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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 technical occupations are included in section 2. Section 3 contains nine essays describing these new and emerging technologies with implications for technical occupations: process control, microelectronic monitors and controls, computer-based design and manufacture, robotics, software, optical data transmission, automotive services, renewable energy technologies, 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)

TECHNOLOGIES OF THE '80s: THEIR IMPACT ON TECHNICAL OCCUPATIONS

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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.

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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.

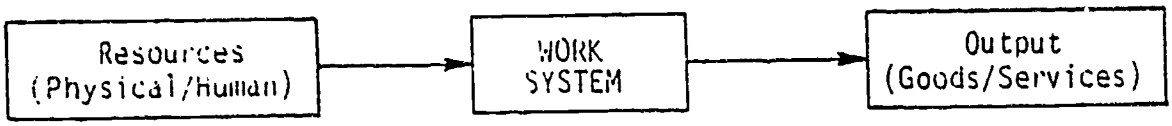

Figure 1. Input/Output Model

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:

Technology = Production function

= F(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 technological change. 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 technological 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. Many examples can be cited of such "revolutions" demanding new, skilled technicians in areas such as aviation or electronics, each with a myriad of innovative subdevelopments. 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 = $\frac{\text{Work System Output (goods/services)}}{\text{Total Resources Used (labor, capital, materials, energy)}}$

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

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

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

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

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 = $\frac{f(L,C,M,E)}{L+C+M+E}$

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

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

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

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

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, 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 different types of electronic vacuum tubes. 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 the transistor as a decided improvement over vacuum tube electronics in terms of power and maintenance costs, but bringing with it a change in the layout of electronic systems and the way these are assembled and serviced. 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. Large-scale and very-large-scale circuit integration, making the microprocessor possible, has proven and will continue to prove an incredible advancement over fully "wired" electronics component systems.

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 Technical 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 TECHNICAL OCCUPATIONS

Technologies selected for inclusion are those determined by application of the criteria to have programmatic implications for Technical 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.

The concept of Software is not new, but advanced computer technologies and increasingly sophisticated computer applications have caused software technology to develop and change accordingly. Software refers generally to the computer programs which direct the machine to perform specific tasks. New programming "languages" and techniques, and the development and use of new and important general or special-purpose computer programs, constitute the areas of interest in software technology. The term "software engineering" has come into use in recent years to describe systematic approaches to computer program development.

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.

Electronics has emerged full-blown as an essential, functional element in automotive design and manufacture, and will greatly alter the skills needed for provision of Automotive Services in the immediate future. Electronic technology now affects or controls automotive components including alternators, voltage regulators, ignition systems, gasoline fuel injection, etc. Automotive design, weight and the materials used in manufacture of parts are changing dramatically with transverse engines, front-wheel drives and the expanding use of plastics and composites.

Renewable Energy Technologies (RETs) are receiving renewed emphasis and application. Sources or methods for the production of usable energy such as solar, wind power and biomass conversion are being studied and implemented in agricultural, architectural and other settings as economic, conservation, and/or fuel-saving measures.

TECHNOLOGY ESSAYS

The following essays describe the new and emerging technologies identified as impacting Technical 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:

AL FLEMING, currently Industry Editor of Automotive News, has been writing about the automotive industry since 1955. Mr. Fleming's syndicated column "Detroit Update" appears nationally, while his radio broadcast "Auto Report" is heard daily on station WWJ in Detroit.

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PROCESS CONTROL AND TECHNICAL WORKERS

by
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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.

Although the concept cf distributed control is quite appealing, the implementation of it will be a very slow and tedious process. Several problems exist and it may take many years to resolve them. Even then, it is not likely that they will ever be completely resolved, and there will always be technical difficulties to overcome in practice. The major problem is that of standardization. There is an up-and-coming supply of digital controllers, digital output sensors, digital data acquisition systems, microcomputers, and minicomputers as manufacturers attempt to capture some part of a fiercely competitive market.

PRODUCTION ENGINEERING

Very few process plants in operation today have distributed control systems in operation. They have older, analog control systems with some bits and pieces of digital control technology. Production engineering will strive to replace these older controls with new, more efficient, digital controls and there will be a need for technicians who can bridge the gap. These technicians will need both to understand the existing technology and new technology. Engineers will be quite happy to tell management how wonderful computers are, but the real problems in implementation, especially in a retrofitting situation, do not become apparent until the equipment is in the field. It will take a special breed of technician to install, troubleshoot, and get running equipment in the field. It will take a good, solid background in both new and old aspects of process control technology along with experience in dealing with problems associated with retrofitting.

In all of the areas of technical training for process control technology, the key to success is "hands-on." No amount of reading and lectures can even begin to document the problems encountered when trying to program a computer or connect computers to each other and to peripherals. Lack of standardization takes on a whole new meaning when you have to make equipment communicate in spite of it. The successful technician will be the one who is comfortable in dealing with problems and takes them as a matter of course.

PROCESS CONTROL DESIGN SUPPORT

There is no standard for software techniques or communications links so each company is doing it their own way, with the major companies hoping that their way will become the standard. This makes the task of putting together a distributed control system a very difficult one. The controller you buy today may be obsolete tomorrow, and even if it is not, it most likely will not communicate with another controller without some sort of modifications.

All of this has led some process plants to contract out the entire distributed control system to another company. This company is then responsible for studying the entire process plant, determining what controllers and sensors should be used, how each process control loop should be handled, how many levels there should be in the distributed control hierarchy, and what micro's and mini's should be used. The company is also responsible for establishing the communications link throughout the system and providing the software which will make the whole thing run properly. This level of design engineering will require quite a bit of technical support in several areas. Different areas will require an emphasis on different aspects of computer technology, and it may be that the field of computer technician will start to contain areas of specialization, just as the field of electrical engineering now does. Some of the areas of specialization will be instrumentation technicians who handle process controllers and data acquisition systems, systems technicians who handle the hardware and software aspects of the computer hierarchy, and computer-aided design and computer-aided drafting system technicians who will keep these systems running for the design engineers.

Technicians in any of these areas will need to have a basic understanding of computer technology. They should know the difference between analog and digital signals, should know something about digital logic, and should know the basics of computer architecture and memory. They should have a basic understanding of A/D (analog-to-digital) conversion, D/A conversion, multiplexing, and serial and parallel data transfer. They should be familiar with computer peripherals such as CRT's, disk drives, printers, and plotters.

There are many microprocessor trainer courses on the market. These are single board computers with the microprocessor chip, a limited amount of memory, and usually an A/D and a D/A converter. They give a good basic understanding of computer architecture, signal conversion, data processing, and memory. In addition, they teach assembly level programming, which gives a good foundation upon which to build other programming courses.

After mastering the basic steps in microprocessors, some experience on a minicomputer with peripherals is advised. This should include a short course in programming and also emphasize the use of the peripherals. It should discuss how data is transferred from the computer to the peripheral and back. With this good, solid foundation, an area of specialization may be taken up. Different areas will require a more thorough understanding of some aspect of computer technology.

INSTRUMENTATION

Instrumentation technicians will have to handle microprocessor-based circuit boards in almost anything that they touch. In order to test, calibrate, and repair these instruments, a technician should know how they work. In the field of process control technology most of the instruments that the technician handles will be controllers, data acquisition systems, and sensors. To understand these instruments, there should be a good understanding of analog to digital and digital to analog conversion, signal multiplexing, memory chips, and sensor signals. Most controllers are now being made as flexible as possible, with programming done in the field to suit the user's needs. These controllers are programmed by the user in a special process control language. The instrumentation technician, then, will have to become more familiar with process terms and what they mean, so that he can program the controller. In order to prepare instrumentation technicians for this particular area, the vocational school should provide a course in process industries. The course should explain what the process industries are and what sorts of things are done in a process plant. It should explain process parameters such as temperature, pressure, flow, level, and chemical composition. Some discussion of three-mode control should be included. Some of the more popular three-mode controllers and/or data acquisition systems could be on hand to demonstrate how they work, how they are programmed, and how they would be connected into the larger control system.

DISTRIBUTED CONTROL SYSTEMS

Distributed control systems technicians will be less interested in the front end, or the data acquisition, and more interested in the interconnection of the various computers in the hierarchy. These technicians will need a more thorough understanding of communications and cabling between computers. They will be more concerned with the programming of each computer to perform its own task, and with the techniques to load these programs and test the interaction of the computers.

Special equipment to train distributed control system technicians might consist of a few microcomputers and a minicomputer linked together in a hierarchy to control a laboratory-scale process. A CRT with some form of graphical data presentation such as would be found in a process plant should be included. This "mini-process plant" could give hands-on experience with system hierarchy and present a good idea of the real world problems in implementing such a system. Typical problems such as noise, errors in transmission, and failure of one component in the system could be explored.

COMPUTER AIDED DESIGN AND DRAFTING SYSTEMS

Companies who design distributed control systems will be using computer aided design and computer drafting systems extensively. They will become dependent on these systems as will design engineers in other areas. Technicians will be needed to run and maintain these systems, add new equipment as it becomes available, and teach engineers how to use the system. These technicians will need to be familiar with "user aspects" of computers. That is, they will need to know how to run a computer, load programs through peripherals such as tape and disk drives, talk to the computer through a CRT keyboard, connect new peripherals and add hardware to the system. They will need to know the general architecture of the system on which they are working and be able to tell the engineers which buttons to push in order to do something.

These systems are quite costly and a vocational school cannot be expected to purchase a system for educational purposes. However, arrangements may be made for students to be sent on a two-week training program at a manufacturer of one of these systems as part of the vocational school training. All of these systems are different, but experience on a popular system would provide a good foundation for understanding these types of systems in general.

THE FUTURE

The short-term outlook for process control technology is a continued strive toward digital technology. Controllers will have more power and flexibility packed into a smaller package at a lower cost. Data acquisition systems will process data and control several process loops simultaneously while reporting results to a higher level computer. Sensors will be developed to interface directly with computers. Hierarchies will be refined and communications protocol researched to optimize the flow of information within the hierarchy. Unfortunately, everyone will be going off on his/her own tangent and the field will become more and more confusing, until some standard is achieved. Taking all of this into account, the need for computer oriented technicians is going to continue to grow at a rapid pace. These technicians will be affected by the growing confusion in the process control industry, and in order to be successful they will have to understand the source of the confusion and how to work within it.

MICROELECTRONIC MONITORS AND CONTROLS AND TECHNICAL WORKERS

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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 microprocessor, 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.

Microelectronic monitors and controls are used in industrial electronic systems. A few examples are given here:

- Automated industrial processes;
- Computer-controlled machine operation;
- Intrusion and fire alarm systems for industrial plants;
- Robot controlled assembly;
- Central monitors for medical electronic instruments;
- Military tactical control centers;
- Aircraft cockpit monitors and controls; and
- Automotive (including truck and bus) operating panels that display parameter inputs.

Of course, this is only a partial list. All technicians that work directly or indirectly on the types of systems described above are involved with microelectronic monitors and controls. Older systems that are being converted to microprocessor and digital control require new display and control panels to provide a person/machine interface with the new operation. New systems are being designed around this microelectronic control technology. Companies that design and build the above-mentioned systems are potential employers of technicians in this field. Since new designs require innovation, it is not likely that persons employed in this field will be replaced by computer-operated or automated (machinery) equipment.

Technicians that work with microelectronic monitors and controls perform assembly, testing, and measuring of new systems. They are also used for troubleshooting, maintenance, and repair of systems that are in operation. Examples of specific job activities are:

- testing and evaluating new systems;
- quality assurance in new system construction;
- troubleshooting panels;
- troubleshooting control circuitry;
- test and measurement of transducer inputs;
- calibration of displays;
- modification of existing system; and
- prototyping new monitor and control systems under the supervision of engineers.

There are actually two technologies involved in this type of work: measurement and display of system parameters, and control of various parts of a system on the measurements. It is possible for a technician to have a good working knowledge of both areas of involvement. Some of the facets of these subjects are common knowledge to technicians in other fields. Some examples of specific knowledge and skills are required are:

- theory and operation of various types of test equipment--especially digital test equipment;
- communications;
- telemetering;
- transducer theory and bridge theory;
- analog-to-digital and digital-to-analog conversion;
- calibration techniques--with an understanding of standards for measurements and testing protocols;
- the use of thyristors in control systems;
- theory and application of microprocessors and their peripherals;
- microprocessor polling techniques;
- data acquisition, data transmission, data retrieval and data storage; and
- modems.

The depth of understanding required for these subjects depends upon the level of responsiblity of the technician as it relates to the company hierarchy. For example, at the entrance level it would not be necessary to have an extensive knowledge of data transmission.

Furthermore, the complexity of the microelectronic monitor and control system will dictate the level of knowledge required. Some simpler systems require a knowledge of digital electronics but not microprocessors. The indication is that a course on this subject should have two levels of achievement: entry level and advanced.

In addition to the laboratory equipment used for training in general electronics subjects, the specialized equipment required includes:

- digital voltmeters;
- frequency counters;
- microprocessor trainers (or evaluation kits) with supplemental memory, I/O I.C., and asynchronous I.C.;
- modem (especially RS232C);
- transducers;
- A/D and D/A converters;
- logic and analyzers (16-track preferred);
- logic probes;
- logic pulsers; and
- industrial electronics trainers.

There is a rapid increase in the number of fully-automated electronic systems in use. These systems must be interfaced with humans, and the technology for doing this is becoming increasingly complex. The fact that each installation requires its own unique design makes this type of work especially attractive since it is not likely that a technician could be replaced by a computer-generated system.

COMPUTER-BASED DESIGN AND MANUFACTURE: TECHNICAL WORKERS

by
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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 technical work, and on the manner in which 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 technical occupations considered in this report include:

- Technicians in support of design or production in manufacturing enterprises such as automotive, appliances, aerospace, and electronics.
- Scientific programmers, including software engineers, systems analysts, and numerical control part programmers.

TECHNICIANS IN SUPPORT OF DESIGN OR PRODUCTION

This group includes personnel involved in the design of manufactured parts and also personnel involved in factory management tasks. The latter include inventory control, production process planning, and material requirements or manufacturing resources planning.

In both design and manufacturing applications, the computer can be asked to retrieve information based on appropriate criteria, such as part geometry or material. In this manner, the CAD/CAM system eliminates or at least reduces the continuing re-creation of information that already exists.

In design, typical tasks involve the use of interactive computer graphics systems to generate an image of a part or a product on the graphics system cathode ray tube (CRT) screen. The creation of an image on the CRT screen is generally termed geometric modelling. It is critically important to understand that this model is a representation of an object which will be manufactured. It then becomes clear that the other considerations which come later in the manufacturing cycle--choices of tooling, materials, and methods of manufacture, to name just a few--must be allowed to influence this geometric model at its very inception, lest the profitability of manufacturing the product be placed in jeopardy by a design choice which is incompatible with available manufacturing techniques. Consequently, it is imperative that technicians engaged in design support activities be familiar with manufacturing as well as design requirements.

Interactive computer graphics systems are used extensively in electronic circuit design. As far back as the late 1960's, circuit complexity and the demand for specialized circuits had increased to the point that computer graphics became the only practical way to satisfy the demand. And today's large-scale integrated circuits would be impossible to design without computer graphics systems. The electronics industry was one of the first to make wide-scale use of interactive computer graphics, mainly with two-dimensional systems. However, now that three-dimensional graphics is a practical reality, mechanical applications are thought by most experts in the field to offer the greatest potential for future growth. The number of such installations is growing by more than 40 per cent annually.

Factory management embraces those parts of CAM that tend to link several discrete elements of computer-based design and manufacture, coordinating the operations of an entire factory. The work activities here include inventory control, production process planning, and material requirements or manufacturing resources planning. The human-computer system interface in all of these work activities is also the interactive computer graphics system, in most cases, with direct display on the CRT screen and hard copy available from a printer or plotter.

The use of computer-based systems for inventory control is well-established and, as in most other areas of computer application, the computer system relieves the inventory clerks and other personnel from much of the record-keeping drudgery. These persons are, therefore, free to apply their talents directly to the management of inventory. This shift will ultimately be reflected in a demand for personnel with a higher level of inventory management skills than has heretofore been the case.

Material requirements and manufacturing resources planning systems are rapidly developing and emerging technologies in the factory management area. It is perhaps too early to attempt to define specific occupational requirements, but it can be noted that such systems are intended to link production requirements with shop capabilities and materials availability in such a way that reliable production schedules and costs can be determined well ahead of the time that actual production begins. It seems clear, then, that the personnel trained for these occupations will at least need to have a broad-spectrum understanding of manufacturing principles, as well as a sound grasp of the basic principles of using interactive computer graphics-based manufacturing aids.

Production process planning is a basic element of manufacturing operations planning. Here again, the computer has been applied to organize and store information in a logical fashion, essentially capturing the priceless knowledge developed by individuals. Retaining this information is difficult at best with traditional methods, because all too often the information is known only to the person who developed it, and is therefore lost when that person changes jobs or retires.

The growth of low-volume manufacturing (production lots of less than 50 parts) has been and will continue to be a powerful driving force for acceptance of computer-aided process planning technology. Future systems are expected to expand the emphasis on shop-floor control, with closed-l op communication and control of material flow through the plant. In such systems, process definitions and master production schedules will be stored in the computer. Manufacturing process data, such as status information on machines, tools, and manpower, will be fed back from the shop floor to the computer. The computer will analyze these data and determine times and locations for production events. It will also allocate resources and compare actual performance with the master production schedule. The output from this process will command and initiate job changes, machine setups, job starts, and other production-related activities.

SCIENTIFIC PROGRAMMERS

This group includes personnel involved in creating programs which are the operating commands for the numerically controlled machines and equipment which actually manufacture parts. In many cases, these same people also do tool and fixture design, and mold design tasks. And they go on to create the programs for producing the tools, fixtures, and molds.

Numerical control (NC) is probably the most mature of all the computer technologies involved in manufacturing. NC and computer numerical control (CNC) refer to the use of sets of coded instructions to control machine tools and direct the operation of machines in making parts. NC and CNC programs are also increasingly being used to control automated inspection machines.

In the early days of NC, numerical control instructions, or part programs, were written manually--a tedious, costly, time-consuming, and error-prone task. Computer-assisted systems, with interactive computer graphics in many cases, now perform many of the tedious routine steps needed to generate a part program, leaving the part programmer free to apply his or her talents to optimizing the machining operations for maximum productivity. Many of the NC programming systems also provide for preview, on the CRT screen, of the tool path, simulating the tool motion so that the programmer can verify the accuracy of the program.

Because so many of the tasks involved in the CAD/CAM applications discussed in this report are performed via interactive computer graphics systems, as are various other technical activities, workers entering technical trades will do well to have had exposure to some kind of interactive computing. Of course, the closer this computing is to actual technical support operations (actual or simulated), the better. It seems clear that teaching institutions must have CAD/CAM equipment available for the most effective hands-on demonstration and practice. Similarly, considering computer-based systems which are dedicated to specific tasks, such as numerical control part programming, it would be desirable to have one or more actual or simulated production mechanisms (e.g., numerically controlled machine tools) available so that the accuracy and usefulness of programs can be demonstrated.

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, and 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.

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 AND TECHNICAL TRAINING

by
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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, 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, robotics technicians must have a working knowledge of a number of different technologies.

Work activities in robotics technology will include robot mechanisms and controls design, manufacturing and testing, robotic system design and implementation and robot field support. The latter area will include maintenance and programming ("teaching") training, diagnostics and problem analysis and installation supervision and start-up.

Knowledge areas in robot mechanisms and controls design will include: electro-mechanical devices and systems such as automatic control systems and servomechanisms; fluid power devices and systems; solid state electronics; and computers and microprocessors. Specific knowledge requirements will include: electric dc servo drives; position and velocity measuring devices; fluid power actuators and control devices;

computer and microprocessor circuits, software and programming; and analogue-to-digital and digital-to-analogue conversion.

Skills required for mechanisms and controls design, manufacturing and testing will include: prototype development and testing; system analysis including design, selection and testing application of engineering data; component selection, testing and evaluation; test cell set-up, instrumentation and operation; and computer and microprocessor programming and documentation. Skill requirements may also include preparation and writing of maintenance procedures, "teaching" manuals and other service and instruction documents.

Robot system design and implementation is primarily concerned with the application of robots in manufacturing operations. These activities may be performed as part of a user's manufacturing engineering organization or as part of a robot or system supplier's applications engineering group. Knowledge areas will include: a broad spectrum of industrial processes; industrial control systems; and industrial robotics. Specific knowledge requirements will include: programmable and solid state industrial controls; mechanism design and control; fluid power actuators and control devices; specifications and capabilities of industrial robots; and material and parts conveying and orienting methods.

Skills required for robot system design and implementation will include: preparation of plant work area layouts; determination of robot performance parameters, based upon task analysis; design of robot end-of-arm devices and control circuits; configuration and programming of programmable controllers; development of equipment interfacing systems; development, set-up and demonstration mock-ups; laboratory simulations of actual robot operations; design of material and parts conveying and orienting systems and controls; and selection of robot equipment, based upon task requirements.

Knowledge areas and related skills in the activity of robot field support are more closely related to specific robot products than are other robot technician tasks. A general knowledge of fluid mechanics, electronics, automatic control systems, servo-mechanisms and microprocessors/mini-computers will be required as a base for the development of specific knowledge and skills. The specific knowledge and skills for robot field support are usually developed through special training programs provided by the equipment suppliers.

There are two basic disciplines which need to be addressed in the technical 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 dynamics; fluid power actuators and controls; and servo-mechanisms. The electrical/electronic area of instruction will include: basic electronic circuits; solid-state electronics; industrial electronics and controls; electronic instrumentation and electrical dc drive systems.

Laboratory equipment requirements for fluid power technology will include: pneumatic and hydraulic linear and rotary actuators, solenoid valves and servo valves; hydraulic power units; pneumatic and hydraulic "breadboard" test benches. Current robot fluid power/control components and at least one current pneumatic-drive non-servo and one hydraulic-drive servo-controlled will also be required. Some elements of these robots would also be used for instruction in the electrical/electronic technology area.

Laboratory equipment requirements for the electrical/electronics technology will include: dc servo drive motors and controls; transducers and feedback devices; electro-mechanical 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 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. As an alternative, any of the small electric-drive "teaching" robot/mini-computer systems can be used.

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 production is expected to grow at the rate of about 35% per year throughout the 1980's. Current (that is, mid-1982) estimates are that there are about 20,000 people involved, in the U.S., in all phases of robotics, including design, manufacturing, marketing, application, maintenance, research and development, and education and training. At this time, it is estimated that about 15 percent of these activities could be performed by robotics technicians. By the end of the 1980's, the total number of people involved in robotics is expected to reach 60,000 and the percentage of robotics technician activities is expected to increase to 20 percent.

SOFTWARE DEVELOPMENTS AND TECHNICAL PERSONNEL

by
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There have been no sudden breakthroughs in the area of computer software, but there is a relentless driving force that keeps it constantly changing and evolving. Any educational program for computer professionals must be revised periodically to stay up to date. The "engine" that keeps everything moving is, as usual, economic, and is caused by the ever greater computer power per dollar that is available and in use. Features in applications software that seemed expensive frills only a while ago are now expected. Therefore, what might have been considered adequate software five years ago, may seem clumsy or primitive by today's standards.

There are some clearly identifiable trends in the evoluntionary improvement of user software. Programs must have a much improved "User Interface" with features like checking all input for errors and if interactive, providing useful prompts or even user assistance. A menu-driven approach is also often used. In the technical area, this is addressed by producers of software. This includes the scientific programmer, the programmer/analyst, and the systems analyst. Some of the education now appropriate in these fields may also be appropriate for the specifiers of software. This could include technicians and consumers of technical applications software.

WORK ACTIVITIES WHICH INVOLVE THE TECHNOLOGY

While there may not be any dramatic change in what programmers do from what they did several years ago, there is a much higher expectation of the products of well-trained programmers and analysts. Any scientific or applications programmer is now expected to produce well-structured code using the techniques commonly called "structured programming." This includes "GOTO-LESS programs," using the "WHILE "and" "IF THEN-ELSE" structures, and top-down implementation. It also includes developing good documentation with the programs as they are developed. Explicit training and experience in teamwork with other computer professionals may also be expected.

KNOWLEDGE AND SKILLS

Programmers need to be comfortable with one of the modern, structured computer languages. BASIC or FORTRAN IV alone is no longer considered adequate, even though these are still widely used and often have considerable advantages. Most common among the "structured" languages are Pascal, Ada, and PL/I. FORTRAN 77 can also be used in an appropriately structured way.

Programmers should be exposed to design approaches commonly associated with structured programming such as "stepwide refinement." It is crucial that educators provide actual experience in developing large programs, using "top-down" implementation methods. Experience in larger projects with cooperating teams of programmers is also desirable.

While not essential for producing up-to-date software, exposure to a modern operating system (control program) is also useful. Systems like the UNIX (TM) operating system have been expressly designed for software development and will provide the student with exposure to the many useful "software tools." Programmers need to be familiar enough with an operating system to design and write good user interfaces. This also requires the ability to produce good displays on video screens, complete user control of keyboard input/output and, if applicable, access to clock or timer facilities.

SPECIAL EQUIPMENT AND FACILITIES

In addition to the general qualities of modern software mentioned previously, it is almost unthinkable to not take advantage of interactive techniques for many kinds of application software. Appropriate education in developing and using interactive software requires access to modern interactive educational computing facilities. Two approaches are possible--having both available to the student is ideal. First and most traditional is a time-sharing computer system where multiple users share the same computer, accessing the system from video terminals. Second and rapidly increasing in popularity is the use of the "personal computer." Both approaches have their advantages. Except in database applications, where the large disk storage space is essential, the personal computer is the preferred tool for teaching modern programming. The desirable user interface features which are becoming so important will not seem too expensive on a local machine that serves only one user at a time.

If time-sharing access is used, then the speed of telecommunications facilities becomes important. Connection at 300 baud (approximately 30 characters per second), the most common remote connection a few years ago, is rapidly being superseded by the 1200 baud connection. Ideal is the 9600 baud local connection.

GROWTH AND TRENDS

It is only a slight exaggeration to say that computer processor power is almost free. Communications remains relatively expensive and will remain so until the optical fiber rather than the copper wire is the typical way phone and data communications are achieved. This will all lead to an ever-increasing dependence on the personal computers and the extremely powerful successors already being developed.

Computer-aided-instruction, while still expensive in terms of developing materials, will be cheap to use. Both programmers adept at developing CAI systems and programmers capable of producing such material will be in demand.

OPTICAL DATA TRANSMISSION AND TECHNICAL WORKERS

by
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Optical (or fiber-optic) data transmission involves the use of optical fibers (sometimes called guided-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. This new technology is coming into increasing use because in many applications it offers significant advantages over wire 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.

Many technical workers will be impacted directly by fiber optics, and will work directly with fiber-optic communication systems or their components. These workers include electronic technicians, instrumentation technicians, computer technicians, and field-service specialists dealing with electronic, computer, and communications equipment. The degree of the impact will depend on the extent to wich fiber optics penetrates various industries. The spread of fiber optics is likely to create demand for technicians with training specifically in fiber optics. Such specialized technicians would be required by heavy users of fiber optics (e.g. telephone companies) and by companies which manufacture fiber-optic equipment or incorporate fiber optics in systems they produce.

Technicians working with fiber optics will perform tasks including assembly, testing measurement, and troubleshooting which require higher-level skills and a deeper understanding of the technology than needed by trade or industrial workers. Technicians generally will need to be familiar with conventional equipment as well as fiber optics. Specific work tasks will include:

- Field and laboratory measurements
- Diagnosis of fiber-optic components and systems
- Production and quality control
- Repair and replacement of malfunctioning equipment
- Modification of existing systems to incorporate fiber optics
- Modification of existing fiber-optic systems
- Assembly of special-purpose fiber-optic equipment under the supervision of engineers

Many of the skills and knowledges required of technicians working with optical transmission systems are similar to those required of technicians in electronics and other fields. For example, the basic principles of diagnostic testing and quality control are similar, but the procedural details are different. Some of the specific knowledges and skills required include:

- Principles of fiber-optic transmission
- Measurement procedures and techniques
- Structure and characteristics of optical transmitters, receivers and cables
- Losses in optical systems

- Understanding of digital transmission, analog transmission, and multiplexing
- Differences between optical and electronic systems
- Transmitter and receiver structure
- Mechanical tolerances of optical transmission systems

The depth of understanding required will vary depending on the nature of a technician's work. Those working with only a single fiber-optic system or subsystem while spending most of their time with other equipment will require less knowledge than those working continually with fiber optics. This points to a need for a two-tiered curriculum. One program would aim at providing students specializing in areas such as electronics or quality control with a general understanding of the nature of fiber optics. The other would aim at providing in-depth training in fiber optics for students who would specialize in fiber-optic systems. The latter program would be analogous to existing curricula in fields such as laser technology, which train students specifically to work with laser and electro-optical equipment.

Special equipment required for training fiber-optic technicians (in addition to standard laboratory electronics) includes:

- Samples of fiber, cable, connectors, couplers, light sources, detectors, transmitters, receivers, and electronic components
- Optical time-domain reflectometer
- Optical attenuation meter
- High-speed oscilloscopes and other electronic test equipment
- Digital and analog signal generators
- Bit error rate meters
- Electromagnetic interference test and demonstration equipment

- Multiplexers and demultiplexers
- Cut-away models of couplers, connectors and fibers which show light transmission
- Fiber splicing equipment
- Microscope
- Infrared viewer
- Light sources and detectors for use at different wavelengths

Fiber optics is a very rapidly growing technology. Sales in some areas have more than doubled in a year's time, and overall volume is likely to continue increasing at 30% to 50% (or more) per year over the next three to five years. This will create an increasing demand for technicians who understand fiber optics. At the moment, virtually all technician training in fiber optics is at the in-service level, provided by employers to their employees or new hires, or offered for technicians already working in related fields. There seems to be very little being done at the two-year college level.

The larges immediate demand for fiber-optics technicians will probably come from the telephone industry, and from the rapidly growing fiber-optics industry itself. Longer-term growth will occur in the computer, instrumentation, electric-power and process-control industries, with automotive and heavy equipment prospects promising but somewhat uncertain. Several military fiber-optic systems are about to enter production, a development that will stimulate military need for both field and shop technicians.

IMPACT OF NEW TECHNOLOGIES ON AUTOMOTIVE SE ES

by
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Technological, engineering and manufacturing advances in cars and trucks are bringing about a dramatic change in automotive service and maintenance operations. The sweeping changes that are under way will be reflected in the need for new skills in those who hope to service and repair the parts, components, equipment and systems that comprise the new automotive technology.

Every major vehicle system is affected by the new technology including the body, chassis, engine, transmission, electrical, steering, suspension, brakes and air conditioning/heating. Also growing in importance are such specialized systems as automatic safety restraints, theft prevention and the entire field of entertainment sound systems and "talking" cars. Accordingly, as vehicles become more sophisticated, they will require higher levels of serviceability than ever before, including new service techniques and repair skills.

Here are some of the general trends in automotive products and systems that can be expected to result from current or planned technological innovations.

- A shift to smaller engines with fewer cylinders as a result of continued market emphasis on fuel economy;
- Widespread use of gasoline and diesel engine turbocharging and supercharging as a way to extend vehicle performance and power;
- Continued emphasis on the reconfiguration of cars and light trucks to front-wheel-drive, with the engine located transversely between the front wheels as an increasingly important trend;

- Significantly greater application of electronic engine, driveline and entertainment systems;
- Heavy use of integral body frame, or unibody design, for all cars and light-duty trucks;
- Predominant use of front and rear disc brakes;
- A modest decrease in the use of air conditioning, power brakes and power steering in small cars with small engines; and
- Use of less steel in the typical car of the future, with more use of plastics and aluminum.

An all-encompassing trend in the automobile industry is serviceability by design. Automobile company design and manufacturing engineers are starting to work more closely with advance product service engineers, who evaluate the vehicle from a mechanic's viewpoint and, if necessary, recommend ways to enhance serviceability.

They also are working with product and manufacturing engineers to develop service and maintenance procedures, taking into consideration the ease of diagnosis, service, repair and the impact of the new design on shop equipment.

Computerized systems will be used increasingly in the future to improve service efficiency and pinpoint specific areas of an automobile requiring service. In large service shops, particularly, computerized systems will increase efficiency by scheduling car repair jobs and organizing the flow of manpower and parts through the shop. The computer system tracks each vehicle through its maintenance or repair stages, matches the right mechanic with the job, indicates which mechanics are already at work on vehicles, and estimates how long it will be before a customer's vehicle is ready for pickup.

Other computer systems will be used to help customers accurately and fully describe auto problems to service personnel, by asking a series of questions about the nature and location of the vehicle's problems. The customer would merely touch appropriate answers displayed on a videoscreen and eventually get a printout describing the problem and possible causes.

Service technicians in shops and dealerships will need a working knowledge of these computer systems to cope with such emerging sophisticated technologies as computerized engine controls, electronic fuel injection systems, advanced automatic transmissions, new suspensions and various components involved in front-wheel-drive and "alternative fuel" care.

By 1985 over 90 percent of all new cars made in the U.S. will be front-wheel-drive with transversely mounted engines to provide more usable interior space in smaller, lighter vehicles. The remaining rear-drive cars will be mostly sporty or performance-oriented models.

Four-cylinder engines will replace V-8s as the most widely used powerplant, because, as vehicle weight is reduced, smaller engines can be used to improve mileage without giving up performance.

ENGINES

Not only will new engines be smaller displacement, averaging about 2.5 liters in the mid-1980s, they will incorporate new technology to improve efficiency, reduce friction and permit higher compression ratios with the same octane unleaded fuel that is available today.

As V-8s are phased out of all except a few passenger cars, some innovative configurations will challenge service personnel and mechanics. In both gasoline and diesel applications, these include V-5, V-4 and 3-cylinder engines, as well as new V-6 and inline 4-cylinder powerplants. Use of supercharging and additional use of turbocharging are also likely.

ON-BOARD COMPUTERS

Automotive service people will face greater use of on-board computers and electronic engine controls on vehicles, not only to help control exhaust emissions and improve fuel economy, but for additional functions. One result will be the wider use of electronic fuel injection for engines. Also, the use of digital instrumentation will increase in the next few years to provide such information as vehicle speed, fuel economy and driving range available with the fuel remaining in the tank.

In some cases, the car's computer will control the shifting of the automatic transmission to improve its efficiency and reduce exhaust emissions. It will continue to be used to control converter clutches on more automotive transmissions, providing a mechanical lockup to eliminate slippage. To help improve vehicle serviceability, the on-board computer also will be used to verify engine and emission control system operation, and self-diagnostic capabilities will be expanded.

TRANSMISSIONS

Service operations of the future will see new transmissions that are being developed for use with smaller engines and vehicles, including 4-speed automatics in which the final gear is an automatic overdrive, and more efficient manual transmissions, including 5-speeds.

Now being evaluated for possible use on small cars is a different concept in transmissions. Called the continuously variable transmission, it features a belt-drive, which pushes instead of pulls, and holds out the promise of providing a more efficient engine-transmission system for smaller cars.

ELECTRONICS

By 1985, an estimated 80 percent of all cars serviced in the U.S. will employ a microprocessor. The figure will rise to 95 percent by 1990. They will be used for automotive electronics uses including engine and drivetrain controls, diagnostics, driver assistance, braking controls, instrumentation and "talking cars." The latter consists of an electronic module capable of producing preprogrammed warning messages in synthesized speech which has a human quality.

MATERIALS

A working knowledge of new automotive materials will be needed by the auto service trade in coming years. High-strength/low-alloy steel, aluminum, magnesium and other lightweight metals will make up relatively larger shares of basically lighter vehicles in the next few years. But the biggest advance is expected to be made by plastics.

Plastics not only are lightweight, but are corrosion resistant and can be formed into complex, one-piece parts. For example, a plastic bumper support on a sports car consolidates 15 separate pieces (formerly metal) into just three, while a one-piece rear spring replaces a 10-leaf steel one.

More use of plastic hoods, fenders, tailgates, removable roof panels--more all-plastic bodies--can be expected.

Developments in automotive powerplants are also under way that could result in new requirements for the auto service trade. These include electrically-powered vehicles, gas turbines, stratified-charge engines, and vehicles that operate on fuels such as ethanol and methanol.

RENEWABLE ENERGY TECHNOLOGIES-TECHNICAL

by
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Renewable energy technologies (RETs) consist of biomass, solar, and wind conversion systems; hydro systems, are not "new" as are the others, and thus have been largely excluded from our discussions. Although simple in concept, most of the RETs systems employ "new" technologies in their design/production and they require special awareness and new skills in their installation, operation, and maintenance. In general, they are more complex, and have unique thermal and chemical characteristics which must interface with and which influence traditional energy systems.

Technical occupations which are required to accommodate these new enegy technologies are primarily in the industrial/manufacturing areas, building trades, and the energy operations/maintenance trades. Specific work activities discussed include:

1. Industrial/manufacturing technicians
2. Building trades technicians (Heating, Air conditioning, Electrical)
3. Energy systems technicians (Building Engineers)
4. Architectural technicians
5. RETs as a separate technical area

The requirements for knowledge, skills and special equipment are discussed for each of these technical job categories.

INDUSTRIAL/MANUFACTURING TECHNICIANS

The design and production of RETs systems and equipment, in general, do not require new basic skills; but they do require an awareness of efficiency, tolerances, and thermo-chemical and mechanical characteristics of systems not generally encountered in design and manufacturing of traditional energy equipment. Biomass, solar, and wind equipment, for example, must be actively exposed to weather and corrosive environments not encountered in traditional heating, cooling, or generation. Designing and manufacturing a piece of equipment expected to last for twenty years in full sunlight and weather exposure requires an appreciation for materials, workmanship, and maintainability not engineered into many products. These new systems, whether fermenting corn for power alcohol, collecting the sun's rays for heating, or capturing the power of the wind, must operate at greater efficiencies, and at tighter tolerances to be economical. They must, in most cases, also be built to interface with traditional energy systems. In total, these requirements imply greater complexities in control, sensing, and safety measures.

Although no special equipment or training materials are considered necessary for the industrial/manufacturing technicians, it is important that the above awarenesses be incorporated into training so that any exposure to RETs will trigger an appreciation for the basic characteristics of these new systems.

BUILDING TRADES TECHNICIANS

Active solar collector systems and passive solar approaches are now frequently encountered in the construction and heating-cooling installation/service trades. Plumbing, glass, heating/air-conditioning, and electrical technicians will be expected to understand the basic terminology, and the complexities of the controls, sensing, heatstorage and interface requirements. The new solar technologies demand greater awareness of the entire structure and the entire energy system. From the installation and service viewpoint, complexities in the solar system present a new set of concerns - more wiring, more valves, more controls, more careful installation. For example, in a solar system, efficiency is very dependent on seals, precise orientation, and rigorous insulation. Generally, these systems must gain maximum advantage of every ray of sunlight so they require a higher degree of concern for such details.

Special equipment (such as a model system simulator or components) and basic training materials may be considered in certain regions of the country where solar is becoming commonplace (California, Southwestern Sunbelt states). Although equipment expenditures can be minimized by using some equipment and instruments of other curricula such as heating; air conditioning and refrigeration, and the building trades, equipment such as collector arrays (liquid and air, flat plate and concentrating) and special meters, sensors and similar instruments should be available for instruction of solar technicians. Detailed tours of a working active solar system and a passive solar structure are suggested. Basic solar terminology is also recommended.

ENERGY SYSTEM TECHNICIANS (BUILDING ENGINEERS)

The heating and cooling plants for many commercial buildings (offices, hospitals, apartments, schools, hotels) now incorporate solar systems or features. The operations and maintenance of such systems require awareness of fundamental components, systems layout/features and interface with traditional energy systems.

A detailed tour of an operational active commercial scale solar system and a commercial structure which employs passive solar features is recommended.

ARCHITECTURAL TECHNICIAN

Solar technologies are immediately relevant to architectural work activities. Passive solar features including day-lighting, sun spaces, natural ventilation, and thermal masses, have heavily impacted traditional building design, orientation, landscape, materials and systems. Active solar and the approaching photovoltaic technologies are options now frequently considered for initial installation or future modification. Awareness of sun rights, seasonal variation, proper orientation, and energy systems interaction are important for the architectural trades. It is very important that technicians working in the architectural field learn the terminology and have considerable familiarity with solar systems. The Sun is now one of the major energy sources for new building design.

Training equipment/materials should definitely include building models and detailed tours of current building/architectural design practices as they relate to both active and passive solar approaches.

RETs AS SEPARATELY IDENTIFIABLE TECHNICAL AREAS

As a final point and perspective, it should be recognized that the RETs themselves are becoming separately identifiable technical/vocational areas, and in some regions, certain architectural firms, builders, heating/air-conditioning contractors, and landscapers now specialize in solar systems. Wind or biomass specialties are also developing, although their current levels do not pose technical training impacts as solar does.

THE NEAR TERM FUTURE FOR RENEWABLE ENERGY TECHNOLOGIES

A continuing growth of renewable energy technologies over the next few years will require increasing numbers of technicians who must be aware of or knowledgeable about such systems. Wood burning, passive and active solar technologies will continue to show up in retrofit and new construction; in some areas, solar hot water will be the norm. Wood burning stoves are now common in about ten percent of American homes. Solar applications will almost triple by 1985 - reaching into almost one million homes and over 25,000 commercial buildings.[1] Solar systems and terminology will be common in the architectural, building trades and heating/cooling installation/service trades. A familiarity with these RET systems will certainly be an advantage for today's student in these technical vocational areas.

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[1]Estimate of installation for solar and wood derived from Alternative Energy Data Summary for U.S., RTM Corporation, March 1982.

MICROCOMPUTERS AND MICROPROCESSORS IN TECHNICAL OCCUPATIONS

by
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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 subtrate.

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 "gates", 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 of microprocessors to technicians lies in their endless applications to almost every task involving equipment control and scientific or engineering design and management. We should take as examples here the work activities of Programming Technicians and Engineering Technicians.

Programming Technicians

The scientific programmer labor force is that which is in greatest demand in the market today. This technical field is usually subdivided into specific disciplines such as applications programmers, system programmers, systems analysts, systems designers, sy. m architects, information specialists and the like. Because of the tremendous and increasing need for workers in all these areas, individuals are able to advance up the career ladder without having a college degree. Rather, because of the rapid changes in computer hardware, computer software and data communications, the computer technician should plan on taking additional courses or training every one-to-two years. Community colleges and technical schools can not only prepare entry-level programmers, but can play an important role in providing relevant continuing education.

Herein, we confine discussion to entry-level positions.

Generally, the first jobs for which computer technicians are hired are as applications programmers. The training needed is in one of the more widely used higher order languages (HOLs) used for writing programs for both personal computers and conventional computers. These HOLs include CP/M, BASIC, COBOL, FORTRAN, and PASCAL. They allow a programmer to take carefully specified applications and program them on a wide variety of computers without having to know about the computer itself. It is noteworthy that such HOLs long associated with large "mainframe" computers are available in versions which are compatible with most popular desktop computers.

After the programmer has become adept at applications programming, the next step up the career ladder may be to become a systems programmer or a systems analyst/designer. In both these latter instances, the computer technician needs a rather extensive knowledge of the particular computer system hardware, the specified application and programming methodology. Assembler or machine-level programming skills will need to be developed which are used in personal computer systems--as in large computer systems--to control input, output, and internal functions that actually get the job done. Microprocessors are themselves programmed by developers to perform their designated functions. To produce the complex operations which allow small computers--from the business-oriented machine to the electronic game with its light and sound displays and joystick controls--to perform their functions, the "chip" is designed with program logic.

Since microprocessors exist internally to the machines which incorporate them, and since personal computers are designed for relative ease-of-use by persons with varying backgrounds, it is doubtful that the development of these technologies will create a large number of jobs within companies that make use of these computers. Yet the application packages and computer-based systems on which these "end users" will increasingly rely must come from somewhere. Computer companies that develop personal computers employ programmers to produce the user programs and to develop new applications for desktop machines or microprocessors. Moreover, there are already hundreds of independent "software houses" which invent and distribute applications programs for these devices. Even entrepreneurial possibilities exist for the creative programmer with a novel application idea. It is in such endeavors that the programmer with knowledge of microcomputer and microprocessor systems may find a productive role.

For the preparation of entry-level programming technicians in microcomputers, most educational institutions will not need to purchase additional equipment, for the simple reason that most institutions already will own and operate a set of personal computers. They may, however, wish to purchase additional computers from different companies, to expose their students to specific systems and thus prepare them to work with several different desktop computers on the market.

Engineering Technicians

Microprocessors are used extensively to monitor and control the proper setting and operation of instruments and equipment in round-the-clock service activities. Some more common instances are electric power plants, nuclear power generating plants, traffic lights, mass transportation systems, and local telephone exchanges. More and more of these real-time operations are being converted from manual to automated control.

In real-time control systems, such as those just listed, instruments which monitor the operation of all the equipment units in the system are connected to microprocessors programmed to check that the the instrument readings are in the allowable range. If the readings are out of range and the equipment is determined to be malfunctioning, the computer will take corrective action such as activating switches to turn off the malfunctioning equipment or to change its operation to meet required parameters. The microprocessor may also activate an alarm or dial a telephone number that will cause engineering technicians to report for duty. Such automated facilities are generally more responsive and reliable than the replaced facility.

Engineering technicians who install or operate the computer system need to understand the microprocessor application programs, how to input changes to the program and how to connect and disconnect instrumentation to the computer input/output channels. Of course, the technician also needs to be trained in the specific engineering application such as electric power plant or telephone utility operation.

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 may 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 direct connection via dedicated phone or wire to instruments or machines. Networking of computers to other computérs 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.

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.

Binkley, D.P., and Major, H.W. A complete system for distributed processing and laboratory data management. American Laboratory, 1981, 13 (9), 66-76.

Laboratories can often be semi-automated for efficiency through distributed processing (i.e., networking different databases), and the architecture of one such system is described. Probable users and user functions of such systems are given.

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 for-

eign 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 en gines 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."

CAM-I advances computer-aided manufacturing. High Technology, Industrial Technology, November/December 1981, 1 (2), 26-27.

CAM-I, Computer-Aided Manufacturing-International, a non-profit industry association based in Arlington, Texas, is promoting industry standardization for computer languages, data and techniques to enhance the use of CAM in industry. The organization currently sponsors six technical projects that focus on specific aspects of computer-aided manufacturing.

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.

Chemicals, energy to gain from gene splicing. Chemical and Engineering News, 1981, 59 (35), 10.

Indicates genetic engineering areas of application over a range of industrial sectors, and notes oil and chemical companies with major investments in the technology.

Computers and manufacturing. Chilton's IRON AGE, Special advertising section, June 22, 1981, A2-A22.

Numerical control, more than any one development, has contributed to improving productivity, increasing efficiency, achieving quality in American industry. The fundamental reason for numerical control is to make machining more controllable. The real excitement today is in CAD/CAM systems. Certainly they offer enormous payback. Increases in productivity of 3 to 1 are not unusual.

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.

Converging on a consensus--Hierarchial handling control. Production Engineering, August 1981, pp. 54-58.

Microprocessors have led to these key benefits for users: greater operating reliability in controls; quicker start-ups with easier last minute modifications; simpler maintenance via built-in diagnostics; replaceable modularized elements with more than one source for spares; cheaper, more efficient, less stressful movement of materials and machine parts; the ability to do more with equipment of higher order of automatic control; expandable, thus can work to longer-range strategic plan anticipating plant-wide integrated control handling.

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.

Cromie, W. J. Robots: A growing, maturing population. SciQuest, March 1981, 54 (3), 12-16.

U.S., Western Europe, and Japan have built between 17,000 and 20,000 robots, most of which replace humans in factory jobs that are hard, dangerous or boring. They weld and paint auto and truck bodies, load and unload hot, heavy metal forms into machines that stamp or cast them into various shapes. They also do simple, monotonous assembly work on typewriters, watches, pocket calculators and various electronic devices. About 3,200 of them work in the U.S.

Robots are distinguishable from so-called automatic machines because they can switch jobs quickly. According to the Robot Institute of America, the most "talented" robots cost between $5 and $6 an hour to operate and maintain. An ordinary human on an assembly line, say in an automobile plant, earns about $17 an hour in wages and benefits.

DDP nets violators in Ohio. Data Management, January 1981, 19 (1), 24BB-24DD.

Describes a distributed data processing (DDP) system with over 1200 remote terminals serving the Ohio State Highway Patrol. Evaluation and training are covered.

Dymmel, M.D. Reacting to new technology: The communications industry. VocEd, January/February 1982, 57 (1), 41-43.

Technological change has already been felt strongly by the communications industry and its workers. Both traditional telephone communications and nontraditional communications (including interconnect, data, video, residential and commercial security alarm services, "office of the future" equipment and others) have changed and expanded dramatically. The computer plays an ever more important role in the determination of job skills required or no longer required by the communications industry as technology advances. The availability of a skilled workforce will be critical in the 1980s. The total information industry by 1990 will open 1.4 million new jobs. Community college technical programs, military skills training, vocational-technical schools, specific skills training programs and apprenticeship training will be called upon to fill the need.

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.

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.

Green, A. M. Captive NC builders see more systems in their future. Chilton's Iron Age, April 27, 1981, 224, 51-54.

Numerically controlled machine tools hold a pivotal position in the resurgence of American industry. Together with robots, materials handling devices and limited manpower, they will form manufacturing cells to increase productive efficiency. Systems, automation and unmanned systems are logical replacements for people--first in hostile environments, then in the second and third production shifts.

Haavind, R. Future looks bright for guided wave optics. High Technology, November/December 1981, 1 (2), 35-43.

By the end of this decade, the flow of data, video, electronic mail, telephone conversations, and teleconferencing will in crease manyfold. Available transmission facilities such as satellites for both domestic and overseas traffic could become overloaded in the near future. A new kind of communications link with huge capacity and the ability to go for 35 to possibly 100 kilometers without repeater stations is causing excitement at communications research laboratories around the word. Recent rapid advances in a number of world critical research areas make monomode fiber optic lightguides very promising for the future. Their enormous capacity and their potential for carrying data very long distances with little distortion have long been recognized, but advances in processes to make the extremely minute monomode fibers have recently been made.

Hatvany, J., and Janos, J. Software products for manufacturing design and control. Proceedings of the IEEE, 1980, 68, 1050-1053.
Software problems constraining the growth of CAD/CAM technology are reviewed. Directions the industry may take are offered.

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.

Hexagons, computer models hold promise for small farms. Seedsmen's Digest, January 1981, pp. 46-47.

The hexagon is, in some ways, the shape of things to come for small farms around the world. Hexagonal plantings are being used at Michigan State University's Agricultural Experiment Station as a means to gather information about growing systems of crops raised simultaneously in shared, limited space. All information essential to growing the crops (weather--sunlight, temperature and rain, and nutrients and soil moisture) is fed into a computer and different combinations of variables are then programmed to find which conditions will produce the best harvest and predicting yields. This technique of computer modeling or simulation of growing systems will provide a new and speedy method to generate specific and detailed information on how to produce maximum harvest in virtually any crop. Literally years of field trials may no longer be necessary.

Huber, R. F. Tell it to your machines. Production, June 1980 pp. 102-104

Voice input or voice-aided programming is now being used in the metal-working industries generally serving one of two functions: As a programming method for numerical control and as a data input method for manufacturing information systems. On NC or CNC programming, major advantages include the fact that the programmer does not need to be an expert at keyboarding; he can use his voice to take data directly from the blueprint and enter it into the program. Voice programming for numerical control (VNC) allows factory personnel using normal English words to speak commands needed for parts programming.

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.

Impacts of applied genetics: Micro-organisms, plants, and animals. Washington, DC: U.S. Congress, Office of Technology Assessment, 1981. (Note: See summary articles in BioScience, March 1981, p. 198, and June 1981, p. 426).

According to OTA, genetic technologies may help fulfill some basic needs. The report describes technologies now operating or in development in such applications as chemical processing, food processing, plant breeding, and energy.

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.

Kao, C. Fiber optics--Worldwide. Telephone Engineer and Management, 1980, 84 (17), 43-46.

Presents an expert's perspective on the state-of-the-art and future trends in fiber optics usage in the telecommunications industry.

Karapita, A.T. Intravenous therapy: Past, present, and future. Dimensions in Health Service, March 1980, 57 (5), 20-23.

Briefly mentions home health care and microprocessor-based monitoring/control as developments which will influence intravenous therapy in the years ahead.

Kinnucan, P. Local networks battle for billion-dollar market. High Technology, Nov/Dec 1981, 1(2), 64-72.

A revolution is brewing in computer communications. A new technology, local area networks, links computer gear located within a geographically restricted area, such as a building or an office complex. The spread of low-cost computers into the office, laboratory and factory is rapidly creating a billion-dollar market for specialized communications equipment.

Knutti, J.W., Allen, H.V., and Meindl, J.D. Integrated circuit implantable systems. Biomedical Sciences Instrumentation, 1979, 15, 105-112.

Describes basic components and logical structure of totally implantable telemetry systems. These systems are used primarily in research with free-roaming animals, but have applications in drug and toxicological research as well. They have been used to measure physiological parameters such as deep-body blood flow, dimension, pressure and bioelectrical data.

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 automati-

cally 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.

Lerner, E.J. Computer-aided manufacturing. IEEE Spectrum, November 1981, pp. 34-39.

The metalworking industries that produce medium-sized batches are likely candidates for CAM. In traditional nonautomated metalworking, each machine is actually cutting metal only about five percent of the time, whereas in automated systems metal cutting may approach 70 to 100 percent of the available time, leading from tenfold to twentyfold increases in tool production.

Lightweight plastic "composites" are rivaling aluminum and steel. The Wall Street Journal, January 23, 1981, p. 29.

Describes the emergence and growth of lightweight plastic composites which can replace metals in certain machine parts, especially in automobiles' structural parts.

Making sludge a fuel source. Nation's Business, October 1981, pp. 25-26.

A North Carolina firm is marketing a remarkable process that converts sludge into usable water and clean, burnable fuel. Raw sludge is pumped through a grinder, mixed with sulfuric acid, then sprayed into a pressurized chamber filled with oxygen and ozone. The oxygen and ozone cook the sludge chemically as it is recirculated. Bacteria and viruses are killed and the sulfuric acid provides hydrogen ions that react with the sludge to form water and carbon dioxide. All that takes 90 minutes and the residue has burning qualities similar to those of soft coal. The process is also economical, costing half the price of the conventional treatment.

McDonnell-Douglas unit introduces new CAD/CAM. American Metal Market, November 2, 1981, pp. 12, 16.

Notes growth potential for CAD/CAM in smaller businesses as a result of the introduction of a small-size single terminal system.

Merchant, M.E. Computer-integrated manufacturing: Key to survival. Machine and Tool BLUE BOOK, November 1981, pp. 52-22.

There is a worldwide trend toward technical excellence leading to more efficient production. Achievement of this goal relies on computer-integrated manufacturing--the integration of numerical control, computer-aided design and computer-aided manufacturing. The computer is a systems tool capable of unifying all manufacturing into a computer-integrated manufacturing system, a system that starts from the human creative input, along with the input of needs to be satisfied by the product.

Mills, H.D. Software engineering education. Proceedings of the IEEE, 1980, 68, 1158-1162.

Commonalities and differences between university and vocational education in software engineering are discussed. Career structures and professional practices are organized and reviewed. New and developing computer technologies have diminished effectiveness unless the "software gap" is closed, it is asserted.

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.

Ouchi, W. "How Japan gets the most from its workers." San Francisco Chronicle, Tuesday, July 21, 1981, Section B-1.

When an important decision needs to be made in a Japanese organization, everyone who will feel its impact is involved in making that decision. This article discusses the Theory Z approach to management. Probably the best known feature of Japanese organizations is their participative approach to decision making. Theory Z suggests that involved workers are the key to productivity.

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.

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.

Pratt, M. Will that compute? Agricultural Engineering. September 1981, pp. 10-11.

Article provides descriptions of applications of computers in agriculture, agricultural research, agribusiness and industry: (1) John Deere Dealer Audio Response Terminal System (DART); (2) Farm records--feed consumption and production, etc. (listing given of numerous practical on-farm computer uses); (3) Research on remote water and energy management system (WASC); (4) Microprocessor-based data acquisition systems; (5) Inventory control--by industry; (6) CAD/CAM for designing equipment; (7) Potentiometers for automotive and field-equipment operations. Among practical, on-farm computer uses mentioned are: financial and business records; management decisions, including market information and production records; automated production, monitoring and process control, including equipment monitors; equipment guidance; environmental control in confined animal and plant production systems; automatic control of materials handling; and optimal control of other energy-dependent processes.

Raskin, J. and Whitney, T. Perspectives on personal computing. IEEE Computer, January 1981, pp. 67-73.

Definition, brief history, discussion of types of problems, software, hardware, networks and future trends of personal computers.

Riedlinger, T. Electrical vehicle battery fueled by aluminum plate. Modern Metals, pp. 68-75.

Prototype proves viability of aluminum-air battery for non-polluting, long-range electric vehicle that generates recyclable by-product. Development of cost-effective fuel alloys could trigger huge global market for aluminum, reduce dependence on imported oil.

Robinson, A.L. Micromainframe is newest computer on a chip. Science, 1 May 1981, 212, 527.

Announces development of a 32-bit high-level programmable computer miniaturized to sell at low cost. Programming will remain the major cost consideration in application.

Roworth, D.A.A. Fiber optics for industrial applications. Optics and Laser Technology, 1980, 12, 255-259.

Overviews current and expanding areas of fiber optics use (e.g., in communications), and predicts growth in local industrial communications usage. Fiber optic data transmission is described technically.

Sheppard, L.C. The computer in the care of critically ill patients. Proceedings of the IEEE, 1979, 67, 1300-1306.

Describes applications of computer systems in intensive and cardiac care. The importance of clinical measurements in critical care is shown, and an example system is described which measures and charts physiological parameters as well as helping with drug prescription. Organizational environments conducive to system implementation are described.

Shumate, K.C. Ada--A new language that will impact commercial users. Data Management, 1981, 19 (8), 23, 25.

Describes business applications of the high-level programming language Ada and its special features. Ada was originally developed by DoD but is expected to find expanding use wherever large programs must be written and maintained over a long period of time, e.g., in operating systems, compilers, communication systems and simulation systems.

Somers, E. Medical devices in the 1980s. Dimensions in Health Service, October 1979, 56 (10), 27-28.

Provides a brief assessment of expected growth in certain medical technologies, including fetal monitoring systems, implantable infusion pumps, and implantable telemetry monitors.

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.

Tesar, Delbert. Our weakening trade position in manufactured goods: A commentary on mechanical technology. PE Professional Engineer, August 1979, 49 (8), pp. 34-36.

This article discusses the effects of our lack of R&D emphasis on Mechanical Technology as compared to our trading partners in Europe and Asia. Our lagging efforts have brought about a decrease in productivity and a consequent superiority by other nations such as Japan and West Germany. Recommendations are presented for the solution of the problem. They include: a cohesive and structured national program for mechanical technology and manufacturing; the establishment of ten technology centers; heavy participation of industrial governing boards in these centers; substantial initial federal funding; and others. The nature of mechanical technology and robot technology are discussed.

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.

Waddell, R.L. Automotive electronics--The black box comes of age. Ward's Auto World, November 1980, pp. 23-26.

With few exceptions, every gasoline-powered passenger car that comes off the line for sale in the U.S. from now on will be controlled, one way or another, through integrated semiconductor-chip circuitry compacted in mysterious black boxes whose potential usefulness has only begun to be tapped. The need stems from the inability of mechanical or electromechanical devices to respond fast enough with sufficient accuracy to meet emission standards set by the EPA and still deliver engine performance and fuel economy demanded in today's automotive marketplace. The article discusses state-of-the-art automobile electronics and projections for the future.

Worthy, W. Supercritical fluids offer improved separations. <u>Chemical and Engineering News</u>, 1981, <u>59</u> (31), 16-17.

Overviews the use of supercritical fluids (SCF; gases compressed to densities approximating liquid) in a new chemical extraction/separation technology. The process capitalizes on physical properties of SCFs to result in effects similar to usual fractional distillation. SCF extraction technology is being investigated as an energy-efficient alternative in the production of ethanol, specialty chemicals and biologicals; in processing of potato chips and similar products; in the extraction of oil from seed; and in other applications.

Wrigley, A. Flying high: Materials in the '82s. <u>Ward's Auto World</u>, September 1981, pp. 45-50.

Materials substitution heads the list for '82 weight-reduction innovations by U.S. automakers. Aluminum, plastics, magnesium and high-strength steel (HSS) are all being used, along with more galvanized steel for better corrosion resistance. Downsizing--replacement of smaller models for larger ones--continues as the industry's chief weight-saving weapon, of course, but the materials mentioned constitute a much larger unit content in the '82 models than in previous years' models.

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