Productivity improvements in two fabricated metals industries

Output per employee-hour has risen faster in valves and pipe fittings than it has in fabricated pipe and fittings, both industries show high levels of capital spending

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Labor productivity trends vary widely in two industries in the fabricated metals group—valves and pipe fittings and fabricated pipe and fittings—in part, because the technologies applied in the manufacture of their products differ.[1] Furthermore, although valves and pipe fittings are classified as a single industry, their products are fundamentally unlike in the ways in which they are manufactured, and in the extent of scale economies and industry support required in servicing them after they have been installed. Products of both industries are used to control and transmit liquid and gaseous fluids.

In the valves and pipe fittings industry, productivity, as measured by output per employee hour, rose at an average annual rate of 1.3 percent between 1954 and 1981, as output increased 3.0 percent and employee hours, 1.7 percent. In fabricated pipe and fittings, productivity advanced 0.3 percent a year between 1958 and 1981, as a 4.3-percent gain in output was offset by a 4.1-percent increase in employee hours. Productivity in all manufacturing industries averaged 2.5 percent during the 1954–81 period, as output increased 3.3 percent and employee hours, 0.8 percent.

Three distinct periods marked the long-term productivity trend, during which annual rates deviated significantly from that trend. These rates moved as follows (in percent):

Period	*Valves and pipe fittings*	*Fabricated pipe and fittings*	*Manufacturing*
1959–65 ...	3.7	1.5	3.7
1965–73 ...	1.0	0.8	2.8
1973–81 ...	1.0	−2.6	1.5

The reasons for the productivity slowdown are not clear. In both industries, employee hours rose more rapidly in relation to output after 1965 than in the earlier part of the 1954–81 period. While the employee-hour rate for valves and pipe fittings was less than a third of the output rate over the 1959–65 span, and a little more than half for fabricated pipe, it rose to nearly two-thirds of the output rate in 1973–81 for the former industry, and to 1½ times the output rate for the latter. In brief, hiring accelerated relative to output gains in the 1970's and tended to dampen productivity advances. The pattern was similar for all of manufacturing.

Year-to-year movements in output per employee hour of the two industries also show a high degree of volatility. In valves and pipe fittings, productivity declined in 10 of the 27 years studied, in fabricated pipe, in 9 of 23. It dropped as much as 9 percent in the former (in 1958), and 11 percent in the latter (in 1970), and climbed as much as 12 percent in both (in 1955 and 1959). In all manufacturing, productivity dipped in only 4 years between 1954 and 1981, and by more than 0.5 percent in but one of the years—1974.

In most years of productivity decline in the two industries, output as well as employee hours decreased, but these at a

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lesser rate. In some years, output rose, but less than employee hours.

Demand spurs output growth

Output of valves and pipe fittings more than doubled between 1954 and 1981, setting a record of 113 in 1981 (1977 = 100). Output of fabricated pipe also doubled over the 1958–81 span, reaching its peak of almost 108 in 1978.[2]

Output trends underwent sizable year-to-year swings,[3] as well as alternations between periods of rapid and greatly slowed expansion. (See the following tabulation.) These movements did not parallel total manufacturing output after 1973, when output of the two industries was spurred by intensified worldwide demand from extractive industries.

	Average annual rates of change (in percent)		
	Valves and pipe fittings	*Fabricated pipe and fittings*	*Manufacturing*
1959–65	7.0	3.4	5.5
1965–73	1.7	1.7	4.1
1973–81	2.6	4.5	1.2

Among key determinants of the rise in the production of valves and pipe fittings, and of fabricated pipe and fittings, were the expansion in industrial and public utility demand, particularly during the boom years of the early and mid-sixties; gains in the construction of sewer and water works during much of the period studied; and intensified needs of energy-related extractive and pipeline industries, again mostly during the 1970's. In addition, expanding foreign trade in valves and pipe fittings importantly contributed to output, especially during the 1970's, with exports moving up from 10 percent of the industry's value of shipments in 1972 to 14 percent in 1979.[4]

Among large-scale users of valves and pipe fittings (as well as of fabricated pipe) was the chemicals industry. Following the 1960's, the industry accounted for about one-sixth of total domestic valve shipments and probably about the same proportion of shipments of pipe fittings and fabricated pipe.[5] (The markets for these industries and components are identical or closely related.) Chemicals almost doubled plant and equipment outlays (adjusted for price changes) in the early 1960's, then reduced them. After 1973, however, the industry raised real outlays once again, and, in 1979, they stood nearly twice as high as 1973 levels.

Nearly one-half of industrial valves output was absorbed in recent years by energy-related extracting, processing, and distributing industries. Growth in extractive activities, especially in the installation of drilling platforms, spurred demand for fabricated pipe.[6] In the 1960's, drilling of oil and gas wells dropped sharply, but after 1970, the decline was reversed. In 1979, both the number of wells and footage drilled ran roughly 75 percent above 1970 levels.

Expansion of electrical generating capacity also bolstered output of the two industries reviewed here, their products being essential in the circulation of water and steam (and in the condensation of steam). Whereas the total number of electrical generating stations barely changed over the period covered, the proportion of stations generating 500,000 kilowatts or more rose from under 3 percent in 1960 to 13 percent in 1980. The number of nuclear and gas-turbine driven power-generating plants likewise increased. These increases spelled a shift to larger, more capacious and heat- and pressure-resistant valves and fabricated pipe.

Water supply systems and sewage facilities also represented important markets for valves and pipe fittings, as well as for fabricated pipe, claiming more than 11 percent of valve shipments alone. The rate at which water and sewage systems were put in place was comparatively steady in the 1950's and 1960's. It accelerated in the 1970's, slackening, however, after 1978. Among reasons for the faster rate in the 1970's was funding under the Water Pollution Control Act of 1972, which spurred the construction of advanced waste water plants for the elimination and dilution of chemicals and other industrial pollutants.[7] Responding to the growth and locational shifts in population and housing, put-in-place water supply facility construction rose from an average annual rate of 1 percent in the 1950's to nearly 7 percent in the 1960's, thereafter slowing to little more than 2 percent.

Changes in production technology

Improvements in the manufacture of valves and pipe fittings, and to an extent of fabricated pipe, have usually hinged on technological advances in metalworking machinery and pertinent electronic controls. Some of the larger valve manufacturers sought to overcome the drawbacks of small lot production by adopting group technology.

Small lot production—often involving tens or hundreds of products made to specification—characterizes the manufacture of many kinds of valves and pipe fittings[8]. Nevertheless, the efficiency of turning out varieties of valves and pipe fittings, each in relatively small lots, has steadily improved. Increasingly, automated machining devices speed production. In a growing number of establishments, families of parts common to different product varieties are machined, then distributed to bins for final assembly. The assembly worker, hitherto stationary while the parts and the products to be assembled moved to and away from him, now moves between the various bins and the various products to be assembled.[9]

The manufacture of families of common parts saves labor in setting up machine tools, as well as in streamlining the flow of production. The authors of a text on group technology—a term that covers methods of manufacturing common parts particularly suited to small lot production—state: "In the typical manufacturing plant, the excessive setup time, caused by the product mix and small lot sizes, may be the most significant part of total production time."[10] Because reduction of setup time remains a key problem for valve manufacturers, more and more establishments are re-

organizing key production operations, so that parts common to a variety of products may be machined sequentially, rather than on a product-by-product basis.[11]

Adoption of computer-controlled machine tool technology has facilitated small lot production. One example is a numerically controlled lathe featuring automatic tool changers and capable of machining parts of a variety of weights (5 to 600 pounds) and shapes. The range of lot sizes machined on the lathe varies from single, complex components to more than 700. The increasing diversity of valve specifications,[12] together with the small lot sizes ordered, favors wider adoption of automated production machinery, whose users also benefit from its high rate of metalworking speeds.

Computer-aided design (CAD) has facilitated the production of high-performance valves. Such valves require close tolerances in their dimensions, and, as noted, must often be capable of operating under high pressure and temperature extremes, internal as well as environmental. In some establishments, CAD has saved up to 50 percent of engineering work in some operations in comparison with conventional methods, and hence has also achieved optimality of valve design more rapidly.[13] The manufacture of valves to close tolerances requires numerically-controlled and, increasingly, computer numerically-controlled turret lathes and other lathes, as well as horizontal spindle machining centers capable of great accuracy in repeat performances. Some firms program families of common parts into the computers controlling their machine tools, reportedly reducing programers' time by one-quarter to one-third, compared to earlier programing procedures.[14]

Advances in the productivity of pipe and tube fittings manufacture have, in general, also hinged on the use of sophisticated metalworking equipment. When fittings are mass produced, they enter the machining process as forgings. These forgings are drilled to specified diameters, threaded or beveled, and deburred. Setup often appears still to be manual, because runs are comparatively long, making setup time less of a cost variable, compared with small lot production. Manual, rather than automatic, feeding of the forgings to the metalcutting machinery also prevails in many establishments. Apparently, this type of mass production operation has experienced little improvement in productivity.[15]

Advances in technology specifically keyed to the manufacture of fittings include ballistic and hydraulic flaring machines. (Flares on fittings serve as seals.) Prior to the advent of these machines, flaring was accomplished by handtools, and could not be peformed on heavier wall tubing or fittings. A large group of fittings, however, is not flared. Flareless fittings are joined either by biting into the metal or by compression. In compression, the seal consists of a rubber ring recessed into the metal. The technology used in fabricating these fittings is considerably more complex and exacting than in manufacturing flared fittings, and therefore demands greater operator skill.[16]

Tubes and fittings are often worked and readied for application by means of specialized handtools. These handtools have been significantly improved over the period reviewed here. For example, the cutting edge of tube cutters has been made more efficient through adaptable contouring and harder materials. Benders have come to be adjustable for wear, as well as for bending hard or soft tubing. Flaring tools have been improved so as virtually to eliminate the risk of thinning the flared tube wall or applying excessive torque. Burnishing of the flared face, which makes for a tighter seal, has become more efficient, and has been made part of the manual flaring operation.[17]

Fabricated pipe is cut, bent, threaded, and welded to customer specifications. Specifications vary within fairly narrow ranges, and production processes are fairly standardized.

The industry has recently adapted computerized patterning controls for precision cutting of pipe. These controls have replaced templates in the technically more advanced shops. (Templates were made in-house, and required a skilled operator in their use.) Time between cuts is reduced because the positioning, preheating, and start and depth of cut are computer controlled. Preparation of appropriate computer programs takes as little as one-fifth of the time required for a conventional template. In addition, computer-controlled systems are more accurate, and can be applied so as to minimize waste.[18]

Pipe welding has been largely mechanized since the 1960's, except for smaller jobs, where manual welding is preferred. The "duty cycle" of welding—minutes per 8-hour period actually spent by the operator—has been significantly increased, as has the deposition rate of the filler metal that makes the weld.[19] The bending of pipe has been speeded up by computer controlled induction heating. This facilitates bending by various leveraging devices. The operation continues to require considerable skill.

Employment

During the 1954–81 period, employment in valves and pipe fittings rose at an annual rate of 1.8 percent, a figure not significantly different from the 1.7-percent rate for employee hours. The 1981 employment and hours levels ran about 50 percent above those for 1954. (However, in 1982, employment dropped sharply; currently, it numbers fewer than 85,000 workers.)

Employee hours rose rapidly in the early part of the review period, slowed down from 1965 to 1973, and acceleratead once again thereafter, as the following tabulation shows, using average annual rates of change in percent:

	Valves and pipe fittings	*Fabricated pipe*
1954–81	1.7	4.3*
1959–65	3.1	1.9
1965–73	0.7	0.9
1973–81	1.6	7.3

*1951–81

Year-to-year fluctuations in employee hours were pronounced, particularly in periods of recession and recovery. The largest increase in year-to-year movements, 11 percent in 1974, was followed by the largest decline, 10 percent in 1975.

Employment in the fabricated pipe and fittings industry more than doubled between 1958 and 1981, rising at an average annual rate of 4.3 percent, as did employee hours. Employee hours rose faster in the early 1960's than in the following years, but increased at a very high rate between 1973 and 1981. Year-to-year swings, associated with movements in the business cycle, ranged from a 14-percent drop in 1961 to an 11-percent gain in 1967. In the 1970's, large annual increments—of as much as 22 percent in 1976—swamped dips of 3 percent in 1975 and 4 percent in 1980.

Accessions and separations in valves and pipe fittings averaged little more than two-thirds of the average for durables during the 1970's (data for earlier years are not available). Comparatively low labor turnover is probably related, in part, to the skill, composition, and high proportion of nonproduction employees in the industry's work force.

Nonproduction workers accounted for 30 percent of total employment in valves and pipe fittings in the late 1970's and in 1981, as against an estimated 22 percent in the mid-1950's. Employment of nonproduction workers rose at an average annual rate of 2.9 percent between 1954 and 1981, of production workers at 1.3 percent. The greater increase in nonproduction workers was linked largely to expanded hiring of engineers and other professionals needed to design the growing diversity of products manufactured in the industry, together with the appropriate production processes. In fabricated pipe, the proportion of nonproduction workers declined slightly to 22 percent over the 1958–81 span, reflecting the somewhat greater expansion of the production than of the nonproduction work force (4.7 percent annually versus 3.3 percent).

Data on the occupational composition of the two industries are available only for the miscellaneous fabricated products group as a whole. The two industries account for about one-half of the group's employment. Their occupational mix probably does not deviate much from the group's for most occupations. The distribution of professional and technical workers in miscellaneous fabricated metals in 1980 was slightly lower than for manufacturing (7 versus 10 percent)—except that the group's proportion of mechanical engineers and drafters was slightly higher. Indications are that that proportion is exceeded in valves and pipe fittings, but not quite so high in the fabricated pipe industry. The group also employed relatively more clerical workers. Metalworking craftworkers represented 6 percent of the group's employment, twice the proportion for manufacturing. Here, again, fabricated pipe may have run below the group average; valves and pipe fittings above. The proportion of operatives, 45 percent, was roughly the same, although semiskilled metalworking operatives (including welders and lathe machine operators), who accounted for 20 percent of the group's total employment, had nearly three times the proportion for manufacturing. In general, the occupational mix of the group closely paralleled that for durables manufacturing, particularly for blue-collar workers. This is also suggested by average hourly earnings levels, which have coincided with the durables manufacturing average since data became available in 1972.

Capital expenditures

Plant and equipment expenditures by establishments making valve and pipe fittings and fabricated pipe exceeded the average for all manufacturing during the period reviewed. After adjusting for changes in the cost of new machinery and equipment and new structures,[20] capital outlays by valve and pipe fittings manufacturers rose at an average annual rate of almost 7 percent between 1958 and 1980, those by fabricated pipe firms by 11 percent—compared with little more than 5 percent for all manufacturing establishments.

These expenditures rates fluctuated considerably in the course of the review period. Real plant and equipment expenditures weakened much less in the 1960's and early 1970's in valves and pipe fittings than in all manufacturing, and was comparatively strong for fabricated pipe. All the rates shown accelerated during the 1970's, reflecting, for the two industries, strong pressures on capacity from stepped-up domestic and foreign demand, especially from oil and

Table 1. Productivity and related indexes for the valves and pipe fittings industry, 1954–81

[1977 = 100]

Year	Output per employee hour	Output	All employee hours	Employees
1954	70.3	50.9	72.4	70.7
1955	78.7	58.4	74.2	70.2
1956	82.7	64.2	77.6	74.1
1957	79.3	61.9	78.1	75.3
1958	72.2	51.6	71.5	70.7
1959	76.5	54.0	70.6	69.9
1960	75.0	51.8	69.1	69.0
1961	81.3	57.7	71.0	70.3
1962	83.4	63.8	76.5	74.8
1963	84.3	63.8	75.7	74.0
1964	86.6	68.7	79.3	75.3
1965	96.4	81.0	84.0	80.9
1966	95.1	85.0	89.4	84.8
1967	91.3	82.9	90.8	87.7
1968	92.3	82.5	89.4	87.9
1969	94.1	86.1	91.5	88.5
1970	93.6	86.7	92.6	89.7
1971	98.3	86.5	88.0	86.7
1972	100.7	88.1	87.5	86.8
1973	103.3	98.4	95.3	93.2
1974	94.3	99.5	105.5	99.0
1975	92.4	87.3	94.5	94.2
1976	91.1	86.9	95.4	94.5
1977	100.0	100.0	100.0	100.0
1978	100.9	104.7	103.8	104.0
1979	104.3	112.8	108.2	107.9
1980	101.4	109.6	108.1	107.9
1981	103.5	113.1	109.3	109.0
	Average annual rates of change			
1954–81	1.3	3.0	1.7	1.8
1975–81	2.2	5.0	2.8	2.8

gas extraction. The following tabulation shows average annual rates, in percent, based on constant dollars:

	Valves and pipe fittings	*Fabricated pipe and fittings*	*Manufacturing*
1958–80	6.5	10.9	5.2
1959–65	5.6	0.0	8.8
1965–73	2.3	5.6	0.3
1973–79	6.6	10.0	5.1

Both industries (as well as manufacturing) spent a higher proportion of their capital outlays on machinery and equipment in the 1970's than in earlier years—exceeding 75 percent of total outlays, and in some years, topping 80 percent. Earlier, the proportion was usually well below those levels. In the 1950's and 1960's, firms very often moved their operations into spacious one-story structures at preferred locations, making subsequent expenditures on structures less necessary. At the same time, they continued to update their equipment throughout the 1970's.[21]

Capital expenditures per employee, $2,120, in 1978, for the valves and pipe fittings industry, had not changed significantly relative to the comparable fiture for all manufacturing over the preceding two decades, remaining at 75 percent of the all manufacturing figure. In fabricated pipe, per-employee expenditures, $1,924 in 1978, rose considerably relative to manufacturing, with the ratio rising to 67 percent in 1978 from 46 percent in 1958.

Structure of industry

Between 1958 and 1977, the number of establishments rose 50 percent in valves and pipe fittings, and doubled in the fabricated pipe industry. In all manufacturing, that number rose by less than one-fifth over the period. Nearly three-fourths of the increase in valve and pipe fittings manufacturing establishments occurred in the 1–99-employee size classes—which accounted for less than a third of the increase in employment. All but one-eighth of the increase in the number of fabricated pipe establishments came in the smaller employment size classes (with less than 100 employees), where one-half of the rise in jobs developed.

The size distribution of employment did not change much between 1958 and 1977 in either of the two industries. For example, about 70 percent of all establishments in valve and pipe fittings, and 90 percent in fabricated pipe employed fewer than 100 employees in 1977, as well as in 1958 and in other quinquennial census years during the 19-year interval. In all these years, the smaller valves and pipe fittings establishments accounted for 15 percent of industry employment, the smaller fabricated pipe establishments accounted for 40 percent. The number of establishments with 500 employees or more rose but slightly. The overall trend was toward smaller, probably more specialized firms. This is suggested by declining concentration ratios: in 1977, the eight largest manufacturers of valves and pipe fittings accounted for 21 percent of the industry's value of shipments, compared with 27 percent in 1958. In fabricated pipe, the comparable ratios were 29 and 39 percent.[22]

Table 2. Productivity and related indexes for the fabricated pipe and fittings industry, 1958–81

[1977 = 100]

Year	Output per employee hour	Output	All employee hours	Employees
1958	84.9	47.8	56.3	53.9
1959	94.7	47.8	50.5	47.2
1960	84.9	43.3	51.0	47.9
1961	97.5	42.6	43.7	41.8
1962	98.5	44.9	45.6	42.9
1963	93.0	45.0	48.4	46.1
1964	97.3	51.1	52.5	49.6
1965	100.9	57.4	56.9	54.6
1966	100.3	62.0	61.8	57.8
1967	96.9	66.4	68.5	64.5
1968	100.1	69.6	69.5	65.2
1969	105.8	67.9	64.2	58.5
1970	94.0	57.7	61.4	57.4
1971	97.0	58.5	60.3	58.5
1972	106.0	67.3	63.5	62.1
1973	110.2	77.6	70.4	68.8
1974	111.4	85.8	77.0	74.1
1975	104.0	78.1	75.1	73.4
1976	97.4	89.5	91.9	90.4
1977	100.0	100.0	100.0	100.0
1978	100.7	107.9	107.2	107.1
1979	90.1	107.0	118.8	116.7
1980	89.9	102.8	114.3	113.5
1981	93.1	106.8	114.7	113.5
	Average annual rates of change			
1958–81	0.3	4.3	4.1	4.3
1975–81	−2.1	4.7	6.9	7.1

Continued productivity gains likely

Continued gains are likely in the labor productivity of the two industries examined here as numerically controlled and computer machine tools diffuse, computer-aided design and manufacturing techniques are more widely adopted, and greater efficiency in small-lot production by such means as group technology spreads among establishments. Underutilization of capacity, however, has plagued both industries since about mid-1981, and may be expected to continue to retard productivity improvement for some time.[23] Output of valves and pipe fittings, and fabricated pipe, was recently reduced as demand from the extractive and chemical industries weakened; demand is unlikely in the near future to reach the levels of the 1970's. The Alaskan Gas Transportation System, for example, which would require large amounts of valves and fittings, will not materialize until the late 1980's or the 1990's.[24] The part of the industry's output destined for use in offshore drilling projects, oil and gas pipelines, refineries, and petrochemical plants is not expected to expand in the near future, nor are exports related to such output. This also holds for power generating facilities, affecting fabricated pipe in particular. In contrast, it is anticipated that water and waste water projects will expand in the near-term future, as housing starts are expected to increase and replacement of obsolete facilities is scheduled.[25]

Thus, advances in labor productivity hinge not only on the adoption of more up-to-date labor-saving equipment and production organization, but possibly also on eliminating less efficient plants, which were allowed to operate in the 1970's because of pressures on capacity utilization. □

FOOTNOTES

[1] The valves and pipe fittings manufacturing industry is designated as SIC 3494, and the fabricated pipe and fabricated pipe fittings industry as SIC 3498 in the Standard Industrial Classification (SIC) Manual of the Office of Management and Budget (1972 ed.). Valves and pipe fittings are used to control the flow of liquids or gases in pipes and mains, and in machinery; plumbers' brass goods are not included. Establishments in the fabricated pipe and pipe fittings industry cut, bend, thread, and otherwise work purchased pipe.

Average annual rates of change are based on the linear least squares of the logarithms of the index numbers. Extensions of the measures of productivity and related variables will appear in the annual BLS Bulletin, *Productivity Measures for Selected Industries*.

[2] As noted, valves are used to regulate fluids. Pipe fittings and fabricated pipe and fittings are likewise associated with the regulation of fluids, but they are structurally less complex than valves and have no functionally moving parts. Valves are not classified uniformly, but variously by type of closing member, actuating principle, or the material of which they are made. A closing member may be such as to permit throttling, or limit flow to a single direction, or allow the rapid opening and closing of a conduit. The actuating principle may be hydraulic, pneumatic, or electric. Materials, while predominantly steel, may also include brass and iron. The industry seems to prefer classification by type of closing member—for example, ball, butterfly, gate, globe—each type, together with the size of the valve and the material of which it is made, being adapted to erosive or corrosive fluid characteristics, as well as to temperature and pressure. See Valve Manufacturers Association, *Valves for Industry*, p. 6.

Pipe fittings account for about one-fifth of the value of shipments of the valves and pipe fittings industry and are usually manufactured in separate establishments. They include flanges and other shapes forged or extruded so as to conform to the pipe or vessel to which they would be welded or otherwise fastened. They further include socket weld and threaded fittings and couplings, unions, plugs, and bushings.

The census classifies fabricated pipe only by the ferrous or nonferrous material of which it consists. Shops manufacturing pipe fittings, or fabricating pipe, purchase preshaped forgings or extrusions from specialized mills (classified in the primary metals industry). The forged or extruded pipe may be cut, bent, welded, heat-treated, or otherwise worked upon according to user specifications. It should be noted that pipe used, for example, for oil and gas or water conduits is not normally "fabricated," but simply welded onsite.

[3]*Year-to-year movements*	*Valves and Pipe fittings*	*Fabricated pipe and fittings*	*Manufacturing*
		(In percent)	
Largest rise	18 (1965)	15 (1973)	11 (1973)
Largest drop.....	12 (1975)	15 (1970)	6 (1970)

[4] See John Duke, "Construction machinery industry posts slow rise in productivity," *Monthly Labor Review*, July 1980, pp. 33–36; Horst Brand and Clyde Huffstutler, "Productivity in pump and compressor manufacturing," *Monthly Labor Review*, December 1982, pp. 38–45; John Duke and Horst Brand, "Cyclical behavior of productivity in the machine tool industry," *Monthly Labor Review*, November 1981, pp. 27–34.

[5] Information from Valve Manufacturers Association, Washington, D.C.

[6] Information from Pipe Fabricating Institute, Pittsburgh, Pa.

[7] Joseph T. Finn., *Labor and Material Requirements for Sewer Works Construction*, Bulletin 2003 (Bureau of Labor Statistics, 1979), p. 2.

[8] For an examination of the problems of small-lot manufacturing, see *Manufacturing Technology—A Changing Challenge to Improved Productivity* (Report to the Congress by the Comptroller General of the United States, June 3, 1976).

[9] Industry source.

[10] Marvin F. De Vries and others, *Group Technology: An Overview and Bibliography* (Cincinnati, Ohio, Machinability Data Center, 1976, p. 2), Publication No. MDC 76–601.

[11] Industry source.

[12] The increasing variability of valve and pipe fitting products is, in part, reflected in the rising number of 7-digit product lines in the quinquennial Census of Manufactures. The number of such lines used in developing the BLS output measure for the industry rose as follows:

1954–58:26
1958–63:30
1963–67:31
1967–72:64
1972–77:83

Each product line usually includes a range of dimensions and special features of the given generic product.

[13] Greg Jendreas, "CAD Speeds Valve into Production," *American Machinist*, October 1982, pp. 116–19.

[14] *Ibid.*, p. 119.

[15] Industry source.

[16] "A Basic Guide to Hydraulic Tube Fittings," *Know Your Hoses, Tubing, and Fittings*, a compendium of articles from *Hydraulics and Pneumatics*, 1983, pp. 6–12.

[17] L. Kowal, "A Guide to Good Tube Working Practices," *Know Your Hoses, Tubing, and Fittings*, pp. 21–25. Information also from industry sources.

[18] Industry sources. See also Charles L. Bell, "Fabricated Structural Metal," *The Impact of Technology on Labor in Five Industries*, BLS Bulletin 2137 (Bureau of Labor Statistics, 1982), p. 38.

[19] *Ibid.* Information also from industry sources.

[20] To adjust for changes in the cost of new machinery and structures, the pertinent implicit price deflators published in table B–3 of the February 1983 *Economic Report of the President* were used.

[21] Industry source.

[22] *Concentration Ratios in Manufacturing* (Washington, 1977 Census of Manufactures, 1981), table 7.

[23] Industry sources.

[24] See *1983 U.S. Industrial Outlook* (U.S. Department of Commerce, 1983), p. 24–3.

[25] *Ibid.*, ch. 1.

APPENDIX: Measurement techniques and limitations

Indexes of output per employee hour measure changes in the relation between the output of an industry and employee hours expended on that output. An index of output per employee hour is derived by dividing an index of output by an index of industry employee hours.

The preferred output index for manufacturing industries would be obtained from data on quantities of the various goods produced by the industry, each weighted (multiplied) by the employee hours required to produce one unit of each good in some specified base period. Thus, those goods which require more labor time to produce are given more importance in the index.

In the absence of physical quantity data, the output indexes for the valves and pipe fittings, and the fabricated pipe and fittings industries were constructed using a deflated value technique. The value of shipments of the various product classes was adjusted for price changes by appropriate Producer Price Indexes to derive real output measures. These, in turn, were combined with employee hour weights to derive the overall output measure. These procedures result

in a final output index that is conceptually close to the preferred output measure.

The indexes of output per employee hour relate total output to one input—labor time. The indexes do not measure the specific contribution of labor, capital, or any other single factor. Rather, they reflect the joint effect of factors such as changes in technology, capital investment, capacity utilization, plant design and layout, skill and efforts of the work force, managerial ability, and labor-management relations.

Productivity pluses and minuses

In trying to solve the productivity equation, certain forces will exert a negative influence, others a positive influence. An examination of the plus side of the productivity equation reveals marked qualitative improvements in the American work force, a potential talent boom in the prime-age 25–44 group, and a growing awareness of the importance of the human factor. It also demonstrates that the human resources available to American organizations have an enormous untapped potential; that union-management relations are not a serious or insurmountable obstacle to improved worker productivity; that inflation provides a strong economic incentive to press hard for improved productivity; and, finally, that the shift to the Sun Belt offers a new base of investment and opportunity for growth.

An analysis of the minus side of the equation confirms that obstacles to productivity do exist. Productivity is discouraged when employees have no real job security and fear layoffs due to plant closures and economic recession; when the real purchasing power of employees is eroded by inflation; when workplaces do not keep up with the changes in society; and when technology is so poorly introduced that it antagonizes the work force. The productivity of organizations also suffers when negative attitudes toward other workers discourage them from using full potential and when information is hoarded to the detriment of work in progress. Yet every negative can be converted to a positive in the sense that it is a problem that has a solution. To the extent that management policies face these problems, they can transform obstacles into opportunities.

—JEROME M. ROSOW, ed.
Productivity: Prospects for Growth
(New York, Van Nostrand Reinhold Co., 1981), pp. 273–74.