DIGITAL COMPUTER

NEWSLETTER

OFFICE OF NAVAL RESEARCH • MATHEMATICAL SCIENCES DIVISION

D D C

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Approved by

The Under Secretary of the Navy

25 September 1961

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Editorial Notices

EDITORIAL POLICY

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.

ERRATA

There is an old adage in some organizations that they can accomplish the difficult in a short time, but the impossible takes a little longer. For the Newsletter, the impossible took ten years and then occurred in the masthead of the April issue. Because the masthead is a photo replica, and has been in use for ten years, it is not seen by the editor. Somehow, for the April issue, someone literally dug up (and it wasn't easy) a photo replica that went out of use in 1956. So to keep the record straight, the Newsletter continues to be a publication of the Mathematical Sciences Division; it did not move to the Physical Sciences Division.

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

CDC 3600 Computing System
Air Force Missile Development Center
Holloman Air Force Base, New Mexico 88330

The Air Force Missile Development Center has a CDC 3600 with a CDC 160A satellite. The hardware configuration provides access to all tapes, printers, and card readers from either computer. An in-house developed time-share program for the 160A simultaneously drives three printers, two plotters, a card reader, and a card punch. All these peripheral jobs proceed at full speed and start or stop independently of each other. A remote terminal with a CDC 8090 processor is being connected via telephone line to the system.

Micro C Computer
American Bosch Arma Corporation
Garden City, N.Y. 11532

The Micro C Computer was developed especially for use on Navy surface ships and submarines. The Micro C is a compact, general purpose, digital computer designed for military environments. It is especially suited to Navy maintenance requirements, as the computer is modularized and malfunctions can rapidly be isolated to a plug-in throw-away module. The machine is an outgrowth of the ARMA product line of micro computers and is logically and electrically similar to micro-computers designed for missile environments.

Arithmetic and Memory Characteristics

Organization	Serial, single address
Number System	Binary, fixed point, fractional, two's complement for negative numbers
Clock Frequency	972 kc
Execution Rate	36000 words/second
Data Format	22 bits (including sign), non-return to zero
Program Storage	4608 words, expandable to 6144 words, 22 bits each, individually addressable
Working Storage	1792 words, 22 bits
Memory Access	Random: 3 microseconds

Memory Type*	NDRO multi-aperture core
Input-Output Addresses	256 separate locations available
Instruction Repertoire	20 separate operations
Instruction Time	27 microsec/word

Instructions Included:

Clear and Add	1 word time
Transfer	1 word time
Add	1 word time
Subtract	1 word time
Store	1 word time
Shift n Places	n + 1 word time
Multiply (Single Precision)	5 word times
Multiply (Double Precision)	5 word times
Square Root	12 to 22 word times
Divide	12 word times

*Also can be supplied with a single aperture ferrite core DRO memory of up to 32,000 words.

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Physical Characteristics

Size (cubic feet)	3.87	(For computer with 6144 words of NDRO memory, I/O complement as described under characteristics of Typical Inputs and Outputs and a completely self-contained power supply.)
Weight (pounds)	150	
Power (watts)	215	

Non-Rotating Memory

Random Access	Bi-aperture ferrite core
Non-destructive	Non-volatile readout
0-100°C Operation	No temperature or current control

Reliable Discrete Components

Miniaturized version of existing proven parts
Semiconductors—silicon of latest configuration
Semiconductors—passivated or hermetically sealed
Rigid component specifications and thorough parts testing

Power Input

115 v single phase, 60 cps
DC, 400 cps, 2400 cps options available.

The Micro C's components are arranged on substrate wafers which carry printed resistors and printed wiring. Only six different types of logical modules comprise the entire logic electronics. A typical wafer will contain two flip-flops and their input gates. The wafers are mounted in a module which is sealed and which plugs into a tray. The tray may contain approximately 185 modules. Intermodule wiring is by wire wrapped connections to the terminals of the connectors into which the modules are plugged. Four trays comprise the entire computer complement of circuit modules.

Environmental Specifications

Operative

Vibration	0.2g^2/cps, 15-2000 cps
Acoustic Noise	140 db up to 10,000 cps
Acceleration	11 g
Humidity	100%, 20 hours
Temperature	0° to 85°C
Explosive Atmosphere	MIL-E-5272
Radio Interference	MIL-I-6181D

Non-Operative

Vibration	3 g rms, 5-300 cps
Shock	4" drop test, impulse 100 g's rise time of 35 ms and decay of 6 ms
Humidity	10 cycle - 95% R.H.
Altitude	350,000 feet
Temperature	-62° to +100°C
Salt Atmosphere	50 hours
Fungus Resistance	MIL-E-5272
Sand and Dust	MIL-E-5272
Rain	MIL-E-5272

Typical Inputs and Outputs

Inputs

Gimbal Angle	3 (DIPO)
Pivot Angle	3 (DIPO)
Accelerometers	3 (Arma)

Typical Inputs and Outputs (Continued)

Inputs (Continued)

Input Discretes	60
Serial Data	36 kc
Punched Tape	
Keyboard	
AGE	
Land or Sea Navigation Inputs	
Steering Commands	3 (d.c. Analog)

Stellar Sensor Command can be provided for Missile Guidance	2 (d.c. step)
Telemetry	324 kc, 36 kc
Serial Data	36 kc
Output Discretes	30 momentary + 30 on-off
Prescan Control for Parallel Data Input	
Keyboard Verify	
AGE Control	
Arm Inibit	

The IBM 7040/7094 Direct Couple System

Western Data Processing Center
University of California
Los Angeles, California

The power of the new Direct Couple System, which in the future will be the only one available, will be better understood if one first reviews the operation of the stand-alone system. In the old system, job decks submitted to WDPC for processing are first put on magnetic tape as a separate operation on the 1410 computer. These magnetic input tapes, with many jobs per tape, are physically carried to and hung on tape drives attached to the 7094. Processing is then carried out, the output being written on other tapes. These output tapes are then carried back to the 1410 for printing and punching. As each program is run, special tapes may have to be hung, sense switches set, or other operator interventions performed. Also, even the reading and writing of magnetic tape is slow when compared to 7094 core memory speeds.

In sum, then several manual operations may be required for the processing of each job. Inherent in this system are some wasted time and motion and a large burden on computer operators to develop procedures to run the computer efficiently. The Direct Couple System was developed to lend greater efficiency to the computer by eliminating the need for some of these manual operations.

In the WDPC Direct Couple Configuration, a 7094 and a 7040 are connected electronically directly from core to core. The 7094 communicates only with the 7040, and this communication is carried out essentially at core speeds. All input/output devices are connected to the 7040, including a 1301 disc file.

Operationally, the system configuration is utilized as follows. All actual job processing, except for utility functions such as tape copying, is accomplished on the 7094. The 7040 carries out all utility functions and all input and output functions. When a job is received by the 7040, it is blocked into a special disc format, assigned an internal job number and a priority code, and stacked on the 1301 disc file to await processing by the 7094. If special tapes are required, they are requested, read, blocked, and stacked on the disc to await processing. As the 7094 processes the job, output is stacked on the disc, and when the job is completed, the output records, in their turn, are printed and punched by the 7040. The control program in the 7040 is set up in such a fashion as to be able to do many different things without wasteful inactivity waiting for completion of any particular function. The 7040 system may be thought of as another stage of buffering between the outside world and the 7094. Jobs are processed effectively at 7094 speeds with no wasteful stops or operator intervention. The total system is not an insignificant amount more efficient than the tape-to-tape stand-alone 7094 system with offline 1410.

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Two new computers for time-sharing were announced by International Business Machines Corporation.

The IBM System/360 Model 64 and Model 66 are designed specifically for time-sharing applications in which a computer system serves many people simultaneously.

The computers will be able to handle a number of different jobs at once. They will provide the equivalent of large-scale scientific computing facilities to engineers and scientists working at a variety of terminals remote from the computer itself.

To a man at a terminal, the effect will be the same as sitting at the main controls of the computer. He will have the essential facilities of the data processing center available on call. Dozens of users will be able to enter problems at the same time without interfering with one another, or even knowing that others are using the computer.

The central computer will operate in a "conversational" way with each terminal, acknowledging data entry and automatically checking for clerical or logical errors. For many problems, such instant response, or "conversational mode" of operation, reduces problem-solving time from a matter of days or hours to only minutes or seconds.

In addition to operating in a "conversational" time-sharing way, Models 64 and 66 can also be performing standard data processing calculations. To do all these jobs effectively, the new models of System/360 combine several major advances in computer circuit design and programming.

These include channel controllers and dynamic relocation of memory. Dynamic relocation refers to a method of using memory space efficiently when programs and data are being moved frequently in and out of the system. This method makes use of new electronic circuitry known as associative memory, and frees the computer user of the need to keep track of exactly where information is located during the actual processing.

As multiprocessing systems, the new computers are able to "partition" themselves into different arrangements of memories and central processors to suit different workload conditions.

The key differences between the new time-sharing computers and previously-announced

IBM System/360 equipment are the dynamic relocation feature and the channel controller which permit flexible interconnection of processors, memories and input-output equipment. Up to four computer processors, eight memories and four channel controllers can be linked together in a single configuration.

Models 64 and 66 use the full set of System/360 programming instructions plus extra instructions to direct the time-sharing features. Programs prepared on the two new machines can be recompiled for use on other System/360 equipment.

TIME-SHARING APPLICATIONS

Time-sharing systems are particularly useful in data processing installations that handle a wide variety of scientific and engineering problems. Generally, each problem takes a relatively short amount of actual computer time—on the average, less than a minute.

Engineering groups, large scientific research organizations and university data processing centers typically have the kind of problem mix suitable for time-sharing. At present, computer centers operating in such environments use a job-shop technique for processing the work load.

Scientists bring in their problems and the computer center staff puts them in a stack to wait their turn on the computer. When the problem has been processed, the results have to be sorted and returned. Although the computer itself may do the calculation in a few seconds, it takes much more time for a problem to get through the queue and the physical sorting and delivery procedure.

Time-shared systems not only provide instant response, but lead to a whole new way of using computers to solve problems. The scientist or engineer can work continuously on a problem. He can call on the powerful computer at will to make partial test runs. As a result, he can use the computer to help develop the problem itself in addition to using it to get a solution to a calculation. This method of operation usually results in a much more thorough problem analysis with less expenditure of research and engineering time and effort.

System/360 Models 64 and 66 will be available in a wide variety of configurations. With

the channel controllers, up to four central processors can share a pool of main memory units capable of storing up to 2 million characters.

The polymorphic configurations—those with more than one memory, central processor and channel controller—will provide the ability to incorporate "fail safe" techniques so that computation can continue in case a memory or central processor or channel controller needs maintenance.

Memory cycle time for the Model 64 is 2 microseconds for eight characters of information. Cycle time for the Model 66 is 1 microsecond. Additional core storage, up to 8 million characters, is available through the IBM 2361 large core storage unit.

Computing Centers

Computing Facility
University of California
Los Angeles, 24, California

In April 1961, the Numerical Analysis Research Project relinquished control of the SWAC Computer to the newly established UCLA Computing Facility, which at that time acquired an IBM 7090. In December 1961, a 1401 was added to the computing complex. Upgrading of the 7090 to a 7094, and addition of a Direct Data Connection, were performed in February of 1964. A second 1401 was added in November 1964. It includes a 1311 disc drive.

The SWAC has been connected to the second 1401 through the I/O adapter, and to the 7094 through the Direct Data Connection. The SWAC-1401 combination is used primarily to record on digital magnetic tape various analog records brought by the researchers of several campus departments, and to transfer paper tape records to magnetic tape. It is useful also for the conversion of row binary cards into 7094 compatible magnetic tape records.

An on-line system of the Culler-Fried type utilizes the Direct Data Connection between the SWAC and the 7094. The SWAC acts as a digital-to-analog converter for the display scope, inspects the keyboard symbols, and interrupts the 7094 for the required calculations. Although the Culler-Fried system presently uses the 7094 on an exclusive basis, it is planned to confine it to 16k of the memory, and permit production runs of other jobs in the other half of the memory. The monitor to permit this is now being programmed.

An interpretive programming language, PAT (Personalized Array Translator), has been implemented from a 1620 program by Mr. Glen Johnson, a member of the staff of the Computing Facility. This permits rapid coding of problems involving matrices and vectors. Since it occupies very little memory, it is planned to have it co-exist at times with the Culler-Fried on-line system, to permit simultaneous access to the 7094 by two independent on-line groups.

An assembly program, SWACAP, has been written for the SWAC computer. It resembles the MAP language in its symbolism. Assembly is done on the 1401, which produces either row binary object programs for direct insertion in the SWAC card reader, or loads the SWAC memory through the I/O adapter connection. This work was done by Val Schorre, a staff member.

The SWAC is approaching the 15th anniversary of its dedication which occurred on August 17, 1950. Our efforts to keep it operative have been successful, as evidenced by the comments preceding. Modernization by systematic replacement of failing parts with quality controlled components has reduced maintenance to 1 hour per day. An occasional malfunction of a catastrophic nature has usually resulted in a planned overhaul of all related areas in order to prevent recurrence of that particular trouble. Present plans call for replacement of the one remaining large area of unreliability: the Williams tube memory. A core replacement has been under construction for some years, but has made slow progress due to personnel turnover (mostly students). It is now possible to purchase a custom designed memory which may be more suitable. The demands on SWAC by the previously mentioned applications are light enough so that no serious interference with calculations has occurred, despite the disparity in reliability between it and the 7094.

The Computing Facility operates its computers on a 24-hour basis 7 days a week. The weekend time is not always used, but lengthy jobs are pre-empting it more and more frequently. Users of the machines come from every department on campus except the Graduate School of Business Administration, which uses the Western Data Processing Center, and the Medical School, which operates the Health Sciences Computing Facility with NIH help. The major users are in the physical sciences, of course, partly for historical reasons and partly because of the problems of programming in non-physical science areas. The English Department, however, is currently engaged in a project of producing definitive editions of the works of some early English poets, Political Science is doing statistical work of several kinds on emerging African nations, and there are active projects in Sociology and Education. A relatively new series of projects is beginning in the Library

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Services. Programs for indexing, abstracting, and information retrieval are being prepared.

Because the installation is in an educational institution, varied types of access to the computers are permitted. Unscheduled open shop access for periods not exceeding five minutes, and for debugging purposes only, is provided in three 1-hour time slots daily. Scheduled open shop occupies 7 hours daily, with runs up to 1 hour in length. Closed shop operations use 9 hours. The remainder is used by the staff for on-line systems, maintenance, and miscellaneous experimental programming.

This mixture of accesses has proved highly satisfactory. A user can ignore open shop completely and still obtain two turn-arounds per day. Open shop users find that they can influence the operation of their programs by their presence and thereby often avoid resubmittal of their runs. The Computing Facility is fortunate in having experimentally minded users who are anxious to avail themselves of these opportunities.

Department of Computer Science
University of Illinois
Urbana, Illinois

The University of Illinois Board of Trustees has approved changing the name of the Digital Computer Laboratory to the Department of Computer Science. In view of the expanding teaching program of the laboratory and other developments in its services, the general term "department" more accurately describes its functions than the title "laboratory."

The laboratory, established in 1949 and given the status of department in 1957, had as its principal purpose the design and construction of a computing system and the carrying out of the research ancillary to that goal. More recently there has been a change in emphasis toward the education and service aspects of the department.

The completion of ILLIAC II, the acquisition of the IBM 7094, and the establishment of Mathematics 195, a basic programming course, as a required course in the engineering curriculum have been the important factors in bringing about this change.

The Department of Computer Science will continue its instructional program through related departments—mathematics, electrical engineering, physics, and chemistry. It will maintain the present balance between engineering research and other phases of research.

John R. Pasta, Research Professor of Physics, has been head of the laboratory since May 1, 1964, succeeding Professor A. H. Taub.

Manpower Management System
International Business Machines Corporation
Washington, D.C. 20036

A highly-advanced manpower information system, using five IBM System/360s, will provide virtually instant access to an inventory of the skills and talents of each of the more than one million men and women in the United States Navy.

The five data processing systems will be installed for the Navy's Bureau of Naval Personnel. These new systems are designed to permit the Navy to:

● Obtain on demand, personnel management information which will heighten its effectiveness in emergency situations.

● Forecast personnel requirements of both existing and future weapons systems using operations research techniques, mathematical models, and simulations.

The advanced systems will be capable of providing swift access to more than a half billion characters of stored information. The systems will permit the Navy to apply computer-to-computer information exchange and retrieval to its world-wide personnel requirements.

Education, training, experience, location, and other stores of information that will help to forecast potential abilities of each of more than one million officers and men on active duty, in the reserves, and in retired status, will be processed by the system.

Two IBM System/360s—a Model 40 and a Model 30—will be located at BuPers Headquarters in Washington, D. C. Three other System/360 Model 30's will be located at Personnel Accounting Machine Installations (PAMIs) at remote locations—Norfolk, Va.; San Diego, Calif.; and Bainbridge, Md. The Norfolk PAMI processes Atlantic Fleet data, San Diego processes information for the Pacific Fleet, and Bainbridge handles manpower information for the continental United States.

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A central "data bank" containing active master files holding the Navy's complete roster of officers, enlisted men, Naval activities and requirements will be maintained at BuPers.

The computer's central data bank will be comprised of mass storage units. Stored information will be instantly available to the BuPers computer as well as the remote PAMI computers.

Changing information about Navy personnel, such as expanded skills, will flow to BuPers over a defense communication network. The new data will be entered into the central computer bank and simultaneously transmitted from BuPers to the appropriate PAMI computer, thereby updating previously stored information. Officers charged with personnel management within the Atlantic Fleet, for example, will use the PAMI computer at Norfolk. If a response cannot be made at that level, the inquiry will be handled by the BuPers computer.

By using the communication network to link all of the System/360s, information will be entered into the BuPers and the PAMI data banks when the changes are reported. The present Navy manpower information system computers process information in batches at the end of periodic accounting cycles.

Computer Science Center
University of Maryland
College Park, Maryland 20742

The Computer Science Center of the University of Maryland is an interdisciplinary academic department not affiliated with any school or college of the University. Its function encompasses three areas: research, service, and education.

Since September 1964, the Center has been operating with an IBM 7094-I (16 tape drives), two IBM-1401 satellites (sharing 6 tape drives with the 7094), and associated equipment. Between March 1963, when the Center was established, and September 1964, an IBM 7090/1401 system was in use. In September 1964, a branch center was opened in Baltimore to service the Baltimore campus. It is called the Health Sciences Center and operates an IBM 1620.

An addition to the Center's building was completed in March 1965, doubling the floor space and providing necessary space for staff, users, and equipment. Expansion such as this reflects the tremendous growth in computer activity at the University and anticipates a continuing development in the Center's role as an all-university facility.

The Director of the Center is Dr. Werner C. Rheinboldt. John P. Menard is Associate Director and Robert L. Jones is Assistant Director. In addition to Professor Rheinboldt, the professional faculty includes Research Associate Professors A. Rosenfeld and R. Glasser; Research Assistant Professors E. Schweppe, J. Ortega, and R. Austing; and nine part-time faculty consultants from other academic areas. The Systems Analysis group is headed by A. Beam and R. Herbold. The Center also maintains programming and operating staffs.

Currently there are more than 225 research projects using the facilities of the Center. The following topics will give some indication of the variety of these projects.

In the area of programming systems work constant effort is directed to up-dating our system so that the research user of the machines is able to use, insofar as possible, the appropriate computer language for his problem. A number of subsystems were added to the original IBM-IBSYS monitor. Some of them facilitate the use of such languages as IPL-V, OMNITAB, MAD, UMAP, and ALGOL; others represent special developments of multi-precision packages such as MPP and PRECISE; MOIST provides flexible I/O; and still others combine a wide variety of computational aspects under one system such as X-RAY-65 which is concerned with crystallographic structure determination. In addition, the MAMOS submonitor was developed by the Center's systems group.

Projects in other areas of computer science research include the following: finding and analyzing algorithms for the determination of solutions of a general operator equation in Banach spaces; kinetic theory and spectroscopic studies on the fundamental properties of molecules; computational work in plasma physics, including an in situ probe system to measure ionospheric parameters and experimentation with rotating laboratory models which simulate the general circulation of the atmosphere; radio astronomical observations and gallactic and stellar models; and the psychomotoric testing of pilots. A major project is underway in Image Processing and Automatic Pattern Recognition. This project has many facets, including the following: discrimination of connected regions and of "solid" from "broken" regions; measures of shape "skeleton," "capacity," and "frame;" and computer-generated patterns for vision research. Applications have been made to such

areas as cloud pattern analysis and contour map processing.

In the fall semester of 1965, the Center will begin offering credit courses in Computer Science at the undergraduate level. A basic sequence will emphasize the algorithmic approach to the solution of problems, rather than computer programming as such, and will make extensive use of the computer. Two courses at the 100 level will consider the language and structure of computers more generally, along with applications. Additional courses are planned.

Courant Institute of Mathematical Sciences
AEC Computing and Applied Mathematics Center
New York University
New York 3, New York

The AEC Computing and Applied Mathematics Center at the Courant Institute of Mathematical Sciences of New York University will install a Control Data Corporation 6600 in their new building, Warren Weaver Hall, in April 1965.

The 6600 has 10 peripheral processors for I/O and a central processor with 10 functional units which concurrently perform arithmetic, logical, incrementing, and branch instructions. The floating add unit has an execution time of 400 nanoseconds; each of the two floating multiply units has an execution time of 1 microsecond. The initial configuration of this installation will include 131,072 60-bit words of core store, a console display, a disk, a card reader, a punch, a printer, and 7 magnetic tape drives.

The Courant Institute invites applications to its postdoctoral visiting membership program in the fields of numerical analysis and non-numerical computing.

The Moore School Problem-Solving Facility
University of Pennsylvania
Philadelphia, Pennsylvania 19104

The Problem Solving facility of The Moore School of Electrical Engineering, University of Pennsylvania, integrates results of the research program that has been in process since 1959. The pilot system is due for completion in April 1965; however, parts of it became functional in September 1964. This will expand existing University of Pennsylvania computer facilities into a time-sharing system with remote consoles. The primary motivation was the need to implement a Problem Solving facility with remote inquiry/display subsystems with access to the processing and mass storage facilities of the University Computer Center. The inclusion of a number of remote CRT stations allows "simultaneous" use of sharing of a large computer by a number of users, making it possible to enhance the effectiveness of any existing computer facilities by allowing man-machine interaction at the problem level without unnecessarily tying up the system for any one user or group of users.

A similar facility was originally applied to Navy logistics problems for which the storage of a large file is necessary. For this purpose the system is a successor of a similar, less versatile system implemented with participation of the Moore School at the Naval Aviation Supply Office. The latter system has been in operation since October 1962, and has since been used operationally. The type of problems for which the system is being designed include library applications, large simulation studies, and real-time tactical and strategic problems.

On-Line Computer Center
Space Technology Laboratories
Thompson Ramo Wooldridge Inc.
Redondo Beach, California

In January, TRW Space Technology Laboratories unveiled a new and powerful tool for advanced design engineers, scientists, and mathematicians. Called an On-Line Computer, it allows an experimenter or designer to "talk" directly to a digital computer, give it instructions, program it, observe the computed results immediately and, if necessary, modify his program—all in his own language and with his own problem-solving technique.

The TRW On-Line Computing system is unique because it is specifically tailored to the user. It is the scientist or engineer who originates a problem and works on it directly rather than a programmer or others professionally

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concerned with computing. The system is as convenient as a desk calculator—except that, as with any electronic digital computer, all operations are many times faster and completely automatic once the user has supplied data and instructions to it.

This type of on-line computing system was conceived originally by Drs. Glen J. Culler and Burton D. Fried, in 1961 for TRW's Computer Division (now part of the Bunker-Ramo Corporation) and has been serving TRW and Bunker-Ramo engineers and scientists ever since. The version demonstrated today is much more flexible and convenient than the original model. At TRW Space Technology Laboratories, a 5-hour lecture and laboratory course qualifies an engineer to use the On-Line Computer unassisted. Dr. Fried, a Theoretical Physicist at TRW-STL, admits to knowing nothing about computers, but finds an On-Line Computer "a crucially important tool" in his plasma physics investigations.

Dr. Culler regularly uses a remote on-line station in Santa Barbara connected by telephone data link to the original computer located at the Bunker-Ramo facility in Canoga Park, California. As a Professor of Mathematics at the University of California (and consultant to TRW), Dr. Culler uses the system extensively to teach such difficult subjects as numerical analysis and other forms of higher mathematics. Further use of the On-Line Computer as a teaching aid is being considered by other educators.

The TRW On-Line Computer uses a Bunker-Ramo 340 computer (a medium-size, digital computer) to which are connected four computing stations. Each station has a console with two keyboards for controlling the computer operations and a display tube on which results are presented in graphical and/or numerical form. All four consoles may be used simultaneously and independently. Expansion of the system to 12 stations, some connected to the computer by remote telephone data link, is planned for the future.

Never before has an experimental approach to problem-solving been available so directly to the engineer. This direct communication with the On-Line Computer is most valuable for solving problems where the experience and judgment of the user are applied at each step and several methods of solution must be attempted before discovering a successful one.

The value of allowing a design engineer to program the computer in his own language and to see the results as they are being computed is inestimable. But, the time that can be saved in proposal-efforts and on normal projects is also

quite substantial. Equally important, the charges for on-line computing time are about one-tenth the rate for larger digital computers.

An earlier version of the On-Line Computer system has been used successfully to solve a wide variety of advanced research problems in physics and engineering design, including non-linear integral and partial differential equations, missile control problems, and basic problems in superconductivity and quantum electrodynamics.

Another recent application was in the proposal effort for the abort guidance system to back up the primary guidance system of the Lunar Excursion Module of the Apollo Spacecraft. The problem was to determine the variety of mission possibilities under which an abort condition could exist. For each possibility, the engineers had to determine the proper action that would permit the safe return of the LEM to the Apollo Command Module. Neither desk calculation or programming for a high speed computer of all the possibilities and counteractions would have been possible in the time available to prepare the proposal. But, with the On-Line Computer, the job was completed in the time allowed and to the satisfaction of the customer, Grumman Aircraft and Engineering Company, who awarded the contract to TRW Space Technology Laboratories late in 1964.

To operate the TRW On-Line Computer, the user need only push the keys on the two keyboards at the console. One keyboard is for entering and selecting data; the other is for performing operations on the data. While this resembles superficially a desk calculator technique, the mathematical operations available in the On-Line Computer are far more extensive and powerful. By a single key push, for example, mathematical operations can be performed on a whole list of numbers (or function) as well as on a single number. Moreover, lists of operations can be generated by successive key pushes to create programs which the computer can execute.

In addition to initiating computer actions by a series of key pushes, the user can, at any time, cause the computer to display partial results or intermediate steps in a problem, including graphs showing any variable plotted against any other.

When attempting to solve a problem, the engineer or scientist makes use of the standard operations of elementary and advanced mathematics (algebra, calculus, differential and integral equations, and so on). Each of these operations is controlled by a single key on one of

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the keyboards. Of crucial importance, however, is the "console programming" feature which allows him to compose any combination of these operations into new ones, tailored by him to his particular problem or problem area. He, therefore, is able to accumulate a personal library of programs in his own "problem-oriented" language, created by him at the console, for reuse when a related problem needs solving in the future.

The BR-340 computer associated with the On-Line Computer has an 8,000-word magnetic core memory, a 48,000-word magnetic drum for data storage, and 2 magnetic tape units. In addition to the usual printed list of numbers representing the results of a calculation, a Cal Comp Plotter will provide a paper copy of any graph or other data shown on the display tube. Also, the display tube may be photographed by a polaroid camera.

The On-Line Computer is part of TRW's Computation and Data Reduction Centers (CDRC), which is under the technical direction of Dr. Eldred C. Nelson. The heart of the Computing Center of CDRC (but not presently involved in the On-Line Computer operation) is a pair of IBM 7094 fully transistorized digital computers and all the peripheral equipment necessary to print daily a quantity of data equivalent to the contents of a Sunday New York Times newspaper.

The units are being used in the design of trajectories for space missions, to design spacecraft themselves and to perform analyses on ballistic missile flights.

For post-flight analyses, data telemetered from missiles and spacecraft are first reduced and transcribed in the Data Reduction Center of CDRC. Special equipment converts the analog data collected in space to a form suitable for the digital computers. Also, tapes are prepared in this center that provide trajectory instructions for the boost vehicles used on all the manned spacecraft flights and for the nation's ballistic missiles.

TRW Space Technology Laboratories is an operating group of Thompson Ramo Wooldridge, Inc., one of the nation's leading manufacturers of aviation, aerospace, electronics and automotive products. In its modern facilities in Redondo Beach, California, TRW-STL is designing and producing the Orbiting Geophysical Observatory and Interplanetary Pioneer spacecraft for the National Aeronautics and Space Administration and the Nuclear Detection (Vela) Satellites for the U. S. Air Force. TRW-STL is also providing Systems Integration and Test Support for the U. S. Navy's antisubmarine warfare program. For more than 10 years, TRW-STL has also provided systems engineering and technical direction for the Thor, Atlas, Titan, and Minuteman Ballistic Missile Programs.

Computers and Centers, Overseas

Industridata AB was formed by ASEA, FACIT, SAAB, and the Scandinavian Power Company to promote administrative and scientific data processing. The data centers in Stockholm, Gothenburg, and Malmö are equipped with the Swedish-built computers FACIT EDB and SAAB D21. In June there will be delivered a General Electric GE-625 to ASEA, Västerås (70 miles from Stockholm) with a Datanet 30. This installation will be operated by Industridata for many varieties of remote terminal equipment.

Initially a UNIVAC 1004 will be installed in Solna, where the headquarters of Industridata is located. At the data center in Gothenburg and at most customers there will be paper tape terminals capable of transmitting at a speed of 600-1200 bauds. This system will be worked out in cooperation with General Electric and the ITT Company. The paper tape terminals will also be equipped with Olivetti typewriters having a speed of 40 characters per second.

Programming will be made in ALGOL, COBOL, and FORTRAN, and special systems will be worked out for various engineering applications. The network of terminals will be very advanced thanks to the special communication machine, Datanet 30. There are also negotiations with the Swedish Board of Telecommunications for entering lines with a capacity of 60,000 bauds. Normally the data will be transferred over switched lines.

GENERAL

With the EL X2, the N. V. ELECTRO-LOGICA has constructed a data processing system which combines great processing speeds with low prices, a small basic installation with practically unlimited expanding possibilities and a simple programming code with possibilities of expansion in a widely varying field. In the construction of this machine, naturally fully transistorized and built with miniature components, the severe rationalization in designing the logical units has enabled the utilization of labour-saving, and, therefore, cost-saving-techniques. This enables ELECTROLOGICA to launch the EL X2 at very low prices.

The basic, limited-size installation consists of a central processor; a 4096-word core store, which corresponds to about 30,000 decimal digits; a teleprinter for input/output with 56 different symbols and 69 positions per line; and a five-channel punched-tape input for automatic operation of the keyboard. It has an output speed of 10 symbols/sec. The possibilities of expansion, on the other hand, are very many. The composition of the machine can, each time in conformity with the existing need, be selected freely and developed from simple apparatus in the initial stages of the automatization into large systems, suitable for processing mass quantities of information.

CENTRAL PROCESSOR

The central processor consists of three parts: the arithmetic unit, the control system, and the interrupt system. It is installed in a metal cabinet (81-1/2 × 31 × 30 inches), to which the control panel is also fixed.

COMMUNICATION WITH PERIPHERAL APPARATUS

The communication with the peripheral apparatus is attended to by the control unit, a part of the central processor, which at the same time makes use of the interrupt system. An interrupt signal is issued when the auxiliary unit concerned has completed an instruction to transport a number of information units stated in the program and can therefore accept a new

instruction. The control is then automatically shifted to the appurtenant standard interrupt program, which, if necessary, attends to the initiation of a following information transport. The interrupt system guarantees an efficient operation of the auxiliary equipment and makes possible a large measure of simultaneity in the operation of central processor and peripheral equipment. The standard interrupt programs are delivered together with the apparatus.

CORE STORE

The word length is 27 binary positions + 1 parity bit; this corresponds to seven or eight decimal digits + sign. The access time to the store is 2.5 microseconds. The size of the store can be expanded to a maximum of 32,768 words. 4096 words of store are housed in a metal cabinet of the same measurements as mentioned above.

MASS STORE

For storing mass quantities of information magnetic discs and magnetic drums can be connected. A magnetic disc unit consists of at least 4 and at most 16 discs. On each disc 450,000 words can be written. The rotation time is 60 milliseconds. The access time to an arbitrarily situated word on one of the discs is, on an average, 195 milliseconds. The magnetic drum has 512 tracks of 1024 words, so, in total, 524,288 words can be recorded on 1 drum. The rotation time is 42 milliseconds; the average access time 21 milliseconds.

NUMBER OF AUXILIARY DEVICES

A maximum of 16 auxiliary devices can be connected to the EL X2, a number of magnetic tape units connected serially counting as one device. The user is entirely free to choose from the great variety of input/output equipment.

INPUT/OUTPUT EQUIPMENT

Besides the teleprinter with punched tape input mentioned under "basic installation" the following auxiliary equipment can be connected to the EL X2:

- five-channel punched tape output to the teleprinter; speed 10 symb./sec.

- punched tape reader EL 1000 for input of five-, seven-, or eight-channel punched tape; speed 1000 symb./sec.

- tape punch P 150 for output in five-, seven-, or eight-channel punched tape; speed 150 symb./sec.

- punched card read and punch unit; two tracks, speed 7200 cards/hour/track

- fast card reader; speed 42,000 cards/ hour

- card punch; speed 18,000 cards/hour

- line printer RD 5/10; 50 different symbols, 144 positions per line; set automatically at a speed of 5 alphanumeric or 10 numerical lines/sec.

- fast line printer RD 20; 50 different symbols, 144 positions per line; speed 20 lines/sec.

- a clock with twofold function; it indicates the time with an accuracy of 10 ms and signals the ends of program controlled time intervals from 10 ms upwards.

AND EVEN.........THE EL X8

In case of a very great increase of activities the possibility exists of engaging the EL X8. This can be done in several ways:

- The central processor of the EL X2 is replaced by that of the EL X8. In that case the peripheral equipment is connected to the EL X8.

- The central processor of the EL X2 together with its auxiliary equipment are connected to the EL X8 as a satellite installation.

To realize these possibilities, it has been arranged that EL X2 programs can be executed on the EL X8. The representation of the EL X2 instruction is, in fact, the same as that of the corresponding EL X8 instructions; in both machines the communication with the peripheral equipment is based on the same principles.

THE INSTRUCTION ARSENAL

Besides the arithmetical operations—additions, subtractions, multiplications and divisions—the EL X2 understands a great number of transport, jump, and shift instructions and several logical operations. For the internal recording of the so-called function part of these instructions, i.e., the part which describes the nature of the instruction, no fewer than 12 binary positions are available. The number of

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possibilities which can be realized in this way is extremely great; greater than is necessary for the most extensive system of instructions. The remaining possibilities are utilized by providing the instructions with a number of subsidiary functions, e.g.: questions, reactions to questions, address modification or indirect addressing, and use of constants not taking up any store space. In this way instructions with a fourfold function can be composed which carry with it a very great efficiency.

THE PROGRAMMER'S CODE

The expansion of the function of elementary instructions described above appears to full advantage in the code used by the programmer. Moreover, this code is easy to operate. The nature of the operations is indicated by the sign which is customary for them or by their abbreviated name. Operands can at will be named in such a way that their name corresponds with the nature of the quantity concerned.

Needless to say, the desired clearness of the programs is greatly advanced by this. This clearness is of great importance if programs are exchanged with other users.

Address modification and indirect addressing finally make available to the programmer the means by which very flexible programs can be drawn up.

SOME INSTRUCTION TIMES

addition:	37.5	microseconds
subtraction:	40	microseconds
multiplication:	250	microseconds
division:	350	microseconds

SOFTWARE

The user of the EL X2 has at his disposal:

● interrupt programs for the communication of the central processor with the peripheral equipment;

● standard programs which are used by the programmers to be able to work in a simple way with the input/output equipment, such as sorting programs for magnetic tape apparatus;

● an extensive subroutine library;

● complete programs of operations of frequent occurrence in the administrative and technical/scientific fields.

Moreover, compilers of various programming languages are developed.

Istituto di Elettrotecnica
Centro di Elettronica
Universita' di Genova
Genova, Italy

A new research group has been formed at the Istituto di Elettrotecnica of the Universita' di Genova, under the directorship of Professor Enrico Astuni. The group has centered its activities around the following three themes:

● Characterization of switching components (presently, field-effect transistors are being investigated),

● Study of iterative sequential networks, and

● Implementation of a series of computer programs for the synthesis of logical networks.

Concerning this last point, the Institute does not have its own computer; rather, the University of Genoa has established a Computing Center to work for all departments of the University. The Computing Center is equipped with medium scale IBM equipment, and for jobs exceeding its capacity other University Computing Centers in Italy are available under a coordinated plan.

TAC-A High-Speed Real-Time Computer
The Marconi Company Limited
Chelmsford, Essex, England

INTRODUCTION

Teams of Marconi engineers have been engaged over a long period in the application of digital methods to a succession of complex Military systems. These projects have provided unique experience of the requirements of Digital Systems Engineering, and have led to the development of a range of advanced semiconductor circuits designed for reliable operation over

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long periods. These circuits, of which the reliability has now been proved by experience in the field, have been applied to the TAC computer—a high-speed general-purpose machine for real-time data processing and control.

In real-time applications the computer is taking part in a process as it occurs. Examples are:

1. The monitoring of the operation of industrial plant, involving the detection of equipment failure and the measurement and display of temperatures, pressures, and flows.

2. The control of industrial equipment such as steam turbines, boilers, fractionating columns, of ground or air traffic, or of military weapons systems.

3. The generation and reception of teleprinter or other digital messages for subsequent processing, for rerouting, or for display.

Because, in general, the related process cannot be held up whenever the computer fails, reliability is an essential design objective. Equally the computer must be capable of ready integration into a wide variety of environments, and must be directly compatible with a corresponding range of equipment for sensing variables and for storing and displaying them.

FEATURES

High Speed

TAC is a parallel machine working with fast transistor circuitry and its consequent high speed of operation frequently means a reduction in peripheral equipment. Most simple orders such as fetch, add, subtract, etc. are obeyed in 22 μs. Multiplication takes 92 μs and unlimited input orders only 10 μs per word.

Reliability

Well toleranced and conservatively rated semiconductor components are used throughout. The computer is built largely of diode-transistor nor/nand elements constructed on high-grade fiberglas printed circuit boards. Independent tests on the standard logic circuits have continued for over 27 million semiconductor hours with only 1 failure.

Highway Input/Output System

An easily expanded input/output facility is essential for real time process control com-

puters. The highway system on TAC allows the number of external devices to be increased from 2 or 3 in the basic installation up to about 100 or more with no changes to existing equipment.

Priority Interrupt

This facility, which is vital for real time computers, allows any external device to demand the computer's attention at any time. A system of priorities is allocated so that simultaneous interrupts do not cause confusion in the machine. Typical applications include the operation of sequential control equipment, and the handling of alarms.

Peripheral Equipment Available

It is not sufficient just to develop a computer for real time application. A whole range of elements is needed from which particular systems can readily be assembled. The principal elements designed for use with TAC are:

1. The Digital Scanning Unit, for sensing pushbutton commands, contact closures, and so on.

2. The Analogue Scanning Unit, for measuring plant parameters.

3. The Marconi Cathode Ray Tube Tabular Display System, which presents up-to-date information to operators in plain language on a CRT screen, allowing rapid communication between operator and computer.

4. The Magnetic Drum Unit, to provide economical storage of information where relatively rapid access is important.

5. The Magnetic Tape Unit, for the economical storage of large quantities of information where longer access times are permissible.

Electric typewriters and printers are, of course, also available.

Systems Analysis

Many real time computer systems are extremely complex and the Marconi Company maintains a group of System Analysts who design complete systems to customers requirements. Both small and large systems have been handled including some multiple computer installations each involving over 100 racks of equipment.

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COMPUTER DESIGN

General

TAC is a fixed-point, parallel computer with a 20-bit word, and a 4096-word core store. It is a single address, sequential machine which implies simple programming and an economical equipment design.

Storage

The 4096-word ferrite core store has an access time of 4 μs and a cycle time of 10 μs. Data and instructions are stored interchangeably and are transferred to and from the store via the memory register M. Normally as soon as one instruction has been obeyed, the next instruction is already waiting in the register M to be transferred to the control register.

Control

The Control System includes two registers, C (the control register) and E (the instruction counter). C contains the instruction currently being obeyed, and its contents are decoded by the Control Unit which controls the action of the various parts of the computer and the flow of information between them. The register E, which consists of only 12 binary digits, contains the address of the next instruction. Since instructions are normally obeyed in sequence, E is increased by one at the start of each order. Jump orders, however, may completely change the value of E, so the next instruction is then obtained from an entirely different part of the store.

Arithmetic

The Arithmetic System includes the three registers A, B, and D, each of 20 binary digits. A and B normally act as a double length accumulator (i.e., 40 binary digits) with B as the less significant half, so that when adding to B, any overflow is automatically added into A. D may be used as a single length accumulator. The Arithmetic System includes, besides A, B, and D, the Arithmetic Unit which contains all the logical circuits required to perform additions, shifts, and transfers. More complex operations are carried out by repetition of these simple functions under the direction of the control unit.

The Input/Output System

The computer input/output system is based on the use of a 'highway.' The computer is con-

Figure 1--TAC block diagram

nected to its peripheral units by a highway consisting of:

1. A data highway of 20 lines, allowing information to be transmitted from computer to peripheral units, or conversely at up to 10^5 words per second.

2. A Route Selection highway which is used to address a particular peripheral unit. The Route Selection Register is set by the programme, and the highway activates the selected peripheral unit while inhibiting the action of all others.

3. A control highway which includes an 'interrupt' line, data exchange control lines, and an indication of whether an input or an output process is demanded.

When a peripheral unit requires attention it indicates this by earthing the 'interrupt' line. This diverts the computer into the 'interrupt sub-routine' which will interrogate the highway to discover which units need attention, and will deal with them before returning to programme. This feature is of great value in real-time systems since it avoids the need for programmed

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examination of the demands of peripheral units, which can be extremely wasteful of time.

TAC ORDER CODE

Input/Output

00	Unlimited input to N onwards	$16 + 10 \times$ μs
01	Unlimited output from N onwards	$16 + 10 \times$ μs
02	Input to N	24 μs
03	Output from N	24 μs
04	Input to A or D	⎫
05	Output from A or D	⎬ 16 μs
06		⎪
07	Send N	⎭

Transfers and Simple Arithmetic

10	Fetch N to A	⎫
11	Add N to A	⎪
12	Subtract N from A	⎬ 22 μs
13	& N with A	⎪
14	Store in N from A	⎭

15	(AB) - N	22 μs
16	Justify AB	16 μs
17	Clear N	22 μs

20	Fetch N to B	⎫
21	Add N to B	⎪
22	Subtract N from B	⎬ 22 μs
23	& N with B	⎪
24	Store in N from B	⎭

25	D - A or A - D	16 μs
26	Comp. AB or D	24 μs
27	Clear AB or D	16 μs

30	Fetch N to D	⎫
31	Add N to D	⎪
32	Subtract N from D	⎬ 22 μs
33	& N with D	⎪
34	Store in N from D	⎭

35	-	
36	Ones in A - D	16 - 49 μs
37	-	

Multiplication (and similar operations) and Shifts

40	Multiply (AB) by N: product in AB	92 μs
41	Multiply (AB) by N: product rounded off in A	94 μs
42	Divide AB by N	100 μs
43	Square Root of AB	80-155 μs

44	Shift AB left N places	⎫
45	Shift AB right N places	⎬ $6 + 2N$ μs
46	Shift D left N places	⎪
47	Shift D right N places	⎭

Jumps (jump 12 μs; no jump 16 μs)

Jump to N if	50	AB zero
	51	AB non-zero
	52	AB positive
	53	AB negative
	54	B trigger set
	55	B trigger not set
Jump to N and	56	clear prohibition I
	57	Link to N. 22 μs
Jump to N if	60	D zero
	61	D non-zero
	62	D positive
	63	D negative
	64	fail trigger set
	65	clear or set prohibition F
Jump to N and	66	clear prohibition R
	67	Jump to N.

Miscellaneous

70	B order (B N 77)	22 μs
71	Modify next instruction with D or N (D if address = 0)	15 or 24 μs
72	Count next word up to N	36 μs
73	Decimal to Binary conversion	64 μs
74	Binary to Decimal conversion	67 μs
75	Transfer priority or RSR to D	16 μs
76	Set RSR to N	16 μs
77	Clear or Set prohibition	16 μs

N.B. Where there are two alternatives (e.g., 04 Input to A or D), address 0 implies the first alternative and address 1 the second, except in order 71.

ENGINEERING FORM

The computer is housed in racks 7 feet (312 cm) tall by 10 feet (305 cm) wide by 15 inches (38 cm) deep, overall. Its associated control desk, which incorporates a tape punch and a high-speed tape reader as standard, is 4-1/2 feet (137 cm) wide by 28 inches (71 cm) deep.

The dissipation of the computer and desk, including paper tape equipment, is 1.2 kw. The machine is powered from 45/65 cycles per second mains at 240 volts ±6%. The machine is capable of operation at ambient temperatures of up to 40°C.

A supply of cool air is recommended since the semiconductor reliability increases as the operating temperature is reduced.

SPECIAL FEATURES

1. Should a peripheral unit be disconnected or switched off the computer will not be capable of communicating with it. Input or output orders will then 'fail,' and the computer is automatically linked to a special sub-routine which can arrange, for example, for print-out to take place using a second printer where a first has not responded. The highway will still operate normally for the remaining units.

2. All highways are specially designed to withstand electrical interference.

3. The computer is protected against loss of programme through mains failure, and can be supplied with special batteries to permit continued operation for a limited period.

4. A 'watchdog timer' can be provided to indicate computer failure. It will operate an alarm unless reset regularly by the computer programme.

5. The computer control desk provides excellent facilities for programme testing and for machine maintenance.

Miscellaneous

On-Line Experiments in Particle Physics

The Maniac III computer has been used on-line with physics experiments at the University of Chicago Cyclotron. Much of the experimentation involved the use, for the first time in a physics experiment, of the wire spark chamber that was developed at the University's Institute for Computer Research. Spark chambers are particle detectors that provide geometric information about the location of a particle track. The wire chamber developed at Chicago divides the chamber into many strips, thereby producing digitized coordinate information directly from the spark. The coordinate information is written into a memory core by the spark current for later readout under control of the computer or of a preprocesser. Track location ac-curacy of about ±1/2 mm has been routinely observed. The experiment in which the spark chamber was employed was the measurement of the energy spectrum of electrons from mu-meson decay. Momentum analysis was made by using a magnetic field, the spark chambers delineating the electron track through the magnetic field with a minimum of material in the track. Run-time programs that reconstruct the track in space and analyze the curvature of the track in a magnetic field follow the immediate tests for the legality of the event. Data rates were low enough that direct computer control of the experiment was unnecessary. Thirty thousand events were accumulated per day.

PLATO II and III

INTRODUCTION

The purpose of the PLATO project (see Digital Computer Newsletters dated Oct. 1961, July 1962, Apr., July, Oct. 1964, Jan. and Apr. 1965) has been to develop an automatic computer-controlled teaching system of sufficient flexibility to permit experimental evaluation of a large variety of ideas in automatic instruction including simultaneous tutoring of a large number of students in a variety of subjects. The PLATO system differs from most teaching systems in that the power of a large digital computer is available to teach each student since one such computer controls all student stations. The project work has fallen into three categories, no two of which are wholly separate from each other: (1) development of the tools for research; (2) learning and teaching research; and (3) provision of a prototype for multi-student teaching machines.

PLATO III SYSTEM EQUIPMENT

During the fourth quarter 1964, work continued in the development and construction of circuitry required for the realization of a 20-student-station teaching system.

Student station circuitry constructed thru December 1964 includes all that is required for the operation of eight student stations. Only three of the eight stations are fully operable, however, the remaining five stations are undergoing installation and check out and were expected to be fully operable during the first quarter 1965. An intermediate goal of 10 student stations, to be fully operable in November 1964 has not been met, mainly because of slowness of delivery of required electronic components.

Development continues on special circuitry which will update present equipment or provide special system facilities. Included are transistor deflection, power control, master keyset, and master video switch.

THE CATO SYSTEMS PROGRAM

The CATO (Compiler for Automatic Teaching Operations) systems program consists mainly of the following:

FORTRAN RESIDENT (modified version):
CATOCOM - the compiler part which
corresponds to FORTBIN;
LOGICOMP - the logical section of the
compiler;
CATORES - the resident program for
CATO-compiled teaching
programs.

Since the tentative completion of CATO programs in the last quarter, the system has gone through its initial trial period. During this period, various errors in all above parts have been uncovered and corrected. CATORES had the least, while LOGICOMP had the most. Also, some desirable changes in the systems programs have been suggested by the users of the CATO system. These are being considered, and changes to the systems programs are being made accordingly.

The subroutines called TRANSFER and CONNECT were added to the systems library tape. The former is a multipurpose routine which allows the users to treat pairs of characters to be equivalent, count number of characters, ignore, and/or find certain ones, or store them in a specified way. The latter routine is used for communication between student (or teacher) stations.

PLASMA DISCHARGE DISPLAY TUBE RESEARCH

The purpose of the plasma-display tube project is to develop an inexpensive substitute for the present PLATO memory-tube complex. This new system should cost less than one-twentieth of the present one.* One of the novel characteristics of the plasma-display tube is the innate ability to display information that is stored, so it will be called the plasma-display tube rather than plasma-memory tube. The present memory tube may be compared to the plasma display tube system as follows.

Figure 1 shows a block diagram of the present memory-tube complex. Digital spot
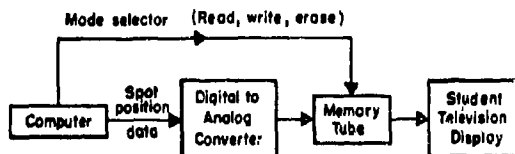
Mode selector (Read, write, erase)

Figure 1--Present student memory tube complex

*As each student site must have a memory device, the savings for even a small number of student sites can be large.

position data, generated by the digital computer, must be converted to an analog signal to position the electron beam of the Raytheon memory tube. Depending on the mode selected by the computer, this beam reads, writes, or erases a spot on the storage tube. To display the information of the memory tube on the student television screen it is necessary to form a video signal from the stored data. Figure 2 gives a block diagram of the plasma display tube complex.
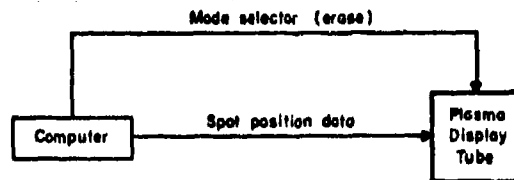
Mode selector (erase)

Figure 2--Proposed student plasma display tube complex

Only one mode is necessary for control of the plasma-display tube, the erase mode. Digital spot position data are directly used by the plasma-display tube and, as mentioned above, the storage and display features are innate to the plasma-display device.

A matrix of gas cells makes up the plasma-display tube; Fig. 3 shows a simple matrix consisting of four rows and four columns. The cells are filled with an inert gas. The principle of operation is as follows: The firing voltage V_f is greater than the sustaining voltage V_s; when a cell that is not fired is held at V_s, it remains unfired. To fire a cell, the corresponding row and column are selected and a pulse added to each of polarity such that the voltages across the cell add and raise the voltage above V_f, firing the cell. Either pulse alone is too small to initiate a discharge. If at least one set of conductors (rows or columns) is transparent, innate display results. Once a cell is fired, it is maintained by V_s which is always across the array. As was previously mentioned,[1] the switches may be made of elements similar to the gas cells of the matrix and by suitable interconnection the number of external connections is reduced from 2^{n+1} to $2(2n+1)$. For an array consisting of 256 by 256 cells, the number of external connections is reduced from 512 to 34. The row and column conductors are placed externally to eliminate firing of adjacent cells under certain situations (see Fig. 4).

[1]Coordinated Science Laboratory Quarterly Progress Report for December 1963, January and February 1964.
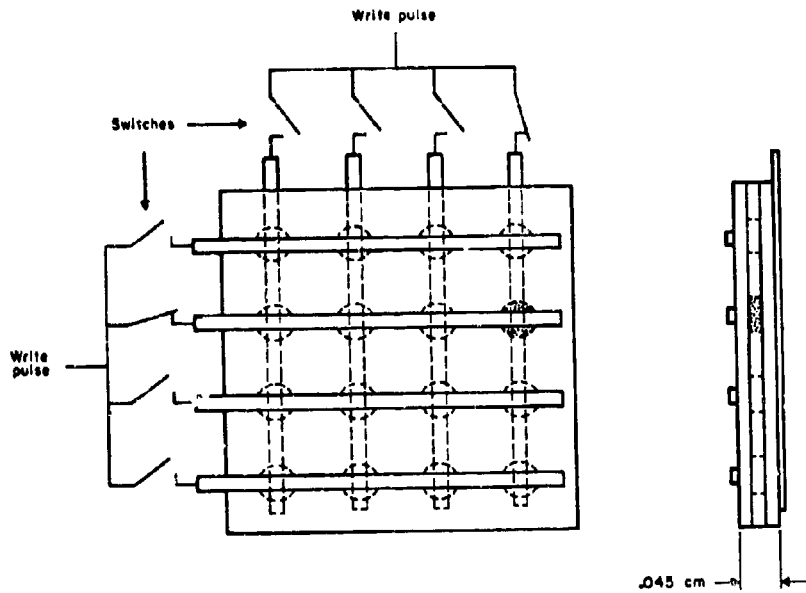
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Write pulse

Switches

Write pulse

.045 cm

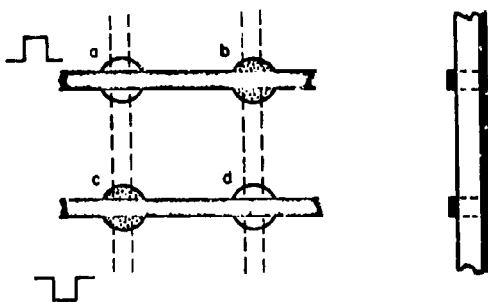Figure 3--Plasma display device with matrix of gas cells

Figure 4--Firing of adjacency problem--
either a or d could fire

Let us assume that the row and column
conductor is placed in contact with the gas
cells, as in Fig. 4, and adjacent cells b and c
are fired. Assume we wish to light cell a, so
pulses are placed on the appropriate row and
column of the matrix; however, since cells b
and c are fired, the pulses are also applied
across cell d. Hence, either cell a or d, or
both, will fire. Putting the row and column
conductors on the outside adds a series imped-
ance to each cell, helping to isolate cells, and
attenuates the pulse as it passes through fired
cells. Sputtering problems are eliminated and
construction is simplified by the external con-
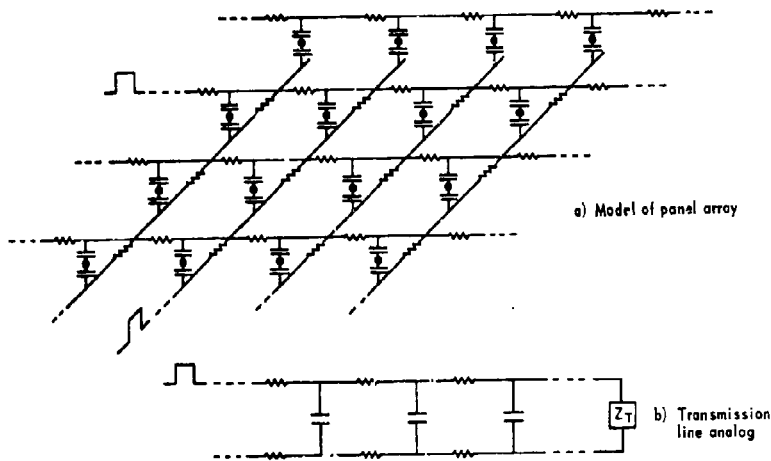ductors.

a) Model of panel array

b) Transmission
line analog

Z_T

Figure 5--Panel matrix model

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Transparent conductors have a non-zero resistance, typically a few ohms between each cell, which is capacitatively coupled into the cells. A transmission line analog may be made for the matrix (see Fig. 5) and a worse-case analysis done to determine the upper frequency such that writing pulses are attenuated less than 10-percent in traveling across the array. The result from such a calculation, using measured values of r and c for a one-cell structure, shown in Fig. 6, indicates that $f < 10^6$ cps.
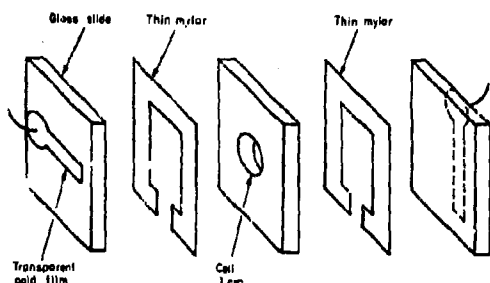

Figure 6--Construction of a one cell display tube

One main problem remains to be solved in making a practical plasma display tube. This is the problem of charge build-up on the walls of the gas cell which lowers the firing potential to V_s. A number of experiments are currently being performed to eliminate this charge buildup, and it is expected that a solution will be reported next quarter.

PLATO LEARNING AND TEACHING RESEARCH

Text-Tester

A preliminary version of TEXT-TESTER, a PLATO teaching logic designed to help evaluate new textbooks, is now available. This program permits each student to "manipulate" the test as he would a book; e.g., he can flip pages, skipping text, exercises, and even chapters, and answer questions whenever he elects to. In addition, the student can request that the system judge his answers.

Provisions are included for the author to quickly change portions of the text, to insert attitudinal or other questions calling for paragraph answers from the students, and insert tests of any length which are automatically administered by the system at the appropriate point in the student's progress through the text, despite the fact that the student is not required to follow any predetermined path through the materials.

Programs for analyzing data generated by TEXT-TESTER are being planned.

When TEXT-TESTER was demonstrated to representatives of the Elementary School Science Project, the School Science Curriculum Project, and the University of Illinois Social Studies Curriculum Study Center (curriculum projects located at the University of Illinois), the prospect of having this evaluative tool available was enthusiastically received.

Controlled Inter-station Communication

In considering the possible research uses of the PLATO system I discovered that the capability of communicating among stations would generalize PLATO by establishing a new dimension of PLATO research. With the capability of a controlled inter-station communication it would, for example, be possible to perform experiments in gaming, simulation, and group interaction of interest to the behavioral scientists. PLATO would offer an advantage over conventional studies of this sort because it would supply very flexible but completely defined means of communication together with a full recording of "moves" in experiment in a form convenient for later analysis. The rules controlling the interaction, via keyset and TV screen, could take a number of different forms; for example, rules explicitly imposed by the program, rules imposed and changed by one or more players during a game, or rules derived from the successive actions of the players.

In order to make possible the controlled inter-station communication it was necessary only to modify the compiler by adding a 20-word routine, CONNECT. That such a small change permits such a strong generalization of PLATO's usefulness is evidence of the maturity of the PLATO system. Like other features of the compiler, CONNECT is easy for the programmer to use, thereby placing the emphasis where it belongs, on the objectives and techniques of the lesson-writer or game-designer.

During this quarter, several dozen faculty members, some from curriculum study groups and others representing various areas in the behavioral sciences, have viewed demonstrations of the generalized PLATO and given us their comments on PLATO's potential usefulness in new curriculum and behavioral science research. Discussion with these people and also with representatives of the Department of Defense interested in command and control problems have substantiated our contention that we have indeed added a valuable new dimension to PLATO's capabilities.

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PLATO Control for Real Experiments

In the past, the PLATO teaching stations have been used for presenting lesson material to students as well as allowing them to perform experiments simulated by the computer. The possibility of using the student stations for controlling experiments and receiving data from them was examined during this quarter. In co-operation with F. Propst, an experiment involving pulse height counting was chosen for our first project. Digital data from the experiment are inserted into the computer via the keyset lines. The output functions from the PLATO system, normally used for writing on the student's screen, are used for controlling the variables of the experiment. By using the subroutine called CONNECT, the experimenter can use one student station to describe the experiment which the computer then controls on another station. At the completion of the experiment, the experimenter can process the results and have the calculations displayed in visual form on his TV screen. These features have been tested using a preliminary experiment. A second program is in progress which will allow the experimenter to combine the results of several experiments.

Although this concept was originally developed to allow experimenters to perform and analyze experiments quickly, its use as a teaching tool is also important. All the student stations have access to the experiment. Thus, the students can perform indi vidual experiments with a relatively expensive piece of equipment which normally could not be supplied to them.

Demonstration Programs for the PLATO System

The lesson, TEACHER, which explains the structure and operation of the PLATO system, has been completed. It provides a discussion of the system as a whole, the television display, the keyset, and the programming logic. The lesson demonstrates many of the major capabilities of the PLATO system and is the first in a series of lessons to instruct potential PLATO lesson-writers. Since the lesson was coded in PLATO compiler language, it serves as a simple reference model for compiler format.

The revised version of "Perimeters of Polygons" has been completed and, together with the "Addition of Fractions" program, will be used as an example of PLATO tutorial logic.

REPLAB

In the interest of debugging the PLATO compiler, the REPLAB program (scientific inquiry training sequence based on the bimetal strip experiment) has been rewritten in compiler language. This is the third language in which it has been programmed (ILLIAC, CODAP, and PLATO compiler). Several minor compiler changes were suggested by the reprogramming.

The factor analysis of the student data from the REPLAB runs of the spring of 1964 is still being carried on.

Historic SEAC Computer Parts Presented to Smithsonian

National Bureau of Standards
Washington, D.C. 20234

After 15 years of service, one of the Nation's pioneer electronic computers, SEAC, reached its final resting place on February 24. In a small ceremony held in the computer laboratory of the National Bureau of Standards (U.S. Department of Commerce) Dr. A. V. Astin, NBS Director, presented typical parts of SEAC to Dr. Walter F. Cannon, Curator in Charge, Division of Physical Sciences, of the Smithsonian Institution. The parts were from the computer's memory, computing unit, and control console.

When completed at NBS in 1950, SEAC (Standards Electronic Automatic Computer) was the first internally progr   digital computer to go into operation in the United States.[1] Developed originally to enable the Air Force to attack massive logistic problems, SEAC was also used to perform computations required in the design of the first H-bomb.

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[1]SEAC, the National Bureau of Standards Eastern Automatic Computer, NBS Tech. News Bull. 34, 121-125 (Sept. 1950); SEAC improvements increase computing power, NBS Tech. News Bull. 38, 8-13 (Jan. 1954); and Electronic Computer Research issue of the NBS Tech. News Bull. 42, 57-66 (April 1958).

SEAC has since been used in a wide variety of computer research, including experimentation in automatic searching of chemical patents and the manipulation of pictorial data, and in such novel tasks as moving "cars" on streets existing only in the computer memory. SEAC also demonstrated the feasibility of techniques which contributed to successive generations of computers.

Current problems and experiments now require the higher speeds and greater memory capacities of the more modern machines. Because of this, SEAC was "retired" in a special

ceremony April 23, 1964.[2] At that time, many of the group which originally developed and built the machine gathered at the Bureau to bid the machine farewell.

Now, SEAC is physically disappearing. It is being dismantled, and except for those parts going to the Smithsonian for display, its usable remains will be scattered through government surplus distribution.

[2]NBS pioneer digital computer retired, NBS Tech. News Bull. 48, 112-114 (July 1964).

Computer Plots Potential Nuclear Damage
National Bureau of Standards
Washington, D.C.

The NBS Institute for Applied Technology (U.S. Department of Commerce) has developed a computer program for use by the Defense Communications Agency (DCA) in planning its worldwide communications network. The DCA is designing the system for continued operation in the event of any national emergency; its sites, materials, and construction features must therefore be selected to withstand the effects of a nuclear bomb. The computer program was devised by Mai Liis Joel and Douglas D. Lottridge of the NBS Information Technology Division. It is used with a plotter to produce overlays showing on standard maps the "hardness" required of installations to withstand hypothetical nuclear attacks.

OVERPRESSURE FROM NUCLEAR BLASTS

A nuclear detonation affects life, structures, and weather in several ways—by the shock wave, heat, and other radiation. The DCA is interested in knowing the immediate effects on stations of a communications network from hypothetical detonations of assumed intensity and height. Stations directly under a prime target might be annihilated, some a few miles away might escape if massively protected, and others still farther out might survive even though poorly protected. To plan its communications system, the DCA must know, for certain assumed attacks, just how much protection would be needed at alternative locations.

The immediate destructive power of an explosion can be calculated as "overpressure" (shock wave pressure in pounds per square inch above the prevailing atmosphere) if the distance from the burst and its height and yield are

known. The overpressure from a given blast becomes less with increasing distance from it and in this program is assumed to be the same at all points equidistant from it; thus circles of overpressure values can be drawn around a target. (See Fig. 1.)

FACILITY HARDNESS

The ability of a structure to withstand a blast is called "hardness" and is expressed as the pounds of overpressure which it can withstand. A building hardened to 2 psi could withstand blasts having overpressures less than 2 psi but would be destroyed by greater ones. The hardness requirements of a more remote site might be lower and cost of construction there less, but this advantage would have to be balanced against any increased cost and uncertainty of maintaining and communicating with the station. Geographic presentations of hardness requirements are essential to the DCA, since site selection may involve trade-offs among several factors.

The DCA can now quickly determine lethal radii of overpressures around prime targets by use of the Bureau program to compute and plot the circles along which specified values of overpressure are expected. This computation is performed on a digital computer and the results encoded on magnetic tape. The tape is used to drive a plotter printing concentric circles of overpressures on transparent overlays on the same scale as the World Aeronautical Charts. The hardness requirements at tentative sites for specific hypothesized attacks of one or several simultaneous blasts can be visually determined and compared by placing the appropriate overlay on the chart showing the assumed target and sites being considered.
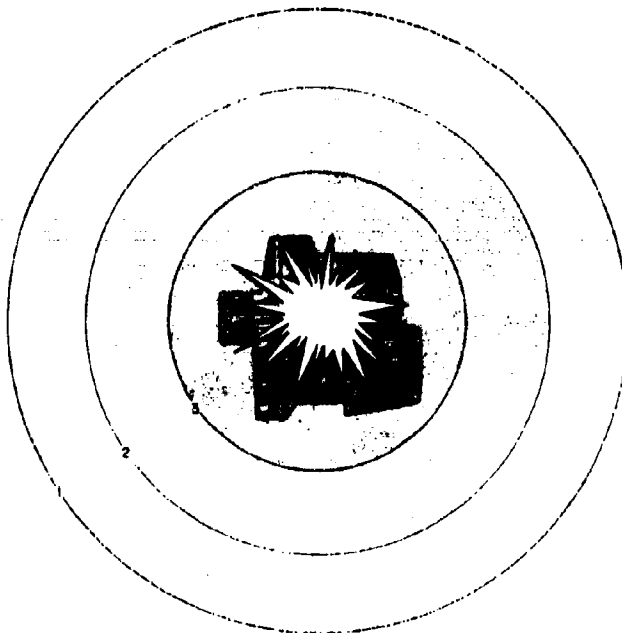
Figure 1

The computer program and the overlays produced admittedly do not take into consideration all factors which affect the suitability of facility sites. Considerations of topography and prevailing climate could be added to an overlay, but would seriously limit ease of using the method. In its present form the program provides readily available guidelines, as required, eliminating the need for laborious hand calculations and manual mapping.

SUPPLEMENTARY INFORMATION[1]

Correction for Off-Target Blasts

The fact that a bomb may not detonate immediately above its intended target, but may miss in an unpredictable direction by a distance related to probability, is allowed for in the computer program by the "circular error probable" (CEP) factor. A miss would result in overpressures higher than calculated at one side of the target and the destruction of facilities not adequately overhardened. While facilities on the opposite side of the target would be less taxed and their survival more favored, the program makes allowance for the CEP in order to evaluate realistically the worst-case overpressure.

The probabilities of overpressure exceeding hardness for various CEP distance values have been calculated. These can be used to select a specified number of CEP's to be added to each lethal radius; this "CEP multiplier" is an input parameter of the program. Its net effect is to enable some facilities to meet off-target excesses and to give others the advantage of being overhardened.

[1] For further technical information see, "A program for plotting circles of constant overpressure around targetted points," by Mai Liis Joel and Douglas D. Lottridge, NBS Tech. Note 249 (Oct. 1964), available at the cost of 40 cents from the Superintendent of Documents, U.S. Government Printing Office, Washington, D. C. 20402.

A computer system that can learn to handle increasingly complex tasks by using its own past experience plus human guidance is being developed by Mrs. Aiko Hormann at System Development Corporation, Santa Monica, Calif. The system is called "Gaku," which is a Japanese name denoting learning.

The Office of Naval Research has announced the award of a contract to SDC to provide partial support for the continuation of Mrs. Hormann's research under ONR's information systems research program.

Gaku is not a machine but a new way of using a digital computer in partnership with man. In the conventional method of using a computer, fully-detailed instructions must be programmed into the machine, specifying the exact steps needed to arrive at the solution to a given problem. These methods are inadequate if the data are incomplete and the solution procedure not precisely known in advance. Further, it is not feasible to store in the computer's memory all the specific procedures required to solve all problems, some of which may not even be conceived at the time the system is designed.

Gaku overcomes this basic difficulty by utilizing instructions and procedures of a more general nature. This material actually consists of general rules for decision making and information handling which the system can apply to a wide variety of problems. When given a specific problem, Gaku then uses these general procedures to work out an appropriate course of search and experimentation leading toward the desired particular solution.

Gaku has four major components or mechanisms. First, there is a programming mechanism for manipulating basic operations and prestructured programs, similar to a programmer's function normally done outside the computer. The second and key component is the problem-oriented mechanism which is responsible for determining the overt behavior of the system. This mechanism both constructs and carries out the required sequence of actions leading to the solution of a given problem. It contains the procedural rules, mentioned above, which choose actions more efficiently than random trial-and-error search. These rules are of a step-by-step nature, causing the mechanism to attack problems in piecemeal fashion.

This process, however, tends to lose sight of the total picture of the given problem. Con-

sequently this "near sightedness" of the problem-oriented mechanism is corrected by a third mechanism which takes a larger view, often at an abstract level, of a given task. This component called the planning mechanism is capable of analyzing the structure of a given problem and placing guideposts on the road to the solution. After surveying the task as a whole, this mechanism subdivides the task into a hierarchy of subtasks, each of which is supposed to be easier to perform than the original task. This hierarchy of subtasks constitutes a rough sketch of a possible course of action that guides the problem-oriented mechanism.

To make efficient use of Gaku's experience, the problem-oriented mechanism is also influenced by the induction mechanism, which takes a still larger view of a given task. The induction mechanism can survey the system's past experience with various problems and apply relevant experience to new problems.

Although it may be noted that many of the features of Gaku are based on what is known about human intelligence and learning, the system is not intended to be a deliberate imitation of human processes. Gaku works in partnership with man, who is its teacher in the early stages. Gradually the system increases its capability as it works with its human colleague. He assists by giving Gaku samples of other previously-solved problems relating to the subject, general information which might be in the form of a lecture and suggestions on how the task might be done.

In order to evaluate Gaku's performance and detect its limitations, Mrs. Hormann has used as a testing vehicle a sequence of increasingly difficult problems taken from the Tower of Hanoi puzzle. This puzzle involves a tower or stack of disks of increasing size from the top to bottom. The problem is to transfer the disks from the peg on which they rest to either of two empty pegs in the fewest possible moves but moving only one disk at a time and never placing a larger disk on top of a smaller one. Humans faced with this puzzle sometimes take hours to solve it, and some give up completely.

Gaku started by working on the relatively simple three-disk case. After solving it, the system used this experience to find the solution moves for progressively more difficult problems involving a larger number of disks, finally finding a general solution pattern through the induction mechanism.

Currently the system is only in a rudimentary stage and is not yet able to handle a wide variety of complex tasks. There are many problems of both a technical and conceptual nature that must be solved before the desired generality and versatility can be achieved.

In her continuing research Mrs. Hormann will look for new ways to make the system more efficient and general-purpose. One of the principal areas to be covered in the next phase of research sponsored by ONR is to improve communications between the human tutor and Gaku. The object is to permit the tutor or experimenter to define problems and give suggestions to Gaku in a manner flexible and broad enough to resemble the approach of a teacher to a human student.

The Office of Naval Research is providing partial support under ONR's Information Systems research program because the modern Navy continues to become increasingly sophisticated and complex, and consequently the demands made upon Navy people also increase. Military commanders must sift through more information in less time, laboratory scientists and engineers must use new mathematics on more difficult problems, and operators and technicians are faced with almost unbelievably complex machines. Yet the capabilities of people cannot be changed: human memory capacity is relatively fixed, conceptual grasp of multiple simultaneous factors is limited, and the distribution of intellectual talents within the total population remains constant. The Navy is already expending tremendous amounts of time and money on training, bringing human talents and skills up to very high levels of performance, yet even more is required for effective operation—effectiveness that is critical to survival of our national freedom.

Thus the Navy is forced to turn more and more toward machine aids to help men perform their complex intellectual processes. Modern computers and electronic data processing equipment have already contributed very significantly to many of our activities, but several highly useful and desirable processes still lie beyond the capability of even our most powerful present day machines. Such processes include analysis of poorly defined situations, identification of meaningful patterns in data, and synthesis of possible courses of action. These are just the activities with which the military commander or scientific problem solver is primarily concerned, and thus any help along these lines provided to him by machines should increase his effectiveness remarkably.

Because these desirable capabilities lie largely beyond the current state of the computer art, the Information Systems Branch of the Office of Naval Research is supporting a program of basic research in computer augmentation of human reasoning. Mrs. Hormann's project is one possible approach to solving the Navy's problem.

Redundant Digital Counting Circuits
The Pennsylvania State University
University Park, Pennsylvania

In the Computer Facilities, Department of Electrical Engineering, at The Pennsylvania State University, research is being conducted on redundant digital counting circuits.

The results of the first efforts have shown that by using minimum distance three-state assignments and considering error states when deriving the input equations, counters tolerant of a single error can be synthesized. Although one Flip-flop in the counter might be in error, the other Flip-flops will continue to sequence correctly. Thus, acceptable sequencing will continue with a malfunctioning unit present in the circuit. Because of the error correcting properties of the state assignment, the correct count can be recovered. A one bit error introduced by noise or an intermittent malfunction will be automatically corrected.

Redundancy is incorporated as an inherent result of the initial design procedure rather than being included after a nonredundant working design has been obtained. Instead of using any of the known methods of simplification of Boolean functions, the synthesis procedure involves the selection of a minimum number of terms which satisfy a concise set of distance and intersection properties. The selection procedure is intrinsically suitable for machine computation.

It is estimated that the cost of an error-tolerant counter would be about three or four times the cost of a standard counter, including the cost of the circuitry necessary to recover a state. Several different approaches are being taken in an effort to reduce this cost and to explore other characteristics of the error-tolerant

counters. One approach is to use dual function synthesis to derive the Flip-flop input equations. Another approach is to use a minimum distance four-state assignment, and a third method is to investigate the results of using minority logic. This additional work is being supported by The Bureau of Naval Weapons and is under the supervision of Dr. Roy L. Russo.

Automatic Control Center
Purdue University
Lafayette, Indiana

Two major problems of adaptive and self-optimizing control are those of identification and optimization. If a controlled system is partially or completely unknown it is convenient to determine its mathematical input-output characteristics automatically so that with this information the controller can adapt itself to the system. A promising approach involves the use of a delay line synthesizer model of the system. Here the delay line operator relating system output to input is approximated by a linear combination of pure delays. The accuracy of the approximation has been determined for commonly occurring systems and inputs. As a result the magnitude of the delays and number of terms in a linear combination of delays to achieve a given accuracy are known. The problem remains of automatically determining the model so that it describes the system to the desired accuracy. This may be done by fitting the response of the model to a given input to that of the system to the same input. A remarkable property of the delay line synthesizer is that the variation of a coefficient in the delay line operator affects the response of the model primarily in one corresponding time domain only. It is necessary to run through the adjustment of the coefficients a few times only to fit a time response of the model to that of the system. This is analogous to frequency response curve fitting where adjustments affect certain ranges of frequency only. This problem is under study.

When the controlled system is identified an adaptive controller must adjust its characteristics to fit the system. Preferably this should be done to give optimal control. Optimality is thus a problem that must be solved. For a given controlled system, given disturbances, and given constraints on the controller, one must determine the characteristics of the controller to yield optimal response. For the case of a single controlled variable this means that the maximum error in the variable must be minimized, the solution should have a minimum number of oscillations, transient duration should be minimized and other performance indices satisfied. A typical constraint on the controller

is that the rate of change of its output, namely the controlling variable, is bounded. This is often equivalent to the condition that the power available for control is bounded. This saturation limitation always exists in practice. For sudden disturbances and systems likely to occur in practice, and this saturation limitation, a single control function suffices to yield optimal control. The theory has been extended to an arbitrary disturbance where an uncontrollable portion, which the controller cannot follow to keep the system error at zero precisely, is followed by a controllable portion sufficiently long to enable the controller to bring the system error to zero. The control function in this case involves only instantaneous measurements of the state variables, and average values of the disturbance and its rate of change for a properly chosen future time interval. If these values are not known they must be estimated. Errors in the estimations cause the system to be non-optimal, but if they are small the system is sub-optimal. The theory for sudden disturbances on a single controlled variable—single controlling variable system has been extended to the single controlled variable case with two controlling variables. Here a check-decision process is needed for optimal control. This can be readily automated with a digital computer.

Where a disturbance is known in advance, correction can be initiated before the disturbance occurs. For saturation systems, an improvement of as much as 8:1 in the maximum system error is possible if the disturbance is known sufficiently far in advance. If the disturbance is known in advance, but not for a sufficiently long time interval, the improvement is not as great. In fact, up to a point, the optimal control that can be achieved improves as the amount of time the disturbance is known in advance increases.

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The MINOS II Pattern Recognition Facility

Stanford Research Institute
Menlo Park, California 94025

With the addition of a small digital computer, the MINOS II learning machine built in the Applied Physics Laboratory at SRI has evolved into a flexible facility for pattern recognition. The MINOS II facility is able to accept pattern information from a variety of sources, digital, analog, and optical, and to assume various learning-machine structures.

The heart of the facility is the MINOS II learning machine, or adaptive pattern classifier, built under the sponsorship of the U.S. Army Electronics Laboratories. MINOS II belongs to a class of pattern recognition machines utilizing adaptive threshold logic units (TLU's). The central feature of MINOS II is a bank of 66 TLU's, each containing 102 stored adaptive analog weights, or multipliers. The analog weights are stored in a matrix of tape-wound magnetic cores addressed by coincident currents. The weights of each TLU form an adaptive template vector, whose correlations (dot products) with the 102-element pattern vectors are electrically generated on the read-out line of the TLU. During training, the weight vectors are automatically adapted by a complex algorithm built into the machine.

Early in 1965, MINOS II was joined to the SDS 910, a small binary digital computer. The computer communicates with the input buffer which holds the patterns, and reads back the decision information from MINOS II. The computer can also read the 66 analog sums (dot products) through an A/D converter.

The SDS 910 computer was first viewed as a controller and monitor for MINOS II, providing faster operation, immediate diagnosis, on-line analysis of results, and control of preprocessing for selective attention experiments. But it was soon discovered that the combined system opened many new avenues of research. The computer can rearrange the outputs of the TLU's in MINOS II into different decision-functions. In this way, whole new classes of learning-machine structures can be formed and tested. The SDS 910 can also act as a simulated learning-machine, providing valuable direct comparisons of different structures and of hardware vs idealization.

Analog data can be brought to the computer through the same A/D converter used to read the dot products, and preprocessed into pattern format. The flexibility of the new facility also allows input of patterns from two optical preprocessors, a push-button retina, and standard computer peripherals, as well as patterns generated directly in the computer.

Presently under construction is an optical preprocessor for the facility which produces 1024 replications one input images. Each image replica is filtered by a photographic mask, providing 1024 binary decisions which are then logically combined into a 102-element patterns for MINOS II. Input to the preprocessor is provided by a TV camera whose scanning of pictures and scenes can be computer controlled.

The MINOS II facility is being used for pattern-recognition research on a wide variety of subjects, including graphical symbols, analog signal recognition, weather prediction, multimodal mathematical distributions, and automata system studies.

INTRODUCTION

A Clearinghouse for Federal Scientific and Technical Information to serve as the central source for Government research data in the physical sciences and engineering has been established in the U.S. Department of Commerce, and has taken over the document distribution program of the Office of Technical Services.

Development of the Clearinghouse was endorsed in February 1964 by the Federal Council for Science and Technology, an advisory body to the President. The Council specifically calls for the Clearinghouse to serve as the single agency through which unclassified technical reports and translations generated by all Government agencies are uniformly indexed and made available to the public; provide information on Federal research in progress; and operate a

referral service to sources of specialized technical expertise in the Government.

ORGANIZATION

According to Commerce officials, the Clearinghouse has completed its programming and expansion of staff and facilities and is now carrying out these missions. The agency is using computer and other modern data processing and reproduction equipment and techniques in order to speed and increase the flow of technical information to scientists and engineers throughout the country. As a further increase in efficiency, all Clearinghouse personnel and facilities were assembled in a new building in Springfield, Va., near Washington, in October.

The Clearinghouse is a part of the new Institute for Applied Technology in the National Bureau of Standards. The Institute is headed by Dr. Donald A. Schon, formerly of Arthur D. Little, Inc., Cambridge, Mass. The director of the Clearinghouse is Bernard M. Fry, formerly with the National Science Foundation and Atomic Energy Commission.

In addition to providing research information to industry, the Clearinghouse is designed to reduce duplication in both industry and Government in research and information processing. According to Dr. Schon, savings to the Government of about $500,000 will be realized during the first year of operation as a result of reducing duplication of document processing and distribution within the Government.

A major step in this direction was a recent agreement between the Department of Commerce and the Department of Defense whereby the Clearinghouse assumed the task of processing all unclassified/unlimited DoD research reports, as well as reproduction and distribution of these documents to both the public and DoD agencies and contractors.

Hereafter, orders for documents formerly handled by OTS should be addressed to Clearinghouse, U.S. Department of Commerce, Springfield, Va. 22151.

CLEARINGHOUSE TO PARTICIPATE IN NEW FEDERAL TECHNOLOGY "SPIN-OFF" PROGRAM

Getting "spin-off" technology from Federal research into the hands of companies who can use it to expand and improve their business is the object of a new U.S. Department of Commerce program which functions in cooperation with state and local organizations.

The program has been developed by the Institute for Applied Technology, National Bureau of Standards. State universities, commerce and development agencies, and similar organizations are cooperating in the program in a rapidly-growing number of States. The role of these organizations is to serve as distributors of informational materials supplied by IAT and to help IAT determine what type of technology can be used most effectively by firms in their areas.

Typical of the State and local organizations now participating are Associated Industries of Georgia, Tennessee Industrial Research Advisory Service, Pennsylvania Department of Commerce, Connecticut Manufacturers Association, Tennessee Manufacturers Association, Pennsylvania Manufacturers Association, Pennsylvania Smaller Manufacturers Association, Pennsylvania State University, Mellon Institute, Franklin Institute, North Carolina State College, and University of Tennessee.

Informational materials from IAT consist largely of two regular services. One is the "Fast Announcement Service" designed to inform industry promptly of new Government R & D reports determined by National Bureau of Standards scientists and engineers to be of special significance to industry. These reports are classified into 49 industrial subject areas to permit pinpointing the distribution of the announcements.

The other service is a "Package" program for the retrospective presentation of Government R & D. Under this program, searches for relevant reports are conducted through the Government R & D literature over the last 2 years on subjects recommended largely by State development and university-industry groups and trade associations. Each package contains reports, bibliographies, and price lists. A five-page summary, or review of the Package, is published for separate distribution and also as part of the package. Specific subjects are treated such as fire extinguishing materials, hot machining of metals, and grease lubrication.

While the "Fast Announcements" and the five-page Package reviews are being distributed by local organizations in many states, any company can obtain these services directly from the Clearinghouse. There is no charge for the "Fast Announcement Service," and package reviews are sold at 50 cents each.

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The Clearinghouse is the center in the Federal Government for the collection and distribution of unclassified technical reports growing out of the defense, space, atomic energy, and other Federal research programs in the physical sciences and engineering. It is currently collecting over 50,000 documents a year which are available to industry at the cost of reproduction and handling.

These reports are reviewed by IAT and NBS staffs to determine which are of high industrial interest. It is these selected reports which are announced through the "Fast Announcement Service." This new effort is increasing and speeding the flow of Government-generated technology into industry, since the problem industry has faced in the past has been the winnowing out of useful material from the vast stockpile of reports collected by the Clearinghouse, according to the IAT.

The IAT regional dissemination program and the Clearinghouse itself exist because it is the desire of the Government to get Federally-financed research, already paid for with tax dollars, into industrial utilization as rapidly as possible, IAT officials say. Use of this technology in the development of new products and more efficient products or processes benefits the general public and contributes to national economic growth. Reports collected by the Clearinghouse, therefore, are sold to industry at prices covering only the cost of reproduction and handling, and a report that may represent the expenditure of thousands of dollars of Government research may be purchased by industry for as little as a dollar.

The Clearinghouse was established on the framework of the technical information services of the older Office of Technical Services in the Department of Commerce; however, both the missions and the staff and facilities to create the Clearinghouse represent a great expansion of the OTS program.

The position of the Clearinghouse in the physical sciences and engineering is comparable to that of the National Agricultural Library, Department of Agriculture, and the National Library of Medicine, Department of Health, Education, and Welfare.

MODERN EQUIPMENT AND TECHNIQUES SPEED AND ECONOMIZE CLEARINGHOUSE ACTIVITIES

The Clearinghouse has incorporated several innovations into its document handling operations, including mechanized systems, and is planning to take advantage of new technical developments. This streamlining affects all phases of the Clearinghouse system—microprinting, order processing, inventory control, indexing, and publication preparation.

Reproduction

A significant innovation in the Clearinghouse is the use of microfiche—a sheet of microfilm. Microfiche, 4 × 6 inches, are made for all documents received. Clearinghouse microfiche are based on uniform standards (overall size and reduction ratio) agreed to by Federal agencies.

Microfiche has many advantages over standard 35-mm microfilm. A single sheet contains up to 60 document pages with a heading for file purposes. Second sheets (trailers) needed for larger reports contain 72 pages. Fiche are cheaply and easily produced, filed, and retrieved. They require little storage space, nearly 1500 sheets in paper jackets can be accommodated in two 4 × 6-inch file drawers. Hard copy (blowback), at 60 percent of the original copy size, can be easily reproduced. Copies of documents not in printed stock are provided one at a time from microfiche.

Since Clearinghouse fiche adhere to Federal standards, which in turn are based on international standards, they can be used universally on standard reading and reproducing equipment. Duplicate fiche are made on Diazo film equipment so new only one machine is in use on a production basis. (The Clearinghouse machine is Ser. #2.)

The Clearinghouse employs an economical process to stock printed copies of research reports and translations. Five new tandem offset presses installed in the plant are capable of printing both sides of a page simultaneously. The presses, with automatic sorters attached, print and collate in one operation.

Reports selected for full-size printing are first photographed on 35-mm film. This film is run through electrostatic copy enlargers to produce inexpensive, short-run paper mats for the presses. A standard printing run is 50 copies of each document. All pages requiring special handling, such as those containing half-tone photographs, are processed for mats separately on other equipment.

The Clearinghouse microprinting plant expects to produce about 2 million copies of documents, either on microfiche or in reproduction form, in fiscal year 1965.

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Automation

Automated data processing will play a big role in future operations. The Clearinghouse now uses the Univac 1107 computer system of the Defense Documentation Center, Department of Defense, to get some of its document indexes. As programs are developed, the Clearinghouse will be able to search its vast collection of reports automatically to prepare special selective bibliographies and fee literature searches. Before the end of 1965 the scientific and technical community will be able to buy duplicate magnetic computer tapes containing the necessary document retrieval data for do-it-yourself literature searches of new reports received by the Clearinghouse.

Order-Processing

A semi-automated system is now speeding the processing of orders received. As in any large volume operation, the advantages of minimum inventory levels, quick and accurate verification of orders, rapid billing, and complete records on the receipt and sale of each document are easier to achieve with an automated system.

Each incoming order is verified, and then broken down by the individual documents requested. This order extraction process does away with unnecessary delay, permitting the Clearinghouse to send out each part of the order as it is ready. If the report ordered is on the shelf it is mailed to the customer within 24 hours. When reproduction is necessary, it may take up to 5 days.

The inventory control system used by the Clearinghouse makes it possible to record accurately the receipt and sales history of each report. When inventory control detects a consistent demand for a report, not carried in printed stock but provided one copy at a time, a printing order is placed to provide minimum stock for quicker distribution.

Preparing Publications

The preparation of copy for Clearinghouse document announcement journals and catalog cards is partially mechanized. Punched paper tape equipment provides, from one typing, journal camera copy, catalog card camera copy, and punched paper tape for the input of bibliographic information to the computer. This bibliographic record stored in the computer will, in the near future, provide the Clearinghouse with the capability of automated literature searching and other document management information.

The Clearinghouse has made definite plans for using electronic photocomposition equipment to prepare its periodical document announcement publications. The Defense Documentation Center, the Clearinghouse, and the Government Printing Office are now working out arrangements for using Linofilm machines and GPO's Autoset program.

This method involves using the Univac 1107 to sort the announcement journal entries into sequence, create the supplemental indexes, and prepare magnetic tapes to GPO for the photocomposition. In this system, the page format, type style, number of columns, and items per page are determined by the GPO computer from a program tape previously prepared on the 1107. This information is subsequently fed into Linofilm machines, and a plate for each page is produced. Presently such a system can set copy at about 100 characters per minute. The ultimate is 6000 characters per minute. Electronic photocomposition eliminates time-consuming manual preparation of at least three lengthy and frequently issued Government publications.

Microphotography

All documents entering the Clearinghouse collection as of July 15, 1964 are available on microfiche (Fig. 1) as well as full-size reproduction. The International Standards Organization size of 105 mm × 148 mm (approximately 4 × 6 inches) sheets of microfiche will be used. Image size will be generally an 18:1 reduction. If a document contains 57 pages or less, normally only one sheet of microfiche will be necessary. Additional "Trailer sheets" are used for longer reports.

The Clearinghouse microfiche are the same size as those of other Government agencies. Microfiche has the following advantages over microfilm: it's cheaper to produce, faster to make, simpler to file, easier to retrieve, and stores compactly.

U.S. PATENT ANNOUNCEMENTS

The Clearinghouse is expanding its U.S. Patent announcement services in two categories, Government-owned U.S. Patents and U.S. Patents in High-Interest Subject Areas. Both these efforts contribute to an integration of patent information with other Government-sponsored R&D literature in announcement to the public.
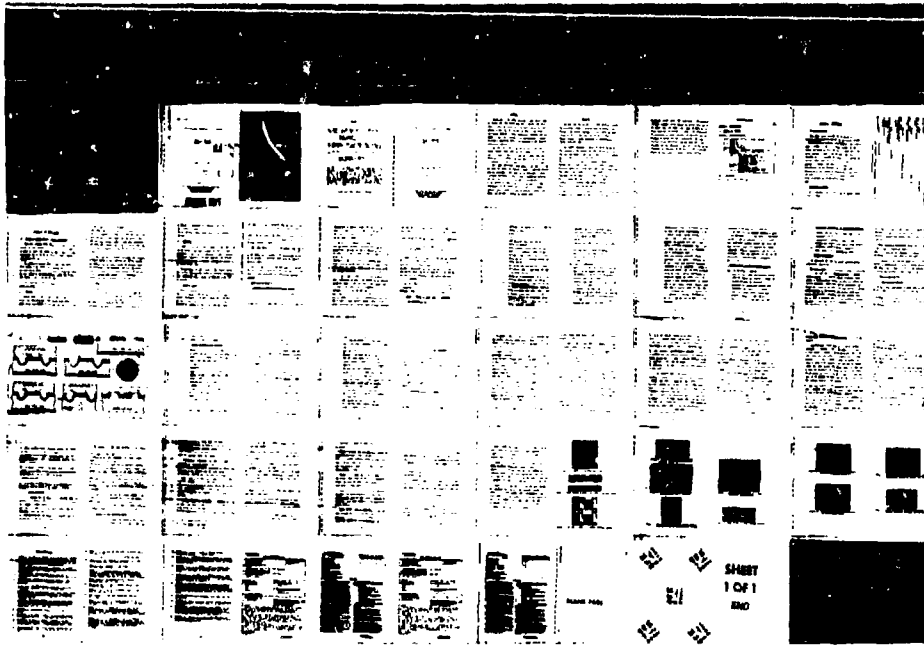
Figure 1 — Typical microfiche

Government-Owned U.S. Patents

Beginning with the January 5, 1965, issue of U.S. Government Research and Development Reports, the Clearinghouse has been announcing abstracts of recently issued Government-owned patents. These patents were previously announced in a semi-annual report called the "Patent Abstract Series," which has been discontinued. The new procedure results in more timely announcement of Government-owned patents as a source of scientific and technical information and as a current awareness source of royalty-free, nonexclusive patents for use by industry and the technical public.

U.S. Patents in High-Interest Subject Areas

The Clearinghouse is implementing a new program involving announcement of all recent U.S. Patents within areas of high industrial interest. The program began with the announcement in U.S. Government Research and Development Reports of all patents allowed in the area of Lubricants. All patents in this area from January 1965 forward will be included. This pilot project will be followed by coverage of other areas of high industrial interest as resources permit. This effort is part of the overall goal of bringing together the announcement of Government scientific and technical

publications in one unified journal for the public.

GOVERNMENT-WIDE INDEX

A comprehensive, unified index to Government research and development reports, resulting from machine merger of input from the major Federal agencies is being issued monthly by the Clearinghouse.

This consolidated index to Government-sponsored technical literature—the Government-Wide Index to Federal Research and Development Reports—will provide scientists, engineers, and research managers with a single source index to new unclassified/unlimited Government technical information.

The Government-Wide Index consists of the standard points of access to report literature—subject, author, source, and report number indexes.

For this project the Clearinghouse is using the computer facilities of the Aerospace Research Applications Center located at the University of Indiana. The Index will be made up from the machinable document records prepared by the Atomic Energy Commission, National Aeronautics and Space Administration, Department of Defense, and the Clearinghouse

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for their own document announcement journals, avoiding duplication of data preparation.

Each of these agencies is now sending ARAC its machine records which ARAC reformats by computer into the index format specified by the Clearinghouse. The magnetic tape produced from this operation contains one record of the input from all contributing agencies.

This information is then sorted into sequence for each of the four indexes. Camera-ready copy for the publication is produced by computer printout. This copy will be proofread and the Index pages made up at the Clearinghouse. The Index will be printed and distributed by the Superintendent of Documents, U.S. Government Printing Office.

Issued about the middle of each month, the Government-Wide Index includes material from the previous month's issues of Nuclear Science Abstracts (AEC), Scientific and Technical Aerospace Reports (NASA), Technical Abstract Bulletin (Defense Documentation Center), and the U.S. Government Research and Development Reports (Clearinghouse).

The first issue of the Index covered technical reports of these agencies from January 1, 1965.

TECHNICAL TRANSLATION AND FOREIGN TECHNOLOGY PROGRAMS

In recognition of the growing importance of foreign research and development to United States science and industry, the Clearinghouse for Federal Scientific and Technical Information has expanded its role as the Government center for the collection and distribution of translated Slavic, Oriental, and other foreign technical literature.

Thousands of complete translations and many more thousands of abstracts of articles and books are prepared each year by Federal agencies for their own use. These items are made available to the Clearinghouse for cataloging, announcement, and sale to the research and industrial community at the cost of reproduction and handling.

The Clearinghouse also catalogs and announces translations available from other sources, both public and private, including commercial translators, publishers, and universities. It has a cooperative working arrangement with the Special Libraries Association Translations Center to announce the availability of increasing numbers of translations from industry and other private organizations. Abroad, the Clearinghouse is cooperating with the European Translations Center at Delft, Netherlands, to announce translations available in Western languages.

If an individual wants to know if a particular foreign work has been translated or is being translated, he can phone, wire, or write the Clearinghouse for the information. In this way extensive duplication of translation effort is prevented.

To announce and index new translations available to the public, as well as list translations in process which will eventually be available, the Clearinghouse in cooperation with SLA, publishes Technical Translations twice a month. This journal, sold by the Superintendent of Documents at $12 per year ($16 foreign mailing), serves as a central source of information in the United States on translated technical material available.

Foreign Currency Translations

The Special Foreign Currency Science Information (P.L. 480) Program is a Government-wide translation activity. Currencies accrued in certain countries from the sale of surplus agricultural commodities are utilized for the preparation of translations of scientific literature for eight Government agencies. The National Science Foundation administers this program, and the Clearinghouse is responsible for the public announcement and dissemination of the translated materials.

At present, the foreign countries participating in the program are Israel, Poland, and Yugoslavia. Eight foreign languages (Russian, Polish, Rumanian, Serbo-Croation, French, German, Arabic, and Hebrew) are translated. The greatest volume is from the Russian.

The agencies participating in the Program do their own initial distribution of P.L. 480 translations, but they are also listed in Technical Translations and sold by the Clearinghouse.

Foreign Technology Program

A new program is under way to make available to industry and the technical community more information on significant foreign technology represented in the Russian, East European, and Communist Chinese literature.

The principal objectives of this new foreign technology program are:

1. To expand the availability of significant foreign technological literature not now translated but judged of interest by U.S. industry and the technical community.

2. Publication of a new abstract series in cooperation with other agencies covering technical papers produced in Eastern Europe, USSR, and Communist China.

3. Establishment of an information activity in the Clearinghouse which will maintain a comprehensive bibliographic record and provide information service on research establishments and laboratories in foreign countries of interest to industry and the technical community.

CURRENT RESEARCH AND DEVELOPMENT IN PROGRESS

Beginning in July 1965 the Clearinghouse for Federal Scientific and Technical Information will take steps to provide information about unclassified Government-sponsored research and development projects currently underway—indicating who is doing what research in the physical sciences, engineering, and related technology—in order to prevent duplication of technical work.

The Science Information Exchange of the Smithsonian Institution is cooperating with the Clearinghouse in this effort. The SIE will furnish the Clearinghouse, on a current basis, a copy of each Notice of Research Project it prepares in the fields of the physical sciences, engineering, and related technology. The Clearinghouse will receive from SIE only NRP's on active grants and contracts. The Clearinghouse will also negotiate directly with other Federal agencies with research and development programs to obtain reports on current development projects not furnished SIE.

This current research information will be cataloged and made available in a monthly announcement journal. The new service will offer listings by project, title, performing organization, principal investigators, term of contract or grant, and descriptive terms for the new research reported. The file created through the input of this research and development in progress information will also be used in general Clearinghouse reference services to answer inquiries in specific areas.

TECHNICAL LITERATURE SEARCHING SERVICE

The Clearinghouse for Federal Scientific and Technical Information has broadened its literature searching services in response to an increasing number of requests by industry and private research organizations for access to Government-held collections of scientific and technical literature. The collections include unclassified research reports on defense, atomic energy, space, and other agency projects, as well as technical translations and information on Government owned patents.

The service is operated by the Clearinghouse in cooperation with the Department of Agriculture, the Department of the Interior, and the Science and Technology Division of the Library of Congress. The program provides a fast and economical method by which a large segment of the public with special, often urgent, needs for research information can tap these four major Government literature resources. It offers "tailor-made" bibliographies suited to the day-to-day as well as long-range information requirements of scientists, engineers, and technical administrators. Steps are underway to make available under this program the literature resources and specialized information services of other Government agencies, as well.

How the Program Works

Subscribers to this service can request that a literature search be made by the Library of Congress, the Department of the Interior, the Department of Agriculture or the Clearinghouse, or any combination thereof. If desired, a literature search can be performed by all four agencies simultaneously.

The Science and Technology Division of the Library of Congress covers the published literature of the vast science and technology collection at the Library. The Clearinghouse, acting as an agent, arranges for searches of the science and technology collections at the Departments of Agriculture and the Interior. In addition, the Clearinghouse searches its own collection of reports derived from Government-sponsored research and development as well as its large holdings of technical translations.

The flexibility of the service accommodates pin-point research on individual subjects or in-depth coverage of broadly related fields. The Clearinghouse collection itself has more than 350,000 documents resulting from many

billions of dollars spent for Government research ($15 billion in 1963). Additionally, the large translation collection is a valuable source of information on foreign research and development activities.

Two Kinds of Services

The Literature Searching Service provides two kinds of bibliographies:

1. "Current Awareness" bibliography for keeping subscribers abreast of new developments in their fields of interest on a periodic basis.

2. Retrospective bibliographic searches listing literature available on a subject at the time a request is made.

How to Subscribe

Search of the document collections of the Clearinghouse, the Library of Congress, and the Departments of Agriculture or the Interior are performed to the extent indicated by an inquirer on the subscription form TS-L-70. Each completed form must include all search requirements.

● For the "current awareness" bibliography service, the subscriber outlines the ge-

neric and specific subject fields in which he is interested. He will then receive references to pertinent materials at intervals prescribed on the subscription form (1 month, 3 months, and so forth).

● Subscribers to the "retrospective" bibliography service state the subject field of interest and receive a list of references currently applicable as of the date of the request.

● The form TS-L-70, "Request for Special Literature Search" can be used as an authorized work order to the Clearinghouse. When the services of the Library of Congress or Departments of Agriculture or the Interior are desired, the request form also served as a work order and the Clearinghouse transmits the request to these sources as an agent for the subscriber.

● Time required for different compilations varies widely. The subscriber may set a limit on the time to be spent on searching for his information. Prescribed limitations can be specified for any or all of the four sources. The fees for this service is $11 per hour with a minimum of 8 hours or $88.

● An advanced deposit may be placed with the Clearinghouse against which the cost of searches may be charged. Government Printing Office deposit accounts are not applicable to this service.

Automatic System for Condensing Ejector Research
U.S. Naval Underwater Ordnance Station
Newport, Rhode Island 02844

Applications of condensing ejectors as torpedo turbine exhaust gas pumps are a continuing research project of NAV UNDERWATER ORDSTA. For deep-running, open-cycle thermal torpedoes, it is necessary to increase the relatively low pressure turbine exhaust gas in order to overcome the high back pressure imposed by increased operational depths. Fundamental, analytical, and theoretical studies to determine the phenomenalogical nature of the two-phase, multicomponent flow in the device are being conducted at a fully instrumented test facility capable of simulating present and future tactical situations.

Experimental confirmation of the theoretically derived analytical flow models demand sophisticated instrumentation systems to fully evaluate the many inter-related two-phase flow parameters. To meet these requirements, a

fully automatic data acquisition and reduction system was conceived, Fig. 1.

Seventy-two channels of information are available in the test control center at an instrumentation patch panel. From this patch panel any channel of information may be displayed on 1 of 50 visual indicators on the test control console. Thirty-eight oscillograph channels are available for graphic recording of test operating conditions and results. The most critical instrumentation data signals are recorded on analog magnetic tape using frequency modulation techniques.

This system is most heavily relied upon because of its versatility and high data sampling rate. The data gathered in this manner is then available for direct automatic reduction to finished tabulations of calculated performance parameters in tabular and graphic form.
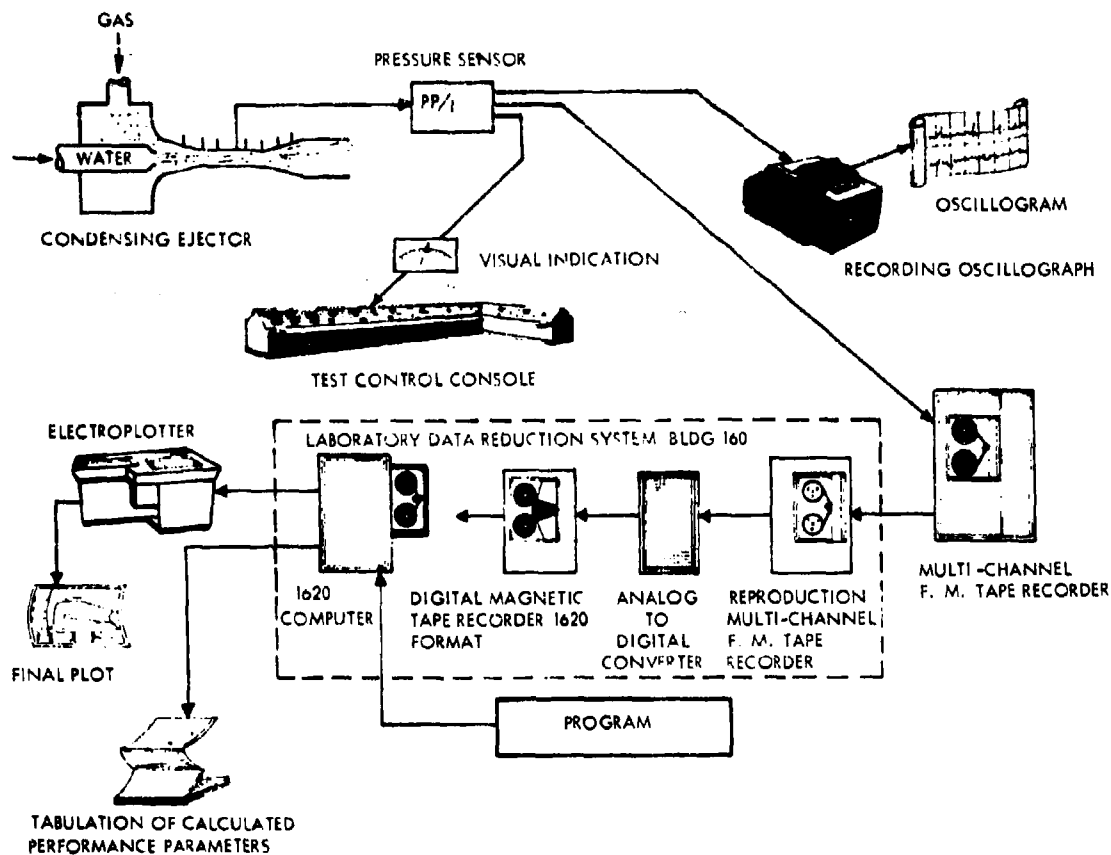
Figure 1—Condensing ejector data acquisition and reduction

Up to 12 test facility data channels can be recorded simultaneously on the analog tape along with a voice channel and a data information time channel. Samples of the data channels are taken sequentially each 100 microseconds on an analog to digital convertor for multiplexing into a common output. The voice channel is utilized for relating pertinent test information required for proper digitizing. After being digitized, the data is stored in the A-D System's co. which has a 4096 position capacity. After a predetermined number of digits have been gathered, a data dump is initiated and the digits written upon the digital output tape in a computer compatible format.

The NAV UNDERWATER ORDSTA analog to digital converter can handle sampling rates of 5000 or 10,000 samples per second, depending on the density selected for the output digital tape. The multiplexer operates on a major scan where it samples from 4 to 12 channels,

12 times each. The resulting maximum sample output would be a 12 × 12 matrix. A logic section determines the samples to be entered on to tape by choosing a position on a selection switch which allows the choice of 1, 2, 3, 4, 6, or 12 equally time-separated samples per major scan.

A computer program has been written for reduction of the digitized data. Calibrations for each of the data channels are forwarded from the test site to the computing facility for use as input data for the particular runs involved. The test values consisting of temperatures, pressures, and flows are obtained directly from the input digital tape by the program's applying the appropriate calibration factors. The program then makes use of selected regions of the steam tables incorporated into it to assist in determining the thermodynamic properties of the primary gas steam. Simultaneous iterative solutions of the momentum, energy, and continuity equations are also obtained by the use of two-phase-flow-correlation techniques.

The computer output furnishes the test engineer with computed ejector performance parameters as well as the original 12 temperatures, pressures, and flows describing the tests conducted. The data are obtained in a format directly compatible with a digital plotter to produce graphical records of the recorded data. The output data as presented are grouped for direct comparison of related variables and can be used as input for further determinations and correlations. Data to be permanently retained are stored on magnetic tape.

This automatic data acquisition and reduction system has greatly accelerated the condensing ejector test effort. Increased data sampling has allowed testing of more geometrical condensing ejector configurations over a larger range of operating conditions than has heretofore been possible. Direct access to the computer has reduced the time between the actual test and critical analysis and review of the test data from days to a few hours. This has been accomplished while performing computational analyses of an increasingly complex nature.