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DIGITAL COMPUTER NEWSLETTER

The purpose of this newsletter is to provide a medium for the interchange among interested persons of information concerning recent developments in various digital computer projects. Distribution is limited to government agencies, contractors, and contributors.

OFFICE OF NAVAL RESEARCH • MATHEMATICAL SCIENCES DIVISION

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DEPARTMENT OF THE NAVY
OFFICE OF NAVAL RESEARCH
WASHINGTON, D. C. 20360

IN REPLY REFER TO
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MICROELECTRONICS AND LARGE SYSTEMS

November 17, 18, 1964

Department of Interior Auditorium, Washington, D. C.

A Symposium on Microelectronics and Large Systems, co-sponsored by the Office of Naval Research Information Systems Branch and the Univac Division of Sperry Rand Corporation, will be held on Tuesday and Wednesday, November 17 and 18 1964. This Symposium will be conducted in the auditorium in the Department of the Interior Building, on C Street between 18th and 19th Streets, N.W., Washington D. C.

This Symposium will be generally concerned with the application of microcircuits to very large computing systems. The emphasis will be on various novel approaches to this problem rather than conventional hybrid techniques that replace discrete circuits by equivalent microcircuits. One specific subject of interest will be the unique logic capabilities possessed by large arrays of inexpensive logic circuits. An attempt will be made to present the state-of-the-art of large microelectronic systems, a limited amount of the present research on large systems, a few of the different logic systems, and some special techniques that are particularly applicable to very large microelectronic systems. It will not be the purpose of this Symposium to review and analyze all appropriate efforts and results, but rather to present representative aspects of the field. Accordingly the number of invited speakers has been limited in order to allow the speakers to develop and discuss their topics in greater depth. It is anticipated that formal proceedings will be published in the Summer of 1965.

Attendance at this unclassified Symposium is open to all interested technical personnel. Further information and a preliminary program, when available, may be obtained by contacting:

Mr. John E. Kumpf
Univac Division of Sperry Rand
2121 Wisconsin Avenue, N.W.
Washington 7, D. C.
Area Code 202-338-8510 Ext. 307

S. J. Mathis, Jr.

S. J. MATHIS, JR.
Office of Naval Research
Symposium Co-Chairman

Editorial Policy Notices

CURRENT PUBLICATION PLAN

Because of staffing problems the Digital Computer Newsletter was not published in October 1962 and during 1963. Commencing with the January 1964 issue, however, the normal quarterly schedule was resumed.

To assist our readers in maintaining continuity in the state of the art, the January issue was devoted entirely to material scheduled for previous issues. The April issue is a combination of new material and some older contributions which could not be included in the January issue.

EDITORIAL

The Digital Computer Newsletter, although a Department of the Navy publication, is not restricted to the publication of Navy-originated material. The Office of Naval Research welcomes contributions to the Newsletter from any source. The Newsletter is subjected to certain limitations in size which prevent publishing all the material received. However, items which are not printed are kept on file and are made available to interested personnel within the Government.

DCN is published quarterly (January, April, July, and October). Material for specific issues must be received by the editor at least three months in advance.

It is to be noted that the publication of information pertaining to commercial products does not, in any way, imply Navy approval of those products, nor does it mean that Navy vouches for the accuracy of the statements made by the various contributors. The information contained herein is to be considered only as being representative of the state-of-the-art and not as the sole product or technique available.

CONTRIBUTIONS

The Office of Naval Research welcomes contributions to the Newsletter from any source. Your contributions will provide assistance in improving the contents of the publication, thereby making it an even better medium for the exchange of information between government laboratories, academic institutions, and industry. It is hoped that the readers will participate to an even greater extent than in the past in transmitting technical material and suggestions to the editor for future issues. Material for specific issues must be received by the editor at least three months in advance. It is often impossible for the editor, because of limited time and personnel, to acknowledge individually all material received.

CIRCULATION

The Newsletter is distributed, without charge, to interested military and government agencies, to contractors for the Federal Government, and to contributors of material for publication.

For many years, in addition to the ONR initial distribution, the Newsletter was reprinted by the Association for Computing Machinery as a supplement to their Journal and, more recently, as a supplement to their Communications. The Association decided that their Communications could better serve its members by concentrating on ACM editorial material. Accordingly, effective with the combined January-April 1961 issue, the Newsletter became available only by direct distribution from the Office of Naval Research.

Requests to receive the Newsletter regularly should be submitted to the editor. Contractors of the Federal Government should reference applicable contracts in their requests.

All communications pertaining to the Newsletter should be addressed to:

GORDON D. GOLDSTEIN, Editor
Digital Computer Newsletter
Informations Systems Branch
Office of Naval Research
Washington, D. C. 20360

Computers and Data Processors, North America

D825 System to Naval Research Laboratory

Burroughs Corporation
Detroit 32, Michigan

A D825 modular data processing system, the electronic computer industry's first large scale, general purpose system with thin film memory to be delivered, has successfully passed the Naval Research Laboratory's rigid acceptance trials. The D825, the first system in Burroughs newly developed, fully modular D800 series, was delivered on contract schedule and quickly passed the Navy's tests. The Navy has not revealed how it will use the highly flexible, solid-state system. The D825 was developed and produced by Burroughs Laboratories in Paoli, Pa., a division of Burroughs Defense and Space Group.

Processing of data is greatly speeded by 1 microsecond access to newly developed thin film memories in the arithmetic units which serve as a "scratch pad" memory. Another memory feature is that if power fails, information being processed is retrieved without loss of data when processing is resumed after power restoration.

The Air Force has ordered 17 of the D825 systems in a $24,450,000 contract for its back-up interceptor control (BUIC) system to assist in protection of the North American continent against air attack. Another D325 at Burroughs Laboratories in Paoli was used in a successful Telstar communications experiment. Telstar received computer test messages from the D825 and relayed them to Burroughs corporate headquarters in Detroit where they were printed out of an S203 high speed electrostatic printer.

The modular concept, on which the D825 is based, permits easy expandability, without changing programming or instructions, by addition of memory, computer, control, and other modules as needed; allows simultaneous processing of multiple problems, and provides the ability to establish priorities in operation.

These abilities are vital in military electronic command and control situations which demand high speed processing, maximum reliability and the greatest versatility. They are made possible by the D825's automatic operating and scheduling program (AOSP). This program, acting as central director and assigner of duties for all of the functional devices in the system, allocates devices to problems on the basis of equipment availability. Because of this new approach to computer organization, the system can operate efficiently even if all elements are not available at a given time.

The D825 can be expanded from a basic system to include from 1 to 4 computer modules, 1 to 16 memories, 1 to 10 input-output control modules, 1 or 2 input-output exchanges, and 1 to 64 peripheral devices for each I/O exchange. These devices may be chosen from a broad range of magnetic tape transports, drums and disc files, paper tape perforators and readers, displays, consoles, and supervisory printers, high speed page printers, data converters, communications equipment, special real time clocks, and inter-system data links.

Computing Centers

Medical Research Computing Center

University of California, Los Angeles
Los Angeles 24, California

During 1963 the nation's largest computing installation for medical research was placed in operation at UCLA's Center for the Health Sciences. Demonstrations of its use in brain, heart, blood and other medical research underscore the growing importance of computers in medicine.

The new $3,300,000 Health Sciences Computing Facility was made possible by grants from the National Institutes of Health. It consists of IBM 7094 and 1410 data processing systems. They are able to exchange information and computing power electronically with other medical research centers. Storage of large masses of research data for instantaneous retrieval and processing is provided by two IBM 1301 disk storage units which can handle nearly 112 million characters of information.

The UCLA facility could be the forerunner of a number of similar centers in different parts of the nation which one day may provide physicians and medical scientists with direct access to a computer for assistance in diagnosis, as well as research.

The new computing center has two major functions: to provide computing support for medical research, and to serve as a base for research in the use of the computer itself, as it relates to biology and medicine. The existence of this center reflects a policy of the National Institutes of Health to help provide broad investigational resources to institutions at which it also sponsors individual research projects.

The computing system at UCLA now is:

- Helping provide significant new knowledge on the organization of brain systems during sleep, fatigue, weightlessness, vibration, prolonged darkness and other conditions astronauts may encounter in space flight;
- Analyzing brain wave data acquired by an experimental astronaut helmet developed by scientists at UCLA's Brain Research Institute and Space Biology Laboratory;
- Proving that complex biochemical experiments now conducted in the laboratory may one day be performed more rapidly, precisely and economically with computer assistance. In one project, chemical responses of blood to various factors in surgery are simulated and analyzed by the computer;
- Aiding the analysis of huge masses of medical data. In one effort, the computer is a principal tool in a Los Angeles heart study aimed at discovering causes associated with heart disease and conditions which keep people free of heart trouble;
- Serving as a tool in research aimed at development of a hospital-wide system of automated record handling, storage and retrieval. This project involves development of a computer-stored "thesaurus" of disease conditions for automatic coding of disease.

NIH is especially interested in this facility's role as a laboratory within a laboratory. Under the grant, UCLA's Biomedical Data Processing Group will continue its pioneering work in research and development of statistical, mathematical, and educational techniques which will further broaden the computer's value to medical science.

Dr. Dixon and Dr. Frank J. Massey, biostatisticians in the School of Public Health, head a UCLA team responsible for creating a series of computer programs valuable in sophisticated statistical analysis of a wide variety of medical data. This continuing effort has resulted to date in creation of more than 50 separate computer programs. These programs, known as the BIMD series, have been distributed by UCLA, on request, to more than 150 research centers throughout the nation. They are considered to be the most comprehensive collection of general purpose data processing programs currently available for use in medical research. A majority of more than 100 medical research projects currently assisted by the Health Sciences Computing Facility use the BIMD series programs. For example, one of these programs is the basis of the spectral analysis of electroencephalographic records.

CIT Computing Center

California Institute of Technology
Pasadena, California

In December 1963 the research capabilities of the California Institute of Technology were greatly advanced by the addition of a versatile computer complex designed to serve a wide variety of scientific and engineering research programs.

Dedicated were the handsome new, three-story Willis H. Booth Computing Center Building, large IBM information processing facilities, and auxiliary equipment with remote stations that enable students, faculty members, and research facilities to make full use of the system at any time. Many investigators can use it, in effect, simultaneously.

The heart of the sophisticated system combines two large IBM computers—a 7090 and a 7040. Caltech electronics engineers in cooperation with IBM engineers have linked the two so that the 7040 handles the "housekeeping chores," such as monitoring input and output, thus enabling the 7090 to devote virtually all of its time to high-speed calculating.

Somewhat as the 7040 monitors the 7090, an IBM 7288 Multiplexor controls the traffic of communication between the 7040 and other components, several of which were designed by Caltech engineers. These include consoles remote from the computing center, various display devices such as printers, a Burroughs 220 computer, and data-gathering units capable of controlling experiments, gathering data from them, and relaying the information to the computing center.

"This large, flexible, versatile system was tailored to meet Caltech's specific needs," said Dr. Gilbert D. McCann, Jr., director of the computing center. "It is for use on a wide variety of research projects, and is designed to interact with the people, the research, and the educational activities of the Institute."

The system is designed for a wide variety of applications and to handle, virtually simultaneously, the problems of many different research projects. Data can be fed into consoles to be relayed to the interplexing system, where the data will be reassigned, with some problems being referred perhaps to the Burroughs 220 for solution. The 7040 itself may resolve some problems. It will refer complex ones to the 7090. The 7040 may stop the 7090 from working on one problem, direct it to store the information concerning that problem so that it may tackle a more pressing problem, solve it, and then resume work on the original one. This may take from a few seconds up to a few minutes.

The data reduction complex can meet the requirements of many individual research projects. The data may be brought to the computing center for conventional processing. Or a Caltech-designed console may be set up in any laboratory, on a permanent or temporary basis, so that researchers may "converse" with the computer. In this way their research may be directed by computer results with a minimum loss of time.

The computing center also may be directly linked with research facilities and will take data directly from such instruments as the atom-smashing synchrotron. In addition, the computer center is set up to conduct experiments, turning on and off stimuli at stated times and recording the resulting data. In neurobiological studies, for instance, the optic nerve of a crab's eye may be connected directly with the computer. Thus a light passed in front of the living eye stimulates nerve impulses that go directly into the computer via the optic nerve. These trains of nerve impulses are recorded and analyzed.

"One of the major purposes of the new center is to make it possible for Caltech to undertake big research programs," Dr. McCann said. "The tremendous data reduction tasks required of many complex modern research programs, such as those involved in understanding the origins and evolution of the universe, the geophysics of the earth or the workings of the brain, find the human mind incapable of coping with them. Such data reduction tasks are so great that scientists, without computers, could not reduce the data within their lifetimes."

With computers becoming more and more useful in science and engineering, the need to understand their theory and operation becomes urgent. Caltech students are being taught how to program and operate computer systems as an important part of their technical education.

The computing system will continue to grow and expand to meet the changing requirements of Caltech. In addition to providing space for computing facilities, laboratories, offices, and classrooms, the Booth Computing

Center also houses an elaborate electronics shop. In it engineers and technicians under the supervision of electronics engineer Charles B. Ray design and build components for the system.

When the computing complex is operating at full potential, by the spring of 1964, it will be available to any of Caltech's 800 research projects. Eventually, the system probably will be linked with Celtech's satellite "campuses," the Mount Wilson and Palomar Observatories, and the Caltech Radio Observatory in Owens Valley.

The new computing center building was made possible by gifts from the Booth Ferris Foundation of New York City and the National Science Foundation.

Institute for Computer Research

University of Chicago
Chicago, Illinois

ALGOL Compiler

A one-pass ALGOL Compiler is in operation on the Maniac III computer at the Institute. It includes all features of the 1963 revision of ALGOL 60 except that it does not handle recursive procedures or own variables. These restrictions will be removed from the two-pass compiler now under development for the CDC 3600 in cooperation with the Argonne National Laboratory. This work has been under the direction of H. Kanner with P. Kosinski and Charles Robinson participating.

Spark Chamber

A digitized spark chamber using wire electrodes and core storage is under development for on-line operation with the computer to handle experiments in high energy physics. Small modules of these chambers have been operated with the cyclotron at the University of Chicago, and we hope shortly to have a physics experiment completed and ready for publication. This work is being carried on by a group headed by Michael Neumann. A novel feature of this program is that very high data rates are obtainable, considerably higher than those permitted by most other spark chamber systems which permit automatic data retrieval.

Maniac III Computer

The Maniac III computer has been in steady operation for the past year and a half. Approximately half of the available time has been used for programming studies, the remainder of the time being used for engineering work toward completion of the basic machine. (The Maniac III computer was described in Digital Computer Newsletter April and July 1960). Extensive arithmetic acceptance tests have been run totalling well over a million examples of each of the various kinds of arithmetic operations the machine permits.

Personnel Changes at the Institute

The Institute Director's office has been taken over by R. H. Miller and Mr. John Shepherd now serves as Chief Engineer on the Maniac III program.

1604-A Delivery to Weizmann Institute, Israel

Control Data Corporation
Minneapolis 20, Minnesota

In January 1963, Control Data Corporation delivered its first 1604-A system overseas to the Weizmann Institute, Rehovoth, Israel.

The key unit to be installed is the Control Data 1604-A, while a second computer, the desk-size Control Data 160-A, is to be used in conjunction with the 1604-A. Either computer commands and controls a wide range of peripheral equipment, including 12 new Control Data 606 pneumatically controlled Magnetic Tape Units, a 1000-line-a-minute printer, a card-reader and card-punch system, and additional magnetic core memory and arithmetic units.

Representatives of The Weizmann Institute, which is located near Tel Aviv, Israel, indicated that broad research plans are in store for the Control Data computers. Among the major problems that the computers will help solve is one that involves the determination of atomic energy levels from pure theory. The Weizmann Institute's Nuclear Physics Department is also planning "bubble chamber" investigations in cooperation with CERN, the Central European Research Organization, hoping to shed new light on the nature of elementary particles.

The Control Data 1604-A/160-A Computer complex will be put to work in most research departments of The Weizmann Institute. The range of activity includes hydro-dynamics, investigation of ocean tides to determine and predict tide levels, geophysics and the examination of the earth's natural oscillation as well as "forced" tremors resulting from earthquakes and nuclear explosions, and low temperature crystallography.

Digital Computer Laboratory

University of Illinois
Urbana, Illinois

The Circuit Research Group of the Digital Computer Laboratory has successfully operated a tunnel-diode buffer amplifier at above 1 kMc. This amplifier can accept a signal from a generator of arbitrary impedance without giving rise to reflections. The power gain is about 100, the voltage gain 1.3. The amplifier consists of two broadside-coupled strip lines with the input line having 200-ohm characteristic impedance and the "output" line being kept at a 20-ohm level. The output line is terminated by 20 ohms and -20 ohms respectively, the latter being obtained from an appropriately biased tunnel diode.

Work is in progress to build photocoupled logical elements: these are infra-red Gallium-Arsenide lamps and Riesz-type photocells. Switching times of the order of 10 nanoseconds have been obtained.

Other work in progress covers Hot Electron Logic, Microplasm Switching, and theoretical work in the semiconductor area.

Computing Center

Los Alamos Scientific Laboratory
Los Alamos, New Mexico 87544

The MANIAC II Computer at Los Alamos Scientific Laboratory now has 20,480 words of core memory; the barrier grid memory has been dismantled.

The MADCAP Language, which uses 86 character sub- and superscripting Flexowriters, has been most successful and is going into its fourth major edition. It has been expanded to include a suitable notation for combinatorial and set-theoretic calculations.

The NET program (described in Los Alamos Report LA-2853) for calculating both transient and steady-state behavior of electronic circuits is in full production. Machine time is available for circuit calculations, to Government agencies and contractors; the price is $250 an hour.

Computer Aided Medical Treatment

Texas Institute for Rehabilitation and Research
Houston, Texas

A new approach to treatment and rehabilitation of victims of crippling disease and injury has slashed long-term stays here between one-third and one-half. Using computers and other electronic aids, physicians at the Texas Institute for Rehabilitation and Research are opening new frontiers in treatment of long-term illnesses.

As a result of this work, sponsored by the Vocational Rehabilitation Administration, The

National Aeronautics and Space Administration has asked the Institute to study the effects on healthy persons of extended inactivity in a prone position, such as that required for space travel.

Dr. William A. Spencer, Director of the 54-bed research affiliate of the Baylor University College of Medicine, has coined a name for the approach TIRR is taking. He calls it "medical humanetics, a union of medicine, psychology, social science, mathematics, and computer technology. We treat the 'whole man,' not just his illness.

A cornerstone of this approach has been the use of Baylor's two IBM data processing systems, a 1401 and a 1620, to analyze and correlate thousands of pieces of data about individual patients. The result has been a wealth of information enabling physicians at TIRR to anticipate more accurately the course of a disease and select the treatment which hastens recovery without placing stresses on the patient's system. Also this has meant a direct reduction in hospital stays at TIRR, sometimes as much as one half. This means twice as many patients can be treated. The implications in a world of overcrowded hospitals are obvious.

TIRR is using techniques it developed in treating sick people to determine the effects of prolonged bed rest on healthy persons. Numerous data are being recorded by electronic physiological monitoring equipment developed by Baylor and TIRR. The information is being analyzed by an IBM 7094 computer at NASA's Houston space center.

We expect to determine the precise effects of prolonged inactivity on the human body and how to minimize those effects.

One of the problems which has been attacked at TIRR by Dr. Paul R. Harrington is that of scoliosis. This condition affects 30,000 Americans each year—80 percent of them children—by causing severe and often fatal distortion of their spines. Computer measurement of data has enabled TIRR to improve a surgical method of straightening spines with assurance that the operation will be lastingly effective. The computer has calculated the precise time period, 12 weeks to the day, that patients should spend in a post-operative cast. Computer analysis indicated that after a shorter period the spine tends to return toward its original position. After longer periods, other organs and body systems are adversely affected.

The most important overall human problem TIRR deals with is rehabilitation of paralyzed patients. Here, knowledge of the probable course of the illness or condition is a major factor in deciding the kind and time of treatment. Doctors must decide, for example, how soon a paralyzed patient's body can be elevated to a sitting position. If attempted too soon, this position could place heavy stress on the heart. Computer analysis of data on many patients indicated that persons with paralysis of the legs only (paraplegia) could be placed in an upright position on a motorized table after 2 weeks of gradual treatment. Those who had lost motor power in all four limbs (quadriplegia) required 2 months before they could be tilted to an upright position without excessive heart stress, computer analysis showed. Knowing this, TIRR adapted jet pilots' "G-suits" for use by patients. G-suits are worn by pilots to prevent blood from "piling up" in lower limbs during gravity stress. The adapted suits enable patients to be brought to upright positions early in their rehabilitation. In a similar way other necessary treatment could be accelerated.

Another problem: how to conduct early rehabilitation procedures such as exercises in physical and occupational therapy, without putting physiological stresses on the patient's system. In some patients, reactions were so subtle and general that they had been considered insignificant. The reactions included increased pulse rate, nausea, mood changes, and decreased ability to concentrate. Computer analysis showed that some paralyzed patients were producing excessive amounts of the hormone, cortisone, and that cortisone levels were significantly higher in patients with spinal cord injuries than in those with polio-induced paralysis. Physicians at TIRR are now trying to learn how to offset these stress conditions and start patients on an earlier road to recovery.

Some of TIRR's other findings based on computer analysis of patient data: Doctors can predict, soon after an accident or the onset of an illness affecting the nervous system, whether a patient will recover muscle strength quickly or slowly. Unsuspected heart trouble in diabetics can be diagnosed by measuring the "wave velocity" of a patient's pulse. Children with cystic fibrosis will suffer less stunting of growth if they undergo oxygen deep-breathing exercises several times daily.

Dr. Spencer describes the electronic computer as "an extension of the human mind which offers physicians a new freedom to practice the art of medicine. We are flooded by a rising sea of data: blood pressure readings, electrocardiograms, temperature charts, and lab tests. In addition, thousands of research reports are published monthly. Computers will enable us to tie all this information together, to find out what it means in terms of one patient--how he changes from day to day and week to week, and to compare his condition to that of others before and after him.

NUOS Computing Facility

U.S. Naval Underwater Ordnance Station
Newport, Rhode Island

The computing facility at the Naval Underwater Ordnance Station consists of an IBM 1620 Computer with 60K memory and floating point hardware. Input/output is by card or magnetic tape. Supporting equipment includes an Analog to Digital Converter, a Paper Tape to Magnetic Tape Converter, Boscar Model N Film Reader, a Telecordex Oscillograph Reader, an Electroplotter, and an assortment of IBM peripheral equipment.

The facility is staffed by 12 mathematicians and is participating in a graduate level cooperative program with Northeastern University. Evaluation of underwater range tracking systems form the major workload of the IBM 1602. Mathematics have been developed and programs written for estimating the best sound velocity and for underwater tracking using both synchronous and asynchronous data. Other problems handled by the group includes digital simulation of tactical situations. These studies are basically used to determine the overall weapon system effectiveness and is measured generally as a kill probability. Statistical application of the 1620 computer to the evaluation of oceanographic information forms a third major workload for the computer. Studies are continuing in the determination of sound velocity, density, salinity content, movement of surface and subsurface currents, and in the periodicities exhibited by oceanographic data.

Direct mathematical support is provided to project engineers and to other proximate naval activities as required.

Computation Center

U.S. Naval Weapons Laboratory
Dahlgren, Virginia

STRETCH Hardware Configuration

The STRETCH (IBM 7030) computer has been in operation since October 1962. The system includes the following components:

Core Memory:* 49K (49,152 72-bit words consisting of 64-data plus 8-check bits)

A Memory: two 8K (air cooled)

B Memory: two 16K (air cooled)

2 Tape Channels

10 Tape Units (729IV): five units per channel

1 Disk Memory: 2,097,152 words

1 Card Reader: 1000 cards per minute

1 Card Punch: 250 cards per minute

1 Printer: 600 lines per minute

1 Operator's Console

Two IBM 1401 (Model C4, 8K memory) systems in an adjoining area are available for input-output processing.

STRETCH Programming Aids

The software package provided by IBM includes a FORTRAN compiler, STRETCH Assembly Program (STRAP), STRETCH Macro Language Processor (SMAC), Input-Output Control Subroutine (IOCS), and Master Control Program (MCP).

NWL has made several additions to the original software package provided by IBM. These additions include a Segmented Loader, a Sort-Merge Program, a Post-Mortem Dump facility, mathematical subroutines, extensions to IOCS, and a 1401 I/O package.

The Segmented Loader provides a means of running a computer program which is too large to fit into core memory at one time. The facility makes it possible to partition the coding such that each partition (segment) can be loaded into core memory as needed. A Technical Memorandum No. K-22/62, "A Method of Program Segmentation for the STRETCH Computer," is available.

The Sort-Merge Program is a generalized subroutine for sorting FORTRAN logical binary records or FORTRAN prepared BCD records. The subroutine uses a polyphase-merge technique which is more efficient than the commonly used cascade-merge technique. A Technical Memorandum No. K-30/63, "7030 Sort-Merge Program," is available.

The Post-Mortem Dump was designed primarily with the FORTRAN programmer in mind and eliminates much of the tedium associated with program debugging by presenting the values of program symbols in a readily assimilable form. A Technical Memorandum No. K-73/63, "Post-Mortem Dump Facility for STRETCH," is available.

Included in the mathematical subroutines are Zeros of a Polynomial, Least Squares Polynomial Fit, Matrix Inversion, Integration, Normal Frequency Function, Random Number Generation, and Data Smoothing.

The following features have been incorporated into IOCS:

End-of-file detection on disk and tape,

Format extensions for data handling applications,

Automatic output editing features, and

Increased buffers for BCD data.

The 1401 I/O package was designed to process STRETCH system input and output with as much efficiency and flexibility as possible. The input section of the package checks control card validity, fetches programs from a merge tape if called for, and thus prepares STRETCH system input tapes. The output section of the package produces listings (both 1403 and CRT) and punches cards from STRETCH system output tapes.

NORC

The design of a one-pass FORTRAN compiler for NORC has been completed. An almost complete subset of the FORTRAN IV language as possible can be processed by the initial version.

Implementation of the FORTRAN compiler was facilitated by the addition of a new instruction in the NORC which simplifies the setting of index registers.

Polaris DGBC Serial O

Serial O, a prototype of the Digital Geoballistic Computer (DGBC) used for fire control on later Polaris submarines, was installed at this laboratory during the summer of 1963. Simulators for some of the shipboard devices with which the DGBC normally communicates are installed, and others are being constructed. Serial O is used for development and testing of computer programs for use by the Polaris fleet.

Computers and Centers, Overseas

Laboratorio di Elettronica
Universita Degli Studi Di Genova
Genoa, Italy

Since October 1963, Dr. Ing. Arrigo L. Frisiani has been Professor in Charge of the Computers' Section of the recently established Electronic Engineering curriculum at the University of Genoa. Students attending the regular course on computers will be able to use the facilities of the University's Computing Center (presently equipped with an IBM 1620) in order to gain a better insight into the problems and the machines. Research projects will be undertaken at the local Laboratorio di Elettronica, especially in the fields of Boolean Algebra and didactical computers. Dr. Frisiani welcomes suggestions, publications, and any material that may be useful in the general planning of the activities.

2002 and 3003 Computing Systems

Siemens and Halske A. G.
Munich, Germany

GENERAL SYSTEM LAYOUT

The Siemens Model-3003 Data Processing System is suitable for a great variety of applications and meets many of the requirements imposed on a modern computer installation. The system is composed of a number of units designed to operate independently and on a time-sharing basis. It can be roughly subdivided into internal units and peripheral units. The internal units include the central unit, the arithmetic unit, and the working storage unit. The peripheral units consist of controls and devices which permit data to be stored or to be read in and out.

INTERNAL UNITS

Central Unit

The flow of information throughout the Siemens Model-3003 Data Processing System proceeds under the control of the central unit. The central unit supplies the instructions to be carried out to the arithmetic unit and the peripheral units and controls the exchange of data between the units mentioned and the working storage unit. The central unit also features a data control regulating the flow of data, and a program control for running the individual routines.

Data Control—The data control regulates the data flow between the working storage and the other units. In addition, the data control furnishes the unit which was connected to the working storage during the preceding cycle with the address of the next working storage location. If a unit has to be connected to the working storage for a transfer of data, this unit conveys a request to the data control of the central unit. Since the units of the Model-3003 work independently, several of them may be in operation simultaneously, and it may happen that several units initiate requests at the same instant.

In this case, the requests conveyed by the various units are collected in a so-called request register and served in order of priority. Each unit is assigned a priority rating with respect to requests conveyed to the data control. The priorities can be assigned to the units arbitrarily, but the most favorable order of priorities can be established by considering the specific setup of the data processing system and the application it is put to.

The request register is cyclically searched by a request identifier. A successful search causes a connection to be established between the requesting unit and the working storage for the duration of one cycle having a length of 12.5 μsec.

This 12.5 μsec cycle accommodates the time for identifying the request; the time for building up the connection between the respective unit and the working storage; and the time for reading four characters into or out of the working storage, which equals a maximum data flow rate of 320,000 characters per second.

Program Control—The program control of the central unit reads the instructions out of the working storage and distributes them to the units for which they are meant. The instructions to be carried out are passed to the various units through program channels. Up to 16 program channels can be connected with the program control, one of which invariably serves for connecting the arithmetic unit. 15 program channels are freely available for connecting peripheral units.

In transferring instructions, the program control of the central unit remains linked with the corresponding units only for that period of time that is absolutely necessary. The program control only initiates the programmed operations in the executing unit. The operation, which frequently is of much longer duration than the initiating function, is executed by the respective unit on its own. In the meantime, the program control can serve other units, thus enabling several units to work in parallel.

Shortly before the instruction last received by a unit has been executed, the unit sends an interrupt request to the program control. This enables the program control to supply new instructions to a unit while previous ones are still being executed. These interrupts determine the program continuation. The interrupts initiated by the units are read into a register of the program control, the so-called program interrupt register. As soon as an interrupt has arrived at the program interrupt register, the current program is broken at the earliest possible moment.

There are conditional and unconditional interrupts. A conditional interrupt causes the current program to be broken only at an instant where the program control interprets an instruction after the execution of which the program may be interrupted. An unconditional interrupt, on the other hand, causes the program to be broken in any case after the execution of the instructions just being dealt with.

The peripheral units report the completion of each operation through a conditional interrupt to the program control. If several conditional interrupts are stored, they are obeyed in order of priority. Each program channel which links the peripheral units with the program control can be assigned a certain priority.

Conditional interrupts entail, as the current program permits, conditional program breaks. Information on whether a program may be interrupted is obtained from the so-called interrupt designator of the instructions to be executed. The programmer can mark the points where a program may be broken. This provides a means of coordinating the time-sharing operation of the peripheral units. Besides, it is possible to provide for precedence handling of certain programs. The coordination functions required for this purpose are accomplished by an executive program.

If the arithmetic unit is given an instruction which it finds to be wrong in format, the program control receives an error signal which takes the form of an unconditional interrupt.

Thanks to this novel mode of operation of the central unit, the Siemens Model-3003 Data Processing System is capable of handling several input and output processes simultaneously with respect to each other, but also with respect to the internal routine. In addition, the system can run several interdependent or independent routines on a time-sharing basis.

This leads to a high degree of efficiency in data processing and permits the operating speeds of all units of the system to be exploited to the maximum possible extent.

Arithmetic Unit

The arithmetic unit performs arithmetical and logical operations. In the Model-3003 Data Processing System, a distinction has to be drawn between operations with words of fixed length and operations with words of variable length. To accomplish these operations, the arithmetic unit is connected to the program and data control.

In the case of operations with a fixed word length (24 bits), the arithmetical operations are carried out on a fixed-point binary notation basis. Besides performing arithmetical operations, the unit is capable of carrying out a series of shift functions, logical connectives, forking operations, and jump instructions, using words of fixed length.

When operations with words of variable length are performed, the operands may comprise an optional number of decimal digits, letters, or special characters, with the word length being limited only by the capacity of the working storage. This enables the available storage capacity to be utilized to the optimum extent. Each discrete character in the working storage is addressable, that is, can be read or written individually.

By using instruction words of variable length, it is possible, over and above the performance of arithmetical operations, to transfer character sequences within the working storage, to compare two trains of characters on the basis of a pre-established sorting sequence, and to search a sequence of characters for one particular character. Additions and subtractions are accomplished in the add-to-store logic, that is, an operand is replaced by the sum (a + b to a).

Working Storage Unit—The working storage unit encompasses a magnetic-core storage and the control circuitry required for storage operations.

The working storage unit of the Siemens Model-3003 Data Processing System is in supply in three setups which differ only in storage capacity. The capacity options are 16,384; 32,768; and 65,536 characters; a character is considered to be a figure, a letter, or a special symbol. Each character is coded by six bits.

Each character is individually addressable, but it is likewise possible to provide access to four characters in the working storage unit by one address. It should be noted in this connection that to achieve a high operating speed, the information flow from and to the peripheral units proceeds in blocks of four characters each, i.e., four characters are transferred and stored simultaneously.

The Siemens Model-3003 Data Processing System can handle words of fixed and variable length. The use of variable-length words facilitates operation in commercial applications, while fixed-length words are better suited to the solution of engineering and scientific problems and to programming.

Each fixed-length word in the Siemens 3003 system consists of 24 bits, i.e., four characters. This length is consistent with the length of the various working storage locations. A fixed-length word can be interpreted in the system as a binary-coded instruction word, as a binary number with sign, and as a binary bit pattern, that is a 24-digit sequence of zeros and ones.

The length of a variable-length word is established either by a number-of-character signal or by a fixed end-of-word signal. If the end-of-word signal mode is employed, the word length or the number of characters is limited only by the capacity of the working storage. If the number-of-character signal mode is used, the variable word length is 63 characters or less.

PERIPHERAL UNITS

The Siemens 3003 Data Processing System provides for the optional connection of up to 15 peripheral units. Each such unit is composed of a control and one or several data handling devices. Each peripheral unit operates independently; several input and output operations can be performed simultaneously with each other and with the internal processing routine. For carrying out input and output operations, the peripheral units concerned associate themselves directly with the working storage unit.

Each peripheral unit is linked to the computer through a data channel and a program channel; the former is a communication path between the working storage unit and the peripheral unit, and the latter a communication path between the program control and the peripheral unit.

The peripheral units address their requests for transfer of data to the data control via the data channel. Since the units are capable of working in parallel, such requests for data may arrive from several peripheral units simultaneously. They are then served in the order of priority; the individual priority ratings are permanently assigned to the data channels and, thus to the individual units. The higher the input and output speed of a peripheral unit, the higher must be the priority rating assigned to its request signal.

When a peripheral unit is connected to the data processor, the respective data channel should be accorded a priority rating consistent with the input and output speed of the peripheral unit concerned. Every peripheral unit can pass a request to the program control, which has the effect of a conditional interrupt of the program. This provides for coordination between the operation of the central unit and that of the peripheral units in such a manner that no idle time occurs on any of the units.

Some input and output units that can be linked to the Siemens 3003 Data Processing System are:

- Paper tape input unit

- Paper tape output unit

- Typewriter unit. This unit consists of one to three typewriters and the associated controls, and is connected via a data channel and a program channel. The typewriter unit serves as the operator's position in the system.

One typewriter, the so-called master typewriter is required in each case, while one or two so-called secondary typewriters may be linked to the unit as optional adjuncts. The secondary typewriters may be detached from the data processing system to accomplish other functions, for instance the preparation of punched tape. Either the keyboard or the tape-transmitter attachments fitted to the typewriters may be used for data input; a record of the data being fed into the system is logged by the typewriter in either case. The maximum input and output speed amounts to 10 characters per second. The typewriters of the unit are capable of 100 percent simultaneous operation.

- Card Reader Unit 088

- Card Punch Unit 514

- Printer Unit. This unit consists of the Siemens high-speed printer and is connected via a data channel and a program channel. The output speed of the Siemens high-speed printer varies between 12.5 lines per second with alphanumeric data output and 25 lines per second with purely numeric data output. Each line has 132 printing positions. Start and stop of the printing process are controlled only by the information handled and are not subject to a fixed cycle (free-wheeling feature).

The high-speed printer is designed to accommodate one or two paper forms at option. It is thus capable of concurrently printing two documents which may differ in format and contents. The paper feed function for the two tracks can be put under program control. A distinction is made between the line feed function and the form feed function. The latter proceeds under the control of a punched tape which is stepped in synchronism with the form to be printed.

- Mangetic-Tape Unit. The unit consists of one to eight Siemens TM-2 magnetic tape drives and associated control, and is connected via a data channel and a program channel.

The Siemens TM-2 magnetic tape drives are designed for a reading and writing speed of 46,000 characters per second, but can optionally be adapted to a reading and writing speed of 30,000 characters per second. The information density is 120 and 80 characters per centimeter, respectively. The data are organized on the magnetic tapes in blocks of variable length. Each character is coded by six bits plus one parity-check bit, the bits are arranged on the tape in the direction perpendicular to the feed direction. The seven bits of a character are written or read simultaneously.

MANUAL CONTROL OF THE SIEMENS MODEL-3003 DATA PROCESSING SYSTEM

The operator controls the Siemens Model-3003 Data Processing System by means of the typewriter unit. This unit, as mentioned earlier, is provided with a master typewriter and may be augmented by one or two secondary typewriters. The master typewriter is in any case connected, regardless of system setup.

The secondary typewriters are not necessarily set up in the same room as the data processing system, thus permitting the latter to be controlled from a spatially separated location. The secondary typewriters can be cut in for input to the system, or they may be detached for independent operation. Operator control can be exercised from the typewriter keyboard and the tape-transmitter attachment. All operating manipulations and manual interventions in the program are logged automatically.

Table I. SIEMENS DATA PROCESSING SYSTEMS CHARACTERISTICS

Characteristics	Siemens[a] 2002		Siemens 3003
Monthly Rental (Typical)	$13,900[b]		$10,250[b]
First Delivery (Month and Year)	6/59		12/63
Processor Speed			
Complete add time in microseconds	180		345[c]
Storage cycle time in microseconds	90 core	23 000 drum	12.5[d]

Table I. SIEMENS DATA PROCESSING SYSTEMS CHARACTERISTICS (Continued)

Characteristics	Siemens[a] 2002		Siemens 3002
Internal Storage			
Capacity in words	1000-100 000	10 000	16384-65536
Type	core	drum	core
Logic			
Word size	12 decimals[e]		1 alphanumeric character[f]
Instruction address	1		1 - 2
Magnetic Tape			
Thousands of characters per second	30 or 46[g]		30 or 46[g]
Buffering	Reading, writing and computing can be performed simultaneously		Reading, writing and computing can be performed simultaneously; multiple simultaneous operations are possible[h]
Maximum units attachable	60		120
Random Access File			
Capacity	-		25.8 millions[i]
Access time in milliseconds			136
Peripheral Devices			
Cards per minute: In	650		650
Out	100		100
Paper tape characters per second: In	200		400
Out	60		60
Printer, lines per minute	750-1500[j]		750-1500[j]
Off-Line Equipment	same[k]		same[m]
Other Features			
Program interrupt	-		yes
Index registers	3		-
Indirect addressing	yes		yes
Floating-point arithmetic	yes		-
Console typewriter	output		input/output
Software			
Algebraic compiler	1/62[n]		-
Business compiler	-		7/65[o]

[a]See Digital Computer Newsletter (Apr. 1959)
[b]Typical rental for magnetic tape system
[c]Add time assumes a five-character field
[d]Four characters are read or written in every cycle
[e]Word size is 12 decimals plus sign
[f]Variable-length instructions operate on variable length data fields; moreover, fixed-length instructions operate on 24-bit words
[g]Magnetic tapes are IBM compatible
[h]Up to 15 channels for peripheral equipment may operate full simultaneously (input and output)
[i]For each disc file unit
[j]With two independently controlled paper tracks
[k]Card equipment may be used off-line
[m]Card equipment and typewriter may be used off-line
[n]ALGOL
[o]COBOL

On-Line Cheque Handling and Accounting

Standard Elektrik Lorenz AG
Stuttgart, Germany

Standard Elektrik Lorenz, an ITT associate, has delivered a test installation for on-line processing of cheques and money transfer orders in the German Post Cheque Service. This installation is one of the steps in the automation efforts for this service.

The German Post Cheque System comprises 13 Post Cheque Offices (PCO) in the main cities. It is operated by the Deutche Bundespost (German Federal Post) in a similar, but restricted mode as a bank institution, mainly: money transfer between any accounts at the same or a different PCO; cash payment from an account to a private address; and cash payment onto an account from any post office counter.

The total number of accounts is 2,000,000, in a single PCO 150,000 to 300,000. The average traffic in a PCO is 150,000 to 500,000 documents per day, moving 30,000 to 100,000 accounts. The daily routine work in a PCO has several firm restrictions in time. All orders arriving by 10 a.m., and urgent orders until 1 p.m., have to be booked the same day. A small number of orders from the cashier's desk in the office building have to be treated immediately.

When all accounting is finished, account statements must be printed for all accounts moved. They contain the mailing address of the account holder, the previous balance, all movements, and the new balance.

These account statements and appropriate credit documents must be mained to the holder. Check lists must be printed and attached to those documents, which have to be mailed to other CPO's for crediting or to local post offices for cash payment. All outgoing mail shall reach the receivers (customers or post offices) early the next day, so it has to leave the PCO by 6 p.m. for the night trains.

The on-line test installation at the PCO Nurnberg will be operative for 20,000 accounts during spring 1964.

Weapons Research Establishment

Department of Supply
Salisbury, South Australia

COMPUTING EQUIPMENT

The Australian Weapons Research Establishment uses digital computing facilities to process trials data from the Woomera Guided Missile Range, and for scientific and engineering computations which arise in the research work of the Establishment. The present facilities consist of an IBM 7090/1401 combination (see DCN, July 1961) obtained from joint British-Australian financial resources.

The 7090 has been in use since February 1961, when it replaced WREDAC (the Elliott 403) as the central processor in a magnetic tape oriented data processing system. This fact, and the requirement to provide a general computing facility for non-specialists led to a choice of equipment including a 32-K store, two data channels, eight 729 Model II tape units, a card reader, a card punch, and a printer, the last three being used on-line. This represented the minimum selection of units for compatibility with pre-existing non-IBM ancillary equipment, and for satisfactory operation with the FORTRAN and FAP coding languages under the FORTRAN Monitor System. The availability of the IBM 7090 and the ease of use of the FORTRAN coding language has led to a steady and rapid growth in the demand for general computing services on the 7090, additional to the predicted growth arising from the data processing needs of the large and more complex missile trials now current. See Table I. To meet this increasing demand, equipment re-organizations and additions have been made from time to time and the hours of operation have been extended to a regular two-shift day, with extensions to three shifts when needed. The equipment modifications have been designed to give all-tape operation of the IBM 7090 with the removal off-line of all functions except those essential to correct operation, such as on-line prints of instructions to operators. This has been effected by the addition of an IBM 1401, Model C3, together with a card reading and punching unit, a fast printer, and two tape units, and by the removal of the on-line punch (721). The tape data transmission to and from the 7090 has also been speeded up by introduction of five additional 729 Model IV tape units. The current tape distribution on the 7090 is five tapes on channel A and six tapes on channel B. The two tapes normally attached to the 1401 can be cabled to the 7090 to give a total of 13 7090-tapes if required.

Based on the central 7090/1401 facility, the remainder of a "second generation" data processing system is also nearing completion (see below). This has involved the design and construction of improved analogue-to-digital converters and digital-to-digital format converters. These are expected to have a capacity 10 times that of the valve machines they replace and also have greater control flexibility. They will enable more sophisticated programming techniques on the 7090, such as automatic recognition of the source of data and the type of processing required, and will record additional data quantities which will assist in the automatic detection and correction of errors.

The standard operating mode of the IBM 7090 is with version 2 of the FORTRAN Monitor modified for local conditions. Fur instance, two major features of trials data processing work are the number of repeated uses of a programme which may be required in the composition of a single monitor run and the generation of large amounts of tape output which is destined for re-input to the 7090 for further processing. Normal FORTRAN Monitor procedure in the first case is to provide a copy of the programme deck with each data deck. This requires multiple copies of such programme decks and repeated complete reloadings of the same programme both at the card-to-tape transcription stage on the 1401 and in the tape to store transfers on the 7090. This duplication has been eliminated by incorporating a save procedure in the monitor, whereby at the end of each job the programme is saved until the nature of the next job has been established. This enables a programme restart without further loading, when appropriate, and permits operators to stack as many data decks as are appropriate behind each programme deck when assembling monitor runs. The tape output and re-input problems are handled by a combination of programme conventions, special routines, and monitor modifications. All data for long term retention, or subsequent re-input, is output onto a standare tape (A6) in binary form, and each record is automatically provided with a unique reference giving the spool number and the sequential position of the record on the spool. All subsequent references to data on that tape use this code and when re-input to the 7090 is required this code provides an easily programmable means of tape positioning if the code values are given as input data for the job. The system automatically ensures the carry over of output sequential numbering from job to job and contains provision for continuing on to a new spool. These facilities enable the 7090 to continue with a single primary output tape for as long as is operationally convenient.

The modifications to the monitor described, with others, have proved an efficient solution to some of the operating problems that arise with a variable job mixture, often containing many short runs, and a complicated tape input situation. A further major operating improvement is expected with the fitting of manual tape positioning controls to the tape units used for re-input. These will enable operators to position tapes (approximately) at load time, and will substantially reduce the large time losses which accumulate when many jobs involve preliminary spacing over large lengths of tape under programme control before reaching the data required. It is planned to combine this present manner of operation with the new facilities offered by IBSYS, but a basic problem is achieving compatibility between the specialised tape input-output system and the generalised facilities of IBSYS. It is hoped to implement a solution requiring the residence of IBSYS and the existing monitor on the same system tape with a free interchange between the two via control cards.

Operation of the IBM 7090 is on a closed shop basis. Access to the machine is restricted to the operating staff except for any person whose presence may be desirable to derive full benefits from a programme run. All input is submitted to a computing office with standard documentation covering the operations required and accounting information. After logging the job, input received at the computing office is sent to the machine room where monitor decks are composed on the basis of job priorities and estimated execution times. These decks are loaded onto a peripheral input tape via the IBM 1401 to await the availability of the 7090. The 1401 is in continuous operation with a multiple utility programme which permits concurrent tape-to-card or printer and card-to-tape operations. For a standard production job of normal priority the interval between submission to the computing office and the availability there of the output is approximately 5 hours. There is a provision, rarely exercised, for an over-riding priority which gives immediate access to the 7090. Also, jobs of low priority may be delayed till higher priorities have been satisfied, although delays of more than 1 day are uncommon. The collection of the output from the computing office is the responsibility of the customer who is given telephone notification of its availability. It should be mentioned here that Establishment users are spread in individual buildings, over an area of several square miles.

The programming organization for the IBM 7090 falls into two distinct divisions. First there is a group of approximately 12 mathematician-programmers who are engaged on major data processing problems and on systems type work. They are responsible for programmes which use some 45 percent of the available time at present, and their duties may extend from problem analysis and the development of numerical methods to handling routine queries. This group provides the main body of programming expertise in the Establishment and may also undertake the programming of problems of importance which cannot be conveniently handled by non-specialists. The second division of programmers is composed of all others with a problem to run on the 7090. These users are responsible for their own programming, usually in the FORTRAN language; courses in elementary programming are held from time to time to assist them. The services of the specialist programmers are also available to these users on a consultative basis. This system functions satisfactorily for general problem solving on the computer, and calls for assistance from the specialists are gradually decreasing in number with the spread of programming knowledge and experience.

Table I. WEAPONS RESEARCH ESTABLISHMENT COMPUTER USAGE

6-Month Period Ending	Total "On" Time (Hours)	Operating[a] Ratio (%)	Percentage Distribution of Useful time	
			W.R.E.	External
June 1961	383	98.7	95.0	5.0
Dec. 1961	641	97.0	89.7	10.3
June 1962	1222	96.2	85.7	14.3
Dec. 1962	1568	98.3	92.1	7.9
June 1963	1478[b]	95.5	89.6	10.4
Dec. 1963	2094	97.2	86.9	13.1

[a]Operating Ratio = 100 (Total scheduled "on" time -- time lost in unscheduled maintenance and power failures)/Total scheduled "on" time.
[b]IBM 1401 installed November 1962.

THE MARK II DATA CONVERSION SYSTEM

Since 1956, an automatic data conversion system at W.R.E. has processed range instrumentation data which are recorded at Woomera on magnetic tapes, termed Primary Records. A Primary Record is replayed into the conversion system at the Salisbury laboratories to make a further magnetic record, the Secondary Record, of the now digitally encoded data. Until 2 years ago, processing of the data was performed by the WREDAC computer, for which the system was tailored, but which has now been replaced by an IBM 7090 and an IBM 1401. This system has been handling telemetered data, radio-Doppler data, and AN/FPS16 radar data. In order both to keep pace with increasing peak loads from extended range instrumentation system, and to utilise fully the available input data rate of the 7090, a new converter system has been designed and manufactured at W.R.E. New features include faster conversion rates, the facility for recording identification data, extensive checking facilities, and flexibility in construction to allow for expansion.

System Components

Because of the diverse data processing operations performed, the system is functionally and physically broken down into a number of discrete units which are interconnected as shown in Fig. 1.

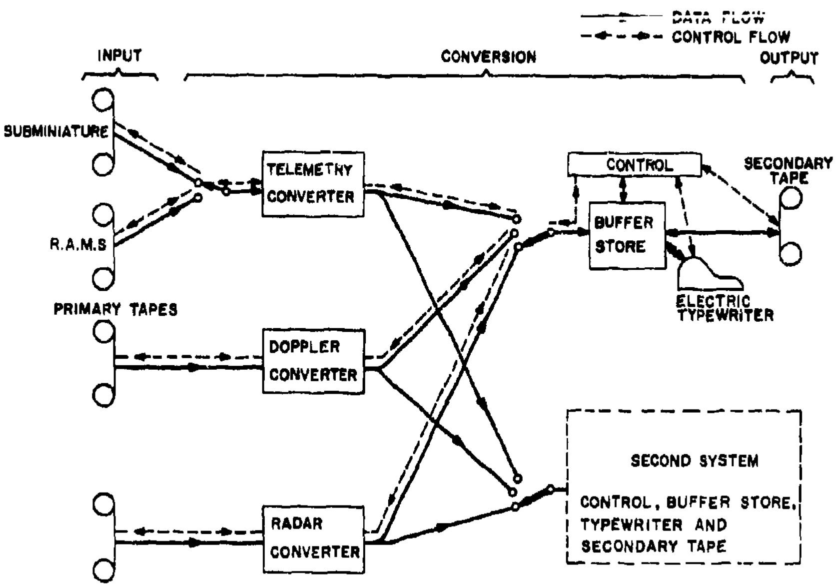

Figure 1. W.R.E. Mk II Data Conversion System.

Firstly, there is a particular unit for reproducing and converting the signals from each of the primary instrumentation systems, viz., Telemetry, Doppler, and Radar. These units produce encoded data in a common character format, 6 bits in parallel, at a peak rate of 166 K characters per second. Then, a magnetic core Buffer Store accepts data from any one converter at a time for blocking into discrete records to make the Secondary Record to the IBM specification at 41.6 K characters per second (i.e., 555 bits per inch recorded at 75 inches per second).

Overall control is achieved by a Control Unit which automatically controls both the conversion sequence from the Primary Record to the Secondary Record, and the Secondary Record data-check sequence which provides a data printout on an electric typewriter.

An economy in magnetic core storage, control circuitry, and digital tape units is achieved by time-sharing these among a number of primary-data converters through the System Switch shown in Fig. 1. In principle, any number of primary-data converters may be accommodated by the one complex of Control Unit, and the like. To take care of peak loads, however, a second system of Control, Store, and so on is planned as shown in Fig. 1. Each converter may be completely isolated from the Buffer Store and Control Unit through the System Switch so that it is possible to assess, say, a Telemetry Primary Record, while converting and recording either Doppler or Radar data.

Telemetry Converter

Typically, telemetered data on the Primary Record consists of a frequency modulated subcarrier, bearing 23 variables and a synchronising signal, all time-multiplexed. The subcarrier signal is demodulated and a strobe generator produces channel strobe pulses which are the common pulses for an analogue-to-digital converter. The recovered signal is passed through an optimised filter before each channel is digitised to 10-bit precision. One time sample per frame is generated from a recorded clock signal and added to the other variables before the data pass to the Buffer Store. The converter will handle sampling rates up to 12 K per second, producing 27 K characters per second, which allows most telemetered data to be converted without time expansion.

Doppler Converter

After the sinusoidal Doppler signals are recovered from frequency modulated carriers on the Primary Record, they are passed through narrow band tracking filters to improve signal-to-noise ratio. These signals are measured over regular but selectable time intervals against a coded clock track on the primary

Record. Up to seven such signals varying from 0-20 Kc may be measured simultaneously. At the maximum sampling rate of 100 per second, 5400 characters per second are generated.

Radar Converter

The radar outputs from shaft encoders are recorded on the Primary Record in a digital format differing from the IBM tape format. Consequently, only a digital format conversion is required in this case, data rates allowing a time compression by a factor of four during conversion. In fact this converter is being designed to handle a wide range of digital formats in an effort to cope with the increasing number of instruments which produce their output in digital form.

Buffer Store

The Buffer Store is a magnetic matrix core store, with a capacity of 2048 seven-bit characters. Locations can only be addressed sequentially, both for writing and reading transfers, and these are destructive. There are two sets of address registers, one for reading and one for writing so that a complete and regular sequence may be interleaved with the intermittent writing sequence. The period for either writing or reading is 6 μsec, and three writing transfers may be interleaved between two consecutive reading transfers which are separated by 24 μsec for the 41.6-K-character per second tape rate. Data is stored in the character configuration of seven bits in parallel, six for data and one for parity.

Identification Data

In order to facilitate the computer programming and tape search tasks, each Data File on a Secondary Record is preceded by an Identification Data File of 84 characters. Of these, the first 42 characters are reserved for parameters such as Reel number, Date of Creation, and Time for Retention, and so forth, which are standard for the data processing system, while the remainder of the file is devoted to parameters concerned with the data conversion process. These range from identifying codes for a particular instrument, through elapsed time codes which define the conversion times, to the bandwidth of analogue signal filters. The data are inserted by an automatic sequence which gathers the codes from a number of sources. Infrequently changed variables are obtained from coded switches located on the console while those pertaining to control functions in a particular data converter are read from the converter control switches. When the Identification File is written, a printout is obtained from the tape through the electric typewriter so that the operator can check not only that the data is correctly written, but that the controls are set according to the instruction sheet. Alternatively, in special cases, the identification data may be inserted from a paper tape through a tape reader attached to the typewriter.

Project Status

At the present time, a Telemetry Converter, a Doppler Converter, Buffer Store, Control Unit, and peripherals have been installed and are being commissioned as a system.

THE W.R.E. FLIGHT SAFETY SYSTEM

Like most missile test centres, the Weapons Research Establishment Range at Woomera operates within strictly defined boundaries, and means must be provided to ensure that rockets and their debris fall within these boundaries. The problem is particularly critical in the case of long range ballistic missiles because the impact point of these missiles is sensitive to their velocity at the instant their engines cease to thrust.

The general solution to this problem involves tracking equipment to measure the present position of the missile, and an on-line computer to accept this data and solve the ballistic equations, so as to predict where the missile would land if thrust ceased at any instant. The coordinates of these predicted impact points will be displayed to the Range Safety Officer, and if they approach the range boundaries, the latter will use a radio command link to force engine cut-off and thus confine the impact. In practice the hardware required to provide the solution may take various forms according to the missile trajectory. In fact in the W.R.E. System three overlapping phases are used:

1. Launch to 10,000 feet altitude. Sky-screens using pre-computed boundaries, and a voice link to the Safety Officer;

2. 3000 - 65,000 feet altitude. Optical tracking instruments feed missile position to analogue impact predictors, with plotting table display of impact points;

3. 50,000 feet to end of powered flight. Two AN/FPS16 radars feed digital missile position data to a digital computer. The predicted impact points are then converted to analogue form and displayed to the Safety Officer on a plotting table.

The basic philosophy of the system and much of the equipment involved is similar to that of other ranges, for example Cape Kennedy, but two of the major components may be of interest to readers of the Newsletter because they were designed and built at W.R.E. These are the digital data links which transmit data from the radars to the digital computer, and the digital computer itself.

The Digital Data Links

The two AN/FPS16 radars are approximately 30 and 120 miles from the computer site, respectively; Bell "J2" carrier systems are available for communication between these points. The digital output from the radar is serial at a rate of 40 samples per second, with each sample consisting of 20 bits of range, 17 bits of elevation angle and 17 bits of azimuth angle. For the sake of standardisation the data link accepts parallel digits at the sender and produces parallel digits at the receiver so that a buffer is required between the radar output and the data link output.

The link uses four channels of the J2 system, with digits transmitted in each channel at a rate of 1200 bauds. Three channels are used for range, elevation, and azimuth data, respectively, with 10 bits per channel per sample providing a synchronising code. A majority vote at the receivers over the three synchronising codes provides single error correction on synch. The fourth channel contains 18 redundant digits which constitute a Hamming code for single error correction and double error detection over the radar parameter digits. There are a number of spare digits in the format some of which have been used to indicate various radar operating conditions.

The modulation scheme used in the data links is frequency shift keying, with 2 cycles of a 2400-cps waveform representing "1," and one cycle of a 1200-cps waveform representing "0." The receiver uses an autocorrelation detector. The entire equipment is transistorised, and some 12 terminals at various stations on the Range have been in operation for about 3 years with a minimum of maintenance troubles. The double error rate is about 1 in 10^6 bits.

The Digital Impact Predictor (DIP)

The digital impact predictor is a high speed, transistorised, general purpose computer with input registers designed to match the receivers of the data links described above. A brief specification of the computer is as follows:

Mode:	Parallel, binary
Word length:	31 bits + sign
Order code:	Single address, 2 instructions per word, repertoire of 20 instructions
Store:	4096 words in magnetic cores, cycle time 5.4 μsec
Clock rate:	5 Mc

Duration of elementary operations (excluding the time to "bring down" the instruction):

Add/subtract	5.6 μsec
Multiply	49.4 μsec (average)
Divide	69.8 μsec
Extract square root	70 μsec (average)

Input:	Paper tape reader @ 50 characters per second 7 registers for on-line digital data
Output:	Paper tape punch @ 50 characters per second 6 registers for on-line digital data.

Tracking data from both radars are fed to the computer simultaneously, and the program selects that radars with the higher signal-to-noise ratio, provided that its lock-on indication is set. The computer output consists of x and y impact co-ordinates; x, y, and z present position co-ordinates for acquisition purposes and various system status digits. All inputs and outputs from the DIP are recorded for post-flight analysis and to provide realistic signals for personnel training purposes.

ACKNOWLEDGMENT

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Medical Research use of Computer

The Weizmann Institute of Science
Rehovoth, Israel

A new medical device is being proposed at the department of electronics of the Weizmann Institute.

It has been shown in animal experiments that a small magnet called pod can be inserted into blood vessels, urethra, and other tubes and can be guided by external magnetic fields into areas of the body to which direct access is impossible or entails difficult surgery. Magnetic fields can perform the physical guidance of the pod, but the necessary adjustment and variation of these fields during the operation will probably require the use of computing devices in many of its applications.

So far different devices of this type have been designed, and experiments were performed on models of human blood vessels as well as on live dogs. System engineering has started on the guiding of the device.

When the pod reaches its target it should be able to perform different tasks. This may be by direct mechanical action or by the application of drugs or other chemicals which one might want to release for therapeutic, diagnostic or research purposes; or it can be used as a source of radiation or heat.

The release of drugs "in situ" could obviate side effects of drugs to the rest of the human body thus allowing the use of drugs which would otherwise be severly restricted and enabling the application of much higher concentration in any restricted area.

Information on the device was published in a lecture by E.H. Frei and S. Leibinzohn and on its use in Cardiology by N. Neufeld, E.H. Frei, and S. Leibinzohn at the 16th Annual Conference Engineering in Medicine and Biology.

Miscellaneous

IBM 1401 as a Law Enforcement Aid

Detroit Police Department
Detroit, Michigan

A high-speed computer will help the Detroit Police Department combat crime by scientifically pinpointing crime patterns and areas of high crime potential in the city.

With advance information based on rapid analysis of crime reports, the Department will be able to assign members of the police force to probable trouble spots before the trouble occurs. This will be a major step forward in the important area of crime prevention.

It was recently announced that an IBM 1401 data processing system has been installed as part of an accelerated program to make the city's law enforcement procedures the best in the county. In addition to daily review of crime reports, the computer will be used to store and process the Department's many other active record files, including arrest reports and dispositions, clearance and recovery reports, traffic tickets, pawnshop records, gun and bicycle registration records, personnel records, and so forth.

The availability of electronic equipment for developing vital information will be a great asset to the Department. Because of the immediate use in the field and the computer's tremendous facility for producing vital statistical reports, greater achievement in the apprehension of the criminal and more effective prevention of crime can be expected. The 1401 will provide up-to-the-minute information on the entire file of offense and arrest records, thereby allowing more efficient planning of work load and assignments.

The new IBM system, consisting of eight separate machines, is installed in a remodeled section of the Police Headquarters building. Detroit's Police Department is among the first to install a computer of this type.

The Police Department has been preparing for this computer since October, 1962 at which time several members of the Department began training on a 1401 computer at IBM's Detroit Education Center.

The Department has been making use of conventional punched card equipment since 1920. These machines, however, have neither the speed nor capacity to handle the advanced applications to be run on the 1401 system.

CURRENT-WORKING PROGRAMS NOW IN USE

1. By updating the offense report files daily, the computer will weigh crime reports according to a pre-established plan that takes into account the work load and specific crime patterns. This operation would provide a continuing analysis of the need for police throughout the city. A rapid analysis of these reports would show areas in the city where certain types of offenses are exceptionally high or low. Accumulative semi-monthly or weekly crime figures would permit selective use of personnel.

2. Information regarding methods employed in committing crimes (Modus Operandi) will be analyzed by the computer to assist the Department in the apprehension of criminals.

3. Traffic tickets will be [illegible] the system along with traffic accident [illegible] show a correlation between enforcement activities and accident experience.

4. Personnel records, now being printed from punched cards, can be automatically prepared on the 1401's high-speed printer.

5. Prepare monthly and special reports for the Women's Division, Accident Prevention, Youth, and other Bureaus.

PROPOSED FUTURE USES

1. Pawnshop records, stolen property records, gun registration files, and stolen-auto files could all be rapidly inspected by the computer.

2. Officer activity reports could be put in punched card form for rapid analysis by the

computer. There would be too many reports to handle manually in an organization as large as the Detroit Police Department.

3. Radio assignment records, handled by the computer, would provide a close check on manpower distribution techniques; could provide accurate time data with regard to distribution of offenses and calls for service; and could be used to show the actual time officers spent on the call.

4. Latent prints obtained at the scene of a crime could be searched rapidly against a master file of known criminal prints.

Electronic Photo Composition System

A. B. Dick Company
Chicago 48, Illinois

The vast amount of electronic printing knowledge A. B. Dick Company has gained with its experience in address-label systems, page printing systems and facsimile systems is now being applied to the development of a computer-compatible, fully electronic, photo composition system. This system, which will be one of the most sophisticated combinations of the two arts of printing and electronics, may well be a revolutionary factor in graphic arts printing.

With this system, all the speed-reducing mechanical steps of type composition are removed. This means the development will go one step beyond recent efforts to link data processing equipment with automated typesetting machines. Efforts in the mechanical area have produced equipment that will convert copy to type at speeds up to 12 characters per second. Mechanical optical composition devices again offer speeds of only 10 characters per second.

With fully electronic systems such as A. B. Dick Company's Electronic Photo Composition System, complete advantage can be taken of medium scale computer speeds in the range of 30,000 characters per second. The basic considerations being followed in developing an electronic photo composer are to produce a unit that converts information from machine or coded language into alphanumeric light patterns on a high revolution cathode ray tube. The light patterns have the characteristics of graphic arts printing and are reproduced on an imaging medium such as a photo-sensitive film or paper suitable for making printing plates. Present economies desired in this system necessitate holding the speed in the area of 1500 to 2000 characters per second, but maximum use of computer speeds is possible with the same principles.

This type of system not only reduces the cycle time between information input and the production of a printable plate but will provide significant increases in accuracy and quality of printing plus offering major reduction in proofreading time.

Elements of the system are a recording control unit and an automatic recording unit. The control device will accept fully edited seven-channel pulse-coded information, either directly from the computer or from a tape storage unit adapted to handle and read computer prepared magnetic tapes. Input could also come from perforated paper tape using computer or teletype system punch coding.

The control unit includes the circuits in the electronic elements necessary for controlling the timing and flow of input information, checking the accuracy of the information (re-reading in the event of a detected error), and delivering the checked information to the recorder unit.

Delivered information will define type face and size, the specific characters and symbols to be printed, line composition, and word and line spacing.

The recorder electronically processes and photo-composes the delivered information. A character generator converts the original input to a video type signal. This signal is used to display the information in the desired format on the face plate of a high resolution cathode ray tube. An automatic camera then picks up the images and transfers them onto a photo-sensitive medium. The final output of the recorder is an exposed but unprocessed photographic film or photo-sensitive paper.

A. B. Dick Company's recent inroads in the field of electronics represents a modern day extension of its mechanical and chemical duplicating processes. The Videograph division is emblematic of a vast field of electronic data presentation systems that are currently being marketed, in later stages of production, or are under development for future availability. The Company feels that within these systems may well rest the principles which will give business and industry the type of duplicating and copying equipment that will be required to meet the complex communications needs of the future.

PLATO II and III

University of Illinois
Urbana, Illinois

Introduction

The purpose of the PLATO project (see DCN, October 1961 and July 1962) is to develop an automatic teaching system for tutoring simultaneously a large number of students in a variety of subjects. The central control element of the teaching system is a general purpose digital computer. The PLATO system differs from most teaching systems in that a single high-speed digital computer is used to control all student stations. Thus, it can bring to bear the power of a large digital computer in teaching each student.

Inquiry Training

The PLATO-Inquiry Training Program (REPLAB—Responsive Environment Programmed Laboratory), described in the progress reports,[1, 2] presents the pupil with a concrete event on motion pictures film using equipment auxiliary to the PLATO student station. A program in the PLATO laboratory mode then presents to the pupil a series of questions which he has to answer about the event. The questions vary from questions about what was in the film and what happened, to questions which are more theoretical and pertain to why the event took place. The pupil at all times has the choice of trying to answer the questions or trying to gather additional information. The basic choices provided in the PLATO laboratory are to answer questions, see film again, check properties, check conditions, or experiment.

While PLATO-REPLAB was designed principally to help pupils learn more about the inquiry process, its use in this respect will be limited until more problems have been programmed for this purpose. At present, only two problems have been adapted for this purpose, one in physics and one in nursing. (See section "Programmed Instruction for Student Nurses").

REPLAB also has value as a diagnostic instrument for the assessing of inquiry skills and strategies. It is for this purpose that it was utilized as part of an Inquiry Training program during July and August. Fourteen children who had just completed the sixth grade were given a 6-week Inquiry Training program. Half of these were tested before the program on PLATO-REPLAB (bi-metal strip physics experiment) and the entire group was tested at the end. Through the use of a special analysis of the students' records written for this REPLAB program, the strategies of the children tested were readily displayed and analyzed. Individual differences among the subjects were clearly discernible and the effects of the training program on the inquiry skills of the children could be detected.

Proof Lab

The program for PLATO LAB called "Proof" is nearing completion. Three lessons, written in two simplified versions of the program, have been tried out with ninth-grade students and with staff members of the UICSM mathematics projects. With these versions of the program it is possible for students to construct proofs of theorems in algebra on the blackboard with the computer checking each key pressed for violations in logic, such as improper omission of grouping symbols, completing a substitution in a generalization which does not connect with previous line, failing to copy or replace all characters on a line before advancing to the next line, and so on. Parts of the program which remain unfinished include subroutines for formation of a summary statement when called for and for storing theorems the student has already proved, so that he can call on them, if needed, in a later proof.

Programmed Instruction for Student Nurses

Use of the PLATO laboratory mode for teaching clinical nursing by inquiry method was

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[1] University of Illinois Coordinated Science Laboratory Progress Report for Dec. 1962, Jan. and Feb. 1963 (5.3).

[2] University of Illinois Coordinated Science Laboratory Progress Report for Mar., Apr., and May 1963 (5.2; 5.4).

described in Ref. 2. Pre- and post-tests along with a test to determine cognitive style were given to the students. An attempt to determine any gross differences in material learned by the PLATO group and the non-PLATO group was done using T-score comparisons on their pre- and post-test. The correlation coefficients relating the post-test scores, cognitive style scores, number of experiments, and other system variables have been calculated and will be available in a forthcoming report. A T-score of 0.1 for 11 degrees of freedom showed no significant difference between the two groups on their pre-test scores. A similar calculation on the post-test scores, however, showed a T-score of 1.9 which is significant at the 10-percent level. A correlation coefficient of 0.85 was found relating the number of experiments performed by the students and their post-test scores, while a negative correlation coefficient of 0.75 was found relating the number of incorrect answers to the post-test scores. High correlation was found relating an inferential cognitive style and a good performance on the system. For example, the correlation coefficients with inferential cognitive style were: post-test 0.58, number of experiments performed 0.72, and the number of times conditions were checked 0.921. Although the small size of the group prohibits conclusive findings, it appears that those students who inquired the most, learned the most. All but one post-test score of the students in the PLATO group was equal to or greater than the highest post-test score of the other group.

Physiological Correlates of Mathematical Discovery

In a study exploring possible physiological correlates of discovery, heart rate was recorded while subjects worked through a PLATO II instructional program, called CHAOS, that was designed to induce discoveries of formulae needed to solve the "criterion" problems. A statistical analysis of the data was performed using Duncan's new method for multi-group comparisons. For the analysis, each session was divided into from 40 to 80 phases, classified as to the type of problem solving activity the student was performing: (1) first-time discoveries, (2) re-discoveries, (3) wrong discoveries, (4) routine calculation, (5) unknown activity, or (6) resting before or after a session.

Out of 15 sessions, employing 8 different students, 8 sessions showed significantly higher heart rates during one or more of the discovery phase types than during routine calculation, where statistical significance was defined at the 10 percent level. The breakdown by types of discovery phases is as follows: (1) First time discoveries were accompanied by significantly higher heart rates in five sessions, three of these being significant at the 1-percent level; (2) re-discoveries were accompanied by significantly higher heart rates in two sessions; and (3) wrong discovery was accompanied by significantly higher heart rates in five lessons, in three cases the difference being significant at the 5-percent level.

The largest obstacle to demonstration of a physiological correlate of discovery appears to be that of designing an instructional program in which the discoveries are more clearly delineated and are more striking in the nature of the insight produced. Experiments with phase-type definitions show that the level of significance is extremely sensitive to change in definition.

R. A. Avner, of this laboratory, has experimented with a timed program that reduces chance for individual differences in responses to discovery. In the program, the numerical patterns that the subjects had to recognize were much simpler than those used in the aforementioned program. Data were collected for 17 subjects. The results of preliminary analyses are consonant with the hypothesis that there is an increase in heart rate accompanying initial pattern recognition.

PLATO III Programming

During the last quarter, the input-output routines for the PLATO III program for use with the new PLATO III equipment were prepared. These routines allow the CDC 1604 to inject student requests and student answers for processing by the main PLATO III program and to control the central slide selector and individual student storage tubes. More specifically, the main input routine makes use of the interrupt feature of the CDC 1604. When a student request is transmitted from his keyset to the central computer, the program is interrupted and the request and student identification stored in a temporary file in the core memory of the computer. After the computer has resumed and finished its present business, it returns to process the requests in this file, sequentially. The output routines included routines to command the central slide selector to display a given slide to a given student, to write the results of a computer judging routine ("OK" or "NO") on a given student's storage tube, to display a student's answer to a question, to erase a student answer, and so forth.

The availability of the input-output routines, together with the main routine previously finished, represents the essential completion of the PLATO III program. A few peripheral programs are still being written. The most important of these are programs for recording the progress of a student during a lesson, as well as data processing routines for subsequent analysis and presentation of these data. It is expected that these routines will be finished during the next quarter.

In the meantime, code checking of the program with the equipment has begun. Several minor errors and misunderstandings between programmers and equipment designers were uncovered and corrected. It is expected that the remaining ailments of the system will be found and treated within the next few weeks.

Finally, demonstration lesson material for displaying the main features of PLATO III is being considered, discussed, and written. In this connection, it should be recalled that the main new features of PLATO III (vis-a-vis PLATO II) are (1) the ability of the program to insert supplementary material and exercises as a function of its evaluation of the student's performance, and (2) the possibility of multiple help sequences for each question—the one entered depending on the computer's diagnosis of the student's error.

PLATO III System Equipment

All of the PLATO III equipment necessary for the operation of two student stations, although only one of the two slide scanners is presently installed, has undergone preliminary testing. Testing has included limited operation with the portions of the PLATO III input-output program completed for the CDC 1604, as well as with the other input-output routines.

Equipment Shared by All Students

Input-Output Interface—This equipment has been subjected to the testing mentioned above with satisfactory results. Additional circuitry needed for the operation of four more student stations has been completed, but not tested.

Slide Scanner—Deflection circuitry for the two presently operational slide scanners is being developed in order that greater drift stability may be achieved than that provided by the existing deflection circuitry.

X-Y Character and Selective Erase Circuitry—Performance evaluation of X-Y character and selective erase digital-analog converter circuitry with respect to conversion precision was undertaken during the past quarter. Results show that successive increment variations and output linearity are well within the design objectives of 12 and 0.4 percent, respectively.

Short and long term drift evaluation of the above have been cursory due to lack of environmental facilities. Early results of operation of the above in the PLATO III system environment, however, suggest adequate short-term drift stability.

Individual Student Equipment

Storage Tube Module—Deflection signal cross-talk has been reduced to a satisfactory small value through the redesign of line-driver circuitry and the use of new, low-capacitance reed relay circuitry. The existing two operational prototype modules are being modified to include the new circuitry.

Development of transistor deflection circuitry which holds the promise of greater efficiency than that presently realized will continue during the coming quarter.

Tests with the CDC 1604 indicate satisfactory operation of the storage tube control logic. Only two sets of the storage tube control logic circuitry have been completed thus far.

Keysets—Operation of the two operational keyboards and the associated input circuitry with the CDC 1604 computer has proved satisfactory during preliminary testing.

Video Switches—The two completed video switches have been tested with the one slide scanner in operation with the PLATO III equipment. Preliminary testing indicates satisfactory operation. The video switch package, however, is being redesigned mechanically to allow greater ease of maintenance, as well as more compact packaging.

Project MAC—Goals and Status

Massachusetts Institute of Technology
Cambridge, Massachusetts

The Department of the Navy's Office of Naval Research, on behalf of the Advanced Research Projects Agency of the Department of Defense, has awarded a contract of $2,220,000 to the Massachusetts Institute of Technology for initiation of a major national program of research on advanced computer systems and their exploitation.

The research will be carried out at M.I.T. under the project name, "MAC," an acronym derived from two titles: Machine-Aided Cognition, expressing the broad project objective, and Multiple-Access computer, describing its major tool. This project, directed by Professor Robert M. Fano, Ford Professor of Engineering, is intended to be the initial phase of a national effort that is expected to involve an increasing number of universities and research centers.

An essential part of the MAC project will be the evolutionary development of a large computer system that will be easily and independently accessible to a large number of people and truly responsive to their individual needs. An equally essential part of MAC will be the investigation of new ways in which computers can aid people in their creative work, whether it be research, engineering design, management, or education. The emphasis will be on placing the "logical power" of computers at the service of people, where, when, and in the amount wanted, somewhat in the same manner as electrical power is presently distributed."

Objectives

The evolutionary development of a large time-shared computer system is only one of MAC's tasks. The broad Project objective is to develop application of time sharing through a major experimental effort involving a wide spectrum of uses operating with whatever time-shared computer facility that may be currently available.

The scope of the user-oriented effort is suggested by the following extract from the Project work statement:

"(Project MAC) will advance to the greatest degree possible the following areas contributory to the development and use of time sharing and other advanced computer systems:

1. Organization and design of time sharing systems, executive programs, monitor programs, scheduling programs, and utility programs.

3. Computer-Aided Design.

2. Programming languages and programming systems.

4. Public and authorized use of computer procedures and information files.

5. Input-output equipment for close man-computer interaction.

6. On-line computation in the physical sciences, life-sciences, and social sciences.

7. Computer-directed instruction.

8. Heuristic programming.

9. Powerful cognitive programs.

10. Computer assistance in thinking, problem solving, and decision making.

11. Operation of time-sharing systems.

12. Management information and decision systems.

13. Symbolic processes.

14. Machine structures, memory organization, and order codes.

15. Interrelations between information processing and communications."

Facilities

Physically, Project MAC is located adjacent to the M.I.T. campus in the Technology Square office complex. It occupies the eighth and ninth floors of the Beta Building, 545 Technology Square, Cambridge, Mass. 02139.

Because the Computation Center is already heavily loaded, it cannot supply the computer time required by MAC. Furthermore, experimentation with systems would be drastically limited by the obligation of the Center to provide continuous service to a large number of users. Thus the Project has acquired a time-shared computer system to meet its special needs.

In setting up its initial computer facility, MAC has taken advantage of the time-sharing experience of the M.I.T. Computation Center. The Center, which first ran time-sharing on a 704 in 1960, has evolved a machine configuration and a supervisory system which, copied by MAC, will allow the Project to begin its experimental work with an immediately operational facility.

MAC's large-scale computer is an augmented IBM 7094. It has been modified to operate with two banks of 32-K core memory, and it has six data channels. Modifications in addition to the two-bank core memory include hardware facilities for relocation and memory protection. These features, together with an interrupt clock and a special operating mode in which input-output operations and certain other instructions result in traps, were necessary to assure successful operation of independent programs coexisting in core.

Two basic motivations for adding the second core bank, which is reserved for the supervisor, are (1) to avoid imposing severe memory restrictions on users because of the large supervisor, and (2) to permit use of existing programs (e.g., FAP) which require all or most of core.

The Programmed Transmission Control (7750) is a stored-program computer which serves as the interface between a 7094 data channel and up to 112 telegraph-rate (100 or so bits/sec) terminal devices. Alternatively, higher-rate terminals (e.g., 1200 bits/sec) may be traded for groups of low-rate lines. The 7750 is compatible with Bell System data sets.

The initial 7750 configuration at Project MAC will be three 1200-bit terminals, 24 terminals for Model 35 Teletypes, and 28 terminals for IBM 1050 Selectric typewriter stations, all interconnected through a dial network. (The Computation Center's 7750 will be identical, except the number of Teletype terminals will be 16). In the near future connections to other services, such as TWX, TWX-prime, and Telex, will be added. An arrangement to allow the computer to initiate calls will be an early addition.

Present plans call for the 1200-bit lines to be used, through data sets, for intercommunication between the MAC and Computation Center 7094's, and also as one means of connecting the 7094 to some of the other computers at M.I.T. Two PDP-1's and a 1620 will be fitted for this connection. As the experimental program develops, it is doubtless that other uses will arise.

MAC plans to install a 16-K PDP-1 with Microtapes, high-speed channel, and scope display with character generator and light pen. This machine is one of those mentioned above which will be adapted for 1200-bit-per-second connection to the 7750. For another class of experiments the same machine will be connected at a much higher rate through the PDP-1 high-speed channel to the 7094 direct-data connection. The basic role of the MAC PDP-1 is that of an extremely flexible, high quality (i.e., high data-rate) terminal for man-machine interaction.

The M.I.T. Electrical Engineering Department's PDP-1, which is itself time shared, will also participate, possibly by maintaining several display and typewriter terminals.

The Compatible Time-Sharing System

MAC's initial operating system will be the M.I.T. Compatible Time-Sharing System (CTSS).[1] This is an evolving program whose first public demonstration took place in 1961; CTSS includes executive, scheduling, debugging, assembler/compiler and input/output facilities. The programming languages now or soon to be available in CTSS are FORTRAN, FAP, MAD, COMIT and LISP. Others are planned for future inclusion.

In a typical session at a terminal, a user might first log in, giving his identification. He might then type in a subroutine, using the MAD language. He could call for a printout of his input. Edit it to correct errors, and then call for a MAD compilation. The resulting binary program, possibly with others previously compiled, could be loaded and run, and results or post-mortem data obtained. If necessary, the contents of registers may be examined, corrections made to the source program, recompilation accomplished, and then another run would be made, and so on. To terminate the session the user would log out; at this time he would receive from the supervisor accounting data indicating how much actual computer time he had used.

CTSS allows a conventional batch-processing load to be operated as "background." Any computer capacity not demanded by time-sharing users is absorbed by the background.

Summer Study

Project MAC conducted a 6-week Summer Study at M.I.T. in July and August 1963, at which over 100 participants, drawn from academic institutions and governmental and industrial laboratories, met to consider various aspects of the MAC effort. Machine structures, languages and compilers, and terminal equipment and their uses were considered at length.

As a working demonstration for the Study, the M.I.T. Computation Center provided some

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[1]A programmer's manual for CTSS has been published (Corbato, et al., The Compatible Time-Sharing System; A Programmer's Guide (the M.I.T. Press, Cambridge, 1963)).

30 hours per week of time-shared operation of its 7090, using Teletype terminals located in the participants' offices. Participants coded, debugged, and ran programs simultaneously with the normal Computation Center time-sharing load and batch-processing background.

Aside from its demonstration value, this operation represented a valuable operational test of the 21-terminal version of the Center's Compatible Time-Sharing System.

System Development Corporation, which is also conducting a large time-sharing project, made their time-shared computer (located in Santa Monica, California) available via the Bell System TWX (Teletypewriter Exchange) network. By use of a TWX terminal installed at Project MAC, programs were written, debugged, and operated on the Santa Monica computer, an while the computer was working simultaneously with other time-sharing users located in Santa Monica.

A report of the Summer Study is in preparation. It will be available late this year.

Philosophy

It is part of the MAC objective to make "computing power" available on a public-utility basis, with an operating philosophy analogous to that of an electric power utility. The keynote is ease of access—smooth, close coupling between the user and his problem as represented by data and program in the computer. One can visualize a human user and the computer "collaborating" in a real-time dialogue on the solution of a problem. Each party will supply those capabilities which are his forte—for the man, imagination, insight, inspiration, and heuristics; for the computer, enormous computing power, high-speed data retrieval from a vast store, elaborate housekeeping, and so on.

The MAC concept postulates that the time-sharing mode of operation differs in an extremely significant way from the batch-processing mode. The heart of the MAC experiment will be a thorough exploration of this difference.

Symposium on Computer Augmentation of Human Reasoning
June 16-17, 1964
Office of Naval Research
Washington, D.C. 20360

A Symposium on Computer Augmentation of Human Reasoning, co-sponsored by the Office of Naval Research Information Systems Branch and The Bunker-Ramo Corporation, will be held on Tuesday and Wednesday, June 16 and 17, 1964. The Symposium will be conducted in the Main Conference Room, #1315, New State Department Building, on 23rd Street between C and E Streets, N.W., Washington, D.C. Objectives of the Symposium are twofold:

1. To highlight the importance to human decision makers and problem solvers of the significance of recent research results concerning the use of computers in such areas as defining the problem, discerning important relationships in the data, and synthesizing possible solutions or methods of attack; and

2. To identify the remaining critical areas in which subsequent research effort should be focused.

At present, computers are used primarily for manipulating numerical data according to existing algorithms, or for implementing trial-and-error approaches, such as the Monte Carlo method, but it is now clear that such restrictions are no longer necessary.

It is not the purpose of this Symposium to review all appropriate efforts and results, but rather to present representative aspects of the field. Accordingly, the number of invited papers has been limited to allow speakers to develop and discuss their topics in some depth. It is anticipated that formal Proceedings of the Symposium will be published in the autumn of 1964.

Attendance at this unclassified Symposium is open to all interested technical personnel. Further information and a preliminary Symposium program may be obtained by contacting:

Mr. Charles H. Wacker
The Bunker-Ramo Corporation
8433 Fallbrook Avenue
Canoga Park, California
Area Code 213, 346-6000

UNIVAC 1107, Toronto City Traffic Control

Univac Division of Sperry Rand Corp.
New York 19, New York

The timing and phasing of traffic signals in response to vehicle flow by a UNIVAC 1107—the initial phase in a complex traffic control system that will ultimately cover all of Metropolitan Toronto—was initiated in August 1963.

The use of a powerful, real-time computer marks the introduction of an entirely new concept of traffic control that will provide virtually unlimited flexibility in the way that traffic signals can be made to respond to second-by-second changes in traffic conditions. As vehicles pass near magnetically-sensitive detector units buried beneath street surfaces, signals are flashed to the computer in City Hall. These signals enable the computer to calculate optimum phasing and timing of traffic signals that will expedite the flow of traffic.

Traffic sensors will be installed in the approaches to approximately 1000 intersections, so that by January 1965, the 1107 Computer will be controlling all timed signals within the Municipality of Metropolitan Toronto. Metropolitan Toronto is a federation of 13 separate municipalities; it was incorporated on April 15, 1953 and vested with authority to provide major region-wide services.

THE TRAFFIC PROBLEM

The number of registered vehicles in Metropolitan Toronto increased from 330,000 in 1953 to 585,000 in 1962, a gain of more than 75 percent. During the same period, population rose from 1,174,000 to 1,625,405, a rise of 38.4 percent. There are now 2.8 persons per vehicle in the area (compared to 3.6 persons per vehicle in 1953) giving Metropolitan Toronto one of the highest ratios of population to car ownership on the North American Continent. By 1957, it had become obvious that rapidly growing urban areas surrounding the city of Toronto and the consequent continuing increases in traffic volume would require much more than a mere enlargement of the existing traffic signal system.

Mr. Sam Cass and a group of traffic consultants known as Traffic Research Corp., set out to outline a program which could cope with a daily multi-directional flow of a half-million vehicles. A new system would have to provide sufficient flexibility to accommodate future traffic situations in Toronto and outlying areas; ways to incorporate future improvements in t. affic control techniques and devices (such as signs for indicating optimum speeds and routes); and detailed traffic flow information which would be used in upgrading the system.

In 1957, many types of specialized traffic signal equipment and systems were available which respond in one way or another to traffic movements. Although these equipments had helped to improve traffic flow in some cities, their value in many traffic situations was limited. For example, no equipment was available that could detect traffic congestion; ironically it sometimes even systematically aggravated rather than alleviated a chronic traffic problem. In Metropolitan Toronto the best of such equipment would not significantly improve existing traffic conditions, much less solve the more serious problems which a continual increase in vehicle registration would introduce. Obviously, the solution was not to be found in the use of existing traffic control equipment.

The possibility of using an electronic computer to control traffic soon captured the attention of the engineers conducting the study because computers were then beginning to penetrate the process control industry. These systems could accept inputs from many remote locations; also, they were being endowed with larger memories and faster cycling speeds so that masses of data could be absorbed, computed, and relayed rapidly to remotely-located control elements.

Because controlling movement of vehicles through streets is analogous to controlling the flow of fluids and gases in a process control system, the study concentrated on the feasibility of using an electronic computer to control a network of traffic signals. The results indicated that using a computer for traffic control was operationally and economically feasible.

Authorities of the Metropolitan Toronto Council, when presented with the proposal for such a system, saw that it offered potential exceeding anything yet attempted in Canada or the U.S., and authorized allocation of funds for a pilot study under actual traffic conditions.

THE PILOT STUDY

Traffic Research Corporation was commissioned to conduct a pilot study to test a "computerized" traffic control system under actual traffic conditions. This study was initiated in the summer of 1959 and terminated in the spring of 1961. Two broad range objectives were established:

1. Prove that an electronic computer could be integrated with an existing traffic signal network to provide a flexible, reliable and well-coordinated signal system, and

2. Demonstrate how this powerful traffic control system could be used to improve traffic flow, measure the improvement, and provide enough traffic data to make additional and significant improvements.

To carry out the study, traffic detectors were installed at some of the busiest intersections in Toronto, including nine signals along Eglinton Avenue, a major east-west metropolitan thoroughfare. This street passes through very dense areas of stores, supermarkets, schools, high-rise apartments, and office buildings. The road grade is level at the east and west ends and fairly rolling in the central region for a distance of about 1.7 miles. Intersecting Eglinton Avenue are some of the busiest north-south thoroughfares in the city. At the Yonge-Eglinton intersection, for example, the northern terminal of the Yonge Street subway connects with one of the largest trolley and motor bus interchanges in the country.

Detectors were located on all approaches at distances ranging from 200 to 600 feet back from the intersection. The final test area used in the last stages of the study consisted of 16 signalized intersections covering the same 1.7 miles but opening out to an area a half mile in width.

Detectors were connected to telephone lines and transmitted traffic counts to the central computer site. A small modification unit was installed in the signal control boxes to enable the computer to take control of the signal from the local controller. A monitor line from the local controller was also connected to the central computer site in order that the computer could detect the state of the signal at any given time.

PILOT STUDY FINDINGS

When the automatic system was compared with the existing fixed time system these improvements were noted:

- In the evening rush hours the automatic system decreased the average delay per vehicle by some 11 percent. In the morning rush hours the average delay per vehicle decreased some 25 percent and congestion was reduced by 28 percent.

- Rush hour speeds which often average less than 12 to 13 miles per hour can be increased with computer control to over 16 miles an hour.

- For a given delay, traffic volumes may be increased up to 20 percent.

These figures described the performance of the automatic system developed only to an intermediate stage of efficiency. With further development of the control programs, and with an extended area of control of traffic, greater benefits are anticipated.

The pilot study demonstrated that an electronic-computer-controlled traffic control system is practical for city-wide installation. In the Metropolitan Toronto area, over 50 thousand vehicle hours of delay are caused by rush hour traffic congestion every day. If even 50 percent of the results achieved in this study were realized throughout the entire traffic area, a reduction in total traffic delay exceeding 9000 vehicle-hours daily could be realized. This would amount to a direct saving to the motoring public of over 2 million dollars per year in vehicle operating expenses alone. In addition, the resulting increase in peak capacity of the road system would be comparable to the improvement which could be achieved by the expenditure of 20 to 40 million dollars for widening existing street facilities or building new roads.

HOW THE SYSTEM OPERATES

The new system of traffic control designed for the Municipality of Metropolitan Toronto is a network of traffic signals and traffic detectors connected by wire lines to a UNIVAC 1107. The computer will continuously and automatically analyze the movement of vehicles within the controlled area. Traffic flow will be hastened and congestion will be minimized by the computer's second-by-second control of the phasing and duration of "stop" and "go" signals located at approximately 1000 critical intersections.

The computer is now operating in its ground floor site in the Toronto City Hall. One Hundred traffic signals have been connected to the computer and are now being directly controlled by the computer. By January, 1965, traffic flow through 1000 intersections will be controlled by the computer.

Traffic Flow is measured by relatively low-cost, easily maintained sensors, which transmit data over Bell Telephone Company wires to the computer. Because the detectors will be installed in all streets feeding into critical intersections, the computer can constantly monitor traffic flow all over the Metropolitan Toronto area and detect potential traffic jams before they occur.

A master control program, consisting of a large number of electronically-stored instructions, enables the 1107 to execute logical and mathematical computations (with data supplied by the sensors) and use the results of these computations to control timing of traffic signals. Here's a typical control sequence:

1. Appropriate initial instructions are given to the system through the control console.

2. As the computer observes each signal in a predetermined order, it energizes the modification unit of each corresponding street intersection controller, acquiring direct remote control.

3. Conventional timers within each traffic signal which had been controlling signal duration during the period of "local control" are disconnected and remain inoperative until re-engaged by the computer itself.

4. During this computer control phase, current traffic data coming from traffic detectors and controller monitors are read continuously by the computer.

5. Separate computations are made for each intersection in order to determine which signals, if any, should be switched.

6. Appropriate output pulses are transmitted from the computer site to signals which should be changed.

7. Moments after a control box has been set, special monitors transmit data to the computer which indicates whether the control boxes and signals have been set the way the computer has ordered.

This entire sequence is repeated for each traffic intersection in the system every 2 seconds. Any equipment malfunction can be detected immediately; however, the computer releases control of the affected intersections (which revert to standard timers within the control boxes) until the fault is corrected. Remote operation of the various signal displays at 1000 intersections require the installation of 3000 output lines from the computer site.

PRINCIPAL ELEMENTS OF THE SYSTEM

In addition to the traditional elements found in most conventional traffic control systems (traffic lights and/or semaphores, time cycle or program signal controllers, and street-side manual pushbuttons) the new Toronto Traffic Control system also includes:

- The 1107 Computer, a powerful system and appropriate interface equipment.

- Sensors to detect and signal both "passage" and "presence" of vehicles (replace other pavement devices).

- Communications lines in a network linking all intersections to a central point.

- Converters to convert the output of the sensor into a communicable message (tone, pulse, and so on).

- Communications devices to gather and transmit sensed traffic data to central computer, and multiplexers to permit transmission of multiple signals over the same lines.

The new Metropolitan Toronto Traffic Control System is composed of three main elements: Sensor Element, Communications Element, and the Computer Control Element.

Sensor Element

Traffic detectors are magnetic field devices to which normal electrical current will be supplied. An automobile in the immediate vicinity disturbs the magnetic field set up by the device and a tone is transmitted over a multiplexed line to the central control point.

These detectors are not traditional traffic counters, but are binary devices specifically designed for a computer-based system. They represent a substantial improvement in terms of cost and reliability when compared to physical contact devices in the street, or the overhead sensing devices used in earlier experiments. The wires leading from the detector to the telephone line connection box at the intersection will be laid in a saw cut made in the road surface.

Communications Element

Signals traveling to the control center move over leased telephone lines. Feedback from the control center to the signal controller, which activates the traffic signal, moves in the same way. In the pilot test five telephone connections were used for controls: one for remote switching to manual conditions, one for remote indexing of the switching solenoids, and one to each of the three cam switches to monitor the signals. The parallel use of five lines is the simplest method technically. Interference from outside power sources is minimized when telephone lines are used.

The communications features also include a multiplexer which terminates the detector signals coming from the street over telephone lines. These signals are identified by tone and distributed from the multiplexer over cable to an "input scanner" which is in effect the interface (or buffer) between the central control mechanism and the communication system.

Computer Control Element

The heart of the computer system is the 1107 for traffic simulation and analysis, and a smaller "Special-Purpose Traffic Control Computer" for controlling the input from and the output to, the various traffic signals in the city. An Input Scanner is also used for receiving signals describing the city's traffic conditions and an Output Distributor sends traffic control signals. In addition an Inter-Computer Synchronizer functions as a communications link between the two computers.

OTHER USES FOR SYSTEM

After all traffic control detectors have been tied into the 1107 system (January 1965), other data processing projects are expected to be performed by the computer without impeding its ability to maintain second-by-second control of the traffic system itself. Some of this work will include: traffic assignment studies (i.e., determining optimum routes for traffic according to time of day), police statistics, and accident studies by location, frequency and type. In addition, the computer may become the hub of enforcement record keeping in which records for violations and subsequent disposition will be stored in the computer's memory and be available on a real-time basis.

Digital Static Resolver

U.S. Navy Bureau of Naval Weapons (RREN)
Washington, D.C. 20360

The Engineering Division (RREN) of the Bureau of Naval Weapons awarded a contract to the Computer Control Company (3C) of Los Angeles, California for the development of a special purpose digital computer known as a "Static Resolver" (SR). The SR is intended as a stabilization computer for use in advanced shipboard fire control systems in conjunction with a general purpose digital computer. The SR is also applicable for aircraft stabilization applications. The contract was awarded June 1963 and delivery will be made in June 1964 to the Naval Ordnance Test Station, China Lake, California for test and evaluation.

Present stabilization techniques involve the use of analog computers which employ such analog devices as precision potentiometers, resolver chains, and servomotors which have limited accuracy and are comparatively unreliable because of brushes and rotating parts. With increased data handling requirements, accuracy requirements, and system complexity, the use of analog techniques is diminishing. In its place, the use of digital techniques is rapidly increasing with attendant improvement in speed of operation, accuracy, reliability, data handling, information storage capability, flexibility, ability to handle more complex problems, and simplicity since all calculations involve simple arithmetic, and all operations are derived from simple yes-no type decisions. Analog systems become very large for increased accuracy and storage and are not flexible since a set of components designed and connected to solve one problem cannot be easily rearranged to solve another problem.

While the optimum shipboard digital system has not been determined it is certain to include one or more general-purpose digital computers in conjunction with a number of special purpose digital computers. The SR falls into the latter category. While the SR is performing stabilization computations at a high data rate for a launcher or gun mount, for example, the general purpose digital computer can be busy solving slow data rate problems. The operations performed by the SR are generally time consuming and awkward when performed by a general purpose computer, so that with the SR operating as a satellite system, valuable computer time is saved on the general purpose computer which can be used to perform additional tasks.

The SR is capable of operating in three different modes as follows:

1. Furnish stabilized deck position data for two shipboard platforms such as missile launchers and gun mounts. This involves the computation of platform train and elevation angles from given horizontal cartesian coordinates X, Y, Z from a general purpose digital computer and roll, pitch and heading angles from the ship's gyro compass.

2. Furnish stabilized horizontal target position data to the general purpose digital computer for two target tracking radars. This involves the computation of cartesian coordinates X, Y, Z from given radar train and elevation angles, range vector, and roll, pitch and heading angles from the ship gyro compass.

3. Furnish stabilized deck position data for one shipboard platform such as a missile launcher or gun mount and stabilized horizontal target position data to the general purpose digital computer for one target tracking radar.

While the Static Resolver is capable of operating in all three of the above modes it is designed to operate in only one of these modes at any given time. The Static Resolver is fully automatic with a built in program. After all input data is entered the operation starts automatically. After each operation the proper data transfer takes place automatically and upon completion of the operation the outputs are automatically made available in the output storage registers. After completion of one program the Static Resolver automatically begins a new one.

All input and output data are in parallel, 15-bit (40 seconds of arc) natural binary form. Voltage levels, current levels, and waveform characteristics are compatible with present shipboard general purpose digital computers.

The total time to make one complete computation is 500 microseconds. For example, the SR can compute stabilized train and elevation angles for one missile launcher, in 500 microseconds (2000 times per sec). Both the train and elevation angles are available simultaneously. If two launchers are multiplexed to the output, as in Mode 1, each launcher could be updated for train and elevation at a maximum rate of 1000 times per second, the Static Resolver alternately updating the two launchers.

The Static Resolver will be equipped with a control panel for manual operation and checkout of its computations. The control panel will contain such features as a display of operating registers, manual-automatic control switch, start button, operating mode selection switch and buttons for manual entry of data into the operating registers. A checkout chart will be furnished which will give calculated output data for specified input data. It will be possible to checkout the static resolver while it is completely disconnected from the rest of the operating system, except for the 115-volt, 400-cycle, single phase, 30-watt power supply.

The estimated size of the static resolver is less than .1 cubic foot and it will weigh approximately 40 pounds. For maximum reliability electronic circuitry will be fabricated in microelectronic form such as thin films, integrated silicon chips or a combination of both. Separately attached elements such as conventional transistors, diodes, capacitors, resistors, inductors, or transformers will not be used except as necessary due to the limitations in the state-of-the-art of microelectronic techniques.

The design approach for the SR used by 3C is simple and unique and incorporates as the main component a 3C Digital Resolver (DR). The DR is a computational device which allows high-speed manipulations of transcendentals with a substantial saving in hardware complexity as compared to general purpose digital computers. This unique device coupled with proper input and output registers and gating makes up the SR. The SR program is wired in and no memory is required.

It is envisioned that the Static Resolver will find many applications in Bureau of Naval Weapons digital systems to provide computations of stabilization quantities related to differently oriented sets of axes and where high accuracy with minimum complexity is demanded. The Static Resolver can be employed as a separate computer or incorporated as part of a general purpose digital computer with common power supplies, and so forth.

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