Technology and Its Impact on Labor in Four Industries

Tires/Aluminum
Aerospace/Banking

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U.S. Department of Labor
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Preface

This bulletin appraises some of the major technological changes emerging among selected American industries and discusses the impact of these changes on productivity and labor over the next 5 to 10 years. It contains separate reports on the following four industries: Tires and inner tubes (SIC 3011); aluminum (SIC 3334, 54, 55); aerospace (SIC 372, 376); and commercial banking (SIC 602).

This publication is one of a series which presents the results of the Bureau's continuing research on productivity and technological developments in major industries. Previous bulletins in this series are included in the list of BLS publications on technological change at the end of this bulletin.

The bulletin was prepared in the Bureau's Office of Productivity and Technology, Jerome A. Mark, Associate Commissioner, under the direction of Charles W. Ardolini, Chief, Division of Industry Productivity and Technology Studies. Individual industry reports were written under the supervision of Rose N. Zeisel and Richard W. Riche, by A. Harvey Belitsky (tires and inner tubes); Richard W. Lyon (aluminum); Charles L. Bell (aerospace); and Robert V. Critchlow (commercial banking).

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Chapter 1. Tires and Inner Tubes

Summary

The conversion of most of the industry's capacity to the production of radial tires, along with the total or partial closing of 26 plants during the period 1973-84, has greatly affected the tire and inner tube industry (SIC 3011).

The application of microprocessor-controlled instruments in tire manufacturing has advanced the pace of automation. However, the linkage of microprocessor controls to a central computer is only likely to become significant in the next 10 years, and the robot is still in the experimental stage in tire plants.

The output of tires declined at an average annual rate of −1.4 percent during 1973-84, but, assuming improvement in auto sales, the outlook is for a modest growth in output, despite the greatly improved service life of tires and substantial tire imports.

An average annual rate of productivity increase of 4.2 percent during 1973-84 was associated with a substantially greater decline in employee hours than in output. The productivity improvement was related primarily to the installation of new equipment to accommodate the shift in demand to radial tires.

In constant dollars, average annual plant and equipment outlays for the period 1970-82 were more than 10 percent higher than during 1960-70 because the industry found it necessary to make sizable investments in plant and equipment to produce radial tires.

Employment declined at an average annual rate of −1.7 percent during 1970-84, but there were sharp cyclical fluctuations during the period. In 1984, 94,000 persons were working in tire establishments, the lowest number since the early 1940's, and the decline is expected to continue. On the basis of its moderate version of economic growth, BLS projects an average annual decline of about 1 percent for the period 1984-95. It is likely that there will be greater worker involvement in the management of the production process.

Technology in the 1980's

The conversion to the production of radial tires, which started in the early 1970's, has had a major influence on the industry. The technological changes (together with cyclical movements) affected employment, productivity, labor-management relations, and other aspects of the structure of the industry.

In 1983, radial tires accounted for about 73 percent of all passenger tires: At least 84 percent of original-equipment tires and 70 percent of replacement tires. Excluding the bias-ply temporary spare tires, with which the newest automobiles are equipped, virtually all original-equipment passenger tires were radial in 1983. In the combined truck and bus tire market, radials accounted for about 36 percent of all tires: 47 percent of original-equipment tires and 34 percent of replacement tires. Diffusion of radials on commercial vehicles is expected to continue.

Technological improvements in tire belting materials (usually steel wire) are not expected to alter unit labor requirements significantly. Moreover, use of fiberglass belt tires by automobile manufacturers is not expected to increase, as had been anticipated. Some newer synthetic materials, such as aramid, are more durable (5 times stronger than steel), lighter in weight, and run cooler than steel-belted tires, and, therefore, may last longer.

Another development—the so-called "run-flat" tire—could eliminate the spare tire. However, it is still in an experimental stage of development.

Currently, the major technological improvements are the increasing application of microprocessor controls and the use of computer controls. While robot development and application are underway in the larger plants, according to industry spokesmen, data are not available on this technology. The effects of these technologies on labor requirements vary considerably, as summarized in table 1 and discussed below.

Microprocessor controls

The application of microelectronic technology—especially microprocessor controls—in new equipment and its adaptation to older machinery is greatly advancing the pace of automation in the industry. Microelectronic changes contrast sharply with such traditional changes as faster machines and better conveyorization.

A microprocessor-controlled instrument (MCI) controls functions in any programmable sequence and has several operating advantages over an instrument comprised of extensive relay controls, or mechanical switches that control electrical current. An MCI, consisting of a large-scale, integrated circuit or a set of integrated circuits, performs the functions of a central processing unit and is often used in combination with sensor devices. MCI's are cost effective at individual process levels where the greater power and range of computers are not required.

The principal improvements from the use of MCI's are usually evident in the reduction of defective parts and are associated with slightly lower unit labor requirements. Materials savings and energy conservation are additional benefits.

Moreover, operators can adapt quite readily to MCI's. The MCI may have a programmable controller, and the machine's operator only needs to select a combination of letters and numbers in order to make parameter changes. In addition, the variables of a process usually only require monitoring the measurements of components or stock that are on continuous display. Monitoring is aided by alarms that are set to prevent problems with material or a machine. The MCI is simpler than a network of relay controls, which may require considerable labor for wiring, debugging, and maintenance. However, maintenance personnel need a knowledge of electronics to maintain MCI equipment.

There is some uncertainty as to the rate of diffusion of MCI's. Athough the larger tire manufacturers are known to have undertaken substantial development of these technological improvements, data on their utilization are unavailable. Also, many companies have made substantive changes in the innovations introduced by firms mainly engaged in developing and manufacturing tire-producing equipment.

The linkage of microprocessor controls to a central computer and the utilization of robots are primarily in the experimental stage within single plants or at the central research and development facilities of tire manufacturing companies.

The technological improvements in controls have been generally limited to some processes of tire manufacturing, or to only portions of processes. The processes include: Stock preparation and mixing of materials; component preparation or extrusion of treads, beads, belts, and plies; calendering, in which liquid rubber is applied to steel, fiberglass, or polyester webs to form the plies; tirebuilding, in which components are assembled on building drums; molding and curing, in which steam and temperature cycles are controlled; and testing and inspection.

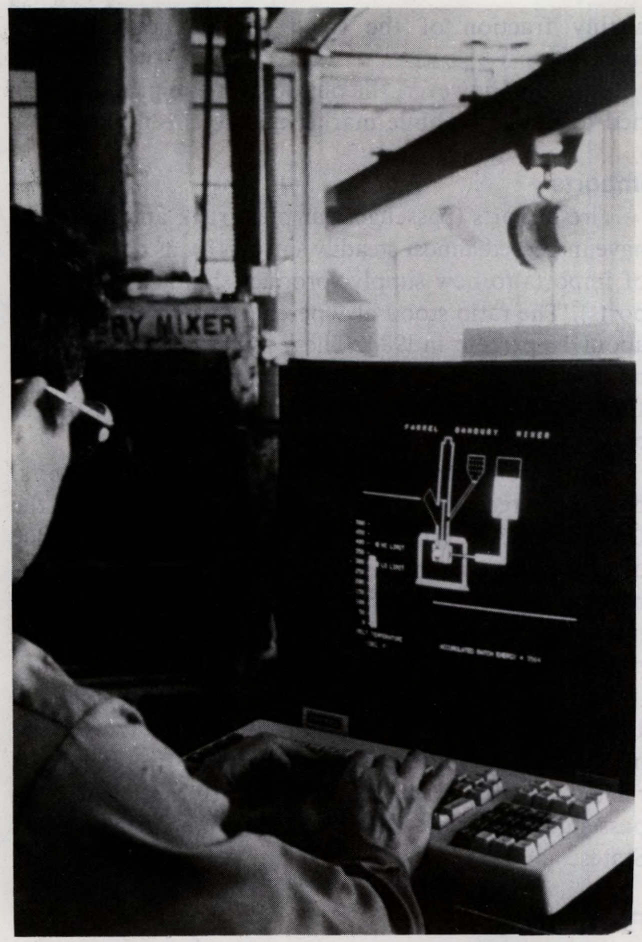
While MCI's have been applied to all of the tire manufacturing processes, substantial reductions in unit labor requirements have resulted in only the two following processes.

MCI in tirebuilding. Unlike the application of only MCI's in most of the processes, at least two plants have consolidated their tirebuilding microprocessors into a computer-controlled station. In these plants, virtually full automation of the process occurs after tire components are taken to a station, and a computer program automatically controls the building of the tires. This automated process is applied to 10-20 percent of passenger radial tires.

Labor requirements are sharply reduced in what is the most labor-intensive process, with only one or two workers needed to monitor a station.

Table 1. Major technology changes in tires

Technology	Description	Labor implications	Diffusion
Microprocessor-controlled instrumentation (MCI)	Computer-like device, consisting of a large-scale integrated circuit or set of circuits which perform the functions of a central processing unit. A controller on the MCI is programmable. MCI replaces a large network of relay controls.	Operator on simplest MCI's only needs to manipulate programmed symbols; no training needed for operator familiar with relay controls. May be associated with slightly lower labor requirements.	See tirebuilding and testing below.
MCI in tirebuilding	Consists of consolidation of microprocessors into a computer-controlled station. Full automation after tire components are taken to station.	Sharply reduces the most labor-intensive process since only 1 or 2 workers needed to monitor the station.	Used for 10-20 percent of passenger radial tire capacity. Diffusion expected to increase rapidly during next 5-10 years.
MCI in testing and inspection	Microprocessors, which may be coordinated with a computer, used in acquiring data from testing instruments. Greatly increases amount of data received, automatically processed, and used for rapid decision-making.	Sharp overall reduction in labor requirements, including some workers engaged in visual inspection. Replaces operators who analyzed X-rays and made decisions.	MCI's found in more than 80 percent of the largest firms; likely to be diffused to all firms within less than 10 years.
Computer applications:			
Linkage of microprocessor controls into host computer	All or most processes in tire manufacturing can be coordinated by computer.	Labor requirements are sharply reduced in some processes.	Usage is expected to accelerate from a modest level during next 5-10 years.
Computer-aided design (CAD)	A great deal of modeling is possible, and tread designs can be derived much more rapidly.	The need for drafters is greatly reduced.	CAD may account for 75 percent of all design work, and continued increase is expected.



An operator programs a microprocessor-controlled batch-mixing system that processes rubber compounds.

There are at least two obstacles to the development of this automated process by more manufacturers of radial tires. They are: (1) The complication of an additional tirebuilding stage for radials that is absent in the production of bias and bias-belted tires; and (2) the wide variety of tire types and sizes that need to be produced. Nevertheless, it is expected that the use of this technology will increase in the next 5-10 years.

MCI in testing and inspection. The use of microprocessors to acquire data from testing instruments has greatly increased the amount of data that can be received, automatically processed, and used for rapid decision-making. MCI's are used in two forms of testing: (1) Tire endurance, which is otherwise tested by an imaging system that uses X-ray; and (2) tire uniformity, which is primarily related to balance and assumes special importance with regard to radial tires. In at least one plant of a large manufacturing company, testing for uniformity is coordinated by a computer that relies on programming from the firm's research and development facility.

In some plants, the number of workers required in testing and inspection in radial tire production has been sharply reduced. The displaced workers include the rather skilled operators who analyzed X-rays, graphs, and charts and then made decisions on the basis of much less data than are currently available. Fewer workers are also needed for visual inspection.

The use of MCI's in this process is found in more than 80 percent of the facilities of the largest firms, and is likely to be diffused to all firms within less than 10 years.

Computer applications

The diffusion of microprocessor controls that are linked into so-called host computers is expected to accelerate from a modest level during the next 5-10 years. Several of the larger companies are working on computers to control (or coordinate) all or most of the processes in tire manufacturing. The linkage of various controls into a central computer can insure the overall efficiency of individual microprocessors. The declining cost of the computer memory and the availability of more powerful microprocessors could facilitate linkage with a central computer.

While computer control does not significantly reduce labor requirements in all of the processes, necessary technical adjustments are made more efficiently than by an operator. For example, in calendering, the computer presents a model of the process, and any needed adjustment can be made automatically.

Tire manufacturers are also applying computers in important ways that are not directly associated with production. For instance, perhaps 75 percent of all design work is performed by computer-aided design (CAD). Diffusion of the technology is expected to increase because it sharply reduces unit labor requirements. CAD, which permits a great deal of modeling, is very extensively used to derive tread designs and is much faster than designing without computers. CAD has resulted in a considerable reduction in the number of drafters required. For example, in the mold design department of one plant, the number of drafters was reduced 80 percent.

Robot applications

According to industry representatives, a variety of different robot applications by the larger tire manufacturers is underway, but data on the extent and nature of their use are unavailable. Since special handling equipment is less costly than robots, and considerable variation exists in product mix, robots may not yet be widely applicable. But one company is using robots, at least experimentally, in tirebuilding. The robots load and unload components from conveyors and pick up and combine components. It was also reported that robots can perform rather sophisticated tasks, including design work. Greater use of robots is expected and may be stimulated by systems under development which incorporate 10 to 20 independent microprocessors.

Output and Productivity Trends

Output

About 209 million passenger car, truck, and bus tires were produced in 1984. This was 11 percent below the peak number of tires produced in 1977, but roughly at the level of output in 1974.

The output of tires fluctuated sharply in 1970-84, largely in response to two major recessions. On average for the 14 years, output registered a small annual decline of −0.5 percent (chart 1). During the first years (1970-73), output increased at an exceptionally rapid rate of 7.6 percent annually, but this was offset by an average decline of −1.4 percent in the next 11 years, 1973-84. In the latter period, output fell in six of the years, including double-digit rates of decline in 1975 and 1980. The industry's output experience in 1970-84 contrasted sharply with the very rapid rate of output growth during 1960-70.

Even during 1960-75, when the average annual rate of increase in output was 5.0 percent, the rate of increase grew smaller in successive 5-year periods. Passenger car tires, which accounted for 83 percent of all tires (passenger car plus truck and bus) produced in 1984, have been greatly affected by cyclical and secular changes in both the original-equipment and replacement tire markets. Replacement tires accounted for 70-79 percent of domestic passenger car tires in 1970-84.

Several reasons account for the declining output of passenger car tires over the decade. The greater longevity of tires has been an important factor in the replacement market. Within a short period of time, tire service life has been doubled as a result of, first, the wide adoption of bias-belted tires and, later, of steel-belted radial tires. Similarly, the longer wearing rear tires on the rapidly growing share of automobiles with front-wheel drive more than offset the faster wearing front tires on such cars. Moreover, when gasoline prices increased and remained relatively high, the average annual miles driven in passenger cars declined, and, until recent years, this had a negative impact on the replacement tire market.

The original-equipment tire market has, of course, been severely depressed by the reduction in domestic car sales. Sales of new cars averaged 6.7 million during 1980-84, only 79 percent of the average sales in the previous 5 years and at the levels of 1960-64.

While greatly improved service life will place limits on expansion in passenger tire output, some analysts believe that the outlook is for modest growth in view of the higher average age of cars, the possibility of a greater number of miles being driven, and an increase in the number of people of driving age. A further factor is the weight-saving "mini-spares" on most new automobiles, which have only a tiny fraction of the tread life of normal spare tires.

Basically, however, the outlook for tire production is tied to the automobile market and to tire imports.

Imports

Tire imports (passenger car plus truck and bus tires) have increased almost steadily since 1970, as did the ratio of imports to new supply (product shipments plus imports). The ratio stood at 9 percent in 1973 and rose to about 16 percent in 1984. These imports, moreover, do not include the tires mounted on imported vehicles. In 1984, the market share (in units) of imported passenger cars was 23 percent, up from 15 percent in 1973.

Sharp competition exists not only from imports, but, more recently, from tire plants established in the United States by foreign firms. In the last few years, one of the foreign firms with plants in this country has become the sixth largest tire producer. The six largest tiremakers account for more than 80 percent of total tire production.

The export/shipment ratio was about 4 percent in 1984, compared with 2 percent in 1970 and 2 1/2 percent in 1973. A potential expansion in U.S. tire exports is related to the faster annual growth anticipated in passenger car registrations abroad than in the United States.

Productivity

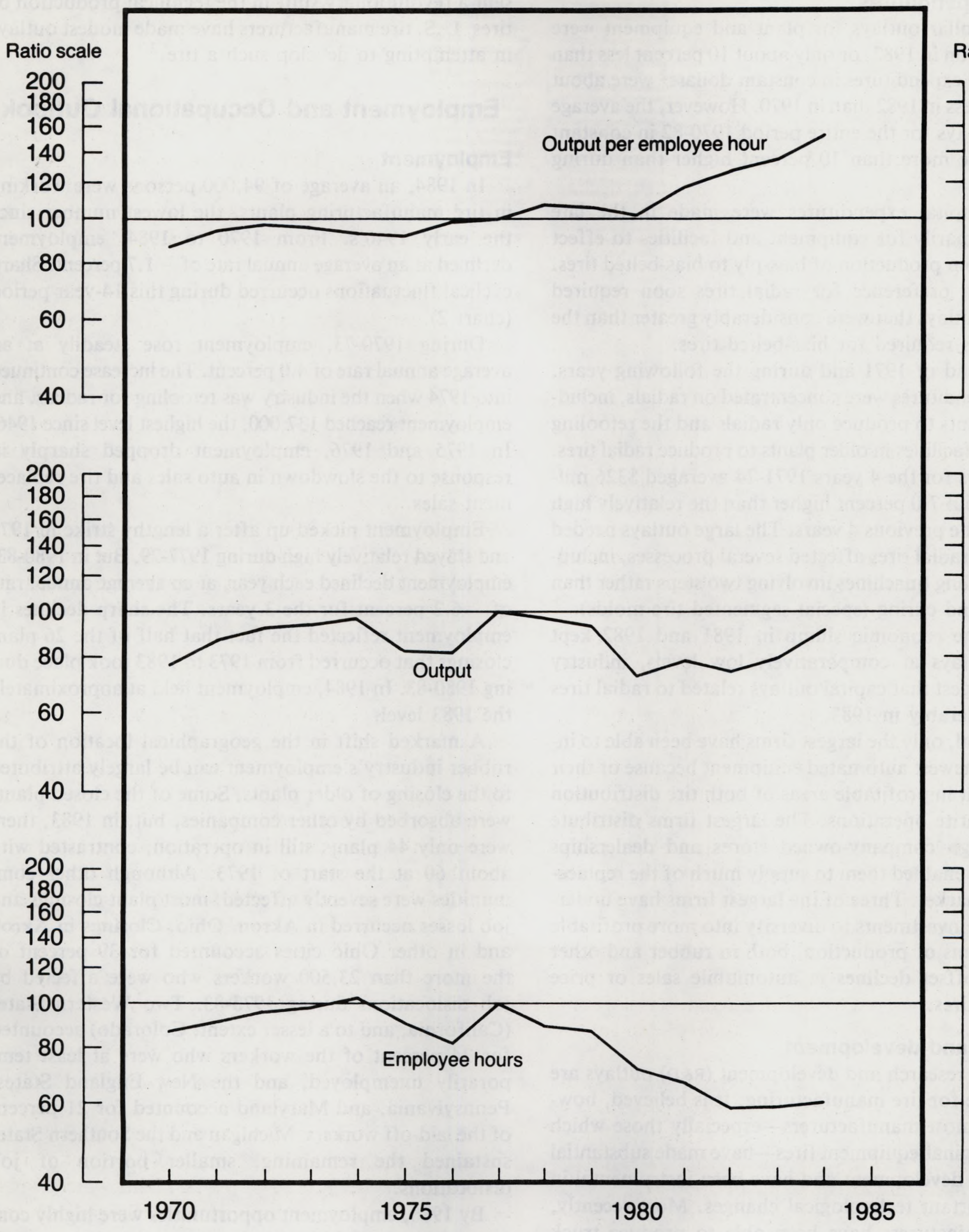
Productivity increased during 1970-84 at an average annual rate of 3.2 percent, compared with 4.0 percent during 1960-70. However, the productivity advances in the two periods were associated with vastly different changes in output and hours. During 1960-70, output rose 6.0 percent annually, while employee hours grew at one-third that rate. In contrast, the productivity increase during 1970-84 was associated with a decline in output (−0.5 percent annually) and a very sharp drop in hours (−3.6 percent). In the early years of the last decade (1970-73), productivity increased less than 3.0 percent annually, but thereafter, in 1973-84, rose more rapidly at the rate of 4.2 percent per year.

The productivity increase during 1973-84 reflected to a large extent the removal from production of older equipment. Of particular note were 26 plant closings within the 11 years.[1] The degree of obsolescence of tiremaking equipment was considerably lowered in that period, in part because 21 of the 26 plants which closed were manufacturers of bias-ply tires. Specialized and more efficient equipment to accommodate the growing demand for radial tires had not been fully installed in many of those plants. In the 6 years ended in 1984, productivity rose at an annual rate of 6.4 percent as the drop in hours far outstripped the decline in output.

[1] Two were partial closings.

Chart 1. Output per employee hour and related data, tires and inner tubes, 1970-84

(Index, 1977 = 100)



Source: Bureau of Labor Statistics.

Investment

Capital expenditures

While dollar outlays for plant and equipment were $235.6 million in 1982, or only about 10 percent less than in 1970, the expenditures in constant dollars[2] were about 55 percent less in 1982 than in 1970. However, the average annual outlays for the entire period 1970-82 in constant dollars were more than 10 percent higher than during 1960-70.

Large capital expenditures were made in the late 1960's, primarily for equipment and facilities to effect the shift from production of bias-ply to bias-belted tires. However, a preference for radial tires soon required retooling outlays that were considerably greater than the sizable ones required for bias-belted tires.

By the end of 1971 and during the following years, capital expenditures were concentrated on radials, including new plants to produce only radials and the retooling of bias-tire facilities in older plants to produce radial tires. Real outlays for the 4 years 1971-74 averaged $326 million, or about 7.0 percent higher than the relatively high outlays in the previous 4 years. The large outlays needed to produce radial tires affected several processes, including tirebuilding (machines involving two steps rather than one step) and curing (special segmented tire molds).

While the economic slump in 1981 and 1982 kept capital outlays at comparatively low levels, industry reports suggest that capital outlays related to radial tires rose considerably in 1983.

In general, only the largest firms have been able to invest in the newest automated equipment because of their involvement in profitable areas of both tire distribution and of nontire operations. The largest firms distribute tires through company-owned stores and dealerships which have enabled them to supply much of the replacement tire market. Three of the largest firms have undertaken large investments to diversify into more profitable nontire forms of production, both in rubber and other fields, to offset declines in automobile sales or price cutting in tires.

Research and development

Data on research and development (R&D) outlays are unavailable for tire manufacturing. It is believed, however, that most manufacturers—especially those which provide original-equipment tires—have made substantial outlays for development and have been instrumental in some important technological changes. Most recently, U.S. manufacturers have been able to produce truck radials that can be retreaded, as was possible much earlier on foreign makes. At the same time, firms that supply the tire manufacturers with machinery and materials have developed technological advances in tire manufacture.

[2] Capital expenditures deflated by the implicit price deflator for producers' durable equipment.

A foreign firm is apparently the leader in the development of a liquid-injection molded tire that would represent a revolutionary shift in the technical production of tires. U.S. tire manufacturers have made modest outlays in attempting to develop such a tire.[3]

Employment and Occupational Outlook

Employment

In 1984, an average of 94,000 persons were working in tire manufacturing plants, the lowest number since the early 1940's. From 1970 to 1984, employment declined at an average annual rate of −1.7 percent. Sharp cyclical fluctuations occurred during this 14-year period (chart 2).

During 1970-73, employment rose steadily at an average annual rate of 4.0 percent. The increase continued into 1974 when the industry was retooling for radials, and employment reached 137,000, the highest level since 1946. In 1975 and 1976, employment dropped sharply in response to the slowdown in auto sales and tire replacement sales.

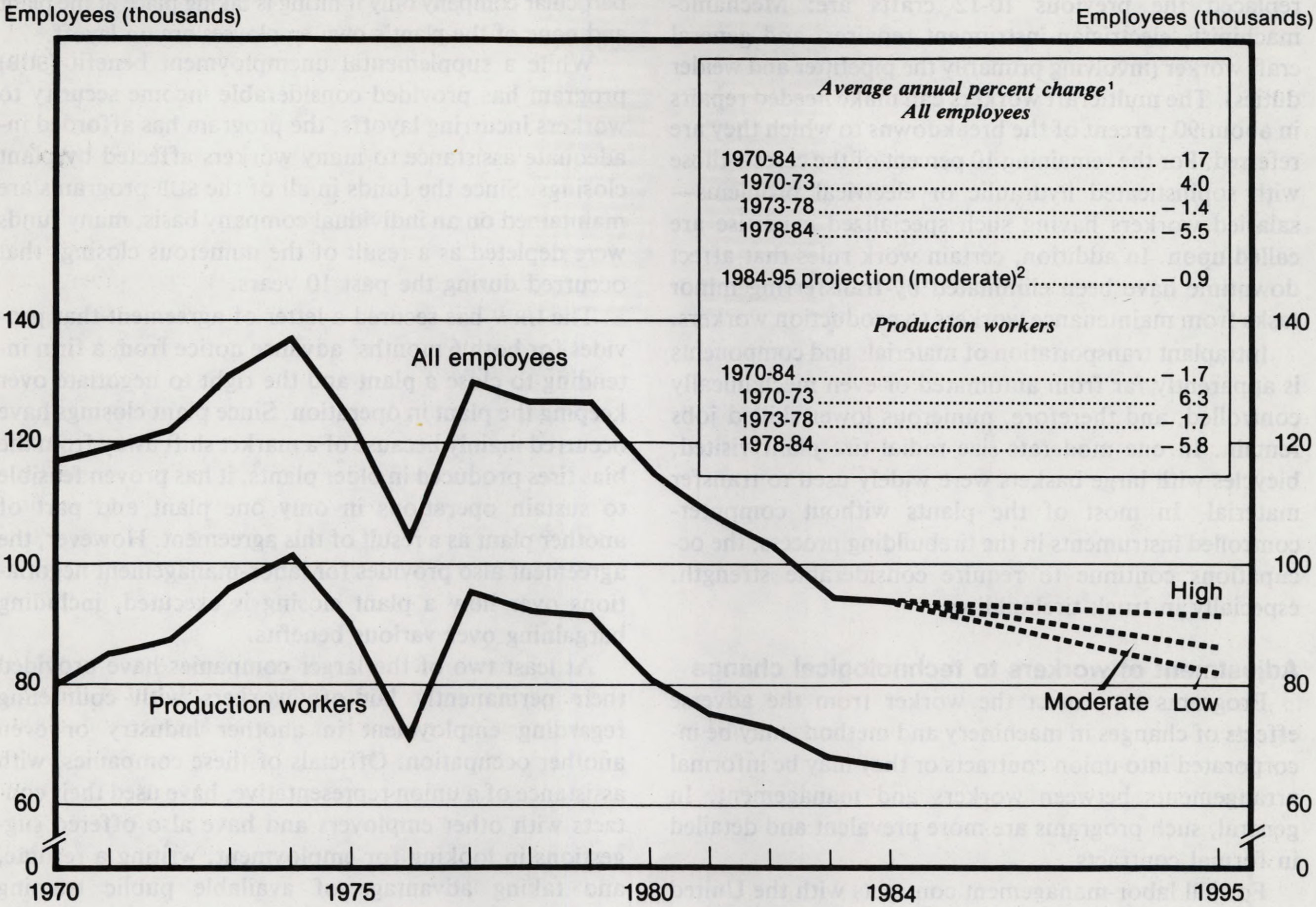
Employment picked up after a lengthy strike in 1976 and stayed relatively high during 1977-79. But in 1980-83, employment declined each year, at an average annual rate of −6.2 percent for the 3 years. The sharp declines in employment reflected the fact that half of the 26 plant closings that occurred from 1973 to 1983 took place during 1980-83. In 1984, employment held at approximately the 1983 level.

A marked shift in the geographical location of the rubber industry's employment can be largely attributed to the closing of older plants. Some of the closed plants were absorbed by other companies, but, in 1983, there were only 44 plants still in operation, contrasted with about 60 at the start of 1973. Although other communities were severely affected, most plant closings and job losses occurred in Akron, Ohio. Closings in Akron and in other Ohio cities accounted for 39 percent of the more than 23,500 workers who were affected by job dislocations during 1973-83. Two Western States (California, and to a lesser extent, Colorado) accounted for 24 percent of the workers who were at least temporarily unemployed, and the New England States, Pennsylvania, and Maryland accounted for 21 percent of the laid-off workers. Michigan and the Southern States sustained the remaining, smaller portion of job dislocations.

By 1980, employment opportunities were highly concentrated in the Southern States. As a result of new plants and major investments in existing plants, more than two-thirds of total tire capacity was located in the South, or nearly double the share of capacity in that region in 1970.

[3] *Business Week,* Dec. 26, 1983, pp. 44B, 44D.

Chart 2. Employment in tires and inner tubes, 1970-84, and projections, 1984-95



[1]Least squares trends method for historical data; compound interest method for projections.
[2]See text footnote 4.
Source: Bureau of Labor Statistics.

The ratio of production workers to all employees was generally over 70 percent during 1970-84. This relatively stable ratio reflects the difficulty of fully automating and coordinating the control of the tire manufacturing processes and the fact that production of a radial tire requires more labor per tire than a nonradial tire. The average ratio of production workers to all employees was slightly higher in the tire industry than in total manufacturing in 1984.

The Bureau of Labor Statistics, on the basis of its moderate version of economic growth, projects an annual decline of about 1 percent in the industry's overall employment to 1995 from the very low level in 1984.[4] Based on this projection, employment in 1995 would continue to be well below the levels of the first half of the 1980's.

Occupations

As indicated in the technology section, the use of microprocessor controls has not required radical adjustments by the workers trained in older technologies. In general, the number of operators and maintenance workers has not been sharply reduced. No entirely new jobs have resulted from the technological changes; the duties for some occupations have been simplified.

However, the use of computers to coordinate microprocessor-controlled instruments and computer-aided design can have considerable impact upon some occupations. With computers controlling instruments, the number of operators needed is sharply reduced and only a small number of programmers may be required, especially if the software is developed at a firm's central R&D facilities. Computer-assisted drafting greatly reduces the need for drafters, but a stronger background in mathematics is required for those still employed in design.

Major changes have occurred in the job duties of maintenance workers and some other occupations as result of management's attempt to reduce labor requirements and improve efficiency. Workers in the various traditional craft occupations have been replaced by a much smaller number of multicraft maintenance

[4] BLS projections for industry employment in 1995 are based on three alternative versions of economic growth. For details on assumptions and methodology used to develop these projections, see the *Monthly Labor Review*, November 1985.

workers. In one company, 3 basic classifications that have replaced the previous 10-12 crafts are: Mechanic-machinist, electrician-instrument repairer, and general craft worker (involving primarily the pipefitter and welder duties). The multicraft workers can make needed repairs in about 90 percent of the breakdowns to which they are referred. For the remaining 10 percent of the cases—those with sophisticated hydraulic or electrical problems—salaried workers having such specialized expertise are called upon. In addition, certain work rules that affect downtime have been eliminated by transferring minor tasks from maintenance workers to production workers.

Intraplant transportation of materials and components is apparently far from automated or even mechanically controlled, and therefore, numerous lower skilled jobs remain. In one moderate-size radial tire plant visited, bicycles with large baskets were widely used to transfer material. In most of the plants without computer-controlled instruments in the tirebuilding process, the occupations continue to require considerable strength, especially in truck tirebuilding.

Adjustment of workers to technological change

Programs to protect the worker from the adverse effects of changes in machinery and methods may be incorporated into union contracts or they may be informal arrangements between workers and management. In general, such programs are more prevalent and detailed in formal contracts.

Formal labor-management contracts with the United Rubber, Cork, Linoleum and Plastic Workers of America (URW) cover nearly 80 percent of the production workers in this industry, somewhat lower than the percentage of workers covered in 1970. The decline in union coverage is primarily associated with the numerous plant closings in the highly organized North and the new facilities often located in rural southern communities that have a lower rate of unionization.

Although the bargaining agreements do not include a requirement for advance notice of technological change, it is often the practice of management to inform a local URW representative about the intended introduction of a technological change. The plant-wide seniority system which prevails in agreements provides a measure of job security when technological change takes place. While a recent agreement placed some limitations on the number of laid-off workers who may transfer into another job classification, workers whose jobs are eliminated may use their seniority to qualify for training that will enable them to displace workers in other positions who have less seniority.

A small proportion of all permanently laid-off tire workers have used their transfer rights under a preferential hiring clause to secure employment in other plants covered by the URW's master contract. Under the clause, laid-off workers receive preference at another plant of a particular company only if hiring is taking place at the plant and none of the plant's own employees are on layoff.

While a supplemental unemployment benefit (SUB) program has provided considerable income security to workers incurring layoffs, the program has afforded inadequate assistance to many workers affected by plant closings. Since the funds in all of the SUB programs are maintained on an individual company basis, many funds were depleted as a result of the numerous closings that occurred during the past 10 years.

The URW has secured a letter of agreement that provides for both 6 months' advance notice from a firm intending to close a plant and the right to negotiate over keeping the plant in operation. Since plant closings have occurred mainly because of a market shift away from the bias tires produced in older plants, it has proven feasible to sustain operations in only one plant and part of another plant as a result of this agreement. However, the agreement also provides for labor-management negotiations over how a plant closing is executed, including bargaining over various benefits.

At least two of the larger companies have provided their permanently laid-off workers with counseling regarding employment in another industry or even another occupation. Officials of these companies, with assistance of a union representative, have used their contacts with other employers and have also offered suggestions in looking for employment, writing a resume, and taking advantage of available public training opportunities.

Beginning in 1976, the bargaining contract has provided workers with various forms of financial assistance when plant closings have not been avoidable. For example, laid-off workers can retire with full pension benefits if they have 25 years of service. Workers who are ineligible for retirement can receive special separation payments that are graduated on the basis of years of service, with such payments being in lieu of any deferred pension benefits.

The apprenticeship training for the three basic job classifications that cover many maintenance skills has considerably changed from the traditional program. The course is 20 to 24 months long as opposed to the earlier 48-month course. While most of the training continues to be on the job, a home-study form of training consisting of numerous relatively short learning units with specific objectives is also provided.

Arrangements are likely to continue for additional worker involvement in the management of production processes, initiated in at least some of the larger firms during recent years. A rationale for such involvement is the interest in lowering absenteeism. In several plants that have participative management, the workers are given the opportunity to discuss or suggest improvements in production or to make suggestions about improving their own jobs.

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Chapter 2. Aluminum

Summary

Technological changes in the aluminum industry (SIC 3334 and 3353-55) primarily involve modification of conventional processes rather than radical changes in technology. Specific innovations being introduced include improvements in the vessels (or pots) in which molten aluminum is produced by an electrolytic process, more energy-efficient furnaces that produce anodes used in the pots, the introduction of computer control and advanced instrumentation, continuous casting, and improved material handling. Benefits include lower energy and labor requirements and higher quality.

Output in the aluminum industry is responsive to developments in the general economy. In primary aluminum, output increased at an average annual rate of only 0.6 percent during 1970-84; in the fabricating sector, which includes rolling, drawing, and extruding mills, output increased at a higher 2.0-percent annual rate. In both sectors, output gains were highest during the earlier years of this period and fell sharply during 1974-75 and 1981-82, periods when the economy was depressed. The outlook is for aluminum shipments to extend recent gains and to increase over the next several years, with the largest markets in containers and packaging, building and construction, and transportation. However, prospects for primary production are less favorable as high power costs, increased imports of ingots, and recycling of aluminium are expected to result in further reductions in U.S. capacity.

Productivity (output per employee hour) increased in both primary aluminum and fabricating during 1970-84. In primary aluminum, output per employee hour increased at an average annual rate of only 1.0 percent over this period—well below the gains achieved in fabricating mills, where output per employee hour rose at an annual rate of 2.7 percent. In both sectors, productivity declined during the recession period 1974-75, but increased significantly from 1982 to 1984 as output rose in the economic recovery.

Between 1970 and 1981, the aluminum industry allocated $3.7 billion (constant 1972 dollars) to increase capacity and improve efficiency. The largest share of spending (57 percent) was by firms in the fabricating sector. The aluminum industry is capital intensive, and capital expenditures per production worker in both primary aluminum and fabricating were well above the average in all manufacturing.

Employment in the segments of the aluminum industry covered in this bulletin declined from 91,700 to 82,600 workers—by 9.9 percent—over the period 1970-84. The sharpest rate of decline was in primary smelters. Employment in both sectors fell during the mid-1970's and during 1980-82 when the general economy was weak. However, prospects for employment growth appear improved based on an increase in demand for aluminum associated with the upturn in the economy which began in 1983.

New technology has not resulted in widespread displacement; the general market demand for aluminum has been the major factor affecting the level of employment. Although most occupations are expected to continue to involve generally the same skills, innovations such as computer process control and advanced instrumentation have modified job requirements of some key occupations, including potline tenders and rolling mill operators. Their duties involve more extensive monitoring of production operations from modern control stations and fewer manual tasks.

In newly constructed plants where state-of-the-art technology is in place, the number of potline tenders, rolling mill operators, and other production workers per unit of output is less.

Importantly, energy requirements in new plants are sharply lower than in older facilities. The aluminum industry has made substantial progress in energy conservation; the Aluminum Association reports that a pound of aluminum in 1983 shipped as a finished or semifinished product required nearly 22 percent less energy than in 1972.

The aluminum industry is highly unionized, and work force adjustments associated with new technology and other changes have been handled in the context of general provisions of collective bargaining agreements.

Industry Structure

The industry covered in this bulletin consists of both primary plants (or smelters) (SIC 3334), where alumina, refined from bauxite, is converted to aluminum through an electrolytic process, and the fabricating sector of the industry (SIC 3353, 54, 55), where aluminum is converted into sheet, plate, bar, tubing, and other basic shapes through rolling, drawing, and extruding operations.[1]

The aluminum industry has grown rapidly, particularly since World War II, and shipments of aluminum products exceed those of copper and other leading nonferrous metals. Aluminum is a versatile metal, lightweight and corrosion resistant, and is used for products ranging from beverage containers to missiles and jets. The top three markets in 1983 were containers and packaging, building and construction, and transportation.

Because the industry is energy intensive, primary aluminum plants are located near sources of abundant power. Establishments engaged in fabricating aluminum products are more widely dispersed and located closer to markets.

In 1984, about 82,600 workers were employed in the sectors of the industry covered by this bulletin, with nearly 3 out of 4 employees engaged in rolling, drawing, and extruding operations.

Technology in the 1980's

Technological change in the aluminum industry generally involves an improvement in a segment of the process of smelting and fabricating aluminum within an existing plant. When new facilities are constructed, however, the level of technology is generally higher than in older plants, and energy costs and labor requirements per unit of output are lower. New technology has allowed some plants to remain competitive, thereby maintaining jobs and capacity in the United States.

The aluminum industry has been spending substantial sums to modernize plant and equipment. Specific innovations in primary plants include improvements in the design of the pots, where molten aluminum is produced by an electrolytic reduction process; the installation of improved linings and insulation in the pots; and the introduction of computer process control to monitor production. Other innovations include new types of furnaces which lower energy and labor requirements in the production of the carbon anodes used in the "prebaked anode" pots, and improved casting equipment to produce billets and ingots for shipment to fabricating plants. In the development stage are innovations such as direct reduction and electrolysis of aluminum chloride, which differ significantly from the long-standing Hall-Heroult method of producing aluminum.

In aluminum fabrication, improvements in rolling and drawing mills include computer control, advanced instrumentation, and larger capacity equipment. In extruding operations, more powerful and more highly automated presses and material handling systems are major changes. In addition, dies used in extruding presses are being are being produced by computer-aided design and computer-aided manufacturing (CAD/CAM) methods which improve product quality, and some applications of continuous extrusion systems are being introduced. Continuous casting is a highly efficient process in limited use to produce mill stock for finished rolled products.

A description of major technological improvements in the aluminum industry, their impact on labor, and prospects for further diffusion are summarized in table 2. A more extensive discussion of the impact of technology on the work force is contained in the section on employment and occupational trends.

[1] The industry examined excludes establishments primarily engaged in recovery of aluminum from scrap (the secondary industry), which is part of SIC 3341, secondary smelting and refining of nonferrous metals. Also excluded are aluminum foundries (castings), which are classified as SIC 3361, and aluminum forgings, which are part of SIC 3463, nonferrous forgings.

Table 2. Major technology changes in aluminum

Technology	Description	Labor implications	Diffusion
Primary aluminum			
Improved Hall-Heroult reduction technology	Larger reduction cells, or pots, that handle higher currents, allow greater production without increased voltage. Other changes include larger, more efficient anodes; computer process control; use of silicon rectifiers in place of the less efficient mercury arc type in converting power to direct current used in potlines; addition of lithium compounds to electrolyte to increase conductivity; raising proportion of aluminum fluoride in electrolyte to increase efficiency; and improved material to line and insulate pots which save energy and extend their service life.	Increased efficiency and capacity of reduction pots has resulted in fewer pots per potline in new smelters. Thus, requirements for potline monitors, potliners, anode tenders, carbon setters, and others involved in potline operations, per unit of output, are reduced in these plants. Increase in anode size and modification of cathode design also have increased productivity. Technological improvements that extend the production life of potlines have reduced maintenance requirements slightly.	Adopted most extensively in newly constructed potlines built to increase capacity or to replace obsolete facilities. Changes are less extensive in the older potlines.

Table 2. Major technology changes in aluminum—Continued

Technology	Description	Labor implications	Diffusion
Improved anode baking	New furnace designs which improve flue combustion and improved refractories which allow less heat loss increase fuel efficiency and furnace productivity in baking the carbon anodes used in reduction pots. More uniform baking temperatures improve anode quality, making possible lower energy use in reduction pots. Large multipurpose cranes are used to charge and discharge furnaces.	Increased productivity of new baking furnaces lowers unit labor requirements for furnace operators and other workers. More automatic operation will increase monitoring and lessen manual duties of operators.	Most anode baking improvements accompany modern furnace facilities being installed in new smelters. Projected energy savings will be weighed against furnace replacement costs in deciding whether to adopt these improvements in existing anode plants.
Improved casting	New computer-controlled direct chill casters with larger cylinder strokes and improved mold assemblies increase the size and number of billets and ingots cast per drop. Lower scrap rates, faster mold preparation, and reduced maintenance are also benefits of improved casters. Control systems on new equipment monitor temperature precisely with multiple digital readouts available to operators.	Both startup and operating labor requirements for new casters are lower than for old machines. A casting operator and an assistant, aided by a material handling worker for ingot loading, comprise the machine crew at one installation. Maintenance costs are lower with the new equipment.	Advances in casting technology are introduced most extensively in new casthouses and the modernization of existing ones. (Casting improvements described here generally apply also to casting operations in fabricating establishments with remelt facilities.)
Aluminum fabrication			
Improved rolling mill operations	Basic equipment improvements increasing productivity in aluminum rolling include wider mills with more powerful drives and larger coils. Improved mill rolls and lubricants also increase efficiency and quality.	Increased productivity and yield in new and renovated mills enable plants to operate at a given capacity with fewer mills and employees than formerly.	The benefits of computers, advanced instrumentation, and equipment improvements that can be "added on" to existing mills are expected to result in industrywide adoption of these new technologies.
	Computers and advanced instrumentation regulate mill speed and product variables. Computers are also applied to control sawing, milling, and other plant operations and in casthouses.	Rolling mill operators and helpers are among occupations affected by computer control and automation of material handling.	
	Material-handling tasks are being automated in rolling mills. Some mills use computer-controlled cranes to transport coils.	Use of computers requires operators and machine tenders to be involved in more monitoring and fewer manual tasks. Training will be required for employees associated with new technology.	
Improved aluminum extruding operations	Productivity in extruding is being increased by more powerful presses; alloys that improve billet quality and allow faster extrusion speeds; and computer-based programmable control systems. Extrusion dies produced by computer-aided design and manufacturing (CAD/CAM) techniques increase press efficiency and product quality. Computer control is being extended to prepress billet shearing and handling as well as pulling, stretching, and sawing of extruded shapes. Heat treating operations also are being placed under computer control.	A fully automated extrusion line requires a minimum crew of two, compared with seven in a less mechanized plant. Stretcher operators and helpers, saw helpers, and die-head men are eliminated in computerized systems. The material handling job of runner is not required when a computer-controlled puller is used. Press operators are being trained to operate terminals that monitor the status of extruding operations.	Highly automated extrusion systems are in use in only a few plants. Adoption of new technology is typically on a "building block" or a piecemeal basis. New presses being installed incorporate programmable controllers, and they are being added to existing presses.
	Continuous extrusion for a limited number of products is just coming into commercial use.	Significant reduction in labor in some product lines will result.	Diffusion is limited but expected to increase as continuous feedstock availability increases.
Continuous casting	Molten metal is converted directly into aluminum sheet, bypassing casting, ingot preparation, and hot rolling operations. Liquid metal is directed through a nozzle into a cavity between rotating sets of water-cooled cylinders and is immediately solidified and forms a continuous sheet. This sheet is wound into coils to be cold rolled to produce aluminum mill sheet and foil products. Continuous casting is used to produce redraw rod.	Substitution of continuous casting to produce reroll stock or rod eliminates several production jobs including casting operator and helpers, ingot cutting and scalping machine operators, oven tenders, and hot rolling mill operators and helpers. Also, requirements for material handling occupations, including crane operators and truckdrivers, are reduced with continuous casting.	Continuous casting is used by only a few establishments. However, this highly regarded technology will be adopted more widely when aging facilities are replaced, and in mills where capacity is to be expanded.

Primary Aluminum Production

Aluminum is produced by the Hall-Heroult electrolytic reduction process, which has long been the only commercial production method. Although improvements in the process have been adopted, production and maintenance workers have been only marginally affected by these changes.

The impact of technology on employment can be more fully understood by a review of the process of producing aluminum. In the Hall-Heroult process, molten cryolite (a fluoride of sodium and aluminum) is maintained at nearly 1,000 degrees centigrade in carbon-lined steel cells or pots. From 100 to 240 pots may be connected in electrical series to form a potline which is overseen by employees called potline monitors—one of the largest production worker categories. The cryolite serves as an electrolyte and as a solvent for the aluminum oxide (alumina) which is added to it. Carbon anodes located above the pots extend into the electrolyte. When direct current passes through the electrolyte to the cathodic carbon linings in the pots, the alumina in solution is decomposed into aluminum and oxygen. The oxygen is released as carbon dioxide.[2]

Periodically, the molten aluminum is siphoned into crucibles and poured directly into ingot molds or into holding furnaces for refining and alloying before casting into ingots and billets. Molten metal also may be transported from the smelter to fabricating plants.

The modern Hall-Heroult method, although unchanged in principle, differs from the early process. Substantial productivity gains and energy savings have been achieved through improved equipment, materials, and process control.

Aluminum reduction (smelting) consumes large amounts of electricity, which accounts for about one-third of the total cost of primary aluminum production. Thus, the industry has given major emphasis to increasing electrical efficiency. Energy conservation received added impetus from sharply rising costs during the energy crisis in the 1970's.

Improvements in the design of the pot increase efficiency and reduce labor requirements for potline monitors and other workers on the production line. Also, anodes and pots of greater size accept more amperage and produce more aluminum with greater energy efficiency.

Comparing the potline of a new reduction plant (or smelter) with one built approximately a decade earlier illustrates the gains associated with technological improvements. High amperage, low current density pots in the new reduction plant have substantially greater capacity than the older pots. In the new plant, despite 25 percent fewer pots in the production line, capacity is 13 percent greater, and energy and labor requirements per unit of output are sharply lower.

Improvements in materials which line and insulate the pots also are raising efficiency. Improved carbon materials and new techniques for installing linings save electrical energy and extend the life of the pots. Consequently, labor requirements for potliners, who maintain the linings, are cut back. Some of the new linings last 3 times longer than those used in the early 1960's.

Power consumption also is reduced by replacing mercury arc rectifiers with more efficient silicon rectifiers to convert alternating current to direct current for the electrolytic process. Energy savings of 3 percent have been reported following this change. In many smelters, use of electricity also is decreased by adding lithium compounds to the electrolyte to increase conductivity. The consumption of electrical energy is further reduced by raising the proportion of aluminum fluoride in the electrolyte.

Computer monitoring of potlines has resulted in more efficient use of labor and electricity. Heat generated in the electrolyte with a given current depends on the distance between the anode and the cathode. Closer control of this spacing by computers enables temperature in the electrolyte to be maintained at optimum levels more consistently.

In addition, computers and microprocessors control feeding the alumina to the cell and the frequency and duration of the "anode effect."[3] The computers deal with most operational instability unaided, but have the capability to alert the pot monitors to those pots requiring attention. The computers also accumulate and display data on the performance of each production unit.

Improved anode baking

Several major improvements are being incorporated in modern furnaces which produce the prebaked anodes used in the pots. Better insulated and more tightly sealed furnace refractories lower heat loss; new flue designs improve anode quality and extend flue life; and a system that automatically maintains furnace drafts within precise, preset limits provides more efficient furnace operation than manual control. Gains of more than 100 percent in fuel efficiency and furnace productivity have been reported. Moreover, average flue life is increased by 50 percent or more and the improved carbon quality of the anodes increases current efficiency and reduces carbon consumption in the reduction pots.

[2] The prebaked anode system is used by about two-thirds of the smelters in the United States. The Soderberg electrolytic reduction cell, the other major system, uses a continuous anode which is controlled in a different manner than the prebaked anode. Although labor requirements in the Soderberg system are lower, more electrical energy is required.

[3] The normal concentration of alumina is in the range of 3 to 10 percent, which provides sufficient resistance in the bath to maintain optimum operating temperature. When the alumina concentration falls below 3 percent, the resistance increases sharply, and the voltage drop across the pot increases sharply. This phenomenon is known as the "anode effect.".

Large multipurpose cranes also are used in modern furnace installations to place anodes into the baking pits and to cover them with a blanket of coke. These cranes also extract the coke from the pits by vacuum and then remove the anodes. Productivity is increased since one man operating the crane can load and unload the furnace.

Improved casthouse operations

Molten metal from the smelter is transported to the casthouse, transferred into holding furnaces, alloyed, and poured into molds to produce billets and ingots for shipment to fabricating plants.[4] In the casthouses, extrusion and rolling ingots are produced by the direct chill (DC) process, using a vertical or horizontal caster. In a typical vertical caster, as metal enters the mold, the mold base is lowered through a water spray which chills the newly formed ingot as it moves downward through the mold. Ingot length is limited by the depth to which the mold bottom can be lowered. Longer lengths can be produced horizontally, where the constraint of casting pit depth is removed.

Casters of improved design with advanced control systems increase productivity in modernized casthouse operations. A vertical caster, introduced as part of a general plant modernization at one mill, increased production sharply compared to less advanced equipment in the older plant section. The new machine allows ingot molds to be located closer together and increases the size and number of ingots cast in a single "drop." The new casters operate with a smaller crew—one operator, one assistant, and a helper to load ingots for heat treating. Other benefits include reduced maintenance, lower scrap rates, and faster preparation of the mold between casting cycles. A modern control system on the new casters monitors temperature and features various digital readouts.

Technologies under development

Improvements in the Hall-Heroult process and new methods undergoing development have long-range potential to reduce labor, capital, energy, and material requirements in primary aluminum production. However, the new methods are not expected to be applied commercially in the near future.

Inert anode. Development of an inert anode for the Hall-Heroult process is being attempted which, when used with a refractory metal cathode also being developed, would eliminate carbon consumption and the facilities and labor required to prepare and change anodes. Affected employees would include anode tenders, carbon setters, potliners (in part), and rodding anode renewers who, combined, comprise one of the largest groups of plantworkers. A major producer and the U.S. Department of Energy are constructing laboratory pilot cells or pots incorporating these improvements.

Direct reduction. Direct or carbothermic reduction processes utilize high temperatures—obtained in arc or blast furnaces—to produce aluminum from aluminum-bearing ores, or from refined alumina. Unit energy requirements are greatly reduced in these processes. One direct reduction system being developed that is attractive to producers eliminates the refining step required to produce alumina for the Hall-Heroult process. Moreover, since domestic aluminum-bearing ores of lower purity can be used, dependence on foreign supplies of bauxite would be lessened.[5] Capital investment would probably be lower than for Hall-Heroult smelting because anode plants would no longer be required and output from a single production unit would be greater.

The labor impact also would be significant, with anode rebuilders and carbon setters among occupations no longer required. However, refining steps beyond initial smelting would be needed to ensure an acceptable final product, and one drawback of this type of direct reduction is the impurities that remain after processing. A long-term project to investigate the technical feasibility of this process is underway with support from the U.S. Department of Energy.

Technology for direct or carbothermic reduction of refined alumina to aluminum metal without substantial impurities is under development; technical feasibility has already been demonstrated in a small pilot project. This technology reportedly has the potential to substantially lower energy, labor, and capital cost relative to a modern electrolytic plant.

Electrolysis of aluminum chloride. This new process combines alumina with chlorine in a chemical reactor to produce aluminum chloride, which is then electrolyzed to produce aluminum and chlorine. The chlorine is recycled to the reactor in a closed system.

Unlike the Hall-Heroult method, the chloride system can process a wide variety of aluminum-bearing materials and is not limited to bauxite. Moreover, pollution may well be less than in the Hall-Heroult process, which requires that potentially harmful fluoride gas be collected. In addition, the chloride process reportedly uses 30 percent less energy than the most efficient Hall-Heroult potlines—a substantial cost saving.

The labor requirements of a chloride process plant would differ considerably from those of a Hall-Heroult

[4] A portion—often substantial—of potline output may be shipped in molten state to users within trucking distance of the plant, thus eliminating smelter casting costs and the expense of remelting by fabricators. One major producer ships about 40 percent of total reduction plant output in this manner.

[5] Hall-Heroult pots require alumina refined from bauxite by the Bayer process. Over 90 percent of the bauxite is obtained outside the United States. The present method of producing aluminum is often referred to as the Bayer-Hall process.

smelter. Anode tenders and others engaged in anode building and replacement would no longer be needed. On the other hand, new positions would be required because a chemical reactor is needed in the process. Jobs involving maintenance and console monitoring could be expected to increase.

Aluminum Fabrication

Rolling, drawing, and extruding establishments manufacture a variety of semifabricated aluminum products. Improvements in traditional methods, the use of more efficient processes, advances in material handling, and improved control of production are increasing productivity in fabricating plants. These innovations raise quality and reduce unit labor, capital, and energy requirements.

The most significant development in aluminum fabrication is the widespread adoption of computers and advanced instrumentation. Improved control has increased performance of processing and material handling equipment. Examples of applications of process control and other improvements are examined below in the operations in which they are employed.

Rolling mill operations

Advances in equipment and improved control over processing increase efficiency in rolling mill operations. Extended mill widths, more powerful drives, and processing of larger coils are prominent improvements in aluminum rolling mills. Improved rolls and rolling lubricants also increase productivity and quality. In addition to improvements in basic equipment, computer control of mill speeds and product variables such as strip gauge and shape allow mills to run at higher speeds, increase product quality, and reduce waste products.

Many of the advances in rolling technology that will be adopted more widely over the next decade are already installed in a large foil plant which is a leader in applying new technology. These include computer-based shape and gauge controls, new rolls in which the shape of the strip can be changed during operation to maintain uniformity, and improved lubrication procedures to reduce breaks in the aluminum strip. A new rolling mill introduced at this plant operates at speeds up to 7,500 feet per minute, 3 times faster than older mills.

At this facility, where some older mills were retrofitted with advanced controls and improved rolls, speed increased 50 percent, and foil quality improved. Renovation of additional mills is planned, with computer control to be extended plantwide. In addition, more than 50 percent of the rolling mills are scheduled to be closed, with no loss of capacity anticipated. Although crew size in retrofitted mills is the same as before modernization, fewer crews will be required as the number of mills is cut back.

Material handling also is undergoing extensive automation in rolling mills. In cold rolling mills, for example, computer-controlled cranes transport coils from storage bins to a conveyor to be carried to a preparation station. At this point, sensors feed data on the coil to the mill computer, which sets up the rolling operation. The coil is automatically loaded and threaded into the mill and removed from the mill after rolling. At several plants, the rolls that compress the strip are being changed automatically. In one instance, the new procedure takes 5 minutes, compared with 45 minutes for older mills in the plant. Occupations affected by these advances include crane operators and material handling laborers. However, more electronics technicians and maintenance workers are needed in establishments introducing these changes.

Extruding operations

More powerful presses, automated production and material handling systems, and improved dies and continuous extrusion systems are among key innovations increasing productivity in aluminum extruding. Average press size currently is about 50 percent greater than in the early 1970's, and the greater extrudability of new billet alloys can be handled more effectively. Almost all new presses are equipped with programmable control systems, and they are being added to existing presses. Other improvements in press controls include automatic systems to regulate extrusion speed. These advances reduce scrap formation, a major concern of the industry.

Extrusion production steps before and after the press operation also are being modernized by computer control and other advances. In new press systems, aluminum is transported automatically from heat treatment to a shear and cut into computer-selected billet lengths. Extrusions leaving the press are guided along the runout table by a computer-controlled puller to their programmed length, automatically moved on to be stretched to programmed tensions, sawed into predetermined lengths, and loaded onto carts for movement into and from aging ovens. The only manual handling in modern computerized systems involves packaging finished extrusions.

Automated extrusion systems require a minimum crew of two (the press and saw operators) compared with a crew of seven on conventional presses. Although automated systems eliminate traditional jobs, including stretcher operators and helpers, they require programmers and other computer personnel and additional maintenance workers. Automated extrusion systems probably are not feasible for most smaller establishments because production runs are short and the systems are expensive. However, some degree of new technology will be adopted consistent with their resources and production patterns.

Dies used in extruding presses are being produced by computer-aided design and manufacturing (CAD/CAM) techniques which improve die quality. In turn, these high-quality dies raise press efficiency and product quality in extrusion establishments.

Continuous extrusion systems for selected hollow and solid shapes are beginning to appear which are capable of significantly lowering labor requirements and reducing scrap for selected products.

Continuous casting

Continuous casting is a highly efficient method to produce mill reroll stock for processing into finished rolled products. In one type of continuous caster, molten metal is forced through a nozzle into the space between two rotating, water-cooled casting cylinders where it solidifies and forms a continuous strip which is wound into coils. In continuous casting, the conventional steps of casting and cutting of ingots, machining to eliminate surface defects, and heat treating are eliminated along with material handling tasks associated with these operations. Hot rolling also is eliminated or reduced to one stage. Continuous casting reduces labor, capital, and energy (it uses less than a third of the energy required in the conventional method). Specific jobs eliminated in continuous casting include ingot casting operators and hot rolling mill operators. Also, fewer material handling workers, including crane operators and truckdrivers, are required.

Continuous casting is used by only a few mills, mainly in the production of reroll stock for further reduction by cold rolling for end use in beverage cans and foil wrapping. However, expanded use of the process for other rolled products is expected.

Output and Productivity Outlook

Output

Output in the primary aluminum industry, mainly ingots of varied shapes and sizes, increased at an average annual rate of only 0.6 percent between 1970 and 1984. (See charts 3 and 4.) The rate was highest during the early period, 1970-73, 3.9 percent compared with 1.1 percent during the middle period, 1973-78, and a 4.0-percent rate of decline during 1978-84.

Output in the aluminum industry is responsive to developments in the general economy; output in primary aluminum fell by 20.3 percent from 1974 to 1975 and by 27.1 percent from 1981 to 1982, periods when the economy turned downward. The latter period of slack demand led to closings of six primary aluminum plants, with an estimated annual capacity of nearly 800,000 short tons idle at the end of 1982.[6] In addition, some potlines in operating plants were closed; the U.S. Bureau of Mines reported a total of about 2.5 million tons of idle capacity at the end of 1982. By 1983, however, prospects for the industry improved as the economy recovered and primary production increased by 2.4 percent from 1982 to 1983. In 1984, this expansion continued, but by midyear, sharply higher imports, rising inventories, and declining prices for aluminum ingot were reported.[7] However, output for the full year 1984 increased 22.4 percent over 1983.

Output in the fabricating sector (rolling, drawing, and extruding) generally followed the pattern described for primary aluminum. Fabricated products are more numerous than primary products and include such items as flat rolled basic shapes including sheet, plate, and foil, and extruded products such as rods, bars, shapes, and tubing.

Over the period 1970-84, output of fabricated products increased at an average annual rate of 2.0 percent. During the early period 1970-73, demand for aluminum was strong, and output increased at an average annual rate of 16.3 percent. Between 1973 and 1978, however, the annual rate of increase fell sharply to 1.7 percent, and during 1978-84, declined at an annual rate of 2.1 percent.

The general economic downturn also affected this sector adversely. In 1975, output in aluminum rolling, drawing, and extruding declined by 29.7 percent; in 1982 by 12.3 percent. However, output in the fabricating sector recovered more sharply than in primary aluminum in 1983, increasing by 15.3 percent, as the economy recovered from recession and demand for aluminum products was strong. Output in this sector increased an additional 7.0 percent in 1984.

Aluminum production is expected to continue to increase through the 1980's, with containers and packaging, building and construction, and transportation remaining the largest markets. The use of aluminum in autos and trucks, for example, is expected to increase from 137 pounds per vehicle in 1985 to about 200 pounds by 1990.[8]

According to the U.S. Department of Commerce, total shipments of aluminum are expected to increase at a compound annual rate of about 3.5 percent through 1989.[9] However, most expansion of primary aluminum capacity may be overseas because energy and other costs are expected to remain high in the United States. Moreover, increased imports of aluminum ingots and increased recycling also will lower demand for primary aluminum from U.S. plants.

Productivity

Productivity (output per employee hour) increased in both primary aluminum and fabricating over the period 1970-84 (charts 3 and 4). However, the productivity gain in rolling, drawing, and extruding mills over this period

[6] *1983 U.S. Industrial Outlook,* U.S. Department of Commerce, Bureau of Industrial Economics, chap. 19, p. 19-10.

[7] *1985 U.S. Industrial Outlook,* U.S. Department of Commerce, International Trade Administration, chap. 20, p. 20-8.

[8] *Ibid.,* p. 20-10.

[9] *Ibid.*

was substantially higher than in primary aluminum. The productivity change in both sectors was characterized by substantial variation in rate and direction.

Productivity in primary aluminum increased at a relatively modest average annual rate of 1.0 percent between 1970 and 1984. During 1970-73, however, output per employee hour increased by an annual rate of 2.1 percent, and output increased by 3.9 percent, more than double the 1.8-percent annual rate of increase in employee hours. Between 1973 and 1978, however, output per employee hour declined at an annual rate of 0.7 percent. This period included the 1974-75 recession, when output per employee hour fell by 13.2 percent. Productivity improved markedly from 1978 to 1984, with output per employee hour increasing at an average annual rate of 3.2 percent. In 1984, output per employee hour in primary aluminum rose sharply—by 10.1 percent—as output increased by 22.4 percent and employee hours rose a lesser 11.1 percent.

Productivity in aluminum fabrication increased at a relatively strong average annual rate of 2.7 percent during 1970-84. Over this period, output increased at an annual rate of 2.0 percent, and employee hours declined at an annual rate of 0.7 percent. The productivity gain in aluminum rolling, drawing, and extruding was the greatest in 1970-73; output per employee hour rose by a substantial average annual rate of 13.0 percent as output surged at an annual rate of 16.3 percent and employee hours rose at a lower annual rate of 2.9 percent.

The productivity growth rate slowed markedly during 1973-78, however, with output per employee hour increasing at an average annual rate of 2.2 percent. As in primary aluminum, output per employee hour in fabricating fell during the recession period 1974-75, down by 9.2 percent. During 1978-83, output per employee hour increased at a slower annual rate of 1.8 percent. However, in 1983, output per employee hour rose sharply by 11.3 percent, as output gains associated with economic recovery greatly exceeded expansion in employee hours. A slightly higher increase in output compared to employee hours in 1984 resulted in an additional productivity gain of 0.2 percent.

Productivity change is difficult to assess since measures of output per employee hour reflect a number of interrelated factors, including technology, capital investment per worker, utilization of capacity, skill and effort of the work force and management, and other related factors. The specific contribution of labor, capital, or any other variable cannot be determined. However, if projections of a higher volume of shipments of aluminum through the second half of the 1980's are realized, and investment in new technology continues as expected, the productivity record of the industry could improve.

Investment

Capital expenditures in the primary aluminum and aluminum fabricating sectors have been rising as demand for aluminum products has intensified. During 1970-81, these industries spent $3.7 billion (constant 1972 dollars) to increase capacity and improve efficiency.[10]

Spending by primary aluminum plants totaled $1.6 billion in real terms over the period, with a high of $214.4 million in 1981. Marked swings in annual investment in primary aluminum reflect, in part, the comparatively small number of producers in the industry. The cost of establishing a new smelter will raise the level of industry expenditures significantly. For example, a new smelter constructed during the latter part of this period cost $350 million in current dollars.

Primary aluminum capacity increased almost 40 percent between 1970 and 1982 as new smelters were constructed and existing plants were expanded and upgraded. However, as indicated earlier, industry experts anticipate that future major additions to primary aluminum capacity will be overseas where energy costs are lower. Thus, future domestic spending for new projects may be reduced.

Fabricating establishments invested $2.1 billion (constant dollars) between 1970 and 1981 in new plant and equipment, including a high of $255.5 million in 1980. While a consistent pattern of increasing annual investment was not evident, the trend of capital spending reflected anticipated increases in production.

Capital expenditures per production worker in primary aluminum and aluminum fabrication have been higher than in all manufacturing. The average per production worker in aluminum fabrication between 1970 and 1981 exceeded all manufacturing by 61 percent, while the average in the highly capital-intensive primary industry exceeded that for all manufacturing by 165 percent.

Employment and Occupational Trends

Employment

Employment in the primary aluminum and rolling, drawing, and extruding sectors of the industry combined declined from 91,700 to 82,600 workers over the period 1970-84, or by 9.9 percent. (See charts 5 and 6.) Sixty percent of the decline was in rolling, drawing, and extruding mills, which employed more than 70 percent of the work force in 1984 in the two sectors combined. Production workers made up about 75 percent of the work force and accounted for nearly the entire downturn in employment over this period. Employment in both sectors of the industry moved sharply lower during the decline in the economy during the mid-1970's and during 1980-82. The change in demand for aluminum rather than new technology was the most significant factor affecting the level of employment over this period.

Prospects for employment growth appear more favor-

[10] U.S. Department of Commerce, Bureau of Industrial Economics, Office of Research, Analysis, and Statistics.

able for both primary aluminum and rolling, drawing, and extruding mills, based on projected gains in shipments and the upturn in the economy which began in 1983. A more detailed analysis of employment trends in primary aluminum and in fabricating mills is presented below.

Primary aluminum. In 1984, a total of 23,100 employees worked in the primary mills which convert alumina to aluminum—well below the 26,700 employed in 1970. Employment moved generally higher throughout the 1970's, and peaked at 32,800 in 1980. The periods 1974-75 and 1980-83 were exceptions to the general rise in employment over this period. Between 1980 and 1983, employment declined by 35 percent as demand for aluminum slackened and by 1983 had fallen to the lowest level in the period. Some less efficient plants which closed during this period are not expected to reopen.

An examination of employment data shown in chart 5 provides a broader view of employment change in primary aluminum. During 1970-73, employment increased at an average annual rate of 1.9 percent, slowed slightly during 1973-78 to an annual growth rate of 1.3 percent, and declined during the more recent period, 1978-83, at an annual rate of 7.4 percent. An employment gain of 7.9 percent in 1984 accompanied the substantial increase in production in this sector and marked a reversal from the 1980-83 decline.

Rolling, drawing, and extruding. Employment in this sector declined from 65,000 to 59,500 workers over the period 1970-84. The downward trend in employment followed a somewhat different pattern compared to primary aluminum. The rate of decline between 1973 and 1975, which included a recession, was much more severe, at an annual rate of 12.0 percent compared to 4.8 percent in primary aluminum. The precipitousness of this decline is illustrated by the fact that 1973 was the highest level of employment in rolling, drawing, and extruding mills over the period 1970-84, and the number employed in 1975 was the lowest. However, the trend differed for these two sectors of the industry during the more recent period 1979-83. Although employment in fabricating mills fell off sharply, at an annual rate of 6.0 percent during 1979-82, the decline in the primary sector, which took place from 1980 to 1983, was far greater—at an annual rate of 14.5 percent.

As indicated in chart 6, the employment situation in rolling, drawing, and extruding mills appeared to worsen progressively over the longer span 1970-82. Between 1970 and 1973, employment increased at an annual rate of 1.4 percent, turned down over the years 1973-78 at an annual rate of 0.3 percent, and experienced a further deterioration during 1978-82, when employment moved sharply lower at an annual rate of 4.4 percent. Between 1982 and 1984, however, employment increased at an annual rate of 3.3 percent.

Occupations

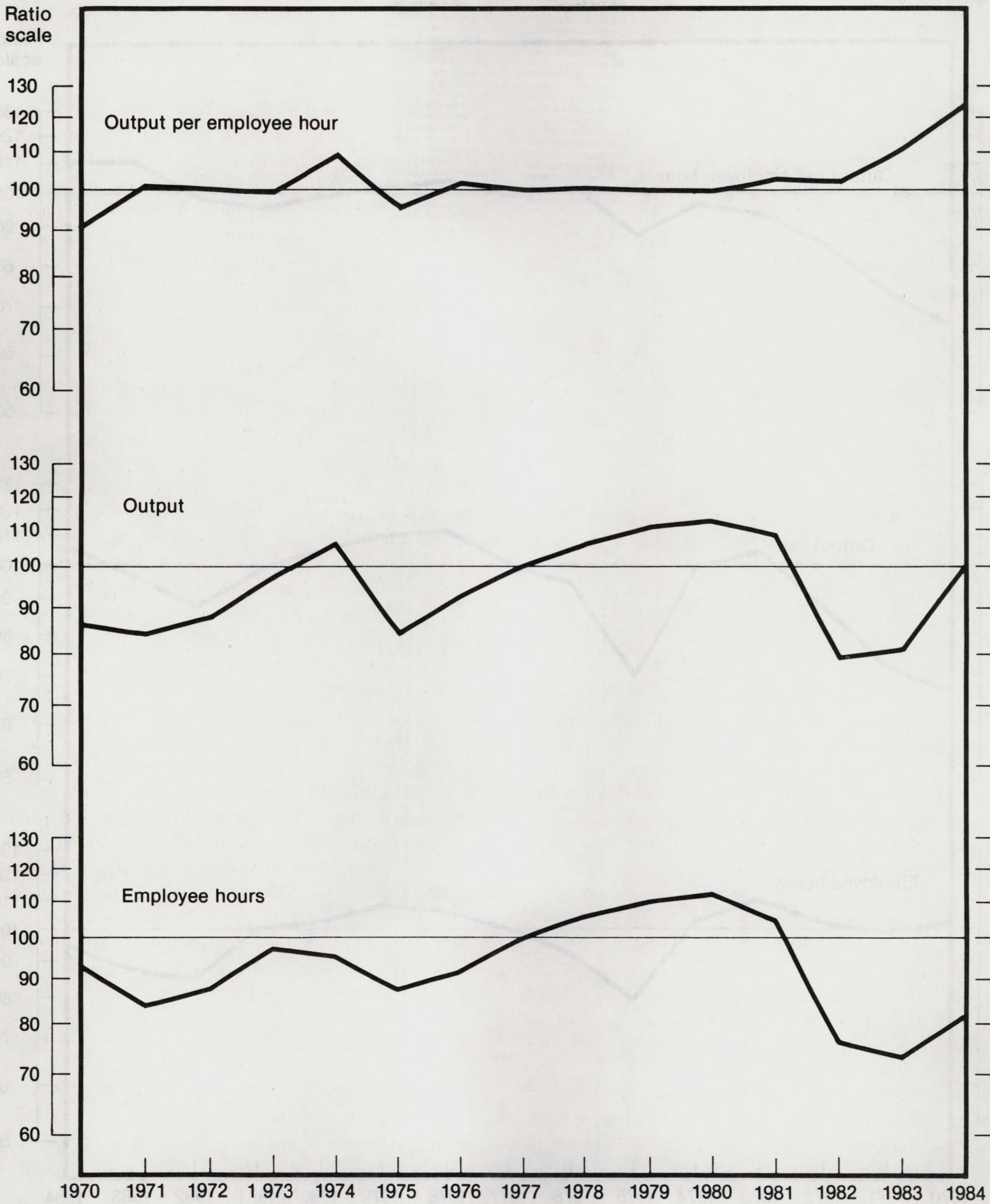
BLS projections of employment by occupation are not available for primary aluminum or fabricating; however the trends in technology suggest some changes for the next decade. Although new technology is lowering unit labor requirements of pot tenders, casting operators, rolling mill operators, and other workers in primary and fabrication plants, widespread displacement is not anticipated. Moreover, most occupations in aluminum production and fabrication into the mid-1990's are expected to involve generally the same skills and duties as in the past, with several important exceptions discussed below.

The work force changes accompanying technological improvements in the aluminum industry are generally similar to those in other capital-intensive industries, such as steel and paper. The introduction of computer process control and advanced instrumentation in potline and rolling mill operations has modified the jobs of potline tenders and rolling mill operators to include more extensive monitoring of production operations from modernized control stations and less direct manual involvement. Maintenance skills are reportedly higher for these systems. In primary aluminum, improvements in the design of the pots and the materials used to line them reduce labor requirements of pot tenders and potliners who monitor and maintain them. Furthermore, the general improvement in equipment to move molten metal and fabricated products through production steps affects a wide range of occupations in primary aluminum and fabrication operations, with improved handling and lower labor requirements generally accompanying these changes.

Because the production of aluminum is capital and energy intensive, most changes involve modifications of portions of the production process, rather than the construction of entirely new plants. When expensive new facilities are constructed, however, they incorporate the latest technologies, which require less energy and labor than older facilities. In new mills, for example, the number of potline tenders and liners, rolling mill operators, and related production workers required for comparable levels of output are lower than in less modernized facilities. Moreover, some experts foresee that new technology may result in combining jobs, that is, workers increasingly will take responsibility for several tasks, such as both the operation and maintenance of rolling and extrusion equipment. Although unit labor requirements are lower in new plants, it is important to keep in mind that the major incentive to modernization—particularly in primary aluminum plants—is to lower energy costs.

The extent to which mechanization of aluminum reduction and fabrication processes will affect the structure of the work force will depend on several key factors, including the availability of funds for modernization, the impact of foreign competition, and the general outlook for the industry.

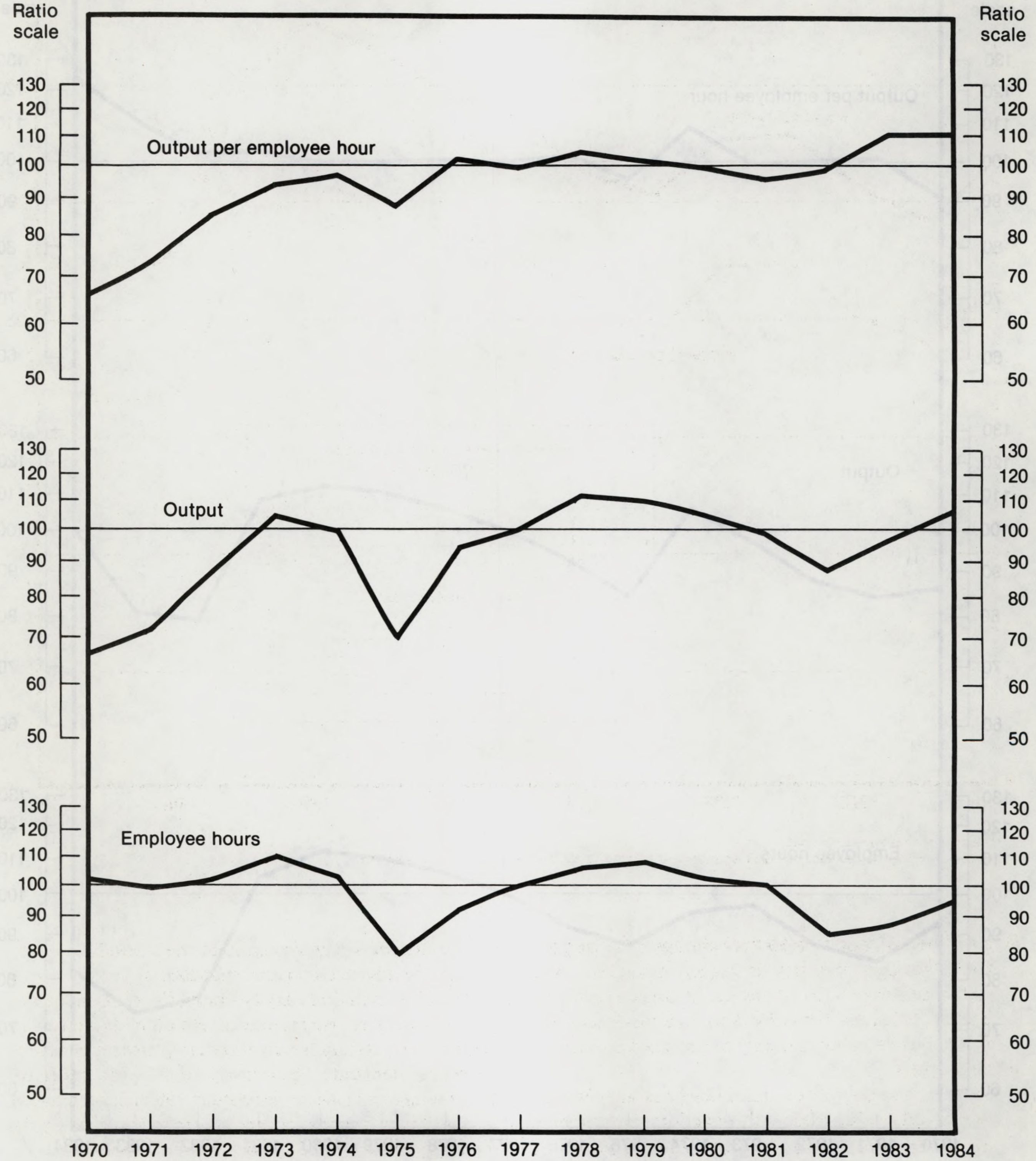
Chart 3. Output per employee hour and related data, primary aluminum, 1970-84
(Index, 1977 = 100)



Source: Bureau of Labor Statistics.

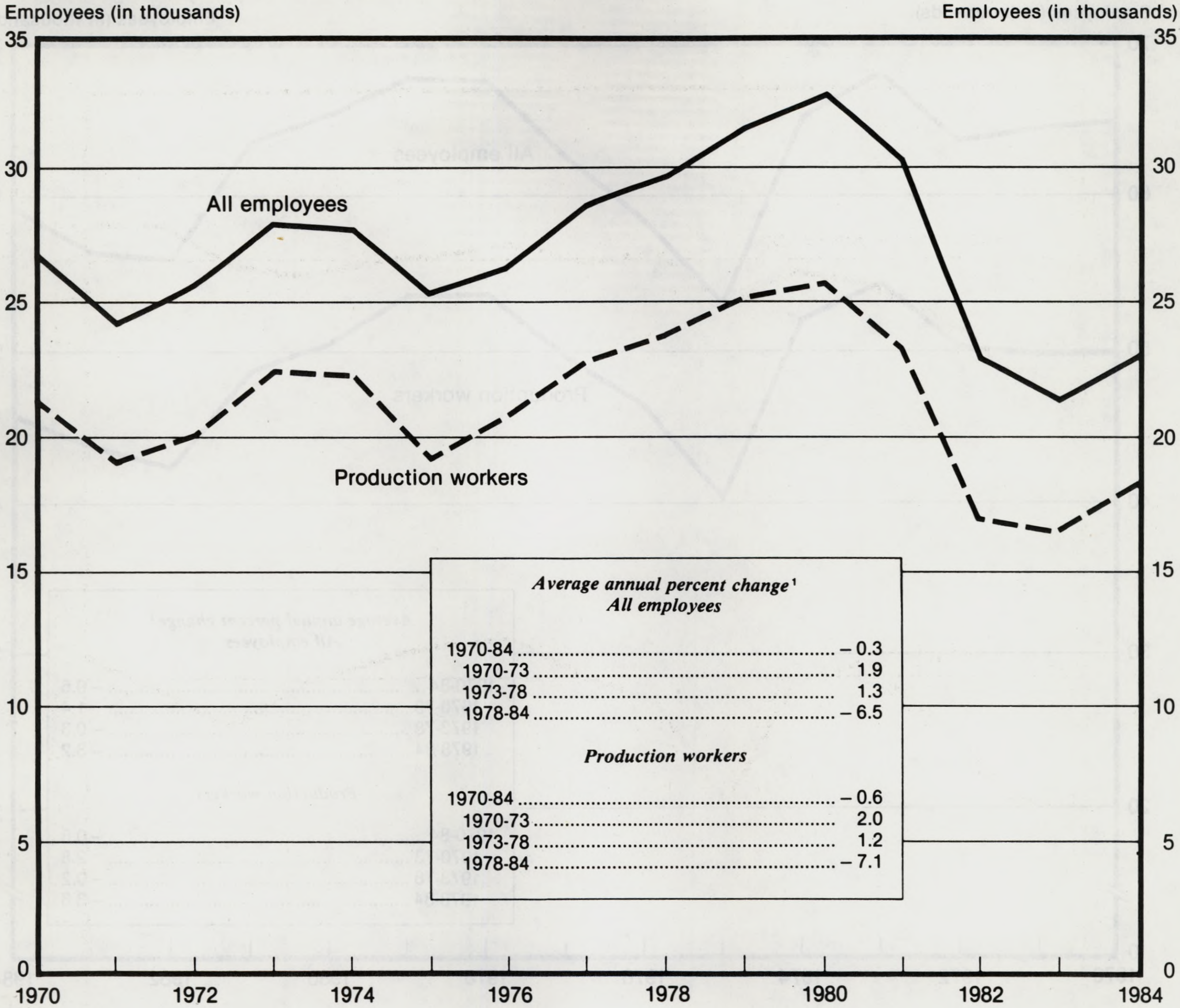
Chart 4. Output per employee hour and related data, aluminum rolling, drawing, and extruding, 1970-84

(Index, 1977 = 100)



Source: Bureau of Labor Statistics.

Chart 5. Employment in primary aluminum, 1970-84



[1]Least squares trends method.
Source: Bureau of the Census. 1984 employment estimated by the Bureau of Labor Statistics.

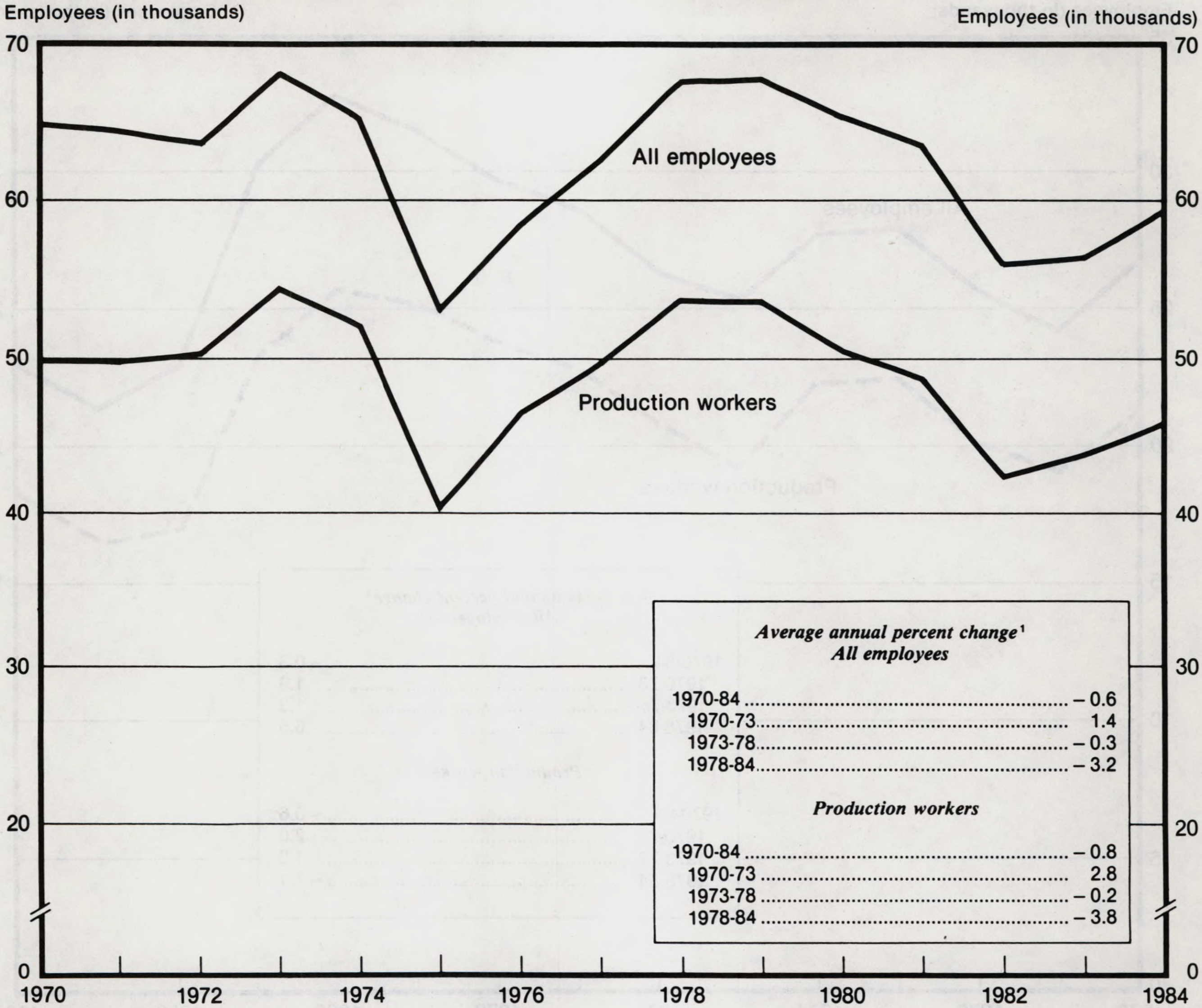
Adjustment of workers to technological change

The aluminum industry is highly unionized. The United Steelworkers of America (AFL-CIO) and the Aluminum, Brick and Glass Workers International Union (AFL-CIO) represent the majority of process and maintenance workers.

The introduction of new technology has not resulted in widespread displacement, and work force adjustments to advanced process control technology, continuous casting, and other innovations have been handled in the context of general provisions of collective bargaining agreements related to seniority, training, wage rate determination, and related topics. The collective bargaining agreements negotiated between major producers and unions include a requirement that the union be notified 90 days in advance of plant shutdowns.

The aluminum industry is among the U.S. industries which have faced increased competition in domestic and foreign markets and is now recovering from a period of depressed demand. Accordingly, the 3-year collective bargaining agreement negotiated in 1983 between major producers and unions recognized problems faced by the industry, and included major wage and benefit concessions by the unions to reduce costs. These include no general wage increase; a reduction in cost-of-living benefits, and a cutback in other benefits. Some benefits were strengthened, but the net effect was a slowdown in the rise of wage and benefit costs. A 1985 contract be-

Chart 6. Employment in aluminum rolling, drawing, and extruding, 1970-84



[1] Least squares trends method.

Source: Bureau of the Census. 1984 employment estimated by the Bureau of Labor Statistics.

tween a major producer and the United Steelworkers superseded the 1983 agreement and involved a cutback in wages and benefits in exchange for the issuance of company stock to the employees. The union also received a seat on the company's board of directors.

These concessions are expected to strengthen job security, as some plants scheduled for closing will remain in operation because of a lower cost structure. Moreover, additional funds will be available to modernize and generally improve the competitive position of the industry. On the other hand, supplementary agreements negotiated at some plants over the past several years have cut back crew size on potlines and in other operations. Some firms which have instituted labor cutbacks have allowed early retirement to ease the impact on the work force.

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Chapter 3. Aerospace

Summary

The aerospace industry (SIC 372, aircraft and parts; SIC 376, missiles and space vehicles) has been in the forefront in adopting computer technologies to improve product quality and reliability and increase labor productivity. This has taken the form of automating the machine tools used in production through widespread use of computer numerical control and computer-aided design and manufacture, and, with less frequency, industrial robots. Adoption of new technologies has been stimulated, in part, by the need to develop less labor-intensive means of manufacturing new products, such as composite materials, to replace metals in aircraft.

BLS has not developed a productivity measure for the aerospace industry because of the complexity of the industry and the limitations of available data. The data available suggest that in the aircraft and parts industry, output per employee hour rose at a modest rate during the period 1972-82, as real output increased at only a slightly more rapid rate than employee hours. These trends compare unfavorably with the earlier years, 1960-73, when productivity growth was more substantial. In the missiles and space vehicles industry, productivity showed little or no growth during 1972-82 as shipments fell at approximately the same modest rate as employee hours.

Real investment in the aircraft and parts industry slipped sharply in the early 1970's, to its lowest level in two decades, then turned around during the late 1970's and peaked in 1980. The low level of investment during the early years is attributable to excess capacity as a result of the winding down of the Vietnam War and the economic recession. The upturn during the late 1970's occurred as output expanded rapidly. In the missiles and space vehicles industry, investment also declined erratically through most of the early 1970's, to its lowest level since the mid-1950's, before increasing sharply in the late 1970's and early 1980's. Nevertheless, the 1981 peak was only half the record 1967 level of investment.

Employment in the aircraft and parts industry fluctuated widely during the 1970-84 period due to changing economic and political conditions. Overall, employment grew an average of 0.9 percent annually, but, by 1984, it was about one-third below its Vietnam-era peak. BLS projects that by 1995 employment in this industry will approximate the 1970 level, an increase of 1.1 percent annually from 1984, assuming moderate growth of the economy. In the missiles and space vehicles industry, employment generally declined during the early to mid-1970's, then rose sharply in the late 1970's and early 1980's. BLS projects that employment in 1995 for this industry will be sharply higher than in 1984, increasing at a rate of 2.2 percent annually over the period, assuming moderate growth of the economy.

Industry Structure

The aerospace industry is one of the most highly concentrated large industries due to the enormous capital requirements for aerospace projects, long startup period for each project, economies of scale, and the high-technology nature of the industry. In the commercial aviation sector, there are currently only three manufacturers, and, in the jet engine market, two producers have an overwhelming share. The military and general aviation sectors are less concentrated, although through consolidations the number of producers is declining. The growing internationalization of the industry is likely to cause some restructuring of these sectors, however.

A large number of suppliers and job shops subcontract to the principal aircraft and engine manufacturers. For example, one large airframe builder has a network of 3,500 subcontractors and suppliers (not all classified as aerospace) which together produce about half the components of each plane. Competition is intense among these companies, which, for the most part, are relatively small, having less than 250 workers, in contrast to the very large size of the prime contractors.

Technology in the 1980's

The major focus of technological improvement has been the automation of machine tools used in production. Automation has taken the form of widespread use of numerical control (NC), ranging from comparatively simple hand-used NC to minicomputer- and microprocessor-based units (i.e., computer numerical control, CNC), to large and complex direct numerical control (DNC) systems. These technologies improve product quality and lower unit labor requirements. Also, industrial robots are being adopted in production areas characterized by long production runs and simple, repetitive steps. Their application in this industry is limited, however, because complexity and small batch runs are the norm.

The development of several new aircraft products has been a major stimulus for the diffusion of new manufacturing technologies. In particular, greater acceptance of composite materials in aircraft as a substitute for heavier weight metals has led to the development of new fabricating techniques to replace more labor-intensive conventional methods. Also, use of harder steels than tool steel has led to the diffusion of laser and electrochemical equipment.

The major technology changes in the aerospace industry, their implications for labor and their diffusion are summarized in table 3.

Numerical control

The numerical control of machine tools is used throughout the aerospace industry. NC technology, first developed in rudimentary form by a defense subcontractor for the production of complex aircraft and missile parts during the late 1940's, was adopted on a large scale during the 1960's and early 1970's. In 1978, the aircraft and parts industry had the largest number of NC machines of any industry—7,500—amounting to 14 percent of the total for all metalworking industries.[1] By 1983, there were 8,800 NC machines in the aircraft and parts industry,[2] which accounted for 9 percent of that industry's machine tools, a proportion exceeded by only one other metalworking industry. In the missiles and space vehicles industry, about 8 percent of all machine tools were NC.

Basic NC, a major step towards automating the machining process, features an electronic controller which automatically directs machine movement by reading coded instructions in digital form. The instructions, which are most commonly transmitted to the machine by means of perforated tape, indicate the moves, sequences, tools, and motions that the machinery will need to produce the part.

[1] "The 13th Annual Inventory of Metalworking Equipment, 1983," *American Machinist*, November 1983, pp. 113-44.

[2] *Ibid.*

Table 3. Major technology changes in aerospace

Technology	Description	Labor implications	Diffusion
Numerical control (NC)	Machine tool movement controlled automatically by electronic controller. Instructions are transmitted to machine by perforated tape, punchcard, etc. Reduces setup time, increases operating rates and accuracy compared to manual operations.	Reduces unit labor requirements for machine operators. Requires less skill than manual operation of tools. Creates new position of programmer.	In 1983, 9 percent of all machine tools in the aircraft industry and 8 percent in the missile industry had NC, CNC, or DNC.
Computer numerical control (CNC)	Microcomputer located on machine tool controls operations. Makes program changes easier than for simple NC unit. With CNC, tool can be connected to master computer.	Substantially lowers unit labor requirements for programming and machining. Allows the consolidation of three jobs—computer programmer, maintainer, and machinist—into one position under certain conditions. Reduces skill requirements for programming and machining.	Accounts for a rising proportion of NC machine tools in use. Rapid growth stimulated by increased capability of CNC machines and sharp declines in microcomputer costs. Continued rapid diffusion expected.
Direct numerical control (DNC)	Master computer "supervises" operations of individual CNC machine tools on shop floor.	Similar to CNC.	Diffusion generally limited to largest plants. Aircraft industry use more extensive than most other industries. Diffusion increasing.
Computer-aided design/computer-aided manufacture (CAD/CAM)	CAD is a highly efficient computerized drafting tool in the form of a CRT; allows operator to easily alter or rotate parts designs. Designs can be stored in central computer or transferred to other areas. CAM controls machine operation and material handling on shop floor. Improves accuracy.	Reduces unit labor requirements for drafters and programmers. With CAD, time required to design a part can be cut between one-eighth and one-half that necessary for manual drafting. Most workers can be retrained to operate CAD/CAM in a relatively short time.	Extensively adopted by large aircraft and parts manufacturers in last decade. Diffusion expanding to smaller firms due to falling prices and improved capability. Some major firms are requiring that their subcontractors have CAD/CAM to facilitate intercompany transfer of data and drawings.
Industrial robot	Manipulator (i.e., arm or machine) moves tool parts or materials through programmed motions to perform variety of simple tasks, e.g., drilling holes, spray painting, or welding.	Substantially boosts productivity; e.g., where it formerly took five workers 6 hours to manually paint an aircraft section, with painting robot, two workers are required in the same time.	78 robots in operation in aircraft industry in 1983; diffusion low due to batch-oriented nature of much of aircraft production. Expanded use expected in areas which can be readily automated.
Flexible manufacturing system	Computer-controlled work stations are linked by sophisticated materials handling system. Allows randomized routing of parts. Can accommodate the machining of a wide range of products. Reduces inventory costs.	Reduces unit labor requirements by two-thirds compared to conventional equipment. Requires only unskilled workers to load and unload system on the shop floor. Highly skilled electronic technicians are required for maintenance.	Two systems have become operational within the last 2 years. Two others are under construction.

NC can substantially boost productivity by reducing downtime relative to older methods. One major area of time savings is setup. By cutting down on setup time, actual operating time can be increased. Whereas the average conventional tool may be operating only about 15 to 20 percent of each shift; with NC, it conceivably could be operating up to 40 percent of the shift.

Use of NC also reduces requirements for skilled labor. For example, the position of template maker is eliminated because machine movement is automatically controlled by tape. Typically, a manufacturing engineer will determine machine movement, while a computer programmer will program the tapes.

Requirements for skilled machinists are also reduced. With conventional equipment, the machinist generally has to make each part separately. With the NC equipment, the machinist sets up the equipment and ensures that it is working properly and a lower skilled operator then monitors the machine's operation.

Other advantages of the NC include closer tolerances, higher speeds, and considerable scrap savings. With NC, the parts are more consistent because the same program can be used to make the part each time it is produced, while with a manually guided machine tool, the pieces may be subject to some variation, depending on the machinist's skill.

Computer numerical control

A more sophisticated type of automated machine control which substantially reduces unit labor requirements is computer numerical control (CNC). This technology became a feasible alternative to basic NC during the mid-1970's. In a CNC unit, a minicomputer is used to control basic NC functions by means of programs which are stored in the minicomputer's memory. When a part is to be machined, a stored program is retrieved from the computer's memory, and the operation is then performed, with the computer element becoming the control unit.

CNC has several features which give it a substantial edge over a simple NC unit. First, the machine operator can easily modify the program on a CNC unit by revising the data stored in the computer, rather than sending a punchtape back to the computer room for the programmer to rewrite. Moreover, the computer is more reliable than tape; the tape, tape puncher, and tape reader of a simple NC machine can frequently malfunction. A third major advantage of CNC over NC is that the CNC units can be connected to other master computers (DNC, which is discussed below).

Unit labor reductions can be substantial with CNC, when compared to conventional equipment. For instance, at one aircraft manufacturing plant which installed three computer-controlled tube-bending machines to bend both aluminum and steel, one operator can produce 60 pieces of tubing in less than half a day.[3] By contrast, it took two workers 5 days to produce the same amount of tubing using conventional equipment.

Labor savings can also result from job consolidations once a CNC unit is brought online. In some cases, three separate jobs—computer programmer, machine maintainer, and machinist—can be merged into one job on the shop floor. This is possible largely because of the relative simplicity of CNC programming compared to NC. Older NC equipment generally requires highly skilled programmers while the new CNC technology is simple enough to use so that a worker with limited programming experience can become proficient. However, in many plants, management separates programming from machine tool operation. By increasing the division of labor (rather than consolidating it), management is able to remove much of the decisionmaking and discretion from the shop floor and, therefore, can fill the machine operator's job with a less skilled worker.

Diffusion of CNC machine tools in the aerospace industry has increased because CNC has substantially greater capability than NC, and has become more affordable as the cost of computers has fallen.

Direct numerical control

Closely related to CNC is direct numerical control (DNC), which is used in some very large aircraft plants. With a DNC system, a central computer is able to program and run simultaneously a number of CNC machines on the factory floor. The shop-floor machines in turn indicate to the central controlling computer when its commands are carried out. At one large plant which manufactures gas turbine aircraft engines, a central computer "supervises" the operation of 103 CNC machine tools, as well as an automated material handling system. Additional CNC machine tools are being added to the system.

Productivity is substantially boosted with DNC. For instance, at one large aircraft plant with DNC, the plant's tools are now cutting metal 38 percent of the time that they are in operation compared to 15 percent previously.

Generally, the same labor is required for DNC as CNC. However, unlike CNC, the worker does not have to enter data at his own work station; rather, data are sent automatically to his station from the central computer.

Computer-aided design/computer-aided manufacture

Computer-aided design/computer-aided manufacture (CAD/CAM) is yet another computer application which was first developed for the aerospace industry. This technology facilitates both the design and manufacture of parts and can substantially increase productivity. CAD can operate independently of CAM, but greater efficiency results when the two systems are closely coordinated.

The CAD system serves as a highly sophisticated drafting tool. The design engineer or drafter is provided with an electronic drafting board in the form of a cathode ray

[3] *Iron Age,* July 14, 1982, p. 64.

tube (CRT) on which parts and assemblies can be displayed. The system allows the engineer to easily switch or rotate design variations, as the computer adjusts every line, angle, and cross-section. The completed design can be stored in the central computer or passed through the computer directly to the manufacturing operations (i.e., manufacturing engineers, programmers, etc.).

The second part of the technology, CAM, is the application of computers to integrate design with the manufacturing process. With a sophisticated CAD/CAM system, manufacturing engineers can pull computer-generated designs and modeling data from a computer, then use the computer and stored information to design the tooling, fixtures, and control procedures needed to make the piece. CAM also serves as a system to control the operations of machine tools (which may be CNC or robots) on the shop floor and can be used for planning.

The productivity advantage of this technology—whether CAD alone or the integrated CAD/CAM system—is substantial. With CAD alone, the time required to design a part is frequently cut to between one-eighth to one-half of that necessary for manual drafting. For instance, one large plant which manufactures helicopter blades recently installed a CAD/CAM system; the engineering of parts now takes only one-eighth to one-fourth as long as the conventional method of detailing from blueprints. Time savings result not only because drafting is facilitated but because the design and data can be transferred through the computer from the design shop to the manufacturing shop several miles away in seconds. Under the old system, a drafter in the manufacturing shop would have to duplicate the design-shop drawing by superimposing a piece of paper and hand copying it line by line.

An additional advantage of CAD/CAM is that it is considerably more accurate than drafting by hand; CAD/CAM- manufactured parts can be finished to closer tolerances and with fewer errors. This provides major savings during subsequent assembly operations because the closer tolerances make assembly simpler and less costly. Also, because the programming of parts can be done so quickly with CAD/CAM, it becomes economically feasible to program for even very small batch production.

In many cases, workers are retrained to operate a CAD/CAM system. At one aircraft plant, 100 workers (design engineers, tool engineers, structural designers, and drafters) underwent a 6-month, in-house training program when the new CAD/CAM system was installed. No workers were laid off at that time. More recently, new drafters were given a 3-week, 3-hour-per-day training program to become fully functional on the CAD/CAM system.

Since 1974, when CAD/CAM systems first came into use, they have been widely diffused throughout the aerospace industry. Initially, the technology was adopted by the major aerospace companies, but, with lower computer prices and improvements in the technology, it is spreading to smaller firms. Some of the major aircraft manufacturers are requesting that their suppliers and subcontractors be equipped with CAD/CAM to facilitate intercompany transfer of drawings and data.

Industrial robots

Industrial robots are being adopted by aerospace manufacturers to do simple manual tasks such as drilling holes, spray painting, and welding. These functions are comparatively easy to adapt to robots because the paths the robot is to follow are predictable, the tasks are repetitive, and little sensing capability is required. Robots are also being used to some degree to lay graphite on composite production lines.

Large productivity gains are associated with the adoption of industrial robots. For example, after a major aircraft manufacturer installed a robot in the plant's vertical tail construction station, unit labor requirements were reduced by almost two-thirds. Formerly, it took a worker a full day to drill all the necessary holes in a graphite epoxy skin; with the robot, he can drill between two and three skins each day.[4] The original operator was retrained to operate the robot. At a second aircraft plant, a spray-painting robot was installed to paint airplane sections. Previously, using conventional equipment, five workers needed 8 hours to manually paint the aircraft section; with the robot, only two workers are required to paint the piece in the same period of time.[5]

Product reliability is another factor favoring the diffusion of robots. Error is reduced because robot-produced parts are the same every time, and they are of consistently high quality. And since parts can be made to closer tolerances, subsequent assembly operations are facilitated.

Despite the apparent advantages, diffusion of the robot is low in aerospace relative to high-volume industries such as automobiles and appliances. A 1983 survey revealed 78 robots in the aircraft industry out of a total of 2,744 in all metalworking industries.[6] The low diffusion is attributable to the nature of aerospace production, which is largely batch or job oriented. Nevertheless, diffusion is expected to increase in those areas which can be automated. One aircraft manufacturer who had eight robots in 1982 predicted that the company would have 40 within the next several years.[7] At a second plant with three robots, management plans to add dozens more as part of a $1 billion modernization program.[8]

[4] *Iron Age,* July 14, 1984, p. 63.
[5] *Aviation Week and Space Technology*, Aug. 2, 1982, p. 78.
[6] "The 13th Annual Inventory of Metalworking Equipment, 1983," *American Machinist*, November 1983.
[7] *Aviation Week and Space Technology*, Aug. 2, 1982, p. 77.
[8] *Ibid.,* April 19, 1984, p. 27.

Flexible manufacturing system

On the cutting edge of technological development in the aerospace industry is the flexible manufacturing system (FMS), which can reduce downtime and unit labor requirements. At one plant with an FMS, unit labor requirements to produce parts were reduced to an average of only one-third of that required for conventional equipment.

An FMS consists of a series of computer-controlled work stations which are linked by a sophisticated material-handling system to transport work pieces from one station to the next. The system allows the randomized routing of parts to different work stations, rather than necessarily running them in a straight line through the stations. In addition, the system can be sufficiently flexible to accommodate the machining of a wide range of products through use of quick-change, automated tooling and computer control. For example, at one plant producing fuselage sections for the B-1 bomber, 541 different parts can be produced with relatively quick changeover of tooling. By contrast, a conventional transfer line is typically designed to machine a single piece.

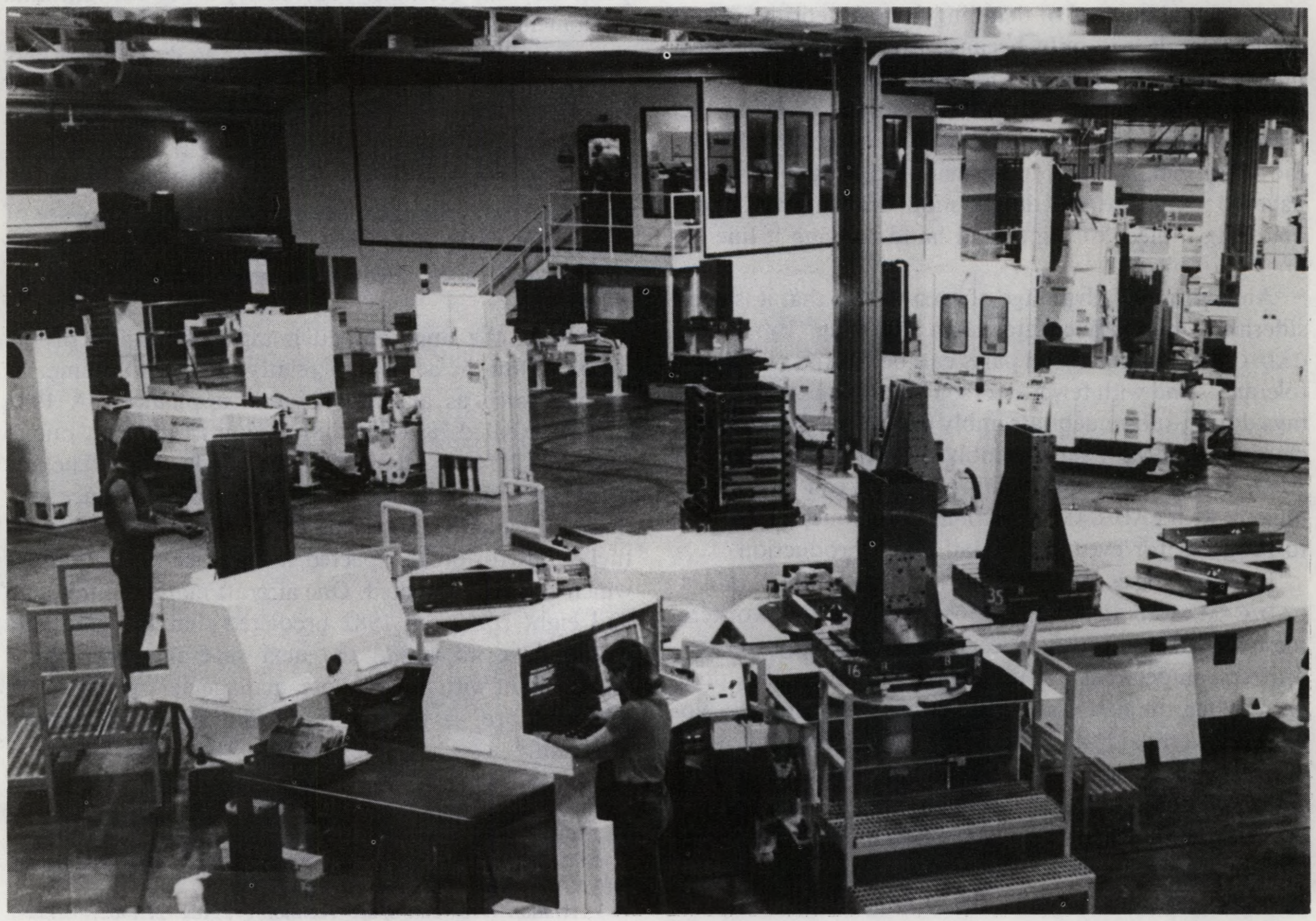
The major advantage of flexible manufacturing is that it allows more economical production of small quantities of a variety of parts. This is achieved through reducing downtime and improving machine utilization and material handling, thereby cutting unit labor requirements. One FMS is designed to result in 80- to 85-percent machine-time use, compared to 15 to 25 percent for conventional manufacturing setups.[9] Another advantage of this system is that inventory costs can be minimized since new parts can be so readily and cheaply produced.

Output and Productivity Trends

Output

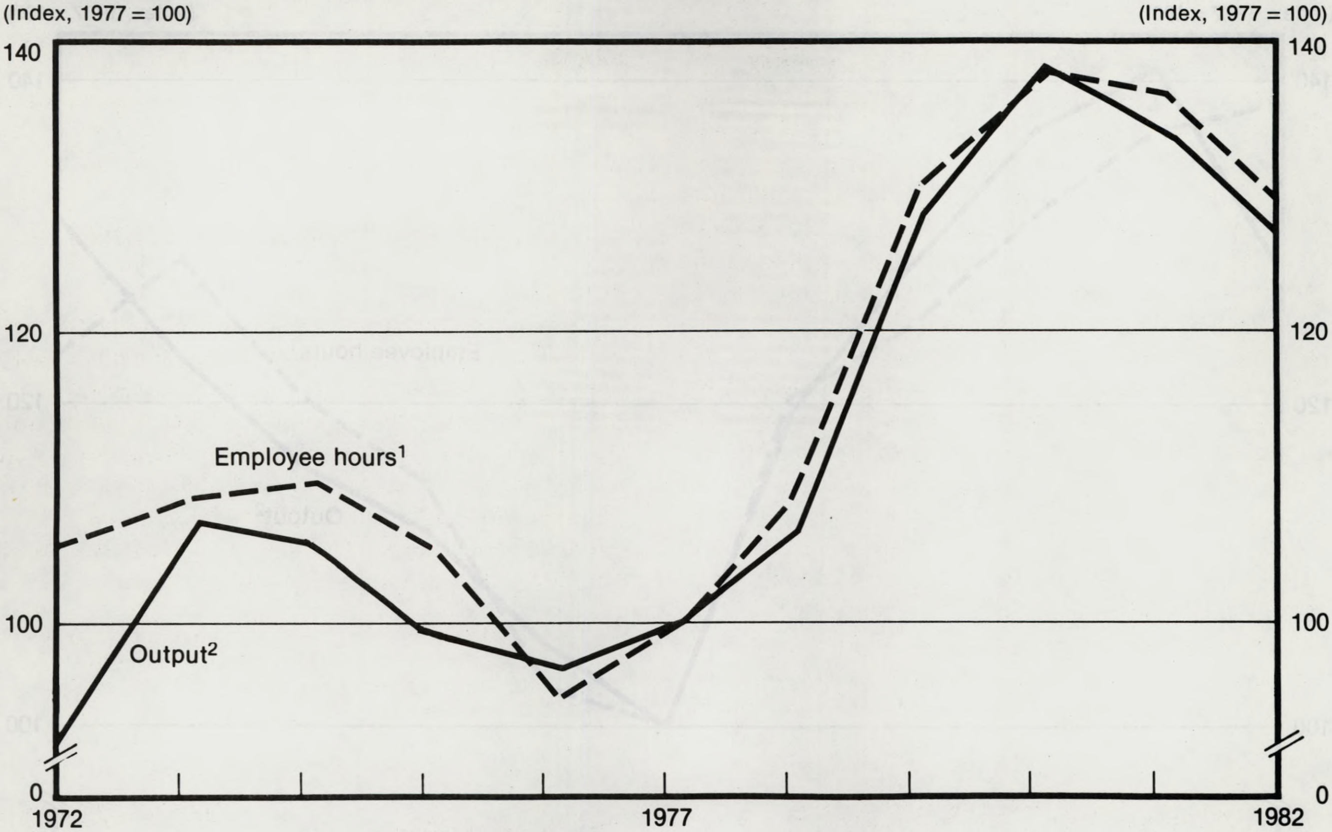
Output in the aerospace industry is highly volatile, as a result of both changing economic conditions and differing perceptions of the Nation's defense requirements (chart 7 and 8). While there is no definitive measure of output, available data[10] indicate sharp fluctuations, but relatively good overall growth. In the 1972-82 period, estimates of real output growth range from 3 1/2 percent (Census) to 4 1/2 percent (Federal Reserve). The rate of output growth for all durable goods was 2.4 percent during that period (BLS).

[9] *Aviation Week and Space Technology*, Aug. 2, 1982, pp. 46-47.
[10] Bureau of the Census, *Census of Manufactures*, deflated value of shipments; Board of Governors of the Federal Reserve Board, Index of Industrial Production.



Operators monitor a flexible manufacturing system used to machine fuselage parts.

Chart 7. Output and employee hours, aircraft and parts, 1972-82



[1]Based on data from the Bureau of the Census and the Bureau of Labor Statistics.
[2]Deflated value of shipments based on Bureau of the Census and Bureau of Labor Statistics data.
Source: Bureau of Labor Statistics.

Output in the aircraft and parts industry declined during the early 1970's due to the 1970 recession (which collasped the commercial aircraft market) and to reduced military demand associated with the winding down of the Vietnam War. It increased in 1973, only to fall again as a result of the 1974-75 recession. The late 1970's and 1980 were marked by a sharp rise in production due to strength in the civil aircraft sector which was offset to some degree by a decline in military production.

During the early 1980's, aircraft production was depressed by recession, high interest rates, and greater foreign competition. Commercial large transport and general aviation aircraft production was hurt by lower corporate profits, the restructuring of domestic airlines, and stiff competition overseas. Unit sales were especially depressed in the general aviation sector, falling from 17,811 in 1978 to 4,266 in 1982. Dollar sales were not hurt as much because of a change of product mix in favor of higher priced turbo and commuter jets. Weakness in these important sectors was partially offset by gains in the military sector.

The growing internationalization of the aircraft industry has contributed to the decline in domestic output in recent years. Foreign producers have gained an increased share of the global aircraft market, which had historically been overwhelmingly dominated by U.S. manufacturers. For the period 1964-79, U.S. commercial jets represented almost 90 percent of the annual global market. Between 1980 and early 1984, the U.S. share of the wide-body transport aircraft market, which accounts for almost half of the total large transport market (dollar value), was estimated to be 68 percent.[11]

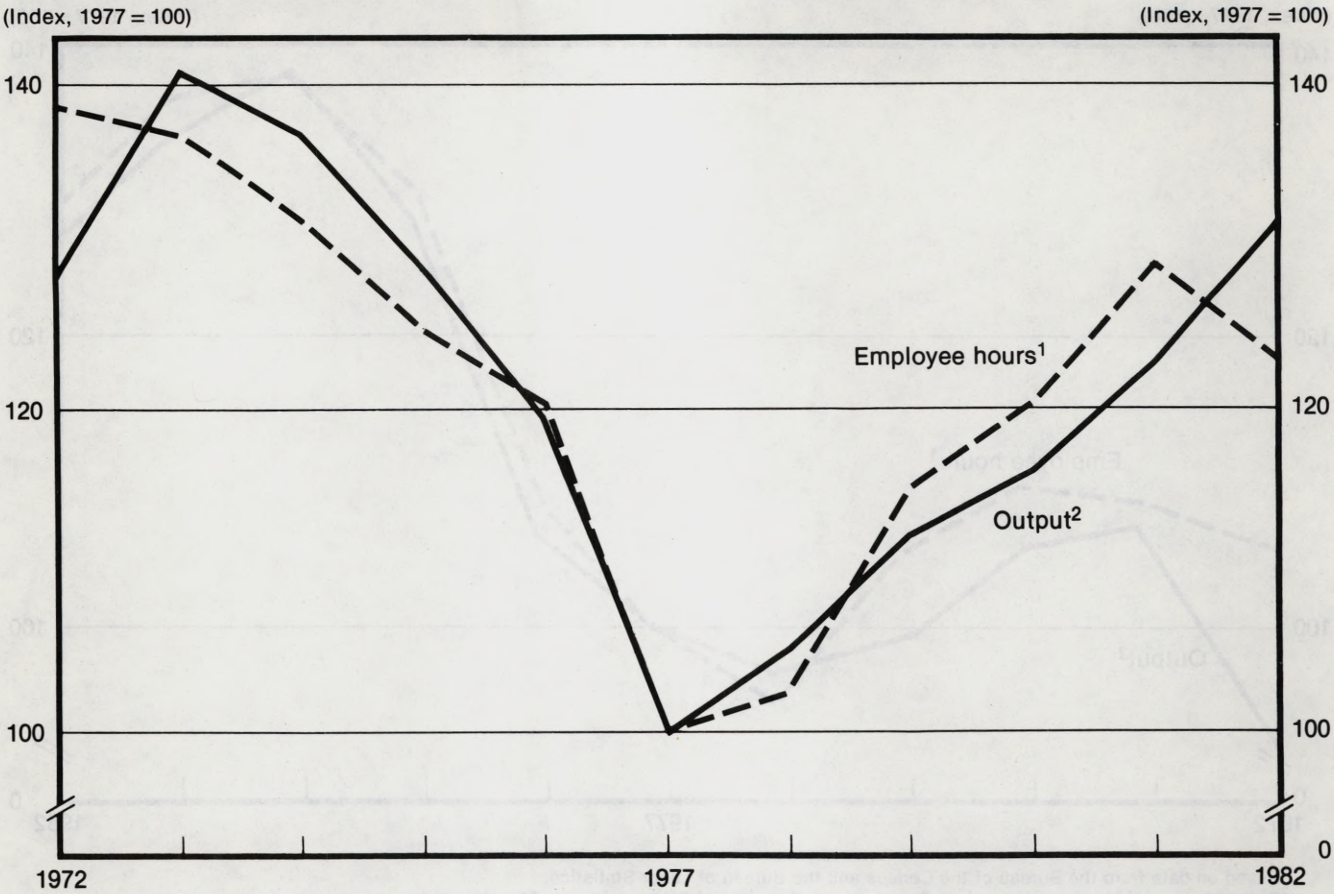
Moreover, foreign producers have been able to make substantial inroads into the U.S. aircraft market, with their greatest penetration in the general aviation sector (36-percent share in 1982 compared to 10 percent in 1978) and the helicopter sector (35-percent share in 1982 compared to 14 percent in 1978).

During the remainder of the decade, output growth in the aircraft and parts industry is expected to be strong, in large part due to high military demand. The prospects for commercial transport are also expected to improve, because the existing airfleet is aging, noisy, and fuel inefficient.

Output in the missiles and space vehicles industry is, like aircraft, highly volatile. It declined sharply during

[11] U.S. Department of Commerce, International Trade Administration.

Chart 8. Output and employee hours, missiles and space vehicles, 1972-82



[1]Based on data from the Bureau of the Census and the Bureau of Labor Statistics.
[2]Deflated value of shipments based on data from Bureau of the Census and Bureau of Labor Statistics.
Source: Bureau of Labor Statistics.

most of the 1970's to reach a low in 1977, then rebounded as the Nation began to rebuild its defenses. The missiles and space vehicles industry has become the most rapidly growing aerospace sector, with space products its most dynamic segment. A strong export market has also boosted sales. Overall, for the entire period 1972-82, output declined by about 1 percent annually because of the weakness in early years.

Output growth is expected to continue for the missiles and space vehicles industry if the country follows through on its planned defense expenditures. The Department of Commerce projects very rapid growth in the missiles and space vehicles sector during the remainder of the decade and only slightly less rapid growth for shipments of space propulsion units and space vehicle equipment.[12]

Productivity

Available data suggest that output per employee hour in the aircraft and parts industry increased at a modest rate during the period 1972-82 (no earlier or later data available). Real output is estimated to have increased by approximately 3 1/2 to 4 1/2 percent annually during those years (see above), while employee hours (based on Bureau of the Census data) rose by about 3 percent annually.

The small decline in the ratio of payroll to value added through 1981 (0.7 percent annually) would also indicate relatively slow productivity growth. The low growth contrasts with the stronger productivity increase of the 1960-73 years when aircraft industry output rose more than 3 percent and employee hours fell by about 1 percent annually.[13]

The slower growth in productivity during the latter period can be at least in part attributed to the volatile shifts in output, with delayed adjustments in employment. The growing complexity of the product (such as increasing amounts of electronic gear) and more frequent changes in design have also been cited as causes for the limited productivity gains.

[12] *1985 U.S. Industrial Outlook*, U.S. Department of Commerce, International Trade Administration, p. 37-10.

[13] *Technological Change and Manpower Trends in Five Industries*, Bulletin 1856, Bureau of Labor Statistics, pp. 38-39.

In the missiles and space vehicles industry, available data[14] suggest that productivity showed little or no increase between 1972 and 1982. During those years, shipments declined by slightly more than 1 percent annually while employee hours decreased at approximately the same rate.

Investment

Capital expenditures

Following the decline in the early 1970's, real capital expenditures in the aircraft and parts industry increased very sharply.[15] They reached a peak in 1980, at well over twice the 1970 level, then fell slightly in 1981 (latest available data).

The low level of expenditures during the early 1970's—lower than at any time since the late 1940's—was largely due to the accumulation of substantial excess capacity during the Vietnam War buildup of the late 1960's and the recession in the early 1970's. In contrast, investment was pushed upward by rising production levels and new aircraft programs during the late 1970's.

In current dollars, aircraft industry capital expenditures were $1.6 billion in 1981, or nearly 5 times the dollar outlays in 1970. Investment is being largely directed toward modernizing existing facilities.

Capital expenditures per employee have been below the average for all manufacturing industries although the spread has narrowed in recent years. For the years 1972-74, the level of capital expenditures per employee in the aircraft industry was less than one-third the average in all manufacturing industries; for the period 1979-81, it averaged one-quarter less.

In the guided missiles and space vehicles industry, real capital expenditures increased sharply in the late 1970's after years of decline, and nearly doubled between 1978 and 1981. Despite the recent sharp rise, the 1981 level was only slightly more than half the peak expenditures of 1967. In current dollars, $369 million was spent in 1981.

The upward trend during the late 1970's was associated with rising capacity utilization, the Nation's military buildup, and expansion of the space program. Due to expected expansion of numerous weapons and space programs, continued rapid real increase in capital expenditures is likely.

Research and development

The aerospace industry has historically been a leader in research and development (R&D) spending. In 1982, for instance, outlays for R&D were $14.0 billion, more than any other manufacturing industry and nearly one-fourth the R&D expenditures of all industries.

Moreover, R&D funding as a percentage of net sales in aerospace is far higher than in most other industries, amounting to 18.3 percent in 1982, compared to only 3.7 percent in all manufacturing industries. The level of expenditures increased modestly (in constant dollars) between 1970 and 1982.

The Federal Government contributes a large share of these expenditures. In 1982, Federal funds accounted for nearly three-fourths of total aerospace funds for R&D. These Federal outlays were more than half of total Federal R&D expenditures.

A portion of Federal Government R&D outlays is used to fund programs designed to improve production methods in defense contractor plants. One program (Technology Modernization or TechMod) helps manufacturers pay for the implementation of new technologies in plants. A second major program (Manufacturing Technology or ManTech) is designed to develop productivity-enhancing manufacturing technologies. At least one-quarter of 1984 funding for ManTech was concerned with computer-aided manufacturing.[16]

Employment and Occupational Outlook

Employment

Employment in the aircraft and parts industry is characterized by sharp fluctuations associated with changing economic and political conditions (chart 9). It rose rapidly during the Vietnam War buildup, to a peak of 846,000 in 1968, then declined precipitously between 1968 and 1972 as the war wound down and the economic climate deteriorated.

Between 1972 and 1974, aircraft employment rose slightly, only to fall again during the 1974-75 recession. The years 1977-80 were marked by rapid growth, as production reached record levels in the commercial and general aviation sectors.

Between 1980 and 1983, employment moved sharply downward, falling by 11 percent, to 578,000, almost one-third below its Vietnam-era peak. It rebounded slightly to 596,000 in 1984, with the increase in aircraft orders.

For the entire period 1970-84, employment in the aircraft and parts industry grew by 0.9 percent annually, triple the rate for durable goods manufacturing.

In the guided missiles and space vehicles industry, employment generally declined between 1972 and 1977, then increased sharply in the late 1970's and early 1980's.

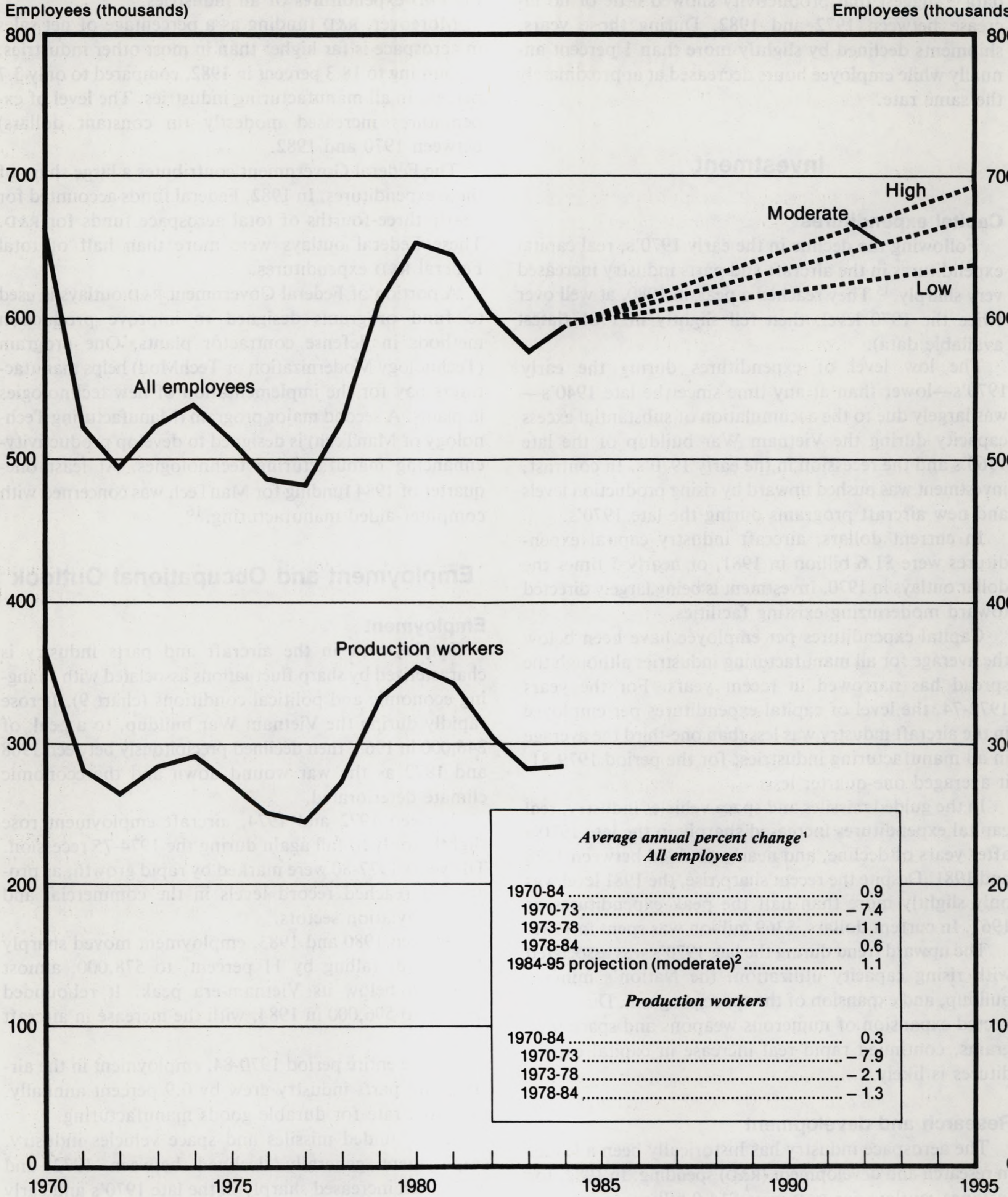
BLS projects that, between 1984 and 1995, employ-

[14] Bureau of the Census hours and deflated value of Census shipments.

[15] U.S. Department of Commerce, Bureau of Industrial Economics, Office of Research, Analysis, and Statistics.

[16] "Employment, Education, and the Workplace," *Computerized Manufacturing Automation,* pp. 314-17.

Chart 9. Employment in aircraft and parts, 1970-84, and projections, 1984-95



[1]Least squares trends method for historical data, compound interest method for projections.
[2]See text footnote 17.
Source: Bureau of Labor Statistics.

ment in the aircraft industry will rise at an average annual rate of 1.1 percent, to 670,000,[17] assuming moderate growth in the economy. This trend would bring employment back to exceed its 1970 level. The missiles and space vehicles industry is expected to increase at a more rapid rate of 2.2 percent annually, to 196,000.[18]

Occupations

The use of technological innovations in the production process and the increasing sophistication of aircraft are contributing to a shift in the occupational composition of the aircraft and parts industry. New production methods are reducing requirements for a wide range of production workers (such as machine tool cutting and forming operators), while increasing the demand for highly educated and skilled professional and technical workers, such as electronic technicians, computer programmers, engineers, and other technically trained personnel. This is particularly true for CNC equipment, where computer programmers are replacing machine operators and machinists.

In both the aircraft and the missiles and space vehicles industries, the ratio of production workers to total employment is very low relative to other industries. For instance, in 1984, production workers accounted for 48 percent of total employment in the aircraft industry, and 33 percent in the missiles and space vehicles industry. By contrast, they accounted for 67 percent of total employment in all durable goods industries. The low proportion of production workers is associated with the increased sophistication of the technologies which require relatively more professional and technical personnel.

BLS occupational projections for the aircraft industry for 1995 suggest that these trends will continue, i.e., that the share of production worker employment will decline. Professional and technical workers, and managers and related workers are expected to increase. An employment gain of 25 percent is projected for engineers, who already accounted for almost one-seventh of total employment in 1984. Other occupations which are expected to grow rapidly are electrical and electronic technicians and computer programmers.

In the missiles and space vehicles industry, BLS projects that by 1995 the patterns of change will be similar to those in the aircraft industry. Engineering occupations, one-fourth of all jobs in 1984, will grow by about one-third from 1984 to 1995.

Adjustment of workers to technological change

Programs to protect employees from the adverse effects of changes in machinery and methods of production may be incorporated into contracts, or they may be informal arrangements between labor and management. In general, such programs are more prevalent and detailed in industries which negotiate formal labor-management agreements. Contract provisions to assist workers in their adjustment to technological and associated changes may cover wage rates, job assignments, retraining, transfer rights, layoff procedures, and advance notice of changes planned by management, e.g., machine changes or plant closings. They may include various types of income maintenance programs, such as supplementary unemployment benefits or severance pay.

A large proportion of production workers employed by the major contractors in the aircraft and parts industry are represented by labor-management agreements. By contrast, many of the subcontractors and suppliers are not unionized. The major union is the International Association of Machinists and Aerospace Workers (IAM). Other unions representing smaller numbers of production workers include the United Auto Workers (UAW), the International Brotherhood of Electrical Workers (IBEW), and the International Union of Electrical Workers (IUE). Professional and technical workers are represented at one large aircraft plant by the Seattle Professional Engineering Association. Most professional and technical workers unions are unaffiliated, local units.

While recognizing that it is to the "mutual benefit of both the union and the company to utilize the most effective machines, processes, (and) methods," one major union has been concerned with dislocation and has pushed for additional provisions to help ease worker adjustment to technological change. In negotiations concluded at a major aircraft plant in December 1983, this union won the right to advance notification of management plans to introduce new technology. According to the contract the company will, no less than annually, provide a briefing to the union of the company's plans for the introduction of new technology and will identify its likely impact on job skills.[19]

In the event that jobs are eliminated due to technological change, some assistance, such as retraining, has been included in some negotiated contracts. For example, at one plant, a training program is being developed for current and laid-off employees to qualify them for employment in jobs involving new technology. Priority for training is to be given to laid-off workers with recall rights. At a second plant, a negotiated agreement includes a letter specifying that the company will establish a committee to deal with new technologies with the goal of assuring that employees who are directly laid off due to

[17] BLS projections for industry employment in 1995 are based on three alternative versions of economic growth. For details on assumptions and methodology used to develop these projections, see the *Monthly Labor Review*, November 1985.

[18] *Ibid.*

[19] *Agreement Between The Boeing Company and International Association of Machinists and Aerospace Workers,* 1983, p. 86.

the introduction of new machinery and equipment will be offered retraining in the event that equivalent job opportunities are not available elsewhere.[20]

Other major industry contracts provide for severance payments, supplementary unemployment benefits (SUB), and seniority regulations governing layoff and recall in the event of layoff although no direct reference is made to technology.

[20] *Agreement Between Lockheed-Georgia Company and International Association of Machinists and Aerospace Workers,* 1983, pp. 196-97.

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Chapter 4. Commercial Banking

Summary

The commercial banking industry (SIC 602) has been expanding. Between 1970 and 1983, the volume of services and transactions in commercial banks increased, employment rose, and banks added branches to attract customers by making services more convenient.[1]

Advances in technology make it possible for banks to process the substantial increase in the volume of checks and other documents and to improve efficiency of employees in occupations ranging from managers to check processors. Most of the changes involve electronic computers, video terminal networks, electronic transfer of funds, and high-speed check sorting.

Output of commercial banks (as measured by the BLS composite index of deposits, loans, and trust services) increased by an average annual rate of 4.7 percent between 1970 and 1983. The rate of increase was uneven; the largest increase was in the early and middle years of this span, and between 1982 and 1983. Between 1978 and 1983, output increased at a significantly lower annual rate of 2.6 percent.

Productivity in commercial banking (output per employee hour) increased at an average annual rate of only 0.8 percent during 1970-83, as the rate of growth in employee hours—despite mechanization—nearly matched the rate of expansion in output. During 1978-83, the productivity record worsened as output per employee hour declined at an average annual rate of 0.4 percent when the rate of growth in employee hours exceeded the rate of expansion in output through 1981. The situation changed considerably in 1982-83, as output grew much more rapidly than employee hours.

Employment in commercial banks totaled 1.5 million in 1984; BLS projects a further rise to about 1.7 million employees in 1995. Between 1970 and 1984, employment increased at an average annual rate of 3.7 percent, and a somewhat slower growth rate is anticipated through the mid-1990's. The structure of employment has changed—the proportion of nonsupervisory workers has declined as automation of bank operations has increased. Women accounted for a substantial and growing share of the work force in commercial banks, 72 percent in 1984.

Employment in most occupations is expected to increase through the mid-1990's as demand for commercial banking continues to rise. Growth should be highest for managerial and some professional and technical workers, while growth for clerical workers—the largest group of employees in commercial banking—will be very small. Employment for bank tellers, about 23 percent of the industry work force in 1984, will increase only slightly by 1995 due to further automation of teller functions.

The banking industry makes extensive use of training programs for people entering the industry as well as for those who need further training to meet the demands of new jobs or changing technologies. Training programs include formal classwork, sometimes involving video training techniques, and on-the-job training.

[1] The commercial banking industry covered by this bulletin is defined as Standard Industrial Classification (SIC) 602, commercial and stock savings banks. Included are banks and trust companies which accept deposits for the public and extend credit through loans and investments. Mutual savings banks are excluded.

Technology in the 1980's

A number of technological changes are taking place in commercial banks which affect job skills and employment requirements. Advances in computer technology make possible a growing number of automated customer services and internal banking procedures. Networks of online video terminals allow bank tellers and managers quick access to customer records, and require tellers, bookkeepers, and managerial personnel to be familiar with computer systems and equipment. Also, demand is strong for computer specialists. Automatic teller machines and point-of-sale terminals reduce labor requirements for tellers and for those who proof and sort checks. Despite automation, however, processing bank checks remains labor intensive, as each check going through the banking system must be handled several times. High-speed check-sorting machines are available, but proofing and coding the checks prior to sorting continues to limit major productivity improvement. A description of major technological changes in commercial banking, their impact on labor, and prospects for further diffusion are presented in table 4.

Computerization of bank functions

The most important area of technological change involves a wide assortment of electronic data processing and electronic funds transfer operations that are based on applications of computer technology. The financial services industry, of which commercial banks are a major portion, is second only to the U.S. Government in the number of computers in use.

Table 4. Major technology changes in commercial banking

Technology	Description	Labor implications	Diffusion
Computerization of bank functions	Computers and software packages are used in clearinghouse debits, reconciliation of customer accounts, payroll deposits, depository transfer of checks, balance reporting, and some trust deposit accounting operations.	Bank managers need a knowledge of computer operations. Tellers and some other personnel must be trained to use online video terminals and other computer peripheral equipment. Labor requirements in some operations are lower. Demand for programmers is growing.	In 1984, nearly all commercial banks had some computerized operations, up from 21 percent of all banks in 1965.
Online terminals and other teller aids	Video screen computer terminals connected online to a bank's central computer. Primarily used by bank tellers; to a lesser extent by loan officers and other bank personnel for access to customer records. Some online terminals provide electronic journaling capability which eliminates need for tellers to make lengthy adding machine tapes of daily transactions.	Tellers and others who work with customers must be trained to use video terminals. Customer transactions and accounting tasks can be accomplished more quickly. One bank estimates that teller productivity increased by 20 percent after online terminals were adopted.	Online terminals are being introduced in larger banks, especially those with a number of branches. One large bank has over 1,000 video terminals installed in branches.
	Teller-operated cash dispensing machines provide cash in specified amounts faster and more accurately than tellers can do manually counting the cash.		
Electronic funds transfer (EFT) systems	Automatic teller machines (ATM's) provide many of the services of a human bank teller. ATM's usually are located on exterior bank walls or other places accessible to customers during nonbanking hours. Customer withdrawals, the primary ATM transaction, are made in cash, thereby reducing the volume of checks processed by banks using ATM's.	ATM's reduce the rate of growth in employment of tellers.	The number of ATM's has grown from about 2,000 in 1973, to almost 60,000 in 1984. Experts foresee a further expansion in use of ATM's over the next decade.
	In automated clearing houses (ACH), debit and credit transactions between banks are made electronically without transfer of paper. Transaction time and costs are decreased.	Impact of ACH operations cannot be determined completely, but productivity in affected applications is higher.	ACH transactions have grown from 50 million in 1976 to more than 557 million in 1984, and further growth is expected.
	Wire funds transfer systems provide electronic transfer of large dollar transactions between banks for bank, corporation, or U.S. Government financial activities.	Probable decline in the number of clerical employees needed to handled these transactions.	Widely used in medium and large banks, and in growing use in small banks.
	Point-of-sale (POS) terminals provide immediate charges to a person's checking account for purchases made at retail outlets where POS terminals have been installed, such as supermarkets and gasoline stations.	Point-of-sale terminals could reduce labor requirements for tellers.	Point-of-sale terminals are in very limited use, but installations are expected to increase.
Check processing equipment	Proofing and encoding machines print the dollar amount of each check in magnetic ink character recognition (MICR) characters for machine reading.	Demand for proofing and encoding machine operators, an entry level job, will probably increase only slowly as check volume moves higher. Productivity of check sorters has risen significantly as the speed of new equipment has increased.	All banks use proofing and encoding machines and checksorting machines. Only the largest banks have the volume to justify the larger and faster models.
	High-speed sorting machines read MICR characters and sort checks by bank and individual account number at speeds up to 100,000 checks per hour.		

Computer applications have grown rapidly in the banking industry. According to the American Bankers Association (ABA), 97 percent of all banks had computerized operations in 1980 (most recent survey available), up from 21 percent in 1965. The location of computer processing—onsite for the user bank, or offsite—also has changed over time. In 1965, only 6 percent of banks had onsite computers and 15 percent used offsite computers.[2] By 1980, 26 percent of all banks had onsite computer operations, while 71 percent used the computer facilities of correspondent banks or computer service bureaus. Looking ahead to 1990, an estimated 90 percent of all banks will have onsite computer capacity, due in part to developments in microelectronics technology.[3]

As computer use has grown, expenditures for hardware, software, and salaries of computer staff have moved higher. Computer-related expenses have grown most rapidly for large banks (assets of $500 million and over) and accounted for about 9 percent of their operating expenses in 1980. This is not surprising since 75 percent of large banks were using onsite computers by 1980 (compared to only 23 percent of small banks and 45 percent of medium-sized banks). Many large banks also provide offsite computer services to smaller correspondent banks.[4]

A number of customer services have been computerized. Those mentioned most frequently in the ABA survey include automated clearinghouse (ACH) debits (offered by 56 percent of banks), automated reconciliation of customer accounts (44 percent), automatic payroll deposit (39 percent), ACH credit origination and depository transfer of checks (32 percent), and automated reporting of account balances (25 percent).[5] In large trust departments, most accounting operations are computerized, but only about one-third to one-half of other operations (securities management, tax preparation, stock transfers, etc.) are automated.

The economic benefits available from computerization are illustrated by a bank that installed equipment to automate the handling of a large commercial customer's daily deposit. The deposit consisted of 16-19 bags of coins and currency which had to be counted twice for accuracy. Three tellers spent 5 hours every day processing the deposit. To automate the processing of this deposit, the bank installed a minicomputer, a coin sorter/counter, and a currency/document counter. With this equipment, the deposit is now made by one teller, working for 1 hour, assisted for one-half hour by a second teller. The savings that resulted paid for the new equipment in 10 months.[6]

Online terminals and other teller aids

Online terminals for bank tellers and administrative personnel, teller-operated cash-dispensing machines at teller stations, and other electronically operated equipment have evolved from developments in computer and electronics technology. This equipment improves productivity of bank personnel and increases services available to customers.

Online teller terminals. These video terminals are becoming more widely used because they increase productivity of bank tellers. The terminal networks are used primarily to respond to customer balance inquires and to post customer transactions. Tellers respond to requests for bank balances in a few seconds with online terminals, compared to several minutes by former methods. One bank estimates that productivity of tellers rose by 20 percent after an online teller terminal system was installed.[7] The video screens in modern terminal networks also can be used to relay messages to tellers concerning lost or stolen credit cards or checks, changes in foreign exchange rates, and related matters.

The first online terminals, introduced in the early 1960's in savings banks, were installed to speed up customer service at teller stations in branches of savings banks, and did not have video screens. Although commercial banks were slower to adopt online terminals, their interest increased following the tremendous growth in the number of commercial bank branches during the 1960's and 1970's. Moreover, the capabilities of online teller terminals improved significantly over this period. In 1974, the Bank of America installed terminals in more than 1,000 branches in California, and has expanded this network to include almost 10,000 terminals.[8]

Electronic journaling is another facet of online teller systems that contributes to increased teller efficiency. It eliminates the need for tellers to make lengthy adding machine tapes to validate all of the transactions that occur each day. Rather, the transactions are electronically entered, stored, and recalled. It is also possible for tellers to move from one teller station to another during peak work periods, as each teller has an individual identification code within the terminal system. One bank estimates that electronic journaling added a 4- to 5-percent productivity increase for tellers to the 20 percent already gained from faster response to customer balance inquiry and transactions posting.[9]

Teller-operated cash-dispensing machines. These machines, a fairly recent addition to teller stations, are boxes which contain currency (and sometimes travelers' checks) in various denominations. Tellers use terminals or special keyboards to dispense cash more rapidly than by hand. These teller-operated machines keep track of the amount of cash dispensed, thus eliminating the need to recount the cash before giving it to customers—an additional productivity gain for tellers.

[2] *National Operations/Automation Survey 1981*, American Bankers Association, 1981, p. 7.

[3] William R. Synnott, "Shock Talk: Prospects for the Next Round of Technological Leverage," *ABA Banking Journal*, May 1983, p. 45.

[4] *National Operations/Automation Survey 1981*, p. 7.

[5] *Ibid.*, p. 15.

[6] "Ten-Month Payback From Automating Big Deposits," *ABA Banking Journal*, April 1982, p. 96.

[7] William Friis, "Electronic Journaling Helps Truncate Paper in Branches," *ABA Banking Journal*, January 1983, p. 82.

[8] William Friis, "A 20-Year Retrospective on Teller Terminals," *ABA Banking Journal*, April 1982, p. 76.

[9] *Ibid.*

Online administrative (or "platform") terminals. These terminals are used by most banks that use online teller terminals. Platform terminals carry out a variety of functions for bank administrators—responding to customer inquiries, resolving problems with checking account reconciliations, changing names and addresses in customer files, displaying listings of overdrawn or inactive accounts, and other activities. Increasingly, online terminals are being used to evaluate loan applications or make investment recommendations. Online terminals improve the speed with which bank personnel can get access to customer records, which increases productivity and improves service for customers.

Electronic funds transfer systems

Electronic funds transfer (EFT) procedures have gained importance as banks have sought more efficient methods to process a growing volume of transactions, primarily checks. An estimated 40 billion checks were processed in 1984.[10]

EFT systems rely heavily on computer and communication technology as indicated by the definition provided below:

> "The common factor in these systems is that they speed the transfer of funds by communicating information relating to payments by electronic means rather than by use of paper instruments as is predominant today. Thus, EFT systems are designed to replace manual processes with electronic data processing and to speed the flow of funds through high speed data transmission."[11]

The major technologies used to transfer funds electronically include automatic teller machines, automated clearing houses, wire funds transfer services, and point-of-sale terminals.

Automatic teller machines. The number of automatic teller machines (ATM's) and cash dispensing machines is expanding rapidly. There were an estimated 60,000 teller machines in use by 1984, up from 1,935 in 1973.[12] Since these machines perform many routine functions of a bank teller, their widespread use has implications for tellers and operating procedures, and for bank customer services.

Teller machines activated by customer-inserted credit cards and "debit" cards (plastic bank cards, each with a strip of magnetically coded information) were introduced in the United States in 1969. Cash dispensing machines (which account for about 1 percent of all teller machines) perform only the single function of dispensing cash. The more sophisticated ATM's (introduced in 1971) perform a range of functions, which include dispensing cash, verifying account balances, transferring funds between accounts, and making payments of recurring bills. ATM's reportedly can perform 90 percent of the transaction functions provided at a teller's window.[13] Among the potential uses for ATM's are dispensing travelers' checks and money orders.

Customer carries out banking transactions on an automated teller machine.

Despite mechanization, employment of bank tellers has grown over the years to handle the increasing volume of checks in the banking industry. Two industry surveys indicate that the growing use of ATM's will reduce the demand for tellers in the future. In one survey of 457 banking establishments, 44 percent of the respondents said that ATM's either had already eliminated one or more human tellers or would reduce the need for additional tellers in the future.[14]

Another survey, covering 200 bank executives, focused on projected changes in the number of bank branches during 1983-88. About 19 percent of all fully staffed branches are expected to close during this period. Those branches that remain in service are expected to be staffed

[10] Estimate provided by the Bank Administration Institute.

[11] William C. Niblack, "Development of Electronic Funds Transfer Systems," *Federal Reserve Bank of St. Louis Review,* September 1976, p. 10.

[12] Linda Fenner Zimmer, "ATM's 1983: A Critical Assessment," *The Magazine of Bank Administration,* May 1984.

[13] "Virginia ATM Pioneer Is Still Innovative," *ABA Banking Journal,* June 1982, p. 72.

[14] Linda Fenner Zimmer, "ATM Installations Surge," *The Magazine of Bank Administration,* May 1980, pp. 30-31.

by fewer employees, who will use automated equipment extensively. ATM's were singled out as the most important factor in this change, according to 58 percent of the respondents. In-lobby ATM's and other customer-operated equipment are expected to reduce the number of tellers by 17 percent.[15]

One advantage of ATM's is that they reduce the volume of checks that enter into the bank's operating systems—checks that must be sorted, processed, and in many instances returned to the customers. Reducing check volume is very important to banks. About a decade ago, the banking industry feared that its capacity to process checks would be overwhelmed by the rapidly growing volume of checks. However, faster, more sophisticated check processing and sorting equipment has been introduced which is capable of handling any foreseeable volume of checks adequately. Nonetheless, a huge volume of checks goes through the banking system each year, representing a considerable cost to the industry. New technology that can reduce this cost is welcome. The extent to which ATM's reduce the use of checks is uncertain, but they contribute to some decrease—possibly as much as 7 percent in 1983.[16]

Banks of all sizes use teller machines: A 1981 survey of over 800 banks reported that 14 percent of all small banks, over one-half of medium-sized banks, and roughly three-fourths of the large banks reported one or more ATM's in use during 1980.[17] Most teller machines were located on a bank's own premises; about 90 percent in 1979.[18] Lobby locations proved unpopular—once inside the bank, customers apparently prefer to deal with a human teller. The most popular location is the outside wall of a bank building, where they provide 24-hour banking service to customers.

Acceptance of offsite ATM locations has been slower among both banks and customers—but this is changing, especially with the advent of ATM networks. As banks fulfill their needs for onsite ATM's, they increasingly are being installed offsite in shopping centers, supermarkets, college campuses, hospitals, gas stations, and other locations convenient to the public.

Automated clearing houses. Automated clearing houses (ACH) carry out debit and credit transactions between parties electronically. With electronic methods, transactions are more rapid and less expensive than with paper checks.

When payment is made by conventional check, for example, the check is deposited in the receiving party's bank and then, unless both parties have accounts in the same bank, is sent to the payer's bank—often through another bank or a clearing house designed to handle such transactions. The estimated 40 billion checks that go through the financial system each year require considerable time and labor to process.

When payment is made using ACH, the process differs markedly. With ACH, debit and credit items are electronic signals, usually encoded on reels of computer-generated magnetic tape. The tape contains the amount of various payments; the names, bank numbers, and account numbers of those receiving payments; and the names of the parties making payments. It is this information that is transmitted—not individual pieces of paper.

Automated clearing house operations have been increasing in importance. The U.S. Government first made extensive use of the system in the early 1970's for U.S. Treasury disbursement of Social Security payments, Federal Government payrolls and benefits, and other items. Local, private, automated clearing houses were organized; and in 1976, a national ACH association was formed. In 1976, 50 million ACH transactions took place, 92 percent of which originated with the U.S. Treasury. The process has grown rapidly, especially for private banking; of the 556.6 million transactions reported in 1984, private banking accounted for 61 percent.[19]

The impact of ACH upon labor requirements is difficult to determine precisely, since ACH uses the same computer equipment that banks use for other electronic data processing and fund transfer operations. Thus, banks involved in ACH operations must allocate some computer staff time to handling ACH data. As ACH operations grow, there may well be an increase in demand for computer personnel.

Wire funds transfer services. EFT systems have been developed to handle large dollar transactions between banks. The Federal Reserve Board operates the largest system — FedWire — which is used for large volume interbank payments, such as the sale of reserve account balances between banks and the transfer of large bank and corporate balances. FedWire is also used to transfer U.S. Treasury and Federal agency securities. FedWire handled 38 million fund transfers with a value of $84 trillion, and 5.5 million security transfers valued at $35 trillion, in 1983.

There are two other large wire funds transfer systems: The Clearing House Interbank Payments Systems (CHIPS) is operated by the New York City Clearing House Association, and handles most of the international payments in the United States. In 1983, CHIPS processed 19 million transactions valued at $57 trillion. The Payment and Telecommunications Service Corporation

[15] "Survey Predicts 19% Fewer Branches by '88," *ABA Banking Journal,* August 1983, p. 108.

[16] Linda Fenner Zimmer, *The Status of Retail Payment Systems in the U.S.,* an address to the National ATM Conference, Dec. 10, 1984, p. 8.

[17] *National Operations/Automation Survey 1981,* p. 15.

[18] Linda Fenner Zimmer, "ATM Installations Surge," p. 30.

[19] Data provided by National Automated Clearinghouse Association.

(BankWire and CashWire) serves a network of about 180 member banks, providing funds transfers similar to Fed-Wire, but at a slightly lower cost. BankWire processed 1.8 million transactions, for a value of about $8 trillion, in 1983.

Use of wire funds transfers is growing and may well reduce the need for clerical workers. Prior to the use of EFT technology, fund transfers were made in a series of separate, nonautomated clerical operations. Individual clerks would receive orders, verify accounts, and make transactions. Using EFT technology, one clerk can take an order by phone, enter the order in a CRT terminal, and the computerized accounting systems handle the rest of the operation. Industry experts believe that the number of clerical people has already declined somewhat, and will decline further—but there are no solid statistical data on clerical employment in this area at present.

Point-of-sale terminals. Establishing point-of-sale (POS) networks requires cooperation between banks and retail merchants. The merchants install computer-controlled electronic checkout terminals that accept the debit cards banks issue to their customers for automated teller machines, or sometimes just for use in the POS terminals. When customers make a purchase, they insert their debit card into the merchant's checkout terminal, push the proper buttons on the terminal and in seconds, the customer's bank account is debited for the amount of the purchase and the store's account is credited for the amount of the sale. The merchant's checkout terminal is linked to the bank's computer system. If merchant and customer use different banks, a central switching and processing center handles transactions between the two banks.

POS terminals reduce labor requirements of tellers. When a merchant is paid by check, bank personnel have to process that check. However, when the transaction is carried out using a debit card and a POS terminal, manual processing is eliminated.

Several POS terminal systems are in use around the United States. These are all local systems involving primarily supermarkets and gasoline stations.

Point-of-sale systems probably will continue to grow, although the rate of growth is uncertain. Banks have the computer and electronic capability, but retail merchants have been relunctant to invest in electronic equipment. Also consumers have resisted using debit cards, which require that terminals be manipulated and personal identification numbers be used, and which cause consumer bank accounts to be debited immediately. (By one estimate, for example, only 30 percent of eligible bank customers use ATM's, the first step toward participation in various electronic funds transactions).[20]

[20] Bill Streeter, "EFT Is Back. This Time It May Stay," *ABA Banking Journal,* September 1983, p. 135.

Processing bank checks

Despite substantial investment in new technology, processing checks remains labor intensive. Tellers typically receive checks first, as part of customer deposits, and send them to the proofing and encoding area in commercial banks in bundles, usually accompanied by adding machine tapes showing totals for each bundle of checks.

Proofing and encoding operations are the most labor-intensive portions of check handling. Proofing machine operators read the dollar amount of each check, use a keyboard to enter these numbers into the proofing machine, then insert the check into a slot in the proofing machine, which prints (encodes) the dollar amount onto the check in magnetic ink character recognition (MICR) characters. Once the value of the check has been encoded on the MICR line, along with the bank and individual account numbers, the check can be processed by machine. Proofing and encoding checks will remain labor intensive, since significant improvements in equipment are not anticipated over the next few years.

Doing proofing and encoding is an entry level job. Training is on the job and turnover is high. Output is dependent upon operator skill and motivation, but an operator typically handles between 1,300 and 2,000 checks an hour.

After checks are encoded, they are sorted for return to bank customers. High-speed sorting equipment reads the MICR lines on checks. Commercial banks with more advanced equipment can electronically record the MICR data on tape, photocopy both sides of each check, and sort the checks by a number of criteria—at a speed of up to 100,000 checks an hour. Machines with this capacity have been available since the mid-1970's.

Sorting machine operators must meet higher skill requirements than proofing and coding machine operators. Training involves some classwork as well as on-the-job training. People who succeed at this job often have the potential to become computer operators. There is more physical activity, less boredom, and lower turnover associated with sorting machine work than with proofing and coding operations.

Output and Productivity

Output

The BLS output index for commercial banks is based on three major banking activities: Demand deposit transactions; lending for commercial, consumer, and real estate purposes; and activities related to trusts and estates.[21]

[21] In aggregating these three measures to obtain an output index, the labor requirement per unit of each of the major categories of service in a base period was used to combine dissimilar activities. For additional information on the methodology of constructing the output index and a more detailed account of trends in output in commercial banking, see Horst Brand and John Duke, "Productivity in Commercial Banking: Computers Spur the Advance," *Monthly Labor Review,* December 1982, pp. 19-27.

Output of commercial banks increased by an average annual rate of 4.7 percent between 1970 and 1983.[22] However, the rate of increase slowed significantly within this period: During 1970-73, for example, output increased at a high average annual rate of 8.7 percent, slowed to an annual rate of 5.4 percent for the middle period 1973-78, and to a lower 2.6-percent annual rate during 1978-83. Between 1970 and 1983, output gains were achieved in 11 of 13 years; declines were recorded only in 1974 and 1980 (chart 10).

Demand and time deposits grew steadily between 1970 and 1980, dropping slightly in 1981, then growing through 1983. Strong growth in demand deposits, especially during the late 1960's and early 1970's, spurred the development of EFT and other new technologies. Expansion of financial transactions, such as stock transfers and commodity futures contracts, have increased the number of fund transfers that go through the banking system. Growth in time deposits held by commercial banks has been even more rapid than in demand deposits.

The volume of bank loans is strongly affected by the general level of economic activity. Between 1970 and 1981, the overall loan index declined in 1974, 1975, 1979, and 1980—and rose in the other years. Commercial and credit card loans grew fairly steadily from 1972 through 1979, declined in 1980, and increased slightly each year through 1983. Consumer loans declined from 1978 through 1980, then increased through 1983. Real estate loans, sensitive to mortgage interest rates, dropped sharply between 1978 and 1980, but rose again in 1981, and grew strongly in 1982 and 1983.

Trust services have been the most stable portion of commercial banking output, following a generally upward pattern, but leveling out in 1983. Increases in the number of employee benefit accounts and pension plans have contributed to expanded trust services.

Productivity

Productivity in commercial banking rose only slightly during 1970-83—a period of expansion in bank facilities and services. Over these years, the BLS index of output per employee hour increased at an average annual rate of only 0.8 percent. Although output of commercial banks rose at a more robust annual rate of 4.7 percent over this period as the economy moved to higher levels, the productivity gain was slight because employee hours also rose at a relatively brisk annual rate of 3.9 percent. Employee hours gained sharply, despite substantial investment by banks for computers, ATM's, and the other technologies that lower labor requirements of tellers and other bank staff. In 1982 and 1983, however, output increased sharply—by 4.5 percent in 1982 and 9.6 percent in 1983. In contrast, employee hours rose only slightly (1.6 percent) in 1982 and fell (0.6 percent) in 1983.

Technology is only one factor that determines productivity change in commercial banks. Changes in complexity of banking tasks, in the skill of the work force, and in the location of facilities and organization of work also can be important factors that influence productivity change. For example, the rapid spread of bank branches over this period is considered by some experts to have slowed productivity growth because more labor and other inputs were required per unit of output at these locations, compared to the main offices. Also, commercial banks offer a number of new and more complex services, and most industry people believe that employment would have grown even more rapidly if the new, laborsaving equipment had not become available.

The productivity record in commercial banks varied considerably from year to year with economic conditions. In each of the recession years of 1974 and 1980, for example, productivity declined by over 6 percent when output fell off as demand for commercial banking services slowed and employee hours continued to move higher, by 6.3 and 4.4 percent, respectively. In contrast, productivity gains well above average occurred in years with peak demand for banking services, such as 1973, 1976, 1977, and 1983, when output per employee hour increased by more than 5 percent from the preceding year.

The growth in bank branch offices, a major change in industry structure, has had an impact on productivity and employment. The number of commercial bank offices (main offices and branch offices) grew from 35,585 in 1970 to 55,960 in 1983—an increase of 57 percent. The number of commercial banks grew by less than 10 percent. But the number of branches rose rapidly—from 21,880 in 1970 to 40,913 in 1983—an increase of 87 percent.[23]

Commercial banks began expanding their branches to attract new deposits — often from competing banks. The proportion of banks with branches increased from 29 percent in 1970 to 47 percent of all commercial banks in 1983.

The growth in branch offices has increased banking employment because each branch requires at least a small staff. But this may have had a negative impact on productivity: Industry observers are in agreement that economies of scale have declined as a result of the growth in branches. A branch banking system requires more employee hours per unit of output than does a larger, centralized bank.[24]

Employment and Occupational Trends

Employment

Employment in commercial banks rose steadily over the past decade as demand for a growing array of banking services increased (chart 11). In 1984, commercial

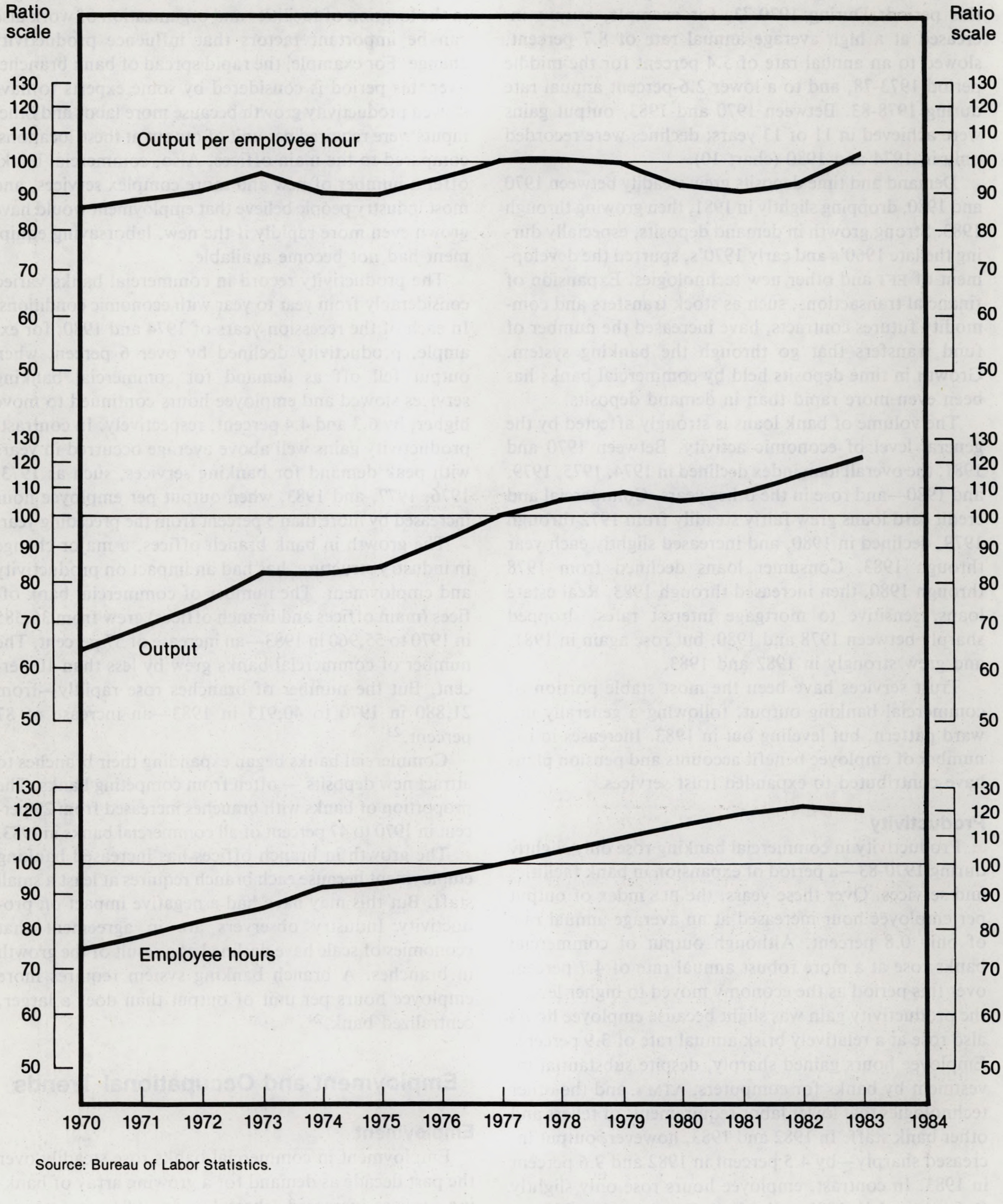
[22] Latest year available for BLS output and productivity measures in commercial banking.

[23] Federal Deposit Insurance Corporation (FDIC) data.

[24] "Productivity in Commercial Banking," pp. 19 and 25.

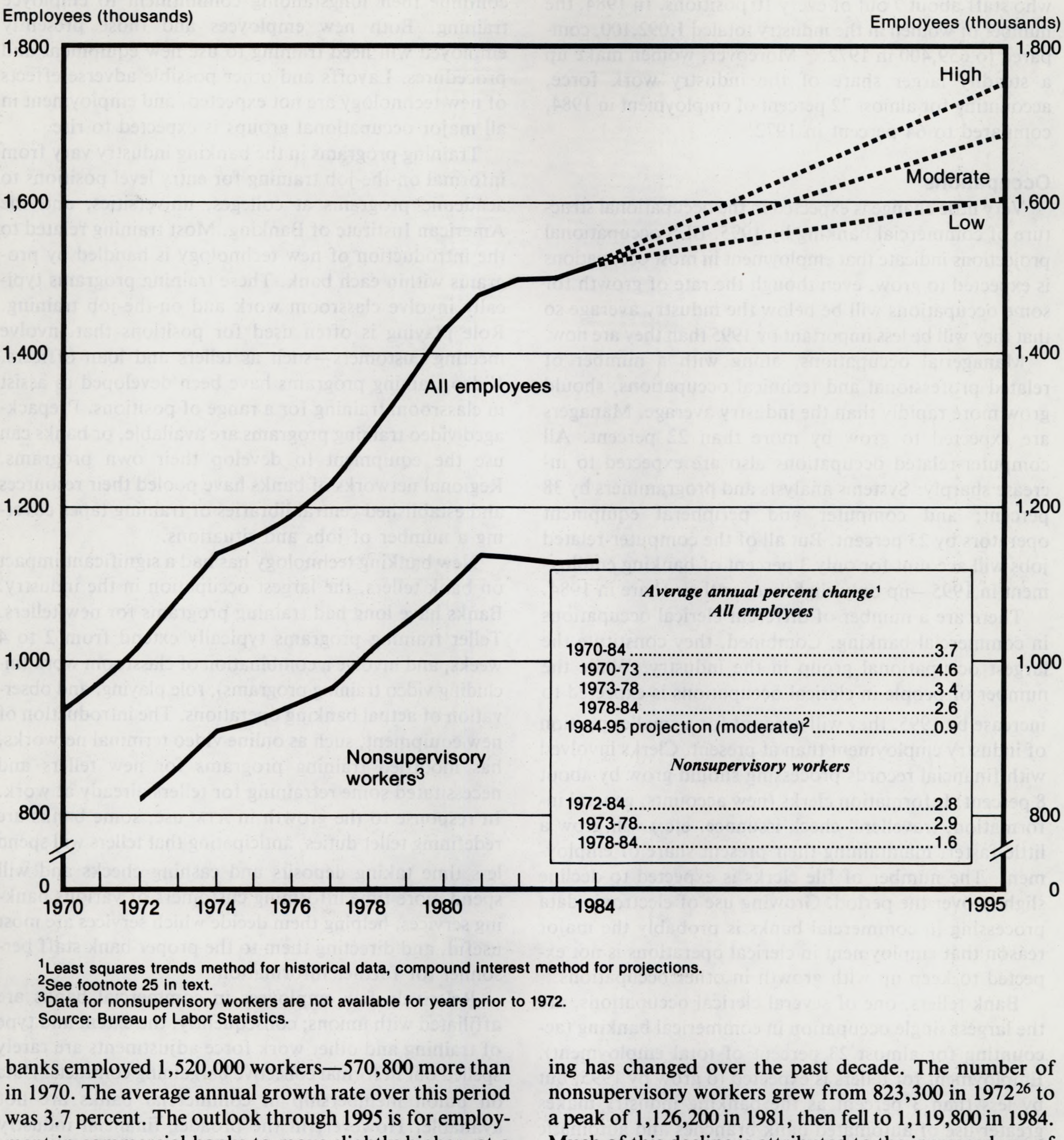
Chart 10. Output per employee hour and related data, commercial banking, 1970-83

(Index, 1977 = 100)



Source: Bureau of Labor Statistics.

Chart 11. Employment in commercial banking, 1970-84, and projections, 1984-95



[1]Least squares trends method for historical data, compound interest method for projections.
[2]See footnote 25 in text.
[3]Data for nonsupervisory workers are not available for years prior to 1972.
Source: Bureau of Labor Statistics.

banks employed 1,520,000 workers—570,800 more than in 1970. The average annual growth rate over this period was 3.7 percent. The outlook through 1995 is for employment in commercial banks to move slightly higher, at a much lower rate of growth. According to the moderate BLS projection, employment in commercial banks may total about 1.7 million in 1995, an annual growth rate of 0.9 percent.[25]

The composition of employment in commercial banking has changed over the past decade. The number of nonsupervisory workers grew from 823,300 in 1972[26] to a peak of 1,126,200 in 1981, then fell to 1,119,800 in 1984. Much of this decline is attributed to the increased use of computers, terminals, and EFT operations. In 1972, nonsupervisory workers accounted for 80 percent of the work force; by 1984, however, they constituted slightly less than 74 percent of employment. The proportion of nonsupervisory workers will probably continue to decline, but the number of people employed is expected to increase until 1995, as demand for banking services continues to rise.

[25] BLS projections for industry employment in 1995 are based on three alternative versions of economic growth. For details on assumptions and methodology used to develop these projections, see *Monthly Labor Review*, November 1985.

[26] Data on employment of nonsupervisory workers are not available for years prior to 1972.

Commercial banks are a major employer of women, who staff about 7 out of every 10 positions. In 1984, the number of women in the industry totaled 1,092,100, compared to 659,400 in 1972.[27] Moreover, women make up a steadily larger share of the industry work force, accounting for almost 72 percent of employment in 1984, compared to 64 percent in 1972.

Occupations

Very little change is expected in the occupational structure of commercial banking by 1995. BLS occupational projections indicate that employment in most occupations is expected to grow, even though the rate of growth for some occupations will be below the industry average so that they will be less important by 1995 than they are now.

Managerial occupations, along with a number of related professional and technical occupations, should grow more rapidly than the industry average. Managers are expected to grow by more than 22 percent. All computer-related occupations also are expected to increase sharply: Systems analysts and programmers by 38 percent; and computer and peripheral equipment operators by 23 percent. But all of the computer-related jobs will account for only 3 percent of banking employment in 1995—up only slightly over their share in 1984.

There are a number of different clerical occupations in commercial banking. Combined, they constitute the largest occupational group in the industry. While the number of people in clerical occupations is expected to increase by 1995, they will account for a smaller portion of industry employment than at present. Clerks involved with financial records processing should grow by about 8 percent. Information clerks (new accounts, general information, travellers' check issuance, etc.) will grow a little faster, maintaining their present share of employment. The number of file clerks is expected to decline slightly over the period. Growing use of electronic data processing in commercial banks is probably the major reason that employment in clerical operations is not expected to keep up with growth in other occupations.

Bank tellers, one of several clerical occupations, are the largest single occupation in commerical banking (accounting for almost 23 percent of total employment). Employment for tellers is expected to grow by 1995, but by less than 3 percent as the banking industry makes greater use of automated bank branches and automatic teller machines.

Adjustment of workers to technological change

As new technologies are used more extensively over the coming decade, commercial banks are expected to continue their longstanding commitment to employee training. Both new employees and those presently employed will need training to use new equipment and procedures. Layoffs and other possible adverse effects of new technology are not expected, and employment in all major occupational groups is expected to rise.

Training programs in the banking industry vary from informal on-the-job training for entry level positions to academic programs at colleges, universities, and the American Institute of Banking. Most training related to the introduction of new technology is handled by programs within each bank. These training programs typically involve classroom work and on-the-job training. Role playing is often used for positions that involve meeting customers—such as tellers and loan officers. Video training programs have been developed to assist in classroom training for a range of positions. Prepackaged video training programs are available, or banks can use the equipment to develop their own programs. Regional networks of banks have pooled their resources and established central libraries of training tapes covering a number of jobs and situations.

New banking technology has had a significant impact on bank tellers, the largest occupation in the industry. Banks have long had training programs for new tellers. Teller training programs typically extend from 2 to 4 weeks, and involve a combination of classroom work (including video training programs), role playing, and observation of actual banking operations. The introduction of new equipment, such as online video terminal networks, has modified training programs for new tellers and necessitated some retraining for tellers already at work. In response to the growth in ATM use, some banks are redefining teller duties, anticipating that tellers will spend less time taking deposits and cashing checks and will spend more time informing customers of various banking services, helping them decide which services are most useful, and directing them to the proper bank staff personnel for further information.

Relatively few employees in commercial banks are affiliated with unions; consequently, the extent and type of training and other work force adjustments are rarely spelled out in formal collective bargaining contracts. Data on union membership in commercial banks are not available. However, in the broader financial industry which involves all banking, credit agencies, and security and commodity services, less than 3 percent of all wage and salary workers were represented by labor organizations in 1980.[28]

[27] Data on employment of women are not available for years prior to 1972.

[28] *Earnings and Other Characteristics of Organized Workers, May 1980*. Bureau of Labor Statistics, Bulletin 2105, September 1981, pp. 15, 17.

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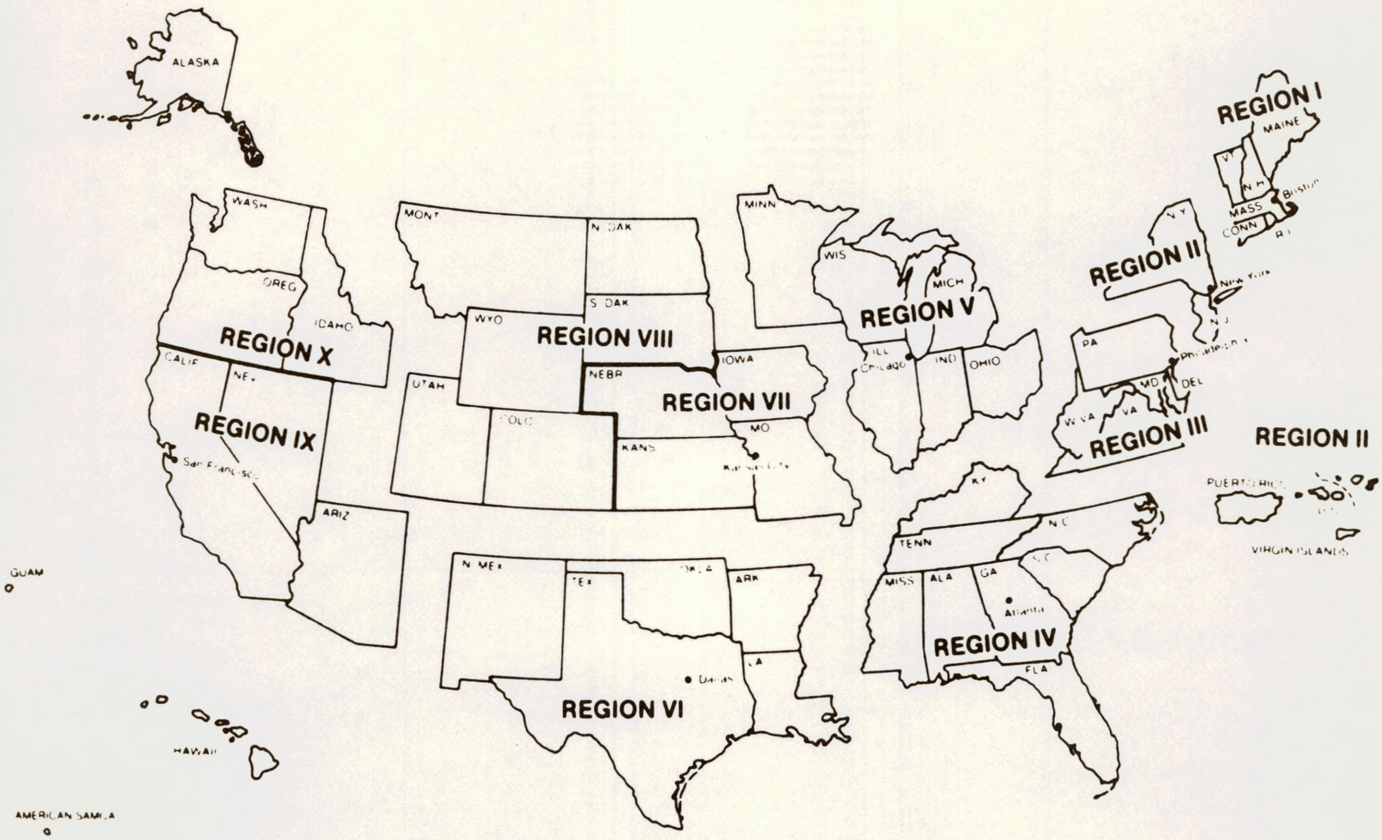

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