DOCUMENT RESUME

ED 222 772 CE 034 312

AUTHOR Jaffe, J. A., Ed.; And Others
TITLE Technologies of the '80s: Their Impact on Trade and Industrial Occupations.
INSTITUTION Conserva, Inc., Raleigh, N.C.
SPONS AGENCY Office of Vocational and Adult Education (ED), Washington, DC.
PUB DATE Sep 82
CONTRACT 300-81-0352
NOTE 85p.; For related documents, see ED 219 527, ED 219 586, and CE 034 303-313.
PUB TYPE Viewpoints (120) -- Reports - Descriptive (141)

EDRS PRICE MF01/PC04 Plus Postage.
DESCRIPTORS Automation; Blue Collar Occupations; *Diffusion (Communication); *Industrial Personnel; Job Skills; Machine Tools; Microcomputers; Postsecondary Education; Secondary Education; Semiskilled Occupations; Service Occupations; *Skilled Occupations; Technical Occupations; *Technological Advancement; *Trade and Industrial Education; *Vocational Education; Welding
IDENTIFIERS Computer Assisted Design; Computer Assisted Manufacturing; *Impact; Microelectronics; Optical Data Transmission; Robotics

ABSTRACT

This report is one of seven that identify major new and emerging technological advances expected to influence major vocational education program areas and to describe the programmatic implications in terms of skill-knowledge requirements, occupations most directly affected, and the anticipated diffusion rate. Chapter 1 considers technology as process, the relation of technology and productivity, and technology as the arbitrator of work. The first of three sections in chapter 2 presents the procedures used to identify and clarify the most innovative, new, and emerging technologies with implications for vocational education. Brief descriptions of the technologies expected to affect trade and industrial occupations are included in section 2. Section 3 contains eight essays describing these new and emerging technologies with implications for trade and industrial occupations: process control, microelectronic monitors and controls, computer-based design and manufacture, robotics, machining, welding, optical data transmission, and microcomputers and microprocessors. Chapter 3 is an annotated bibliography with citations descriptive of new or emerging technologies, their diffusion, or insights as to their vocational implications. (YLB)

ED222772

TECHNOLOGIES OF THE '80s: THEIR IMPACT ON TRADE AND INDUSTRIAL OCCUPATIONS

J. A. Jaffe
E. H. Oglesby
D. W. Drewes

Editors

CONSERVA, Inc.
401 Oberlin Road
Raleigh, NC 27605

September 1982

Contract No. 300810352
U.S. Department of Education
Office of Vocational and Adult Education

CE 034 312

The preparation of this report was supported in whole by the U.S. Department of Education, Office of Vocational and Adult Education. However, the opinions expressed herein do not necessarily reflect position or policy of the Department of Education, and no official endorsement by the Department of Education should be inferred.

2

FOREWORD

Productivity is a critical economic concern. Sagging productivity growth coupled with rising costs and heightened foreign competition are placing American business and industry in an increasingly vulnerable position. In an effort to strengthen its competitive position, American business and industry is investing heavily in capital-intensive technology. However, productivity is people-dependent and its improvement conditioned upon their possessing the technical and organizational skills necessary to utilize technology to its fullest advantage. The development of the work skills required to contribute to the revitalization of America is the central challenge to vocational education.

This report is the result of a contract with the U.S. Department of Education, Office of Vocational and Adult Education to investigate the changing role of vocational education resulting from new and emerging technologies. It identifies the major technological advances expected to influence each of the major vocational education program areas and describes the programmatic implications in terms of skills-knowledge requirements, the occupations most directly affected and the anticipated diffusion rates.

An associated project report, "Working for America: A Worker-Centered Approach to Productivity Improvement," is devoted to an examination of worker-centered productivity and a discussion of the organizational and educational strategies for its improvement. A companion monograph entitled "Vocational Education: Its Role in Productivity

Improvement and Technological Innovation" describes the relationship between productivity and technology and presents mechanisms for state vocational education agency use in productivity improvement and technological innovation.

Technologies described in this paper range from the "hard" technologies with industrial applications, (e.g, robotics and computer-assisted design and manufacture), to "soft" technologies such as alternative work scheduling; (e.g , flexitime, job-sharing); or worker participation in management; (e.g., quality control circles, quality of life groups). Both "hard" and "soft" technologies can be expected to bring rapid and radical change to workers involved in their use. Some technologies may affect only one vocational education instructional area. The effects of other technologies will be felt in several or all of the vocational education instructional areas in varying degrees. In either case, vocational educators must take action to assure the inclusion of the skills demanded by these technologies in their instruction in order to meet the job challenges of the near future.

TABLE OF CONTENTS

CHAPTER I

TECHNOLOGY--THE FORCE FOR CHANGE

TECHNOLOGY AS PROCESS

Technology means many things to many people. Some see technology as the driving force propelling society into the future. Others view it as evidence of an engulfing mechanistic materialism that threatens to destroy our humanistic values. Workers fear that technological advancements will take away their jobs and render their skills obsolete.

All of these are in part true. Undoubtedly, technology influences the future growth and direction of society. Technology is mechanistic and may be used to the detriment of human dignity. Indeed, technological advancements do render certain job skills obsolete. These conditions, however, speak more to the results of technology than to the nature of technology itself.

Technology in essence is the application of information, techniques and tools to material resources so as to achieve desired ends. At the societal level, these desired ends translate into a mix of material goods and services required to satisfy society's wants. Technology provides the ways and means for producing the desired stock of goods and services. Since production implies the use of resources to create products of value, technology provides the means to convert natural resources into material wealth.

Technology, then, can be regarded in the abstract as the process used by a work system to convert inputs into outputs. A work system can be defined as any organization that expends energy (work) to convert resource inputs into outputs in the form of goods and services. Work systems may be defined at any level from society as a whole to a work group at the department or subdepartment level of firms and organizations.

The notion of a work system as an input/output system is shown in Figure 1.

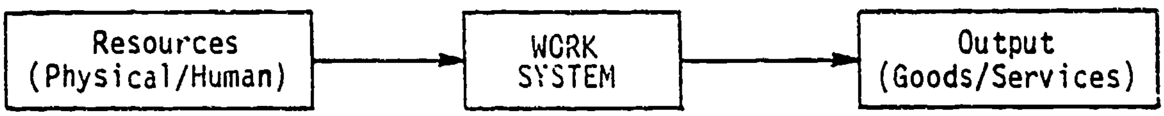

Figure 1. Input/Out Model

As indicated, inputs enter the work system, work in the form of energy expended is performed, and inputs are translated into outputs in the process. The process or rule for translating inputs into outputs is in the essence what is meant by technology. Thus, for any work system, the prevailing technology determines what outputs will be produced as a function of inputs. In the most general sense, technology can be regarded as an input/output function. Technology is not to be equated to either the inputs nor the output products of the work system. Rather, technology is the correspondence rule that determines the outputs resulting from a specific level of input.

Inputs into a work system are the resources used in the process of production. These resources in the most general sense are labor, capital, materials and energy which are frequently referred to as the factors of production. Output of a work system is measured in terms of goods and/or services produced. Using these definitions of input and output, technology can be regarded as the function that maps or transforms the factors of production into goods and/or services produced. In economic terms, this function is called a production function and expressed as:

$$\text{Technology} = \text{Production function}$$
$$= F(\text{labor, capital, materials, energy})$$

Technology, considered as a production function, constrains the way the factors of production combine to produce an output of goods and/or services. For example, technology as process determines the unique contribution of each factor of production with the other factors held constant and determines the impact of substituting one factor for another. Factor substitution occurs when one factor such as capital is used in increasing amounts as a substitute for another factor, such as labor. The important point is that it is the current technology that determines how the factors are inter-related and the relative output contributions of each factor.

Suppose now that an increase in the output of the work system was observed even though all factors of production were held constant. The only way this could occur would be for the production function itself to change. Since technology is equated with the production function, this is defined as <u>technological change</u>. Technological change occurs when efficiencies in the production process allow for increased output without the necessity for more input resources to be used. Thus, if a change in output accrues from training workers to work smarter, but not harder, then a technological change can be said to occur, provided that the increase resulted from more output per unit of labor expended rather than more units of labor being expended (working harder). In a similar manner, technological change can result from any alteration in the production process that results in more output per unit of factors of production used.

Typically, technological changes result from the introduction of labor saving devices. These devices, in the form of equipment and/or tools, make it possible to glean increases in output per hour of labor input. The effect is to alter the production function so as to reflect the increased contribution of labor to production output. Technological change can also result from changes in the managerial and work structure that result in improved output contributions from one or more factors of production. Because of the multitude of sources, the technology of a work group is in a continual process of change. Thus, technology evolves through incremental changes as the work system seeks to fine tune the process through improved production efficiencies.

Periodically, conditions arise that substantially alter the organization of work systems. Responsiveness to these conditions requires that the work systems, to survive, must adopt a new production function. Production functions that differ in form are termed <u>techno-</u>

logical innovations and are to be differentiated from technological changes. Whereas technological change is associated with incremental evolutionary changes in the production function, technological innovation signals a discrete shift from one form of production function to another. This discrete break with the past generally is associated with the introduction of a revolutionary new process that allows resource inputs to be combined in an unprecedented manner. The introduction of the spinning jenny was one such example. This invention allowed one spinner to produce as much in a given hour as 200 could have produced prior to its introduction (Deane, 1979). The impact of these and other significant inventions is to recombine the factors of production in a totally new and significantly more productive fashion. Thus, whereas technological change is evolutionary, technological innovation tends to be revolutionary in its effects.

TECHNOLOGY AND PRODUCTIVITY

Productivity of a work system is typically defined as the ratio of system outputs to system inputs. Productivity increases when more outputs are produced per unit of input. Increased productivity makes possible an increased amount of goods and services per unit of factors of production used and results in an improved standard of living, increases in real income and strengthened price competitiveness. For an expanded discussion of productivity, see the companion project report "Working For America--A Worker-Centered Approach to Productivity Improvement" (CONSERVA, 1982).

The relation of technology and productivity flows from an examination of the definitions of the two concepts. Productivity of a work system can be defined for all factors of production used simultaneously, or each individual factor of production can be considered separately.

(a) Total Factor Productivity $= \dfrac{\text{Work System Output (goods/services)}}{\text{Total Resources Used (labor, capital, materials, energy)}}$

(b) Labor Productivity $= \dfrac{\text{Work System Output (goods/services)}}{\text{Labor Resources Used}}$

(c) Capital Productivity $= \dfrac{\text{Work System Output (goods/services)}}{\text{Capital Expended}}$

(d) Materials Productivity $= \dfrac{\text{Work System Output (goods/services)}}{\text{Materials Used}}$

(e) Energy Productivity $= \dfrac{\text{Used System Output (goods/services)}}{\text{Energy Consumed}}$

Recall that technology was defined as the production function F(labor, capital, materials, energy). Whereas technology is the function itself, a specific output corresponding to an input of L-units of labor, C-units of capital, M-units of materials, and E-units of energy is dictated by the technology and designated as $f(L,C,M,E)$. By substituting for the output, the productivity definitions can be rewritten as:

(a) Total Factor Productivity $= \dfrac{f(L,C,M,E)}{L+C+M+E}$

(b) Labor Factor Productivity $= \dfrac{f(L,C,M,E)}{L}$

(c) Capital Productivity $= \dfrac{f(L,C,M,E)}{C}$

(d) Materials Productivity $= \dfrac{f(L,C,M,E)}{M}$

(e) Energy Productivity $= \dfrac{f(L,C,M,E)}{E}$

Technological change influences the productivity of all factors of production by altering the value of the production function f(L,C,M,E). If the change in technology results in a positive increase, then productivity will also increase accordingly. The explanation is that technological change makes possible increased outputs of goods and services without a corresponding increase in resources used. This increase in the stock of goods and services available is translated into an increase in the standard of living as more wealth is available for distribution. An expanded standard of living creates demand for additional products and services which provides work for more people. Additionally, increased productivity allows goods and services to be priced more competitively since increased productivity lowers per unit production costs. Price stability is beneficial in that it is anti-inflationary and contributes to our ability to compete on the international market.

TECHNOLOGY AND WORK

Technology is the great arbitrator of work. It is technology that specifies how capital goods can be used by workers to convert raw materials into finished products. It is technology that determines the range of human skills and abilities necessary to use the capital goods as production tools. It is technology that specifies the appropriate materials for which the tools can be used and the energy required for their use.

Whereas technology sets the stage and writes the script, it is management that directs the production. Management's decisions determine the desired mix of labor and capital, the rates at which labor and capital will be utilized, the quantity of labor, capital and materials used and the extent of substitutability between elements of labor, capital and energy. It is also management's responsibility to maintain a management climate that facilitates the most efficient and coordinated use of labor and capital. For a discussion of the impact of management climate on productivity and suggested strategies for development of a worker-centered approach to productivity, see the companion project report "Working for America--A Worker-Centered Approach to Productivity Improvement," Chapter III, (CONSERVA, 1982, op. cit).

Innovations incorporated in new capital goods tend to spearhead technological change and innovation. The latest advances in knowledge and theory tend to be embodied in the design and structure of new capital equipment. Innovations and capital goods design have direct implications for labor as a factor of production.

These implications affect not only the human skills requirements, but also the very organization of work itself. Human skills requirements may be relatively unchanged in those cases where new advancements were made without basically altering the production process. A typical example might be the development of new and improved bits for cutting metal. In this case, the advancement could be basically incorporated into the existing process and would require minor alterations in human skills requirements. Contrast now the introduction of computer-controlled machines grouped into manufacturing cells with machines being programmed by computer numerical control and robots loading and unloading work pieces onto the machines. In this example, the very organization of work itself has been drastically changed with consequent changes in the nature and intensity of human skills requirements. This represents a dramatic illustration of the distinction to be drawn between technological change and technological innovation.

The press for technological innovation is strong and mounting in intensity. Productivity growth is sagging in the country, having fallen from an average annual rate of increase 3.1 percent in the period 1948-58 to a mere 0.7 percent for the period 1974-81. (Statement of the Chamber of Commerce of the United States on Productivity, April 2, 1982). There is near universal agreement that the lack of capital has been one of the major causes of this decline. As Lester Thurow, a noted expert on productivity, states,

> The amount of equipment per worker--the capital-labor ratio--is a key ingredient in productivity growth. Better-equipped workers can produce more output per hour, but new capital is also a carrier of new technologies. To put new, more productive technologies to work, workers must be provided with the equipment that embodies those new technologies. Without this additional hardware, or "physical capital," it is impossible to translate new knowledges into new output (Technology Review, November/December 1980, page 45).

In the area of foreign trade, the United States is in the process of moving from being a net exporter to a net importer in major categories of industrial output. As shown by a study recently conducted by the Department of Labor, of the top 17 U.S. export commodities, losses in the world market were experienced in 14 of the commodities. Between 1962 and 1979, the U.S. trade position had deteriorated such that market losses had been experienced in all 17 of the top export commodities. (Congressional Hearings, December 1980 and January 1981).

The report attributed the decline in U.S. international competitiveness to changing supplies of world resources and diminished technological capabilities. The rate of growth of the capital-labor ratio, a measure of the amount of capital available per worker, declined to such an extent that the United States fell from first to sixth in terms of capital available per worker. The United States' share of world capital fell from 42 percent in 1963 to 33 percent in 1975. During the same time, Japan doubled its capital from 7 to 15 percent of the world's share. As the U.S. stock of physical capital fell, so did its human capital. According to Department of Labor analyses, the United States fell from second to seventh in terms of percentage of skilled workers in the labor force-with the U.S. share of skilled workers falling from 29 percent to 26 percent. (Congressional Hearings, December 1980 and January 1981, op. cit.).

As a compounding problem, the United States is reported to be experiencing a severe shortage in skilled labor. In a widely quoted report, the Department of Labor projects average annual training shortfalls in excess of 250,000 persons per year for the next decade (U.S. Department of Labor, 1980). These are regarded as minimum estimates since they result from inclusion of only the 13 occupations with the greatest projected shortages. The Task Force on the Skilled Trade Shortages, which represents a coalition of 13 metalworking industries, estimates an anticipated need for 240,000 journeyworkers in the metal trades by 1985. (America's Skilled Trade Shortage: A Positive Response, 1981). The American Electronics Association, in a survey of its members, projects a need over the next five years for approximately 113,000 technical professionals in eight job categories and an additional 140,000 technical paraprofessionals in 13 job categories. (Shortages in Skilled Labor, November 3, 1981).

America stands at an economic crossroad. In the face of impending labor shortages, American business and industry can follow one of two major courses--one will be business as usual. If that philosophy prevails and a labor shortage materializes, per unit labor costs can be expected to increase, leading to increased prices as businesses seek to maintain their profit picture. Continued sluggishness in capital investments, coupled with the shortage of skilled labor, will dim any prospects for productivity improvements. As a result, inflation can be expected to escalate, our standard of living to diminish, our foreign competition to increase, and the United States will be well on its way to becoming a second-rate power.

As an alternative, the United States can make a significant investment in labor-saving capital in an effort to reverse the productivity trends and to regain the competitive edge. If the strategy is undertaken with vigor, the implications can be profound. Unlike the early '60s when the concern for the effects for technology proved to be unfounded, the United States currently stands on the brink of a technological revolution drawing its force from the emergence of the microprocessor and its ubiquitous applications. Second generation industrial robots with sensing capabilities could perform over 40 percent of the operative jobs in metal working. Within the next two decades, 4 million jobs out of a current 19.7 million manufacturing jobs could be robotized. (National Productivity Review, Winter '81-82).

America is rapidly shifting from a manufacturing to a service-based economy. In 1950, nearly one out of three non-agricultural workers was employed in manufacturing, and only one out of eight employed in services. By 1980, only 22 percent of the non-agricultural work force was in manufacturing as opposed to nearly 20 percent in services. In terms of percent change in employment for the three decade period, manufacturing increased a scant 33 percent in contrast with a 231 percent increase for services (Impact of Technological Change, 1981). The shift is being experienced both in international as well as domestic markets. While we are becoming a large net importer of manufactured goods, the United States now exports about $60 billion worth of services a year. This qualifies the United States as the largest exporter of services in the world, exporting nearly 25 percent of the world's service base. (Presentation of Dr. David L. Birch to the Council of Upper Great Lakes Governors, March 5, 1982). As a consequence of our changing service base, capital investments to facilitate handling and communication of office information can be expected to increase. New capital innovations can be anticipated in the areas of advanced word processors, electronic methods of reproduction and transmission of images and other electronically-augmented telecommunication devices.

The impending technological revolution will not be expected to be entirely bloodless. The transition from a manufacturing to a service economy can be expected to have severe short-run implications for those whose skills have become obsolete because of changes in technological demands. Whereas job displacements may be regarded as but minor perturbations in society's overall growth, they represent crises of major proportion in the lives of those who are experiencing them. In order to ease the transition and to contribute to the more effective and best productive use of our human resources, it is incumbent that quality skills training be provided that is attuned to the demands of emerging technology needs and available to all those who can profit from its exposure. The extent to which vocational education rises to meet these needs will determine the contribution that vocational education makes to the revitalization of the economy and the continued prosperity of society.

CHAPTER II

NEW AND EMERGING TECHNOLOGIES

Vocational education to be responsive to the demands of forthcoming technology must become increasingly aware of the nature of these technologies and their associated training requirements. In recognition of this need, CONSERVA, Inc. was awarded a contract by the U. S. Department of Education to identify the most innovative, new or changing technologies and to assess their occupational implications for specific vocational education program areas. The procedures used to identify and clarify technologies are presented in the first section. Brief descriptions of the identified technologies are included in the second section. Cameo reports describing the major new and emerging technologies with implications for Trade and Industrial occupations are provided in the third section.

IDENTIFICATION AND SELECTION PROCEDURES

In order to identify new or changing technologies with implications for vocational education, project staff reviewed recent years' issues of several hundred different business, trade/industrial, and technical periodicals seeking information concerning technological change or its impact.

In reviewing published articles for possible relevance, three basic characteristics were considered. First, there must have been evidence that the technology is currently being used in the "real world"--i.e., that it is not still "on the drawing board" or futuristic. Second, the technology must have appeared to have direct or indirect implications for the way work is performed, and must impact skills within the training domain of vocational education. Finally, trend projections or other indications were sought as evidence that the technology was being increasingly used, implying greater numbers of jobs affected and resulting importance to vocational educational programming.

Having identified a set of technologies which are new or emerging, which promise growth, and which appear to impact job training, project efforts focused on the possible vocational implications of the technology. The implications were defined in terms of job activities affected, knowledges and skills required to carry forward these job activities, and special equipment or facilities (cost considerations) which might be necessary to instruct vocational students in the technology.

As a means of obtaining technology-specific information, outside experts were sought whose backgrounds and performance records qualified them to speak with authority about specific technologies and their training implications. For each of the identified technologies within a specified vocational education program area, a knowledgeable individual was invited to author a brief, nontechnical essay oriented to vocational education.

Since certain technologies have rather broad occupational implications, authors were allowed discretion as to which occupations or tasks they would emphasize. In making their decisions, authors were requested to consider the developing technology from a training and instructional perspective. Specifically, authors were asked to address the following areas:

- Work activities which involve the technology --

  The kinds of major duties or activities that may be new, changing, or developing as a result of the new or changing technology, with reference to the occupations under discussion.

- Knowledges and skills essential or important for productive completion of such activities --

  Knowledges are awareness of facts and process details, understanding of principles, etc., and "skills" are "hands on" abilities actually to carry out functions. The knowledges and skills to be covered were to relate to the work activity demands of the new or developing technology.

- Special equipment or facilities that would be required to teach such knowledges and skills --

  Aside from books, other usual instructional media, and standard educational facilities, any special devices (e.g., simulators or prototypes) or other capital that might be needed for instruction in identified knowledges or skills.

- Growth and trends in the diffusion or expansion of the technology --

  Observations of recent growth, and projections concerning likely near future expansion, of the technological innovations or changes, in business/industry/other applications that involve occupations under discussion.

TECHNOLOGIES EXPECTED TO IMPACT TRADE AND INDUSTRIAL OCCUPATIONS

Technologies selected for inclusion are those determined by application of the criteria to have programmatic implications for Trade and Industrial occupations. Brief descriptions are presented below. The purpose of these descriptions is to generally and summarily define the technologies being discussed by the experts.

Process Control involves automation of simple or complex industrial processes. A simple or singular process sequence is sometimes referred to as a process "loop." In a well-automated plant, the various loops may be integrated into a complex series. Microprocessors with programmable features contribute to the advancement of process control technology. Related terms include "numeric control" and "direct digital control."

By Microelectronic Monitors and Controls is meant those components of larger systems which may automatically control parts of the larger system, or which can monitor and display to human operators indications of what's going on within the system and transmit operators' instructions to the system. New graphics, voice recognition and synthesis, and sensor capabilities are among the advances in this technology area.

Microcomputers or Personal Computers, also called "desktop" computers, are by now somewhat familiar to us all. Small-sized and affordable by comparative standards ($5,000 or less will buy a sophisticated system), these machines incorporate many of the logical capabilities of larger computers and can be programmed to perform many of the same sorts of tasks. This is made possible by microprocessor technology. Microprocessors, based on large and very large scale integrated circuits, have sometimes been called "computers-on-a-chip." Microprocessors are used not only in microcomputers but in many other "hardware" systems which can then perform computer-like functions.

Optical Data Transmission is a technology which is made possible by advancements in fiber optics--the transmission of light through transparent fiber cables. Light from a point source (normally, a low power laser) can be used to send the intelligible messages by optical, rather than electrical, impulses. Transmission of such signals over optic cable can have some advantages over electrical wire transmission.

Microprocessors and computer systems form the basis of a set of technologies specifically geared toward the design or fabrication of parts and products. Computer-based design and manufacture is the label used herein to cover these systems known variously as CAD/CAM (computer-aided design/computer-assisted manufacture) and CIM (computer-integrated manufacture), used mainly but not exclusively in the production of industrial parts and part assemblies.

Robotics, the field of interest concerned with the construction, maintenance and behavior of robots, is defined in this paper within the context of the use of robots in industrial or business applications. Robots are defined as reprogrammable, multifunctional manipulators designed to move material, parts, tools or specialized devices through variable programmed motions for the performance of a variety of tasks.

Some of the activities of Machining (such as turning, milling, drilling and boring, grinding, finishing, farming, tooling, etc.) are being revolutionized by the newest technologies. Higher speed machining, new uses of lasers, microelectronic controls and operator-less manufacturing systems are bringing about improvements which in turn should boost machine shop productivity.

Welding, specifically the two major processes of resistance welding and arc welding, will see changes in application through automation of the standard processes in the near term. Continued automation in the automotive and other large manufacturing plants is predicted. Robots will handle many of the welding jobs formerly performed by skilled workers. Automation of arc welding is also increasing in high production plants.

TECHNOLOGY ESSAYS

The following essays describe the new and emerging technologies identified as impacting Trade and Industrial occupations. The essays, while edited for consistency, remain basically the products of their authors. Sincere appreciation is expressed to the following experts who have so generously contributed of their time and expertise:

ROSALIE BROSILOW, B.S. is Editor of Welding Design and Fabrication, (circulation: 43,000) and authors a monthly column in that journal highlighting trends in welding technology that will impact the industry. Ms. Brosilow is a former research metallurgist, and has authored numerous articles and technical papers which have been reprinted and quoted in books and journals in the United States and abroad.

THOMAS DROZDA, B.S.I.E., M.B.A., is Editor and Manager the of Reference Publications Department at the Society of Manufacturing Engineers. Formerly engineering editor at Production magazine, Mr. Drozda himself holds a professional engineering license in the state of Michigan and is a Certified Manufacturing Engineer.

JEFFREY C. HECHT, B.S.E.E., M.Ed., is a consultant and writer specializing in physical science and technology. Formerly managing editor of Laser Focus, his articles on technological advances have appeared in a number of popular science magazines. President of Futuretech, a young consulting firm, Mr. Hecht has chaired and moderated symposia on laser technology and on computer networks, and holds professional memberships in a number of technical associations including the American Physical Society and the Optical Society of America.

DONALD E. HEGLAND, M.S., is an Associate Editor of Production Engineering magazine, and has written and edited many articles on manufacturing technology and engineering trends, including computer assisted design and manufacture. He produces an annual production equipment issue Production Engineering which analyzes developments affecting capital equipment in manufacturing.

JOHN LAMOUREUX, B.S.E.E., is a Research Engineer with IIT Research Institute of Chicago. Specializing in control systems and digital circuit design, Mr. Lamoreux has had major responsibilities in layout and planning of control stations, operator panels, and relay logic as well as digital control circuits. He recently co-authored an article on advances in process control published in Science magazine.

WILLIAM R. TANNER is President of Productivity Systems, Inc., Farmington, Michigan. A leading authority and recognized international consultant on industrial robots and automation, he is an expert on installation of robots, performs market studies for production manufacturers and on-site technical evaluations of robot products for prospective users and investors. He is Editor of Industrial Robotics, Volumes I and II and provides technical advice and consulting to major manufacturers and the U.S. government. Mr. Tanner leads the Society of Manufacturing Engineers seminars on robotics and is a member of the Board of the Robot Institute of America.

J. A. SAM WILSON, M.A., is an independent technical writer and advisor. He has authored a manuscript on Industrial Electronics and Controls, as well as educational materials for Certified Electronics Technician examinations.

RUTH M. DAVIS, Ph.D., is founder and President of the Pymatuning Group, Inc., a Washington, D.C.-based science and technology management corporation specializing in modernization, microelectronics, computer, information, and automation management and development. Author of over fifty reports and articles on technology and policy, Dr. Davis is a former Assistant Secretary of Energy for resource applications, and before that Deputy Undersecretary of Defense for research and advanced technology.

PROCESS CONTROL IN THE INDUSTRIAL TRADES

by
John Lamoureux, Research Engineer
ITT Research Institute
Chicago, Illinois

Industry in this country has been drastically changed in recent years by advances in electronics. Cheap, reliable microprocessors have found their way into everything imaginable, and this is only the beginning. The years ahead will see more and more advances in hardware, software, and sensors. Industry will get better and better control at a lower cost, making it possible to improve productivity, reduce waste, improve material utilization, and reduce energy consumption. It is important that a technically educated work force be trained to help support the growth in digital electronics.

The process industries can be defined as those in which the composition of materials is changed by chemical reaction and blending of components to convert raw materials and energy into more valuable products. Process industries also include those involving physical changes such as drying, distillation, and forming through casting and rolling. Chemicals, petroleum, metals, pulp and paper, food, cement, textiles, synthetic fuels, and power production are all examples of the process industries.

PROCESS CONTROL TECHNOLOGY

The control of a process plant is a very complex task. A plant will typically contain thousands of valves, miles of pipe and wire, and numerous pumps, compressors, tanks, vessels, and bins. Several different well-defined operations or "process loops" take place within a single plant, with materials being moved from one to the next continuously. Process parameters such as temperature, pressure, flow, level, and chemical composition must be measured and controlled in order to produce a consistent product under varying input conditions. If the controls cannot compensate for upset conditions, the process must be safely shut down to prevent operator injury or equipment damage. Finally, information from the processes and operations must be transmitted to plant management in order to plan production and make other necessary business decisions.

The current trend in process control technology is toward the concept of distributed control. With this approach, a hierarchy of controllers, microcomputers, minicomputers, and mainframe computers is used to perform functions from process control and data acquisition to data management and scientific computations. At each level of the hierarchy, the computer performs its own function, reports to and receives instructions from the level above it, and receives data from and sends instructions to the level below it.

In a typical distributed control hierarchy, microcomputers and controllers operate at the local level to control process loops and extract and display data. Several microcomputers and controllers report to a single minicomputer, which is responsible for decision making for one segment of the plant. The number of levels in the hierarchy will depend on the number of tasks to be performed and how the work load is to be distributed. At the highest level, a large computer receives data from the minicomputers and performs scientific and business computing functions. The advantages of distributed control are lower controller cost, lower wiring cost, greater flexibility and sophistication of control modes, lower maintenance cost, more accurate data transmission, and a more fail-safe system since each process loop can continue running even if the supervisory computer goes down.

The implementation of distributed control in the process industry will change the aspects of many jobs. It is not within the scope of this paper to discuss them all, but we will consider a few as examples. Electronic and electrical drafting, for instance, will change with the ever growing and wide spread use of computer drafting systems. In construction, the installation of many computers and digital controllers will alter the electrician's work, as diagnostics programmed into the computer hierarchy change maintenance procedures. Finally, operators' interactions with process plant functions will be enhanced as a result of computer graphics display capability. Taken together, these examples will illustrate the general changes to be expected in the process control industry, with regard to jobs and job skills required.

DRAFTING

The life of the drafter will never be the same. In the past, all design drawings--such as those of complex piping conduit arrangements--were done manually from sketches given to the drafter by the engineer. Each revision meant erasures or complete redrawing. With computer aided drafting, most drawing will now be done from a CRT keyboard. Once the drawing has been completed, the drafter presses a button and the drawing is stored in memory for later reference and drawn out by a plotter. Revisions are done by recalling the drawing from memory, altering it on the screen, and initiating a plot. The computer system will do many of the tedious tasks that were once required of the drafter, such as numbering the lines on a ladder diagram or figuring out how to best dimension a drawing.

The drafter will have to become more aware of the design process in order to maintain a role in design. Anyone who learns the system can sit down and push the buttons. For example, an engineer may use the computer drafting system, linked to a computer aided design system, to work out a circuit. He/she will, therefore, have a practically finished drawing by the time he/she completes the design of the circuit. The role of the drafter will be to take the initial circuit drawing and apply the finishing touches to make it ready for the shop. The drafter should be aware of all the auxiliary drawings which normally accompany a circuit drawing and be able to generate them with no further help from the engineer. Instead of taking sketches from an engineer and producing a drawing, then, the draftsman will take the initial drawing from the engineer and generate a complete set of drawings from it.

The training for these drafters should include a review of the design and manufacturing process--what types of drawings are typically generated for a product from the engineering floor to the manufacturing floor. The best training for this type of drafter should include some experience on a computer drafting machine. Since these systems are expensive, a vocational school may not be able to justify the cost. It may, however, be able to arrange with a manufacturer of one of these systems to send students on a two-week training program at their facility as part of a larger overall vocational training. Training on a popular system would help the student to learn some other system much more easily while on the job.

ELECTRICAL CONSTRUCTION

The electrical wiring in the construction of a process plant using a distributed control system will be different from that of previous plants. Until recently, process plant electricians have not had to deal with computer cables to a great extent. Outside of wiring for heavy equipment such as pumps and compressors, most wiring was instrument wiring between sensors, process controllers, actuators, and the control room. This wiring carried analog signals, involved running separate wires for each instrument, and used large numbers of terminal blocks.

In the distributed control concept, signal transmission is almost entirely digital. This means that several controllers can share the same pair of signal wires on a time-sharing basis. New electricians will have to be aware of the limitations of sharing wires. They will be running large amounts of computer cables and will have to know how far a cable can be run without some sort of signal booster. Electricians will find themselves installing signal boosters, modems, computers, and computer peripherals in all parts of the process plant. They should become familiar with the basics of computer technology, especially as it pertains to communications between instruments, computers, and peripherals. They should know what type of cable and connectors should be used between particular devices.

MAINTENANCE

Distributed control systems are being designed with the highest system reliability in mind. This will make maintenance of distributed control systems an easier task. If there is a failure in the system, the system should continue to run, thereby reducing the pressure for immediate repair. Furthermore, self-diagnostics are being introduced which will quickly point out exactly where the fault in the system lies. Systems are being designed to be modular, so that repair in most cases will simply be a matter of replacing a circuit board.

Despite all of this help from the system itself, good maintenance personnel should have a basic understanding of how the system works. If for some reason the self-diagnostics do not work or are inadequate, it will be the responsibility of plant maintenance personnel to repair the system. They should know fundamental principles of computer technology and of distributed control. They should know the architecture of the system with which they are working, how to work with peripherals, and how to run programs. In sum, they should know how to determine what tasks are being performed by what computer and be able to pinpoint problems without the help of the system self-diagnostics, and be able to handle system components electronically as well as physically.

Some experience on a distributed control system would be valuable in the training of maintenance personnel. A few microcomputers and a minicomputer might be linked together in a hierarchy to control a laboratory-scale process. This "mini process plant" could give hands-on experience with system hierarchy and present a good idea of how failures affect the system.

OPERATORS

The operators of process plants will see a drastic change in the control room. Walls of controllers and lights will be replaced by a few CRT screens. With these CRT's, the operator will be able to get an overview of the entire plant or focus in on one or two individual process loops. He/she will be able to simulate various input conditions and see how they would affect an individual process loop or the entire plant.

The training of operators will become less of a learn-by-experience situation and more of a learn-by-simulator situation, at least in the initial stages. Since an operator in the plant will only be looking at a few CRT's and lights, it becomes more realistic to simulate a control room and train the operator by having a computer control the displays. Operator training will become more formal, especially in the case of plants which may pose a danger to the public, such as nuclear power plants. These operators will not have to know computer technology, but will need to feel comfortable in front of a CRT screen in order to perform well. Some training in computer technology may help in making the operators feel more comfortable with a computer controlled process plant.

THE FUTURE

The advances in digital electronics will continue to change process control technology. There will come a day when every part of a process plant, no matter how small, will have at least a microprocessor working there. As the field changes, associated jobs will change to reflect the increased reliance on microprocessors and computers. There will be a continued rise in demand for people who will feel comfortable working with, and around, computers and computer-based systems.

MICROELECTRONIC MONITORS AND CONTROLS AND INDUSTRIAL WORKERS

by
J. A. Sam Wilson
12555 Biscayne Boulevard
Miami, Florida

In order to make effective use of electronics for controlling complex industrial machinery and other electronically controlled systems, it is necessary to utilize monitoring and controlling components. These components serve as a person/machine interface that makes it possible for an operator to review the status of the system operation and, if necessary, override, supplement, or react to the display of status in some special way. By utilizing micro-processor, digital, and other microelectronic technology, it is possible to monitor many inputs to the system and, when necessary, to modify the operation of the system to maintain its performance. Alarms and automatic shutdown equipment may be part of the monitoring and control system.

Trade and industrial workers will be needed by manufacturers of equipment such as:

- medical electronic systems;
- industrial electronics and control systems;
- automated test equipment;
- military tactical system;
- intrusion and fire alarm systems;
- computer-operated systems; and
- data communications and data retrieval systems.

In the field of microelectronic monitors and controls, there are many tasks that can be performed by trade and industrial workers. Examples of the types of work done at this level are:

- installation of new and replacement controls;
- mechanical assembly;
- wiring from schematic drawings;
- simple tests;
- basic repairs and component replacement; and
- preventative maintenance.

Many of the skills required for technical and industrial workers in this technology are the same as for those working at the same level in other electronic jobs. Some examples of these skills are:

- soldering, repairing and replacement of parts on printed circuit boards;
- use of basic test equipment;
- ability to work from blueprints and schematic diagrams;
- an understanding of display circuits;
- cabling; and
- performing test protocols.

It is unlikely that elaborate microelectronic monitor and control systems would be available for classroom work. One reason is that these systems are often custom designed. As an alternative, components that make up these systems can be used for laboratory experiments that supplement the necessary theory. Here are some examples of useful lab equipment:

- transducers with appropriate bridge circuits;
- simple open-loop and closed-loop control circuits;

- printed circuit boards with integrated circuits (for practice in desoldering and soldering components);
- counting and display circuits;
- logic probes; and
- logic pulsers.

This equipment is in addition to the standard laboratory equipment used in first-year basic electronics courses.

Since many of the monitor and control systems are designed for particular applications, it is not likely that this type of work would be endangered by a computer or machine. The increase in microprocessor- and computer-controlled equipment has resulted in an expanding need for new microelectronic and control systems. That, in turn, will assure that there will be a need for trade and industrial personnel in this field of electronics.

COMPUTER-BASED MONITORS AND CONTROLS AND INDUSTRIAL WORKERS

by
Donald E. Hegland, Associate Editor
Production Engineering Magazine
Cleveland, Ohio

For the purposes of this report, computer-based design and manufacture is abbreviated CAD/CAM and is defined as follows:

> "Computer-based systems which facilitate design or physical manufacture mainly of industrial parts and part assemblies. Includes computer-aided design (CAD), computer-assisted manufacture (CAM), and computer-integrated manufacture."

The large-scale implementation of computers and computer systems in the manufacturing community is often described as another industrial revolution. Whether or not this is true, CAD/CAM is an extremely pervasive technology. It has had a greater effect on the nature of industrial production work, and on the manner in which such work is performed, than has any previous technological development since electricity. And this situation will prevail well beyond the turn of the century.

Not only does the computer change the way work is performed, but more significantly it changes the very work itself. The advent of computer-based systems is altering many jobs in very fundamental ways. It is altering some jobs so drastically that it would not be an overstatement to say that certain jobs will disappear and be replaced with new and different jobs. Entirely new job classifications have been and are being created. Hence, any vocational education institution must address itself to, and be prepared to accommodate, major changes at the most basic and fundamental levels in the way it prepares its students for gainful employment in the industrial world--the manufacturing community of tomorrow.

The trade/industrial occupations considered in this report include:

- Industrial production line workers and shop management personnel.
- Maintenance personnel.
- Skilled trades such as tool and die makers and welders.
- Drafters.

INDUSTRIAL PRODUCTION LINE WORKERS AND SHOP MANAGEMENT PERSONNEL

Machine operators and first-line supervisors will increasingly be using manufacturing equipment which is controlled by, or communicates with, some form of computer-based manufacturing control system. The most common example on the factory floor today is the computer numerically controlled (CNC) machine tool. Many of these are stand-alone machines. But more and more, the trend is toward linking groups of CNC machines and connecting them to a host computer. In this manner, part programs can be fed down from the host, and shop-floor data about machine performance can be fed back up to the factory management software system in the host computer.

There is also a growing trend toward CNC systems with Manual Data Input (MDI). In these systems, the operator runs the machine manually, referrig to a blueprint as usual. As the part is being made, the control system is memorizing the process, and recording it as a part program. The program, which is typically recorded on cassette tape, can be removed for storage in a safe place and then when the same parts are needed again, all the operator has to do is set up the appropriate fixtures on the machine, load tools and raw materials, insert the tape cassette, and command the machine to run. The program can also be edited (if, for example, the part design has been changed) and the new version recorded right over the old.

Modern CNC machine tools also have extensive diagnostic programs built into the control system. Some even have capabilities for direct telephone link hookup with mainframe computer systems at the control builder's plant to perform both routine and breakdown maintenance checks. These diagnostic programs enable the operator, and also maintenance personnel, to keep the machine performing at maximum capability and to restore it to service quickly in the event of a breakdown. Most modern CNC systems use cathode ray tube (CRT) screens for communication between the machine control and the operator.

In modern factories, personnel engaged in activities such as order picking, kitting of parts, painting, and even packaging are also interacting more frequently with computer-based systems. For example, order picking, parts kitting, and packaging may be done by following computer printouts or real-time instructions displayed on the CRT screen of a shop-floor computer terminal. In the latter case, personnel are typically required to verify parts withdrawn, packed, and remaining in stock for inventory control purposes.

Painting is an occupational area which is increasingly being affected by robots. While the details of robotics technology lie outside the purview of this report, the need for qualified painters to program painting robots deserves mention. This need will continue to increase in the foreseeable future.

MAINTENANCE PERSONNEL

This occupation becomes more critical to the successful operation of a manufacturing enterprise in direct proportion to the sophistication of the technology employed therein. In particular, the role of preventive maintenance is growing with the realization that periodic maintenance can significantly reduce unplanned--and prohibitively costly--downtime.

Maintenance personnel will increasingly be required to use computer-based diagnostic systems to investigate both production machine and computer-based system malfunctions. There are numerous variations in the way these procedures are performed, but most involve interaction between humans and computers via the ubiquitous terminal and its CRT display. Typically, the instructions and perhaps questions are displayed on the screen, and the person doing the work responds via the terminal keyboard.

Maintenance personnel, and also machine operators and first-line supervisors, will need to have an understanding of the concepts of integrated manufacturing systems, as opposed to isolated pieces of equipment. It will become much more important--both in operating and in maintaining computer-based equipment--to understand not only how the individual elements of the particular manufacturing system function, but also how the individual elements communicate with, and affect the operation of, other elements of the system. An apparent maintenance problem in one area may, in fact, actually be a symptom which occurs in response to a real malfunction in an entirely different area.

SKILLED TRADES

This group includes a number of occupations that might in time be affected by computer-based systems. Two trades which have been and will continue to be affected are tool and die making and welding. Tool and die makers will increasingly be using interactive computer graphics systems, that is, CAD systems, to design tools, dies, fixtures, and molds. They will then use the same CAD systems to create numerical control part programs for the machines on which these tools, dies, fixtures, and molds will be made.

Many welding operations in manufacturing are already being performed by computer-controlled robots. Robot applications are discussed in detail in another report. However, the application of the robot to welding tasks is a significant application of the computer in manufacturing, and it is the computer control of the robot which is germane to this discussion.

The crucial point to be made is that it is not sufficient for the person involved with welding robots to have only knowledge about programming a robot, or welding skills. Both are necessary. Hence, there is a growing need for people who can bring a combination of welding skills and robot programming knowledge to bear in this particular area of manufacturing. The welding tasks involved range from welding large parts such as automobile frame and body members to welding the very small parts typically found in electronics and biomedical instrumentation equipment manufacturing.

Welding robots are usually programmed by leading either the robot itself or an auxiliary training arm through the desired sequence of motions, with the welding parameters inserted in the program sequence at the appropriate points. Off-line programming is less common but increasing, mainly because it does not remove the robot from service. Off-line programming is accomplished with an interactive computer graphics system terminal. The most sophisticated systems allow for animation of the robot motions on the terminal CRT screen.

DRAFTERS

Automated drafting is often equated with computer-aided design (CAD), but in fact it is only a part of a complete CAD/CAM system. Automated drafting produces engineering drawings and other hard copy documents. In fully integrated systems, drawings are produced by plotting various views of the geometric model previously created by the designer and stored in computer memory. However, users not needing the capabilities of a fully integrated system can produce two-dimensional drawings with stand-alone computer-assisted drafting systems.

New drawings can be produced on these less expensive units in much the same manner as models are created with a full computer interactive graphics system. Points and lines are specified with a set of cross-hairs positioned on the CRT screen either by a stylus, joystick, electronic pad, or other technique. The drafting process is speeded, and much mundane work is eliminated, by function menus which construct basic drawing elements from minimal user input. The system also stores frequently used symbols which the drafters can retrieve and position as needed on the drawing.

Most automated drafting systems also have a large digitizing table that resembles a conventional drafting board. Rough sketches can be placed on this table and traced with a cursor maneuvered by hand. As the cursor is placed over points on the drawing, the computer can be instructed to memorize these points. Selected points can then be connected with straight lines or curves, and cleanup routines smooth out curves and do other housekeeping chores.

Some automated drafting systems also automate much of the dimensioning required for drawings. Through menu commands, the drafter can have the system compute and display linear distances between points, radii of arcs, and other dimensions. When the drafter is satisfied with the accuracy and thoroughness of a drawing, a simple command directs the data to a plotter to produce a finished drawing on paper or velum. The data are also stored in computer memory just as hard copy drawings are stored in files.

Many of the tasks involved in the CAD/CAM applications discussed in this report are performed via interactive computer graphics systems and computer terminals with CRT displays, as are many other industrial production tasks. Workers entering these jobs will find it advantageous to have had exposure to some kind of interactive computing. Of course, the closer this computing is to industrial operations (actual or simulated), the better. It seems clear that teaching institutions should have this type of equipment available for hands-on demonstrations and practice.

If skills more task-specific than computer communication are to be taught, it would be highly desirable to have as many items of computer-based production equipment as possible available for training and hands-on practice. For example, such equipment could include CNC machine tools, automated drafting systems, and robots capable of both painting and welding.

The CAD/CAM industry has grown at an annual rate of over 50 per cent for several years, and experts agree that this growth rate will continue for at least the next three to five years. New and expanded applications for computer-based systems are being investigated and developed at an ever-increasing rate, and in new areas every day.

Computer systems will take over, or will enable other systems of automation to take over, many tasks that humans would prefer to avoid. Consequently, humans will increasingly assume roles as managers of equipment and systems. Recognizing this trend, computer-based system vendors are increasingly designing their systems to be "user friendly," meaning that the systems do not intimidate humans who are attempting for the first time to master the control and effective CAD/CAM and trade/industrial occupations operation of a computer-based system.

Even though relatively easy-to-use systems are being developed, one must keep in mind the basic fact that however sophisticated the hardware and software, computer-based systems are only tools. Users must know what they want to do and the best ways to do it. The computer multiplies the power of the human mind, just as the machine tool multiplies the power of human muscles. And just as even the most sophisticated manufacturing machines, so also do computer-based systems put out the best work when under the command of well-trained and highly motivated human operators.

ROBOTICS IN TRADE AND INDUSTRIAL TRAINING

by
William R. Tanner, President
Productivity Systems, Inc.
Farmington, MI

Industrial robots have existed for more than twenty years; however, their use in manufacturing operations has only become common since the late 1970's. The industrial robot is a pneumo-mechanical, hydro-mechanical or electro-mechanical device with an electronic sequencer or logic control. Robots do not involve any unique technology; they are combinations of fluid power or electrical actuators, mechanical power transmitting elements, electro-mechanical control devices, analogue or digital feedback devices, and electro-mechanical or electronic control systems. Robots are unique, however, in that they combine many or all of these elements into a single unit. Thus, industrial workers or skilled tradespersons working with robots must be skilled in a number of different areas.

Work activities in robotics will include general maintenance and repair of robots and ancilliary equipment in manufacturing environments, production work in robot manufacturing operations and skilled trades activities in the installation of robots and related equipment into production facilities. In some industrial operations, the "teaching" or "programming" of the robots may also be included as an activity.

Knowledge areas required for maintenance, repair and programming will include fluid power systems, solid state electronics and electronic controls. Specific knowledge requirements will include: fluid power systems maintenance and repair; electrical and electronic circuit tracing, testing and repair; machinery and mechanisms maintenance and repair; and robot "teaching" techniques.

Skills required will include: handling of fluid power and fluid control devices; use of electrical and electronic test equipment, such as multimeters, voltmeters and oscilloscopes; installations and adjustment of electro-mechanical feedback devices such as encoders, resolvers, tachometers and potentiometers; adjustment of electronic drive and control components such as dc motors, servos and servo amplifiers; installation and adjustment of mechanical components such as harmonic-drive speed reducers, gear sets, couplings, etc.; and robot "teaching," using the manual teaching unit, CRT and keyboard, etc.

In addition, other normal skills such as machinery repair, welding equipment repair, etc., will be used to maintain the ancilliary equipment with which the robots work. This includes: hydro-mechanical or pneumo-mechanical robot end-of-arm tooling ("grippers"); spot welders and arc welders and their controls; drills, screw drivers, grinders and other power tools; conveyors; vibratory bowl and other parts feeders and orienters; parts holding fixtures; and all other equipment associated with the robotic work place.

Production work in robot manufacturing will require knowledge of fluid power systems; solid state electronics; electro-mechanical devices; machinery and mechanisms. Skills required will include: handling of fluid power and fluid control devices; electronics assembly and soldering, including printed circuit board assembly; reading of electrical wiring diagrams; use of electronic test equipment such as ammeters, voltmeters and oscilloscopes; installation and adjustment of electro-mechanical feedback devices; and installation and adjustment of electrical and mechanical drive components.

Because robot production primarily involves assembly, adjustment and testing but not basic manufacturing, there will be little need for tool making and machinist skills. Some welding skills, including aluminum and stainless steel welding as well as mild steel structural welding, are utilized, however.

Skilled trades activities in the installation of robots and related equipment into production facilities do not require specific knowledge beyond the electrical interconnection/interfacing with other equipment in the work place.

There are two basic disciplines which need to be addressed in the trade and industrial education in the field of robotics. These are fluid power technology and electrical/electronic technology. The fluid power area includes: hydraulic and pneumatic fundamentals; fluid power pumps and compressors; and fluid power actuators and controls.

Laboratory equipment requirements for fluid power technology will include: pneumatic and hydraulic linear and rotary actuators, solenoid valves and servo valves; hydraulic power units (pump, motor, reservoir, heat exchanger, accumulator, valves and sensors); pneumatic and hydraulic "breadboard" test benches. Current robot service manuals and fluid power/control components will also be required. At least one current pneumatic-drive non-servo and one hydraulic-drive servo-controlled robot should also be available. Some elements of these robots would also be used for instruction in the electrical/electronic technology area.

The electrical/electronic area of instruction will include: basic electronic circuits; industrial electronics and microprocessors; electrical and electronic troubleshooting; electric drive systems; and electrical/electronic control systems. Laboratory equipment requirements for electrical/electronics technology will include: dc servo drive motors and controls; transducers and feedback devices; electromechanical control devices (relays, stepping switches, etc.); timers, counters, proximity switches, limit switches and photoelectric devices; electronic circuit "breadboards"; electrical power supplies; microprocessors and solid state motion controls; and testing equipment such as ammeters, voltmeters, multimeters, oscilloscopes, etc. Typical current robot electric drive components and service manuals will also be required. A current electric dc servo drive robot with microprocessor control should also be available. If not, the electric drive elements can be used, in conjunction with the control and mechanisms of the hydraulic drive robot mentioned previously.

The population of industrial robots in U.S. manufacturing plants at year end 1981 was about 5,000, with production in 1981 at about 1,500 units. This rate of production is expected to grow at the rate of about 35 percent per year throughout the 1980's. This installed robot base has created, as of 1981, about 1,000 new jobs in robotic maintenance and repair. Based upon the anticipated growth rate, the number of general maintenance and repair jobs is projected to be at least 3,500 by 1985 and more than 15,000 by 1990.

To support this growth rate, the number of robotic production workers is expected to grow to about 850 by 1985 and 3,500 by 1990. In addition, the suppliers to the robot industry of unique components such as servo valves, encoders and other feedback devices, printed circuits, etc., can be expected to add as many as 1,500 production workers to their rolls by 1985 and, perhaps, 6,000 by 1990.

MACHINING

by
Thomas J. Drozda
Division Manager/Editor
Society of Manufacturing Engineers
Dearborn, Michigan

In the machine shop over the next few years, new job skills requiring new training techniques, methods, and teaching equipment will be spurred by the increased use of Computer Numerical Control (CNC) and robotics technologies. The impact of these technologies on training requirements for workers involved with machining operations will be dramatically amplified as more and more metalworking plants invest in such new hardware in efforts to boost machine shop productivity.

The growing technology known as CNC is the computerization of numerical control technology. Numerical control, introduced circa 1960, is a method of machine control that revolutionized low and mid-volume precision parts manufacturing. Reduced to its essential, numerical control of machine tools is a method of control whereby cutting tool paths and other machine motions are automatically controlled through the input of a specially-coded, one-inch-wide paper (or mylar) tape. Preprogrammed machine motions and functions are specified on the tape as a series of punched holes which are interpreted by a tape reader at the machine tool. So called "NC programmers" use special tape preparation equipment to punch NC tapes for different workpieces. Machine tool operators load workpieces at the NC machine tool, load NC tapes, and monitor operation performance, keeping track of tool wear and changing tools as required.

The use of NC technology has yielded a multitude of benefits to machine shop operators. Major benefits include:

1. More efficient production of low and mid-volume workpieces;
2. Reduced changeover cost;
3. Greater workpiece consistency; and
4. Reduced chance for human error--programming of machine tool sequences and functions are dictated by an NC programmer--not the machine tool operator.

The computerization of numerical control has fostered even greater influences on machining operations. Today, nearly every new numerically controlled machine tool is equipped with CNC. Rapid advances in CNC technology will continue to reshape the roles of workers in machining operations in years ahead. Indeed, the change in CNC technology is so rapid that the state-of-the-art is measured in terms of months instead of years.

CNC is different than traditional numerical control in that CNC units feature onboard computing power such that intelligence at the machine tool is increased. A high-powered computer at the machine tool allows the machine tool to communicate with other computer. In addition, the presence of a high-powered computer at the machine tool allows sophisticated manipulation of data which simplifies input requirements for the individual who programs workpieces. In some cases, CNC units allow NC programs to be "down loaded" from a central computer (Direct Numerical Control--DNC) instead of being loaded at machine tools using paper tape as in traditional NC. Some CNC units feature so-called Manual Data Input(MDI)--NC programs for machining of specific workpieces can be entered directly at the machine tool by the machine tool operator using a keypad and special simplified NC programming languages. In this way, NC programs are developed by the machine tool operator using a workpiece blueprint for reference; consequently, high cost NC programmers are not required. These and other major features of NC are made possible by the marriage of computer and numerical control technlogies.

The growth of robotic usage in modern industry is well documented. The literature is replete with case studies showing how various forms of mechanical manipulators have been used to effect major productivity gains in such areas as machine tool loading and unloading, using robots to perform machining operations, and employing robots in machining-related operations. One of the fastest growing industries today, the robotics industry will have a profound effect on the nature of the work performed in the machine shop in the near future.

The technology known as robotics encompasses a rather wide variety of mechanical, electro-mechanical, and pneumatic devices designed to provide the means of accomplishing tasks in the machine shop. Such devices often take the form of a "mechanical arm" complete with a simple "hand" for grasping workpieces or tools. Some robots are designed to perform a single function; while other robots can be reprogrammed to perform various tasks as required. The physical size and load-carrying capacity of industrial robots also varies widely, ranging from small, relatively inexpensive table-top robots to huge robots that can pick up machining spindles and perform complex machining operations on large workpieces.

WORK ACTIVITIES

The growing use of CNC in modern machine shops will have a dramatic impact on the nature of a variety of job functions. Machine tool operators will be affected to the greatest extent; support functions will also be affected, including tool setup personnel and production control workers.

The placement of robots in the machine shop will also influence certain work activities. By far the greatest use of robots will be in machine loading and unloading; machine operators will be affected. Often, the machine loading/unloading function is only part of the machine operator's assigned task. In most cases, the machine operator is also responsible for monitoring machine performance and changing tools as well as checking workpiece quality. These activities may or may not be affected by the increased use of robots, depending on the degree of automation offered by new robotics technology.

KNOWLEDGE AND SKILL REQUIREMENTS

The placement of new CNC technology greatly influences the level of skill required to perform the machine operator's function. As the intelligence of CNC units at the machine tool increases, the machine tool operators will increasingly be called upon to communicate with sophisticated electronic hardware. This communication will take the form of an interface via data entry using a keypad at the machine tool control unit. This basic form of communication is even today somewhat common to experienced NC operators.

In the future, however, machine tool operators will have increasing communications responsibility, especially with the proliferation of MDI control units. Ironically, the role of the machine tool operator has come nearly full circle in recent years. Originally, one of the greatest benefits espoused by the proponents of traditional tape-oriented NC technology, was that the operator's influence on process sequence and workpiece quality could be effectively reduced through the use of NC technology. The NC programmer held the reins--the NC programmer determined process sequence, tooling considerations, and transformed his ideas to NC tapes; the machine tool operator merely was responsible for loading the appropriate NC tape and workpiece and monitoring tools and workpiece quality.

But today, with the introduction of MDI types of CNC units, the operator is once again called upon to take a more active role in establishing machining sequences and process details. The difference, of course, today is that much of the decision-making is automated through the use of sophisticated computers on-board within the CNC units. As mentioned earlier, MDI techniques allow the machine tool operator to input workpiece data from the blueprint directly at the machine control unit; stored algorithms in the CNC units transform data into appropriate machine sequences for machining the workpiece. The idea behind the MDI techniques is that NC programmers, as such, are not required for the programming of many simple workpieces; such functions may be more economically performed by a trained machine tool operator using MDI techniques. The simple languages employed MDI techniques are made possible and the concept is made viable by the increased intelligence provided by sophisticated computers.

With respect to the skill requirements of the machine tool operator, the use of MDI techniques in sophisticated CNC units call for a basic knowledge of computer communications--knowledge of keyboard data entry techniques and additional knowledge of computer hardware including the use of peripherals. More and more, machine tool operators will need to be familiar with alternate types of data medias such as magnetic tape and disk. These skills will become increasingly important as CNC machine tools are combined into DNC networks in the future.

The level of skill required by machine tool operators using MDI techniques may vary significantly depending on the CNC unit being used. Some units may only require a basic knowledge of shop math and blueprint reading while others may require a somewhat sophisticated knowledge of trigonometry and analytical geometry.

The skills of tool set-up personnel and production control workers will also be affected by new CNC technology. More and more, such personnel will be required to interface with computers to perform their functions. Basic computer operations training will be a must for these personnel in the future.

Robotics poses a special problem for machine operators and others responsible for the operation of robots. Skill required for robotics operation is mostly skills involved with the reprogramming of the robots. Often, the initial programming of a robot to perform a specific task is handled by an in-house manufacturing engineer or a service engineer from the supplier company. However, "touch-up" programming is required on a daily basis--studies have shown that such "touch-up" programming is most successfully handled by machine operators and other floor shop personnel who are in daily contact with the robot.

The skills required for such programming by shop floor personnel can vary as widely as do the programming languages used in the many kinds of robots available today. Fortunately, more and more robot suppliers are simplifying programming techniques such that shop floor personnel can reprogram a robot without great difficulty or special skills.

SPECIAL INSTRUCTIONAL EQUIPMENT

Training the work force to become familiar with CNC technology is not an easy task in that technology changes very rapidly. With every new equipment introduction comes new features; new, more powerful capabilities of the control unit; and more details that must be considered by the machine tool operator. Obviously, the best way to teach CNC equipment operation is through hands-on experience with a CNC machining center or like machine tool. In general, it is futile to try to acquire equipment that is purely state of the art for teaching purposes, as such equipment is very expensive and difficult to obtain through normal channels. However, the concept of teaching CNC technology to machine operators is one that can be accomplished relatively efficiently through the acquisition of a control unit itself. When compared to the cost of an expensive machine tool, the relative cost of the control unit alone is somewhat reasonable. Often, machine tool operators can be taught to operate and interface effectively with CNC technology by training on a control unit alone. Special teaching control systems can be set up for much less the cost of a full operational machining system.

In robotics, the need for special equipment is somewhat similar in that the best way to teach robotics programming is to acquire robots for hands-on experience. A general distinction can be made between two types of robots for training purposes. A simple point-to-point robot is relatively inexpensive and the easiest to program in most cases. More powerful and more complex full contouring type robots or continuous path robots are sometimes more difficult to program but should be included in any teaching program as more and more of these sophisticated units are being placed in industry.

The problems of acquiring equipment for teaching purposes poses a difficult task. However, recently, many professional societies have started offering services to educational institutions and machine tool users to help in locating such equipment. For example, the Society of Manufacturing Engineers (SME) is now surveying users and builders of machine tools and building a surplus equipment list. The list specifies surplus equipment that will be available at little or no cost to academic institutions for training purposes. The use of such services in the future may play a key role in helping to match the needs for equipment in the academic world to surplus equipment in industry.

GROWTH AND TRENDS

The growth of CNC technology is characterized by an increasing sophistication in computer application. Machine controls of the future will certainly continue this trend and provide even greater capability in efforts to improve work quality and machining productivity. Also important is the trend toward integration of computerized machining facilities. Over time, more and more plants will provide communication links between central computer and CNC machining operations to provide a central focus and obtain economies of scale inprogramming, etc. Such integration of machining facilities further highlights the need for an affinity between the new shop worker and computer technology.

In robotics, the same scenario is true. Suppliers of robotics technology are working now to simplify programming techniques and improve accuracy and reliability of robots for future application. One of the largest growth industries in metalworking today, the robotics industry holds the promise of significant growth over the next decade with literally dozens of new robot companies being formed to fill special needs in the metalworking industry.

WELDING

by
Rosalie Brosilow, Editor
Welding Design and Fabrication Magazine
Cleveland, Ohio

The two major welding processes used on a large scale in industry are resistance welding and arc welding. Neither process will see significant innovation in the near term, but changes in applications will come through automation of the standard processes. Workers who upgrade their skills in mechanics and in electronics, allowing them to better operate and maintain the automated welding equipment, should do well in the labor force.

Of the two joining processes mentioned, resistance welding is the faster. It finds greatest use in high production operations, such as those in the automotive and appliance industry. In these industries, particularly automotive, welding is already highly automated; the trend continues. Resistance welding was formerly performed by hourly labor, and much of this force is permanently displaced, largely by attrition and by layoffs, since the industry is undergoing a permanent contraction.

The automotive plants and in other large manufacturing plants, the general plant maintenance force, consisting of workers skilled in electrical and mechanical repair, maintain the robots as they do other manufacturing equipment. They normally receive training from the robot supplier; training typically takes two weeks, and the worker's skill then improves on the job. Robot suppliers and users say that workers will move over the long term into manufacture and assembly of robots, but the fact is that total labor content will be reduced. Electronic technicians will be needed, however, for robot manufacture.

The second welding process, arc welding, is a skilled occupation, performed mostly manually now. Automation of arc welding processes is increasing, particularly in high-production plants manufacturing non-critical parts. Management generally takes skilled welders and trains them to run the automated equipment. Engineering does the programming. Here, the welders who run the automated equipment would profit from additional training in electrical and mechanical repair and maintenance and programming.

Robots will take over a growing share of non-critical manual arc welding beginning in 1984. They will replace welders, tackers, and fitup people. In the short term, the displaced workers will move to other jobs for the same employer. Unskilled labor will load and unload parts from the machines and clean them up. Welders who train in electrical and mechnical basics will be valuable.

In thermal cutting, large firms move to automation, replacing hand work and even optical tracking pantographs which use low-level drafting, with numerical control. Generally, the labor that runs the cutting machines loads the NC programs into the controls; engineering prepares the tapes or computer programs. The more workers can learn about maintenance and programming of NC and CNC cutting equipment, the more valuable they will become.

In the United States, most pipeline welding is performed manually. Should automated welding be adopted here as it is in the rest of the world, welders would probably run the automatic machines. They will need the skills to maintain this equipment.

Many fields will not replace skilled arc welders in the foreseeable future. In field construction--bridges, office buildings, ships, towers, process plants--the shortage of welders is serious, and it will continue. Training efforts should concentrate on assuring a good supply of skilled field welders in structural and process plant welding.

OPTICAL DATA TRANSMISSION AND INDUSTRIAL WORKERS

by
Jeff Hecht, President
Futuretech
Auburndale, Massachusetts

Optical (or fiber-optic) data transmission involves the use of optical fibers (sometimes known as quided-wave optics or optical waveguides) to transmit signals in the form of light rather than as electrical currents. Virtually all types of information, including voice, data and video signals, can be encoded for optical transmission. Attractions of optical transmission include: larger information-handling capacity, longer distance transmission when operating at high capacity, small size and weight, ease of installation in existing facilities, freedom from sparks and explosion hazards, immunity to electromagnetic noise and lightning damage, and high security.

A variety of trade and industrial workers will be impacted directly by fiber optics, and will have to work directly with elements of fiber-optic communication systems. Among those affected will be telephone company craft workers, electricians and electrical installers who have traditionally installed communication cables, military personnel handling communications equipment, and factory workers engaged in producing communications quipment.

Trade and industrial workers will perform many tasks with fiber-optic equipment which are similar to those previously performed with electrical communication systems transmitting over metal wires. Generally, workers will need to be familiar with both conventional and optical transmission equipment. Specific activities will include:

- Installation of interior and exterior cables.
- Assembly and installation of systems in accordance with directions
- Splicing fibers and cables
- Connecting cables to terminal equipment
- Testing of components and systems
- Simple repair and replacement of components
- System manufacture in accordance with directions
- Preventative maintenance and cleaning

Many of the skills and knowledges required to work with fiber optics are similar to--although generally not identical with--those required to work with electrical systems. For example, similar or identical equipment is used to install optical and electronic cables. Necessary skills and knowledges include:

- Basic concepts of optical transmission
- Splicing optical fibers and cables
- Identification of optical transmission systems and components
- Identification of obvious faults
- Measurement procedures
- System assembly
- Safety procedures specific to optical transmission systems
- Differences between optical and electronic systems

Trade and industrial workers dealing with fiber-optic systems typically are drawn from the ranks of those who previously worked with similar electrical systems. Telephone companies have reported excellent success in retraining their craftpeople to install, test and work with fiber-optic communication systems.

The basic hardware required for teaching trade and industrial workers is a sampling of equipment that they will eventually use on the job. This would include:

- Optical fibers and cables
- Optical transmitters, receivers and connectors
- Fiber splicer
- Optical attenuation meter
- Optical time-domain reflectometer
- Microscope (for examination of small components)
- Infrared viewer sensitive in the near infrared (to make the light in the fibers visible to the human eye)
- Job-specific equipment (e.g cable installation equipment)

In addition, the training shop should be equipped with standard electrical and electronic test and measurement equipment, such as oscilloscopes. Some of the test equipment listed above is available in the form of plug-in units for oscilloscopes. People being trained for specific assembly or installation tasks should be trained with actual equipment or realistic simulations.

The applications of fiber-optic communications have grown rapidly, and this trend will continue for the next few years. So far, the most extensive penetrations of the technology have been in the telephone system, where optical fibers are used to connect switching offices. Because optical transmission does not present electrical hazards and is immune to electromagnetic interference, it is expected to find many applications in environments where electronic communications have been unavailable or unreliable; among the most promising applications are industrial process control and the electric power industry. Production of several fiber-optic systems for military field use is expected to begin within the next five years.

One of the most far-reaching possibilities is the use of optical transmission for control signals in automobiles (a development which would probably be paralleled by introduction of optical transmission within many kinds of industrial machinery). Use of optical transmission in automobiles, trucks and industrial machinery would impact many trade and industrial workers. Although General Motors was a pioneer in the field, it appears to have slowed down its development effort, and Japanese automakers now seem likely to be the first to introduce the technology commercially.

MICROCOMPUTERS AND MICROPROCESSORS

by
Ruth M. Davis, President
The Pymatuning Group
Washington, D.C.

Microcomputers or personal computers are small-sized (desktop; portable) general purpose computers with many of the logical capabilities of larger machines and supportive of various peripherals and high-level software, generally marketed and priced toward personal consumers and small businesses.

"Desktop" computers may be used just by themselves or they may be connected by phone or wire to other computers in what is called a computer network. In either instance, the personal computer usually consists of five basic units. These units are:

a. an input device like a typewriter keyboard to transmit instructions, programs or information to the computer;

b. a display device similar in appearance to a television set on which the computer prints out text, graphs and pictures; a home television set can be connected to the computer to serve this function;

c. the central processing unit (CPU) which contains the logic and computational chips; this unit is often contained in the same cabinet as the keyboard;

d. the memory unit which controls the disks or cassettes which contain programs and data inserted into the computer; and

e. the printer.

The advent of desktop computers would not have been possible were it not for the profound and exciting developments in microelectronics. The little "chips" referred to above actually replace hundreds or thousands of wiring connections with large-scale (LSI) and very-large-scale (VLSI) integrated circuitry etched into a silicon-based substrate.

Strictly speaking, a microprocessor is such a chip that has been designed and created to perform CPU functions (arithmetical/logical operations). However, since microelectronics chips exist which perform memory storage and retrieval functions, which function as input/output ports, and which even incorporate I/O processing, memory, and logic processing functions altogether (becoming a true "computer-in-a-chip"), we can use the term "microprocessor" liberally in the present discussion to connote these advanced devices as well.

The importance of personal computers and microprocessors to the skilled trades lies in their endless applications to almost every occupation involving equipment control, inventory, and industrial production work of many kinds. Herein, we shall treat just the applications of (a) equipment maintenance and (b) discrete parts manufacturing (e.g., both heavy and light industrial production).

Maintenance and Repair

The maintenance and repair of appliances, machines and instruments is becoming more difficult as their number and variety increases. This is particularly true of electronic appliances such as TV sets, microwave ovens, video games and the like. It is no longer possible to remember the diversity of repair instructions and replacement parts.

The "repair man" is now frequently expected to know how to use a computer terminal or personal computer to call up instructions and replacement part numbers. This necessitates his understanding how to "load" the necessary program and data into the computer and then to use the computer keyboard to call up the information about the specific device he is servicing.

Usually, a short vocational course is all that is required. The course should acquaint the worker with computer terminology and the discipline of precisely following instructions for operating the keyboard. This general "computer literacy" will allow workers to interact with computer-based information systems.

Additionally, repair persons should be able to troubleshoot microelectronic-based systems and to remove and replace the correct microprocessor unit components or circuit boards.

Discrete Parts Manufacturing

The worker engaged in discrete parts manufacturing in most modern production companies now needs to operate numerically-controlled (NC) tools. These tools, commonly used, for example, in metal-forming, parts fabrication or lathe operations, make use of microprocessors programmed to control the tool in any one of a number of tasks. In this instance, the worker usually needs to have completed vocational or occupational training in NC tools or CNC tool operation. Herein, CNC means "computer-numerical control." As another example of the impact of microprocessors on industrial trades, there is now available a programmable fixed articulated robot-arm which can be operated by a personal computer. This is a real breakthrough for it allows small companies to buy inexpensive microprocessors and simple industrial robots. They can then compete competitively with larger companies in customized discrete parts manufacturing through reduced labor costs, improved quality control, and more rapid response to customer requests.

Because of the various different forms and models of NC/CNC robot-arm, and other microprocessor/microcomputer-based manufacturing tools, on-the-job training will still be needed to supplement vocational training, which will probably have to stay at a somewhat general level. Still, vocational training institutions can introduce workers to these systems by exposing them to one or two exemplary systems. Microcomputers are available at many education institutions. A robot arm capable of performing various manipulations and controlled by microcomputer linkage could be acquired at modest expense. But most importantly, the vocational training institution can expose the student, if not to the real job skills, to the concepts and general methods of modern computer-based industrial production. Moreover, by allowing students to work with microcomputers in any way (such as to prepare school assignments) vocational education will help prepare them for an increasingly "computer literate" world of work.

Technology Trends

Personal computer technology is perhaps our most rapidly changing technology. The changes or trends can be categorized by decreasing size, increased memory, increased diversity of displays, increased availability of different program application packages, decreasing costs and improved remote capabilities.

Present day personal computers take about a desk-top worth of space and although portable are awkward to move. Some new personal computers now entering the market will fit in a briefcase. The displays are electroluminescent flat panels which fit on the "side" of the briefcase. This truly miniaturized computer (without the printer) will allow its user to carry the computer home, to school or to work. The user can plug in his/her computer and use it at remote work sites to enhance occupational capabilities tremendously.

Another extremely important and fast-improving aspect of personal computers is their ability to perform complex tasks with remotely-coupled devices or instruments. The technical basis for this emerging use is the connection by acoustic coupler of the computer to an ordinary phone set, as well as the direct connection via dedicated phone or wire to instruments or machines. Networking of computers to other computers or devices which are remotely located is becoming very commonplace. Satellite communications allow such networking to be worldwide.

Another trend is the innovation in computer graphics which to-date have not received much attention from personal computer developers. The new graphics capability will allow diagnostic schematics to be transmitted to and from remote sites, benefitting the repair man operating away from home, and the scientist or engineer controlling experiments, instruments and machines away from laboratory or factory.

Microelectronic technology applied to microprocessors is also growing and changing, and new microprocessor-based instruments and systems appear each day in products ranging from industrial robots to microwave ovens to video games, as well as desktop computers. It is even possible for the sophisticated technician actually to program certain kinds of memory chips directly, to create or change the operations of the larger system.

CHAPTER III

BIBLIOGRAPHY

The following annotated bibliography includes citations descriptive of new or emerging technologies, their diffusion, or insights as to their vocational impacts. The bibliography is the product of considerable resource effort and is judged to be a useful beginning source for those interested in increasing their awareness and understanding of relevant technologies and their practical implications.

Allen, K. Windpower returns to the farm. The Furrow, March 1979, 84 (3), 3-5.

This article discusses new ways to harness wind power, new types of windmill configurations, and ways to use wind power on the farm. Descriptions are given of: air-lift water pump; vertical windmill (lift on blades like aircraft wing) may be more cost-effective than conventional windmill; turbine linked to farmers electric utility line; multi-bladed wheel windmill. Uses of wind power: on dairy farms--auxiliary electrical power used to heat water and chill water, Cornell experiment--agitates water in an airtight container--increases water tem perature; for pumping water for irrigation.

Future: Wind energy probably will never provide a major part of the total U.S. energy requirement. However, it almost surely will become a significant source of energy for smaller utilities, rural homes and agricultural areas.

Arney, T.O. Goals, components, constraints--control systems. Instrumentation in the Mining and Metallurgy Industries, 1980, 7, 135-149.
Describes components and concepts in industrial process control systems architecture. CRT-based operator interface consoles are described. Trends noted include the increase of database management functions within the process control system.

Bell System's No. 5 ESS. Telephony, 1981, 201 (14), 20-26.

This collection of four brief articles describes electronic switching systems (ESS) already in place, and notes ESS as a major breakthrough in modern communications, as they can replace outmoded electromechanical systems. Operator interfaces with the control system are treated. Hardware and system architecture are also covered.

Binstock, M.H. Using advanced control to improve power plant performance. InTech, 1980, 27 (1), 45-48.

Describes the use of advanced control technology in the integration of functions and hence performance improvement in power plants. Valve programming, bypass systems, and pressure controls are among the functions in a sophisticated integrated system.

Brosilow, R. and Weymueller, C.R. Robot welding starts to catch on. Welding Design and Fabrication, November 1980, pp. 184-204.

The time has come for robotic welding. Owing to advances in microprocessors and integrated circuitry during the last few years, computer controls for robot welding equipment have be come readily available at reasonable prices. Along with these drops in costs, hourly rates for welders keep rising making robot welding even more attractive.

Brosilow, R. Automation--Robots...Are robots the answer? Welding Design and Fabrication, October 1981, 54 (10), 92-95.

Economists and social scientists call robots the immediate hope for the economic survival of this country. These machines, they say, are the tireless workers who will lift sagging U.S. productivity, put this country back in the running against foreign competition, and make it once more the light of world industry.

Top executives in industry use the number of robots as a rough gage of the state of sophistication of a plant. The robot represents technological advancement. Japan, by this scale, with its robot population 12,000, outdoes the United States' robot population, 3,000. These automated marvels are indeed doing wonders. They run entire die casting shops almost independent of human intervention; they assemble small and mid-sized engines and motors; they spot weld automobile bodies on the fly.

Bylinsky, G. A new industrial revolution is on the way. Fortune, October 5, 1981, 104 (7), 106-114.

With big computers or small, CAD/CAM is moving along. In the words of Joseph F. Engelberger, president of Unimation, Inc., the leading maker of industrial robots, "the word is out" that CAD/CAM is the wave of the future in manufacturing. CAD/CAM vendors and technicians repeat the refrain that "CAD/CAM has more potential to increase productivity than any other development since electricity."

Chemicals and petrochemicals: Advanced is today. InTech, 1980, 27 (2), 9-31.

Several illustrative examples are given of the use of microprocessors and larger computers for process control in chemical/petrochemical industries. On-stream analysis is mentioned as one particular developing technology.

Computers in manufacturing--180 places you can turn for help. Production, December 1980, 86 (6), 48-81.

COMPUTERS: In U.S. Manufacturing plants today there is an installed base of computers minicomputers and terminals valued at more than $20 billon. NC/CNC: By 1990, it is predicted that 75 percent of the machine tools working in U.S. plants will be under CNC or direct numerical control. DNC: The overwhelming acceptance of CNC has triggered renewed interest in direct numerical control. PROGRAMMABLE CONTROLLERS: In 1981, U.S. demand for PCs will exceed $200 million. CAD/CAM: Today's $400 million CAD/CAM market will grow to from $1.5 to $1.8 billion by 1984. GRAPHICS: Opening the door to computer-aided manufacturing are interactive graphic systems tying computer-aided design to CAM. SOFTWARE: Software to support CNC, DNC and CAD/CAM systems is the big ticket item in computers in manufacturing. It accounts for 85 percent of expenditures.

Cornish, B.M. The smart machines of tomorrow--Implications for society. The Futurist, August 1981, pp. 5-13.

The impact of the microprocessor on society may be as great as that of the automobile or electric light--or greater. The applications of the new technology are seemingly limited only by imagination--not by cost or capability.

Dobson, P.J., and Olejar, J. Centel leaps into the future with fiber optic trunking. Telephone Engineer and Management, 1980, 84 (17), 60-62.

Of interest in this business article is a description of new splicing techniques for fiber optic cable, to be used by field service technicians.

Draper, C.W. Laser surface alloying: A bibliography. Applied Optics, 1981, 20, 3093-3095.

The use of lasers has been growing dramatically in surface alloying processes, which are used when an element is incorporated into a bulk alloy solely to affect the material's response to its immediate environment. References are provided to the technical literature.

Early look finds robots shifting 444,000 workers in the 1980's. American Metal Market, October 12, 1981, p. 12.

Research findings are overviewed concerning the spread of robotics in industry and resulting effects on employment within current job classes.

Edson, L. Slaves of industry. Across the Board: The Conference Board Magazine, July/August 1981, XVIII (7), 5-11.

Some 3,200 robots have already joined the assembly lines of U.S. manufacturing plants -- spotwelding, spray-painting, transferring glass from one part of assembly line to another. They mine coal, spray crops and remove rivets from damaged aircraft. In Australia, they shear sheep. "By the end of the decade we expect to count some 20,000 robots in American industry doing many different things," says Lori Mei, spokeswoman for the Robot Institute of America, the Detroit-based trade association of robot users and manufacturers. "And," she adds, "we anticipate a $2 billion-a-year business, up 3,000 percent from today."

Fleming, A. 1980s--Car of the next decade faces a different world. Ward's Auto World, January 1980, pp. 33-40.

In the 1980s, we will see electronic and computerized gadgetry like never before; exotic construction and materials; small, efficient vehicles; and new ways of producing them. There will be increased use of electronic controls, 2/3 will be compact or smaller in 1989 and 75% will be front-wheel drive. A principal change will be substitution of plastics and aluminum where possible for conventional steel and iron. High-strength, low-alloy steel (HSLA) steel will also be more widely used. On-board diagnostic aids, electronic entertainment and drive information systems and other computer-based features are planned.

Fraade, D.J. Applying computers in multipurpose batch processing plants. InTech, 1980, 27 (12), 34-39.

Treats computer applications in multipurpose batch processing applications. Sensors, controllers, and other areas of development, as well as centralized vs. distributed systems, are discussed. Personnel training, including required skills, is also covered.

Fraade, D.J. Some user aspects of computer control of batch reactors. Instrumentation in the Chemical and Petrolum Industries, 1980, 16, 75-94.

In addition to describing the architecture and application of digitally controlled batch chemical process systems, a training program is described which includes familiarization with computer interaction. The demands on workers' skills are noted.

Froehlich, L. Robots to the rescue? Datamation, January 1981, 85-96.

Discussion of types of robots and what they can do; productivity factors; progress in robot ability; growth of the Industry; and effects on the work force.

Gibson, G.T. Lasers give job shops a high-tech future. Venture, January 1982, pp. 60-61.

The laser job shop is dramatic proof that an old-fashioned industry can receive new life by adding new technology. The laser is emerging as the centerpiece of new laser job shops all around the country. They are used to heat-treat, inscribe serial numbers, cut and weld. Unlike traditional machine tools, lasers never dull and can perform in seconds tasks that can take hours for old- fashioned machines. (author)

Heating up productivity with handling systems. Production Engineering, September 1981, pp. 66-69.

The typical up-to-date plant producing discrete parts contains a number of islands of mechanization and automation embedded in a sea of older techniques. Advances in three areas are paving the way toward problem solutions. One area involves simulation and CAD/CAM; another area is based on advances in microprocessor technology; and the third, an emphasis on flexibility involving robots.

Hegland, D.E. CAD/CAM integration--Key to the automatic factory. Production Engineering, August 1981, pp. 31-35.

CAD systems include automated drafting, geometric modeling, engineering analysis, and kinematics, with all the functions interfaced in many cases. CAM systems include numerical control, robotics, process planning, and factory management, but typically as stand alone systems. Integrating the two disciplines via a common data base is probably the major task facing CAD/CAM vendors and users in the near future. Thus far, the only CAM function that has been linked with CAD is NC tape generation; the other CAM functions still stand alone, for the most part.

Hegland, D.E. Heating up productivity with nontraditional processing. Production Engineering, September 1981, 28 (9), 50-53.

Lasers, ultrasound spark erosion and high speed jets of abrasives or tap water each can solve specific problems in manufacturing. The laser is probably the most versatile of all the

nontraditional machining tools. It cuts and drills virtually any material--hard or soft, brittle or ductile, insulator or conductor. Electrical discharge machining removes material from the workpiece with continuous spark discharges between the workpiece and a shaped tool. Ultrasonic machining erodes the workpiece by the action of an abrasive vibrating at ultrasonic frequency. Abrasive jet machining can be an ideal answer for micromachining of hard, brittle or heat sensitive materials. Water-jet machining removes material with a high velocity stream of water.

Heidary, H.R., Begley, D.L., and Coraor, L.D. Microprocessor-controlled laser scanning system for annealing of semiconductors. Optics and Laser Technology, 1981, 13, 265-269.

Describes a recently developed technique with applications to the manufacture of semiconductors, incorporating digital control and laser technology.

Huber, R.F. The world of productive ideas. Production, August 1980, pp. 96-183.

Machining Centers--more modularity in NC controls; trend toward lighter structures and higher spindle speeds. Turning--more slant bed design, integral NC; automatic loading. Milling--faster machining cycles for metal removal; new NC systems using microprocessors. Drilling and Boring--automatic tool-changing devices; machines are simpler, therefore easier to maintain; latest control systems. Grinding--Solid-state controls, such as programmable controllers and proprietary logic circuitry and CNC with microprocessors; remote machine diagnostics, plug-in replacements of electronic components. Forming--CNC, lower noise levels, higher powered lasers and plasma cutting features. Controls--computer technology (computer numerical control systems; direct numerical control systems and bubble memory); CAD and CAM with interactive computer graphics.

Irving, R.R. Fiber optics helps control critical welding operations. Chilton's Iron Age, October 14, 1981, 224 (29), 83.

Picture an extremely inaccessible welding location where a critical weld had to be made. The tolerances of the weld were exceptionally demanding, but its location was nearly beyond the reach of conventional welding equipment, and well beyond visual inspection range.

This complex welding problem was resolved with the fiber optic welding monitor from American Optical, Scientific Instrument Division, Southbridge, MA. Unaffected by the 250°F temperature and immune to electromagnetic interference, this equipment's flexible, small diameter fiber optics image cable transmitted a clear picture of the weld to an observe stationed outside the sphere, allowing him to make critical adjustments as the welding operation progressed.

Irwin, R.D. Get the most from computerized steel-collar workers. Production Engineering, August 1981, pp. 46-50.

Article condensed from a paper presented at the second annual Wood-Compton Forum, Cleveland, September 1980. Robots have a common mission--extend the efforts or capabilities of humans. Description given of types of robots -- (1) Pick and place; (2) Servo style. Discussion of costs and capabilities of each type. How many robots are now in use? Estimate given--depends on definitions. Information presented on robot safety.

Jones, R.B. Industrial application of programmable logic controller. Instrumentation in the Chemical and Petroleum Industries, 1979, 15, 83-89.

The operations of maintenance technicians are briefly mentioned in this overview of programmable controllers (PC) in chemical production plants.

Karl, L.J., and Jones, D.J. Microprocessors: DDC for large electric utility boilers. InTech, 1980, 27 (7), 47-49.

Describes the advantages of direct digital control for electric utility boilers, with special attention to distributed processing (central control of a number of separate microprocessor-controlled process loops).

Kehoe, T.J. A futuristic look at on-line analytical instrumentation techniques in the 1980's. Analysis Instrumentation, 1979, 17, 1-6.

Discusses history and developing trends of on-line analysis instrumentation. (On-line analyzers are used in continuous chemical production processes to determine the constituency of a fluid stream.) Includes qualitative projections.

Kulkosky, E. CAD/CAM: The new computer wonder. Financial World, July 1, 1979, pp. 12-15.

In its simplest form a CAD/CAM system consists of a minicomputer, a keyboard, a monitor screen, a tablet and light pen, and a computer program. The user can draw an outline of a simple part such as a gear on the screen; add depth automatically to produce a three dimensional version at any desired angle; generate front, side and top views; rotate the part; produce a mirror image; and otherwise manipulate the drawing in just about any way he wishes.

Kulwiec, R.A. Materials handling in the future. National Safety News, 1981, 124 (5), 34-27 (book review).

Computerized control systems in storing and retrieving operations are described. Robotics is mentioned.

Legana, T., Jr. Digital control system user interfaces; The same but different. InTech, 1981, 28 (11), 55-57.

Many options and choices are available for operator interfaces to digital control systems. Article overviews various display and control panel monitor, command, alarm, and recording systems which present different configurations to operators.

Microprocessor-based instrumentation: Better, more, and different. InTech, 1980, 27 (5), 9-24.

Discusses various measurement/control functions of instrumentation which are made possible or enhanced by microprocessors. Included are "intelligent" chromatographs, characterized pH controllers, safety warning systems, compressor control, combustion control, energy management, portable psychrometry, battery chargers, navigation and vehicle monitoring systems, automated test equipment. Gives technical references.

Nelson, R.L. New developments in closed-loop combustion control using flue gas analysis. Analysis Instrumentation, 1980, 18, 71-83.

Describes new developments in combustion control systems used in controlled industrial heating applications. In-line flue gas analysers as well as microprocessor technology have been significant steps forward.

New horizons in water management. American Vegetable Grower, April 1981, pp. 14-20, 44-45, 48.

The water crisis facing the U. S. may be more severe than the present energy crisis. Growers must conserve existing supplies through efficient cultural and irrigation practices. Irrigation accounts for 81 percent of all water consumed in the U.S. and 53 percent of irrigation water comes from groundwater supplies. Trickle (drip) irrigation shows a lot of promise as a conservation method, especially when combined with plastic mulches. Transplants are also being used to save when watering seedlings. Dead levelling of fields (with laser beam levellers) makes it possible to control water flow. Low Energy Precision Application (LEPA) modifies a center pivot system and reduces water usage.

Norman, C. Microelectronics at work: Productivity and Jobs in the World Economy. Washington, D.C.: Worldwatch Institute, 1980.

An overview survey of microelectronics growth in a macroeconomic context. Provides an introduction to micronic circuits and microprocessors, examples of office and factory automation advances, and functional areas where jobs will be created as well as where they may be decreased.

Patterson, W. P. Who will keep the computers running? Industry Week, November 2, 1981, pp. 46-51.

Topics discussed: Statement of the problem--proliferation of computers and dearth of skilled maintenance personnel. Costs skyrocketing; companies and agencies pushed by vendors to do some of their own maintenance. Quotes on salaries, service rates, etc. Advent of vendors' remote diagnostic centers and computers diagnosing one another. Computer companies haven't gone all-out to expand their training programs. Tech schools turn out qualified people for whom there is tremendous competition.

134 Pauly, D., Contreras, J. and Marback, W.D. How to do it better. Newsweek, September 8, 1980, p. 59.

The notion of the "quality circle" wherein small teams of labor and management people are put together in a nonhierarchical setting and asked to spot and solve problems on the production line was developed in the United States in the late 1940's, but has found widespread acceptance and success in Japan. It is another tool for promoting productivity.

140 Rain, C. Nontraditional methods advance machining industry. High Technology, November/December 1981, 1 (2), 55-61.

Industry now uses about 30 nontraditional machining processes and more than 15,000 nontraditional machine tools, a number estimated to double over the next decade. The simple fact behind these developments is that materials are getting stronger, making them more difficult to machine by conventional means. Components are getting as tough as the cutting tools used to machine them. Machinability is hardly an issue in nontraditional machining, because sheer mechanical force is not relied on to remove metal. The newer machining processes don't punish the metal. Many operations in microdrilling would be impractical if not impossible using conventional methods.

Ranieri, M. A. Microprocessor-based control systems. Heating/Piping/Air Conditioning, August 1980, 52(8), 39-42.

Microprocessor-based control systems provide supervisory control over traditional temperature control sysems and provide the user with information as to how his building is performing with regards to energy consumption. The microprocessor is a tool the designer has at his disposal to implement system control. Article details functionality of microprocessors in environmental control, energy management, and total building management. Microelectronics is becoming increasingly important in the HVAC field.

Spalding, I.J. High-power lasers--their industrial and fusion applications. Optics and Laser Technology, 1980, 12, 187-197.

Besides discussing applications in experimental physics, this article describes the application of laser technology for welding, glazing, drilling, alloying, cutting, and hardening, in various industries where these processes are used. Growth trends are noted for the industry. A technical overview of the high-power laser process for spot heating is given.

Stoecker, W. F. Computer applications to supermarkets. Heating/Piping/Air Conditioning, August 1980, 52(8), 55-57.

The major purposes of computer control systems for supermarkets are to conserve energy and to protect food products and equipment while providing comfortable conditions for shoppers. Air conditioning requirements of a supermarket are unique because concentrated refrigeration sometimes overcools certain areas of the store. Monitoring systems that report store temperature, equipment malfunctions, and that can act as timers to shut off energy using equipment when it is not needed can save energy while reducing maintenance costs.

Swanson, K. An advanced combustion control system using distributed microcomputer techniques. Analysis Instrumentation, 1981, 19, 111-116.

Points out the use of microprocessor controls in complex combustion control (furnace) systems.

Thome, R.J., Cline, M.W., and Grillo, J.A. Batch Process Automation. Instrumentation in the Chemical and Petroleum Industries, 1980, 16, 95-101.

Describes functioning systems used by Merck & Co. to control processes, tests, and energy usage, as well as other operations, in batch chemical production. Operator interface and programming considerations for digital batch process control systems are covered.

Thompson, R.A. Direct digital control of batch processes. Instrumentation in the Chemical and Petroleum Industries, 1980, 16, 53-70.

Direct digital control (DDC) systems are described, with reference to industrial batch processes in chemical production. Operator interface is treated with respect to alarm displays and to overview control of single- and multiple-batch operations.

Thornton, J. Robots--Is long-expected boom under way? American Metal Market, October 12, 1981, pp. 12, 14, 17.

A report on projections for robotics in automotive and other machine-tooling industry expressed at a conference on "Robots' Contribution to Productivity."

Triplett, R. D. Current developments in induction cooktops. In Current developments in home appliances (Proceedings of the National Technical Conference of College Educators in Home Economics). Chicago: Association of Home Appliance Manufacturers, 1980, pp. 6-11.

Describes the principles underlying magnetic induction cooking. Predicts growth in market penetration. Describes energy-saving and convenience advantages of induction-based ranges.

Welding for the '80s. Welding Design and Fabrication, November 1980, Special Issue.

This issue presents articles on welding as applied to the major areas of Power, Heavy Vehicles, Construction and Transportation. State-of-the-Art information and projections for the next five to ten years are given.

Will materials change shape of tomorrow's machine tool industry? Iron Age, June 22, 1981, pp. 87-104.

Technical change is changing the machine tool industry. Some of the trends were noted by the CEO of a leading machine tool company as (1) the application of advanced electronics and the integration of them more closely with our machinery products; (2) the development of software which is directly related to getting work done in a factory environment; (3) robotics, including sensors; and (4) R&D aimed at the conversion of many

Williams, V.A. Cutting tools spark productivity gains. Production, April 1980, 85 (4), 72-76.

Cutting tools are the critical link between raw materials and finished products. Most of the recent improvements in cutting

tools are in the area of carbide inserts. These include new and improved grades of carbide, coated carbides, different shape inserts, various types of chip breakers, choice of rake angles and a wide selection of mechanical methods for retaining the inserts. The carbide insert drill ranks among the most significant developments in the last decade in metalcutting.

Williams, V.A. Drilling speeds increased ten-fold. Production, January 1980, pp. 84-89.

Carbide insert drills represent one of the most significant technological advancements since the twist drill was invented. They drill holes up to ten times faster than conventional drills. In the majority of today's highly complex production manufacturing operations, the highest cost factors are direct labor and machine operating time. Reducing either of these factors can make a significant contribution to overall company profits. Changing to carbide insert drills represents one of the fastest approaches to cutting both direct labor and machine operating time and effectively boosting profits. (author)

Wolpert, T. You and your computer--Designed for productivity. Venture, January 1982, pp. 24-26.

A CAD system brings the same efficiency and speed to architectural and engineering design that traditional computer functions bring to tasks such as inventory control. Most computers used for standard business applications are only required to display combinations of numerals, letters and symbols on pre-determined lines on the computer's screen. A CAD system, on the other hand, can display infinite combinations of lines, arcs, vectors, and numbers and letters. As a result, CAD systems require larger memories and data storage capabilities than standard business systesm.

In addition to manufacturers, architects, furniture and other types of designers and a company which provides topographical maps to utilities, construction companies and municipalities are using CAD systems successfully.

REFERENCES

"America's Skilled Trades Shortage: A Positive Response." Prepared by the Public Affairs Committee of the Task Force on the Skilled Trades Shortage, Brecksville, Ohio, March 3, 1981.

Ayres, R. U. and Miller, S. "Robotics, CAM, and Industrial Productivity." National Productivity Review, 1,1, Winter 1981-82, p. 54.

Birch, D. L. Presentation to the Council of Upper Great Lakes Governors, delivered at the Symposium on Small Business, Green Bay, Wisconsin on March 5, 1982.

Deane, P. The First Industrial Revolution. Cambridge, England: Cambridge University Press, 1979, pp. 90-91.

Drewes, D. W. "Working for America--A Worker-Centered Approach to Productivity Improvement." Raleigh, NC: CONSERVA, Inc., September 1982.

John Paul II. "Laborem Exercens: On Human Work." The Third Encyclical of Pope John Paul II reprinted as a supplement in the North Carolina Catholic, September 27, 1981.

Riche, R. W. "Impact of Technological Change." Paper presented at OCED's Second Special Session on Information Technology, Productivity, Working Conditions and Employment, Paris, France, October 19-21, 1981.

Thurow, L. C. "The Productivity Problem." Technology Review, November/December 1980, p. 45.

U.S. Chamber of Commerce. Statement of the Chamber of Commerce of the United States on Productivity, presented to the Senate Committee on Labor and Human Relations by Dr. Ronald D. Utt on April 2, 1982.

U. S. Congress. 97th Congress, 1st Session. Joint Economic Committee. "Shortages in Skilled Labor." Hearing before the Subcommittee on Economic Goals and Intergovernmental Policy, November 3, 1981. Washington: GPO 1982.

U. S. Department of Labor. "Occupational Outlook Quarterly: Computers." Washington: DOL, Summer 1981.

U. S. Department of Labor. "Occupational Projections and Training Data." Washington: DOL, September 1980.

U. S. Senate. 97th Congress, First Session. "Industrial Growth and Productivity," Hearings before the Subcommittee on Industrial Growth and Productivity, December 3 and 5, 1980; January 26, 27, and 28, 1981. Washington: GPO, 1981.