four percent of the group's total workforce throughout the period. Individual firms ranged from 1.1 to 7.4 percent for this parameter, and once again, the larger firms reported the highest percentages.

CAPITAL INVESTMENT - Investment in new plant and equipment by the surveyed forging companies ranged from $37.5 to $43.0 million between 1987 and 1991. Investment as a percent of shipments was 3.35 percent in 1990, and 4.02 percent in 1991. About 75 to 80 percent of investment is spent on new machinery and equipment, and the remainder in plant. Additional and rather significant expenditures were also reported for used equipment. The companies project a continuation of investment in both new and used capital equipment at about these same levels through 1995.

Used equipment expenditures were typically 20 to 25 percent of new investment. This is an extremely high level compared with the all manufacturer average of less than five percent in used machinery and equipment. The broader industry group of which the forging sector is a part, SIC 34 - Fabricated Metal Products, also has a high incidence of buying used machinery at slightly less than 10 percent, but is still well below the forgings average.

High used equipment expenditures occur in part because the technology of the forging production process is mature and not advancing at a very fast rate. This means that the productivity of old machines is almost the same as new machines. Under this circumstance, used equipment's cost/return ratio is high for this industry and, importantly, machinery is available right away. Further, new machinery and equipment can be very expensive with

CAPITAL EXPENDITURES IN PLANT, MACHINERY, AND EQUIPMENT

Year	Total New Investment (in $000s)	New Investment (in $000s)		Purchases of Used Machinery and Equipment (in $000s)
		Plant	Machinery and Equipment	
1987	37,530	9,021	28,509	8,248
1988	42,723	8,799	33,924	10,531
1989	41,976	9,200	32,776	8,425
1990	41,544	11,389	30,155	10,348
1991	42,975	9,646	33,329	9,083
1992	39,554	7,111	32,443	10,275
1993	42,880	8,848	34,032	9,765
1994	40,252	6,505	33,747	9,276
1995	32,407	6,113	26,294	9,486

Source: U.S. Dept. of Commerce, OIRA Industry Survey

long lead times, and often may not be constructed in the United States, so there may also be an exchange rate risk. Companies may not be able to justify the expenditure, especially in today's depressed market, but also in a cyclical industry such as this one. In addition, many plants are older with older vintage equipment fully integrated into their production operations. If a machine breaks down, a similar machine may be desirable to replace it. During the 1987-1991 period, surveyed firms' new investment per employee ranged from $4,136 to $5,507. This is comparable to the all manufacturing average of $4,150 in 1987, and $5,411 in 1990 (the latest available).

RESEARCH AND DEVELOPMENT EXPENDITURES - Research and development (R&D) spending was reported by six of the nine firms. For the group, it ranged from a low of $12.7 million in 1991 to a high of $15.5 million in 1988. As a percent of shipments, R&D was 1.14 percent in 1990, and 1.18 percent in 1991. Two companies experiencing financial problems have reduced R&D rather sharply from beginning period levels. R&D per employee ranged from a low of $1,528 in 1987 to a high of $1,716 in 1988. The surveyed forging companies reported spending an average of $200-225 thousand per person dedicated to research and development. For comparison, in 1991, all manufacturing R&D expenditures were about 3.6 percent of sales, and averaged about $6,000 per employee[27].

RESEARCH AND DEVELOPMENT EXPENDITURES, 1987-1991
(in $000s)

Category	1987	1988	1989	1990	1991
Material	1,950	1,913	1,938	1,859	1,597
Production Processes	6,731	7,972	7,861	7,580	6,836
Product Development	5,183	5,601	5,449	4,718	4,223
Total Research	13,864	15,486	15,248	14,157	12,656

Note: Includes estimate for one firm that did not report 1987 data.

Source: U.S. Dept. of Commerce, OIRA Industry Survey

The opportunity for technological advancement is not evenly distributed across industries. However, these opportunities combined with competitive forces make R&D per sales and R&D per employee good measures of the rate of technological change. These indicators show that the technology in most other sectors of the economy is advancing more rapidly than it is for forgings. The forging sector is making R&D investments however. The surveyed group reported spending more than half its R&D budget on production process research activities to improve efficiency. Most manufacturing sectors earmark a majority of

[27]Business Week magazine, June , 1992, p.

their research spending for product development. However, the forging group spent only about a third of their R&D budgets on product development.

SELECTED TECHNOLOGY USE AND INTEREST

Technology	No Interest	Looking Into	Began Using Last 3 Years	Have Used Over 3 Years
CAD/CAM	-	1	-	6
Induction Heat Treat	5	-	-	2
Robotics	3	3	-	1
Non-Contact Gaging	1	4	1	2
Flexible Cell Manufacturing	2	2	2	-
Powder Metallurgy	4	1	-	2
Just-In-Time	2	1	4	-
Statistical Process Control	-	-	3	4
Concurrent Engineering	-	1	5	1
Total Quality Management	-	2	5	-
Programmable Presses*	-	-	-	1

* Mentioned by only one company in 'Other' category

Source: U.S. Dept. of Commerce, OIRA Industry Survey

Among other things, the firms are studying the application of precision or near-net shape forging, faster die changing, robotics, non-destructive testing, CAD/CAM and flexible cell manufacturing. Their research has often provided a catalyst for new investment dollars to implement process improvements and innovations.

FINANCIAL PERFORMANCE - Six of the nine firms reported financial information for their forging operations. Before-tax profits for the six were highest in 1990, when they reached $43.2 million. However, they plummeted dramatically to a loss of $107.2 million in 1991, as sales fell by over 15 percent. All of the firms showed a drop in profits in 1991, and half of them reported negative results. Two firms showed losses for the five-year period, and a third barely finished on the plus side. The six taken together show a slight loss for the 1987-1991 period.

PROFITABILITY, 1987-1991

	1987	1988	1989	1990	1991
Net Sales	734,754	723,756	829,926	836,106	707,809
Cost of Goods Sold	661,002	642,890	747,005	738,421	670,698
Operating Income	73,752	70,866	82,921	97,685	378,121
Net Income Before Taxes	22,805	12,371	24,751	43,214	-107,203
% Net Income to Sales	3.10%	1.71%	2.98%	5.17%	-15.15%
# Reporting Losses	1 of 6	2 of 6	1 of 6	none	3 of 6

Source: U.S. Dept. of Commerce, OIRA Industry Survey

Profit margins were low, except in 1989, and even then, at 5.2 percent, profitability was only mediocre. All manufacturing averaged slightly over seven percent profit between 1986 and 1990[28] with a high of 8.8 percent, and a low of 4.2 percent. Durable goods manufacturers had a five year average return of 5.1 percent that ranged from 1.2 to 7.7 percent.

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[28]U.S. Department of Commerce, Economics and Statistics Administration, Office of Business Analysis, "Financial Ratios for Manufacturing Corporations, Third Quarter 1991".

An analysis of the financial balance sheets reported by the group indicates a reserve of strength. Three of the companies have no outstanding debt, and the other three have taken measures to reduce their debt burden to manageable amounts. Total long-term debt dropped over 38 percent between 1987 and 1991. This is not surprising since rising long-term debt commonly occurs in rapidly growing sectors where additions to capacity are needed to keep pace with an expanding market. In forgings, however, overcapacity is forcing firms to close down in a contracting market. As a portion of total assets, debt dropped from 35 percent to 25 percent. Long-term assets (total assets minus current assets) began the period at $449 million, but dropped over 23 percent to $345 million by the end of the period. Equity also dropped, by 6.4 percent from $350 to $328 million.

FINANCIAL BALANCES, 1987-1991
(IN $000S)

	1987	1988	1989	1990	1991
Current Assets	292,279	323,456	346,026	318,328	288,797
Current Liabilities	91,525	140,614	129,176	119,166	127,841
Inventories	191,252	217,656	231,611	211,949	183,151
Total Assets	740,805	809,322	809,360	728,725	633,913
Equity	350,127	405,409	408,240	402,052	327,758
Short Term Debt	6,725	51,029	35,252	22,048	24,642
Long Term Debt	257,104	206,037	205,045	174,091	159,147

Source: U.S. Dept. of Commerce, OIRA Industry Survey

Short-term solvency, measured by the current ratio (current assets/current liabilities), for the group started at 3.19 in 1987, and finished at 2.26. The average for all manufacturing was 1.43 in 1990, and for durable goods producers, 1.50. The forging industry carries very large inventories. If these are removed from current assets, the current ratio is converted into the 'quick ratio', a measure of very short-term solvency. In 1987, the quick ratio for the group stood at 1.10. The next year it fell to .75, before stabilizing and finishing at .83.

The quick ratio is more in line with that of all manufacturing and durables producers, which stood at .86 and .88 in 1990. Long-term solvency, measured by total assets/total liabilities, has averaged over 2.0 during the five year period, and is better than the 1.7 recorded by both all manufacturers and durable goods producers.

Inventory turnover is a measure of the relative efficiency of the use of inventory investment. The forging group reported a low of 3.33 in 1988, and a high of 3.94 in 1990. In contrast, between 1987 and 1990, all manufacturing averaged from 7.32 to 7.44. In 1991, inventory turnover for individual forging companies ranged from 3.36 to almost 15 for a high-volume producer. A correlation between inventory turnover and profit margins is apparent during the first four years, but breaks down in 1991. Inventories were slashed almost 14 percent between 1990 and 1991. Further, since the group was only operating at half capacity, with idle equipment and shorter queue times at each step in the production process, a greater inventory turnover could be achieved.

GOVERNMENT PROGRAMS - Four companies reported varying involvement in the Defense Industrial Modernization Incentives Program (IMIP). IMIP is a joint venture between Government and private companies to reduce weapon system acquisition cost through the implementation of modern manufacturing processes and increased or accelerated capital investments. IMIP is formalized through a contractual business agreement providing Government incentives for contractor capital investment.

One firm reported taking part in an IMIP program to install a modern management system, preventive maintenance system, and forward looking Tool and Die review and repair system. The Tool and Die system will include a laser measurement and recording machine to communicate with engineers. Another firm mentioned a Technology Modernization (often called Tech Mod) program under IMIP, that introduced a systemized approach to production processing in place of the former manual approach. Both of these programs were reported to have reduced lead times, lowered production costs, lowered prices to the military, and made the firm more competitive.

Another firm made a proposal to Wright-Patterson Air Force Base (Dayton, Ohio) for an Optical Dimensional Inspection System. A fourth firm prepared an IMIP presentation through the Government Systems Group at Cincinnati Milacron. The firm suggested IMIP funding for computer aided design and manufacturing and a super machining center for ship shafting.

The firms were asked to identify any problems they perceived with the IMIP programs. One mentioned excess capacity in the industry is pushing back the payoff. Another firm said the Navy is no longer interested in IMIP. Still another stated bureaucratic delays are a problem. In addition to what the firms reported, other IMIP programs involve forgings. The following lists the forging portion of funding by the U.S. Navy and Air Force in recent years.

OTHER IMIP PROGRAMS SPONSORED BY U.S. NAVY AND AIR FORCE
(in $000s)

	FY88	FY89	FY90	FY91	4-year Total	Project Title
Navy	-	-	-	38	38	Deformation Processing of XD Intermetallic Matrix Composites
Navy	-	158	394	656	1,208	Atlas of Formability
Total	-	158	394	694	1,246	
Air Force	1,850	1,840	1,900	1,128	4,718	ManTech for Adv Propulsion Materials
Air Force	352	800	516	113	1,781	ManTech for Adv Propulsion Materials
Total	2,202	2,640	2,416	1,241	6,499	
DOD Total	2,202	2,798	2,810	1,935	7,745	

Source: Office of Industrial Base Assessment, Office of the Secretary of Defense

The purpose of the first listed Navy project is to develop processing for titanium aluminide intermetallic matrix composites. The contractor is Metalworking Tech, Inc. located in Johnstown, PA. The second project is collecting formability data on numerous alloys important to weapon systems. The Air Force projects are both concerned with computer modeling of engine parts. The first project is working with titanium applications, the second with superalloys. General Electric is the prime contractor, and Ladish and Wyman-Gordon are the subcontractors.

COMPETITIVENESS - Several firms noted the forging industry was in the most competitive environment it has ever experienced, but indicated that they expected near-term improvement. Four of the surveyed firms reported they expect their competitive prospects to improve over the next five years, while two indicated their prospects would stay the same, and two others see a decline. Those that see improvement noted that the industry is consolidating, which should further strengthen the strongest firms, and that export opportunities are improving. Those that see their competitive prospects remaining the same indicated competition will remain intense worldwide because of global overcapacity and decreasing demand, especially for large, custom forgings. Additionally, this competitive environment has driven customers to seek price reductions without regard for the forging industry's longer-term survival. The two firms that reported their competitive prospects on the decline noted the expected drops in defense expenditures will create additional surplus capacity, and financially weaken companies in this arena. Further, Third World countries with lower energy and labor costs along with newer equipment present a new and increasing challenge in both the U.S. marketplace, and in foreign markets into which U.S. producers currently export. Some of these Third World countries include Brazil, Mexico, China, South Korea and India[29].

The forging companies cited a wide range of competitive advantages, some of which appear to be industry-wide, while others are unique to individual firms. Several firms mentioned a highly experienced and veteran workforce. After a decade of decline in employment in a mostly unionized industry, the average age of the forging workforce is high. This confers special advantages in terms of know-how and workforce chemistry to U.S. producers which is unique in the world. Other advantages mentioned at least once include: 1) special or unique capabilities such as technical expertise, a wide product range and advanced research facilities, 2) a clean metals program, 3) financial strength, 4) long-term partnerships with customers, 5) a full range of equipment, 6) modern and automated equipment, and 7) vertical integration into materials. In addition, competitive strength in foreign markets was cited as enhanced by the relatively weak dollar, and the strategic export location (at or near water's edge) of certain plants.

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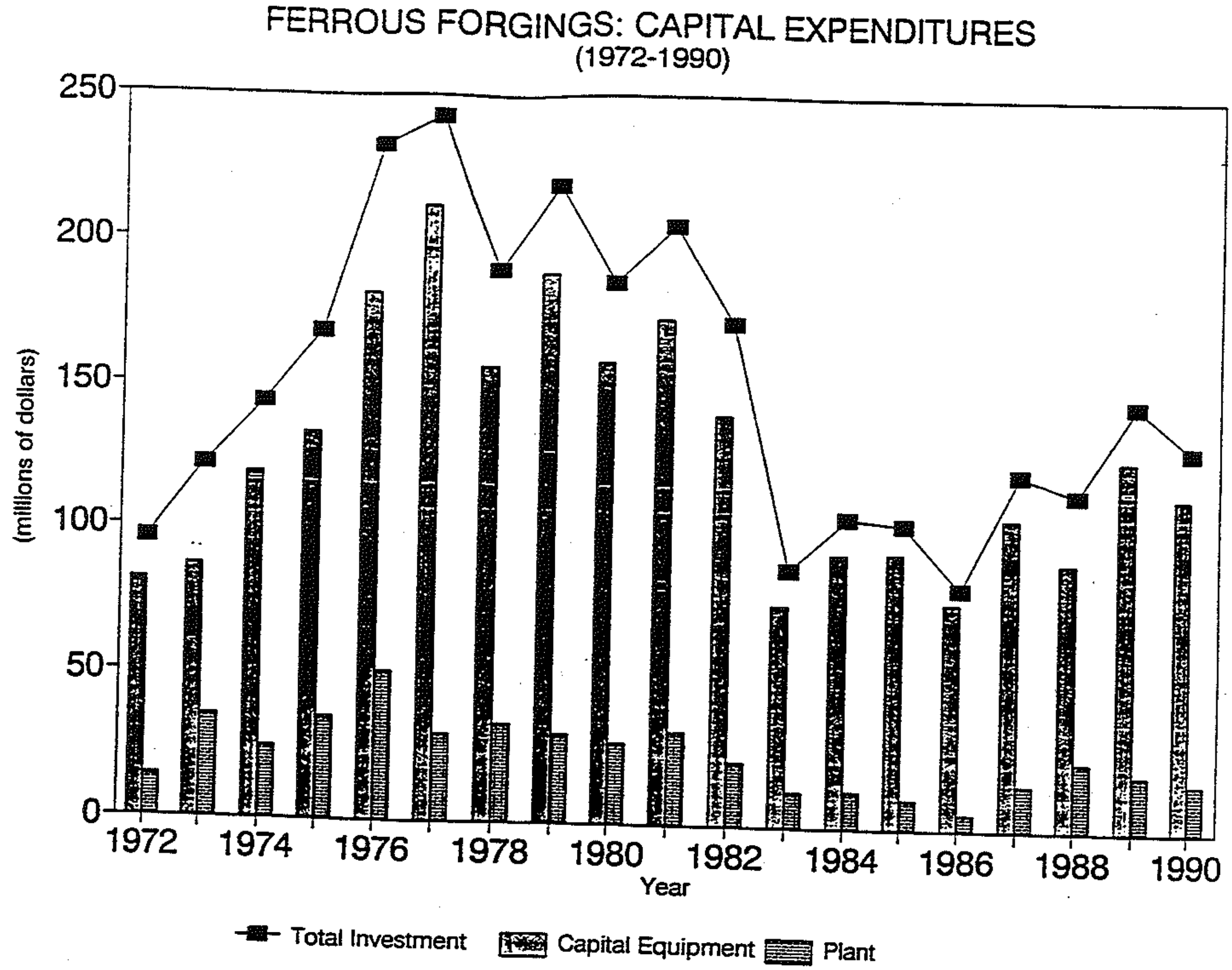
[29]For example, India Forge & Drop Stampings, Ltd. recently established a 100 percent export oriented facility in Pune, India. A seven-fold increase between 1985-1990 in forging exports from India was reported in Business-India (June 9,1991, page 21). Last year, Brazil was found to be dumping railroad wheels in the United States. However, the International Trade Commission could not substantiate injury to the domestic industry so no duties were assessed.

The companies also cited a number of competitive disadvantages. The excess capacity situation in the industry has put pressure on profit margins, and made it difficult to generate the necessary capital needed for facility improvements and other cost reduction investments. In the current environment, cost reductions accomplished in the industry are quickly taken away by customers. Some firms noted foreign government subsidies to steel making and other corporations were reducing their business opportunities. Foreign import duties and other restrictions were also cited.

Further, the globalization of the aerospace industry is fragmenting the U.S. marketplace and placing significant forging market share overseas, a difficult target for U.S. forging producers. In addition, offsets have reduced business and transferred technology to foreign competitors. High labor costs were also mentioned once as a competitive disadvantage. One firm noted the lower aluminum prices currently prevailing encourage what are called "hog-outs" - the cutting of forged aluminum billets to finished shapes on high speed machines, by-passing the forging process altogether. While this greatly increases the amount of scrap, it costs less than the forging process for some designs. Another area for competitive concern are the advances in the technology of competitive materials (plastics, ceramics and composites) and processes (castings, powdered metals and near net shape). These advances continue to put pressure on forging producers and continue to receive large amounts of research funding.

Each of the firms that responded to the survey reported that they are equal to or better than international competitors with respect to technology and quality, and all but one responded that they are cost-competitive. Several reported they are industry leaders worldwide. One firm pointed out it exports 40 percent of its production, and another a significant amount. Others are looking to increase exports, but continue to find obstacles such as large cultural differences in technical communities. Several of the firms are considering joint ventures to expand their opportunities.



Source: Bureau of the Census, Census and Annual Surveys of Manufactures

3.5 percent in the last period. The volatility of investment from one year to the next was over 20 percent, more than twice the volatility of shipments.

FERROUS FORGINGS: EMPLOYMENT, PRODUCTIVITY, SHIPMENTS AND INVESTMENT, (1972-1990)

Year	All Employees	Production Workers	Productivity	Value of Shipments	New Capital Spending	% New Capital Spending to shipments
	(in thousands)		1987=100	(in millions of 1990$)		
1972	34.3	27.8	98.1	4,828.3	95.8	1.98
1973	38.2	30.8	97.0	5,486.4	121.8	2.22
1974	39.4	32.4	95.3	5,532.1	143.7	2.60
1975	36.3	29.4	94.3	4,778.7	168.4	3.52
1976	37.6	30.4	90.7	4,611.3	232.6	5.04
5-Year Avg.	37.2	30.2	95.1	5,047.3	152.5	3.02
1977	39.1	31.0	91.7	4,975.6	242.8	4.88
1978	41.4	32.6	89.0	5,129.7	190.2	3.71
1979	40.2	31.3	88.0	4,971.1	219.0	4.41
1980	38.8	29.8	84.5	4,349.0	185.9	4.28
1981	38.1	29.3	87.5	4,388.1	205.5	4.68
5-Year Avg.	39.5	30.8	88.2	4,762.7	208.7	4.38
1982	30.7	22.4	88.3	3,206.8	172.1	5.37
1983	25.0	18.5	86.6	2,609.9	87.9	3.37
1984	29.8	22.0	87.5	3,277.6	105.8	3.23
1985	27.5	20.1	90.6	3,112.3	104.1	3.35
1986	25.2	18.3	92.0	2,872.6	82.1	2.86
5-Year Avg.	27.6	20.3	89.0	3,015.8	110.4	3.66
1987	26.6	19.1	100.0	3,371.6	121.5	3.60
1988	26.4	19.6	99.0	3,574.8	114.6	3.21
1989	28.4	21.2	97.0	3,806.7	145.8	3.83
1990	28.4	21.3	100.3	3,858.8	130.1	3.37
4-Year Avg.	27.5	20.3	99.1	3,653.0	128.0	3.50

Source: Bureau of the Census, Census and Annual Surveys of Manufactures, 1972-1990

Productivity[20] in the forging industry barely improved between 1972 and 1990. With 1987 equal to 100, productivity in 1972 was 98.1. Productivity dropped steadily after 1972, reaching a low of 84.5 in 1980. From 1982-1986, productivity averaged only 89, but then jumped to 99.1 in the last four years as shipments expanded and employment remained stationary. By 1990, the index was 100.6, the highest of the period.

The reasons for the lack of productivity growth are apparent. The technology used on the production floor has not advanced very quickly. For example, 30 year old properly maintained forging presses are nearly as productive as new presses. Further, where technology has advanced, many firms in the industry were slow to implement it. In addition, some industry sources state that union work rules which increase the number of job titles limit some firms' flexibility to optimize productivity. (Over 70 percent of the industry is unionized.) Trade also had an impact as many high volume forgings, such as axles, crankshafts, connecting rods, and wheels have been increasingly foreign sourced. The remaining business has trended toward smaller production lots that cannot be produced as efficiently. Moreover, import pressures depressed prices. At the same time, the down trend in the market reduced profits, discouraged new investment, and slowed innovation. In addition, environmental and work safety requirements raised compliance costs and lowered productive investment. The industry spokesman estimated productivity could be increased 25-30 percent by empowering and expanding the scope of individuals in the factory and removing many of the job titles.

Some unionized firms, such as Metal Forge in Deshler, Ohio voted to eliminate most of the job titles and adopt the team concept, and have greatly improved productivity. However, in general, older unionized firms are still at a disadvantage. Start-up firms, such as Impact Forge, Viking Forge and Japanese-owned TFO Tech have a competitive edge similar to that new Japanese auto plants have over established American auto companies. These companies can build a modern plant anywhere, such as the South where Right to Work rules prevail; use new equipment; introduce modern management techniques; and operate with younger people without high social costs (pensions, medical, etc.) and antiquated work rules.

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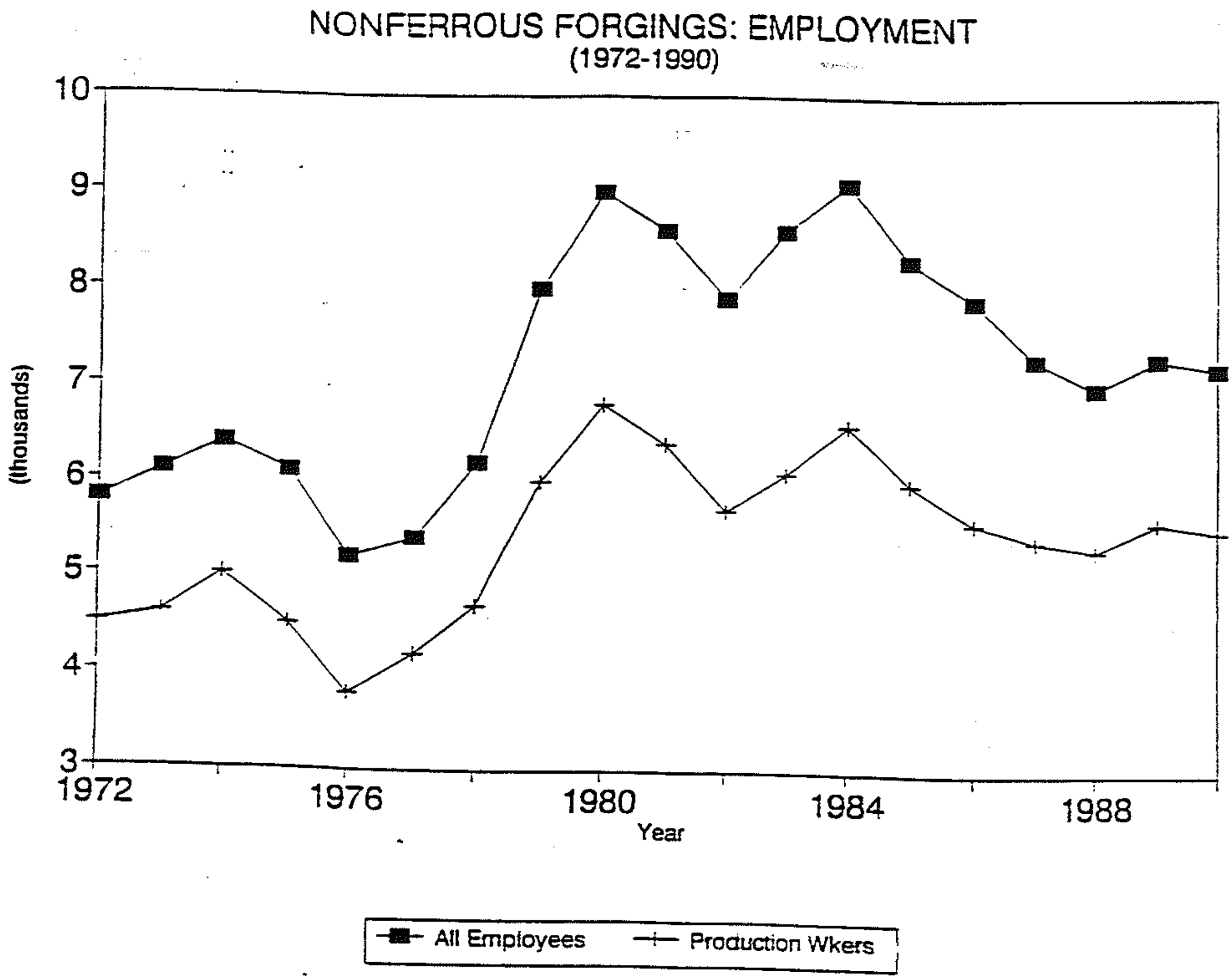
[20]Productivity was measured as shipments per worker hour, calculated by dividing constant dollar shipments by production worker hours. Production worker hours are reported by the Bureau of the Census in its Census and Annual Surveys of Manufactures.

Another competitive U.S. firm is Teledyne Portland Forge which constructed a new impression die forgings plant in Lebanon, Kentucky that features some of the latest technology. The plant is over 100,000 square feet and will make controlled tolerance impression die forgings for farm and off-road vehicles and large trucks. The forge cell



Source: Bureau of the Census, Census and Annual Surveys of Manufactures

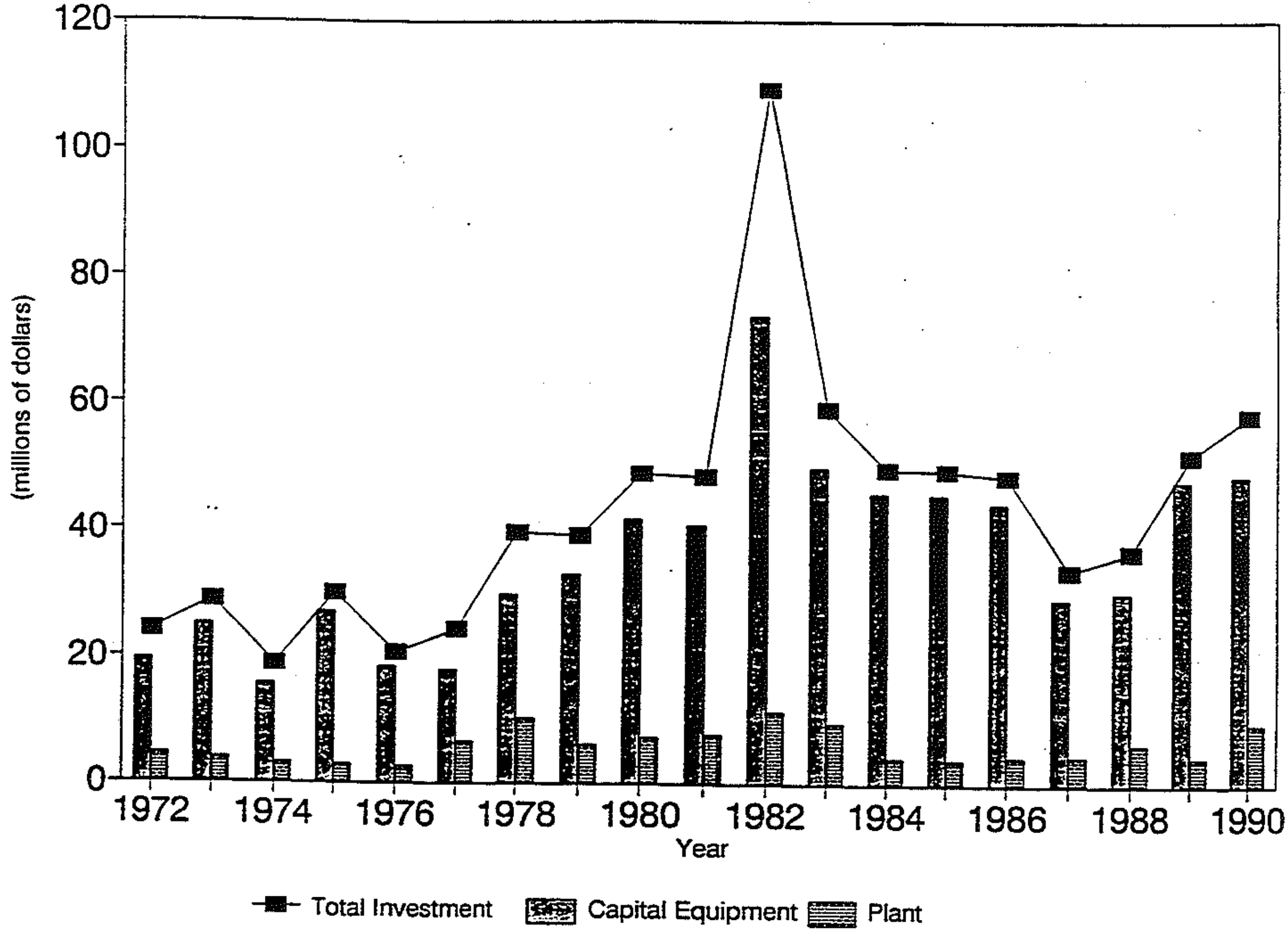
includes a bar descrambler, billet feeder, induction heater, hot shear, descaler, robot billet positioner, screw press, trim press and controlled cooling conveyers.

Nonferrous Forgings - In contrast to ferrous forgings, nonferrous forging shipments increased between 1972-1990 in constant 1990 dollars. The nonferrous forging industry's lowest shipment level was $758.6 million, recorded in 1972 at the beginning of the review period. The industry attained its highest level of $1.35 billion in 1984, at the height of the Reagan defense build-up, up 77 percent from 1972. In the 1972-1976 period, shipments averaged $843.6 million, and then rose more than 31 percent during the next five year period to an average of $1.11 billion. During the 1982-1986 period (the worst period for ferrous forgings), shipments of nonferrous forgings rose another 13.4 percent to an average of $1.26 billion - the best five years observed. During the latest four years, average shipments fell back to $1.14 billion, a decrease of about nine percent. The future should lead to further declines as defense spending decreases.

Employment in the nonferrous forging industry rose and fell in tandem with shipments. During the first five years, employment averaged 5.9 thousand, then rose to 7.4 thousand in the second period. Between 1982-1986, average employment rose another 12.4 percent to 8.4 thousand, before falling back to 7.2 thousand in the last four year period. Employment peaked at 9.1 thousand in 1984. Production workers rose from 4.5 thousand to an average of 5.6 thousand in the second period, then grew to 6.0 thousand in the third five-year period, before settling back to 5.5 thousand in the final period.

Investment in new plant and capital equipment by the nonferrous forging industry measured in constant 1990 dollars ranged from a high of $109.3 million in 1982, to only $18.7 million in 1974. Between 1972-1976, investment averaged $24.4 million, or 2.89 percent of shipments. Expenditures then climbed dramatically by more than 64 percent during the next five years, as average investment reached $40 million - 3.61 percent of shipments. This was during the late 1970's, when new military aircraft came into full production such as the A-10, F-15 and F-16, and the commercial market boomed in the wake of airline deregulation. While the commercial aircraft market contracted in the early 1980's, the defense build-up accelerated and pushed investment up again, this time by almost 58 percent to an average of $63 million during the 1982-1986 period - five percent of shipments. Sale of the government-owned contractor-operated forging press facilities to Alcoa and Wyman-Gordon induced some upgrading of support and auxiliary equipment over the next several years. Investment fell back to $45 million, equal to an average of 3.94 percent of shipments during the latest four years. The volatility of investment from one year to the next was nearly 31 percent, more than four times shipment volatility.

NONFERROUS FORGINGS: CAP'L EXPENDITURES
(1972-1990)



Source: Bureau of the Census, Census and Annual Surveys of Manufactures

Productivity in the nonferrous forging industry showed steady but uneven improvement between 1972-1986, before falling somewhat after the mid-1980's. With 1987 equal to 100, productivity was lowest at 85.3 in 1972, and attained its highest level of 114.0 in 1983. It finished the period at 102.9 in 1990. Overall, productivity growth in the nonferrous sector

NONFERROUS FORGINGS: EMPLOYMENT, PRODUCTIVITY, SHIPMENTS AND INVESTMENT, (1972-90)

Year	All Employees	Production Workers	Productivity	Value of Shipments	New Capital Spending	% New Capital Spending to shipments
	(in thousands)		1987=100	(in $90 millions)		
1972	5.8	4.5	85.3	758.6	23.9	3.15
1973	6.1	4.6	93.2	902.6	28.7	3.18
1974	6.4	5.0	88.1	931.3	18.7	2.00
1975	6.1	4.5	94.4	839.4	30.0	3.57
1976	5.2	3.8	110.5	786.3	20.6	2.62
5-Year Avg.	5.9	4.5	94.3	843.6	24.4	2.89
1977	5.4	4.2	100.3	812.8	24.2	2.98
1978	6.2	4.7	96.5	915.9	39.5	4.32
1979	8.0	6.0	93.4	1,172.7	39.0	3.33
1980	9.0	6.8	99.8	1,312.1	48.8	3.72
1981	8.6	6.4	101.0	1,326.9	48.3	3.64
5-Year Avg.	7.4	5.6	98.2	1,108.1	40.0	3.61
1982	7.9	5.7	113.8	1,191.7	109.3	9.17
1983	8.6	6.1	114.0	1,262.4	58.9	4.66
1984	9.1	6.6	107.2	1,345.3	49.5	3.68
1985	8.3	6.0	111.2	1,286.3	49.1	3.82
1986	7.9	5.6	111.3	1,199.0	48.4	4.03
5-Year Avg.	8.4	6.0	111.5	1,256.9	63.0	5.01
1987	7.3	5.4	100.0	1,126.7	33.5	2.97
1988	7.0	5.3	97.7	1,120.5	36.5	3.25
1989	7.3	5.6	99.1	1,155.2	51.8	4.48
1990	7.2	5.5	102.9	1,159.1	58.1	5.01
4-Year Avg.	7.2	5.5	99.9	1,140.4	45.0	3.94

Source: Bureau of the Census, Census and Annual Surveys of Manufactures, 1972-1990

has not been impressive, and lags most other industries. Many of the same circumstances identified in the ferrous forging sector also apply here. However, the nonferrous sector has not been subject to major import pressures, and profitability has been higher, except perhaps in recent years. Moreover, a growing market as experienced in the nonferrous sector until 1986 usually brings in younger people, which may have relaxed some of the work rules that have long hindered the ferrous forging industry.

FORGING MARKETS - The Cleveland, OH-based Forging Industry Association (FIA) has maintained records of the market outlets of its membership for over 30 years. This information was made available for this study, and is presented here to show market trends over the period 1974-1991. The information is for hot impression die forgings which account for about 75 percent of the value of all forgings (about 60-70 percent for ferrous forgings, and over 80 percent for nonferrous).

The overall market for hot impression die forgings fell 20.3 percent between the first period 1974-1976, and the latest period, 1987-1991 under review. The only end-market that showed a significant gain between these periods was aerospace, which grew by 23.2 percent. However, 1991 aerospace shipments plunged over 16 percent from 1990 levels, which could portend further shrinkage in the future. Other areas that showed slight gains were automotive (up two percent), and ordnance (up almost four percent). In contrast, the industrial sector[21] dropped 47 percent, off-road vehicles plunged 63 percent, the railroad market fell almost 54 percent, and the all other (not defined) category contracted almost 45 percent.

The major markets for hot impression die forgings were aerospace and automotive. During the five years ending in 1991, these two end-markets averaged about 65.2 percent of the total. Aerospace alone accounted for 37 percent. In the first three years of the review period (1974-1976), the automotive and aerospace markets accounted for only 46 percent of the market. This much lower share in the earlier years contrasts with much larger industrial

[21]The industrial sector includes: 1) internal combustion engines (stationary), 2) metalworking and special industry machinery (except nuclear), 3) mechanical power transmission equipment 4) fabricated plate work, special industry machinery (nuclear), 5) petrochemical equipment, 6) plumbing fixtures, valves and fixtures, 7) pumps and compressors, 8) refrigeration, air conditioning and heating, and 9) steam engines and turbines (except locomotives).

TRENDS IN HOT IMPRESSION DIE FORGING MARKETS (1972-1991)

		Major Markets for Hot Impression Die Forgings, 1974-1991 (in millions of constant dollars, 1990)						
Year	Total	Aero-space	Motor Vehicle	Indus-trial	Off-Road Equip.	Ordnance	Rail-road	All Other
1974	4,154	885	943	847	798	162	179	341
1975	3,573	958	675	629	729	179	154	250
1976	3,361	812	825	556	654	152	104	258
3-Year Avg.	3,696	885	815	667	727	164	145	283
1977	3,301	709	911	575	624	112	122	248
1978	3,485	805	899	599	652	94	157	279
1979	3,716	962	877	613	680	93	178	312
1980	3,183	1,127	576	512	522	99	134	213
1981	3,272	1,237	533	550	540	108	98	206
5-Year Avg.	3,391	968	759	570	604	101	138	252
1982	2,545	1,065	346	442	286	149	68	189
1983	2,317	887	450	392	227	148	46	167
1984	2,829	936	699	396	311	221	79	187
1985	2,728	1,082	697	357	234	176	53	190
1986	2,644	1,105	679	307	206	143	48	156
5-Year Avg.	2,625	1,015	574	379	253	167	59	178
1987	2,878	1,137	812	320	250	161	52	147
1988	2,999	1,074	891	330	312	153	75	165
1989	3,062	1,156	828	375	280	174	80	170
1990	3,021	1,134	828	385	272	176	65	161
1991	2,769	950	800	390	235	188	64	141
5-Year Avg.	2,946	1,090	832	360	270	171	67	157

Source: Forging Industry Association

and off-road equipment (includes construction, mining, material handling and farm machinery and equipment) shares whose combined total at the time came close to 40 percent. However, by the last period, these sectors' share was only about 21 percent, reflecting major drops in their absolute market size over the period.

Automotive forgings were at their highest in absolute terms in 1974 at $943 million. They plummeted to only $346 million in 1982, when less than six million cars were produced, but since have returned to earlier levels. As a percent of the total market, automotive forgings ranged from only 13.6 percent in 1982 to 29.7 percent in 1988. Since 1985, automotive forgings have been between 25-30 percent of the market. The aerospace market, comprised mostly of nonferrous forgings, reached its highest level in 1981 at $1.4 billion. As a percentage of the total market, aerospace forgings ranged from 21.3 percent in 1974 to a high of 41.9 percent in 1982, and then, after dipping in the next few years, hit 41.8 percent in 1986. In 1991, aerospace forgings were down to 34.3 percent of the market, their lowest level since 1984.

Nearly all the subsectors of the industrial and off-road equipment forging market contracted over the period, especially in the early 1980's when demand for durable goods collapsed. Foreign producers of end-items containing forgings gained market share in both the United States and overseas markets where U.S. firms formerly exported. The competition in these end-markets put enormous pressures on prices and product quality forcing some well-known firms such as International Harvester, Allis-Chalmers and Dresser Industries into bankruptcy and reorganization. This competition was transmitted through the lower tiers to forgings. As markets contracted, many forging houses were forced to exit the business. The competition among forgers for the remaining business was intense, forcing prices and profits down. Also, direct imports of forgings increased dramatically at this time, as end-users opted for the lower prices being offered by foreign suppliers. Many of the imported forgings were for high volume orders, which particularly hurt larger forging establishments and fragmented the forging industry.

As a result of expected future declines in defense expenditures, aerospace forging shipments (including both ferrous and nonferrous) are expected to contract further in the next few years. Increased aerospace exports could potentially soften or even result in a slight increase in the aerospace market. Since the U.S. aerospace forgings sector is more technically advanced than many of its foreign rivals, this could lead to joint ventures or licensing agreements in which U.S. technology is exchanged for marketing privileges.

However, major obstacles to exporting remain. Airbus Industrie is gaining increased global market share at the expense of U.S. producers and tends to source key components from European sources. Rolls-Royce Engines sources most of its forgings from Heavy Duty Alloys (UK), and along with Fiat is averse to sourcing outside Europe, except when finished products are destined for the United States. Although defense spending in Europe is dropping, European commercial aerospace industries are growing at the same time as the U.S. commercial sector has been shrinking.

The European aerospace forging sector is also becoming more competitive. For example, SNECMA produces turbine blades, ring discs and other parts for major military and civilian projects. Recently, the company installed a fully automated thermal process line for hardening and annealing of forged parts at its plant at Gennevilliers near Paris. Its computers automatically control and monitor the entire process, store information related to processing history, and produce a documentation trail. In addition, Carmel Forge in Haifa, Israel manufactures high-quality forgings for jet engines and airframes, and is considered among the top companies in its field. Over 90 percent of the firm's sales come to the United States. However, Carmel recently laid off more than 20 percent of its workforce because of declining U.S. business.

Far East countries (including Japan, Taiwan, and South Korea) have the fastest growing aerospace sector. However, these markets are mostly closed to American forgers, except where technology is exchanged[22]. Various aerospace forging firms are gaining world-class status. For example, IHI makes gas turbine engine parts including blades, and Sumimoto Heavy Industries recently opened a new $30 million turbine blade plant for aircraft engines near Tokyo.

Both the International Trade Commission and the Forging Industry Association estimate that ferrous forging imports at around 30-40 percent of U.S. consumption. Unfortunately, forging imports (and exports) are buried in basket categories or under different names in the trade statistics and therefore unavailable. Imported forgings have made their deepest inroads into the automotive, industrial and off-road equipment markets. Exports of forgings may be increasing, although this cannot be verified. Some firms have aggressively sought foreign

[22]An exception may be Boeing's 747 (with about 18,600 forgings per plane) that sells primarily on its own merit, although technology may also be transferred.

sales. For example, Finkl & Sons of Chicago reorganized its sales department and promoted several staff members in an effort to expand into world markets.

INVENTORY TURNOVER - Inventory turnover (shipments/inventory) and work-in-process turnover would normally only warrant a cursory review. However, an examination of these measures for ferrous forgings showed a clear downward trend that is somewhat alarming. The work-in-process[23] (WIP) inventory turned over 17.68 times for ferrous forgings in 1972, remained near that level until 1980, and then dropped sharply. The WIP turnover rate ended the period (1972-1990) at its lowest rate of only 9.14 times, slightly greater than half the 1972 high. The total inventory (materials, WIP and finished products) turnover rate followed a similar trend, although it achieved its highest level in 1981 at 6.84. After 1981, it went down and has been below 5.0 since 1985.

The drop in these parameters for the ferrous forging industry appear to indicate a general erosion in efficiency and international competitiveness. The loss of high volume business is apparently a major reason for the decline. This business was lost partly to direct imports, and partly to the production of high volume end-items (that use forgings) being moved off-shore by American manufacturers, or by American firms losing this market segment to imports. Other contributing factors for the deterioration of inventory turnover were likely the aging of equipment and the workforce, chronic overcapacity, lack of innovation, and greater demands for precision, quality assurance, and finish machining. Among individual firms, those with the high volumes tend to have the highest turnover rates.

The nonferrous sector, while not showing an up or down trend, is very low in terms of inventory turnover in relation to the rest of the economy. In fact, of 459 manufacturing industries, in 1988, the nonferrous forging sector ranked 451 in WIP turnover at 4.93, and 442 in total inventory turnover at 3.19 (as reported in Part I). The U.S. nonferrous sector, in common with its foreign competition, is technically inefficient because of the batch processing, complexity and sophistication of its products, and physical constraints and limitations of the production process. This characteristic also helps explain why forgings often pace production in a military surge environment. In contrast, the WIP turnover rate for all manufacturers was over 20, and the total inventory rate about 7.3 in recent years.

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[23]Work-in-process defines inventories (of purchased materials and components) that have begun to flow through the production process where value is added, but have not yet become finished goods waiting for shipment. WIP is a measure of production efficiency. For additional information, the forging manufacturing process was described in Part I.

INVENTORY TURNOVER RATES, 1972-1990

	Ferrous Forgings		Nonferrous Forgings	
	Inventory Turnover	Work-in-Process Turnover	Inventory Turnover	Work-in-Process Turnover
1972	6.45	17.68	3.71	5.73
1973	5.73	16.85	3.48	5.57
1974	5.51	15.77	3.08	4.64
1975	6.22	15.74	3.69	5.96
1976	6.03	17.12	3.99	6.69
1977	6.18	16.67	3.69	5.80
1978	6.30	17.34	3.49	5.77
1979	6.06	15.77	3.46	5.54
1980	6.57	16.98	3.55	5.50
1981	6.84	16.56	4.04	6.73
1982	5.57	13.69	2.80	4.41
1983	4.98	12.01	3.33	5.37
1984	4.71	11.40	3.14	5.43
1985	5.03	11.96	3.33	5.50
1986	4.71	10.51	3.13	5.02
1987	4.92	10.01	3.60	5.74
1988	4.61	9.41	3.19	4.93
1989	4.78	9.19	3.56	6.11
1990	4.90	9.14	3.97	6.81

Source: Bureau of the Census, Census and Annual Surveys of Manufactures, 1972-1990

MAJOR COSTS OF FORGING PRODUCTION - As a percent of shipments, about 90 percent of the cost of forgings in recent years was attributable to materials, labor and energy, leaving little for overhead and other costs. By comparison, for all manufacturing industries these costs averaged 78.7 percent in 1990. During the 17 year period 1974-1990, material, labor and energy costs ranged from 83.7-92.8 percent for ferrous forgings, and averaged 88.3 percent. For nonferrous forgings, they ranged from 77.5-96.4 percent and averaged 85.2 percent. For the most recent five years (1986-1990), these costs averaged 89.1 percent for ferrous forgings, and 91.4 percent for nonferrous forgings.

Since 1983, material, labor and energy costs exceeded 90 percent on several occasions for both the ferrous and nonferrous sectors. For the ferrous forging sector they averaged 91.3 percent between 1982-1986 during the deep contraction in the ferrous forging market when annual shipments averaged only $3.0 billion. In the nonferrous sector, these costs reached 96.4 percent in 1987, and 95.5 percent in 1988, as material costs rose disproportionately, and the sector experienced the third and fourth year of a market contraction. In addition, neither sector apparently was able to pass these higher costs through to customers. Prior to 1983, the costs dipped below 80 percent several times for the nonferrous sector, but never dropped below 83.7 percent for the ferrous sector.

Based on a simple least squares regression line, these cost components increased on trend for both sectors. On trend, ferrous forgings saw a 5.5 percent increase, while for nonferrous forgings the increase was much larger at 18.7 percent. In terms of cost per dollar shipped, these increases would be from 86.0-90.7 cents (1974-1990) for ferrous forgings, and from 77.9-92.5 cents for nonferrous forgings. An upward trend indicates difficulty in passing cost increases through to customers. This situation was brought on by depressed markets that created a protracted buyer's market that persists today. This condition manifests itself in overcapacity, intensified competition, and continuing import pressures. The decline in defense expenditures has aggravated the situation.

Both sectors show significant increases in energy costs, although as a percentage of shipments, energy costs are the smallest of the three components. On trend, energy costs for ferrous forgings rose from 4.2-5.9 cents per dollar of shipments (up 40 percent) between 1974-1990. For nonferrous forgings energy costs increased from 3.2-4.2 cents (up 31

COST ALLOCATION TO ENERGY, LABOR, AND MATERIALS, 1974-1990

	Ferrous Forgings				Nonferrous Forgings			
	Percentage of Total Shipments Spent on...				Percentage of Total Shipments Spent on...			
Year	Energy	Work-Force	Materials	Column Totals	Energy	Work-Force	Materials	Column Totals
1974	3.51	28.72	54.37	86.61	3.24	28.53	50.40	82.17
1975	3.67	27.04	53.02	83.73	3.31	28.38	48.08	79.78
1976	3.94	28.21	52.21	84.36	3.29	26.46	47.94	77.50
1977	4.49	28.72	53.85	87.05	3.46	26.03	51.43	80.93
1978	4.31	28.53	54.50	87.34	3.33	26.11	55.37	84.82
1979	4.54	27.50	56.44	88.48	3.16	24.38	55.06	82.60
1980	5.01	28.63	55.21	88.84	3.41	23.13	57.63	84.17
1981	5.21	28.05	52.81	86.07	3.18	22.25	55.73	81.16
1982	6.04	31.01	51.66	88.71	3.73	24.21	52.05	79.99
1983	6.54	33.26	52.39	92.20	4.42	25.99	49.75	80.17
1984	6.52	32.90	50.79	90.21	4.67	27.59	59.28	91.54
1985	6.69	33.35	52.83	92.81	4.54	27.06	54.88	86.48
1986	5.90	33.96	52.60	92.45	4.17	29.54	53.96	87.67
1987	5.27	32.43	51.72	89.42	3.97	28.46	56.35	88.78
1988	5.08	30.08	53.52	88.67	3.64	28.29	64.52	96.44
1989	4.63	28.88	53.27	86.78	3.60	27.80	64.06	95.46
1990	4.65	29.31	54.12	88.08	3.85	28.91	56.03	88.79
17 year avg.	5.06	30.03	53.25	88.34	3.71	26.65	54.84	85.20
1986-90 avg.	5.11	30.93	53.05	89.08	3.85	28.60	58.98	91.43

Source: Bureau of the Census, Census and Annual Surveys of Manufactures, 1972-1990

percent) per shipment dollar over the period[24]. Energy costs peaked in the first half of the 1980s when oil prices were their highest. Ferrous forgings averaged 6.34 cents per dollar shipped between 1982-1986, and peaked in 1985 at 6.69 cents. The highest five years for the nonferrous forging sector were 1983-1987, when energy costs averaged 4.35 cents per dollar. In 1990, all manufacturing industries averaged 1.98 cents on the dollar for energy.

Both sectors also experienced relative increases in labor costs. Labor costs per shipment dollar for ferrous forgings increased from 28.3-31.7 cents (up 12 percent), while nonferrous rose from 25.5-27.8 cents (up 9 percent) over the period. In contrast, average labor costs for all U.S. manufacturing were 20.5 cents per shipment dollar in 1990, down from 21.9 cents in 1974.

As automation and technology advance and continue to spread across manufacturing industries, variable costs such as labor are pushed down and fixed costs rise. Modern manufacturing is increasingly dominated by fixed costs, which makes investment capital dearer and the ability to service debt more important. The relative drop in total labor costs for all manufacturing to value added over time provides a clear illustration of this trend. Between 1974-1990, total labor costs for all manufacturing declined from 49.4 percent to 44.4 percent of value added.

The two forging sectors moved in the opposite direction, indicating a relative decline in fixed costs. This is due to the aging of equipment (one industry spokesman stated the forging sector's equipment is on average older today than at any time in its history), inadequate R&D and investment, low rates of capacity utilization, severe price competition, and industry fragmentation. More importantly, this has led to decreased industry competitiveness. The ferrous forging sector's labor cost/value added ratio was 60.8 percent in 1974, and rose to 64.1 percent by 1990. The nonferrous sector saw its ratio rise from 50 percent in 1974 to 67.7 percent in 1990.

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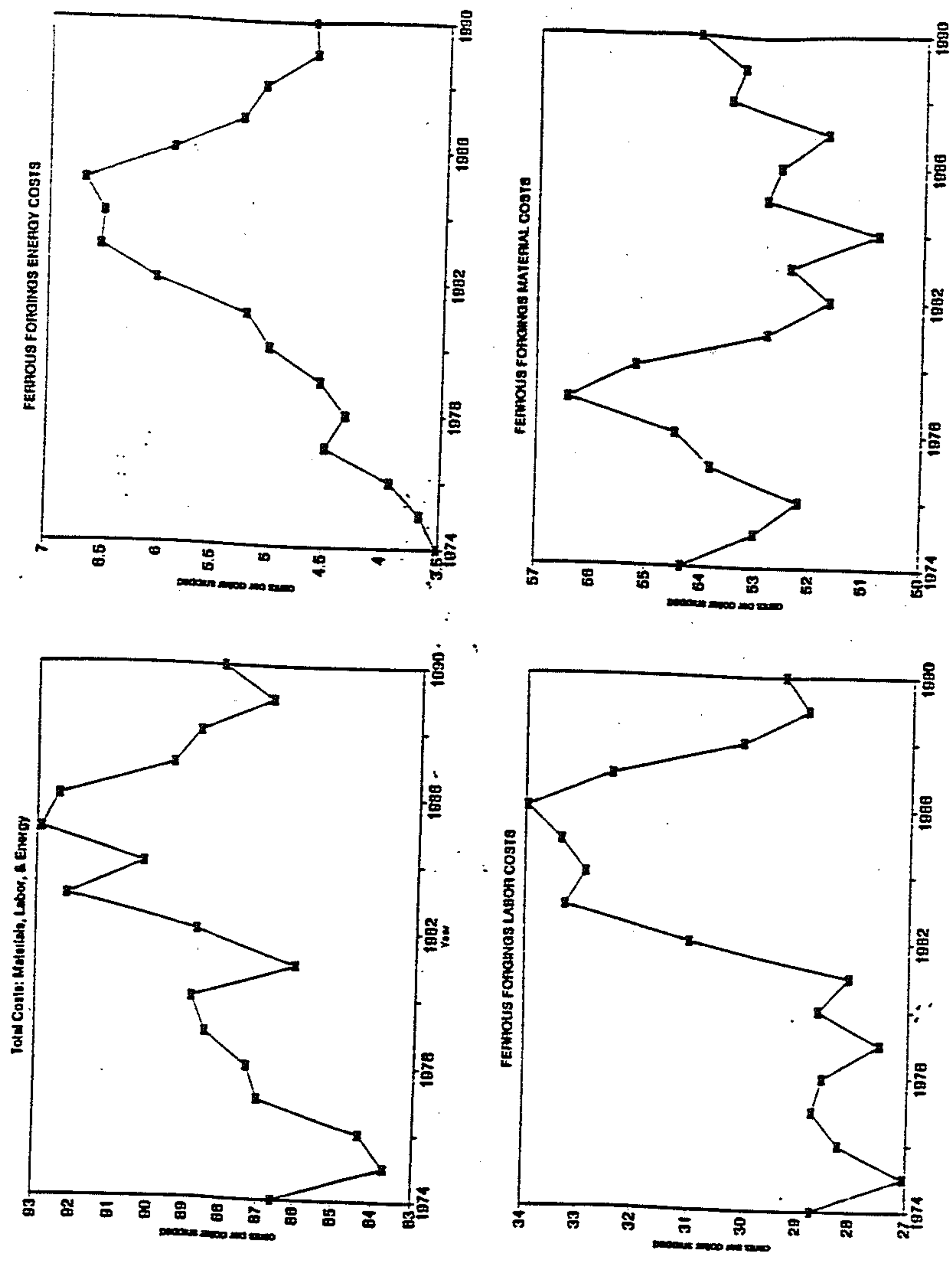
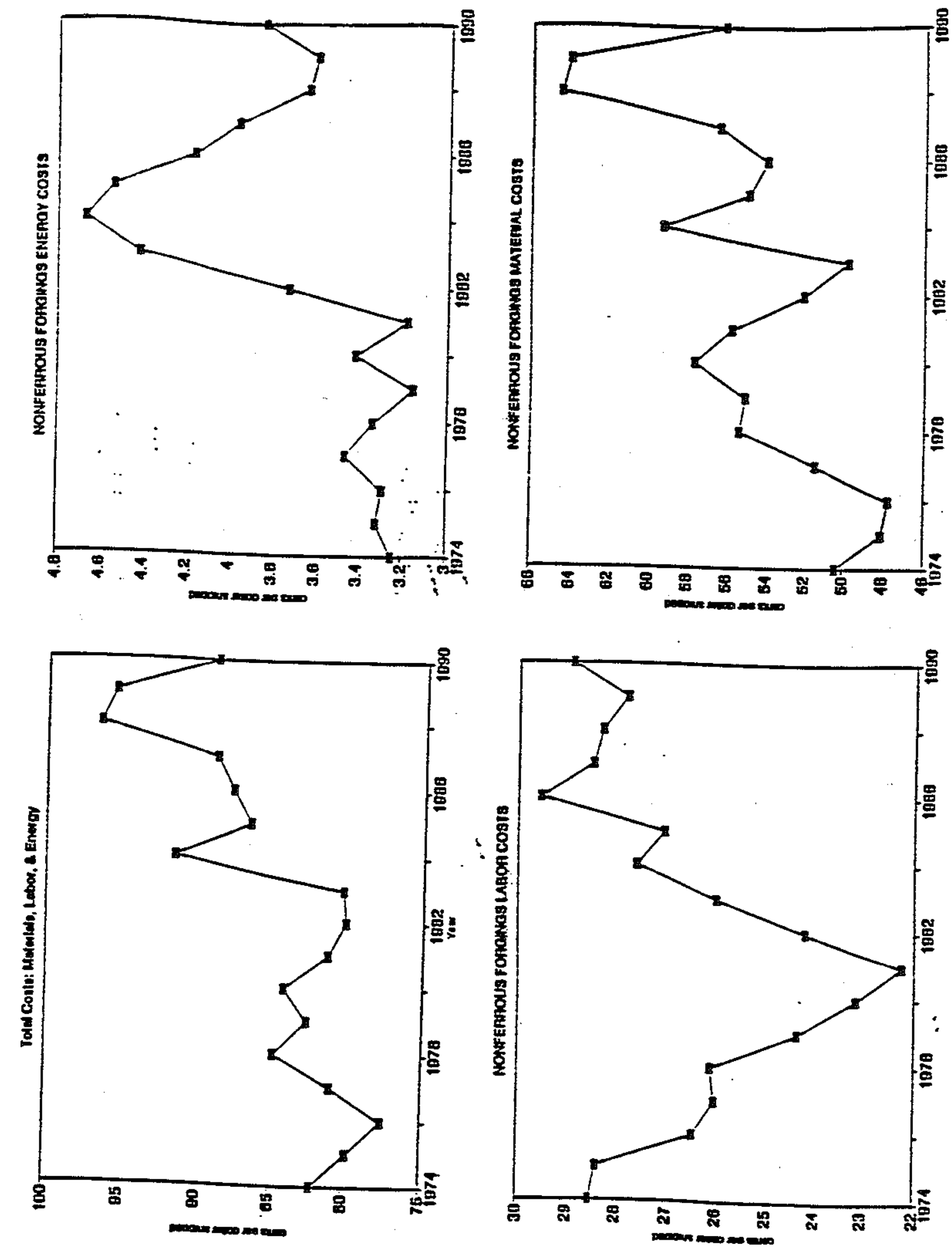
[24]The energy costs for the ferrous forging sector are higher than the nonferrous sector because of differences in forging temperatures. The typical forging temperatures of steels is 2200-2300 degrees Fahrenheit. Aluminum forges at 800 degrees, and copper and brass at about 1500 degrees. These metals, aluminum (60 percent) and copper/brass (30 percent) represent the majority of the forged material for nonferrous forgings.

FERROUS FORGINGS: MAJOR COSTS
(Materials, Labor, and Energy)



Source: Bureau of the Census, Census and Annual Surveys of Manufactures, 1974-1990

NONFERROUS FORGINGS: MAJOR COSTS
(Materials, Labor, and Energy)



Source: Bureau of the Census, Census and Annual Surveys of Manufactures, 1974-1990

Labor costs include payroll, employer contributions to Social Security and other legal payments, and other employer paid programs. The social payments (i.e., non-payroll) rose from 20 percent of payroll in 1974, to over 31 percent in 1990 for ferrous forgers, and from 14.6 to 34.2 percent for nonferrous forgers. Hourly wage rates rose from $6.03 in 1974 to $13.45 in 1990 for ferrous forgings, while nonferrous rates rose from $6.02 to $14.83. The average wage for all manufacturing in 1990 was $11.19. However, high wage rates and social payments are not the crux of the problem.

High wage rates tend to be found in more capital-intensive industries, where higher capital/labor ratios (higher fixed costs) increase labor productivity (output). This is demonstrated very clearly by comparing the most capital-intensive industry, petroleum refining, and the least capital-intensive industry, bookbinding. Petroleum refining pays only 3.02 cents in labor costs per dollar shipped, while the wage rate (1988) was $17.80/hour. In contrast, bookbinding pays 50 cents in labor costs per dollar shipped, but its wage rate was only $7.49/hour. Thus, correlating capital intensity (i.e., productivity) and average wage rates among all manufacturing industries results in a positively sloped trend line[25].

The average for all manufacturing lie at the mid-point of the trend line (i.e., capital intensity of 50 on a scale of 1-100, and average hourly wages $10.66 (1988 data). Ferrous forging capital intensity was recorded at 54.9. On trend, the sector's predicted wage rates would be $10.74. However, its actual wage of $12.42 places it in the upper eight percent of all industries. Capital intensity for nonferrous forgers was 62.3, which predicts a wage of $11.41. The actual average was $13.10, again in the upper eight percent. By this analysis, both forging sectors appear to pay their workforce above a competitive wage, given their capital/labor ratios. However, the real problem is undercapitalized labor, not uncommon in a contracting market. Investment will remain low unless the market is enlarged.

The largest component cost for both forging sectors is materials. For ferrous forgings, material costs averaged 53.3 percent over the period (53.05 in the most recent five years), while nonferrous averaged 54.8 percent (58.98 in the most recent five years). For all manufacturers, material costs were 54.1 percent of the total. While ferrous forging material costs decreased somewhat on trend as a percent of shipments, nonferrous material costs rose,

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[25]The trend line starts at $7.49 and moves up to $13.83 in 459 increments (the number of manufacturing industries), with a standard error of (+,-) $2.34 and an R-squared factor of .32, (ie. 32 percent of variation in wage rates is explained by capital intensity.) Other major influences include regional differences, union membership, gender and age of workforce.

and in two recent years even exceeded 60 percent. On trend, ferrous forgings material costs declined between 1974-1990 from about 53.9 to 52.6 cents per shipment dollar. Nonferrous material costs rose from 49.1 to 60.5 cents (up 23 percent) during the period, before falling in 1990 to 56 cents.

Based on Forging Industry Association market reports, one can calculate the selling price per pound for forgings made from various steels and nonferrous metals. Although this is not an ideal indicator, it does provide insight into movements in the metals cost to the forging companies, data which are otherwise not available. However, other materials besides forging metals are purchased by forging companies. Thus, the actual cost of the metal may only be about 30-40 percent of the final selling price of the forging. Another caveat, the product mix for ferrous forgings changed both qualitatively and quantitatively as industrial markets declined and high volume forgings were displaced. This trend would also change the "relative" cost of materials. Basic engineering principles tell us that high volume production has a higher relative material cost than low volume production. Therefore, material costs during the earlier years of this analysis of the ferrous forging sector may be closer to 40 percent than 30 percent of the final selling price of the forging. This may also, in part explain the slight downtrend in relative material costs observed for the ferrous forging industry.

Given these provisos, carbon steel's forged selling price per pound was 35 cents in 1974. It reached a high in 1984 of 86 cents, and since then ranged between 74 cents (in 1988) and 84 cents (in 1987). In 1991, the price stood at 81 cents (131 percent above 1974). Alloyed steel's forged selling price began the period at 52 cents, peaked at $1.25 per pound in 1985 and 1986, and then finished the period at $1.19. Stainless steel began at $2.35, rose unevenly to a high of $5.91 in 1989, and settled to $4.95 in 1991. Aluminum started the period at $1.75 per pound and finished at $6.03 in 1991. Most of the increase occurred by 1982, when the price reached $5.08. Titanium was $9.07 in 1974, shot up to $43.13 in 1982, and finished the period at $27.30 per pound. Other nonferrous went from $2.56 in 1974 to a high of $12.96 in 1990, and ended the period at $11.47.

In total, all ferrous metals moved from an average of 43 cents per pound in 1974, to $1.09 in 1982 (up 153 percent), and then held fairly steady for the remainder of the period, finishing at $1.05 per pound in 1991. All of this price increase (apparently) was passed through by the ferrous forging sector to customers, although prices remained about the same for the last decade. The price of ferrous forgings is heavily weighted by carbon and alloy steels, which comprise the majority of shipments. Total nonferrous metals began the period at $2.65 per pound, and then rose to $7.62 by 1982 (up 187 percent), finishing the period at $6.94. Nonferrous use is heavily weighted toward aluminum.

The ferrous forging industry is a beneficiary of the much improved U.S. steel industry. Since 1981, many older plants were retired as employment in the steel industry fell 50 percent from over 500 to about 250 thousand in 1991. However, shipments fell only 13 percent from 80 to 70 million (metric) tons, marking major improvements in productivity. Continuous casting installations have expanded from about 20 percent of steel production to nearly 76 percent today. Exports of steel are also up and reached 8.0 percent of shipments in 1991, up from only 1.4 percent in 1987. At the same time, imports fell from 21.3 percent of consumption to 17.9 percent (down about 4.6 million tons)[26].

[26]The steel industry has filed countervailing duty cases against European steel makers in Belgium, France, Germany, Italy, Spain and the United Kingdom, and antidumping cases against these countries, Japan and others. The state subsidies to European steel makers benefit forging companies and other steel intensive industries, and support forging exports to the United States. These subsidies have also made the U.S. industry less competitive in Europe.

PART V - FINDINGS AND RECOMMENDATIONS

GENERAL STATEMENT - Removal of the DFAR on forgings at this time would expand the supply base to foreign sources while the overall market for forgings is contracting, and could jeopardize the financial health and/or lead some of the remaining domestic suppliers to exit the defense market. It is important to remember that the purpose of the forging DFAR was to preserve a domestic forging capability in those areas where forging import penetration was the highest. As a result, only 20 percent of total defense procurement of forgings is covered by the restriction. In 1991, an estimated $836 million of forgings was purchased by the military (excluding $107 million in foreign military sales), only about $180 million was covered by the DFAR. This is down from previous years and has been accompanied by a gradual attrition of forging suppliers. The U.S. Army, Tank and Automotive Command in Warren, Michigan reported single suppliers for some of the forgings under restriction. With the removal of the DFAR restriction, the risk of losing certain U.S. forging capabilities would increase.

The forging areas of high import penetration (crankshafts, connecting rods, axles, etc.) in the commercial sector remain the same. A number of prime contractors would (primarily because of lower prices) be likely to shift some defense forging business to foreign forging suppliers, which in some cases may be affiliated companies, if permitted to do so. Further, forging technology is old and known worldwide. Nations with low wage rates are soliciting both external and internal investment to construct export oriented forging operations.

Since the DFAR on forgings was established in 1984, overall shipments of ferrous forgings barely increased. The increase peaked in 1990, when shipments reached $3.86 billion, the highest level since 1981, and $581.2 million, or about 18 percent above the 1984 level. However, based on Forging Industry Association market reports, 1991 shipments fell an estimated 6.47 percent to $3.61 billion (unadjusted for inflation). And based on Department of Labor ferrous forging industry employment statistics for the first four months of 1992, shipments are believed to have slumped (at least) another 5.0 percent this year to an annual rate of $3.43 billion (unadjusted for inflation), which is only 4.6 percent above the 1984 level ($3.28 billion)[30]. Employment declined over the DFAR period from 29.8 thousand in

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[30]If we assume a two percent inflation rate in 1991 and 1992, the 1990 constant dollar value of 1992 shipments would be $3.3 billion, which is only 0.5 percent above 1984.

1984 to an estimated 25.8 in 1992, down 13.4 percent. Production workers fell from 22 to 19.1 thousand, down 13.2 percent.

The drop in employment and the increase in shipments between 1984-1992 indicates productivity increased by about 20 percent (calculated as shipments per employee). If adjusted for inflation, the increase would be about to 16 percent. However, 1984 was not a good year for productivity, at only 87.5 (1987 = 100). If we assume a simple 2.0 percent inflation rate for the 1992 estimate, productivity rose only 0.8 percent from the 1987 base.

The industry has fragmented into smaller concerns. Fragmentation is accompanied with a drop in competitiveness and reduced R&D spending. Many firms have moved into niche markets, many of which are isolated from import pressures because of small volumes and cost penalties associated with the longer distances for foreign suppliers. However, by narrowing their focus, these firms are able to increase efficiency and better control costs. Seeking niche markets also sacrifices sufficient size to underwrite a strong R&D program, and risks greater volatility in shipments, which could hamper investment, especially in large, or long-term projects. The industry is also plagued with over-capacity which makes it difficult to pass cost increases through to customers. The list of firms that have gone out of business since the late 1970s continues to grow, and now exceeds 110.

Based on the survey results, the forging sector operated at only 50.8 percent of practical capacity in 1991, and suffered huge losses. Both employment and R&D outlays dropped 11 percent between 1990 to 1991. Investment has remained stable, but at rather low rates, and appears to be targeted toward cost reduction projects. At the same time, the age of equipment is at an all time high. Long-term debt fell as a percent of total assets in the last 5 years, which improved the short-term survivability of certain firms, but also indicates that almost no one is expanding capacity.

Nearly all the firms in the industry are looking for ways to cut production costs and raise efficiency. However, because of reduced cash flow many are deferring projects until the economy improves. This pent-up demand for investment will only materialize if the forging market is enlarged. Efficiency measured by work-in-process inventory turnover fell sharply during the 1980's, reaching a low in 1990 of only 9.14 - the fifth straight annual decline, and the ninth decline in the last 10 years. Many firms are in trouble financially.

MAJOR FINDINGS:

THE U.S. FERROUS FORGING INDUSTRY HAS DETERIORATED SINCE 1984.

1. **DEFENSE AND COMMERCIAL DEMAND DOWN** - Forging end-markets in the United States have declined, including defense, and are the major cause of the industry's problems. The Forging Industry Association reports that U.S. forging demand has decreased about 20 percent since the 1970's. While aerospace markets began its decline late in the period and plunged 16 percent in 1991. Automotive markets remained stable, industrial markets declined 47 percent, off-road vehicles plunged 63 percent, railroads fell 54 percent and all other contracted 45 percent.

2. **INDUSTRY FRAGMENTED** - The industry has fragmented into smaller size firms that have difficulty investing in expensive up-to-date equipment, and in sustaining a strong R&D program. This occurred primarily because high volume production lots, which are normally produced by larger firms, were lost to foreign suppliers. Both investment and R&D are down, and the risk of falling behind in the technology and overall competitiveness has increased.

3. **EQUIPMENT OLD** - The age of equipment is at an all-time high. Older equipment requires more maintenance personnel with greater skills. The average age of the labor force is increasing, and near its highest career pay level. Labor productivity is stagnant.

4. **PRODUCTION EFFICIENCY DECLINED** - Inventory turnover rates have declined since 1980, primarily because high volume lots were lost to foreign competitors. The result has been movement to smaller production lots which cannot be produced as efficiently. This also implies an erosion in international competitiveness.

5. **IMPORTS REMAIN HIGH** - Imports of forgings remain high, at an estimated 30-40 percent of the U.S. market. These are primarily high volume forgings.

THE NONFERROUS FORGING SECTOR IS WEAKENING

1. **DEFENSE DECLINES SEVERE** - The nonferrous forging industry has been impacted more by the drop in defense spending because of its greater orientation toward aerospace applications. This will continue as defense procurement budgets follow a downward trend over the foreseeable future.

2. **EXPORTS FOR TECHNOLOGY** - Since the nonferrous sector is internationally competitive, contracting domestic markets may be compensated for by increasing exports. However, exporting may be costly as foreign buyers are demanding technology transfer as part of the sales package. The risk is high that by the end of this decade, the U.S. nonferrous forging sector may no longer be the world-wide technology leader.

3. **SIGNS OF FRAGMENTATION** - Mild fragmentation has occurred in the nonferrous sector as shown by declining concentration ratios. Further fragmentation is likely if the market continues contracting.

4. **LARGE PRESSES IN TROUBLE** - The large presses in the United States used to manufacture forgings are of strategic importance for defense applications. However, their economic viability is now in question.

RECOMMENDATIONS:

1. Make maximum use of Defense Department MANTECH Programs to assist forging defense suppliers to modernize. The potential payback to the Department of Defense is very substantial. The focus should be on the production process, in an effort to reduce costs and increase the capital/labor ratio.

2. Encourage the forging sector to consolidate into larger more technically efficient firms that can both afford and justify investment in the latest technologies, and that take a global perspective.

3. Encourage industry management and unions within the forging sector to work closely in forming more efficient work rules, with fewer job titles, and with a view to increasing productivity.

4. Introduce the industry to the Department of Commerce's Technology Administration programs which assist firms in organizing to increase competitiveness. Programs that may be of particular interest include:

    a. Shared flexible centers for integrated manufacturing, and R&D consortiums. These programs are designed to help smaller firms form joint venture groups to create and/or lease production time on state-of-the-art factory flexible manufacturing systems (FMS); and to promote cooperative participation in shared risk R&D ventures.

    b. Vertically-oriented strategic partnerships that seek to bring together representatives up and down the forging supply chain (i.e., metal and tool suppliers, forgers, forging users) to encourage cooperation in innovation, improve communications, and discuss common problems.

5. Encourage statistical representatives from the Forging Industry Association and Department of Defense to meet with the Department of Commerce's Bureau of the Census to rectify current trade data shortcomings, or to explore possibilities for better government monitoring.

Appendix A - Letter from Defense

OFFICE OF THE ASSISTANT SECRETARY OF DEFENSE

WASHINGTON, DC 20301-8000

PRODUCTION AND LOGISTICS

19 JUN 1991

Mr. John Richards
Deputy Assistant Secretary
for Industrial Resource Administration
Room 3878
U. S. Department of Commerce
Washington, DC 20230

Dear Mr. Richards:

In following-on to our discussion of mutual support for industrial base assessments, I would appreciate your staff's assistance in assessing the domestic forging industry. The purpose of the review is to determine if a procurement restriction to domestic sources for mobilization base purposes that was instituted in 1984, is still necessary. Our preliminary analysis (Enclosed) indicates that the domestic industry may be weakening because barriers against U.S. exports are making investments in modernization and maintenance difficult.

The review will need priority attention as the Defense Acquisition Regulatory Council has informed us that the current procurement restriction is difficult to implement and urgently needs revision. Emphasis should be given to assessing the status of the industry; the effectiveness of the DoD procurement restriction; identifying export barriers that may exist; and identifying future action(s)/recommendations that may be required in order to ensure a responsive and viable domestic capability.

Please let me know whether your office will be able to provide assistance with assessing the forging industry. Mr. John DuBreuil or Mr. Marv Goldstein can be contacted on (703) 756-2310 to answer any questions you may have.

Sincerely,

John B. Todaro
Director, Production Base

Enclosures

RECEIVED JUN 26 199

Appendix B - Letter from Commerce

UNITED STA‹ S DEPARTMENT OF COMMERC
Bureau of Export Administration
Washington, D.C. 20230

JUL 22 1991

Mr. John B. Todaro
Director, Production Base
Production and Logistics
Department of Defense
Washington, D.C. 20301-8000

Dear Mr. Todaro:

I appreciate your recent suggestion that our offices work together on a study of the forgings industry. I look forward to expanding our cooperation on this and other industrial base issues.

Please have your staff contact Mr. Brad Botwin, Director of the Strategic Analysis Division (202) 377-4060, or Mr. John Tucker, the Division's Senior Industry Analyst (202) 377-3984, to schedule a meeting in the near future to further discuss this issue.

Sincerely,

John A. Richards
Deputy Assistant Secretary
for Industrial Resource Administration

Appendix C - Survey Instrument

 IRON AND STEEL FORGINGS, EMPLOYMENT BY CALENDAR QUARTER, 1972-1992

		<-------(in 000s)------->				
YEAR	QUARTER	ALL EMPLOYMENT	PRODUCTION WORKERS	AVERAGE WEEKLY HOURS	AVERAGE ($) WAGE	OVERTIME HOURS
1985	1st	37.7	29.1	42.2	12.22	4.1
1985	2nd	36.5	28.1	42.1	12.25	3.7
1985	3rd	34.5	26.2	41.7	12.36	3.7
1985	4th	33.7	25.7	42.5	12.13	4.1
1986	1st	33.3	25.7	42.4	12.40	4.0
1986	2nd	32.5	24.9	41.7	12.30	3.2
1986	3rd	30.8	23.5	41.1	12.48	3.4
1986	4th	29.8	22.9	41.4	12.39	3.5
1987	1st	30.2	23.2	42.0	12.46	3.6
1987	2nd	30.1	23.1	41.6	12.44	3.5
1987	3rd	29.8	22.8	41.3	12.53	4.0
1987	4th	30.8	23.6	43.3	11.95	5.0
1988	1st	31.4	24.1	43.0	12.72	4.5
1988	2nd	31.8	24.5	43.3	12.95	4.9
1988	3rd	31.3	24.0	42.8	13.10	4.8
1988	4th	32.5	25.0	43.9	12.77	6.0
1989	1st	33.3	25.7	44.3	13.43	5.9
1989	2nd	33.4	25.7	43.2	13.26	4.9
1989	3rd	32.9	25.4	41.8	13.70	4.3
1989	4th	33.2	25.6	42.0	13.64	4.0
1990	1st	33.0	25.3	42.3	12.97	4.0
1990	2nd	33.1	25.4	42.4	12.94	4.0
1990	3rd	32.8	25.0	42.3	12.97	4.3
1990	4th	32.8	25.0	42.3	12.97	4.0
1991	1st	32.4	24.6	42.2	12.94	3.6
1991	2nd	32.0	24.3	41.3	13.08	3.5
1991	3rd	31.0	23.4	40.3	13.40	3.4
1991	4th	30.8	23.3	41.0	13.18	3.5
1992	1st	30.0	22.6	41.5	13.29	3.2
1992	2nd	29.8	22.5	41.1	13.61	3.7

 IRON AND STEEL FORGINGS, EMPLOYMENT BY CALENDAR QUARTER, 1972-1992

YEAR	QUARTER	<-------(in 000s)-------> ALL EMPLOYMENT	PRODUCTION WORKERS	AVERAGE WEEKLY HOURS	AVERAGE ($) WAGE	OVERTIME HOURS
1972	1st	53.6	43.0	41.2	4.81	3.8
1972	2nd	53.9	43.4	41.8	4.91	4.3
1972	3rd	54.1	43.4	41.3	4.97	4.2
1972	4th	56.4	45.8	42.8	4.79	5.4
1973	1st	57.7	47.2	43.5	5.28	6.1
1973	2nd	58.3	47.6	43.0	5.31	6.1
1973	3rd	57.5	46.6	42.0	5.44	5.6
1973	4th	58.6	47.7	43.0	5.31	5.8
1974	1st	57.5	46.5	42.4	5.50	5.4
1974	2nd	58.6	47.7	41.6	5.58	4.7
1974	3rd	58.6	47.4	41.9	5.54	5.4
1974	4th	58.5	47.6	42.4	5.48	5.5
1975	1st	56.3	45.6	40.8	5.91	4.0
1975	2nd	53.6	42.9	40.7	6.11	3.9
1975	3rd	51.5	40.8	40.0	6.21	3.5
1975	4th	50.4	40.1	40.7	6.11	3.7
1976	1st	50.2	39.8	40.5	6.63	3.7
1976	2nd	50.3	40.2	39.7	6.74	3.4
1976	3rd	50.1	39.8	40.3	6.64	4.1
1976	4th	51.2	40.9	39.9	6.71	4.1
1977	1st	49.3	39.4	39.9	7.12	3.8
1977	2nd	48.8	39.1	40.5	7.31	4.0
1977	3rd	48.8	39.1	40.5	7.31	4.3
1977	4th	50.2	40.4	42.5	6.96	5.3
1978	1st	49.8	39.9	41.6	7.91	5.2
1978	2nd	49.4	39.6	42.2	7.90	5.1
1978	3rd	51.4	41.0	42.0	7.94	5.5
1978	4th	56.0	44.8	43.5	7.66	6.1
1979	1st	57.4	45.9	42.7	8.49	5.4
1979	2nd	58.1	46.4	37.8	8.44	3.7
1979	3rd	55.1	42.9	38.3	8.33	3.5
1979	4th	53.5	41.9	39.7	8.04	3.7
1980	1st	49.9	39.2	40.1	9.00	3.8
1980	2nd	46.6	36.1	40.3	9.25	2.9
1980	3rd	42.4	32.1	38.3	9.73	2.8
1980	4th	43.3	33.2	39.8	9.37	3.1
1981	1st	44.6	34.5	40.1	9.91	3.3
1981	2nd	45.7	35.4	40.5	10.08	3.2
1981	3rd	45.6	35.4	39.4	10.36	2.8
1981	4th	44.3	34.4	40.2	10.15	2.7
1982	1st	43.8	33.5	39.4	10.46	2.2
1982	2nd	40.0	30.3	38.7	10.84	2.0
1982	3rd	36.0	26.8	37.8	11.10	1.7
1982	4th	31.7	23.1	38.9	10.78	1.7
1983	1st	30.5	22.3	39.8	11.08	2.2
1983	2nd	30.5	22.7	40.1	11.44	2.7
1983	3rd	31.0	23.2	40.7	11.27	3.2
1983	4th	32.8	24.9	41.7	11.00	4.0
1984	1st	34.0	26.1	42.5	11.90	4.6
1984	2nd	35.7	27.6	42.5	11.95	4.4
1984	3rd	36.6	28.1	41.4	12.27	3.9
1984	4th	37.8	29.2	42.4	11.98	4.3

Appendix D - Labor Statistics

CERTIFICATION

The undersigned certifies that the information herein supplied in response to this questionnaire is complete and correct. The U.S. Code, Title 18 (crimes and Criminal Procedure), Section 1001, makes it a criminal offense to willfully make a false statement or representation to any department or agency of the United States as to any matter within its jurisdiction.

(Date)	(Signature of Authorized Official)
(Area Code/Telephone Number)	(Type or Print Name and Title of Authorized Official)
(Area Code/Telephone Number)	(Type or Print Name and Title of Person to Contact re this Report)

GENERAL COMMENTS

Please use the space below to provide any additional comments or information you may wish regarding your operations, foreign trade barriers/obstructions, or other related issues that impact your firm.

PART VI (continued)

BUSINESS GAINS/LOSSES (DFAR RELATED):

a. Has your firm been qualified for additional defense business as a result of the DFAR? yes___, no___ If yes, has this introduced you to new customers? yes___, no___

b. Please estimate the annual dollar value of foreign sourced forgings (previously used in defense systems) you have displaced with U.S. manufactured product as a result of the DFAR.

$______________

c. For dual use systems, please estimate the annual dollar value of business which was switched from commercial to defense applications and vice-versa for the last five years. Please list the reasons for these switches.

Switched to:	1987	1988	1989	1990	1991
Commercial					
Defense					

____

____

d. Please estimate, if any, the annual dollar value of foreign sourced forgings previously supplied to <u>commercial accounts</u> that you have displaced with U.S. manufactured product since the end of 1987.

$______________

OTHER IMPACTS OF THE DFAR: What other favorable or unfavorable impacts has the DFAR had on your U.S. forging operations?

____

____

____

PART VII INTERNATIONAL COMPETITIVENESS AND MARKETS

COMPETITIVE PROSPECTS: How do you view the competitive prospects for your firm's U.S. forging production operations over the next five years?

They should:
- improve greatly _____
- improve somewhat _____
- stay the same _____
- decline somewhat _____
- decline greatly _____

Please discuss the basis for your answer. ____

____

____

____

____

COMPETITIVE ADVANTAGES/DISADVANTAGES: What are the major competitive advantages/disadvantages you perceive for your firm over the next five years, and what measures are you taking to reduce the disadvantages?

____

____

____

COMPETITIVE FACTORS: Is your firm internationally competitive on a technology, cost and quality basis - and, if not what are you doing to rectify your weak areas?

____

____

____

PART VI FINANCIAL

PROFITABILITY: Please enter the financial information (in $000s) as specified below for the years 1987 to 1991. Include only dollar amounts that apply to your U.S. forging manufacturing operations.

	PROFITABILITY (in $000s)				
	1987	1988	1989	1990	1991
Net Sales (1)					
Cost of Goods Sold (2)					
Operating Income (3)					
Net Income before taxes (4)					

(1)Trade, plus intracompany transfers
(2)Includes materials and component purchases, direct labor, and other factory costs such as depreciation and inventory carrying costs.
(3)Difference between Net Sales and Cost of Goods Sold
(4)Operating income less general, selling and administrative expenses, interest expenses and other expenses, plus other income

FINANCIAL BALANCES: Please provide end of year balance sheet information (in $000s) as specified below for the years shown. Include only dollar amounts that apply to your U.S. forging manufacturing operations.

	FINANCIAL BALANCES (in $000s)				
	1987	1988	1989	1990	1991
Current Assets					
Current Liabilities					
Inventories					
Total Assets					
Equity					
Short Term Debt (1)					
Long Term Debt (2)					

(1) Principal payable in less than one year (2) Principal payable in more than one year

CREDIT RATING: What is your current credit rating? _______(based on S&P's debt rating service, or equivalent) If your credit rating changed in the last five years, please indicate from what to what, and the reason for the change.

____

____

PART V (continued)

TECHNOLOGY: For the following listed technologies, please indicate the level of use in your U.S. forging manufacturing operations.

	no interest	looking into	began using last 3 yrs	have used over 3 yrs
CAD/CAM				
Induction Heat Treat				
Robotics				
Non-Contact Gauging				
Flexible Cell Manufacturing				
Powder Metallurgy				
Just-In-Time				
Statistical Process Control				
Concurrent Engineering				
Total Quality Management				
Other*				

*Specify:____________________

PART V TECHNOLOGY

U.S. CONDUCTED RESEARCH AND DEVELOPMENT: Please enter your firm's forging related research and development (R&D) expenditures from 1987 to 1991 as requested below. Enter separately the dollar amounts (in $000s) expended for: 1) forging materials, 2) forging processing, and 3) product development. (See definition of Research and Development.)

	FORGING RELATED RESEARCH AND DEVELOPMENT EXPENDITURES (in $000s)				
	1987	1988	1989	1990	1991
Forging Materials					
Production Processes					
Product Development					
Total					

DEFENSE RELATED R&D: a) What percent (if any) of your 1990 U.S. R&D budget was expended specifically on defense related projects? b) What percent of your R&D budget expended primarily on commercial projects, also had direct benefits for defense?

a) defense related ______% b) commercial, with defense benefits______%

U.S. GOVERNMENT R&D: In what areas, perhaps those with longer term payoffs, could U.S. Government R&D spending be directed to assist the forging industry.

____

____

____

PART IV (continued)

GOVERNMENT SPONSORED PROGRAMS: (i.e., Industrial Modernization Incentive Program (IMIP) and Manufacturing Technology (Mantech) - see definitions)

a. Has your firm been involved in a Government sponsored IMIP or Mantech program(s) in your U.S. forging manufacturing operations at any time since the end of 1987?

If so, please identify:____

____

____

b. Has this modernization program(s) introduced your firm to new technologies?

please describe:____

____

____

c. Has the program(s):
- resulted in reduced lead times? _____
- lowered production costs? _____
- lowered prices to DOD? _____
- made you more competitive? _____

d. What problems still exist that these programs did not address?

____

____

____

PART IV INVESTMENT

INVESTMENT: Enter expenditures for plant, new machinery and equipment, and used or rebuilt machinery and equipment (in $000s) from 1987 to 1991, and projected amounts from 1992 to 1995 as requested below. Include only dollar amounts that apply to your manufacturing operations.

	INVESTMENT IN FORGING OPERATIONS (in thousands of dollars)		
	Plant	New Machinery and Equipment	Used or Rebuilt Machinery and Equipment
1987			
1988			
1989			
1990			
1991			
projected 1992			
1993			
1994			
1995			

AVAILABILITY OF MACHINE TOOLS AND EQUIPMENT: If you experienced any problems in the availability of machine tools or other manufacturing equipment that adversely affected, or that continues to adversely affect your U.S. forging manufacturing operations, please describe them below, and the actions you took to resolve them.

If none, check here____

____

____

____

____

PART III EMPLOYMENT INFORMATION

EMPLOYMENT: Enter the number of employees (end of year) from 1987 to 1991, as requested below. Please include only the workforce applicable to your forging manufacturing operations.

	1987	1988	1989	1990	1991
Scientists and Engineers					
Production Workers					
Administrative and Other					
Total					
Persons engaged in R&D included in above totals					

LABOR SHORTAGES: If you experienced any shortages or interruptions of labor, labor skills, or certain occupations in the last five years that adversely affected, or that continue to adversely affect your U.S. forging manufacturing operations, please describe them below, and the actions you took to resolve them.

If none, check here____

____

____

____

____

____

PART II (continued)

LEAD TIMES: For forgings produced by your firm, please estimate the normal time (in weeks) each of the operations indicated below contribute to total average lead times for: a) New Orders, and b) Repeat Orders. Beneath the itemized columns enter the time devoted to each operation. Since some of these operations overlap, or may run concurrently, enter the actual elapsed time beneath the cumulative columns. For repeat orders, assume design and engineering was previously accomplished, and materials are inventoried.

	NEW ORDERS (in weeks)		REPEAT ORDERS (in weeks)	
Operations	Itemized	Cumulative	Itemized	Cumulative
Design and Engineering				
Materials and Purchasing				
Tool Preparation				
Production Scheduling				
Queue Time				
In-process Time				
Packaging and Delivery				
Other				

MATERIAL AND SUPPLY SHORTAGES: If you experienced any shortages or supply interruptions of forging metals, materials, dies, tooling or other essential supplies in the last five years that adversely affected, or that continue to adversely affect your U.S. forging manufacturing operations, please describe them below, and the actions you took to resolve them.

If none, check here____

____

____

____

____

PART II FORGING CAPACITY AND PRODUCTION CONSTRAINTS

FORGING CAPACITY: Please estimate the 1991 annual forging capacity (in $000s and in units) of each of your U.S. (or Canadian) forging establishments and enter the information on the table below. (See definition of Practical Capacity)

Establishment Locality	Forging Capacity (in $000s)	Forging Capacity (in units)	Workforce Required at Capacity (#)	Ramp-Up Time* (in months)

*time it takes (in months) to reach capacity production from current level

BOTTLENECKS: For each establishment, identify the top three bottlenecks to ramp-up to capacity production. Please use the letter coded operations shown below (a thru h) to identify the bottlenecks, and after the letter code specify the bottleneck (e.g., f-machinists, or d-hammers). (See definition of Bottleneck.)

a-forging metals	e-testing
b-dies	f-labor
c-heat treatment	g-design/engineering
d-forging equipment	h-other (specify)

Establishment Locality	Bottleneck #1	Bottleneck #2	Bottleneck #3

PART I FIRM IDENTIFICATION AND SHIPMENTS

COMPANY NAME AND ADDRESS: Please provide the name and address of your firm or corporate division.

____

____

____

OWNERSHIP: If your firm is wholly or partly owned by another firm, indicate the name and address of the parent firm and extent of ownership.

____

____

____

Ownership:________%

ESTABLISHMENTS AND SHIPMENTS: Please provide the location of your forging manufacturing establishments in the United States (or Canada), and forging shipments (in $000s) from each location for 1990 and 1991.

				Shipments (in $000s)		
Establishment Locality	State	Zip Code	Type Forgings	1990	1991	Percent for Defense*

*Estimate the approximate percent of 1991 shipments ultimately used in defense systems

DEFINITIONS

BOTTLENECK - During a production expansion, the production process, operation or procedure, or material or labor requirement within your manufacturing establishment that would ultimately prevent or delay increased production.

DFAR - Defense Federal Acquisition Regulation - A restriction requiring domestic (U.S. or Canadian) manufacture of [certain] forgings purchased for military use has been in effect since May 24, 1984 (48 CFR 208.78). This restriction came at the direction of the Deputy Under Secretary of Defense for Research and Engineering in a memorandum for Secretaries of the Military Departments, titled - "Retention of Critical U.S. Forging Capability to meet National Defense Needs in an Emergency". The restriction was formalized in the DFARs in mid-1985. It was also updated several times, reaching its present form in August 1986.

ESTABLISHMENT - All facilities in which forgings are produced. Includes auxiliary facilities operated in conjunction with (whether or not physically separate from) such production facilities. Does not include wholly owned distribution facilities.

FIRM - An individual proprietorship, partnership, joint venture, association, corporation (including any subsidiary corporation in which more than 50 percent of the outstanding voting stock is owned), business trust, cooperative, trustees in bankruptcy, or receivers under decree of any court, owning or controlling one or more establishments as defined above.

FORGINGS - Ferrous or non-ferrous metal products shaped and endowed with improved mechanical properties, notably strength, by the action of hammering or pressing. Typically forged products include valves, pipe fittings and flanges, lifting attachments, crankshafts, connecting rods, parts for turbine engines, aircraft wing and engine attachments, landing gear, axle shafts, and countless other high performance parts.

INDUSTRIAL MODERNIZATION INCENTIVE PROGRAM (IMIP) - IMIP is a joint venture between Government and industry to reduce weapon system acquisition cost through the implementation of modern manufacturing processes and increased or accelerated capital investments. IMIP is formalized through a contractual business agreement with Government providing incentives for contractor capital investment.

MANUFACTURING TECHNOLOGY (MANTECH) - Information that is, or will be used to define, monitor, or control processes and equipment used to manufacture material for the Department of Defense. Its objective is: 1) the timely establishment or improvement of the manufacturing processes, techniques, or equipment required to support current and projected defense programs, and 2) assurance of the ability to produce, reduce lead time, ensure economic availability of end items, reduce costs, increase efficiency, improve reliability, or to enhance safety and anti-pollution measures.

PRACTICAL CAPACITY - Sometimes referred to as engineering or design capacity, this is the greatest level of output achievable within the framework of a realistic work pattern. In estimating practical capacity, please take into account the following considerations:

1. Under most circumstances assume the recent year's product mix. If no or little production took place during this period of a particular item or group of items which you have, or will have the capability to produce and can anticipate receiving orders for in the future, include a reasonable quantity as part of your product mix.
2. Consider only the machinery and equipment in place and ready to operate. Do not consider facilities which have been inoperative for a long period of time and, therefore, require extensive reconditioning before they can be made operative.
3. Take into account the additional downtime for maintenance, repair, or clean-up which would be required as you move from current operations to full capacity.
4. Do not consider overtime pay, added costs for materials, or other costs to be limiting factors in setting capacity.
5. Although it may be possible to expand output by using productive facilities outside your own, such as by contracting out subassembly work, do not assume the use of such outside facilities in greater proportion than has been characteristic of your operations.

PRODUCTION WORKERS - Persons, up through the line supervisor level, engaged in fabricating, processing, assembling, inspecting, receiving, storing, handling, packing, warehousing, or shipping. In addition, persons engaged in supporting activities such as maintenance, repair, product development, auxiliary production for your firm's own use, record keeping, and other services closely associated with production operations at your firm. Employees above the working supervisor level are excluded from this item.

RESEARCH AND DEVELOPMENT - Research and development includes basic and applied research in the sciences and in engineering, and design and development of prototype products and processes. For the purposes of this questionnaire, research and development includes activities carried on by persons trained, either formally or by experience, in the physical sciences including related engineering, if the purpose of such activity is to do one or more of the following things:

1. Pursue a planned search for new knowledge, whether or not the search has reference to a specific application.
2. Apply existing knowledge to problems involved in the creation of a new product or process, including work required to evaluate possible uses.
3. Apply existing knowledge to problems involved in the improvement of a present product or process.

SCIENTISTS AND ENGINEERS - Persons engaged in research and development work or production operations that have at least a four-year college education in the physical sciences or engineering (or work experience equivalent).

SHIPMENTS - Report dollar values of domestically (or Canadian) produced forgings shipped by your firm from each establishment during the reporting period for each category for 1990 and 1991. Such shipments should include inter-plant transfers, but should exclude shipments of products produced by other manufacturers for resale under your brand name. Do not adjust for returned shipments. Estimate the defense portion as a percent of total shipments from each establishment where requested. The defense portion of your business may be identified by those purchase orders having a DO or DX rating and/or a contract number from the Department of Defense, NRC, CIA, FAA, or NASA, as well as the orders of your customers whom you could identify as producing products for defense purposes, and items tested and certified to military specifications shipped to qualified distributors.

UNITED STATES - The term "United States" includes the fifty States, Puerto Rico, the District of Columbia, and the Virgin Islands.

Ref # 66

U.S. Department of Commerce
Bureau of Export Administration

OMB Approval Not Required: less than 10 respondents

NATIONAL SECURITY ASSESSMENT OF THE FERROUS AND NONFERROUS FORGINGS INDUSTRY

THIS REPORT IS REQUIRED BY LAW

Failure to report can result in a maximum fine of $1,000 or imprisonment up to one year, or both. Information furnished herewith is deemed confidential and will not be published or disclosed except in accordance with Section 705 of the Defense Production Act of 1950, as amended (50 U.S.C. App. Sec. 2155).

GENERAL INSTRUCTIONS

1. Please complete this questionnaire in its entirety as it applies to U.S. forging manufacturing operations. **Your response is due by April 10, 1992.** The survey has six parts as follows:

   PART I Firm Identification and Shipments
   PART II Forging Capacity and Production Constraints
   PART III Employment Information
   PART IV Investment
   PART V Technology
   PART VI Financial
   PART VII International Competitiveness and Markets

2. It is not our desire to impose an unreasonable burden on any respondent. IF INFORMATION IS NOT READILY AVAILABLE FROM YOUR RECORDS IN EXACTLY THE FORM REQUESTED,FURNISH ESTIMATES AND DESIGNATE BY THE LETTER "E".

3. Report calendar year data, unless otherwise specified in a particular question. Please make photocopies of forms if additional copies are needed.

4. Questions related to the questionnaire should be directed to Mr. John Tucker, Senior Industry Analyst, (202) 377-3984, U.S. Department of Commerce.

5. Before returning your completed questionnaire, be sure to sign the certification on the last page and identify the person and phone number to contact your firm.

6. Return completed questionnaire by April 10, 1992 to:

   U.S. Department of Commerce
   BXA/OIRA, Attn: Brad Botwin, Director,
   Strategic Analysis Division, Room H3878
   Washington, D.C. 20230