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Robotics: Industry's Revolutionary Workhorse

Jesse W. Wainwright

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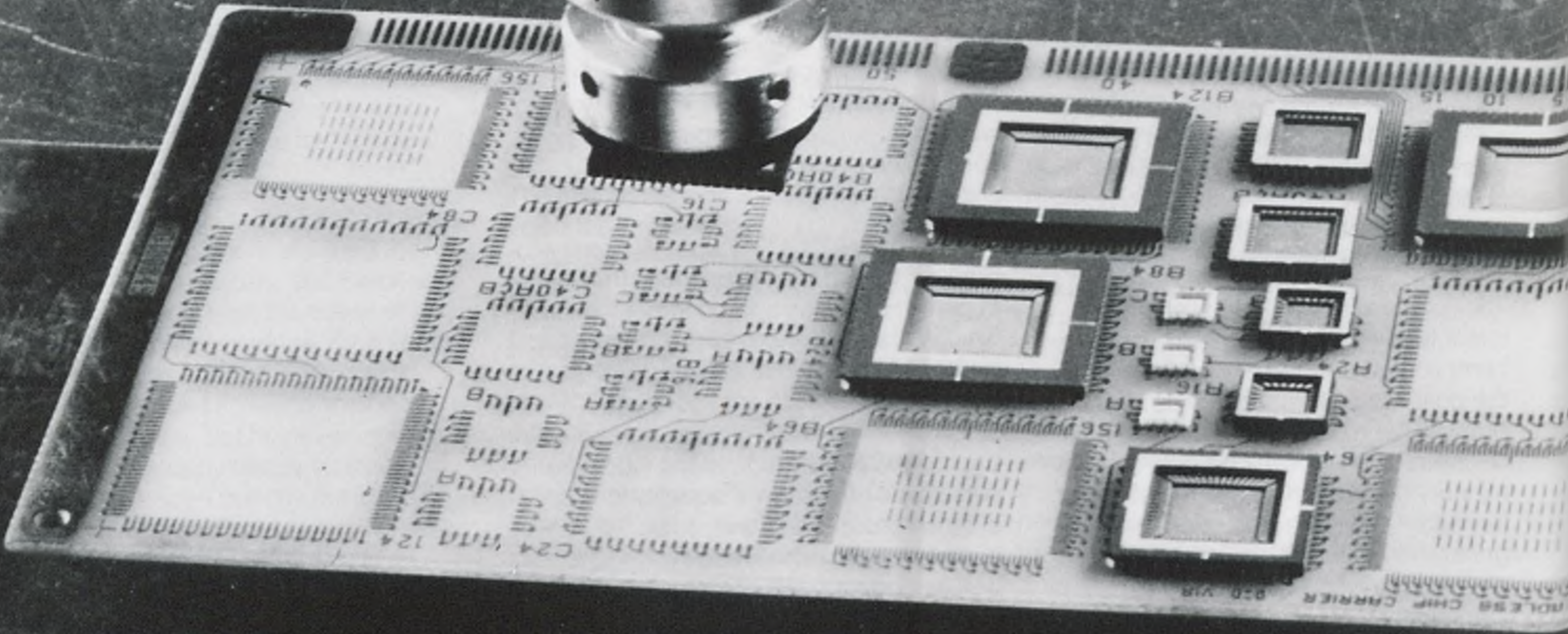
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NATIONAL

ROBOTICS:

Industry's Revolutionary Workhorse



A Mini-Semler™ robot—Control Automation, Inc.'s (Princeton, N.J.) new robot. It is intended primarily for high precision assembly of printed circuits, calculators, small motors, disk drives and keyboards.

By Jesse W. Wainwright

The age of robotics is upon us. Already labor experts and reputable institutions are predicting that robots will cause the loss of millions of manufacturing jobs. Other experts are asserting that more jobs will be created with the advent of factory automation. Both schools of thought present convincing arguments that touch on, among other concerns, the future of manufacturing in the United States, on competition from abroad, and on labor relations.

Most of those who are familiar with the uses of industrial robots agree that robots do help reduce operating costs. Even opponents concede that these mechanical wonders do boost productivity.

1.00

What is a robot?

Many mechanical devices in various shapes and forms have been called robots. American and foreign manufacturers have some disagreement over the appropriate definition of a robot.

The Robotics Institute of America defines a robot as "a reprogrammable, multifunctional manipulator designed to move material, parts, tools, or specialized devices through variable programmed motions for the performance of a variety of tasks."

Predicting the impact of robots on the American labor force is difficult. Obviously robots could change the quantity and type of labor demanded by businesses, but the channels by which employment could be affected are numerous and complex.

Harley Shaiken, a research fellow at the Massachusetts Institute of Technology and consultant with the United Auto Workers, talks of an approximate loss of 100,000 jobs in the auto industry alone.¹ He believes the real issue in this scenario is set against a backdrop of massive layoffs and economic stagnation.²

Carnegie-Mellon University's well-respected Robotic Institute issued a study in 1981 which found that seven percent of the 20 to 25 million manufacturing jobs in the U.S. are potentially expendable.³

Thomas Gunn, an analyst with the Arthur D. Little consulting firm, made perhaps the gloomiest prediction: that the factory work force will be cut by between 20 and 25 percent and up to four million jobs could disappear by 1990.⁴

But other experts and institutions are just as adamantly predicting brighter days ahead for the labor force. James Albus of the National Bureau of Standards argues that Shaiken and the others who are forecasting melancholy for U.S. workers are short-sighted. He believes that the robot industry, growing at a predicted 30 to 50 percent a year and doubling every three or four years, will create more jobs than it eliminates.⁵ The prediction of the Bureau of Labor Statistics that 800,000 jobs will be created in industrial robot production by 1990 tends to support Albus's arguments.⁶

Paul Aron of Daiwa Securities America says that each of the 15,000 robots expected to be installed by 1985 will displace six workers.⁷ But, he contends, retraining would be possible to fill the greater number of jobs which he thinks will be created as a result of automation.

With all these predictions, each from a reputable source, what is one to believe?

The Robot Imperative

"Automate, emigrate or evaporate." This phrase by General Electric executives sums up the reason why most enthusiasts of factory automation support its widespread introduction into the American economy. Thus, unless the manufacturing industry in the United States becomes more highly automated, our factories will not be competitive producers in the international market; companies may be compelled to relocate plants to countries where they can find an abundant and cheap labor supply; the number of people

employed in U.S. factories may dwindle. In other words, the argument goes, robotics must become an integral part of the manufacturing industry if it is to survive.

Robot users and enthusiasts, both here and abroad, claim that automated production does substantially improve resource productivity. The Japanese automobile industry has reported a five-fold increase in productivity—from a daily rate of five or six cars per worker to 30 or 40—brought about primarily by the use of industrial robots.⁸

Renault has determined that robots in operation at its plant in Douai, France are 20 percent more productive than human labor.⁹

In a Boeing plant in Washington state, a robot sands the wings of cruise missiles in 46 minutes, a job that takes eight hours of "diligent effort" by workers.¹⁰ In a General Dynamics plant in Texas, robots drill holes to help make F16 fighter planes and are three to four times more productive than people.¹¹

It appears then, set in the proper environment, robots are far more productive than humans. This increases the incentive for a producer to use more robots relative to less productive inputs such as labor.

There are a number of reasons why robots are more productive than humans. Robots do not get bored or tired and can do the same task repeatedly with almost perfectly even quality. For example, an arc welder cannot keep his torch on the work more than 30 percent of the time because of the hot, dirty environment and the choking smoke.

A robot, on the other hand, can keep its torch on the work about 90 percent of the time. Thus, even though the robot cannot weld any faster than a human, it can turn out about three times as much work.¹² Additionally, robot usage virtually eliminates strikes and absenteeism and significantly cuts time losses in manufacturing.

Robot Operating Cost

Even ignoring the higher productivity of robots, their operating cost is still signifi-

Cincinnati Milacron's T³-726 robot. It uses vision and voice synthesis to serve as dealer in a friendly game of Twenty-one . . . The robot uses its multiplication and division capabilities to keep track of its winning percentage.

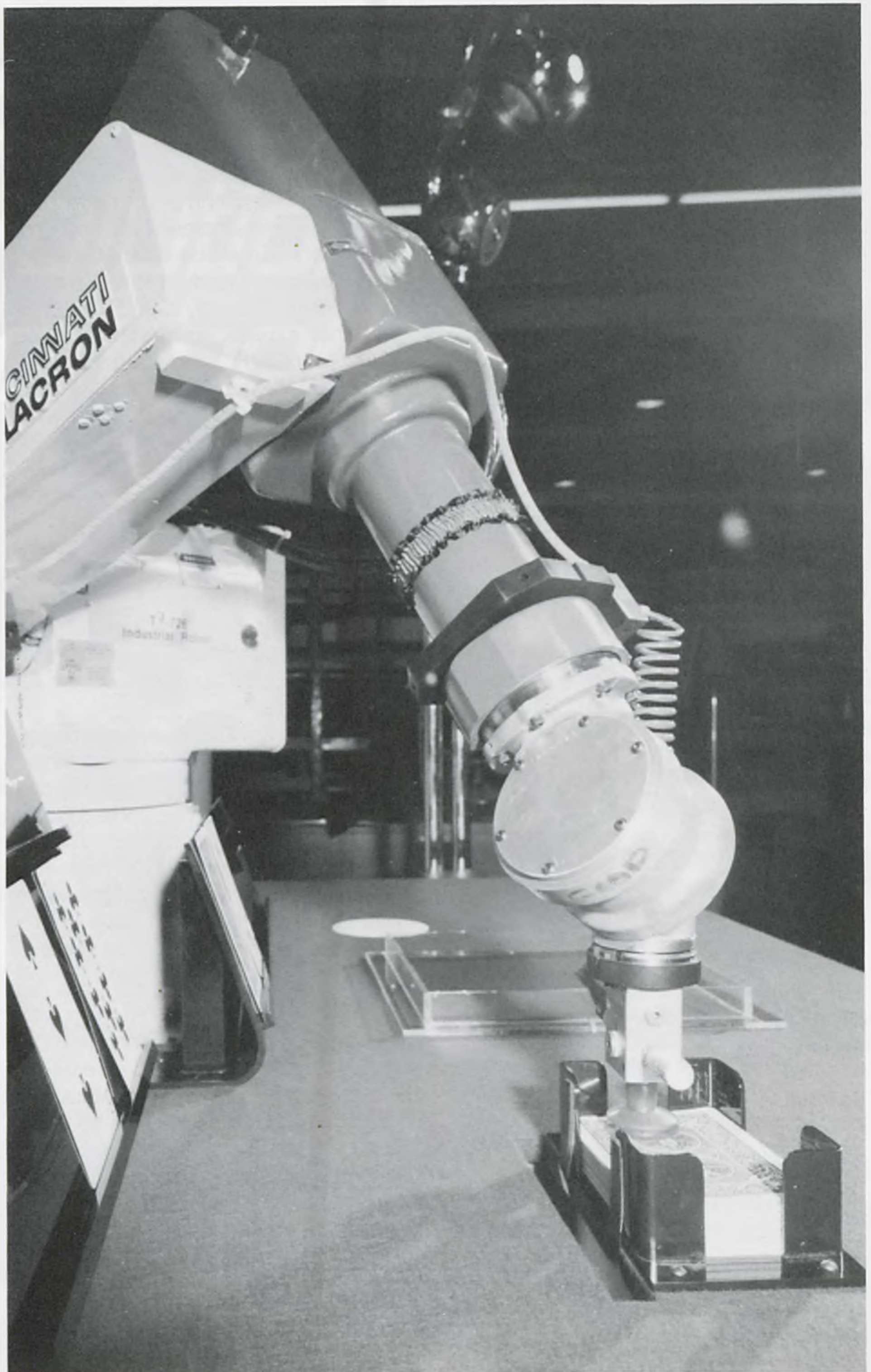
24 cantly lower than the cost of labor. Paul Aron of Daiwa Securities estimates that the operating maintenance cost of a robot is \$8-\$10 an hour, while the *Wall Street Journal* (April 13, 1983, p. 1) estimates the average labor cost, including fringe benefits, to be approximately \$20 an hour. It can be readily seen that robot use results in a dramatic reduction in the hourly cost of resources.

However, detractors of robot usage claim that the high purchase price of robots makes their use prohibitive. Depending on the type and abilities of robots purchased, they may cost from \$30,000 to \$120,000. The Society of Manufacturing Engineers estimates that the price of a robot will average \$35,000 by the mid-1980s.¹³

The expected decline in robot price as output increases is an additional advantage for automation. Eli Lustgarten of Paine Webber Mitchell Hutchins, Inc. brokerage estimates that about 30 percent of the cost of a robot is the electronics and software.

Since the price of these high-technology commodities has consistently fallen, Lustgarten believes that the effect of falling prices in computer related industries will be manifested in the robotics industry.¹⁴ This will mean lower hourly and annual operating cost and, combined with the robot's higher productivity, should create a powerful economic incentive for firms to use robots in their production processes as much as possible.

A potential hindrance to the wholehearted embrace of robots by business is that a robot cannot operate as an isle in a sea of obsolescence. Robots must have near perfect environment in which to work. They cannot think or see to readjust to changes in their work environment. Manufacturing support systems must be advanced enough to supply parts to the high-tech machines at the proper rate and remove the finished product. Meeting this requirement may necessitate an additional capital outlay to finance the conversion, and time.





NC Painting System—GMF Robotics, Inc.

Because of these considerations, it appears that the direct substitution of robots for factory workers, by itself, would not have a substantial impact on the total cost of production.¹⁵

The cost advantages of robot use can still be reached, however, by circumventing or attacking the problem of cost. One way to alleviate the large initial cost is by spreading the retooling process over several years and slowly integrating robots with conventional production. Another possible solution would be to let the robots pay their own tab.

This could occur through several channels which have been alluded to earlier. First, robots could simply pay for themselves by lowering production costs and increasing revenue. At the Nissan Motor Company in Zama, Japan, 150 robots perform the work of 300 workers and outperform them.¹⁶ General Electric in the U.S. has found robots far more productive than human workers. The company frequently cites the case where a robot paid for itself in 10 months.¹⁷ (See Table 1)

Table 1: Median Average Expected Robot Payback Period

	Now	1985
Automotive	2.7 Years	2.0 Years
Casting/Foundry	3.0	2.5
Heavy Manufacturing	3.0	3.0
Light Manufacturing	2.0	2.0
Electrical/Electronic	2.0	2.0
Aerospace	2.0	2.5

Source: Robot Institute of America. (Reprinted from *Robotics and Its Relationship to the Automated Factory* by Eli S. Lustgarten of Paine Webber in *Exploratory Workshop on the Social Impacts of Robotics*, U.S. Congress, Office of Technology Assessment, February 1982.)

A second mechanism through which robots would not only help manufacturers decrease costs but also provide recession resistance is by possibly lowering the break-even point of plant production capacity. Kenichi Ohmae, the manager of an American consulting firm's Tokyo office, reports that Japanese blue chip companies are trying to build companies that make money at anything over 70 percent capacity.¹⁸

At least two Japanese firms claim to have achieved this goal. Toyota Motors has announced that it has attained the 70 percent goal while Fujitsu Fanuc, a manufacturer of numerically controlled machines, claims that it breaks even at 30 percent utilization.¹⁹ As Ohmae emphasizes, these plants prove extremely resilient in economic downturns. Recognition of this fact could lessen American business reluctance to acquiring robots.

In all, these arguments would seem to lead any rational producer to automate. Even without significant competition, a producer would do so to maximize profit. That has not always been the case in the U.S. In an environment that was relatively protected for many years, perhaps more because of its size than the existence of legal barriers, firms did not introduce innovations to maintain a competitive edge.

Some important American industries have experienced cost inefficiencies because of their short-sightedness, financial mismanagement, and lack of resolve. The day of lax attitudes and slowing productivity has passed as perhaps the most compelling reason for automation emerges—survival.

International Competition

Some persons may argue that even a profit maximizing producer may not take advantage of the new technology if the appropriate investment climate does not exist. This may be true for firms operating in a closed economy but no nation's economy exists in absolute isolation today.

If America could afford to ignore the international competition in the goods market or stand idly by and watch the consequent demise of industries of strategic economic importance, then its businesses could afford to postpone automating their productive processes. Since it is generally accepted that America cannot bear the loss of its foreign and domestic markets or stomach strategic dependence on foreign industries, the U.S. economy must use more highly mechanized production processes.

Why is the robot invasion of American industry unavoidable? The most compelling reason is that robots are necessary for the competitiveness of U.S. goods. Currently American and foreign producers are locked in an intense battle for dominance of the international and domestic markets. The winner of the battle will gain the upper hand in selling its goods at home and overseas, causing an increase in output and employment.

Economic growth for the victor should accelerate, and the many social benefits that accompany substantial expansion of an economy should bring general prosperity to the nation.

The effect of worldwide robot use can have dramatic effects on employment. These effects could take two paths, direct and indirect. The direct effect could involve the displacement of one or more U.S. workers by foreign or American robots. If the robots are foreign-made, their use would not only displace American workers in the industry where the robots will be employed but also would directly affect employment in the U.S. robot industry.

The indirect effect seems to be causing the most concern. An article in *The Washington Post* stated, "Competition in robotics, however, is not nearly as important to the U.S. economy as competition—across all manufacturing—from nations that make things in factories using robots."²⁰ In other words, the indirect effect of international robot usage on American employment will come via the price competition of goods produced and the demand for those goods.

If robots enable foreign manufacturers to price their goods below comparable American goods, the market for the same U.S. goods will almost certainly diminish. Facing a curtailed demand for the present, and the future, producers would cut back on production, leading to a reduction in employment.

This scenario has already occurred in several industries in the U.S. The steel industry has suffered a crippling blow in the

26 market, and the auto industry suffered as well. For example, Joji Arai, manager of the U. S. Liaison Office to the Japan Productivity Center, noted that the 35 percent decline in auto output (from 1977 to 1981) resulted in a 20 percent reduction in labor input while the Japanese, using automation and stockless ("Just-in-time") inventory methods reduced labor input by only 10 percent and captured a larger share of the U. S. market.²¹

In hearings before Congress, Jack Sanderson, assistant deputy director of the Directorate of Engineering of the National Science Foundation, cited a report which predicted that unless U. S. production techniques change, we would lose over 50 percent of the men's tailored clothing industry within the next five years.²²

Although recession and other factors played a part, the decline in these industries can be partially credited to the aversion to automation.

The auto industry lost more than a quarter of a million jobs, steel lost tens of thousands and the textile industry lost thousands. How many of these were due to the non-competitiveness of the industry's commodities? It is difficult to say. However, the data seem to indicate that job displacement in the coming years will be greater if we do not automate than if we do.

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Currently the Japanese use more than three times the number of robots as its closest competitor, the United States. Japan's edge in the use of automated factory equipment helps enable the products of its auto, electronic, and metalwork sectors to enjoy a price and quality advantage in the international goods market.

This ascendancy did not happen by coincidence. It is the result of a concerted and cooperative effort among the three sectors [business-labor-government]

with vested interests in automating the factory.

One of the most important reasons for the large-scale application of robots by the Japanese is the active encouragement of their use by labor. This attitude can be traced to the labor-business relationship, the employment practices of corporate Japan, and the labor situation in that country.

As a nation facing a labor shortage of close to a million workers,²³ Japan is almost compelled to use innovations such as the robot to help fuel its economic growth. The workers in Japan heartily embrace this automated equipment for good reasons. They enjoy guaranteed employment (not job security) to the age of 55 to 60; which means that they are not afraid of being unemployed. They receive their mechanical cohorts with open arms knowing that the robot will release them from hot, dull, repetitious and dangerous jobs.²⁴ The company retrains the workers and uses them in more responsible and creative positions. This "humanization" of the work life has contributed to higher morale and reductions in absenteeism.²⁵

In the United States, the situation is much different. For most categories of jobs, there is a surplus of workers. And the slowdown in economic growth forbodes little promise of creating a sufficient number of new jobs.

Without employment security, American workers are wary of automation. Even if the robot does perform "inhuman" tasks, labor realizes that it is more cost-effective for the firm to hire a bright young college graduate with a degree in engineering than to retrain the senior employee with his years of accumulated cost-of-living allowances and fringe benefits.

Therefore, it is understandable that the approximately 800,000 workers in semi-skilled or unskilled metalwork positions (currently the predominant users of robots) are concerned about the technological advancement in the factory.

Another difference is the profit-sharing schemes from which the Japanese work-

ers benefit. All Japanese employees receive two bonuses, each ranging from two to five months pay in June and December. The bonuses are based on company profitability.²⁶ In the past, U. S. workers could not boast of any of these benefits and, thus, had little or no incentive to work harder or more efficiently.

However, there are signs that labor is forcing corporate America to take a hard look at those benefits. According to *The Washington Post*, several major union contracts covering auto, communications, electrical and machine workers have been negotiated to include notice of new technology and retraining for displaced workers.²⁷ Among these contracts are the United Auto Workers' (UAW) trading of wage increases for employment security with Chrysler, and the UAW contract with Ford which established a national training program for laid off workers and for employees whose skills are rapidly becoming outdated.

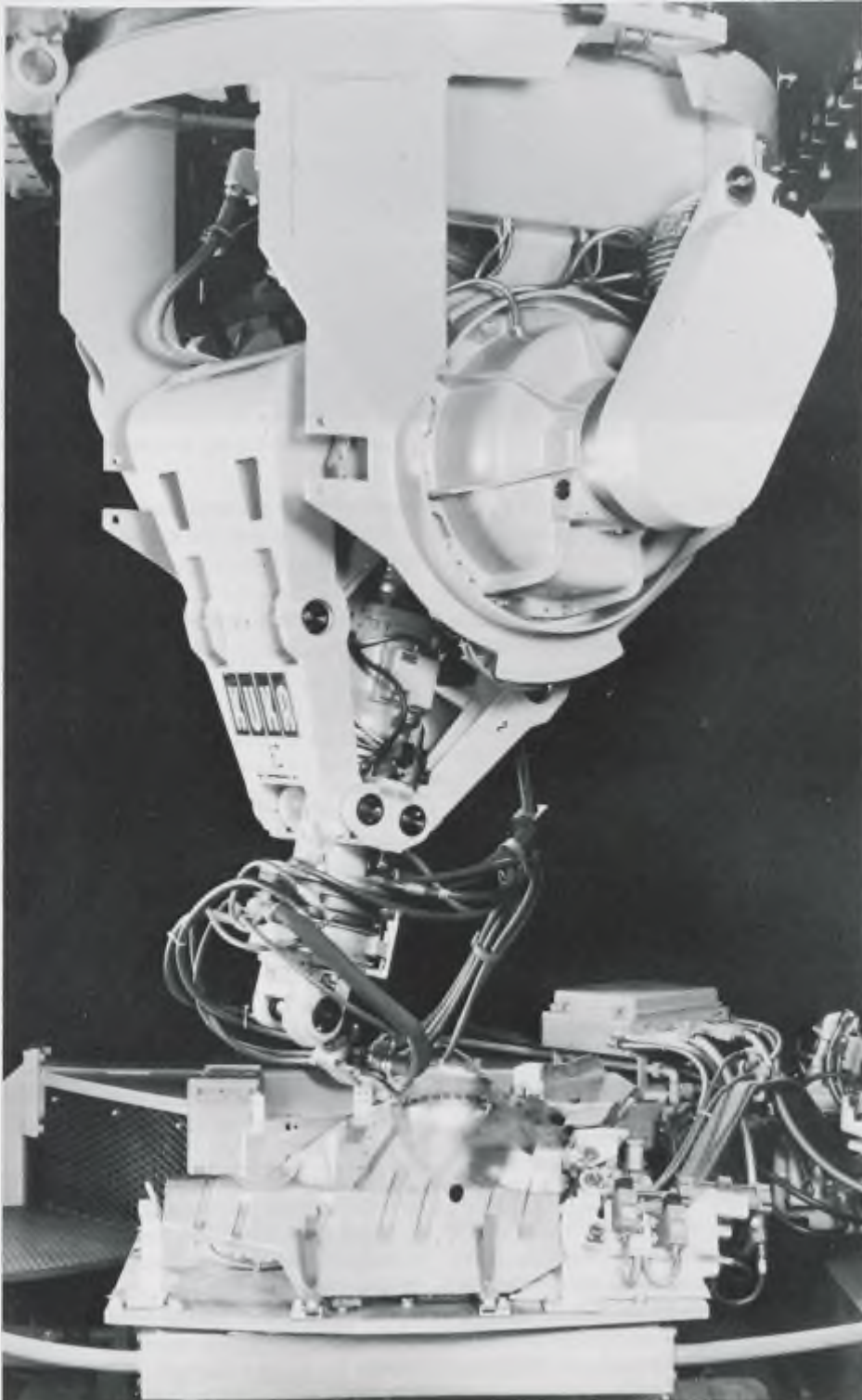
Along with some strides toward employment security, the United Auto Workers' "wage-improvement factor" explicitly calls for an annual benefit based on a percentage of increased productivity, independent of cost-of-living-adjustments.²⁸

These efforts by individual corporations and unions to improve labor-business relations and help prepare for the coming transition are definitely steps in the right direction. However, some experts point out, "On the whole, private industry is doing very little to prepare workers whose jobs may be eliminated or substantially changed by the use of robots."²⁹

In fact, engendering a symbiotic relationship between labor and business management does not even seem to be a high priority, as this statement by the Robotics Institute of America (RIA) and the Carnegie-Mellon Robotics Institute indicates:

Discussions of human factors, if any, tend to be sweeping statements about the importance of gaining the acceptance of workers and top management support,

A KUKA IR 200 series industrial robot welding car body components using D.C. welding technique. —
Expert Automation



and limit human-factor concerns to (the need for) by-passing or eliminating potential pockets of resistance to robotics.³⁰

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The inability of U.S. management to cooperate with labor is very costly to industrial productivity. Important lessons could be learned from the Japanese.

Consider a case study from a Japanese industry. The study found that in the welding department at a Nissan Tochigi Plant, the workers identified all of the 197 production problems being investigated, the foremen 79 percent and the managers only 4 percent.³¹ Utilizing the newly found talents of the workers, productivity at the plant was subsequently raised by more than 20 percent.

What would happen in American industry if the gap between executives and workers was eliminated, and the workers were encouraged to discuss production problems with management? The results here would probably be similar to the results in Japan.

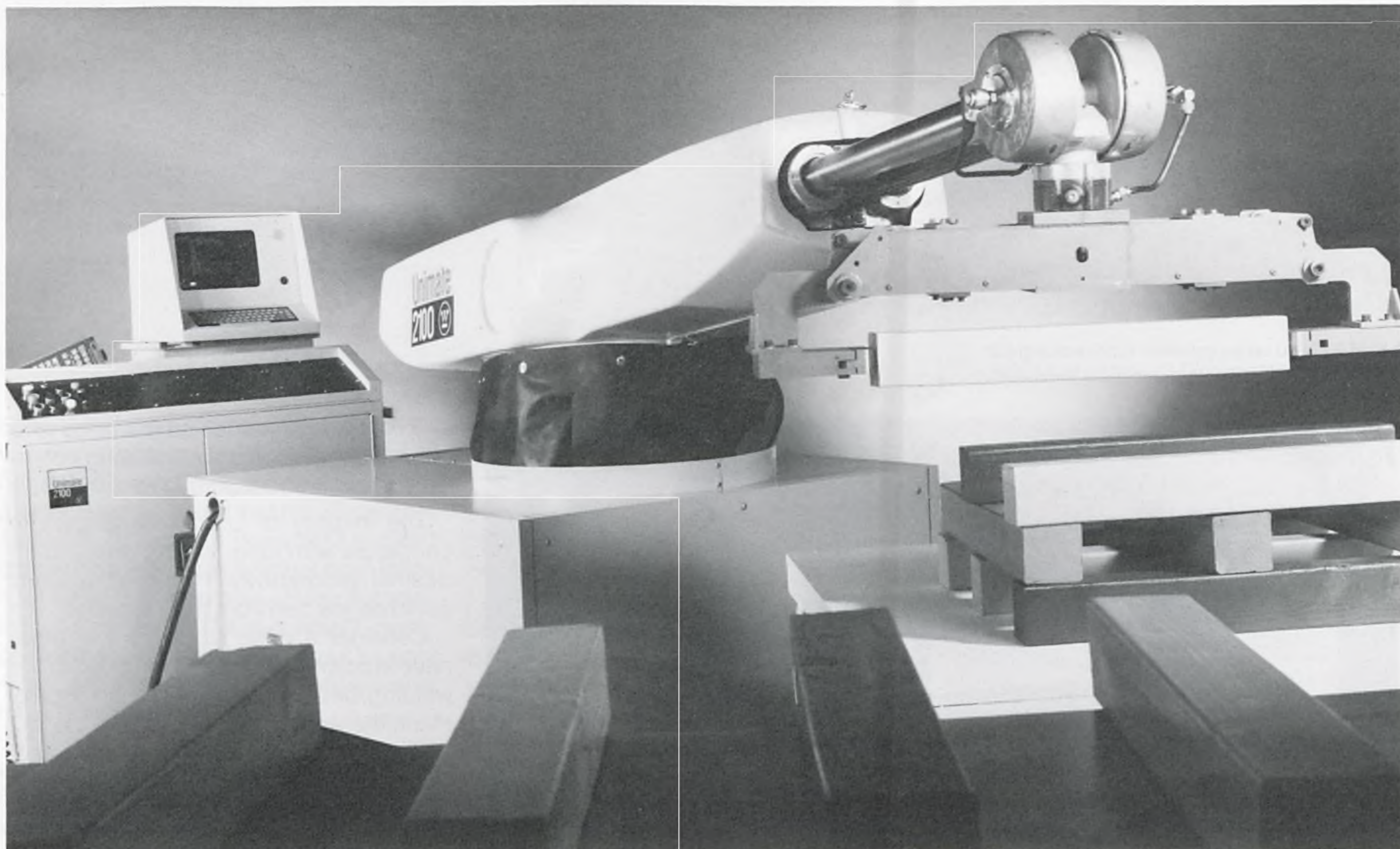
On such an emotionally explosive and potentially divisive issue, it is imperative that there be agreement between management and labor on adopting employment practices that will ensure a smooth and mutually beneficial transition. Without cooperation, the transition to a more fully automated manufacturing process will likely cause disruptions in the factory, and loss of jobs in the auto and metalwork sectors.

Management Policies

The other vital element in the cooperative effort to automate production is management policies. As with labor practices, there are several important differences between the U.S. and the Japanese business communities.

Corporate management in America takes a relatively short-term view of its operations. This is primarily because of the emphasis on stock prices and dividends, for which the bottom line is annual earnings.

The effectiveness of management is judged on the basis of the change in an-



UNIMATE Series 2100 robot. — Westinghouse

nual earnings from the previous year. As a result, management tends to avoid the introduction of equipment and machinery which would cause a downturn in earnings, regardless of how temporary it may be.³²

The typical Japanese management structure tends to take a long-term view of its company's operation. Management is not enthralled with stock prices and options. Many times the executives have either helped begin the company years ago or worked their way to the top over several years. Because of this they are more concerned with perpetuating a healthy, growing company than with yearly earnings. Automating production techniques, an initially costly proposition with long-term payoffs, is therefore more palatable to them.

With guaranteed lifetime employment, labor is a fixed cost in Japan. Businesses constantly search for innovations and new ways to cut costs since they cannot escape the labor cost.

American businesses, however, consider labor a variable cost; and, when profits fall, the work force is among the first factors to be cut back. This view means that corporate America has less incentive to search for cost-cutting innovations.

The American focus on the short-term tends to discourage research and development in capital equipment. Instead, U.S. corporations engage in mergers and acquisitions which can be costly.

The "pacman fever" idea that one can buy needed sources of capital or resources rather than develop and build one's own can result in expenditures of large sums of money without anything being produced. For example, the Bendix-Martin Marietta takeover struggle (1982) required more than \$3 billion of the participants yet resulted in nothing being produced and extensive financial damage to both corporations.³³

Once again, Japanese management is more rational in handling this aspect of the corporate world. Takeovers are not permitted without the consent of the board of directors of the defending company.³⁴ This allows the company to spend more time worrying about its own matters and induces it to develop its own capital equipment rather than try to buy it.

The management policies of executives in the Japanese economy gives their producers an additional advantage in the marketplace. They are not averse to capital spending, they treat labor fairly, and they do not appear to want to swallow the others in acts of vainglory. In these respects, Japanese business management

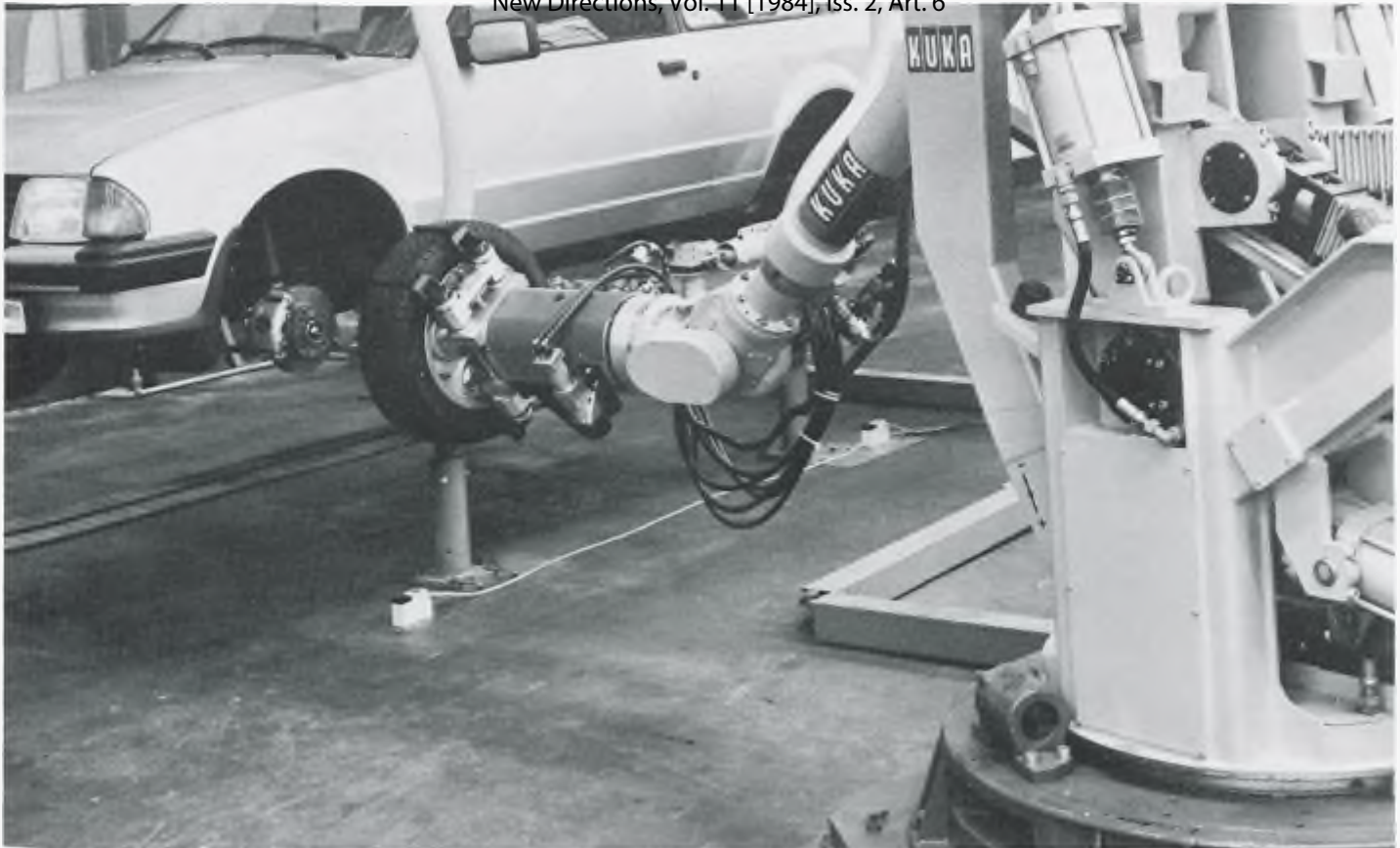
appears to be superior to ours and more suited to cope with the coming shake-up in manufacturing.

Government Support

The last vital element in the effort to automate factory production is the government. The Japanese also have a distinct advantage in this area. The Ministry of Trade and Industry (MITI) plays a positive role in encouraging robot use through a number of channels. Through government inducement and subsidization, the Japan Industrial Robot Association (JIRA) was formed to provide interest-free loans to members to help them develop marketing and application techniques for robots.³⁵

Additionally, JIRA provides an invaluable service by translating in detail and making available for review all applications from anywhere in the world for robot patents. The United States has no counterpart to JIRA.

The MITI was also instrumental in establishing a robot leasing company, Japan Robot Lease (JAROL), which borrows money at low-interest rates from, among others, the government's Japan Development Bank, and leases robots to small and medium size concerns to help increase their productivity.³⁶ JAROL's leasing contracts in 1980 numbered just over



KUKA industrial robot for automatic wheel mounting.
— Westinghouse

50 and amounted to more than \$57 million.³⁷

Besides assisting JIRA and JAROL, the Japanese government permits manufacturers who install robots to depreciate 12.5 percent of the purchase cost in addition to the regular depreciation.³⁸ Thus, by installing an industrial robot, a firm can depreciate 52.5 percent of the robot cost in the first year.

Needless to say, these policies serve as effective incentives for the use of automated factory equipment. Although the U.S. government has taken little direct action to encourage robot use, there are signs now that this is being considered.

Without some type of cooperative labor-government-business effort in America, it would be difficult for U.S. businesses to equal or excel the level of cost and production efficiency in Japan.

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Since all industrialized countries are involved to some extent in the competition to sell goods on the world market and each is seeking to gain an advantage, it would be useful to look at the situation of these nations.

It is clear from the amount of funds being spent across the world on research

and development of automated production techniques that the interest in, and expectations of, robotics is high. In the U.S., present government-sponsored research expenditures total only \$3.6 million for non-defense agencies, but are expected to exceed \$40 million for programs sponsored by the Department of Defense.³⁹

Besides the private robot firms and large corporations (e.g., IBM, General Electric, Texas Instruments and others), the National Science Foundation, the National Aeronautics and Space Administration, the National Bureau of Standards and the Naval Research Laboratory are doing research in robot development.

Other countries are aggressively pursuing the technology also. Great Britain has a program in which 50 percent of the cost of feasibility studies and up to 33 percent of the cost of installing robots is reimbursed by the government. And the French are investing \$50 million on the development of robotics primarily for their auto industry.⁴⁰

According to Delbert Tesar, director of the Center for Intelligent Machines and Robotics at the University of Florida, the Russians are 10 years behind us in technology, yet they are employing more than 400 people in eight research institutes in

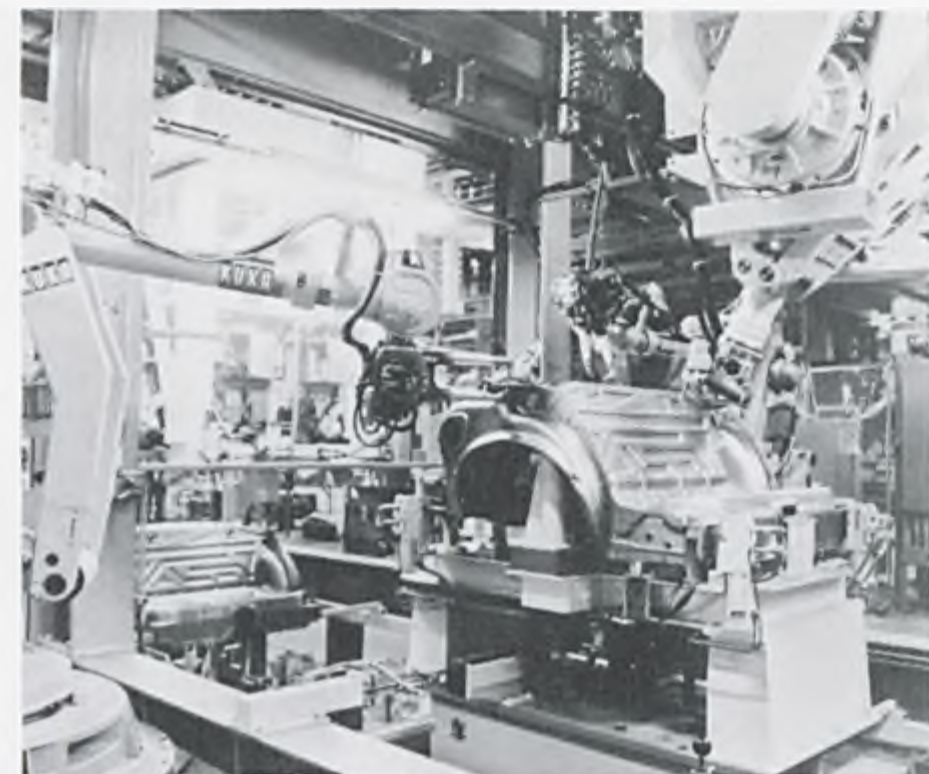
an attempt to match U.S. technology and equal U.S. production by 1985.⁴¹

In fiscal 1979, Japanese universities and public research institutes spent more than \$1.5 million on robot research, and in 1982 the Ministry of Trade and Industry initiated a huge \$150 million research and development program.⁴² It is also significant that many of our trade partners in Western Europe are developing robotics systems, particularly Sweden, Germany, and Italy.⁴³ Research funds, although large, are expected to increase in the future.

These figures point out the intense international competition in robotics technology. They also are indicative of the importance nations place on gaining an edge in production and cost efficiency. Policymakers in these countries obviously believe that automated production is very important in maintaining or gaining a larger share of the international goods market.

In light of the importance of robotics to future production, the funding for research and development in the United States has been "very modest."⁴⁴ And considering the size of the U.S. economy, America would need to spend eight thousand times as much on research and development to equal the proportion spent by the Japanese.

Two KUKA IR 600 series robots and one IR 200 series welding car body components. — *Expert Automation*



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Table 2: International Robot Population

Country	1981	1982
Japan	10,000	14,246
U.S.	3,255	4,700
USSR	—	3,000
West Germany	850	1,420
Great Britain	185	713
Sweden	600	700
France	—	620
Italy	500	353
Czechoslovakia	—	330
Poland	360	240
Norway	200	210
Denmark	—	166
Finland	130	116
Australia	—	62
Netherlands	—	56
Switzerland	—	50
Belgium	20	42
Yugoslavia	—	10
TOTAL	17,500	26,924

Source: Figures for 1981 compiled by Paine Webber; for 1982 by the Carnegie-Mellon Robotics Institute. (Reprinted from *Exploratory Workshop on the Social Impacts of Robotics* and "Socio-Economic Impacts of Industrial Robotics: An Overview," respectively.)

The size of the international robot population (See Table 2) also gives a good indication of robots' importance. The robot population grew by 50 percent from 1981

Table 3: U.S.-Japan Comparison Industrial Robots

	Units		Value (million \$)	
	U.S.	Japan	U.S.	Japan
1980	1,269	3,200	100.5	180
1985	5,195	31,900	441.2	2,150
1990	21,565	57,450	1,884.0	4,450

Source: Report by Paul Aron (vice president, Daiwa Securities Inc.), *Robots Revisited: One Year Later*. Reprinted from *Exploratory Workshop on the Social Impacts of Robotics*, U.S. Congress, House, Office of Technology Assessment, 1982.)

to 1982. As Table 3 indicates, robot use in Japan and the U.S., the two leading users of industrial robots, is expected to grow even faster—by 1,695 and 1,600 percent, respectively—between 1980 and 1990.

A Look Back/Conclusion

The trend to automate that is occurring in the United States (and throughout the industrialized world) is not unlike the course of the American economy since its beginning. Through its ability to borrow European advances and to introduce its own

innovations, the level of technology in America during its first century increased. The mechanization of U.S. industries contributed greatly to productivity growth in the 19th century. Successful economic development during the industrial revolution (19th and early 20th centuries) was accompanied by a compositional shift in the stock of capital in favor of machinery.⁴⁵

The technology of the economy became science and machine-based. There was widespread substitution of machinery for handicraft skills in textiles and the development of the steel plow increased the productiveness of farming.

The invention and application of the steam engine to industry and transportation increased output and lowered transport costs and travel time. A major technical innovation—interchangeable parts and the assembly line—made "the American system of manufacturing" synonymous with mass production.⁴⁶ This elimination of handicraft skills and the abolition of extensive fitting operations were aspects of a system whose central characteristic was the design and utilization of highly specialized machinery.

The ability to invent, produce and use specialized machinery linked the industries together into a larger system of low cost mass manufacture of standardized products.⁴⁷

Simon Kuznets, a leading international expert on economic growth and development, points out that the advanced industrial nations have been and are undergoing a period of industrialization that has lasted over a century. It is characterized by the extended application of technology to the economy. This application of technology refers not only to the 19th century but also to the 20th century and the use of computers and automated equipment in the factory.

It therefore becomes apparent that over the centuries technological progress and economic growth have become partners in the American economy. The current tendency to fully automate production by using robots is clearly a continuation of

Table 4: Machine Tools in Use*

	Under 10 Years	10-20 Years	Over 20 Years
1. United States	31.0%	35.0%	34.0%
Transportation Equipment	23.8	33.0	43.2
Non-Elect. Machinery	32.8	35.1	32.1
Electrical Machinery	33.0	41.7	25.3
Fabricated Metal	27.4	35.2	37.4
Precision Instrument	38.0	36.8	25.1
2. West Germany	37.0	37.0	26.0
3. United Kingdom	39.0	37.0	24.0
4. Japan	61.0	21.0	18.0
5. France	37.0	33.0	30.0
6. Italy	42.0	30.0	28.0
7. Canada	47.0	35.0	18.0

Source: American Machinist; 12th American Machinery Inventory of Metal Working Equipment, 1976-78. (Reprinted from *Exploratory Workshop on the Social Impacts of Robotics*, U.S. Congress, House, Office of Technology Assessment, February 1982.)

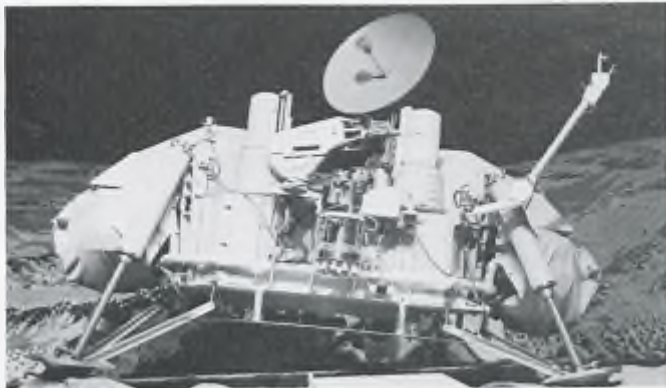
*Data based on 1976-78, except for Japan, France and Italy where the data is based on a 1973-75 survey.

the larger trend of applying technology to manufacturing. (See Table 4)

Based on cost and output considerations and competition in the international markets, it appears that the question of robot proliferation in America is settled. U.S. industries have already fallen behind their Japanese counterparts and they can no longer afford not to respond to the challenge. Without the introduction of automated production equipment in American factories to make and keep cost and output relationships internationally competitive, the damage to the U.S. labor force will likely be dramatic and permanent.

However, it is likely that widespread robot usage will result in jobs being lost in the relevant industries. Many will be created in support industries (e.g., computer hardware and programming) which will offset the aggregate employment loss in robot-using industries.

Unfortunately, it seems that most of the people hired in these other industries will not be the same people who will likely be displaced in robot-using industries. Their



Mechanical arm in use in space exploration—
NASA's Viking Science Test Lander

skills will not be transferable. A commitment to training programs, by business as well as government, is needed.

While automation is an important part of the problem, it is only one part. Other problems, such as unattractive product design, wage increases that are out of step with gains in productivity, lax marketing and sales efforts, and less responsiveness to consumer preferences are also responsible for the decline in competitiveness of U.S. goods. Management attitudes and the structure of the corporate takeover system should be included in this list. These problems affect too many areas for there to be one economic panacea.

Automated manufacturing systems are necessary but not sufficient to address the plethora of problems facing the economy. We need resolve and determination to address the problems of the complete picture. A sincere desire by unions and business can go a long way towards solving the potential employment problem and possible labor unrest.

And a government dedicated to insuring sustained economic growth and full employment can induce the appropriate negotiations. A business sector that conveys concern for its consumers' preferences is more likely to retain them as patrons.

The first step toward a solution is a recognition that what is best for the long-term must begin soon. Although it is generally accepted that America holds an edge in robot technology, the U.S. is not the pacesetter in robot use; and, at this point, application is as important as research.

In order for America to keep pace with Japanese and other economies, U.S. businesses need to make investment decisions now that will make technologically advanced production systems available in future years.

The next step is to galvanize the resolve to make sacrifices (e.g., short-term prof-

its, wage increases) that will more than pay off in the future. Businesses, labor unions, and the government should realize that if emphasis on short-term profits remains the norm, the survival of key American industries and a large number of jobs may become a crucial issue. However, a substantive commitment from these three sectors could result in a cooperative effort that is equal to the challenge. □

The above article was adapted from a senior honors thesis (economics) by Jesse W. Wainwright, who graduated from Howard University last May.

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