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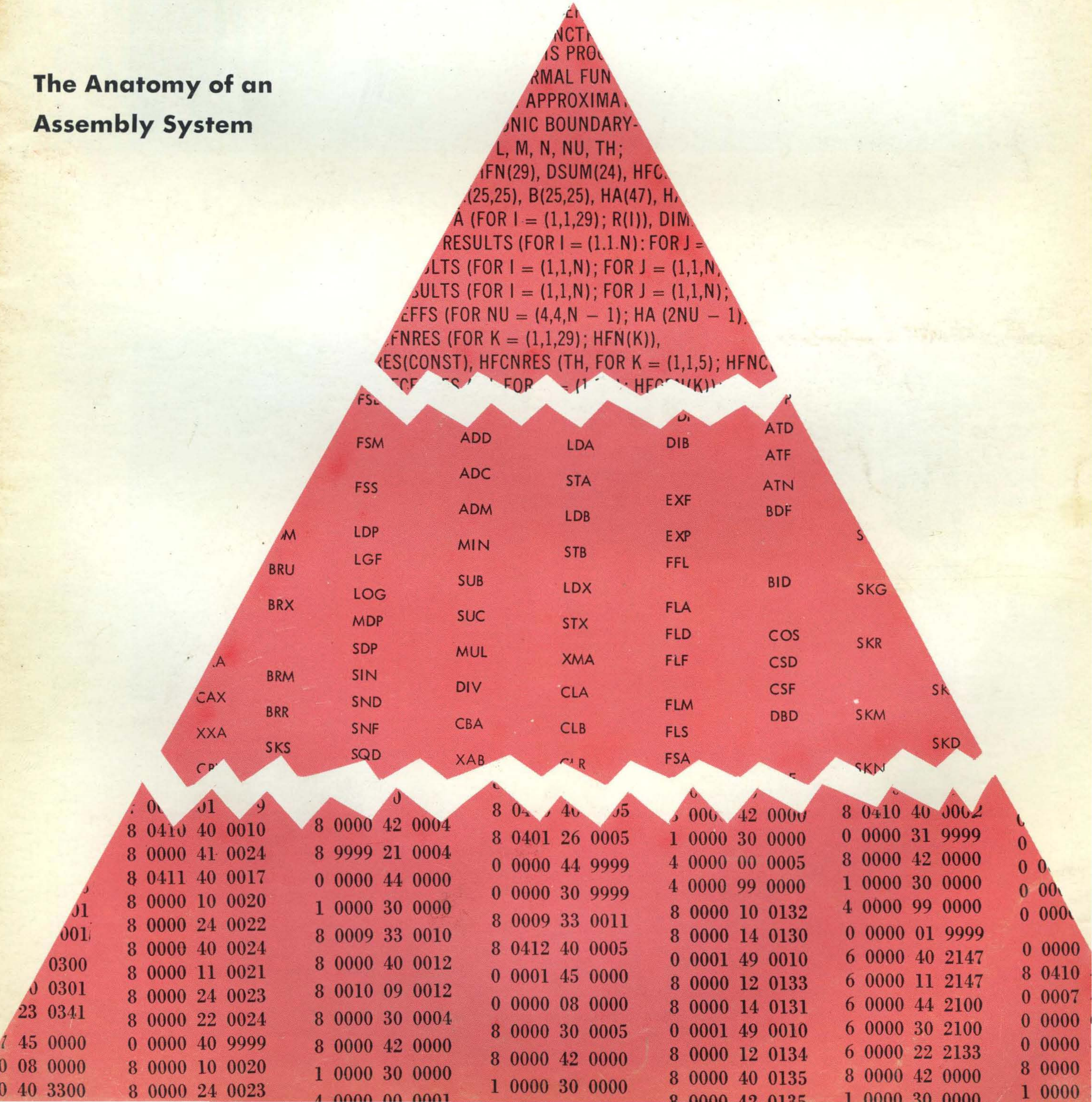
January, 1964

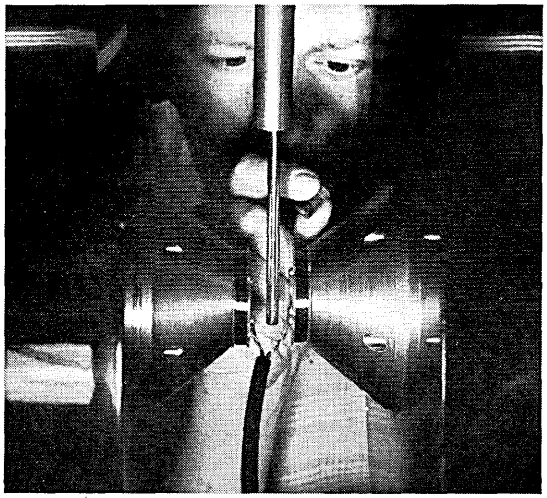
computers and automation

The Anatomy of an Assembly System



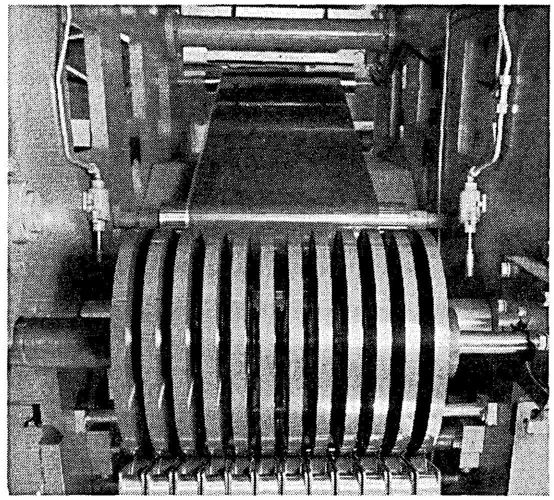
4 WAYS TO IMPROVE COMPUTER TAPE

(And how Memorex did it!)



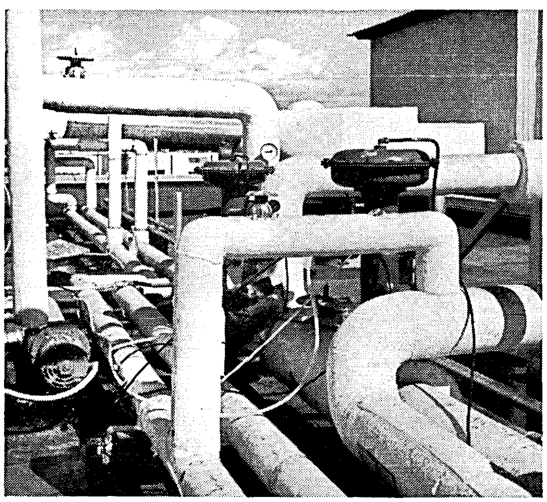
Exercise greater quality control.

The Memorex-designed Vibrating-Sample Magnetometer (VSM) tests basic characteristics of oxide raw material and precise concentration of oxide particles in the tape coating. Extra tests of this kind guarantee the improved performance and reel-to-reel uniformity of Memorex computer tape.



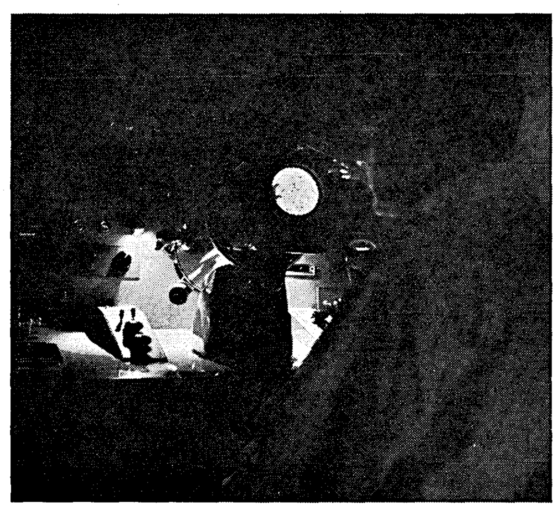
Employ advanced production techniques.

Specially constructed equipment — used to slit Memorex computer tape from jumbo rolls — produces tape with clean, straight edges free from ripples and ridges. A new slitting technique is but one of seventeen manufacturing improvements made to insure superior performance of Memorex tape.



Use a superior production facility.

A conspicuous aspect of the Memorex plant is the complex system of air filtration, humidification, dehumidification, heating and cooling. The unusual high-purity system, equal to that used in pharmaceutical processing, provides a contaminant-free environment — prerequisite to production of improved error-free tape.



Apply research in depth.

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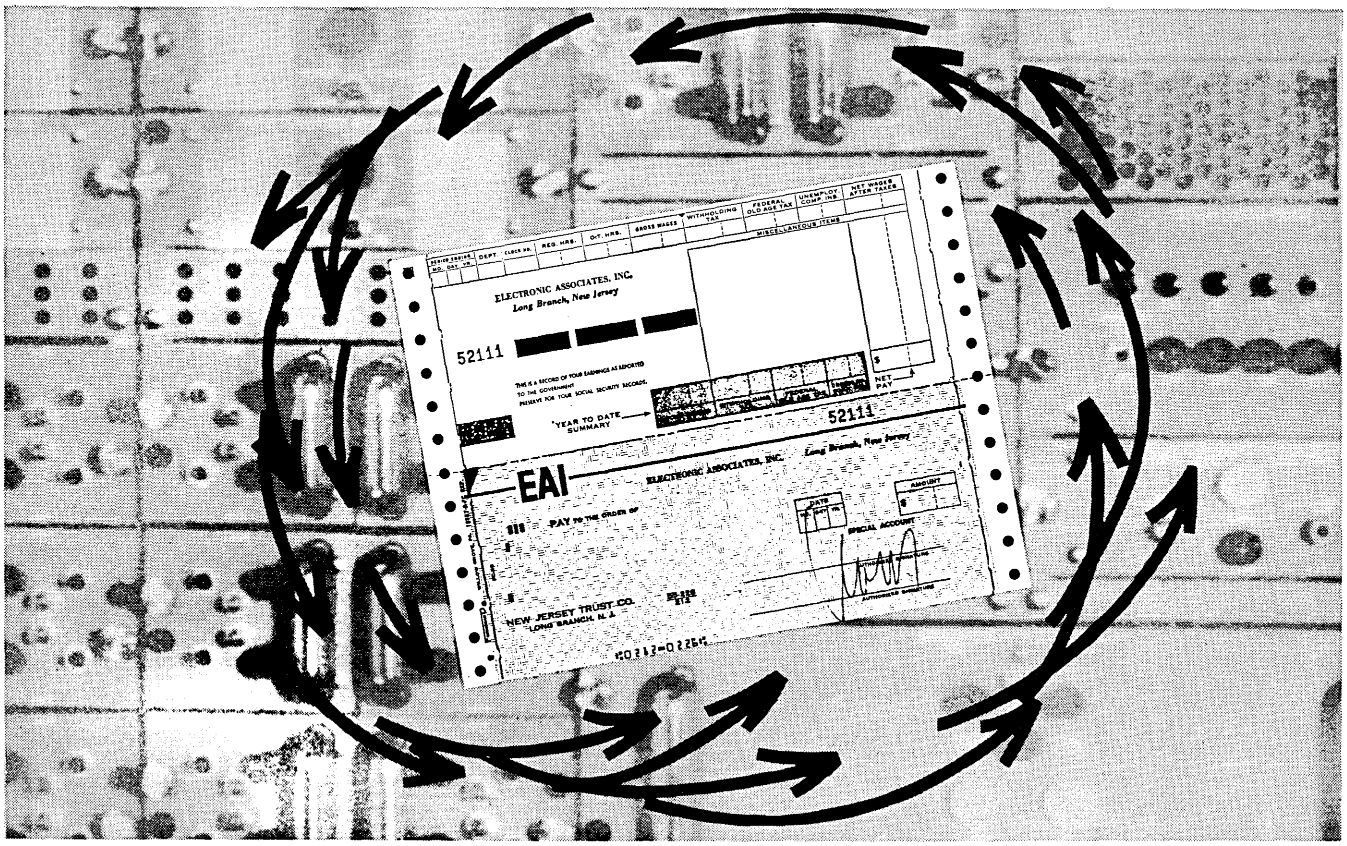

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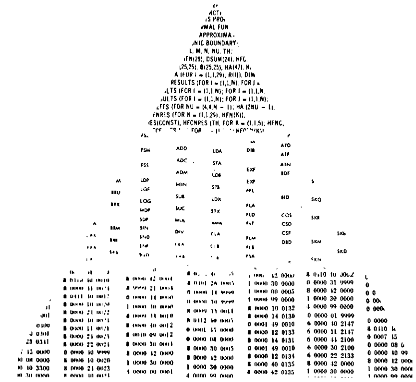
The segmented pyramid on our cover this month represents three phases of automatic programming, i. e., from top to base,
(1) source language statement of the problem,
(2) translation to symbolic instruction codes, and
(3) assembly of actual machine instructions.
J. Worthington discusses these phases in "The Anatomy of an Assembly System" starting on page 18.



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computers and data processors: the design, applications, and implications of information processing systems.

In This Issue

In Every Issue

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Programming: Science, Art or Language?

Programming interests many computer people, and fascinates a large segment of those interested. Part of the reason certainly is the feeling of power and satisfaction acquired by the successful programmer when his problem runs and the solution unfolds before his eyes. Archimedes shouted "Eureka!" and we can too.

What manner of thing is programming? is it a science? is it an art? is it a language? or more besides? In fact, programming is all of these things.

A science according to the dictionary is a "branch of knowledge or study dealing with a body of facts or truths systematically arranged and showing the operation of general laws." Programming is the science which deals with the methods of instructing computers to solve problems.

An art is "an area of skilled performance." Programming is the art of skilfully guiding the computer's processes in order to solve a problem. It requires art to find a good way through the maze of possible processes that can happen inside a computer.

Finally, programming consists of a class of artificial languages — those adapted to expressing ideas so that a computer "understands" and can solve a problem. In fact, expressions such as "machine words" and "machine language" have been in current use since the first digital computer began to operate in 1944.

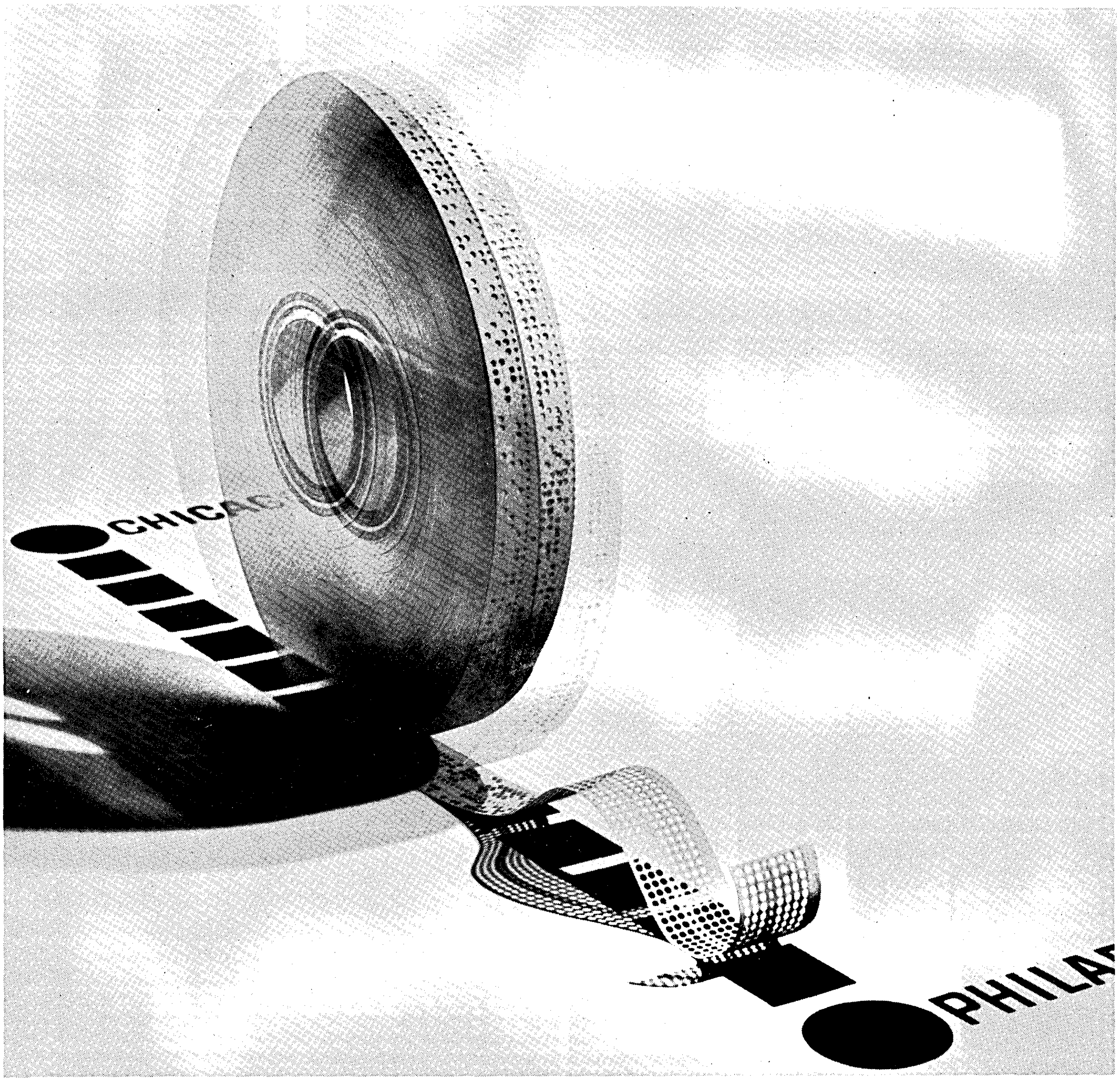
Programming has even a fourth aspect: it constitutes the education of a computer. Anybody who enjoys explaining and teaching is likely to relish many aspects of programming, because the "idiot computer" can be taught so extraordinarily well.

This thesis has several implications. First, people of differing backgrounds and various leanings may all become good programmers: scientists, mathematicians, linguists, teachers, and more besides. In fact, many diverse occupations have graduated members into the programming field.

Second, the many-faceted field of programming will have much to contribute to the mental life of those who work in it. It is likely to be always stimulating and never dull.

Third, there has been some discussion as to whether or not programmers will be superseded 20 or 30 years from now. On the contrary, the diversity of the field will make programmers necessary for a long time to come. Their work may change in some ways, but their services in general will be indispensable. The choice between methods for solution will continue to call for programming experts. And the understanding of problems in the real world in order to put them on computers will continue to require good programmers.

Edmund C. Berkeley
EDITOR



NEW DIRECTIONS FOR COMPUTER TECHNOLOGY AND APPLICATIONS . . . A LONG RANGE PREDICTION

Donald F. Blumberg
Director, Planning and Information Systems
Pennsylvania Research Associates, Inc.
Philadelphia, Pa.

Where do we stand today in the application of data processing systems? What is the future direction of the new technology of information processing?

These and other questions are often raised by the practical executive as he tries to obtain an over-view of the impact of computers and automation in today's economy. From the stream of announcements, claims, literature, and press releases one can be easily overwhelmed by the computer "revolution." The real facts are much less alarming. By and large, computers have been applied in a fairly evolutionary manner. Although there are now over 11,000 data processing systems installed in the United States, the great majority are operating on standard tasks of accounting and financial information processing. Most of these applications are not particularly advanced or sophisticated, and are functionally similar to the punch card tabulating (unit record) equipment which the larger electronic data processing systems replaced. Of course, some extremely advanced applications of data processing have happened, but these have generally been limited to applications in the government, scientific organizations, and large manufacturing firms. The great majority of smaller firms are just beginning to consider the use of EDP.

In fact, the last ten years have only served to demonstrate that computers can be built reliably and for just about any price. It has also been conclusively demonstrated that (through proper planning, careful analysis, and adequate implementation of the application) the data processing system can be an efficient, useful device. Just where do we stand today, and what can we expect tomorrow? We hope to answer these questions in this article.

General Trends in Computer Applications

The United States computer industry has been expanding rapidly since the introduction of commercially available equipment in the latter half of 1952. Some idea of the extent of this growth can be obtained by examining the market for data processing equipment and services during the period from 1953 to 1963 (Figure 1). Three historical trends deserve specific comment: (1) the interrelationship between the special military systems and standard computer systems market, (2) the growing market for data processing services, and (3) the underlying reasons for the apparently high rate of installation.

The military systems market has always been a keystone of the data processing industry's technological development. For example, military expenditure for research and development of advanced computer hardware and "software" to meet emerging military requirements has given a tremendous degree of technical impetus to the field through the years. Military requirements have also led to the development and implementation of a wide range of new applications for information processing. In addition, the Department of Defense (and other agencies of the Federal Government) are major users of commercial data processing equipment. Military procurement of complex weapons and supporting equipment has also led to growth in the utilization of computers in other sectors of the

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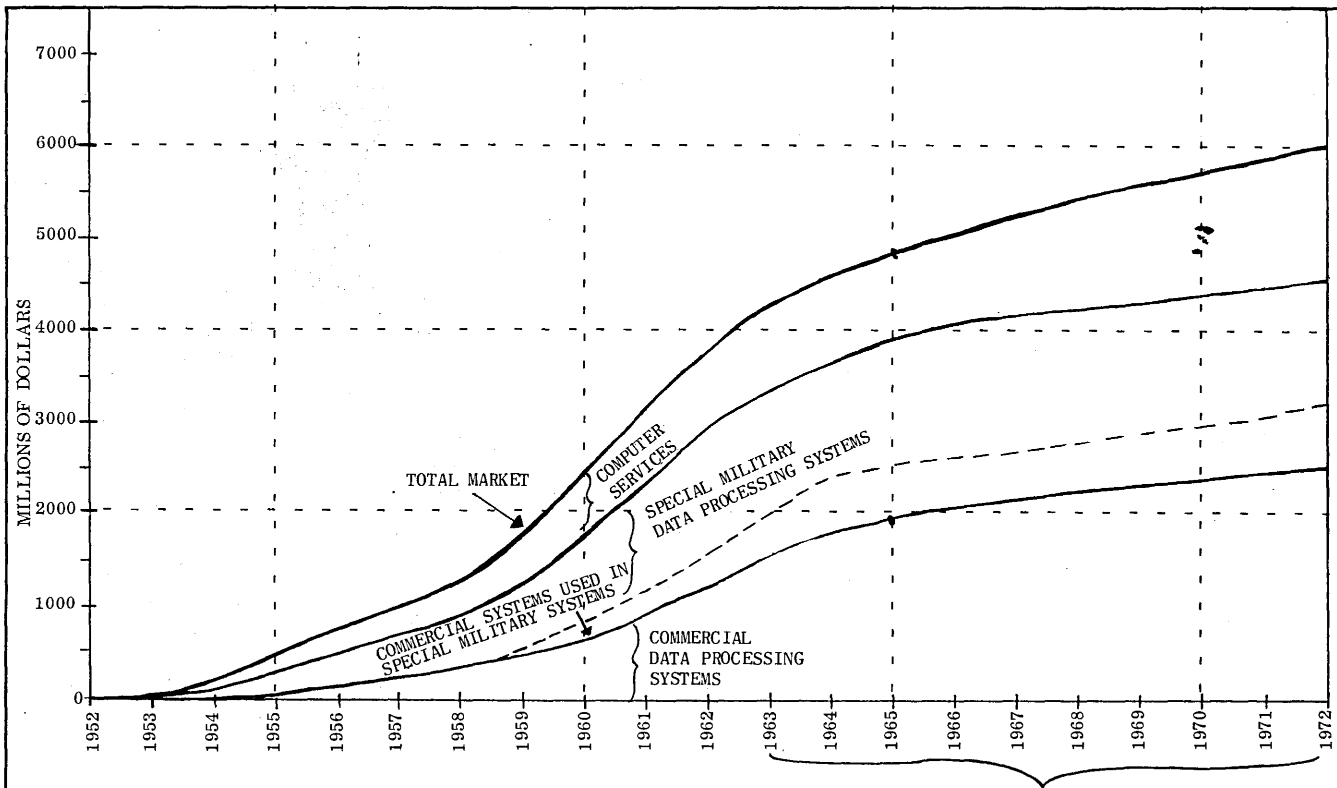

Figure 1. The Data Processing Market, 1952-1972

economy. For example, the large aero-space and electronic manufacturing concerns working on major government contracts have widely applied computing equipment in support of these government programs. Both directly and indirectly, the Federal Government's expenditures for goods and services formed the basis for a large number of data processing applications during the last ten years.

A second major trend which has occurred in the last decade has been the rapid rise in the development of computer services. In the initial stages, the data processing industry was concerned with the design, development, and production of reliable, efficient processing systems. It was believed that the user would easily develop and program his own applications once the machine was made available. With the appearance of a wide range of equipment, it became quite clear that problems involved in the development and programming of the application, and even the operation, of the data processing system could not be passed over lightly. The result was the creation of the new field of computer supporting and consulting services including:

- Applications analysis
- Development of computer programs
- Operation of the computer system, providing available processing as needed (e.g., EDP service bureaus)

This new field has grown to the point where the availability of these services can exert influence on the development of new applications. It is to the advantage of these newly created service organizations to continue to push forward the state-of-the-art, as well as the number of applications of computers. For example, many smaller firms have begun to apply data processing techniques in their operations using the local EDP service center. This avoids a major investment in a machine installation.

Finally, it is important to understand the underlying statistics in the installation rate of small, medium, and large systems over the last ten years. The major growth in the number of units installed since the 1956-1957 period has been due to small-to-medium computer systems. Large-scale systems installations have also increased, but at a much more stable rate. Small systems to date have been largely applied to accounting and administrative operations. A significant percentage of these applications have been upgraded *replacements* of existing punched card and tabulation installations, a fact which has not been widely publicized.[1]

The Present Structure of Computer Use in the United States

Although computers are to be found in almost every sector of the economy, their applications in specific sectors vary, depending on the nature of the problems to be found, the array of technological equipments available at any particular point in time, and the existence of application concepts which have been proved feasible. At present, the *Manufacturing sector* and the *Federal Government sector* of the U. S. economy are the largest single computer users among the ten major sectors of the U. S. economy. However, there is a difference in the degree of utilization of small-medium versus large systems in these and other sectors of the economy (Figure 2). These differences are caused by the variations in computer applications in each of the sectors, as well as the size and structure of each of the industrial segments. For example, certain segments of the economy are so split up that very few firms are big enough to support a large-scale computing

[1] This has been especially true in 1963 when thousands of IBM 1401 and UNIVAC 1004 systems were installed, replacing existing equipment installations.

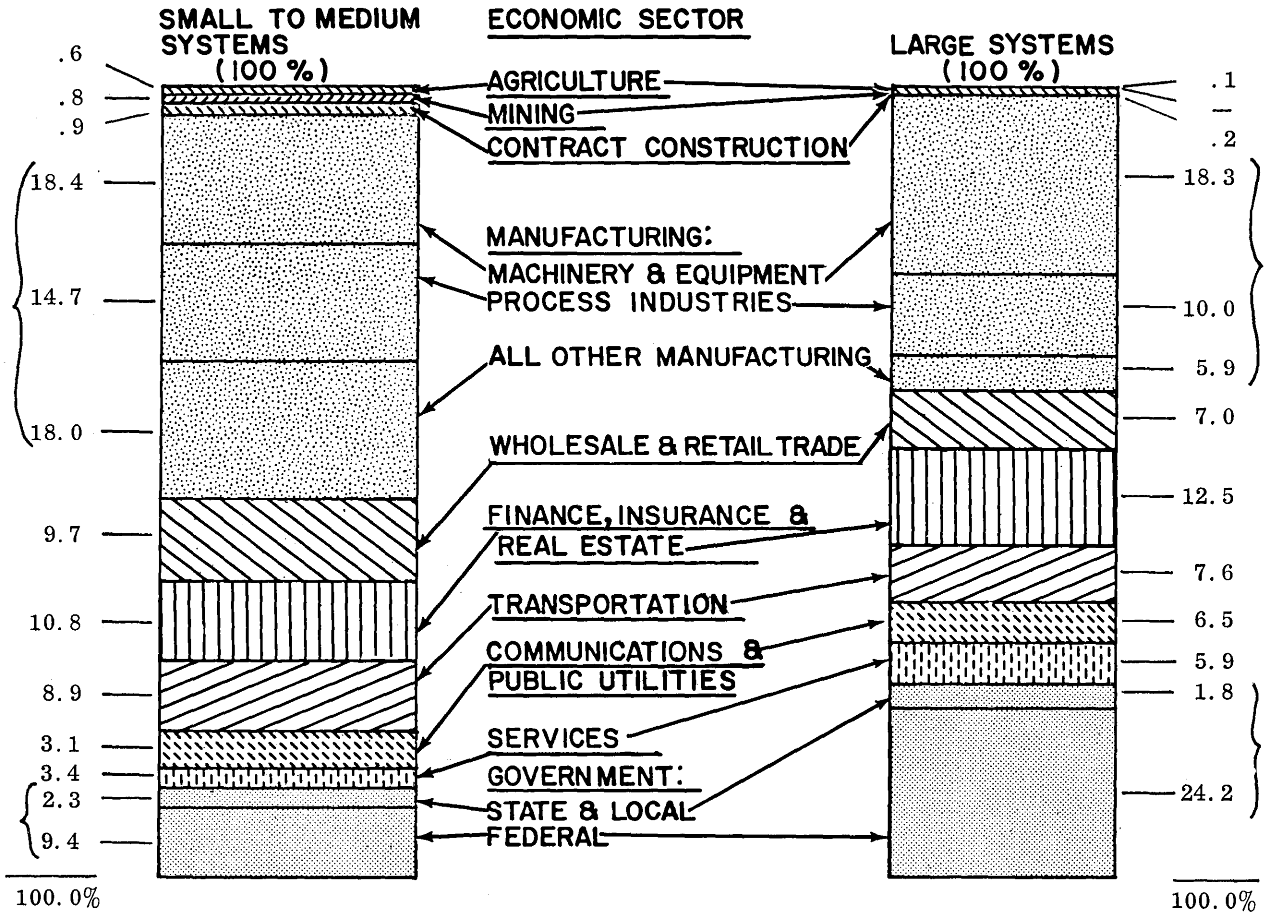

Figure 2. Present use of small-medium and large computer systems in the United States economy.

center. In certain sectors, the lack of appropriate, proved, computer-processing techniques or suitable equipment, has prevented the development of applications. For example, *Agriculture, Mining* and *Contract Construction* use data processing systems to only a limited extent. In these industries, most of the work is done in the field; and the lack of rugged, mobile computer systems that can operate under the usual field conditions have hindered the development of applications for these sectors. These industries also have a limited number of extremely large firms or organization units which can make effective use of large-scale processing systems. It is of interest, however, that the *Agriculture, Mining,* and *Contract Construction* fields have all been marked by extensive use of materials-handling automation.

The *Manufacturing* segment of the economy is the largest single industrial user of data processing equipment. Computers are utilized in a wide range of standard functional areas such as production planning, financial and account processing, warehouse and inventory control, and support of research and development data analysis and calculations. Computers are also being applied to real-time process control and numerical machine tool control.

Machinery and Equipment manufacturing forms a major sub-section of the manufacturing sector of the economy. This industry is composed of over 20,000 companies manufacturing a wide variety of mechanical and electrical systems. sub-systems and components, ranging from carbon resistors to huge hydroelectric turbines and airplanes. Computer use in this sector is extremely heavy for scientific engineering calculations, as well as for the standard business functions. This industry is also beginning to apply computer-assisted numerical machine-tool-control systems. Over 800 such systems are now in use for virtually all types of machine tools.

There are two types of numerical control systems:

- *Positioning or point-to-point control,* in which the tool, such as a drill, can be moved in a location or area, but cannot be angularly displaced: the path taken by the tool between successive points and the work piece is not a consideration.
- *Contour continuous-path control,* in which the cutting axis of the tool itself can be changed, under the direction of the tool's controller: the path taken across the work piece is subject to continuous precise control.

Although point-to-point numerical control systems can be manually programmed, in a significant number of applications the programs are prepared by an off-line computer. Numerically controlled contouring, however, does require a digital computer to provide for the preparation and coding of machine tool commands. Program-controlled, multi-operation machines may also require computers to coordinate their operations on a real-time basis. The application of numerical machine-tool control has increased with the development of standard automatic programs, such as APT and Autoprompt.

Process manufacturing industries are also large users of data processing equipment. For example, petroleum manufacturers were one of the first industrial groups to develop computer techniques for determining optimal blend ratios and to mechanize their billing and sales analysis operations. One of the most significant computer application areas in the process manufacturing industries at present is the development of computers for real-time process control. This application has been developing at a slower rate than was originally predicted, but the number of units installed is significant.

Process-control systems perform one or more of the following functions in the operation of a complete process:

- Data Reduction
- Data Logging
- Complete Data Control

If the system performs all three functions, it is termed a closed-loop operation. More than 50 closed-loop systems have been installed in the process industries, primarily for petro-chemical control applications.

The *Transportation Industry* as a whole has generally not been a major user of data processing equipment. Some of the larger railroads originally installed digital computers for accounting and financial operations, as well as for processing of freight traffic and rate calculations, in the late 1950's, but this application was never completely developed by the smaller railroad systems. More recently, railroads have been experimenting with digital data-transmission operations. However, the present unfavorable state of railroad finances has prevented any substantial development of this application.

The largest segment of computer users within the transportation industry today consists of the airline companies. Almost every major airline firm is developing, or has already installed, a mechanized airline reservation system to maintain automatic count of seat inventories and availability. Some of these systems are also used for processing flight forecasts, weather information, manifest and passenger lists, schedules of operations, and management control reports. Approximately 11 major airline reservation systems are installed as of the end of 1963.

The *Communication and Public Utilities* sector of the economy has also not made significant use of data processing equipment. Most of the larger public power utilities have applied data-processing equipment for accounting and billing. Some of these organizations are now either installing, or considering the installation of, systems for real-time control of load assignment and dispatching. The major communication firm in this country, American Telephone and Telegraph, has always made extensive use of special-purpose data-processing systems for switching and network control. These applications have generally been specially engineered devices, more often considered to be telephone switching and support gear than data processing equipment as such.

The *Wholesale and Retail Trade Sector* has been a fairly substantial, but not overly aggressive, user of small-to-medium-size computer systems. Most of these units have been installed in the wholesale segment of the industry, for inventory control and accounting operations. The automation of retail operations has been under consideration for several years, but most of these applications have been limited to the use of punched cards, punched tags and punched paper tape activated by cash registers as mechanized input/output devices. Larger department stores, as well as major mail order houses, are users of data processing equipment for a wide variety of functions, including billing and accounting, integrated order processing and warehousing inventory control. However, a wide range of retail organizations in this country have not been affected by the application of data processing equipment. Some consideration has been given to the mechanization of the check-out operations in supermarkets with complete sales information prepared at the check-out station and transmitted directly to a control data processing system; but this did not prove to be an economical application. The application of a digital computer system to maintain credit references on all individuals in a regional area has been recently tested on the West Coast.

The wholesale and retail industries have been slow to apply data processing techniques primarily because of the unavailability of equipment geared specifically to their economic and operational requirements. Those organizations large enough to support punched card tabulating equipment for their operations have recently turned toward the application of small-scale computer systems (such as the IBM 1401 and the Remington Rand 1004), but the wholesale and retail field remains an area where computers have not been applied rapidly.

The *Finance, Insurance and Real Estate Field* has been steadily applying the concepts of data processing technology to their operations. The *Insurance* field has been one of the most prolific users of data processing, with industry interest in computers, starting with the original UNIVAC development after World War II. The industry is a larger user of medium and large tape-oriented computers. *Banks* have also been stepping up their application of computers, primarily for real-time systems in support of savings account operations. The applications of computers in the banks have been spurred by the development of Magnetic Ink Character Recognition (MICR) as a standard method of identifying and processing checks. Stock and commodity brokers have also been utilizing data processing equipment. Recently the major stock markets have begun to install large-scale data processing equipment to handle stock price changes and transactions.

The *Service Industries* have also begun to increase their application of data processing equipment in the last two to five years. An entirely new service of providing data processing facilities on call, has emerged. Mechanized credit bureaus and credit card operations have already been mentioned as an application area which has just started to develop. Hospitals have also begun to turn to the use of small-scale computers for accounting and billing operations, as well as for mechanized information retrieval and processing of clinical information. Information service centers are also now appearing, based on the application of digital computers and large capacity memories to provide efficient processing and retrieval of information of a specialized nature, for a fee.

The *Government Sector* has always been an extremely large user of data processing equipment, although state and local government utilization has been negligible. The Federal Government has applied computers to a very wide range of functional areas, from standard accounting to extremely complex systems for the processing of intelligence.

The range of applications of computers and the extent of their penetration in the U. S. economy is surprising.

An estimate of the present proportion of computer applications in the ten major economic sectors of the United States, is shown in Figure 3.

Basis for Long-Range Prediction

In the following predictions, we assume that existing general trends in the data processing industry as discussed above will continue. We also assume that there will be a continuation of the existing world conflict without any substantial lessening in tension. Therefore, we conclude that large military expenditures for technological development in the information technology field will be maintained. The Federal Government will remain a large supporter of the data processing industry, in terms of both research and development expenditures and investments in commercial data processing equipment in standard applications. We also assume that the basic structure of the United States economy will not substantially change in the next ten years. Methods of doing business will generally remain the same. Finally, we assume that data processing *services* will continue to expand, resulting in still greater pressure to develop new applications and software.

The computer industry will continue to grow in evo-

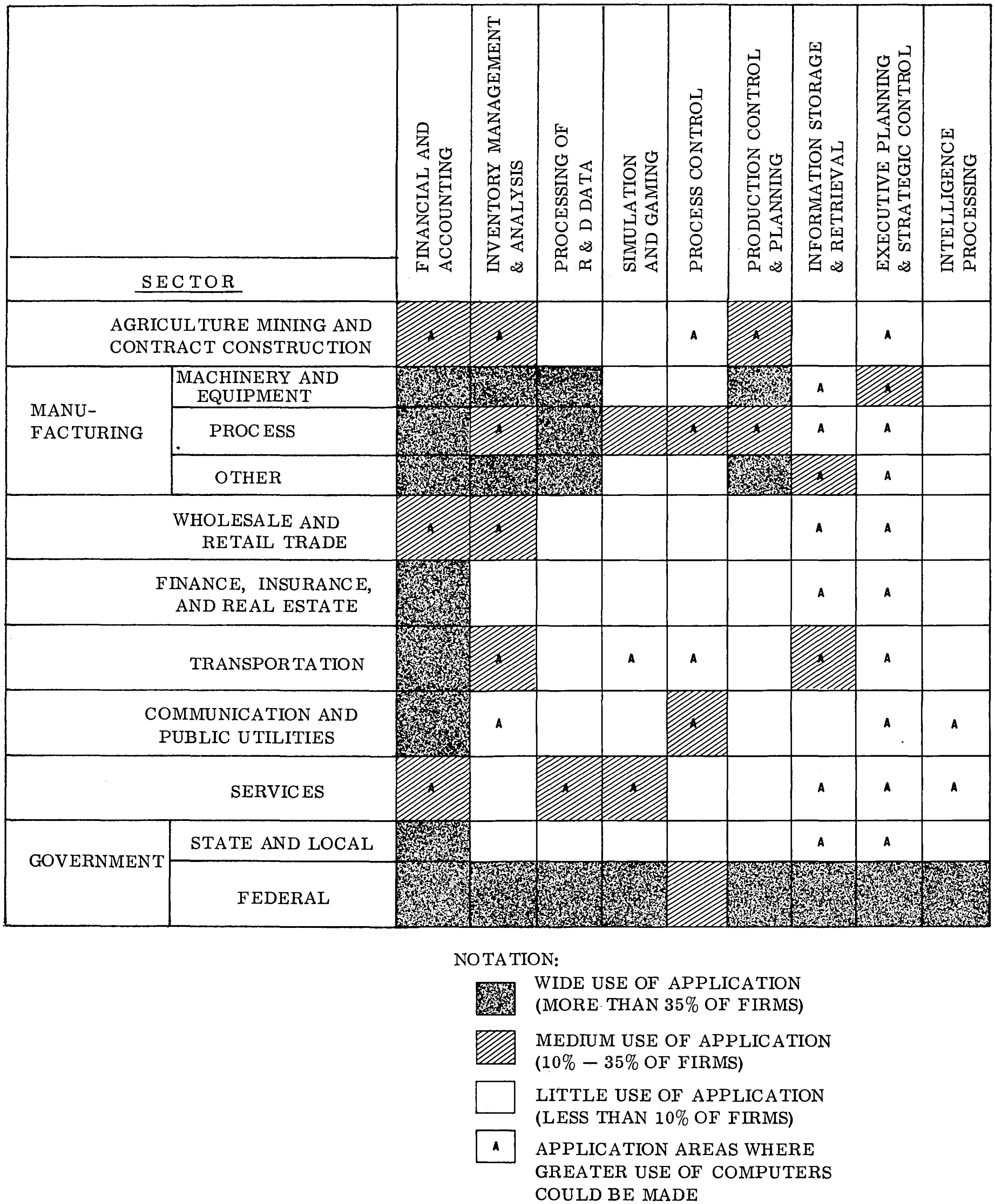

Figure 3. Computer Applications in Various Sectors of the Economy

We predict that the latter half of this decade will also see standardization of general equipment specifications. This has already taken place in some limited areas such as magnetic tape devices, where the desire for format and density to be "IBM compatible" has made it the accepted industry standard by default. For no better reason than weight of numbers, IBM equipment will probably become the guide line for general equipment standards in the industry over the next ten years.

A second major trend will be a continued de-emphasis of the main frame of the computer as the central design problem. Hardware has been continually decreasing in importance in comparison with software over the last ten years. With a slight excursion back to hardware considerations, due to the introduction of micro-electronic circuits in the mid 1960's this trend will continue. By the early 1970's we predict that most of the medium-to-large data processing systems will be generalized, being built up from several standard types of modules, including logic processors, input/output devices, and data storage devices, all connected by a central bus or matrix switching system.

The third major trend appears to be a continuing attack on problems of a qualitative nature, involving some degree of judgment. Those application areas were once thought not susceptible to automation; but we predict they will continue to be investigated as the industry searches deeper for new concepts, and to maintain its rate of growth.

In addition to these general remarks, we put forward some more specific predictions about new developments of interest, both in hardware and applications.

New Developments in Hardware and Devices

We can expect substantial technological improvements and developments in both computer systems and devices in the years 1964-1973. A host of new components and technologies will assist in making these developments possible. Among these are micro-electronics, lasers, and many electronic and electro-optical techniques for storing, scanning, retrieving, and extracting information from images and pictorial data. In fact, we predict that the very organization and structure of computer systems will change over the next ten year period, wiping out the present distinctions between small, medium, and large-size systems and creating two new classes of computers:

- Special-purpose direct digital-control computers
- "Very" low cost computing devices

The trend towards generalized modular-parallel computer systems will place an increased emphasis on input/output devices which can be tied to the system. Among these which will most affect the future of the computer field are:

- Data collection and transmission equipment
- Large screen and console displays
- Printing and copying units
- Optical character recognition and pattern recognition devices

Paralleling these trends in input/output, will be the development of much more efficient, very-high-capacity data and image memories. We are already beginning to see the introduction of extremely fast (nanosecond) random access storage devices, as well as units which can store and retrieve pictorial and image information. By the mid 1960's, content-addressable memories will become commercially available. By 1970 we predict the introduction of inexpensive, very-large-capacity, random-access storage devices.

Computer Systems

We can expect the following developments in computer systems design:

- The physical size of systems will continue to decrease with the introduction of integrated circuitry, and the switch from electro-mechanical to electronic I/O devices associated with the computer.
- Micro-electronic components will probably become cost-competitive with standard logic circuitry by the mid 60's, causing substantial repercussions in the structural design of medium- and large-scale computers. The first generation micro-logic computers may lean towards more mechanization of programs in hardware, and computers with FORTRAN-type and ALGOL-type logical packages may be an early development. However, by the late 60's this trend will be reversed as the applicability of micro-electronics is better understood and becomes extended to memory design.
- Parallel, modular computer systems, iteratively built up from a standard set of logical processor modules, I/O devices, and memories, will become the basic system of the late 1960's. The relatively simple modular logical processor will allow for far more flexibility on the part of computer manufacturers, more homogeneity in the hardware, and the beginnings of a catalog approach to computer purchase. The distinction between small, medium and large systems will be largely eliminated, and applications will be designed primarily on the basis of the number of processors, memories, and I/O required. Standardization in the industry will further limit the number of languages and hardware configurations available.
- There will be continued development of higher-level programming languages and executive routines, making the computer more accessible to the user. This closer man-machine interface will be further enhanced by the availability of displays, permitting continuous discourse and exchange between the man and the machine. This will also permit the application of open-ended programs, which operate on partial data, or incomplete and poorly detailed procedures.
- The mid 1960's will also see the emergence of very inexpensive computers renting for $150-350 per month. These units will be general-purpose stored-program digital units, similar, in many respects, to the logical-processor module used in the larger systems. The system will not have to be very fast since it will be primarily used as a (vastly more efficient) desk calculator with a stored-program memory. In most applications, the system would come preprogrammed, with a keyboard for entry of data and for the call-up of fixed subroutines. Four-address-instruction format with floating binary-coded-decimal capacity will probably be used for simplicity of programming at the expense of efficiency.

These systems will be used in such varied applications as:

- Maintenance of accounts and order processing in a small manufacturing firm or large retail store.
- Production planning and control in a small job shop.
- Engineering calculations in a small scientific lab, where a large computer is not economically feasible or easily accessible.

The late 1960's will also see the emergence of direct digital control systems, characterized by small word lengths (10 to 14 bits) internal analog-digital converters, and specialized operational codes. These devices should prove economical and competitive for the control of processes of 30 loops or larger, as compared to general-purpose digital or analog systems. Batch-sequence control systems, applicable to normal batch-sequence work, assembly-line control, automatic checkout, etc., will also be developed. These units will be character oriented, and will have extensive logical and bit manipulation ability but almost no arithmetic capability.

These devices will be installed in the process manufacturing industries, and will replace both the general-purpose process control systems and many of the analog devices now being used in these areas.[2]

Data Collection and Transmission Equipment

Only recently have manufacturers begun to make available standard devices for data collection, transmission, and automatic control and processing of multiple message channels. Through the late 1950's most data transmission was handled over teletype or telephone lines, and the only reliable standard item for digital data transmission was the IBM data transceiver. However, new equipment such as the GE Datanet 15 and 30, RCA's DASPAN, IBM's 1945/1946, and 7701/7702 series, and Univac's UNISET, coupled with availability of digitally oriented communication links such as Dataphone, have made digital data transmission practical.

We do not see any major technological breakthroughs in data transmission equipment in the next five years. However, there will be continued modifications and improvements in present equipment. Better error detection and correction features will be offered; line signaling and equipment synchronization problems will also be materially reduced. Digital communications services supplied by common carriers will also improve as the number of subscribers increases, and more efficient switching and store-and-forward systems are installed.

We also expect a variety of new data-transmission-oriented remote-collection terminals, including such items as keyboard printers with data buffers, card and stub readers, paper-tape and document readers, and magnetic-tape input and output devices. Voice encoders will probably also appear for limited applications by 1968. Perhaps the most important new development in data transmission in the next ten years will be the establishment of a universal transmission code. The American Standards Association's X3.2 Subcommittee has proposed such a code, which will probably be approved in its present or modified form.

There will be three major directions in the application of data transmission equipment:

- *Remote-Inquiry Data-Processing Applications,* using a central computing facility, tied by data transmission links, to remote locations or inquiry stations.
- *Computer-to-Computer Data Transmission* for load balancing, information transfer, and more efficient use of multiple computer facilities.
- *Store-and-Forward Communications Processors*—to control the flow of both data and administrative messages from a central computer processing facility or remote station, to a large number of other remote stations.

Large Screen and Console Displays

Large screen and console type displays will come into their own, in the coming decade. Many of these devices were built to satisfy military requirements in command control and intelligence applications but they are equally applicable in industrial management information systems. Console displays (generally an alpha-numeric cathode-ray-tube unit) take alpha-numeric and graphic information from a digital computer, providing a buffered input/output link between human operators and a digital processing system. A typical modern console display is Data Display Inc.'s DD 79 system.

Console-type displays will continue to improve during the 1960's. Most units will offer send and receive modes with the system, increased capability for generating complex line drawing and other graphic materials on the CRT face, and large capacity buffer memory associated with the display device. Some console display systems already provide direct interrogation through the use of a "light pen" or other indicating device, by which the display operator can directly query the EDP system.

We can also predict a trend toward lower-cost display systems. Most console displays now sell in the $50,000 to $100,000 range. The major percentage of this cost is generally due to the special-purpose features of the system. As the market for displays grows, the special features will become standard production items and we can expect the cost of a complete display system to fall to approximately $20,000 to $30,000.

Large-screen computer-generated display systems fall into four basic types:

- *Electromechanical Displays*—based on either a rotating disk, on which a series of symbols has been preprogrammed to be called up on command, or some type of stylus inscribing a picture on a semi-opaque medium through which light is projected.
- *Slide Projection Display Systems*—in which a slide is generated through electronic writing techniques, processed rapidly (from 5 to 30 seconds), and then projected on a large screen.
- *Refraction Display Systems*—in this approach, deformations or ripples are formed in a Schlieren medium by the bombardment of electron beams from a conventional electron gun. These deformations produce refractions, causing light to pass through an optical grating or set of diffraction bars to a screen. These variations create patterns of light and dark which are used to create the display.
- *Matrix Display Systems*—this uses a matrix of X and Y lines which are pulsed or triggered to produce a two-dimensional display pattern.

Continuing military requirements will result in further developments in large-screen display devices. Slide-projection displays appear to be the most reliable, and easiest to maintain, and will probably be used to satisfy most industrial requirements. Matrix display systems will probably appear as production equipment by 1968-1970. At present most of the matrix displays have been based on the technique of electroluminescence and have only been produced as laboratory prototypes.

We also predict the appearance of three-dimensional display systems in the 1966-67 period. Experimental versions of such devices have already been developed.

Printing and Copying Units

Most of the printing systems which have been utilized in data processing over the last ten years have been electromechanical. However the next ten years will see the development of a wide variety of printing and copying units based purely on electronic techniques. One example of this new trend is the number of digitally-oriented microfilm printers which have been announced within the last two years. These devices take the output from a digital computer, generate a tabular array or image using a cathode ray tube, and produce a microfilm slide of the image presented on the tube face. Improvements in image accuracy, precise positioning on the tube, and new developments in the optics of the photographic system can be expected. Using the slides or film produced from these devices, it is possible to prepare high-quality offset plates for large-volume printing.

[2] These concepts for direct digital control were originally presented by Mr. Boris Biezer, of Pennsylvania Research Associates, Inc., in a recent talk.

We can also expect dramatic new improvements in the field of electrostatic and Xerographic copiers. Office photocopying and microfilm equipment will be developed as integrated elements of a total information processing system, by the end of the 1960's.

Optical Character and Pattern Recognition

The character and pattern recognition field will experience major growth within the next ten years. Bank check processing through the use of MICR (Magnetic Ink Character Recognition) is now the accepted standard in every large bank in the country. Most credit-card operations are also using optical character recognition equipment for the processing of stylized and formatted information on the charge stub. We estimate that there are now more then 200 optical character recognition and document scanning systems installed or on order in this country. A significant percentage of these installations use Farrington equipment. It is interesting to note that Farrington has been the leader in providing systems suited for special-purpose applications, based upon the assembly of modular elements in different combinations.

However, the optical character recognition field is still in its infancy. After more than five years of research and development, it is still not feasible to read any arbitrarily selected typewritten document. The recognition of handwritten characters on a production basis is even further away. Character recognition developments can be classified into four major categories or approaches:

1. *Stylized-Font Readers*—including magnetic and phosphorescent inks, specially shaped characters, cut characters, etc. These systems are characterized by using two character representations: one which is read by humans and the other which is read by machine. There are many variations to this bi-lingual approach but their applications are fairly limited. This approach is the simplest of the four.

2. *Fixed-Font Readers*—including template matching peepholes, threshhold function weighting schemes, etc. These devices generally use some sort of masking techniques, either optical or logical, and perform the equivalent of correlation analysis of unknown characters to a stored library of recognizable characters. These systems are more flexible than the previous type, but are restricted to a few type fonts at present. More sophisticated versions of this class of system use diagram and word structure to resolve ambiguous situations.

3. *Topological-Properties Readers*—This class of system is based on connectivity and geometric characteristics of characters such as inlets, outlets, cups, caps, horizontals, verticals, crossings, etc. The elements of each character to be read are analyzed and these characteristics are then determined and identified through the use of electronic logic circuits. These systems are capable of handling a wider variety of correct (noise-free) fonts, but are troubled by specks or breaks.

4. *General Adaptive Character and Pattern Recognition Devices*—These devices function as self-organizing systems which intrinsically "learn" the properties of various fonts presented to them, abstracting from these the successful recognition criteria. This type of system is still primarily a laboratory device but offers the greatest flexibility for the future. It is the most complex approach of the four.

Thus, with the exception of *stylized font readers* which are fairly limited in application, and the *general adaptive character and pattern recognition* devices which are still in the laboratory stage, there are two major approaches to optical character recognition; *comparison techniques* involving template matching or map matching, and *topological analysis techniques* involving a logical examination of prime elements of a character to be read.

The military services have also been sponsoring a great deal of research and development in the field of pattern recognition, for applications such as photo interpretation and other military intelligence requirements. We presume that some of these new developments will find their way into the commercial market within the next five years. In addition, as optical character recognition devices become more widely used, experience will be gained in both how to recognize patterns and characters, and the heuristics of associating symbols and figures in order to arrive at a meaningful aggregate. We should begin to see material improvement being made in the efficiency of character recognition equipment in the years 1965-1968.

By 1970 we forecast that military impetus and the basic needs of the data processing industry will force the development and introduction of character recognition equipment which can process random typewritten documents and most printed material produced from known type fonts of standard size.

New Developments in Applications

The application areas discussed in previous sections of this article will continue to be developed over the next ten years. An examination of Figure 3 should give some immediate indications as to which areas will probably receive the greatest impetus. Planning and management control techniques will be among those key application areas at the top of the list for expected further development and expansion in the coming decade. Already a variety of techniques assist middle management to plan and control their day-to-day operations. PERT, PERT-cost, CPM, and RAMPS, are only a few of the many computer-oriented procedures which will be available to the manager in the future. The application of simulation and operational gaming will be further developed to provide a method for testing plan alternatives.

We will also see the development and application of alerting techniques—computer procedures and systems which alert top-level executives to situations which require immediate attention, and provide them with a method for extracting important and critical data from the sea of detail which exists in any large organization.

Information retrieval applications will also be developed at a fairly rapid rate. The larger technical and professional societies are already studying the applications of mechanized techniques for storage and retrieval of technical information. As outlined in the recently published Weinberg Report, the Federal Government will also be developing nationwide computer-assisted information services. Hospitals, credit bureaus, title search companies, and libraries are only a few of the areas where information retrieval applications will be developed in the coming decade.[3]

A third application area in which there will be continued development is industrial process control. Several firms are already investigating the application of special-purpose direct digital control systems and we expect to see a shift to this new application concept by the late 1960's, displacing the existing approach involving large, real-time, general-purpose computer systems.

[3] Look also for the appearance of low-cost systems especially designed for information retrieval applications. An example is the recently announced Recordak Miracode System.

New application areas which will be successfully developed over the next ten years, deserve special comment. These include:

- The Legal Field
- The Printing and Publishing Field
- The Medical Field
- Map Compilation, Production and Utilization

Each of these applications will be briefly discussed below.

The Legal Field

The next ten years will see an emergence of computer applications oriented toward the legal profession. Several study programs, including project "Lawsearch,"[4] work at the Datatrol Corp., and the American Bar Foundation Study of the application of computational techniques in retrieving new legislation information, are all aimed at developing advanced systems for legal information retrieval. The Health Law Center of the University of Pittsburgh, and Lawyers' Research Service, Inc. of New York City are already in operation, providing retrieval services in the legal field.

However, the most significant new development of computers in the legal field will be in an area other then information retrieval. In the next ten years, computers will be applied to *assist* the judiciary, legislators, and regulatory agencies in processing, evaluating, and analyzing complex cases and decisions. The Patent Office, the Department of Justice, and the Internal Revenue Service have already begun to explore the application of computers in support of their legal and regulatory functions. Roy N. Freed (a practising lawyer and specialist in the new role of computers in the legal field) has predicted[5] that computer simulation techniques will be used in such areas as:

- Pre-testing of proposed legislation
- Analyzing the effects of alternative regulatory decisions in specific situations
- Predicting judicial and court decisions as an aid to court scheduling, planning case strategy, and advising clients
- Processing of raw data and evidence, and presentation of factual data, in "big cases."

We predict that the Federal Government regulatory agencies will begin to explore this application concept, in earnest, within the next two years. The introduction of these new techniques on the Federal level will lead to the application of similar approaches for lawyers, legal firms, and state-local government agencies, before the end of the decade.

The Printing and Publishing Field

The printing and publishing field is another area destined for major change in the coming decade. Computer systems for automatic hyphenating, justification, and typesetting are only the first step in a long line of new developments which will substantially affect the printing and publishing field in the coming ten years. The first area of impact will be in newspaper publishing, where the speed and efficiency of a computer could offer substantial improvement over existing methods. At least nine newspaper publishing firms have already installed data processing systems for automatic hyphenating and justification. At least one (The New York Times) is publishing a satellite edition through the combined use of data transmission and automatic typesetting operations. As devices for optical character recognition, image processing, and information retrieval improve, we expect still further advances in the printing and publishing field.

The difficult union problems in the printing-publishing industry make accurate prediction based on technological factors almost impossible. However, we can probably expect the appearance of large printing centers in major metropolitan areas by 1967. These will probably be organized around an existing major newspaper or publishing plant. The introduction of extremely high-speed, flexible photocomposers and advances in offset printing will provide an economic motive for centralization. The high volume which can be handled by such automatic and semiautomatic techniques will materially reduce major components of the cost of printing.

The Medical Field

Computers will also be used to a much greater extent in the medical field. Machine-oriented systems for carrying out complex medical diagnostics have already been developed.[6] On the horizon are a large number of applications involving the use of simulation techniques in medical research. For example, models of the Krebs and Meyer-Embdenhoff cycles have recently been examined as possible candidates for computer simulation within the next two or three years. Machine systems are also being developed to process such diverse medical data as patient records and laboratory experiments. The late 1960's will see a substantial increase in the application of computers and information retrieval systems in large-scale (500 beds and over), general hospitals. Computer techniques for optimal scheduling of hospital facilities, and for the planning of complex surgery and medical care for individual patients are also being developed.

Finally, the large investment in medical electronics research made in the last four years will begin to pay-off in the mid 60's in a variety of new developments to assist both the doctor and patient.

Map Compilation, Production and Utilization

The entire field of map-making and use of maps will be dramatically changed by the introduction of digital techniques. Military requirements have exerted a substantial influence on the development of surveillance photography and reporting by other sensors, such as radar and infrared devices. This vast increase in the availability of raw source data has also caused an interest in techniques for automatic map compilation and production. Several experimental systems are now capable of taking an aerial photograph and, by digital methods, deriving the topography automatically. Techniques for storing map information in digital form have also been developed. Digital computers have also been applied to the problems of rectification and orientation, and to photographic interpretation. We predict that automatic, highly accurate systems for producing both topographic and planimetric maps from aerial photographs will be introduced by 1967. The maps prepared by these systems will be in either printed or digital form.

The availability of digitally-represented maps will also have a major impact on the large number of map users. Highway and construction firms, architects, and regional planning agencies are only a few of the industrial organizations where digitized maps will be of value. For example, highway planning will be materially improved through the availability of maps in digital form. A large number of

[4] Financed by the Council on Library Research and sponsored by three law book publishers, this project is being carried out by Jonker Business Machines, Inc.

[5] See Mr. Freed's excellent survey article "Information Processing in the Legal Field" in the 1962-1963 Data Processing Yearbook.

[6] See, for example, Dr. Keeve Brodman's article "Diagnostic Decisions by Machine" in IRE Transactions on Medical Electronics, July, 1960.

alternative routes could be analyzed in a relatively short period of time. Evaluation of traffic flow, land acquisition costs, cut and fill operations, bridging and overpass requirements, etc., could be carried out in parallel in order to select the optimal route.

We also predict the development of a number of new applications based upon the availability of map information and notation in digital or printed form, during the next ten years.

Some Conclusions

In the previous sections we have attempted to provide a concise view of present and future developments to be expected in the data processing field. In a short discussion like this one, many less important predictable developments in the next ten years have been omitted.

The data processing industry will be moving from adolescence to maturity during the next decade. We believe that the next ten years will be marked by a much greater degree of sophistication on the part of the users. Simply producing a computer will no longer guarantee to a manufacturer a competitive position; instead, manufacturers will be faced with the more difficult problem of developing efficient uses for new computational power.

The industry will also be forced to give some serious consideration to the social implications of the computer field, both for the economy as a whole, and in the computer industry itself. For example, we are training large numbers of technicians, programmers and coders to satisfy present needs. Unfortunately this training has been in terms of fragmented specialties. As software standards are developed, and more efficient natural-language compilers and programming systems are made available to the public, we may find that large numbers of programmers will be forced into technological unemployment such as has been created in other areas of the economy. The social values and contribution of the computer industry to the United States economy as a whole will depend upon a coordinated and mature approach by the computer industry to the problems of technological unemployment and disturbance. A most desired long-range development in the computer field will be the emergence of a social conscience.

In summary, we predict that the emphasis on specific hardware developments which marked the last ten years, will give way to a greater focus on new and advanced applications. Hardware will become less important as systems become more parallel and more modular—capable of being organized to fit any given application. New computer techniques will be developed to assist in areas once considered to be purely judgemental in nature. Finally, the cost of a unit of computing power will be reduced, providing still more segments of our economy with the new tool of information technology. Our success or failure in handling this new power for social good will constitute one of the central issues of the next decade.

CALENDAR OF COMING EVENTS

Jan. 7-9, 1964: 10th National Symposium on Reliability & Quality Control, Statler Hilton Hotel, Washington, D. C.; contact B. W. Marguglio, Fairchild Stratos Corp., Hagerstown, Md.

Jan. 30-31, 1964: Annual Computer Applications Symposium, LaSalle Hotel, Chicago, Ill.; contact Milton M Gutterman, IIT Research Inst., 10 W. 35th St., Chicago, Ill. 60616.

Feb. 3-7, 1964: ASTM International Conference on Materials, Sheraton Hotel, Philadelphia, Pa.; contact H. H. Hamilton, American Society for Testing and Materials, 1916 Race St., Philadelphia 3, Pa.

Feb. 3-7, Mar. 2-6, Apr. 27-May 1, 1964: Courses on Audit and Controls for Electronic Data Processing, American Inst. of Technology, Phoenix, Ariz.; contact Harold Weiss, Director, Computer Institute, The American Institute of Technology, 1100 N. Central Ave., Phoenix, Ariz. 85004

Feb. 5-7, 1964: 5th Winter Conv. on Military Electronics (MILECON), Ambassador Hotel, Los Angeles, Calif.; contact IEEE L. A. Office, 3600 Wilshire Blvd., Los Angeles, Calif.

Feb. 10-14, 1964: 6th Institute on Information Storage and Retrieval, The American University, 1901 F St., N.W., Washington 6, D. C.; contact Marvin M. Wofsey, Asst. Director, Center for Technology and Administration, The American University, Washington 6 D. C.

Feb. 19-21, 1964: International Solid-State Circuits Conference, Sheraton Hotel & Univ. of Pennsylvania, Philadelphia, Pa.; contact Howard Parks, Martin Co., R & AT Dept., Mail 683, Baltimore 3, Md.

Feb. 26-28, 1964: Scintillation and Semiconductor Counter Symposium, Shoreham Hotel, Washington, D. C.; contact Dr. George A. Morton, RCA Labs., Princeton, N. J.

Mar. 23-26, 1964: IRE International Convention, Coliseum and New York Hilton Hotel, New York, N. Y.; contact E. K. Gannett, IRE Hdqs., 1 E. 79 St., New York 21, N. Y.

April 7, 1964: Control Data 160 and 160-A Users Group (SWAP) Meeting, Hilton Hotel, Albuquerque, N. M.; contact J. L. Tischhauser, Organization 7242, Sandia Corp., P. O. Box 5800, Albuquerque, N. M.

April 8-10, 1964: Control Data Large Scale Computer Users Group (CO-OP) Meeting, Hilton Hotel, Albuquerque, N. M.; contact J. L. Tischhauser, Organization 7242, Sandia Corp., P. O. Box 5800, Albuquerque, N. M.

April 13-15, 1964: 3rd Symposium on Micro-Electronics, Chase-Park Plaza Hotel, St. Louis, Mo.; contact H. H. Margulies, P. O. Box 4104, St. Louis, Mo. 63136.

Apr. 20-22, 1964: Univac Users Association Spring Conference Meeting, Sheraton-Chicago Hotel, Chicago, Ill.; contact David D. Johnson, UUA Secretary, Ethyl Corp., 100 Park Ave., New York 17, N. Y.

Apr. 20-24, 1964: Institute on Research Administration, The American University, 1901 F St., N.W., Washington 6, D. C.; contact Marvin M. Wofsey, Asst. Director, Center for Technology and Administration, The American University, Washington 6, D. C.

Apr. 21-23, 1964: 1964 Spring Joint Computer Conference, Sheraton-Park Hotel, Washington, D. C.; contact Zeke Seligsohn, Pub. Rel. Chairman, 1964 SJCC, 326 E. Montgomery Ave., Rockville, Md.

Apr. 22-24, 1964: SWIRECO (SW IRE Conf. and Elec. Show), Dallas Memorial Auditorium, Dallas, Tex.

May 5-6, 1964: 5th National Symposium on Human Factors in Electronics, San Diego, Calif.; contact Wesley Woodson, Convair Astron. Div., San Diego, Calif.

SOFTWARE TUTORIAL

THE ANATOMY OF AN ASSEMBLY SYSTEM

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The editors are pleased to offer the first installment in a series of articles on aspects of computer programming and other phases of software . . . written with the information needs of management, and other non-software specialists in mind.

From the beginning, the major drawback to computer application has been more intellectual than technological. How do you program a machine? That is, how do you express instructions or commands to a computer so it will perform the required operation?

Essentially, man-to-man communication is much cheaper and easier than man-to-machine communication. Man communicates with words or symbols. A computer cannot understand words or symbols; they first must be translated to machine language.

This presents both a conversion and an interpretation problem. A single word between humans may be equivalent to thousands of machine instructions; a few seconds of verbal explanation to a human may be equivalent to hours of explanation to a computer. The explanation to a computer must be achieved in economic terms which make it feasible to use the machine.

While it is possible to convert manually the necessary procedures or formulas to machine language—i.e., to write out the hundreds of detailed statements specifying each operation and the storage locations of data to be acted upon—this is almost always too time consuming to be of any practical value.

Programmers today by-pass this situation through the use of intermediate "translating" systems. These are automated procedures which enable the programmer to write in a language more closely approaching his own, and then have that language translated by the computer into machine language.

By doing this, the programmer is able to simplify the writing of instructions in three ways: First, operation commands can be written in codes that closely resemble the actual English word describing the action. For example, getting the computer to read a punched card is coded mnemonically "R," while the machine's operation code is actually "1." Second, the computer, rather than the programmer, keeps track of the placement of instructions and information in storage. Third, the programmer enjoys the ability to refer to data by name, rather than by storage location when he is writing his instructions. The computer substitutes the actual location for the name during the translation phase.

Like direct machine-language programming, however, the terms of expression must be precise in the way they describe the given procedure to the computer. These near-English statements must convey exactly what the computer is to do.

Actually, the writing of these instructions for a problem, called the *source program,* is a compromise between (1) the way the programmer desires to write, (2) the design and organization of the computer system, and (3) the requirements of the procedures to be expressed.

The language of this source program may be either procedure-oriented or machine-oriented. If procedure-oriented, the language is independent of the computer and can more closely approximate the everyday language of the user. If machine-oriented, the language is generally related to a specific data processing system.

To change (translate) the source program into machine language (the object program) calls for the use of a processor or translator. This is a separate machine-language program which automatically converts the source program into machine coded instructions, assembles the instructions into a completed object program, and, if required, makes storage assignments. Once developed, the object program then can be used by the computer to actually work the problem or problems.

Actually, there are two basic types of translators: Assembly Programs and Compilers. An assembly program is essentially a one-for-one translator; that is, for one source-language instruction which the programmer supplies, the translator produces one machine-language instruction. A compiler however, performs a one-to-many translation. In other words, one statement in the compiler source language results in one *or more* machine instructions.

Assembly Programs

An assembly program's major functions are (1) to assign storage locations to symbols and (2) to supply actual operation codes for symbolic ones. While it is not necessary to know numerical codes, it is necessary to know what operations are in the machine's vocabulary and how these operations manipulate the data. To obtain a product of two numbers, for example, the programmer must know that (1) a number must be placed in the multiplier-quotient register, (2) a multiplication by the second number can then be called for by an instruction (and there might be a choice of several multiply operations which the machine understands), and (3) the product is in a particular register after the multiplication, and can then be stored.

For an assembly program to have the information it needs to assign locations, interpret symbols and "know" how and when to perform its "extra" duties, a source language includes operation codes for which there is no corresponding machine code. These are called "pseudo operations" and each is meaningful to the assembly program.

These pseudo-operation instructions are the one exception to the rule that an assembly program generally produces one machine instruction for each source-language instruction. Some, such as an instruction that a particular subroutine be included in a program, cause more than one machine instruction to be included in the object program; others, such as a request for reserving a block of storage, cause no instructions to be generated.

A sub-routine is a sequence of instructions to perform a specified operation. Some sub-routines are parts of a program which are used repetitively within the same program —discount calculation, for example, for each transaction item in a billing operation. Others, such as end-of-job, may be used only once in a given program, but they can be used in more than one application area.

Other features generally included in an assembly program are:

1. Provisions for arithmetic in the symbolic instruction. For example, an instruction TRA HERE + 2 would result in a transfer to location 00102, "HERE" being the symbol for location 00100. This is referred to as relative addressing.
2. Ability to rename a symbol. This is convenient when a portion of an existing program is included in a new program. What is RATE in one might be SPEED in the other.
3. Conversion of constants into a different number system (especially important for binary machines) where a programmer wishing to use the constant 85 would otherwise have to supply its binary equivalent.
4. Provisions for the necessary linkage for sub-routines.
5. Ability to create a listing of the object program with symbolic instructions, the assembled object program, and any comments the programmer cares to jot down.
6. A list of errors, such as improper use of symbols or meaningless (illegal) operation codes.

How an Assembly Program Works

The assembly program is supplied to the computer with a source program containing near-English operation codes and symbols to represent the data. The assembly provides the computer with a table containing the acceptable near-English operation codes along with their equivalent machine codes.

Each statement of the source program is examined sequentially. To produce the object program, the operation code of each of the source program statements is compared with the operation code table and its equivalent machine codes is inserted in the machine program. If the source program contains an operation code not listed on the table, an error listing is made.

The assembly program must create a table of the defined symbols in the source program and count the storage addresses sequentially. As each symbol is examined, it must be checked to see whether it has been used previously. If it has been used previously to mean the same thing, then the same address will be assigned to the symbol. However, if the symbol has been used previously with a different meaning, a listing then must be made of this error. Each new symbol added to the table increments the address counter.

When a pseudo-operation is encountered, a count is made to determine the amount of memory space that should be reserved to include the constant or incorporate a sub-routine.

Memory assignments are computed from the counts made of storage addresses. The object program is completely assembled after the constants and sub-routines have been entered into the storage reserved for them.

As a final step, cards are punched containing the object program.

This simple assembly program, in total, requires that the computer be supplied with a source program, an operation code table, necessary sub-routines, and constants. The assembly program then must translate both the operation codes and symbols, select sub-routines and constants, and assign memory locations.

In the more advanced programming systems, the programmer is not required to define a symbol the first time he uses it, but supplies definitions which are part of his program after specifying the operations he wants to perform. After a first analysis of the source program, each instruction must be re-analyzed to incorporate the data the computer acquires when it analyzes the definitions.

Assembly programs, it should be clear, are an inherent part of even the most sophisticated programming systems.

Compilers

A compiler, as mentioned previously, generally performs more than one statement per instruction. This means that one statement in the compiler source language results in several machine instructions. The individual statements in the source program which produce these multiple machine-language statements are called macro instructions.

A macro instruction is a method of describing, with a one-line statement, a function to be performed by the object program. This function will normally involve more than one machine-language instruction. A macro instruction does not indicate *how* the function is to be performed by the object program; it merely indicates logically *what* is to be done at this point in the program. In effect, when he writes a macro instruction, he states logical procedures that will, when compiled (or translated), cause the appropriate machine instructions to be generated. The planning of specific routines to perform certain procedures is done by the compiler with much greater clerical accuracy than the programmer could expect of himself, and he is assured of "operative programs."

By contrast, the use of a symbolic language and an assembly program requires that the programmer know not only the logical arrangement of his program, but also exactly how to manipulate this logic within the machine.

Because a compiler is further removed from machine language, it must do more work than an assembly program in producing an object program. Compilers, then, are generally more complex and require more machine time for translation than assembly programs. It is best to assign as much of the programming task to the machine as possible, rather than to the programmer.

The Operation of a Compiler

A compiler language consists of names, actions and rules. The actions may be either arithmetic or functional; the names correspond to the data names used as input. There are certain rules, however, that the programmer must observe in expressing the action he wants his object program to accomplish.

A compiler must translate the source language statements into a form similar to that required by an assembly program. In doing this, it is necessary for the compiler to scan the source program character by character, recognizing significance in certain characters or in certain character combinations. Consider the statement:

COMPUTE DISTANCE = RATE * TIME

A given compiler might read and save the character C, then the character O, and each character up to the blank, which signals that it has reached the end of a word. Taking the characters in combination, it searches a table of verbs it is supposed to know. There it finds COMPUTE, which, according to the rules, should be followed by a name, which, in turn, will be followed by the character =, which will then be followed by an arithmetic expression. (The programmer has been obliged by the rules to follow the sequence.) The compiler continues the scan, acquiring the valid noun DISTANCE and then the expected =. Now, it is prepared to encounter the arithmetic expression. Attaching no special significance to the character combination R-A-T-E, the compiler assumes it to be a name and puts it in a name table. Now it recognizes the asterisk as the multiply symbol by scanning its table of operations. Suppose when it has collected that name TIME, that it finds this is already in the name table; the compiler assumes this is another reference to the same value and does not insert it again. A further scan shows this is the end of the statement. The compiler must then generate the instructions to perform the designated function. The output of this phase is referred to as a macro definition.

For every macro definition that will be developed from a macro instruction, and that will ultimately be written in the compiler itself, there is a separate instruction sequence (within the framework of the compiler itself) called a macro generator.

The macro instructions exist in anticipation of the most commonly needed functions of a user's program. For example, it is anticipated that a user will want certain arithmetic operations, or comparison operations, or input/output functions to be performed in his program. Macro generators performing these functions are included on the library tape and the rules for using the macro as part of the programming language are prescribed.

While most compiler systems allow a powerful range of macro instructions to handle most programming situations, a situation may sometimes arise where a unique and unusual type of operation is to be performed with a fair amount of regularity. For situations of this nature, some compiler systems allow the user to insert macro generators of his own into the compiler system library.

The task that a generator performs can vary from a very simple to a fairly complex analysis, depending on the nature of the variations permitted in the use of the macro statement. The kind of coding that is produced can also vary from a standard set of instructions to a custom-made routine for a very complex statement.

To illustrate what is, for the computer, a simple task, a portion of the program sequence may be given a specific symbolic name and left blank until the coding for a *standard routine* has been generated. These macros which cause standard routines to be placed in appropriate holes in the subsequent routine are called substitution-type macros. In the generation of these standard routines, skeleton instructions in a certain order are obtained from a table which is part of the macro generator. Variable information which is generally specified by the programmer as the operand of the macro instruction is then inserted into the skeleton program. The variable information which the programmer supplies for a standard routine must always be of a particular form, with a specific number and kind of operand entries.

A generator, while the basis of a macro compiler language, is only part of the total compiler system. Generators are used in a specific phase of the compiling process. To illustrate, a simplified flow chart of the scheme used in one compiler system is shown and explained in the following paragraphs.

Phase 1: Edit Source Program.—The primary purpose of this first step in the compiler process is to prepare the individual source program statements for translation. Each statement record is labeled to indicate the type of statement and its place in the source program. Some preliminary checking is done to make certain that the rules for the use of the language have been followed. Finally, each statement is arranged into a new record format required by the next phases. Macro statement records are written on one tape for input to the macro generation phase. Statements originally written in symbolic assembly (one-for-one) language go on another tape for input to phase 3.

Phase 2: Macro Generation.—Inputs to this step in the compiler process are the macro statement records and the library of macro generator programs which interpret them.

Before interpretation of the macro statement records begins, they are sorted by macro code (for example, ARITH, COMP, etc.) so that all like statements are together. This eliminates the need to search the library tape for the proper generator each time a new statement is processed.

As soon as the sort is completed, the first macro statement record is read and the corresponding generator program brought into storage. This program then takes control, analyzes the statement, and generates the sequence of symbolic instructions called for.

It should be noted that the generator programs are designed to produce the most efficient instruction sequence for the particular operation specified. For example, the number, type and sequence of symbolic instructions which result from the interpretation of a COMP (compare) macro are not always the same; they depend on what items the macro statement said were to be compared and what action is specified as a result of the comparison.

Each macro statement is treated in a similar fashion in sequence, new generators being brought into storage as required.

This phase of the compiling process looks for other types of errors in the use of the language and produces an error message when one is detected.

The output of this operation consists of the symbolic statements resulting from the generation process, each appearing as a separate record properly labeled (as in phase 1) to indicate type and location in the program. These are sorted as a final step to return them to original program sequence.

Phase 3: Symbolic Assembly.—Taking the symbolic statement records from phase 1 and 2 and merging them into program sequence as they are processed, this phase produces the object (machine-language) program following the assembly program procedure.

computers and automation

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The index this year for Volume 12 contains over 1600 entries. This index includes all the issues of Volume 12 (1963). Each item printed has been indexed under author, title, and main words of subject. The last part of each entry gives: volume / number (month of issue), page number.

If any reader finds any errors in this index, we shall be glad to publish corrections.

CONSIDERATIONS IN COMPUTER DESIGN —Leading up to a Computer Performing over 3,000,000 Instructions a Second (Part 3—Conclusion)

James E. Thornton
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Control Data Corporation
Chippewa Falls, Wisc.

(Continued from the December issue of **Computers and Automation**, page 25)

Up and down

I can't leave the subject of time without including up and down time. Machines are subject to an imperfection never quite so small as to be neglected. To be sure, methods are available to make this bearable.

Time plays a part in these methods. Aging of components is no longer a primary factor in machine failures. Preventive maintenance allows the machine to be exercised under stress and under critical examination. For such examination to be critical the engineer must have enough time to thoroughly test each element. Here is where the very fast computer really shines. Many more trials may be made in a period of real time than with slower computers. Failure may be stated as a statistical function of the number of trials. *One* failure of a device labels it as faulty but may not be enough to discreetly identify the culprit. Several errors under the critical eye of the maintenance engineer may suffice to identify it. Therefore, the higher rate of trials in real time distinctly improves the maintenance. Axiom — faster computers are more reliable.

LOGIC AND NUMBERS

To a logician, most deductive reasoning can be formulated with symbols and rules very similar to mathematics. In fact, arithmetic could be described as the set of laws governing the logic of numbers. Numerical computation is the logical manipulation of that class of symbols called numbers. Computing machines, of course, are constructed to obey the rules of arithmetic. A common understanding about these machines is that their basic elements are *arithmetic* in nature. Such is not the case. The basic elements are only *logical* and must be especially interconnected for arithmetic.

The machines contain wired-in deductions concerning the beginning arguments. The "wiring-in" is accomplished according to a generalization (about the numerical rules or other logical rules). The deductions are certainties arising from this generalization. By appropriate experiments, the deductions may be tested, with the resulting confirmation or rejection of the generalization. Since the rules governing the wired-in logic of the machine have been fundamentally arithmetic, the confirming experiments are well known. In fact, the generalizations made in the first place are well known and proven.

To be certain

The procedures for using the machine are also based on a deductive method. The factual certainties arising from these procedures are also subject to confirming experiment. The machines, one could say, must first be tested and proven; then the use must be tested and proven. Since the principal use of computing machines has been arithmetic, the problem analysis and the method of solution lend themselves to reasonable test.

Of course the machine can be turned around and used to perform the tests itself. Assuming the wired-in logic is entirely confirmed, the machine may test the proposed use by solving an experimental problem and comparing with a known answer. The solution is found by an organized program of basic machine steps. We stipulate here that the basic steps are proven. Therefore, the experiment should show that the program represents an accurate and correct generalization of the solution. If the test fails, some aspect of the generalization (or its specific embodiment in the program) is rejected.

There are two points of view about this facet of computing machines. The less there is wired into the machine in the way of logic, the more freedom there is for the programmer. On the other hand, with little wired-in logic, the chance for error (of a logical kind) is greater. I suppose this will be subject for argument forever. The current practical solutions contain a minimum of wired-in logic. The principal reasons for this cover areas such as: inability to provide a universally acceptable higher level of logic, substantially longer development periods for confirming the logic, and simple economics of the extra hardware. None of these need be a permanent deterrent to more internal logic.

What has happened in recent years is an attempt to establish this higher level of logic or reasoning by means of *program* organization. Deductive reasoning demands unambiguous symbols and words as well as the grammatical rules of language. Actually, some of the reasons why higher levels are not built in the machines apply to the programming as well. There is a chaos in the present-day universal languages. The development periods for the programs are fully as long as for the basic machine. Huge expenditures of time and money have been made for the effort. Perhaps a look at the logic already built into a modern computer would help.

You pick yours . . .

The fact that computer circuits are more logical than arithmetic is of considerable interest to the student of artificial intelligence. To the engineer, however, the circuits reduce to a very basic switching logic. In this form, open and short circuits represent the arguments and deductions. Electrical current is made to flow (or not) in resistance by the action of transistor switches. The resulting voltage causes other switches to close (or not). Combinations of switches cause various results. These combinations remain fairly simple since the electrical constraints, along with speed losses, limit the kind and number of interconnections. Being simple, the combinations lend themselves to proof by truth tables. This is a form of symbolic logic itself in which initial conditions are the coordinates of a table and the results fill out the table.

Simple combinations can be wired and connected end to end in sufficient chains to form a complex logical combination. The number of combinations possible increases rapidly with each added link in the chain. In order to perform simple arithmetic on whole numbers, those logical combinations are selected which obey the rules of arithmetic. It is entirely possible to construct logic for any known number system. However, the binary-octal system is formed by the simplest logical combinations of switches, and this is the most commonly used system inside the computer. Converting between number systems is a logical operation which can be built into the machine. This particular question is determined by the designer with most regard to the average time wasted in a computation converting and re-converting between the internal number system and the external. In some cases, the total time thus spent has been demonstrated to be so high as to warrant use of the external system (usually decimal) internally as well. This is a fairly good example of the selection of wired-in versus programmed logic.

. . . I'll pick mine

It is, of course, necessary to deal with numbers other than whole numbers, for example, fractions. It is necessary to mix, group, and compare numbers in more and more complex ways. Especially in solutions of scientific problems, the range of magnitudes is enormous and not very predictable. For these problems a logarithmic arithmetic is best suited. In modern scientific computers this is called floating point arithmetic.

There are a number of varieties of floating point methods, being different by the superficial detail, rather than fundamentals. Although this kind of arithmetic is a good deal different from simple integer or fractional arithmetic, these can be usually computed in the floating units.

The typical scientific problem is solved by repetitive steps involving intermediate and partial answers. As the problem solution progresses, the error in defining the original numbers is increased by the errors involved in each arithmetic step. This doesn't mean that the deductive logic of the machine's circuits have somehow produced uncertain answers. At the level of the circuit logic, the answers are still certainties. However, in interconnecting by wires and by program steps the floating point operations, an interesting limit occurs. It is possible to manipulate numbers within the machine of a certain maximum size, or number ot digits, that size being limited by the size of register built into the machine. Numbers can therefore be introduced with a limit on the number of significant digits and thus with an error of something less than the least significant digit. This error is real and can contribute measurably to the accuracy or significance of the answer. For example, it is entirely possible for a long series of arithmetic steps to accumulate an error so large as to completely obscure and invalidate the answer.

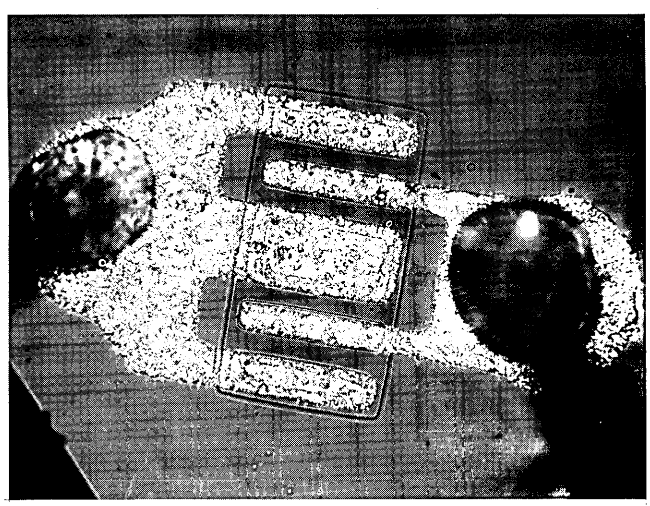
There are methods available for minimizing this sort of floating point loss of significance and accuracy. They range from well accepted methods to quite radical techniques. It must be the designer's duty to provide for as many of these techniques as possible without loss of convenience or speed. This is a good example of a very difficult selection of wired-in versus programmed logic. The logical methods available to the designer are fixed by the nature of the circuits he uses. These are usually of a very simple kind, and he is required to work at the most basic level. It is a tedious hand job, especially as the complexity of the circuit modules increases. There are no barriers more positive to the computer engineer than his use of the last connector pin or transistor location. Fitting the hundreds of thousands of elements together in a sensible array demands a sensible plan.

It can be stated with assurance that the optimum amount of built-in logic will be subject of heated argument. In order to be completely flexible, some convenience and speed must be sacrificed. In order to aim at a higher efficiency in some area, other areas may suffer or be completely ruled out; hence, limiting the general-purpose aspect of the machine. As a matter of fact, though, these thoughts apply to the program standards as well. In order for machine languages to be thorough and efficient, some loss in flexibility will be apparent.

The modern computers have provided a few higher level built-in operations along with the basic ones, most notable being the floating point. The risks in going further are very great. One of the few criteria which makes sense is the computing speed per dollar of cost. The larger the computer, the more freedom there is to include extras. However, it is important to realize that the very large economy-size computer is not feasible unless the user gets large economy.

OF PARTS AND MECHANISMS

In this industry, progress has kept moving with little advance warning of new directions. The lure of profit stimulates innovation, and the spur of competition forces the early arrivals to defend their positions by improved performance. This is a process, described as "creative destruction," where not all are winners. Progress in computing is directly related to time and performance, with economic factors closely following. It is the step up in performance that the engineer seeks by new devices and new logic. The first endorsements don't come from the economist, but the lasting techniques *do* need the stimulant of wide acceptance with resulting savings. The techniques open to the engineer, therefore, tend toward a rather narrow range of devices.



"... the transistor, a triumph of geometry."

It is especially interesting to me that the most modern universally-accepted device for computer circuits, the transistor, is a triumph of geometry. Most of the recent improvements in the transistor come from ingenious methods for providing a thin layer here, a thick layer there, a large surface here, a minimum surface there. The beauty of geometric design has long thrilled men. The transistor mixes crystalline symmetry with etched surfaces visible only by microscope. More than this, the electrical reactions of the transistor can be sharpened to really surprising speed. For the engineer familiar with "lumped constant" effects, the modern components are a revelation. (Note: Lumped constant effects refer to idealized electrical engineering methods.) Although transistor speeds are still in the order of several hundred times slower than the speed of light through the space taken up by the device, the speed is still a surprise. Transistors make excellent switches when limited to low voltages. The speed with which such switches can be opened or closed has increased by several hundred since they were first introduced. Wide acceptance has added the economic stimulant to the very desirable properties of the transistor.

Machines built with transistors today utilize the most simple known circuits. Several variations are available with relatively equal simplicity. The designer's choice is formed from an amalgam of component capability, size and shape, and the geometry of the packaging. Speed being the prime objective, heat, power, construction methods, and so on are the variables for his use.

Good losses

A recent packaging technique with very good efficiency of volume usage is the "cordwood" package used in the **Control Data** 6600. This package gives four surfaces for etching the interconnections. This structure is a step up in module complexity from the small single-board cards of recent years. The density of circuits per unit volume is up by three or four over the cards. A number of gains and losses arise from this kind of packaging. The loss of most importance is in standardization of modules. The package contains so much logic that a flexible minimum set of module types would sacrifice considerable potential efficiency. Another problem is the extra logical complexity of the module. It is of little use to apply mechanized techniques to help with the design of these modules. The job of *designing* with them becomes once more, as in the past, a hand job. Engineering of computers utilizes geometric and topographic methods more than ever.

These are "good" losses, though, since the gains far outweigh them. The improvement in volume density is significant, and well worth the effort in improved speed. The increase in complexity within the module allows for two conditions of circuits, those inside and the interconnections between modules. The effect is to group logic more efficiently in modules so that advantage may be taken of the internal speed and loading rules. Internally, wire lengths of less than three inches are encountered, whereas the average external lengths are perhaps ten times that. This reflects in longer transmission times. The external lines may provide only enough current and voltage to supply (without further transmission time) a fraction of that available internally. These and, of course, the problem of module connector pins and back panel wiring volume all add up to a plus for the more complex "cordwood" package. The loss of flexibility is unfortunate but by no means defeating.

Other more specialized modules are also possible with such techniques, notably the memory package. With suitable connectors and internal framework, a memory may be constructed with complete addressing and storing circuits in one package. This more or less reverses the losses just mentioned, since a memory package may be considered a standard unit to be "plugged in" wherever required. In the **Control Data** 6600 Computer, such memory modules are made up in 4096 word (12-bit) size for use in the peripheral processors. Also, five modules make up one 60-bit memory bank in the central memory.

Form, not dimensions

Packaging techniques which greatly increase the density of circuits are also likely to increase the heat density. The choice of circuit open to the designer may allow a low power dissipation, but generally no large factors are possible, especially for increased speeds. Cooling, or maintaining constant temperature, is very important. Moving air past the dissipating element has been fairly successful in the past. However, one aspect of higher density is the restriction of air flow. Cooling by cold bar conduction, radiating fins and plates, circulating coolant, and the like are among the ways out of the dilemma. The 6600 Computer is freon-cooled.

In very large systems, the sheer volume of logical and memory hardware demands several cabinets or bays of chassis. The length of interconnections between the different portions of this array may be a serious speed problem itself. No design is so cooperative as to allow neat groupings adjacent to each other without the long wire. The most effective geometric forms are the cylinder with interconnections at the axis or the cube with interconnections on the surfaces. The sphere, of course, might appear superior to either. However, the fabrication complexity is a significant drawback. My personal preference is the cylinder. The axis can be the location of interconnections as well as the pivot for moving aside the adjacent parts of maintenance. The principal advantage is in uniform interconnection lengths with quite practical fabrication methods.

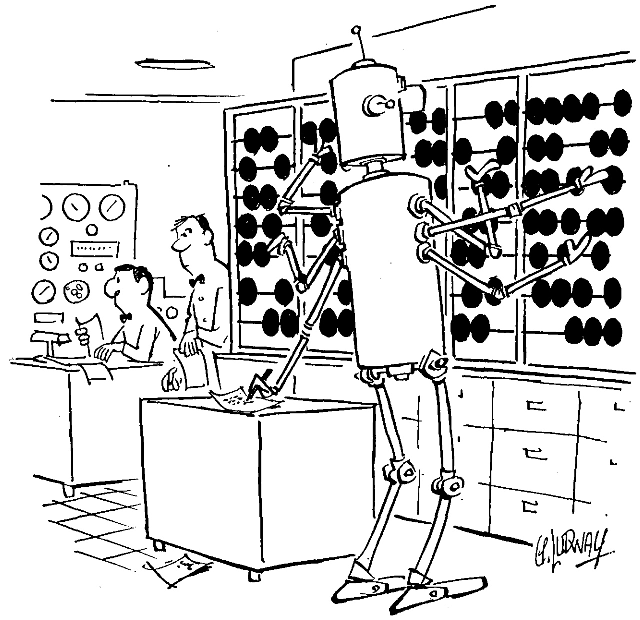
How to succeed . . .

I suppose the picture of computing is of a topsy-turvy growth obeying laws of a commercial "natural" selection. This could be entirely accurate considering how fast it has grown. Things started out in a scholarly vein, but the rush of commerce hasn't allowed much time to think where we're going. In fact, the essential organization of computers hasn't changed at all. The real differences are in the fringe "special effect" operations and the internal methods, which are hidden except for their effect on performance. Even the peripheral systems are quite similar to each other.

. . . without being trying

In my mind, the greatest potential for improvement is with the internal methods (if this isn't already clear), at the risk of loss of fringe operations. The work to be done is really engineering work, pure and simple. As a matter of fact, that's what the results should also be – pure and simple. It's time to set about developing new wiring schemes and new packaging schemes that really fit together. The best of what has been done should be the guide. Most of the time, the best isn't very spectacular or clever; it's just the best. Physical volumes won't reduce as quickly as we'd like; but they will reduce some. Building blocks won't be very flexible; but they can be made neat and tidy. Transmissions of signals won't exceed the speed of light; but sometimes delays are useful. The direction is clear and we'd best get about it, before our elephant stops growing.

MACHINE-MAN SIMULATION



"...But it's a little weak on program documentation."

ADVERTISING INDEX

Following is the index of advertisements. Each item contains: Name and address of the advertiser / page number where the advertisement appears / name of agency if any.

"ACROSS THE EDITOR'S DESK"

Computing and Data Processing Newsletter

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NEW APPLICATIONS

LEGAL RESEARCH BY COMPUTER

Law Research Service, Inc., New York, N.Y., an electronic law retrieval service, turns the chore of clerical research over to a computer, Sperry Rand's Univac III. Attorneys will now be more free to devote time to the actual analysis, evaluation and solution of client problems. The computer, programmed with a vast library of case references, tests the relevance of cases to a research problem at the rate of 120,000 per minute. The computer's speed and accuracy make it possible for Law Research Service, Inc. to mail full prints of relevant cases to an attorney within 24 hours after receipt of his query. The same research could take a lawyer a week or more in a law library.

To use this electronic method of legal research, an attorney calls or writes Law Research Service, Inc. and makes his query; a Law Research editor punches the inquiry onto a card for processing in the computer. Relevant cases are checked for prior history and their current status is determined. A staff of legal specialists at Law Research Service then further reviews the computer results with leading authorities -- also produced by the computer -- for relevance and authenticity. Verified cases are printed in full by a high speed printer. After being collated with the original inquiry, they are mailed to the attorney within 24 hours of receipt.

While the Law Research computer is currently programmed with cases relevant to New York legal questions, the firm is in the process of extending its operations through direct service and franchising to other states. Its arrangement with Sperry Rand is for use of the Univac III for all law retrieval work in the United States and Puerto Rico.

A recent prediction by Los Angeles attorney Reed C. Lawlor includes the observation that.... "Computers may bring about improvements in the administration of justice that men unaided by computers would never have been able to attain."
(For more information, circle 26 on the Readers Service Card.)

CONTROLLED STUDY OF EVOKED BRAIN-WAVE RESPONSES

At Honeywell's Military Products Group Research Department, Orange, Conn., an experiment is now underway designed to determine whether brain wave responses evoked by specific stimuli are reliable indicators of the human brain's overall state or condition at any given time.

The one mechanical ingredient of the brain wave studies is a standard Computer of Average Transients (CAT 400B) manufactured by Mnemotron, Division of Technical Measurement Corp., Pearl River, N.Y. Volunteer subjects with electrodes fastened to their heads are placed in a metal room to shield them from outside electrical interference and from extraneous stimuli such as noise, lights, and vibrations. The computer then receives and analyzes the subjects'

responses to rigidly controlled events presented to them by experimenters outside the chamber.

The specific objective of the present experiment is to learn whether the brain's reaction to one type of continuous sensory stimulation -- a metronome-like clicking sound, for example -- can show the brain's state of reaction to the subject's overall environment. According to research scientists, Dr. Donald I. Tepas, every sensation experienced by man evokes a response in the form of an electrical "signal" in the brain. The trick, he says, is to distinguish the evoked response to a specific stimulation from all other brain activity.

Isolation of evoked responses in these studies, is being accomplished through a summation technique done on-line by the Computer of Average Transients. The CAT both isolates and amplifies the wanted brain "signals" evoked by a specific stimulus by rapidly accumulating brain waves occurring coincidentally with the stimulus signal. Nonsynchronous waves from from routine or unrelated brain activity tend to cancel out, while the synchronous brain waves add up to an observable, measurable signal.
(For more information, circle 70 on the Readers Service Card.)

ASTRONAUTS "FLY" GEMINI MISSIONS IN IBM SIMULATOR

Four astronauts have "flown" a Gemini spacecraft mock-up during simulated descents through the Earth's atmosphere. The simulation runs were made at the Space Guidance Center of the IBM Federal Systems Division, Rockville, Md. These were the first astronaut check-outs of the IBM simulation of the Gemini guidance system. IBM has developed the Gemini simulator computer under contract from the McDonnell Aircraft Corp., prime contractor to the NASA Manned Spacecraft Center for the two-man Gemini spacecraft.

Seated in a mock-up spacecraft, each astronaut made several eight-minute runs in which he manually "guided" the vehicle from the time it entered the Earth's atmosphere at 400,000 feet to 50,000 feet, where the drogue parachute is normally deployed. In these tests, the pilots controlled the spacecraft in the manual and rate command mode. An IBM 7090 computer -- located in another room in the laboratory -- was programmed to perform like a Gemini on-board guidance computer. The 7090 was then fed precalculated information about the aerodynamic forces acting on the spacecraft, the position of the desired touchdown point, gimbal angle and accelerometer readings such as might come from the inertial measuring unit, and other necessary flight data.

IBM TELE-PROCESSING SYSTEM WILL SCORE WINTER OLYMPICS IN INNSBRUCK THIS MONTH

The data communications network, developed by IBM Corporation, New York, N.Y., to score the athletic competition at Innsbruck, Austria, site of the IXth Olympic Winter Games, will cover a 78-square-mile Olympics area. The 1964 Games, beginning January 29, will cover ten times as large an area as the 1960 Games at Squaw Valley, Calif. Central computers and high-speed printers, some up to 25 miles apart, will calculate and disseminate final standings of more than 1300 athletes in 35 events, -- the largest Winter Olympics ever staged. It is expected to put results of all events in the hands of newsmen, officials, spectators and athletes faster than ever before in the history of the Games.

The IBM Tele-Processing system contains IBM 1401 and 1440 computers and remote data transmission units. The system will: (1) compile and print start lists for each event; (2) calculate up-to-the-minute standings for each event as athlete rankings change (results will be telephoned immediately to all scoreboards and the public address systems); (3) record final results in paper tape for immediate teletypewriter transmission by news services to subscribers throughout the world; and (4) print an official certificate for each athlete, showing his final ranking and performance in each competition.

Events held at widely separated points at the same time will be scored immediately by the system, which is controlled by computer programs containing more than 50,000 machine instructions. During peak periods, with six events running at once, the system is expected to process one athlete's score every ten seconds. Results of all contests in progress will be transmitted and printed throughout the Olympic area and reproduced in quantity for officials and newsmen.

Operation of the entire network is controlled from the IBM data processing center in the Innsbruck University gymnasium, adjacent to the press center.

NEW CONTRACTS

GERMAN WEATHER SERVICE ORDERS CONTROL DATA 3600

Control Data International has announced the signing of a contract between the Control Data G.m.b.H. at Frankfurt/Main, Germany, a subsidiary of Control Data Corporation, and the German Weather Service, for a high-speed large-scale Control Data 3600 computer system. The German Weather Service at Offenbach/Main near Frankfurt is one of the five major centers located in the Northern Hemisphere; the four others are in Washington, D.C.; Moscow, U.S.S.R.; Delhi, India; and Tokyo, Japan. There are also five major centers in the Southern Hemisphere.

In acquiring this giant computer, the German Weather Service has increased its powers to make automatic analysis and predictions of current weather conditions and progress in the art of weather research. The system is scheduled for installation in the Spring of 1965.
(For more information, circle 71 on the Readers Service Card.)

AIR FORCE CONTRACT FOR 'HYDAC' COMPUTING SYSTEM

An Air Force contract, in excess of $600,000, has been awarded to Electronic Associates, Inc., Long Branch, N.J., for the HYDAC 2400 computing system. Under the contract, EAI will provide a fully expanded 'hybrid' system which includes an analog computer, a unit which provides arithmetic and memory storage capabilities not normally found in analog units, and interface equipment to tie the units together into an integrated system. (One TR-10 desk top size computer and two TR-48 medium size computers are included in the contract.)

The EAI HYDAC 2400 computer will be used at the Air Force Flight Test Center computer laboratory at Edwards Air Force base in studies associated with the X-20 program, and for basic and applied research studies in the field of manned space vehicle operations.
(For more information, circle 72 on the Readers Service Card.)

GULTON INDUSTRIES TO BUILD DATA TRANSMISSION SYSTEM FOR PROJECT APOLLO

A major contract has been awarded to the CG Electronics Division of Gulton Industries, Albuquerque, N.M., to build the data transmission system for Project Apollo (the nation's moon program). The contract, in excess of $700,000, was awarded by the Apollo Support

Department of General Electric, Daytona Beach, Fla.

The data transmission service will relay electronically from the Saturn booster system all detailed information required by scientists at the control center -- located about 10 miles from the launch pad at Cape Canaveral, Fla. The system will not only tell the scientists what is going on inside the booster system, but will also give them the ability to change what's going on.

STINFO PROGRAM TO BE STUDIED BY C-E-I-R

The Army Directorate of Technical Information, Office of the Chief of Research and Development, located at the Army Research Office, has awarded C-E-I-R Inc., Arlington, Va., a $125,919 contract as part of an Army-wide effort to implement the scientific and technical information (STINFO) program. The scope of the contract includes support of a survey of all STINFO resources at Army installations. Some of the results of the study will provide information about the Army's technical libraries, documentation and evaluation centers, means of reporting scientific and technical information, and the distribution of these reports.

ZIP CODE READER TO BE DEVELOPED BY NCR

The National Cash Register Company, Dayton, Ohio, has signed a $508,817 two-year contract with the United States Post Office for the development of an optical character reading machine to automatically recognize ZIP code addresses on letter mail. For the Post Office application, NCR will use a "flying spot scanner" technique to read rapidly moving envelopes. Unlike optical scanning equipment developed for business use, the ZIP code reader must not be restricted to a single specialized type face.

The Post Office's Office of Research and Engineering, which is in charge of the mechanized development, said the reader would have to "find" ZIP codes anywhere from half an inch to 2½ inches from the bottom of each envelope. Incoming destinations will number up to 100, as determined by the last two ZIP code digits; outgoing destinations number a possible 1000, shown by the first three digits. The machine must also be able to handle letters from 3 to 6 inches high, and up to 11½ inches long and ¼ inch thick.

JPL CONTRACT TO SYSTEMS PROGRAMMING CORP.

Systems Programming Corp., Santa Ana, Calif., has been awarded a $768,000 contract by the California Institute of Technology Jet Propulsion Laboratory, Pasadena, Calif. The contract is for programming support to the JPL computing center and technical staff in their study and solution of problems associated with planetary and lunar space missions conducted by JPL for the National Aeronautics and Space Administration. The contract work will be done at Systems Programming Corporation's Pasadena office.

COMPUTER PRODUCTS INC. AWARDED CONTRACT FOR MARK T-50 COMPUTER

A contract for a MARK T-50 analog computer has been awarded to Computer Products Inc., Belmar, N.J., by the National Aeronautics and Space Administration, Flight Research Center at Edwards, Calif.

The MARK T-50 is a general-purpose, transistorized desk-top analog computer. It is supplied with from 10 to 50 operational amplifiers depending upon customer requirements. The NASA contract calls for 32 operational amplifiers, 60 coefficient-setting potentiometers, 12 integrator networks, 5 multipliers and several other components, including a high-speed repetitive operation unit. It will be used by NASA engineers in conjunction with a NASA variable-stability airplane to perform ground-based simulation.

CSC AWARDED 7 NEW CONTRACTS TOTALING OVER $1 MILLION

Computer Sciences Corp., San Francisco, Calif., has been awarded seven new contracts for programming services and support by Lockheed Missiles & Space Co., Sunnyvale, Calif. The awards are projected to be in excess of $1,000,000.

CSC will provide computer programming support for such large scale equipment as the IBM 7090/7094 computers as part of an Automatic Data Accumulation (ADA) system for Lockheed's Sunnyvale facilities. Programming will include such techniques as use of COmmon Business Oriented Language (COBOL).

The ADA system at Lockheed is part of an overall management and information control system -- essentially a communications and retrieval system to enable production workers at remote locations to continuously add data bit by bit as it is created.

NEW INSTALLATIONS

H-400 SYSTEMS FOR — NIPPON TEL & TEL, ALBUQUERQUE DIVISION OF ACF, VAN CAMP SEA FOOD

The Nippon Telegraph and Telephone Public Corporation of Japan has ordered four Honeywell 400 data processing systems, valued at about $1.7 million, from the Nippon Electric Company. NEP is producing Honeywell computers under terms of a licensing agreement signed with Honeywell EDP in 1962 (see "Computers and Automation", September, 1962). Included in the order are two H-400 processors with 3072 words of memory each; two central processors with 2048 words each; sixteen magnetic tape drives; four on-line high-speed printers; one off-line high-speed printer; and four card-reader-punches. The four systems will handle manual toll accounting for approximately 1.2 million telephone subscribers, including monthly bill preparation, detailed listings of all toll calls and maintenance of the master file. Nippon Telegraph and Telephone serves about 5 million subscribers.

The Albuquerque Division of ACF Industries, Inc., has installed a Honeywell 400 system at the Divisions' New Mexico headquarters. The system consists of a central processor, card reader-punch unit, high speed printer, five magnetic tape drives, paper tape reader, paper tape punch, and a random access storage unit. The Albuquerque Division is an integrated engineering, development, and manufacturing facility under contract to the United States Atomic Energy Commission.

Van Camp Sea Food Company, Los Angeles, Calif., will install a Honeywell 400 EDP system early this year. It will consist of a central processor with 3072 words

of memory, five magnetic tape units, a card reader, high speed printer and multiply/divide and print-storage options. Initially the computer will handle the billing, accounting and payroll applications, market analysis and also control the canned seafood inventory. Later, the system will perform operations research functions, statistical studies and forecasting applications.
(For more information, circle 79 on the Readers Service Card.)

FLORIDA SERVICE BUREAU INSTALLS BURROUGHS B260

Data Processing Bureau, Inc., Winter Haven, Fla., has installed a Burroughs B260 computer. It is getting the work done eight times as fast as the basic punched card equipment which it replaced. The computer includes a B260 solid-state central processor with a 4800-character magnetic core memory, B124 800-card-per-minute reader, B304 300-card-per-minute punch, B231 700-line-per-minute printer, and B141 100-character-per-second paper tape reader.
(For more information, circle 75 on the Readers Service Card.)

CONOCO INSTALLS COMPUTER AUTOMATION SYSTEM

Control Data Corporation's Industrial Group, Control Systems Division, LaJolla, Calif., has installed a computer automation system for Continental Oil Company (Conoco), Cody, Wyoming. The system is used for remote control of crude oil production in five isolated Wyoming oil fields. The Conoco electronic digital telemetering system is operated from a programmable central facility which includes an on-line computer. Each field surveillance or control point is connected by cable to one of six remote satellite units located in the oil fields. The system maintains constant surveillance over lease production and operation of individual wells, tank batteries, and other major items of field equipment, and is also used to control certain aspects of these operations.
(For more information, circle 76 on the Readers Service Card.)

NAVY WORLDWIDE OPERATIONS TO BE CONTROLLED BY UNIVAC 490's

Four UNIVAC 490 Real-Time systems will be used by the U.S. Navy Bureau of Supplies and Accounts (BUSANDA) to control a $3.5 billion worldwide inventory of nearly one million items. The $15 million system, located at four inventory control points in the Unites States, will reduce the lead time to update worldwide inventory from two months to one day. Nearly $1 million inventory balances will be calculated by the computers daily to determine re-supply and re-order points.

The four systems will be located at the following inventory control points: Aviation Supply Office, Philadelphia, Pa.; Electronic Supply Office, Great Lakes; and Ordnance Supply Office and Ships Parts Control Center, both at Mechanicsburg, Pa.
(For more information, circle 77 on the Readers Service Card.)

UNIVAC III's FOR GREAT NORTHERN RAILWAY AND U.S. MARINE CORPS

Great Northern Railway, St. Paul, Minn., has installed a UNIVAC III electronic computer system in its data processing center. The installation consists of a central processor, eleven magnetic tape units, a high speed card reader, a high speed printer and control console. The system will be used to process stockholder records, dividend payments and car records. The new computer system replaces a UNIVAC I system which had been installed in 1957.

Three UNIVAC III computing systems have been ordered by the U.S. Marine Corps Supply Department to control $1.3 billion worldwide inventory of some quarter million items. Three identical one million dollar systems will be located at Albany, Ga.; Philadelphia, Pa.; and Barstow, Calif. Each of the UNIVAC III's will be installed and operational early this year.
(For more information, circle 78 on the Readers Service Card.)

UNIV. of CALIF. INSTALLS GE-225 COMPUTER

A general Electric 225 general purpose computer has been installed at the University of California's Los Alamos Scientific Laboratory, Los Alamos, N.M. The laboratory is operated by the university for the Atomic Energy Commission.

The G-E equipment is being used by the scientific staff as a peripheral processor for the laboratory's larger 7094's and Stretch computers. As a peripheral processor, the GE-225 simultaneously manipulates two printers, a card reader and a card punch. It also prepares input tapes, and processes output tapes for the larger equipment. The full complement of computers is used for data reduction and scientific computation in conjunction with research and development projects in the atomic sciences.
(For more information, circle 80 on the Readers Service Card.)

ORGANIZATION NEWS

TRW AND CONCAST IN CONTINUOUS CASTING AGREEMENT

TRW Computer Division, Thompson Ramo Wooldridge Inc., Canoga Park, Calif., and Concast Incorporated have entered into an agreement wherein TRW digital control computers will be included as an integral part of Concast's continuous casting machines for the metals industry. The computer system will be programmed to determine the maximum casting speed consistent with safety and quality considerations.

TRW will supply all necessary computer hardware, programming, systems engineering, and field engineering and maintenance services for the Concast computer systems. The Concast systems will be offered to all of Concast's licensees.

CONTROL DATA ACQUIRES BRIDGE INCORPORATED

Control Data Corporation, Minneapolis 20, Minn., has announced the acquisition of Bridge Incorporated, Philadelphia, Pa. The agreement, subject to final audit, covers acquisition by Control Data of all the stock of Bridge Incorporated, in return for an undisclosed amount of Control Data stock.

Bridge Incorporated, known for its work in the design and manufacture of peripheral equipment for the electronic data processing industry, will function as a wholly-owned subsidiary of Control Data. Major products include card punch and card reader systems for sale to computer manufacturers.

COMPUTER SYSTEMS ACQUIRES CONCORD CONTROL, INC. OF BOSTON

Computer Systems, Inc., Richmond, Va., has announced the acquisition of Concord Control, Inc., Boston, Mass. The new Boston subsidiary, a 1956 outgrowth of MIT's Servo-Mechanisms Laboratory, was purchased from Dorsett Electronics, Inc., Tulsa, Ohio. Concord Control, Inc., will operate as a wholly owned subsidiary at its present location. It has achieved a reputation for the development of very reliable automated systems in machine tool control, cartography and oceanography.

COMPUTING CENTERS

MEDICAL BILLING SERVICE

U.S. National Bank of Omaha, Omaha, Nebraska, has begun a new service, called "Medical Billing Service", designed to make profitable use of its idle computer time. MBS provides completely automated accounting for doctors. The customer is not required to do his banking with the institution. The Bell Telephone System Data-Phone service for machine transmission of data by regular telephone lines, is used to link doctors' offices directly to the bank's computer center. For a small monthly fee, U.S. National handles virtually all paperwork and bookkeeping involved in patient billing.

When a doctor subscribes to MBS, his office is equipped with a Data-Phone data set and an IBM 1001 card reader. The doctor also is supplied identity cards for each patient containing the following information: (1) doctor code number; (2) patient code number with additional data identifying family members; (3) patient name; and (4) space to record charges for the doctor's convenience. In addition, a file of cards is supplied containing complete information on medical services rendered by the doctor.

A nurse or receptionist, at her convenience each day, dials the computer center. Upon receipt of the audio signal, she first inserts the patient's identity card into the reader. When this is transmitted, she inserts the appropriate service card for the treatment given, and using the keys on the reader she then registers the charge (or payment). At the bank, unattended data set receivers are activated automatically, feeding the incoming data to a keypunch machine which produces exact card duplication of transmitted information. The cards are fed into the bank's GE-225 computer system for final processing. Bills are then prepared and returned to the doctor for mailing or mailed directly by the bank as preferred. (There is no identification of the bank on patient statements.)

MBS provides four basic documents: (1) Patient Statement, sent daily or monthly as requested by the doctor; (2) Medical Service Daily Listing, a complete record of all transactions, supplied daily; (3) Aged Accounts Receivable Statement, showing accounts at 30, 60 and 90-day periods, plus current balance on each, supplied monthly; and (4) Medical Services Analysis Listing, a summary of specific services rendered and related charges, supplied on a monthly basis (more frequently if requested).
(For more information, circle 27 on the Readers Service Card.)

EDUCATION NEWS

NCR GIVES COMPUTER CLASSES FOR AREA HIGH SCHOOL STUDENTS

National Cash Register Company, Dayton, Ohio, is giving a course in computer programming, for the second consecutive year, for some 219 Dayton-area high school juniors and seniors. These students, selected from 664 applicants, spend Saturday mornings learning electronic data processing. Three study groups have been organized to accommodate the large number of students.

This year the study program will use basic algebra to program an NCR 315 computer for solving complex mathematical problems. Dayton Power and Light Company will assist in the educational program by permitting the students to operate D.P.& L's 315 system to check programs and solve test problems.

NCR said the computer course is designed to acquaint the students with electronic data processing as a career and to interest them in developing such skills at the university level. The course is given to the students without charge; instruction is by members of NCR's computer staff who are volunteering their services.
(For more information, circle 33 on the Readers Service Card.)

WESTERN RESERVE UNIVERSITY TO OFFER NEW TYPE COURSE

Western Reserve University, School of Library Science, Cleveland, Ohio, will offer a new type of course in the spring semester, 1964, entitled "Automation of Library Processes and Procedures". This course is planned to survey and evaluate the possible uses of data processing equipment within the traditional library functions -- administration, acquisitions, catalog production, circulation, intercommunication, etc. Punch cards, computers, microrecords, photography, and visuals are discussed; comparative costs are considered; current library installations are reviewed.
(For more information, circle 31 on the Readers Service Card.)

UNIVERSITY OF MINNESOTA USES COMPUTER IN CLASSROOM

A Univac 80 computer system is being used at the University of Minnesota, School of Business Administration, Minneapolis, Minn., for educational and research purposes.

A class in quantitative analysis, "Introduction to Electronic Computers", provides a basic understanding of computers. Four areas covered in the course are: (1) basic ideas of computer programming and computer operation; (2) symbolic and machine language programming using the Univac 80 as an example; (3) macro-instruction programming using Fortran; and (4) new and projected developments in computers.
(For more information, circle 32 on the Readers Service Card.)

NEW PRODUCTS

Digital

THE COMPATIBLES-400

General Electric Company's Computer Department, Phoenix, Ariz., have announced a new family of four business data-processing systems, known as the Compatibles-400. The computers are the GE-425, 435, 455 and 465. They provide a choice of capacities and speeds. The latter two also have floating-point capability, for scientific applications.

The family of computers is "upward-compatible", so that users can move to a larger, more powerful 400 system with no additional investment in programming and peripherals or in retraining costs. Each successive central processor provides 80 per cent greater processor performance.

The GE-425 has a memory access equivalent to 1.28 microseconds per character. The GE-435 has an access equivalent to .68 microseconds per character. The GE-455 has a 2-microseconds-per-word memory access, and the GE-465 a 1-microsecond-per-word access. The latter two have an optional thin-film memory available, operating at 1/2 microsecond per word.

Development of hardware, software and operating systems was carried on simultaneously by a team of users, programmers and engineers, to provide a complete package.
(For more information, circle 33 on the Readers Service Card.)

HONEYWELL EDP ENTERS SMALL COMPUTER MARKET WITH HONEYWELL 200

The Honeywell 200 computer is the first small computer introduced by Honeywell Electronic Data Processing, Wellesley Hills, Mass. It is a low-cost business computer, with speed and performance characteristics comparable to much larger systems. The new system can be run by a single operator. It is easily installed in small office spaces without costly and elaborate site preparation.

Internal operating speed is up to six times greater than other small computers. A single memory cycle takes only two microseconds. A fast control, or "scratch-pad" memory can perform a single operation in 500 nanoseconds (billionths of a second).

The computer has the ability to do four separate tasks simultaneously. Through the use of a traffic control unit, the computer can, for example, perform processing operations, high-speed printing, card punching, and magnetic tape-to-magnetic tape data transfers, all at the same time. A wide variety of peripheral units permits operational flexibility.

An automatic program conversion package, named "Liberator," permits quick and simple translation of 1401, 1440 and 1460 programs to H-200 programs. Half-inch tape drives, standard with the competitive systems, are available with the H-200 in six models. Three models of three-quarter inch drives are also available, providing data compability with existing Honeywell systems.

The basic software system for the H-200 is called Easycoder, a comprehensive and easily-learned programming package which permits rapid application by inexperienced users. In addition to Easycoder, other software aids include a THOR tape handling option routine, off-line conversion packages, Tabsim (a tabulating equipment simulator), and a COBOL '61 compiler and a Fortran II scientific compiler.

The Honeywell 200 will be marketed to new computer users, as a satellite system for large computers, and as a replacement for existing small machines. Deliveries of the system will begin in July 1964. Initial production models will begin a nationwide tour in March.
(For more information, circle 34 on the Readers Service Card.)

TRW-133 TACTICAL MILITARY COMPUTER

TRW's Computer Division, Redondo Beach, Calif., has announced a new medium-size tactical military computer , the TRW-133 -- an advanced version of the TRW-130 (AN/UYK-1) model.

This new stored logic digital system has a read-write cycle of two microseconds. It operates in parallel by 15-bit word elements. Word length is variable in multiples of 15 bits; i.e. 15, 30, 45, etc. Over 8200 instruction combinations are possible, affording users great flexibility in devising tailor-made commands for special problems. The TRW-133 performs additions in 4 microseconds, and multiplications and division in 19 microseconds.

The TRW-133 is compatible with the input-output devices of either the Navy Tactical Data System (NTDS) or the Mobil Opcon system. Data can be accepted from external devices at the rate of 1.25 megabits per second or, with optional high speed equipment, at 7.5 megabits per second. Provision is made for multi-level automatic interrupts, with a six microsecond reaction time. A full line of peripheral equipment is available.

An extensive library of programs is already available, since it is program-compatible with the TRW-130 (AN/UYK-1) computer.

Five TRW-133's are now on order; the first of these, a prototype model, has been built and is in the checkout stage.
(For more information, circle 36 on the Readers Service Card.)

Data Transmitters and A/D Converters

MODEL KD-5040 DATA TRANSMITTER

ITT Corp., Kellogg Communications Systems Division, Chicago, Ill., has developed a solid-state data transmitter using printed circuits. The model KD-5040 device was developed for command and control systems.

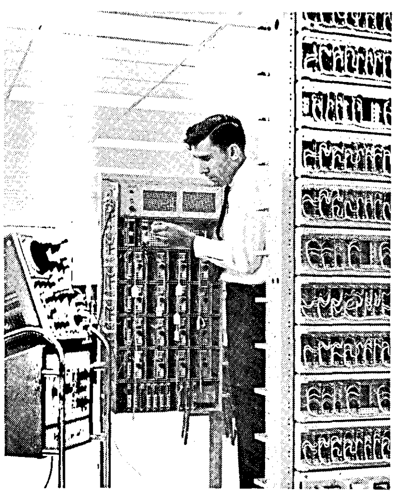
The transmitter scans input storage units for completed messages, and, on locating a loaded unit, locks on it and selects a transmission channel for the information. It inserts various data into the header of the message and sequentially inserts control data in appropriate locations in the message.

The device includes a parallel-to-serial converter, a vertical-

parity detector, and a horizontal-parity generator. Operating and fault indicators are combined with internal fault-isolation circuits to make the model KD-5040 highly reliable.
(For more information, circle 37 on the Readers Service Card.)

SHORT-WAVE VOICE TRANSMISSION IN DIGITAL FORM

A high-speed data system has been developed, which will make possible short-wave transmission of high-quality voice communications in the form of digits when used with "speech scrambling" equipment. The new 27A Duobinary-Datatel® was developed by Lenkurt Electric Co., Inc., a subsidiary of GT&E, New York, N.Y. The system uses a new advance in data-coding techniques to transmit digital signals at 2400 "bits" of information per second. This is twice the traditional digital transmission rate over short-wave or high-frequency radio.



-- Lenkurt Electric engineer James Stuehler is shown performing alignment test on the 27A transmitter, without dust covers during a final system check. A receiver rack is located at right.

The 27A system takes advantage of existing speech scrambling devices; these convert the voice into digits, code the digits for security purposes at the transmitter, then decode and reconvert the digits into a voice form at the receiver. A duobinary coding technique doubles the information-carrying capacity of a typical 2100-bit-per-second high-frequency radio circuit with very little loss in quality. Also, the complex circuitry of other types of high-speed systems is not required.
(For more information, circle 35 on the Readers Service Card.)

Data Collection

IBM 7700 DATA ACQUISITION SYSTEM

The new IBM 7700 data acquisition system can collect facts from 32 sources simultaneously, process them and transmit results to as many as 16 remote printers, display units or plot boards. It was developed by IBM Corp., Data Processing Division, White Plains, N.Y., to handle the huge amounts of data encountered in activities such as space flight, jet engine testing and monitoring industrial processes. Information may originate in a wide variety of environments; it may be brought into the 7700 by varied means of communications. The system can make use of both IBM and customer-furnished terminals and recording devices.

A multiplexor to which 48 communications subchannels may be attached is included within the central processing unit of the IBM 7700. The multiplexor controls the receipt and transfer of data between the processing unit and all remote devices. Collectively, these 48 subchannels can handle up to 9 million bits of information a second. The 7700 has a 2.0 microsecond memory cycle time.

The 7700 system includes a central processing unit which combines an arithmetic and control unit; 16,384 words of core storage (expandable to 49,192 words); and overlapped channels. Each word in core storage consists of 19 bits -- 18 of which are used to record data, while the 19th is a check bit.

First customer deliveries are scheduled for the third quarter of 1964.
(For more information, circle 39 on the Readers Service Card.)

Software

TWO CPM PROGRAMS FOR IBM 1400 SERIES COMPUTERS

The Associated Data Processing Company, Carteret, N.J., has developed Critical Path Method (CPM) and CPM-Time-Cost Optimization programs for the IBM 1401, 1410 and 1460 computers. These programs, in contrast to previous multi-pass card programs, are single pass. They include extensive error detection features and are considered to be the fastest in their class. The programs are written for a 16K machine with on-line card-reader-punch and printer with three tape drives, and are designed to process small and medium sized networks up to 600 events (with modifications up to 2000).
(For more information, circle 40 on the Readers Service Card.)

CULP I

Computer Usage Company, Inc., New York, N.Y., announces the development of a list processing system for the IBM 1401. The Computer Usage List Processor (CULP I) permits a wide range of special applications to be run on a 1401. CULP I programs may mix 1401 instructions, list-manipulating instructions, and list executions. The programmer writes his list-processing commands as 1401 Autocoder macro instructions. (Some knowledge of 1401 programming in Autocoder is a prerequisite to CULP programming.) The system is recommended for heuristic programs, recursive use of subroutines, manipulation of highly structured data, etc.
(For more information, circle 41 on the Readers Service Card.)

COMPUTER PROGRAMS FOR BANKS

General Electric's Computer Department, Phoenix, Ariz., has developed a package of computer programs which permits banks to automate paperwork five times faster than with conventional "tailor-made" routines. Known as BANKPAC, the new library of programs is designed for medium-size banks preparing for computer use. The library of programs handles Demand Deposit, Installment Loan, Savings Transit and Personal Trust.

A basic hardware configuration for BANKPAC automation consists of a central processor with 8192 words of core memory, one document handler, card reader, printer, four magnetic tapes, and such special provisions as "three-way compare", BCD package and special index groups.

BANKPAC is available free-of-charge to all users of General Electric computers and customers of Information Processing Centers. (For more information, circle 42 on the Readers Service Card.)

COMPUTER PROGRAM FOR BUSINESS PLANNING

STATUS, a computerized economic yard stick for the business community, has been introduced by the ITT Data Processing Center of Paramus, N.J. (ITT/DPC is a part of International Telephone and Telegraph Corporation.)

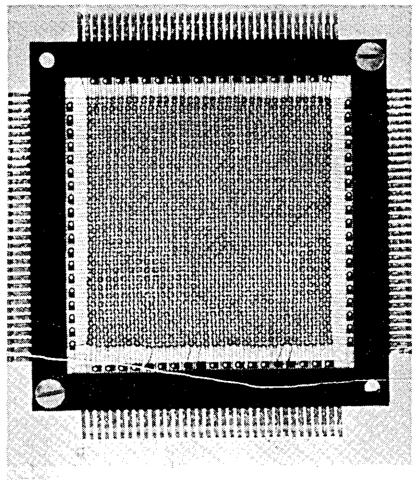
The computer program package applies the statistical techniques time-series analysis and regression analysis to compare the data of a particular business organization against a massive data store compiled by the manufacturer.

The STATUS computer program checks the figures of the client company with all the economic indicators in the data store (constantly updated) and selects several of the most meaningful statistics which relate to the company's activities. Statistics are national, international and industry-wide. Based on these results, the management of the company can make plans for future activities with greater soundness. (For more information, circle 43 on the Readers Service Card.)

Memories

"READ ONLY" MEMORY SYSTEM BY FABRI-TEK

A new approach to fixed or "read only" data storage has been introduced by Fabri-Tek, Incorporated, Amery, Wisc. The system, called PERMACARD, uses the principle of current loops on a pluggable printed circuit word line array to store digital data. These economical memory elements are planes capable of storing 64 words. They are mass produced in a neutral or unwritten state ready for information loading. Information is loaded by altering the word line current paths manually or with automated machinery.

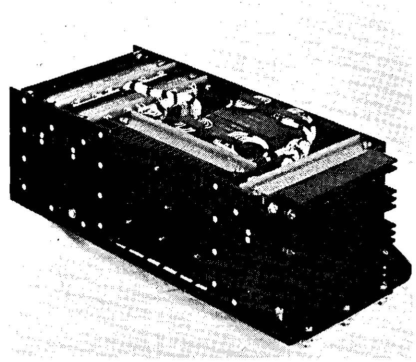


Present system cycle time is 1 microsecond with an access time of 0.5 microseconds. Modes of access are random, read-only non-destructive readout, and parallel readout.

A typical PERMACARD system has 1024 words by 26 bits and has the optional features of: output data registers, output coax or twisted pair drivers, address parity check, data parity check, and self-exerciser.
(For more information, circle 45 on the Readers Service Card.)

SEMS-IR CORE MEMORY

Electronic Memories, Inc., Hawthorne, Calif., has announced a new severe environment core memory, the SEMS-IR. This is a militarized, high-density, random access core memory capable of a 4.5 microsecond read/write time,

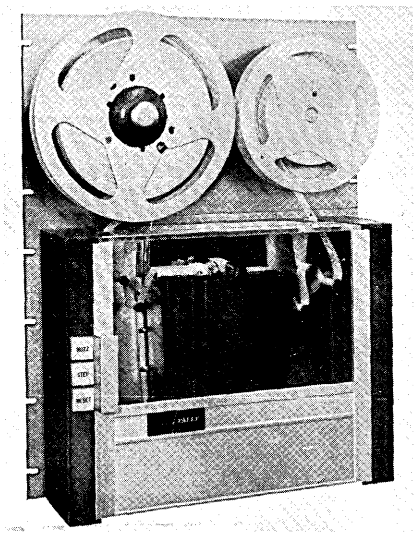


while operating over a temperature range of -55^{0} to $+100^{0}$C. The memory contains 4096 words up to 32 bits in length. It is 350-cubic inches and uses welded magnetic modules in a plug-in configuration for easy field maintenance.
(For more information, circle 44 on the Readers Service Card.)

Input-Output

HIGH SPEED PERFORATOR

Tally Corporation, Seattle, Wash., has announced a high speed perforator capable of punching paper, foil, or Mylar tape at a rate of 150 characters per second. Known as the Model P-150, the new perforator has asynchornous operation, bi-directional tape handling, and pin sense error checking.



The perforators can receive drive pulses at any rate up to their maximum speed. Bi-directional tape handling with a remotely controlled backup speed of 25 cps simplifies error corrections. Timing of parity checking allows the perforator to stop on an erroneous character so that it can be corrected. The unit accepts 5, 6, 7 or 8 channels of data.
(For more information, circle 47 on the Readers Service Card.)

S-C 4020 COMPUTER RECORDER

An advanced S-C 4020 Computer Recorder, compatible with high density tape readers and equipped with a new "quick-look" option, is being made by General Dynamics/Electronics, San Diego, Calif. The S-C 4020 accepts information from large-scale digital computers and translates the data into alphanumeric printing, curves, charts and drawings which are recorded on microfilm and paper in seconds.

The "quick-look" option involves a compact automatic developer together with a mechanical paper-cutting and stacking unit. The operator can check selected pages of a program in less than one second. After the operator has produced some "quick-look" paper copies for program evaluation, the entire program may be run through the normal developing cycle, where high-quality pages are printed for use in report distribution.
(For more information, circle 46 on the Readers Service Card.)

Components

TAPE CLEANER REDUCES ERROR ON MAGNETIC TAPE

Cybetronics, Inc., Waltham, Mass., has announced a new magnetic tape cleaner that safeguards instrumentation data both during the initial recording and subsequent playback. The tape cleaner model E-3, using a mechanical dry cleaning process, eliminates virtually all "dropout" causing particles from magnetic tape.

The device operates by passing the tape over a tungsten carbide scraping blade that has been properly positioned for rake angle and tape tension. This blade skims off the high spots or nodules that adhere to the surface of the tape as well as loosening particles of dirt or oxide that are lightly adhered to the primary oxide surface. The tape is then passed through several wiping stations employing silicon-treated tissue that not only wipes both sides of the tape, but also reduces the static charge on the magnetic tape. The result is a smooth, prime recording medium.

The tolerances on the tape cleaner top plate are held to the same limits as those employed on precision magnetic-tape transports in order to insure extremely precise tape stacking and no damage to tape edges.
(For more information, circle 51 on the Readers Service Card.)

BUSINESS NEWS

AMPEX HITS SALES, EARNING RECORD

Ampex Corp. reports record first half sales, earnings and incoming orders in the six months ended October 31, 1963.

Sales for the first half of fiscal 1964 totaled $48,217,000, up 12 per cent from $43,120,000 in the first half last year. Net earnings after taxes were $2,205,000, compared with $2,169,000, or 28 cents per share on 7,799,407 shares.

Incoming orders for the half year were $50,175,000, up slightly from $49,886,000 in the first half last year. Backlog of orders at the end of the second quarter was $37,002,000, up 4 per cent from $35,544,000 last year.

PACKARD BELL REPORTS $1.2 MILLION NET INCOME

Packard Bell Electronics has reported "a return to profitable operations" with a net income of $1.2 million, for fiscal year 1963, ended September 30. This compares with a loss of $1.4 million in 1962.

Sales of $49.4 million closely approached last year's record-breaking $49.6 million, despite the sale of one division, the Bellwood Division, a door manufacturer.

President Robert Bell stated that Packard Bell's PB250 digital computer was purchased for many diverse applications during the year, including the monitoring of human responses during Army Medical Corps sleep studies. "Our new and advanced general purpose computer, the PB440, has been announced and exhibited to select customers and firm orders have been received," he said. "We will be delivering the first units in January, 1964."

DATA PRODUCTS INCREASES SALES OVER FOUR TIMES IN SIX MONTHS

Data Products Corp. has reported net sales of $3,150,722 for the six month period ended September 28, compared to $761,867 for the same 1962 period. Net income for the period was $254,373, compared to a loss of $811,888 for the same period in 1962.

President Erwin Tomash said that figures for last year's operations were abnormally poor due to low initial shipments and to high start-up and other non-recurring costs. He also mentioned that an office of the firm was opened in Fribourg, Switzerland to service European customers of Data Products and its subsidiary, Informatics.

ITT SETS RECORD HIGHS FIRST NINE MONTHS, 1963

Record highs in sales and revenues, and net income were established during first nine months of 1963 by ITT, Harold S. Geneen, president, reported.

Net income for the nine-months period of 1963 grew to $33,513,737, compared with 1962 figures of $29,363,643.

Sales and revenues for the first nine months of 1963 increased to $914,862,420, compared with $825,613,600 a year earlier.

Orders on hand at September 30, were approximately $835,000,000, compared with $788,000,000 a year ago.

C-E-I-R HAS PROFITABLE SIX MONTHS

A return to profitable operations in the second half of fiscal 1963 and record sales of $18,007,916 for the entire year have been reported by C-E-I-R, Inc.

C-E-I-R, Inc. reported that net profit in the second half was $277,735, compared with a first half loss of $2,136,272. Total loss for the year was $1,858,537, which includes $1,225,476 in special non-recurring charges plus another $432,000 in extraordinary costs during the first six months, all incurred in connection with past expansion and an "arduous and costly" program to streamline the company and improve its financial position.

Despite elimination of several revenue producing, but unprofitable, operations, total 1963 sales of $18,007,916 were up six per cent over sales of $16,989,900 during fiscal 1962, a C-E-I-R spokesman said.

MONTHLY COMPUTER CENSUS

The number of electronic computers installed, or in production at any one time has been increasing at a bewildering pace in the past several years. New vendors have come into the computer market, and familiar machines have gone out of production. Some new machines have been received with open arms by users -- others have been given the cold shoulder.

To aid our readers in keeping up with this mushrooming activity, the editors of COMPUTERS AND AUTOMATION present this monthly report on the number of American-made general purpose computers installed or on order as of the preceding month. We update this computer census monthly, so that it will serve as a "box-score" of progress for readers interested in following the growth of the American computer industry.

Most of the figures are verified by the respective manufacturers. In cases where this is not so, estimates are made based upon information in the reference files of COMPUTERS AND AUTOMATION. The figures are then reviewed by a group of computer industry cognoscenti.

Any additions, or corrections, from informed readers will be welcomed.

AS OF DECEMBER 20, 1963

NAME OF MANUFACTURER	NAME OF COMPUTER	SOLID STATE?	AVERAGE MONTHLY RENTAL	DATE OF FIRST INSTALLATION	NUMBER OF INSTALLATIONS	NUMBER OF UNFILLED ORDERS
Addressograph-Multigraph Corporation	EDP 900 system	Y	$7500	2/61	20	9
Advanced Scientific Instruments	ASI 210	Y	$2850	4/62	11	2
	ASI 2100	Y	$3000	12/63	1	3
Autonetics	RECOMP II	Y	$2495	11/58	98	X
	RECOMP III	Y	$1495	6/61	26	X
Burroughs	205	N	$4600	1/54	67	X
	220	N	$14,000	10/58	47	X
	E101-103	N	$875	1/56	135	X
	B250	Y	$4200	11/61	36	10
	B260	Y	$3750	11/62	60	60
	B270	Y	$7000	7/62	54	45
	B280	Y	$6500	7/62	78	55
	B5000	Y	$16,200	3/63	22	11
Clary	DE-60/DE-60M	Y	$525	2/60	131	6
Computer Control Co.	DDP-19	Y	$2800	6/61	3	X
	DDP-24	Y	$2750	5/63	4	35
	SPEC	Y	$800	5/60	10	0
Control Data Corporation	G-15	N	$1000	7/55	280	X
	G-20	Y	$15,500	4/61	26	1
	160/160A	Y	$1750/$3000	5/60 & 7/61	330	14
	924/924A	Y	$11,000	8/61	20	9
	1604/1604A	Y	$35,000	1/60	52	2
	3600	Y	$52,000	6/63	9	4
	3200	Y	$9000	5/64	0	8
	6600	Y	$150,000	2/64	0	2
Digital Equipment Corp.	PDP-1	Y	Sold only about $120,000	11/60	45	7
	PDP-4	Y	Sold only about $60,000	8/62	19	10
	PDP-5	Y	Sold only about $25,000	9/63	4	12
	PDP-6	Y	Sold only about $300,000	7/64	0	1
El-tronics, Inc.	ALWAC IIIE	N	$1820	2/54	30	X
Friden	6010	Y	$650	6/63	11	35
General Electric	210	Y	$16,000	7/59	71	5
	215	Y	$5500	11/63	8	20
	225	Y	$7000	1/61	170	55
	235	Y	$10,900	12/63	1	10
	425	Y	$6500	7/64	0	12
	435	Y	$12,000	11/64	0	2
	455	Y	$18,000	6/65	0	0
	465	Y	$24,000	6/65	0	0
General Precision	LGP-21	Y	$725	12/62	68	40
	LGP-30	semi	$1300	9/56	460	6
	L-3000	Y	$45,000	1/60	1	0
	RPC-4000	Y	$1875	1/61	100	3

NAME OF MANUFACTURER	NAME OF COMPUTER	SOLID STATE?	AVERAGE MONTHLY RENTAL	DATE OF FIRST INSTALLATION	NUMBER OF INSTALLATIONS	NUMBER OF UNFILLED ORDERS
Honeywell Electronic Data Processing	H-200	Y	$3500	7/64	0	210
	H-290	Y	$3000	8/61	8	X
	H-610	Y	$3500	9/63	2	6
	H-400	Y	$5000	12/61	78	41
	H-800	Y	$22,000	12/60	55	8
	H-1400	Y	$14,000	3/64	0	10
	H-1800	Y	$30,000 up	1/64	0	8
	DATAmatic 1000	N		12/57	5	X
H-W Electronics, Inc.	HW-15K	Y	$490	6/63	1	3
IBM	305	N	$3600	12/57	610	X
	650-card	N	$4000	11/54	470	X
	650-RAMAC	N	$9000	11/54	110	X
	1401	Y	$3500	9/60	6200	1400
	1410	Y	$12,000	11/61	252	245
	1440	Y	$1800	4/63	360	2900
	1460	Y	$9800	10/63	110	340
	1620	Y	$2000	9/60	1350	110
	701	N	$5000	4/53	2	X
	7010	Y	$19,175	10/63	6	28
	702	N	$6900	2/55	2	X
	7030	Y	$160,000	5/61	7	1
	704	N	$32,000	12/55	61	X
	7040	Y	$14,000	6/63	19	70
	7044	Y	$26,000	6/63	12	15
	705	N	$30,000	11/55	112	X
	7070, 2, 4	Y	$24,000	3/60	450	120
	7080	Y	$55,000	8/61	64	24
	709	N	$40,000	8/58	15	X
	7090	Y	$64,000	11/59	250	20
	7094	Y	$70,000	9/62	86	120
	7094 II	Y	$76,000	4/64	0	80
Information Systems, Inc.	ISI-609	Y	$4000	2/58	19	1
ITT	7300 ADX	Y	$25,000	7/62	7	3
Monroe Calculating Machine Co.	Monrobot IX	N	Sold only - $5800	3/58	180	2
	Monrobot XI	Y	$700	12/60	329	184
National Cash Register Co.	NCR - 304	Y	$14,000	1/60	27	0
	- 310	Y	$2000	5/61	42	35
	- 315	Y	$8500	5/62	132	120
	- 390	Y	$1850	5/61	485	220
Packard Bell	PB 250	Y	$1200	12/60	148	9
	PB 440	Y	$3500	1/64	0	10
Philco	1000	Y	$7010	6/63	9	13
	2000-212	Y	$52,000	1/63	6	7
	-210, 211	Y	$40,000	10/58	18	8
Radio Corp. of America	Bizmac	N		-/56	4	X
	RCA 301	Y	$6000	2/61	370	166
	RCA 3301	Y	$15,000	7/64	0	6
	RCA 501	Y	$15,000	6/59	90	10
	RCA 601	Y	$35,000	11/62	3	3
Scientific Data Systems Inc.	SDS-910	Y	$2000	8/62	36	17
	SDS-920	Y	$2700	9/62	28	13
	SDS-930	Y	$4000	4/64	0	3
	SDS-9300	Y	$7000	4/64	0	2
Thompson Ramo Wooldridge, Inc	TRW-230	Y	$2680	8/63	10	8
	RW-300	Y	$6000	3/59	36	2
	TRW-330	Y	$5000	12/60	12	17
	TRW-340	Y	$6000	12/63	1	4
	TRW-530	Y	$6000	8/61	21	5
UNIVAC	I & II	N	$25,000	3/51 & 11/57	40	X
	Solid-State II	Y	$8500	9/62	33	9
	III	Y	$20,000	8/62	38	90
	File Computers	N	$15,000	8/56	52	X
	Solid-State 80, 90, & Step	Y	$8000	8/58	388	12
	490	Y	$26,000	12/61	21	21
	1004	Y	$1500	2/63	650	1820
	1050	Y	$7200	9/63	8	180
	1100 Series (except 1107)	N	$35,000	12/50	20	X
	1107	Y	$45,000	10/62	12	11
	LARC	Y	$135,000	5/60	2	X
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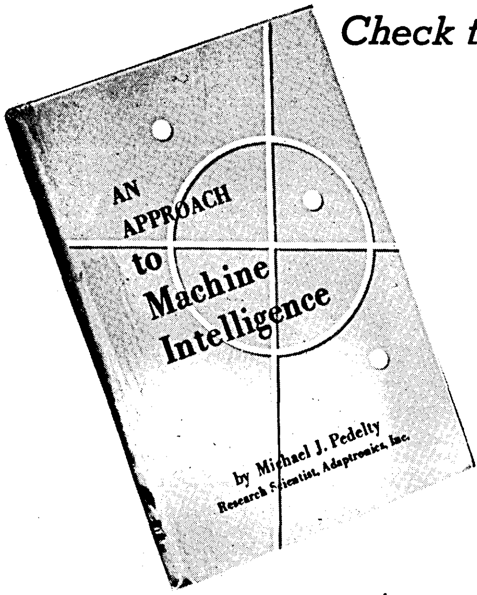

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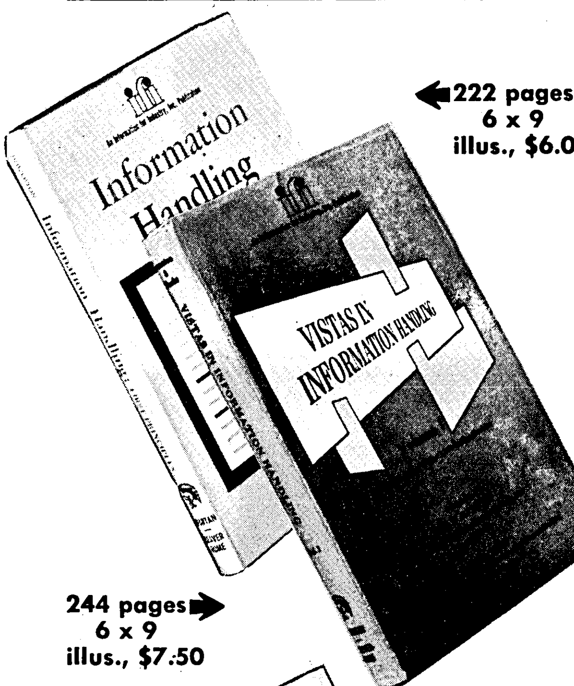

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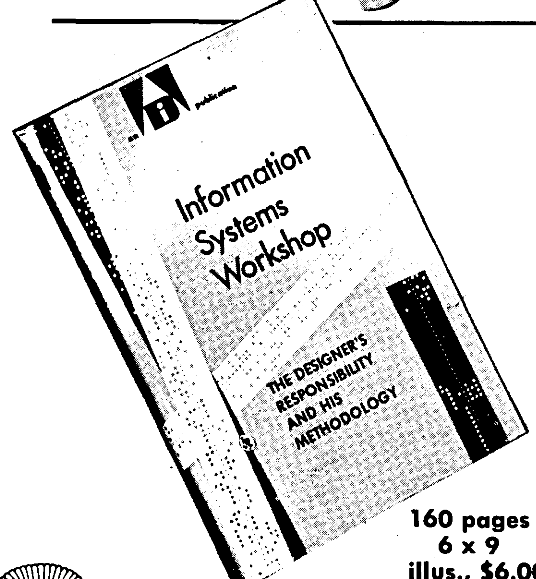

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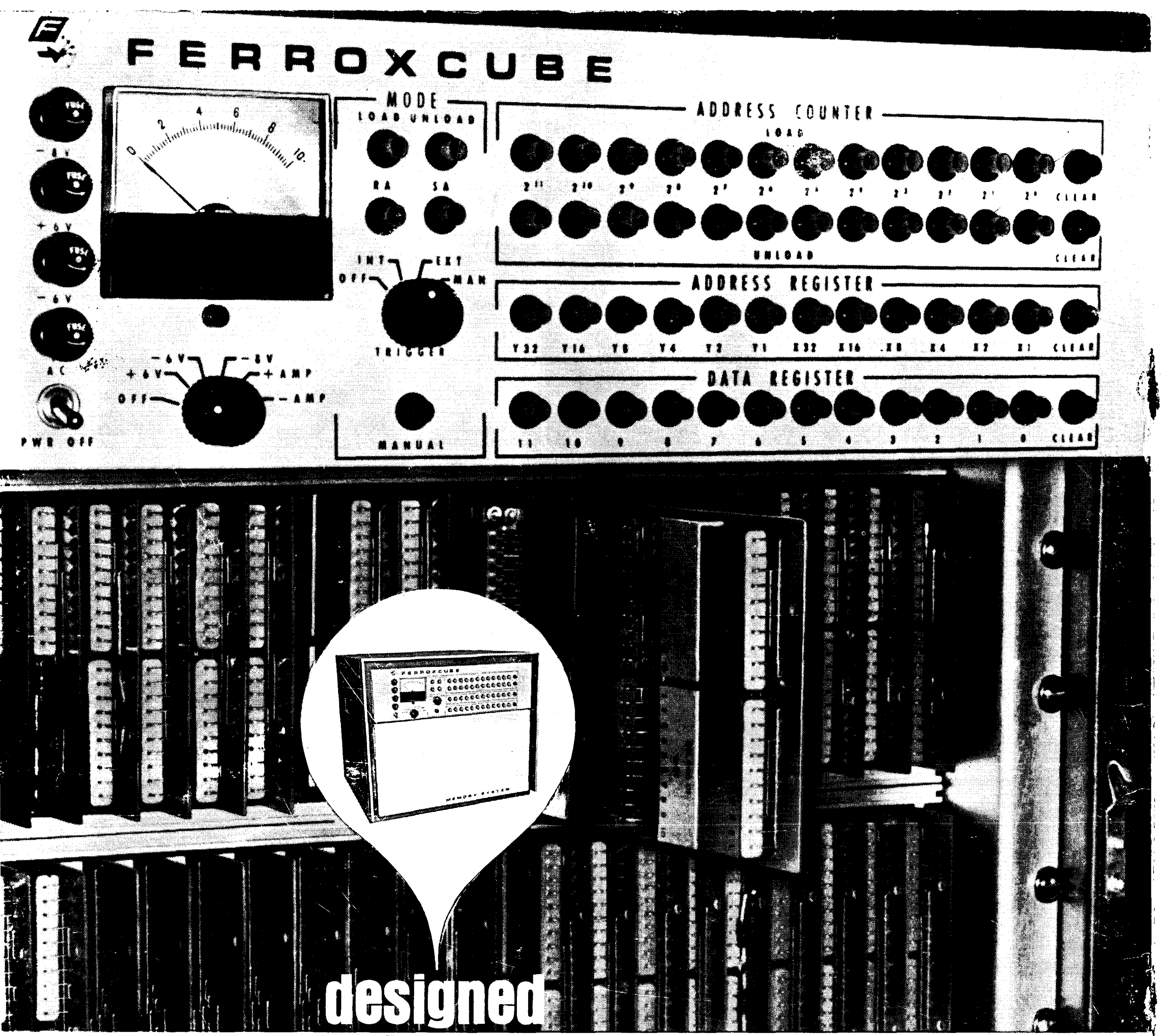

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