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By-Arnstein, George E.

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Automation is a word that describes the workings of computers and the innovations of automatic transfer machines in the factory. As the hallmark of the new industrial revolution, computers displace workers and create a need for new skills and retraining programs. With improved communication between industry and the educational community to alleviate the psychological pressures of a machine economy, automation should lead not only to higher productivity but also a higher standard of living. (TI)

AUTOMATION

The New Industrial Revolution

BY GEORGE E. ARNSTEIN

AMERICAN INDUSTRIAL ARTS ASSOCIATION

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—IBM

The impact of automation has penetrated nearly all aspects of American society. This broad statement underlies the claim that we are living in the middle of the second industrial revolution, a reference which reflects vast social, economic, and physical changes.

The most apparent innovation of the original industrial revolution some 200 years ago was the use of steam power to replace physical labor of human beings and animals. This spectacular breakthrough was followed by other inventions which speeded and improved communications, transportation, and manufacturing. It stimulated world trade and brought about the factory system. Population increased sharply, beginning urban complexes of the present day.

The first industrial revolution increased interdependence of capital and labor. It meant the beginning of the end for the medieval craftsman, the system of guilds, and apprenticeships. At this time, Eli Whitney, American inventor of the cotton gin, encouraged mass production through his manufacture of rifles with interchangeable parts; the venture called for standardization and precision, division of labor, and workers with narrow and specialized skills. No longer did the journeyman and the apprentice make an entire shoe or cart or wheel.

The social consequences of these and other innovations were far-reaching; some of them were beneficial, thanks to greater productivity, and some were adverse because of social dislocation and unexpected changes. Similar changes are occurring in our own times. Automation and technological improvements are producing a revolution of many facets: industrial, it affects goods and services; psychological, it affects attitudes of all per-

sons, especially workers and supervisors; scientific, it was initiated by scientists and, in turn provides tools and resources for scientific advances; economic, it influences the standard of living; social, it changes our mode of life; educational, it makes new demands on manpower resources; and political, its consequences require new responses.

The word "automation" is only about 15 years old, but it has been readily accepted. It has become a synonym for technological changes of all kinds, many of which have nothing to do with automation. It has glamorous overtones, but it also makes many people uncomfortable because they see it as a threat to their jobs and ways of life; they are uncertain whether it means promise or happiness.

—Goodyear Tire & Rubber

Automation has two specific meanings:

1. As part of the manufacturing process, it refers to machines that manufacture parts and pass them on to other machines for further processing, without human intervention. What emerges is either a finished product or a major component of a larger product, such as an automobile.

2. As the self-correcting mechanism by which machines keep track of their own experiences and correct their own deviations and mistakes. The reference here is to closed-loop automation, which includes the principle of feedback, in which information is fed back into the machine so it can modify its own performance.

The mainspring of today's industrial revolution may be said to be the computer, the most spectacular and visible aspect of a large number of scientific advances and inventions with comparably pervasive consequences. Probably foremost among the computer's accomplishments is its ability to remember and to perform certain mental tasks faster and more accurately than human beings. Further, the computer can control certain mechanical processes so effectively that it has caused relief from physical drudgery for thousands of human beings.

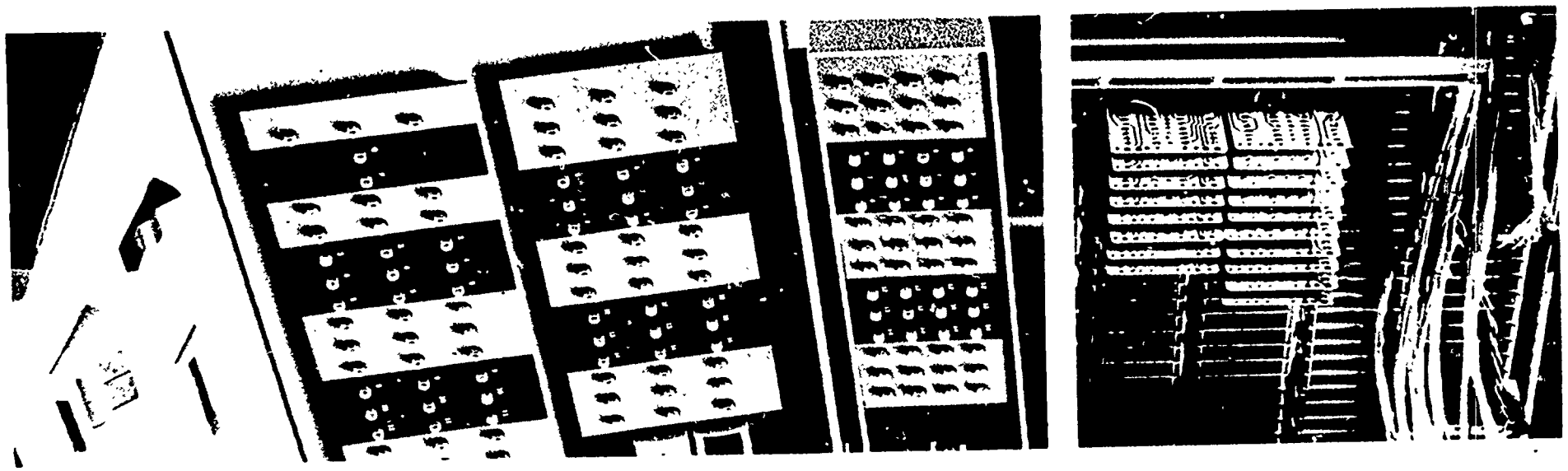
Engineers sometimes denounce computers as stupid beasts that can do little more than add; at other times, they praise the complex results achieved through combinations of addition, memory, and incredible speed. Unlike human beings, computers do not tire, they seldom are ill, their output is even and predictable, and they make few mistakes, thanks in part to their ability to spot and correct their own errors. As computers have become faster and more complex, we need to remind ourselves that they are really decision-making machines which also happen to be able to add. To continue to use the name computer is to sell short some of their most remarkable qualities.

The computer is the essential component of automation—hero and villain in one. It has made contributions to quality control by turning out products within narrow limits of tolerance, and it has contributed to safety in mill and factory. The computer can be run from a distance or close up. Advanced models can be instructed, or programed, in a form of English and their typewriter-like output can produce messages in English. Experimental models understand spoken instructions, and machine translation is becoming intelligible, although it may not be of high literary quality.[1]*

*See bibliography on pg. 16.

After this brief survey of the scene, you will understand more clearly why practically every American, regardless of occupation, can look on automation as a means which helps to make possible our high standard of living and our hopes for a better life in the years to come. However, our hopes are tempered by the threat that we may lose our jobs or that we may not be able to cope with the changes in the society around us.

Accordingly, it may be worthwhile to explore some aspects and implications of automation.



—IBM

The effect of automation is pervasive. Automation is making itself felt:

- In the postal system, where there are efforts being made to find machines that can read addresses and sort mail;
- In manufacturing, where machines can transform a lump of red hot metal into the engine block of an automobile;
- In processing industries, where petroleum is refined from crude oil at one end to a variety of different products at the other end, with a minimum of human attendance;
- In agriculture, where there are now automatic crop-picking machines;
- In retailing, where vending machines and self-service stores have made customers so lonely that hostesses had to be hired;
- In government, where the U. S. Bureau of the Census uses computers to keep track of its statistics and the Internal Revenue Service is switching to a system of numbered accounts to check citizens' tax reports;
- In the office, where employees have become used to odd-looking numbers on checks and to monthly insurance premiums untouched by human hands;
- In the classroom, where programed learning, teaching machines, and new uses for television are being introduced;
- In transportation, where a major airline, before consummating a merger, "flew" its own planes and those of the other airline on paper and on computers for several weeks before deciding on the economics of the merger;
- In communications, where the telephone dial system has been introduced and communications satellites will come into common use in the near future;
- In information retrieval, where the libraries of the future will use electronic and photographic devices rather than the open shelves most of us learned about in high school;
- In science and mathematics, where experimenters can plot an untold number of combinations which were impractical when they had to be done with pencil and paper;
- And especially in the area of decision making, where elaborate models can replace human managerial skills and threaten to invade an area where we thought that human judgment and brains were indispensable.

Scientific Basis

Possibly even more important than the computer is the systematic attempt to invent new things or new ways of doing things. This is a new attitude toward research and development, which has resulted in a phenomenal increase in spending during the past 20 years. This deliberate fostering of invention has brought about the present technological or scientific revolution.

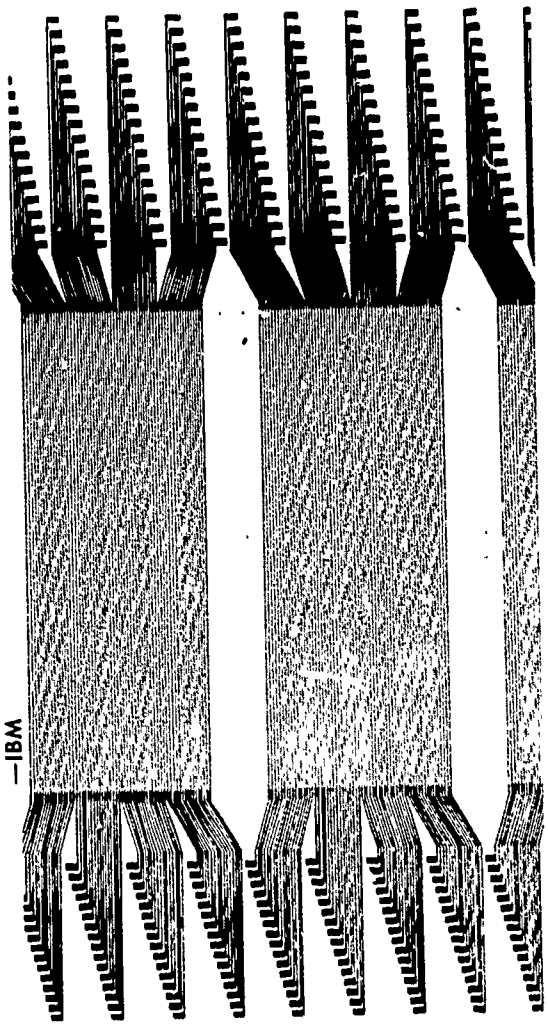
Authorities have used different methods of compilation to plot the growth of budgets for research and development, but they all agree that it has been phenomenal. One expert told a governmental fact-finding committee that in 1941 "the total spent throughout the economy on research was less than $1 billion annually."[2] By 1962, the annual rate was $15 billion per year, and for 1970 this same expert estimated that it would be "at least $25 billion." Estimates of budgets for research and development by the Industrial Conference Board are similar.[3]

As a result of this systematic investigation of new things, the American consumer today is the beneficiary of new products ranging from frozen food to automatic transmissions, from color television to reconstituted "instant" soup. The technological revolution has changed "substitute" from a nasty word used to describe wartime "Ersatz" to a word with new meaning for synthetic, plastic, or other man-made materials which are often superior to the natural materials they replace.

Financial Considerations

The number of scientific breakthroughs and innovations today has outpaced our ability to use them. Lee DuBridge, president of California Institute of Technology, in 1961 gave a speech in which he enumerated some of the techniques available to man, ready to be used but held up because they are expensive. Among the examples cited were these:

- Abundant food for every hungry mouth on earth.
- Ample fresh water, from sea water, to make the deserts bloom.
- Free-flowing traffic instead of congested urban centers.
- Fresh air without man-made pollution over our cities.
- Enough energy from uranium to light and heat homes, factories, mills, and offices.[4]



It is fairly easy to understand why it may be prohibitively expensive to convert salt water into drinking water, but in the case of industrial applications of computers these difficulties are more difficult to diagnose. The following example may serve to illustrate the need for vision and initiative:

When a major corporation or enterprise decides to investigate the possible applications of computers, there is considerable preliminary planning, involving outside experts and prominent managers. When their deliberations lead to a plan, the comptroller or business manager usually is entrusted with the acquisition and installation of the computer. His first effort is to demonstrate that the installation makes sense financially: he keeps track of expenses; he tries to show that the elimination of certain personnel has led to savings in payroll; and he seeks to demonstrate that at the end of 12 or 18 or 24 months the computer has paid for itself. Parenthetically, this has led to the observation that these calculations usually omit the major expenditure of managerial time as well as the cost of expensive consultants which should also be included among the costs of the computer.

The overriding financial considerations often cause computers to be installed and applied first in situations where they merely replace human effort and turn out a comparable product, which may or may not be superior and faster. These and other installations lead to the displacement of labor, a topic to which we will return later. For the moment, it is enough to note that the individual enterprise, usually seeking to make a profit, wants the computer to increase its profit margins and, unfortunate as this may be, does not consider the displacement of labor a part of its corporate responsibility.

Economic Consequences

To continue with our example, the installation of labor-saving devices such as computers, leads to economic consequences that affect all aspects of society.

The computer, whether in a university setting or in a corporation, also offers many opportunities for the performance of new tasks which heretofore could not be performed because of limitations in manpower, money, or time. It is ironic that many installations are so preoccupied with the performance of routine assignments that no computer time is left for the performance of new tasks. While the computer turns out payrolls or keeps track of inventories, there may be market researchers, economists, and other specialists who would like to have access to the computer to plan new products or to test methods. The early economic effect of the computer tends to be one of displacing workers and abolishing certain jobs. With more vision and with long-range plans, the computer also offers opportunities for totally new tasks and the acquisition of new knowledge.

The economic consequences of automation were demonstrated by a recent labor dispute in which a crew of 500 workers in a mail room were about to be reduced to 50 because of the installation of automated equipment. In another situation, a study of a major electric generating facility showed that automation of the latest addition to the plant produced greater efficiency but only a small reduction in the labor force,[5] while the reforms and innovations in the business office cut the number of clerical workers in half.[6]

Cumulatively, these innovations have led to technological displacement of labor in the short run; there

is no agreement among economists whether they cause unemployment on a permanent basis.[7] Similarly, there is no agreement on whether the installation of automated equipment upgrades or downgrades the labor force. The average observer, at first glance, is tempted to conclude that the installation of complicated machinery will call for more skill on the part of the operators than the old equipment or manual tasks required. However, this is not always true. One purpose of much new machinery is to simplify the task of human operators.

One certain outcome of scientific advances and technological innovations is the need for *new* skills. The installation of new machinery makes obsolete old approaches and old skills. In response, an employer may try to educate his present labor force or he may displace labor by looking for new employees with new skills while laying off unnecessary workers or those with obsolete skills. Fortunately, many employers are not motivated exclusively by profit; human considerations do enter into their decisions.

In the petroleum industry, automation was introduced very early. The industry increased the number of products which could be derived from a single barrel of crude oil, lowering the price of fuel oil which thus became a competitor for the uses of coal. The disappearance of the old-fashioned steam locomotive is an example of this; the substitute burns diesel oil. In those parts of the United States which traditionally used coal as a fuel, many home owners have converted to natural gas or fuel oil. Thus automation in the petroleum industry has worked to the disadvantage of the coal mining industry. The results have been displacement of labor and unemployment.

Political Ramifications

These developments have also had political ramifications. Local, state, and federal government officials have devised plans to cope with the economic impact of automation and other technological changes. Various governmental agencies are taking new looks at programs of relief, of surplus food for the unemployed, of unemployment compensation, of manpower development and retraining.[8]

Another ramification of technological change has been the need for capital to buy the machinery of automation. In turn, this calls for more centralized control and clashes with old-fashioned political boundaries, especially at the county and municipal level.

The political ramifications are also making themselves felt in the election booth, with candidates seeking to deal with problems of unemployment on the one hand and new research activities on the other.

International Ramifications

The march of technology affects not only the domestic policies of a nation but also its near neighbors and distant allies and antagonists. Automation is meant to stimulate productivity and lower the cost per unit of production; it influences international trade, its dimensions, and its channels. More than that, the changes in communications and transportation have made possible new concepts of diplomacy and even international alliances.

—IBM

An ambassador today no longer performs the same function he did 200 years ago, if only because he can be in instanteous communication with his home government by means of computers that encode his messages and of electronic devices that provide high-speed transmission. His predecessor had to think for himself, for better or for worse. Ironically, the fully instructed ambassador exists side by side with the sudden new popularity of meetings at or near the summit, made possible in turn by the sudden progress in rapid transportation. The statesman of old could travel only with difficulty. The new statesman can travel speedily and in comfort.

In terms of international trade, the march of technology goes far beyond the importation of Japanese transistor radios to the United States. There is more to it than mere reduction of labor costs. Part of the impact of

automation on the coal mining industry came not through mechanization of the mines but through automation of the refineries which produced a competitive product.

The refineries, in turn, achieve their competitive gains because of the improvements in large tanker fleets, the arrival of far-flung pipelines, and the possibility of importing oil from the Middle East, from Central and South America, and from other parts of the world at a cost low enough to present a real threat to coal. On the other hand, American coal from time to time has been exported to certain foreign countries, either because their resources were not sufficient or because American prices, including shipping charges, were sufficiently low to be competitive. Mechanization and automation in many parts of the world continue to change the picture and the international flow of fuel and other products.

In international trade and politics, technology has produced significant effects and will have further impact in the future. Some of these effects are deliberate and planned, while others are based on the need to appear up to date, as in the case of a Southeast Asian country that wanted to put its entire internal revenue and taxation system on computers since it believed computers are the hallmark of a modern nation; it had not considered whether a computerized system was appropriate for its needs.

Educational Challenge

Automation calls for new skills, clearly different from the old ones.[9] New skills call for more education, re-education, or retraining. Automation also often means, at least in the short run, a displacement of labor, including the need for human adjustments. This is the first and most immediate educational challenge: how to provide new skills for those workers displaced by automation but ready to participate in the new methods and tools. Although certain answers are not yet available, there are commendable efforts being made by business, schools, and state and federal governments to cope with this problem and to provide the new skills needed by a major segment of the labor force. The results have not been entirely encouraging, but they do offer some prospects for success.

It is also ironic that side by side with the large number of unemployed, American society has a large but unknown number of unfilled jobs calling for highly specialized professional persons—engineers and teachers, physicians and medical workers, programmers for new computers, and many others in the so-called service industries which include low-skilled, undesirable assignments in kitchen and cleanup work as well as professional duties in health and educational services.[10]

More basic, and even more challenging, is the problem of how to prepare the young people in school today for the uncertain world of tomorrow. Neither the speed nor the direction of technology are known with certainty sufficient to warrant precise recommendations, but we do know that there is a need for sound liberal education which lays a foundation for the later acquisition of specialized skills.

The greatest need is for a better method of planning, including better communication between industry and the educational community. For competition and other reasons, new products and new techniques may be on the drawing board behind a veil of secrecy. Workers who are willing and able to acquire the new skills are unable to prepare either because they lack adequate warning or because the schools have inadequate knowledge of the skills they should be teaching. The schools thus vacillate between efforts to provide a broad educational foundation and quickly improvised courses to teach specialized skills needed by a nearby employer.

Most people remember when a journeyman carpenter could hope to use a basic body of skills for his entire life. The physician of the recent past was able to acquire his education without having to work too hard to update his skills. Teachers could hope to master their subject matter and teach the next generation on the strength of this knowledge. Now what we are calling for is a new lifelong learning, based on our conviction that we can no longer afford to let each person learn one skill and then hope to live a meaningful life and perform a competent job on the basis of that skill. While educators always did talk about this need for lifelong learning, and the nation always was convinced of the advantages of additional information for a more meaningful life, this was considered almost an extravagance, a luxury rather than a necessity.

The new industrial revolution has made the extravagance of former years a new imperative. To survive as productive members of our society and to enjoy the opportunities offered by additional leisure will require additional knowledge and lifelong learning. It seems certain that all of us, whether we work with hands, words, or ideas, will have to learn two or three or more separate sets of skills.

These skills often lie in areas which have no precise names. All of us know, or think we know, what a carpenter does, what a historian is, or what a machinist does. Today, however, occupations cannot be neatly compartmentalized. A teacher may teach in the old-fashioned sense, or he may be a resource person for an educational television station, where his work eventually will appear on film.

We do know that lifelong learning is imperative, even if we do not know what the specific content must be. Fortunately, there is some available evidence which indicates that an adult *can* learn about as well as a young person, that you *can* teach an old dog new tricks, as long as he has kept alive his learning skills.

—IBM

A good illustration was used by Dr. Herbert Krugman, a social psychologist who participated in a symposium held by the EIA Project in Washington, D. C., early in 1962. In dealing with the problem of success and status, he said the following:

"The core of the matter seems to lie in the importance of having an occupational role, what with 'What do you do?' being always the first question asked after introduction to a stranger. However, 'What do you do?' gets harder to answer all the time, especially as a technologically advancing industry creates jobs that are new, nameless, or difficult to describe. What status is there in saying, 'I am a relay transmitter maintenance technician on the 609 power mag?' The substitute answer is then offered in terms not of what one does, but where, that is, 'I work at the Jones Company.'"

Psychological Problems

One of the most important psychological challenges is the problem of persuading displaced adult workers with little education to go back to school to learn new skills.[11] The psychological hazards include lack of motivation, too much pride in the

old occupation, failure to comprehend the continuing nature of change, and resistance to changes of all kinds. These hazards are emotionally charged and demonstrate one more aspect of the complicated nature of automation.

Studies in factories and other installations have shown that there are certain forces at work which tend to work against the installation of automated machinery. Unions may pressure employers to maintain old jobs or to provide some form of income or employment for those who have manned the plant for years or decades. Management often fails to take the initiative or to understand the implication of automation and its demands for new skills to perform old tasks. Automation means change, and change means, for many people, a threat to established ways of doing things.

Basically, any discussion of psychological problems leads to the fact that union power, self-interest by management, and other obstacles to change are tied to financial considerations, thus demonstrating the interrelation of these aspects of automation.

Despite the complexity, despite the dark aspects of automation, automation and other technological changes will continue to occur. They will continue to perform new tasks more quickly and dependably than man has been able to accomplish before this. Automation means higher productivity and should lead to a higher standard of living. Automation is based on competitive considerations; it will be used as long as it promises to do the job better than the old way did. And this competitive aspect, this promise of greater productivity, probably means that automation will continue to progress despite the financial obstacles, economic difficulties, political ramifications, and the international and educational and psychological problems that accompany it. We must not forget that before automation became as important as it is today we had problems of a psychological and educational nature, we had international complications, and we had political, economic, and financial problems at home and abroad.

Automation is part of the time in which we live, and it is a mistake to credit or blame it too much for the complications and complexities of modern living. Automation is a fact of life; it is a word used to describe the workings of computers and the innovations of automatic transfer machines in the factory; and it is the symbol of the new industrial revolution. •

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—Carl Purcell

Dr. George E. Arnstein is associate director of the NEA Special Project on the Educational Implications of Automation.

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