DIGITAL COMPUTER NEWSLETTER

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

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EDITORIAL

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

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

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

CIRCULATION

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

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

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

All communications pertaining to the Newsletter should be addressed to:

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Computers and Data Processors, North America

Burroughs B2500 and B3500

Burroughs Corporation
Detroit, Michigan 48232

During March 1966 the Burroughs Corporation announced two new series of advanced electronic computer systems in the low to medium price range. These are the B2500 and B3500 data processing systems – the newest members of the Burroughs 500 Systems (see DCN's April 1964 and January 1965), a family of advanced computers being expanded to cover more completely all levels of business, industry, and government activities. Other members of the 500 Systems are the B5500, currently installed in a large number of varied applications, and the B8500. Advanced in technology and performance, these new systems are designed for financial, business, governmental, and scientific data processing. They are multiprocessing systems, capable of handling a number of unrelated problems at the same time.

These computers are equipped with an automatic operating system called the Master Control Program (MCP) and can be used for on-line, real-time, and time-sharing operations. These include inventory and distribution systems, on-line bank systems, and management information systems. Such systems typically employ data communications between a central office and remote areas of activity.

The B2500 and B3500 central processors use newly-developed monolithic integrated circuits, groupings of tiny solid-state devices about the size of a pin head. The circuits can perform basic functions in billionths of a second, while operating at nearly the speed of light. Each circuit can contain the equivalent of dozens of transistors and resistors in varying combinations. The new circuitry, which has permitted engineers to develop faster, more sophisticated, more reliable logic systems at lower costs, was developed jointly by Burroughs Corporation and Fairchild Semiconductor, a division of Fairchild Camera and Instrument Corporation. The new computers are "modular" and "compatible," meaning that as workloads change, users can expand or upgrade their systems without reprograming.

Typical lease prices will range from $4,195 per month for a small B2500 tape system to $20,720 per month for a large B3500 random access system. The range in sale price for these typical systems is from $208,000 to $1,032,000. First deliveries of B2500 systems are scheduled for January 1967. Deliveries of B3500 systems will begin in May 1967.

The design philosophy of these systems is unique. Hardware and software were designed in parallel. This marked a distinct break from the industry's traditional pattern of first building a machine and then forming software to fit it, a process involving considerable compromise. Instead, the Burroughs parallel design concept has resulted in hardware that contains all the logic necessary to allow software to be written and used in the most efficient manner. Conversely, the software makes fullest possible use of all hardware capabilities.

The Master Control Program (MCP) is a comprehensive operating program housed on disk file requiring only 10,000 bytes of resident core memory. The MCP provides for simultaneous input/output and compute operations, multiprocessing (concurrent processing of multiple unrelated programs), and time-sharing (acceptance and processing of programs introduced randomly by multiple users through local or remote input devices). The MCP constantly makes maximum use of system components by controlling the sequence of processing, initiating all input/output operations, and providing automatic handling procedures. Users of small configurations may use an optional subset of the MCP known as the Basic Control Program (BCP). The BCP controls all input/output operations, and allows these operations to be performed simultaneously with computation; however, the operator controls scheduling in a serial manner.

Programing languages include COBOL, FORTRAN, and two assembler languages.

COBOL (COmmon Business Oriented Language) was developed in 1960 and has become a

standard language for expressing data processing problems for general business and financial applications.

FORTRAN (FORmula TRANslation) allows problems to be written in a formula notation similar to algebra. Problems with very large sets of formulae using many variables can be dealt with easily, and variable subscripting is allowed.

A COBOL or FORTRAN program written for a B2500 or B3500 will run on any other MCP-equipped B2500 or B3500. Programmers need not be concerned with the internal workings of the machine, nor do they need any knowledge of machine-language programing. COBOL and FORTRAN programs are written, tested, and amended using a standardized, problem-oriented format. The relative simplicity of these languages speeds programing, and their standardization provides excellent documentation. Documentation is a method of "read-mapping" the elements of a program. This makes it practicable for one programmer to understand and work with programs prepared by another.

Two assembler languages, more closely related to machine language, are also available for optional use. An Advanced Assembler can be used for producing programs to be run under control of the MCP; a Basic Assembler is available for programs to be run serially under control of the BCP. Burroughs assembler languages include a number of macro-instructions which minimize the writing of standard operations. With the help of these macro-instructions at assembly time, and MCP or BCP at run time, the programmer doesn't have to consider the detailed problems of input/output and error conditions. He is, however, still allowed the flexibility inherent in assemblers – e.g., instruction modification, indexing, incrementation, and character or bit manipulation.

The Processor contains the arithmetic units and logic controls of the system.

Fixed point arithmetic is standard. Floating point arithmetic is optional.

Core Memory is available in modules to suit the user's immediate requirements. Basic core memory can be expanded on-site with plug-in modules of 10K, 30K, 60K, or 90K bytes each.

Address Memory is an integrated-circuit "scratch pad" memory unit which replaces conventional "hard registers." It is a physical part of the processor, but it is used both by the processor and peripheral control units during program execution. Size is variable from 24 to 120 words. Cycle time is 100 nanoseconds. Two words of Address Memory are reserved for each input/output channel.

Address Memory stores command information. This means that during program execution, core memory accesses are made only to read or write data; no accesses are required for information relative to addressing. This reduces the number of core accesses required and results in a marked increase in processing speed.

Read Only Memory is a 100-nanosecond resistive type memory device which, like Address Memory, replaces conventional "hard" logic. Read Only Memory contains interpretive routines called micro-programs.

Micro-programs are triggered automatically by the operation codes of the program instructions as they are fetched from core memory. This allows the same circuits to be shared by many separate operations without duplication. This technique permits a more powerful command structure at less cost to the user. Additional Read Only Memory modules may be plugged into the computer to provide for emulation of other systems.

Central Control is a hardware function within the processor which handles requests for core memory accesses coming from peripheral units and the processor. Central Control grants access on a priority basis: generally, the faster peripheral units such as tapes and disk first, the processor last. In case of a simultaneous request from the processor and a peripheral unit, Central Control lets the input/output operation get under way. The processor may then access core memory many times before the input/output operation requires further access.

The Input/Output System consists of peripheral control units and their related input/output channels which operate independently of the processor.

	Basic Core	Max Core	Cycle Time (2 Bytes)	Effective Cycle Time Per Byte
B2500	10K bytes	60K bytes	2 μs	1 μs
B3500	10K bytes	500K bytes	1 μs	500 ns

The processor issues a command to the I/O system, and then proceeds independently until I/O system completes the operation and interrupts the processor. Input/Output operations are independent and any or all I/O channels may operate simultaneously. The I/O system and the processor time-share core memory and address memory under control of the Central Control unit.

A single I/O channel and peripheral control unit may serve a group of peripheral units of the same type. For example, up to ten magnetic tape units may use the same I/O channel and peripheral control unit. Or, multiple channels may be used, in which case they will "float" between peripherals of the same type. Since I/O channels are completely independent, simultaneous input/output operations are normal. Punched cards may be read from two or more units simultaneously, for instance, while one magnetic tape is being read, a second is being written upon and records are being output on a high speed line printer. Up to 20 such operations can be conducted simultaneously.

Since I/O operations, especially in business or financial applications, account for a major portion of system time, the degree of simultaneity provided by the B2500 and B3500 results in a significantly greater production speed than that available in similarly priced competitive systems.

Data may be represented in the processor as four-bit digits, eight-bit alphanumeric characters, or words of 16 consecutive bits. Operands in four-bits representation may be automatically combined in a single program step with others in eight-bit notation without prior transformation. Results may be automatically obtained in either of the two formats. This results in additional savings in program steps and execution time.

The processor's internal code in EBCDIC (Extended Binary Coded Decimal Interchange Code), an eight-bit alphanumeric code. Because many data communications devices transmit in ASCII (American Standard Code for Information Interchange), the processor executes this code directly and without translation. Mode is selected by a program-controlled mode switch.

Instructions are represented as four-bit digits. Instructions are of two basic types: processor instructions and I/O instructions called "descriptors."

Processor instructions are variable in length from one to four syllables. That is, an instruction may contain no address, one address, two addresses, or three addresses. Each syllable contains 24 bits or six digits.

The first two four-bit digits of an instruction are interpreted to be the operation code. The operation code triggers access to the proper string of micro-programs stored in read-only memory. The micro-programs will then fetch the balance of the instruction and perform the required operation.

All address syllables have the same format which represents the base relative address in core memory and designates the index register by which the address is to be increased or decreased.

There are three index registers available to each program within the processor, regardless of how many programs may be in the mix at any time.

The two bits of the high-order digit of an address syllable are called the "address controller." The address controller tells the system whether the data addressed is numeric or alpha data. The address controller may also specify that the contents of the field pointed to be the address is not data at all, but is another address where the data may be found. This technique is known as Indirect Addressing and may be used to any depth.

Indirect addressing may be used with any combination of index registers. For example, consider the common function of table look-ups. A value within a table must be located, and once found it must be referenced by several instructions. Once the value is located, the address of that value may be stored in one location and all other instructions can reference that value through the indirect addressing technique with no address modification necessary.

All addresses in B2500 and B3500 programs are base relative to the beginning of memory. This means that each program is written assuming a starting point as the first cell of memory. During execution of the program, each address is automatically raised by a base register at no cost in execution time. The combination of the base register and the relative address creates a machine absolute location. This hardware capability allows the MCP to assign a program to any area of core memory

which is large enough for that program, and subsequently to relocate the program, if necessary, by changing the base register. The user will not be aware that programs have been relocated, nor need he be concerned in any way.

Memory Protection is a problem that must be solved before a system can multiprocess a random mix of programs. There must be absolute protection against accidentally writing one program over another. The Master Control Program (MCP) for the B2500 and B3500 sets up a positive memory control operation automatically.

As the MCP initiates a program, it sets the base register according to the memory location used, and at the same time sets a limit register to the maximum bounds of the program. In other words, the limit register setting is equal to the base register setting plus total memory requirements for the program which is to be processed.

As data is about to be fetched during the program run, its address is automatically checked against both base and limit register settings. This is done at no cost in execution time. If an address should be generated that is below the base register setting or above the limit register setting, the program is immediately interrupted, the contents of the memory located addressed are left unchanged, and control is transferred to the MCP. The MCP will remove the Program from processing and inform the operator of the address error and its location.

Input/Output Instructions are initiated by sending core addresses to the two words of Address Memory associated with the I/O channel concerned, and by sending control information to the peripheral control unit attached to the respective channel. The peripheral control unit then executes the operation independently from the processor, except that it time-shares the address memory and core memory subsystem with the processor and with other peripheral control units.

After initiating an input or output instruction, the processor immediately proceeds to execute the next instruction in sequence.

As soon as a peripheral control has completed its operation, it will send a "result descriptor" to the processor and set an interrupt bit within the processor. This signals the processor to take whatever action is indicated by virtue of the I/O operation being complete. The peripheral control unit is then ready to accept the next input or output instruction.

The term **INTERRUPT** is used in a special sense within the B2500 and B3500, just as it is in the other Burroughs 500 Systems – the B5500 and B6500. It does not mean that work is actually interrupted or the system held up in any way, rather, a transfer of control takes place from the object program to the MCP or BCP. This permits the Control Program to initiate certain types of operations, or automatically handle errors which, with conventional systems, would either require special programming or result in a time loss through operator intervention.

The MCP-interrupt system also furnishes a means for continuous automatic recognition of exception conditions which otherwise would have to be checked programatically at intervals, again at some cost in processing time.

There are two Operational States within the B2500 and B3500 processor: the Control State when control programs (MCP or BCP) are being executed, and the Normal State when user programs are being executed.

Within the Control State are several privileged instructions which cannot be acted upon when the processor is in Normal State. These privileged instructions permit the MCP or BCP to regulate the system; for example, to initiate I/O operations, and to control the program mix by setting and clearing registers.

When operating in the Normal State the system executes arithmetic, transfers and edits data, and performs comparisons and control transfers.

In addition there are two special instructions which permit efficient Subroutine Processing. It is often necessary to execute a given routine in several different places within a program. Within B2500 and B3500 processors, special instructions called ENTER and EXIT make this function automatic. The programmer needs to write the routine only once. From that point, whenever the routine is needed again the programmer can use the ENTER and EXIT instructions which will automatically pass the necessary parameters to the routine and cause the processor to branch to and execute the routine and then return to the main program in sequence.

A number of Peripheral Units are available to adapt B2500 and B3500 systems to almost

any computational or data processing requirements:

Operator Console: Communications between the operator and the system are made possible by the system console. The console contains Nixie© tube and light displays which inform the operator of the contents of the various registers and the settings of the logical indicators. A set of operating keys used in conjunction with the numeric keyboard allows the operator to read or alter internal memory or system control functions in any manner he desires.

Next to, and considered a part of, the console is the supervisory printer. This is an input or output device which allows direct communication between the system and the operator under program control. For systems using the Master Control Program, the supervisory printer will be the device used for all normal system communications by the operator.

Systems Memory: The systems memory is a single magnetic disk device capable of storing up to two million characters of information. Two units may be used on a system. Information may be retained indefinitely without regeneration. The primary use of systems memory is to house the system software and the user program library; in addition it may be used for any type of working data or general storage. Access time ranges from a theoretical minimum of zero to a maximum of 34 milliseconds, the time required for a full revolution by the disk. Average access time is 17 milliseconds.

Disk File: Bulk disk-file storage is available in modules of 10 million 8-bit characters, expandable to a maximum of 2.5 billion characters. This disk file features one-head-per-track constructions, giving an average access time of 20 milliseconds and a maximum transfer rate of 245 thousand characters per second.

Magnetic Tape: Considerable flexiblity is offered in the area of magnetic tape handling devices. The number of units available on a given system is limited only by the number of I/O channels used. Each I/O channel can handle up to 10 magnetic tape units. The user may choose seven-channel BCL tape or nine-channel EBCDIC tape, and may intermix these if desired. The user may also select any packing density desired up to 1600 bits per inch and may select transfer rates from 36 to 144 thousand characters per second.

The user may choose a standard free standing device which houses one magnetic tape unit within one cabinet, or a new cluster device which provides two to four tape units in a single compact cabinet. The magnetic tape units are capable of reading and spacing in either forward or reverse directions.

Card Readers: Punched card readers are available with speeds of 200 to 1400 cpm. These readers will accept 51, 60, 66, or 80 column cards. Cards punched in binary, BCL, or EBCDIC are read directly; automatic BCL code translation into EBCDIC is provided, if needed. The number of card readers on a given system is limited only by the number of I/O channels available. The readers feature photo electric reading, with character validity and read checking performed according to the character set of the code being read.

Printers: The user may choose from four line printers with speeds ranging up to 1040 lpm. All printers may have either 120 or 132 print positions per line. All have vertical skipping and end-of-page formatting controlled by a punched paper tape. They feature drum printing units containing a complete character set. Special purpose character sets are also available. Again, the number and combinations of printers is limited only by I/O channels available.

For financial applications, models are available for printing 6, 12, or 18 paper listing tapes. Two printers with a total of 36 tapes may be attached to a single B2500 or B3500

Card Punches: Card punches are rated at either 100 or 300 cpm. They will accept standard code or binary output program control. The 300 cpm model features programatic stacker select capabilities.

MICR Sorter Readers: Sorter readers are available for reading and sorting documents encoded with magnetic ink at speeds up to 1565 items per minute. One or two sorters may be used with a system. They are available with 13 or 16 pockets each.

Paper Tape Readers and Punches: Tape readers are rated at 1000 characters per second. Readers accommodate 5-, 6-, 7-, or 8-channel tape as selected by the operator. Tape widths of 11/16, 7/8, or 1 inch are interchangeable. Punches will operate in standard paper tape format in BCL code at 110 characters per second.

The number of readers and punches which can be operated with a system is controlled by the number of I/O channels available.

Data Communications Equipment: The following remote devices may be used to communicate with the B2500 or B3500:

* other B2500 or B3500 systems via dialed or leased lines,
* typewriter inquiry stations,
* Teletypewriter Model 33 or 35 via leased lines or TWX service,
* IBM 1050, UNIVAC 1004, and Digitronics D507 and D509 paper tape transmission devices, via dialed or leased lines,
* Burroughs B606 or other externally buffered data communication terminal units capable of servicing large on-line bank networks.

Additional Software: Every commercial data processing operation has a repetitive need for the sequencing of files (sorting) and the creation of tabulated reports. The B2500 and B3500 software package includes generators to handle both of these requirements with a minimum of specification coding required of the user.

Basic Sort Generator: This program is designed to generate efficient sorting programs suitable for use on smaller configurations of the new systems. The generator accepts parametric input and produces from it a sort program in Basic Assembler language with comments.

Advanced Sort Generator: This program is to be used with MCP-equipped systems. User supplied input is accepted, and from this a sort program in Advanced Assembler language is produced.

Basic Report Generator: This is a magnetic tape based program which accepts problem-oriented specifications and produces an object program for providing the requested reports. Output is provided in Basic Assembler language. The Basic Report Generator will produce an efficient object program in less than 5 minutes.

Advanced Report Generator: This program accepts problem-oriented specifications and provides as output an object program in advanced assembler language. It will generate a symbolic program in less than 10 minutes.

Conversion: Burroughs has solved the reprograming problem and greatly minimized the considerations of operator and programmer retraining and file conversion for present users of IBM 1400 Series and Burroughs B200/300 Series computers who convert to the new B2500 or B3500 systems. They will find that most programs written for the IBM 1400 Series or for the B200/300 Series can be run directly on the new systems in less time. And while users will want to rewrite major programs in order to make most efficient use of the new computers, rewriting can be undertaken on a scheduled, rather than "crash," basis.

Burroughs provides this program compatibility between the older systems and the B2500 and B3500 by a technique known as EMULATION. Emulation is a combined hardware-software approach to simulation. It is far more efficient than conventional methods of simulation which rely on programing alone to provide compatibility.

The B2500 and B3500 processors contain an extremely fast, resistive type storage unit known as Read Only Memory (see page 3). Conventional computers use transistor logic to interpret instructions prior to execution. In the B2500 and B3500, much of this conventional "hard" logic is replaced by hardware level micro-programs. In addition to the standard bank of Read Only Memory, additional banks may be added in which special interpretive routines are stored for translating IBM 1400 Series and B200/300 Series operation codes into duplicate operation codes for the B2500 and B3500. In brief, the emulator produces results identical to those produced on the older systems.

The hardware capability of Read Only Memory is complemented by a relatively simple set of software subroutines. These subroutines will simulate the input/output operations of the IBM 1400 Series and B200/300 Series while still making use of the advanced hardware capabilities of the B2500 and B3500.

Computing Centers

IBM 360/50 for Computing Laboratory

Brown University
Providence, Rhode Island 02912

A new IBM System 360 Model 50 computer has been put into operation at the Brown University Computing Laboratory. At present, there is only one other comparable IBM 360 computer in New England, at the Massachusetts Institute of Technology's Lincoln Laboratory.

The new computer has been rented from IBM for $20,000 a month, with the help of a $500,000 grant from the National Science Foundation. The machine has replaced an IBM Model 7070, which had been in operation since the computing laboratory was opened in 1960. According to Dr. Walter Freiberger, professor of applied mathematics and director of the computing laboratory, the new computer will have an immediate and substantial effect on teaching and research at the university. It will enable a group of physicists studying high-energy atomic particles, for example, to analyze their experimental data at Brown, eliminating the need to travel to Boston or New York.

To make it easier for the physicists and others to use the computer, Dr. Freiberger and his associates are working on a plan to install remote consoles, linked to the computer by telephone lines, in various departments around the campus.

While physicists, mathematicians and engineers traditionally have been the heaviest users of computer time at Brown and elsewhere, Prof. Freiberger expects exciting advances in computer application to be made in the biological and social sciences. For example, the simulation of biological control processes on computers is being studied by investigators in the Division of Biological and Medical Sciences, while psychologists are expected to use the computer extensively to analyze experiments on learning.

The new computer has one other feature that is expected to benefit local business and industry. Unlike earlier machines, which were designed primarily for scientific use, the 360/50 is designed for both scientific and commercial use. Local firms may arrange with the computing laboratory to lease time on the machine and to obtain the services of the professional staff.

Prof. Walter Freiberger, director of the Brown University Computing Laboratory, and his associates have not wasted any time in puting the computer to work. With the support of an $80,000 grant from the International Business Machines Corporation, they are studying ways to make the computer more useful to teachers and businessmen.

In one project, they are seeking to develop ways of using visual displays as input and output media for pictorial material, with the hope that these displays can be used effectively in teaching. In the other, they are attempting to devise mathematical models to help banking and insurance executives make management decisions.

The research on visual displays is being conducted by Andries van Dam, assistant professor of applied mathematics; W. Murray Wonham, associated professor of applied mathematics, and engineering, and Prof. Freiberger. They hope to devise systems to enable the computer to handle data in the form of graphs, geometrical figures and diagrams.

Although humans receive about 80 percent of their sensory data from visual stimulii, the development of visual displays for computers has lagged behind other aspects of computer science, according to Prof. van Dam. Even though visual displays are used extensively in military and space work, they have yet to fulfill their potential as teaching aids.

The equipment being used in the project consists of a cathode ray display tube and a "light pencil," which are being loaned by IBM. Data are put into the computer by "drawing" on the tube with the light pencil. The computer

translates the visual input into its own numerical language, solves the problem, and presents the answer as a visual display.

The task of Prof. van Dam and his students is to design programming systems that will enable the computer to understand the pictorial input and to devise ways of using such a system in teaching. Members of the Division of Engineering are interested in applying such display systems in their courses in teaching such things as circuit theory.

The second study is one in operations analysis, an attempt to bring the methods of modern mathematics to bear on problems of individual and organizational behavior. Although banks, insurance companies, and other large businesses use computers for data processing and routine clerical work, relatively little research has been done by such institutions on the use of computers in decision making.

Associated with Prof. Freiberger in this project are Prof. Martin J. Beckman of the Brown economics department and Prof. Ulf Grenander of the University of Stockholm, who will join the Division of Applied Mathematics as a visiting professor during the next academic year to take part in this and other research projects.

Prof. Grenander, whose Institute of Insurance Mathematics and Mathematical Statistics in Stockholm pioneered modern insurance mathematics, believes problems in banking are ripe for attack by such techniques, which have proved useful in other areas.

IBM 360/67 for Computing Center

Cornell University
Ithaca, New York 14850

Cornell University expects that a number of its scholars, administrators, and students will be able, somewhere around October 1967, to ask questions of a $3 million, IBM central computer a mile or more away and get immediate answers, all while in their own offices or laboratories.

Right now, to get Cornell's central computer working on their problems, these same people have to wait while the problem is taken to the computer in Rand Hall and is assigned a place in a long line. Depending on the question's priority and complexity, getting an answer may take a few hours or overnight.

Reporting to the University's faculty and staff on plans to have a new International Business Machines Corporation System 360, Model 67 (360/67) data processing system installed on campus in the fall of 1967, Franklin A. Long, vice president for research and advanced studies, had this to say:

"This facility is technically a time-sharing, multiple access computer. It will permit simultaneous use by a number of individuals (perhaps 40 or more), some of whom may be located remotely from the central unit."

These capabilities would be in addition to the usual method of computer operation in which a person with a problem takes it to the computer, wherever it is, and awaits his turn.

During school sessions, for example, Cornell's present main computer is in virtually 24-hour operation. At peak periods, students must often wait for up to a day before their problems are processed by the computer and answers returned to them.

Because of its much greater capabilities, the new computer is expected to help alleviate this situation and relieve many other bottlenecks. In fact, Long continued, "It should handle the large majority of Cornell's administrative computations, the computing linked to instructional programs, and computation for research" – a triple-threat installation.

Because of the new computer's capabilities, and its potential range of application, the vice president thinks the impact of the new computer on the academic community will be even greater than the introduction of Cornell's first computer in 1953, or any of its successors.

He noted that, "It will certainly permit us to develop new applications of electronic computers and new ideas in teaching and in data processing for other university needs."

As for capabilities, they line up this way:

* It will do more work in 1 minute than Cornell's first computer could do in a year of round-the-clock operation. It will be such a powerful computing tool it is expected to replace

not only the central computer but most of the six others now in operation on the main Cornell campus.

* It will be eight times as fast as Cornell's present central computer and have a potential "memory" capacity of more than 5.5 million (CQ) "bits" of information – something like the fact content of 5,500 bulky textbooks.

* The computer will have access to any of the 500,000 "bits" of information which can be stored in its main "memory" in 750 billionths of a second. In less than half a second, it can pull out any one of more than five billion "bits" which can be put into its auxiliary memory.

* As for arithmetic, the computer will perform nearly 1 million operations in a second.

But there are also "time-sharing" and "multiple access" to consider, computer capabilities which might permit roughly the following situation in real life:

A professor in his own office finds he needs computer help on some problem. He turns to a typewriter-like machine which is linked to the central computer by means of an ordinary leased telephone line.

By typing briefly on the machine his question is flashed immediately to the computer.

It may already be working on a number of other separate problems, but it takes the new one in stride through time-sharing. The computer performs a few thousand computations on the professor's question, a few thousand on each of the others, and keeps doing this in round-robin fashion until all of them are solved.

This takes so little time, however, the original professor has the illusion that the computer was working on his problem alone. His answer comes back to him in perhaps a couple of seconds. His answer would probably come to him in printed form.

Other such users might have different needs and only require, from time to time, that computer-stored information be displayed in their offices on television-like viewing devices. This type of "terminal" would differ from that of the hypothetical professor's.

With all this in mind, it is possible to envision a broad range of usefulness for the new computer. For instance, the following two examples are drawn from a report on the new computer compiled by a committee headed by Richard W. Conway, Cornell professor of computer science and industrial engineering:

* "The processing of all of the inquiries, charges, discharges, overdue and reserve (book) notifications for all the on-campus University Libraries." The committee said this "would take...(only) a few minutes of computer time each day" – spread through the day in fractions-of-a-second periods as needed.

(Library officials estimate that, on the average, there are more than 6200 recorded transactions – overdue notices; recall notes which ask return of books on loan; book loans, and book returns – on each of the some 360 days a year the Cornell on-campus library system is open. Demand is much higher than this average at times and no one knows how many hundreds of daily "inquiries" are made but not recorded.)

* Or, take another administrative problem. Thousands of student records are now maintained in essentially duplicate files in several different offices on campus. Each office has need for continuous, immediate access to the information these files contain.

If all these data were fed into the new computer's capacious memory, and each office needing it had immediate access to it through its own "terminal" connection, the situation would be revolutionary.

The committee thinks this could help eliminate the need for "duplicate" files. Such a file is not really needed in itself if equivalent access to the information it contains is provided. And files are not only great time consumers to maintain, but take up much valuable space.

A number of universities are planning such systems, authorities on computers say. But it is possible that Cornell's plans for using its new system in every relevant phase of its operations are perhaps the broadest so far.

In any case, the committee says of the past fantastic growth of computer use at Cornell, and the tremendous capability of the planned new IBM computer system:

"Whether the result (of its installation) will be simply continued expansion of computer usage or a revolutionary change in the nature of computer usage remains to be seen, but Cornell will be in the forefront of the determination."

Whether Cornell will purchase or lease the new computer is not yet settled. If purchase is

decided on, University officials say, IBM has indicated it will discount the estimated $3 million cost substantially because of the educational use of the equipment.

Equipment in the new system will include a Model 67 processor, two core storage units, one 2301 drum, one 2314 disk drive, one 2321 data cell, six 2402 magnetic tape units, three 1403 printers, and two 2540 card read/punch units.

Data Processing

Pacific Missile Range
Point Mugu, California 93041

REAL TIME QUALITY REPORTING

A simple procedure has been developed at the Pacific Missile Range for real time quality reporting. It has been in use on a production basis since May 1965. This procedure utilizes the computer to perform the quality assurance analysis at the same time the data is being reduced. The results from the reduction and quality evaluation are not only listed in tabular form, but graphs or "computer pictures" of the results are also given. These computer prepared "pictures" of data and data quality characteristics are output by using the SC-4020 (cathode ray) plotter. These outputs can be put on reproducible paper or on microfilm. Points, symbols, lines, curves, grids, scales, and legends are all prepared by the SC-4020 according to instructions by the IBM 7094 computer.

RANGE SAFETY FROM MISSILE GUIDANCE INFORMATION

The Pacific Missile Range (PMR) has developed instrumentation and an appropriate computer program to utilize missile guidance data for the computation of Instantaneous Impact Prediction (IIP). Equipment has been designed which receives the telemetered velocity information from the missile via pulse coded modulation, converts to binary format and inputs to the computer once each data cycle. After appropriate guidance equation corrections and coordinate transformation, the velocity data are integrated for position and the IIP is computed. This system has the advantage of detecting almost instantaneously any deviation of a missile from its intended heading. Where terminal range safety is a critical problem, this use of missile guidance information is a valuable adjunct to the usual range safety instrumentation.

LASER RADAR APPLICATION

The Pacific Missile Range has initiated a data processing technique for interpreting the signal output of the PMR Laser radar (LIDAR).

The LIDAR is used to obtain information about the atmosphere by utilizing the backscattered reflections from a transmitted laser burst. The return signal, appearing as a voltage deflection on a "fast-writing" oscilloscope, is preserved or photographed with the use of a polaroid camera attachment.

To facilitate analysis of this photographic record, a system has been established to graph the signal intensity versus range data on log-log coordinates. This is accomplished by first carefully retracing with the televiewer, the entire voltage trace thus obtaining a digital coordinate of time and range for each incremental voltage spike. The data cards are then tabulated and placed in a form for easy manual plotting. The next logical step is to develop a computer program to automate the plotting.

Results so far indicate this method to be quite successful and a continuing need for these services is anticipated.

UNDERWATER RANGE

The Pacific Missile Range has been assigned the task of designing, procuring, and implementing a Navy underwater tactical range to be located in the mid-Pacific.

Requirements are to track, record, and display up to 29 targets of which certain selected targets will be displayed in real time. The 29 targets will be comprised of underwater targets, surface craft, aircraft, sonobuoys, and a high speed air-phased weapon system.

Subsurface tracking will be accomplished with sensors operating on sonic principles. Surface and in-air tracking will be accomplished with a multiple target track-while-scan radar as well as with precision instrumentation radars.

Tracking computations will be accomplished on several high-speed digital computers. Technical assistance on the underwater tracking instrumentation is being provided by the Naval Underwater Ordnance Station of Newport, Rhode Island. The Federal Laboratories of the International Telephone and Telegraph Corporation, Nutley, New Jersey is under contract to implement the underwater tracking instrumentation. Completion is scheduled for 1 January 1967.

COMPUTER PROGRAMS FOR STATISTICAL ANALYSIS

The Pacific Missile Range has developed computer programming specifications for the analysis of stochastic processes (i.e., time series). Based on the work of Tukey, et al., the spectral density function corresponding to a stochastic process is used in the analysis of ocean wave profile data, and also employed in the analysis of the frequency content of errors. The analysis of the spectral density breaks a time series function into its frequency components, and estimates significant periods which are hidden in the data.

The computation of the spectral density function is based on approximating the Fourier transform of the estimator of the autocovariance or the autocorrelation function. Completion details are necessarily omitted here but it should be stated that the "Hamming Window" method is utilized for the normalization and smoothing of the spectral density estimate. The spectral analysis model, currently being programmed for the IBM 7094, outputs and plots among others the following: autocovariance and density functions of single series, cross variance, cross-spectral density, phase shifts, coherence, and transfer functions of two time series. Plans now underway, will lead in the near future to a comprehensive and fully automatic statistical analysis system for all tracking operations.

REAL TIME DATA HANDLING SYSTEM

The Real Time Data Handling System (RTDHS) is in the final stages of implementation at the Pacific Missile Range (PMR). Featuring Naval Tactical Data System equipment, the system is built around two Univac CP-642B computers at the primary site and a Univac 1218 computer at each peripheral site. Programming for the peripheral sites has just been completed by Informatics, Inc. The program features automatic handover of radar tracking, on-line boresighting of radars, substitution of equipment and quality determination, all under console control. The primary site computers will be programmed to perform a wide assortment of operations on the data including reformatting, recording, coordinate transformation, impact prediction, best estimate of trajectory, and preparation of data for presentation on display equipment. Two companion systems are scheduled to become operational during the year. A Range Operations Control System will be used in conjunction with the RTDHS to provide, by man-machine interface, automatic support to Range Operations scheduling and control functions. An Instrumentation Data Distribution System (IDDS) will also be used to provide an automatic switching capability for data transmitted throughout the PMR. The IDDS will provide for master control at Point Mugu and local control at the remote sites.

Computer Center

U.S. Naval Ordnance Laboratory
Corona, California 91720

Operation of a newly established Computer Center at the U.S. Naval Ordnance Laboratory, Corona, California, was initiated in February 1966 with the installation of an IBM 360 Model 50 computer system. The center was established to provide for the accomplishment of a growing computer workload at the Laboratory which has in the past been accomplished on computers at other installations.

Most of the current workload consists of one shot computer applications in support of the Laboratory's scientific and engineering projects. Programming, principally in FORTRAN, is performed on an open shop basis by project personnel. An extensive training program is providing the technical staff with the necessary skills in computer usage.

Computing equipment hardware consists of a 2050 central processing unit with 128K bytes of memory, four 2311 disk drives with a total of 29 million bytes of direct access storage, four 2400 magnetic tape units, one 1000-card-per-minute in/300-card-per-minute out read/punch, and one 600-line-per-minute printer. The disks

are tied into the computer via a selector channel and the tape units, card read/punch, and printer are tied in via a selector/multiplexor channel. One of the tape units is equipped to handle seven-track character (rather than nine-track byte) recording to provide for compatibility with other types of computer equipment.

The computer is operated under a sequential version of the IBM 360 Operating System which permits continuous job stack processing. While most input/output and computation operations are currently performed sequentially, future software development is expected to provide for full overlap of computation with input/output. Major areas of computer application are fuze and fuze antenna design and optimization, VLF research, superdirective radiating array research, microwave radiometry, spectroscopy, and missile systems operational analysis.

NRL Procuring CDC 3870 Computer

U.S. Naval Research Laboratory
Washington, D.C. 20390

NRL's computer facilities were expanded early in 1966, thanks to the able efforts of the Ad Hoc Committee for NRL Computation Facilities. This Committee formed to study the current and future computer needs of the Laboratory consisted of Mr. Alan B. Bligh of the Research Computation Center, Chairman; Dr. Louis A Beach of the Radiation Division; Dr. Jerome Karle of the Optics Division; and Mr. Bruce Wald of the Radio Division.

At first, in the summer of 1964, Messrs Bligh, Beach, Karle, and Wald through that 18 months of difficult and time consuming efforts had at last come to a successful end. But because of radical changes in computer technology and pricing from August to November, numerous amendments were made to the proposals. In November the prospective contractors were invited to submit new proposals and bids. Even while the new proposals were being evaluated amendments were still coming in.

In February 1965, all additional amendments were stopped. There then followed a massive and thorough analysis of the advantages and disadvantages of each proposal. After consideration of overall cost, technical character of the machines, and delivery dates, a bid was finally accepted.

The paper work was sent via ONR to the Office of Management Information and ultimately to Mr. Howard Merrill, the Special Assistant to the Secretary of the Navy, who gave final approval to the bid. Thus NRL acquired authorization to procure a new and improved computer facility for the use of its scientists and engineers to aid them in their research problems.

The 2-1/2-year effort has resulted in NRL signing a contract with the Control Data Corporation (CDC), of Minneapolis, for the procurement of a high-speed digital computer designated as CDC 3870. The contract provided for equipment installation which began on January 2, 1966, and acceptance testing of an interim system (CDC 3800) in February 1966. Later in the year, additional equipment to make up the final CDC 3870 computer will be installed. The contract also provides NRL scientists with available time to use the 3600 computer at CDC's Data Center in Rockville, prior to and during the installation of NRL's 3870 computer. Training courses in the use of the new facilities are also being given by CDC to interested Laboratory scientists.

The new computer will be housed in Building 47 which has been under renovation since June of this year. Renovation is expected to be finished by mid-December. The NAREC will remain in Building 47 until it is eventually retired.

The new facilities will hold approximately 65 thousand words in a magnetic core memory, one million words in a magnetic drum memory, and will have six high-performance tape units, certain on-line display devices as well as conventional peripheral equipment.

AUTOMATED SUPPLY PROCEDURES

Automated Supply Procedures are being developed at NEL. Due to the research mission of this Laboratory, supply requirements encompass a multiplicity of requests, low volumes, change of objectives, and short term stock usage. The Supply Division operates on a Consumer Auxiliary Store Concept. This system's main objectives are to maintain an optimum level of stock-on-hand, eliminate voluminous manual record-keeping, manual decoding of the automated documents received from Military supply (MILSTRAP), produce Financial Inventory Reports, and produce comprehensive local reports on an exception basis.

The computer system will maintain complete stock records on magnetic tape. It will use MILSTRAP input directly (without conversion) and local source documents. All input is card-to-tape through a comprehensive machine validation/edit control program. Output will be Financial Inventory Report (NAVCOMPT 2154), local financial, ledger, transaction, and catalog listings.

The programs will be written in COBOL and will be as machine independent as possible. They will allow the system to be run on any medium or large scale computer that has a COBOL compiler, standard sort package and 10 tape drives. Upon completion of the Automated Supply Procedures System, the COBOL programs, User's Manual, Operator's Manual, and program documentation will be made available to anyone requesting them.

DYNAMIC PERSONNEL MANAGEMENT SYSTEM

The U.S. Navy Electronics Laboratory is in the process of developing a computerized Personnel System. There are many objectives of this system. One is to relieve as many of the tedious clerical functions as possible from the Personnel Division. Another objective is to have the flexibility to produce new and different reports as the need becomes apparent (with a 4 to 24 hour turn-around time). The system will be able to generate Form SF 50, Form SF 7, and follow-up forms, automatically. Reporting requirements for PADS will be satisfied automatically, eliminating the current manual tasks.

The system was designed to be machine independent. The COBOL language used in programming allows the system to operate on other computers with very little modification necessary. This language gives other activities the ability to adopt the system as their own even though their computer is different from the computer used at NEL.

The system will provide controls on the data by editing the data fields and reporting edit errors to the Personnel Division for their corrective action. A Data Bank will retain all of the personnel data. Controls on this Data Bank will be developed and the Data Bank itself will be designed to allow for the retention of data requirements in the future.

The installation of this system is expected to occur in the spring of 1966.

MULTIPLE PURPOSE CDC 160 PROGRAM

A multiple purpose CDC 160-A card-to-tape, tape-to-print, tape-to-punch program was completed and implemented at NEL. This program provides simultaneous operation of two activities in any combination. Typically, the card-to-tape and tape-to-print combination is used together to obtain greater than 100-percent increase in throughput over the former programs in use. This program is stored and operated in a continuous run condition such that one activity may be in process and without interruption another activity may be initiated.

A Program Auto Test System was prepared for operation under the 1604B COOP Monitor System. This system generates the many data files from the standard input tape and writes them on the tape drives specified by the user. Control is then turned to the application program. Upon completion of execution, control is returned to PAT with parameters indicating the desired output tapes to be printed. The PAT system copies the printed output from the various tapes onto the standard print tape.

The net effect is that tape files are generated immediately prior to job execution thus providing up-to-date data and not requiring that data exist on a multiplicity of tapes for an operator to mount and dismount. Likewise an

operator does not dismount the few or many output tapes and print the results in the usual manner.

The files of test data are maintained in card decks; they are read onto the COOP input tape via the 160-A computer. The advantages include:

1. The number of tapes required to maintain test data are reduced.

2. The changes to test data are more readily accomplished.

3. Library processing of tapes for test data are eliminated.

4. Output data from various files are printed from one standard tape.

5. Operator time is lessened significantly and useful computer time is recovered.

Computers and Centers, Overseas

Semi-Permanent Capacitive Store

Bell Telephone Manufacturing Company S.A.
Automation Systems Division
Hoboken, Belgium

FUNCTION

The Semi-Permanent Capacitive Store in a unique method to store alphanumeric data by means of an unalterable physical medium, to make the stored information available within a few microseconds, and to allow quick and easy manual modification of the data without interruption of the store's operation.

PHYSICAL SUPPORT OF THE INFORMATION

The data are contained in plastic strips provided with 20 square holes. Each hole represents one binary digit. When the required word length exceeds 20 bits, two or more strips will be associated in parallel. The "binary zero" is represented by a free hole on the strip. The "binary one" is represented by a small metal plate or electrode inserted in a hole. The electrodes are inserted manually by means of a simple tool.

STORAGE OF DATA

Data are stored by introducing the coded strips into their assigned cells. To modify a data-word, the corresponding strip or strips are withdrawn from the store and replaced by other, precoded strips; if the latter are not available the withdrawn strips can be recoded prior to reinserting them in the store. While this modification is being done the rest of the store is unaffected and the remaining information is freely accessible. This is a major requirement in many applications, such as automatic telephone exchanges.

CAPACITY OF THE STORE

The store is subdivided in blocks. Each block contains 400 strips and is subdivided in 20 matrixes of 20 strips each. The capacity of one block is 8000 bits. A store of determined capacity will be obtained by associating the required number of blocks. Blocks will be associated in series to obtain the required number of words and in parallel to obtain the necessary word-length. The maximum capacity is 5000 words of 100 bits each. A complete store contains thus half a million bits.

ACCESS TO THE INFORMATION

Each word has a well-defined numerical address, represented in binary or BCD. The address of a required word and the corresponding data will be handled by the store's digital circuitry. The store's logic can be connected to a computer, a keyboard allowing to key-in an address and equipped with a display making the corresponding information visible, and any other manual or automatic digital system capable of emitting addresses and of receiving and handling the corresponding data. The access time to one word is 4 microseconds.

OPERATION

Each address or word corresponds to one horizontal row of nodes, materialized by one or more strips. The number of vertical columns or read-out wires is equal to the number of bits per word. The data contained in one word are determined by the presence (1) or the absence (0) of an electrode at the corresponding cross-points of row and columns. To extract a word's information, the addressing circuit applies a sine-wave potential to the corresponding row as shown in Fig. 1. Current will be obtained in all columns which are capacitor-coupled to the row by means of the electrodes. These currents will be interpreted by the read-out circuits connected to the columns as binary ones. Inversely, the absence of current in a column will result in a binary zero. The read-out circuits are each

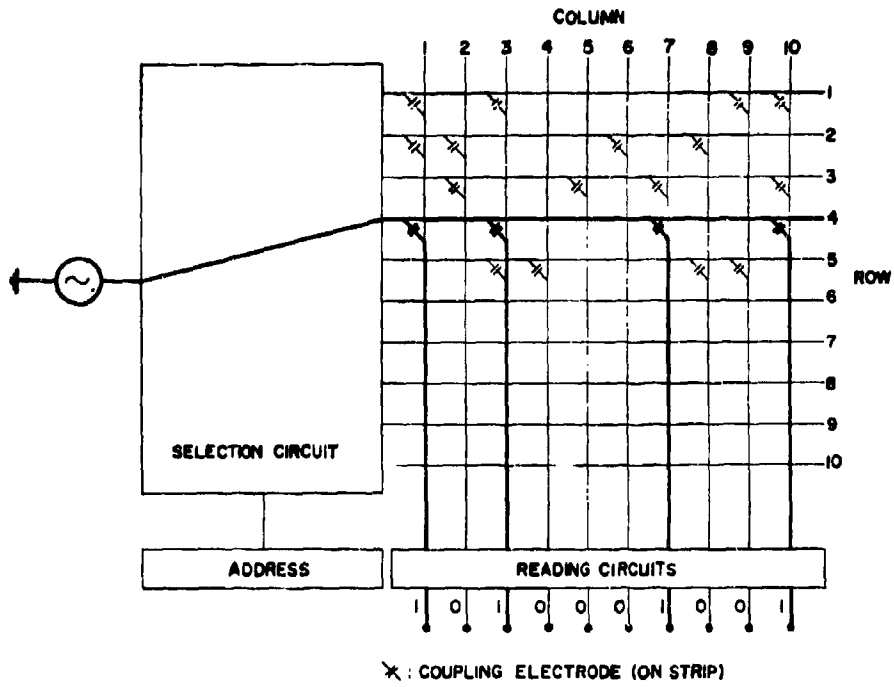


Figure 1

provided with a flip-flop which stores the information of the last-addressed word. This buffer ensures easier handling of the data.

APPLICATIONS

The application field of the Semi-Permanent Capacitive Store is wide and varied, for example:

* Comparison or results: football pools, games, contests, examinations

* Number translators for telephone exchange

* Storage of sub-routines and tables of constants in computers

* Automatic catalogue for mail-order houses (address = code number of item; data = price of item).

Computer Unit
University of Edinburgh
Edinburgh 8, Scotland

Edinburgh University has been chosen by the Department of Education and Science to become the regional computing centre for Scotland and is being allocated £500,000 as an initial grant for purchasing a computer.

The unit is currently embarking upon a project to produce spoken output from a PDP8 in connection with on-line program editing.

Also they have written an efficient compiler for the English Electric KDF9 which accepts Atlas Autocode (an ALGOL-like language).

Atlas I Computer

Institute of Computer Science
University of London
London WC 1, England

The ICT Atlas I Computer is now functioning with a reliability in excess of 90 percent. A high-speed (120 bits per millisecond) data link to Imperial College (one of the constituent colleges of London University) has been installed and will be used for control simulation as well as for normal student and research programming. Three other telephone data links (100 characters per second) to other colleges are operating.

Two I.B.M. compatible magnetic tape decks have been added to the 14 existing Ampex tape decks.

Miscellaneous

Double UNIVAC 494 System

Bache & Company, Inc.
New York, New York 10005

Bache & Co., members of all major stock and commodity exchanges, in January 1966 announced a contract signed with Sperry Rand Corporation's UNIVAC Division for a $3 million electronic computer system, largest yet to be installed on Wall Street.

The nucleus of the new system will be two UNIVAC 494 Real-Time Computers, purchased outright from Sperry Rand. They will be installed at Bache's headquarters at 36 Wall Street.

Harold L. Bache, Chairman of the Board, in announcing the system which will be installed mid 1966 stated that the UNIVAC system had great application to Bache's immediate and future requirements. "Our business is service. The computer will help us to render the fastest, most effective service in the form of up-to-the-minute news information, customer accounting and trading data, and so forth. In addition, an extensive portfolio and security analysis operation is anticipated which will provide the ultimate in service to the large institutions as well as to the individual customer."

Through the use of the new system, Bache & Co. becomes the first brokerage firm to employ real-time computer systems of such magnitude as a total management information tool. It will provide control of a private worldwide wire network and the associated computing machinery necessary to transmit, record, and account for all of the firm's daily business activities.

This system will eventually provide all branch offices with immediate access to files containing over 250 million characters of information. Recognizing rapidly increasing market volumes, Bache has provided for a considerable growth factor. The UNIVAC system has been designed to treat message traffic at the astounding speed of 6 thousandths of a second for the average buy or sell order.

The UNIVAC 494's and an international network of leased telephone, teletype, and transatlantic communication lines will provide Bache customers the following services: New York Stock Exchange and American Stock Exchange transaction accounting, over the counter trading, municipal bonds, corporate underwritings, commodities, business conducted for and by correspondents, research information, and administrative traffic.

The Bache communications network will include 30,000 miles of private teletypewriter circuits in North America alone.

In 1964, Bache & Co. made a careful analysis of the rising market volume trend and determined that its present computer and communications facility would be severely taxed within 3 to 5 years. Of equal importance was the need to meet the company's projected growth and also maintain a consistently high level of customer service. An analysis of these needs showed that the most effective way to handle the company's requirements was to adapt a new concept in the processing of information.

Separate computer and communications complexes presently used by the company now require an extensive amount of duplication and reentry to process every order entered by a customer.

While offering the best data processing and communications system in 1962 when originally installed, the present arrangement sets a limit on the maximum amount of orders, executions, messages, "requests," and so forth that can be handled effectively. In order to process an order entered by a customer in a branch office and return a confirmation upon execution, it is now necessary to perform 29 manual and machine steps.

By consolidating all computer and communications functions, the UNIVAC 494 Real-Time Systems cut execution of an order to 8 steps and trim round trip time by an even greater percentage.

This will enable Bache & Co. to handle much larger volumes of orders and other data and at the same time enhance service provided to its clients.

Bache & Co. maintains branches throughout the United States, as well as in Canada and in Mexico. In addition, it operates offices in England, Holland, France, Germany, Italy, Spain, Hong Kong, Switzerland, and Lebanon.

Each of the two UNIVAC 494 Real-Time Systems includes a central processor with 12 input/output channels, FASTRAND Mass Memory Drums, high speed printers, card readers, UNIVAC Uniservo tape units, communications and switching equipment, plus UNIVAC 1004-11 Card Processors.

Automated Voter Registration

Board of Election Commissioners
Chicago, Illinois 60602

On March 29, 1966 Judge Thaddeus V. Adesko fed a punch card into a business machine to mark the completion of a 2-1/2-year project in which some 1,800,000 voter registrations kept by the Board of Election Commissioners of Chicago were converted to forms which can be processed and updated by computers.

Judge Adesko, who as Presiding Judge of the Circuit Court County Division oversees the operations of the election board, initiated the program to adapt IBM systems to the board's record-keeping procedures.

He said an immediate benefit of the system will be production of machine-printed lists of registered voters for verification books used by judges of election who also serve as registration officers and canvassers. Canvassers use the books to record whether voters are living at addresses from which they are registered.

Formerly, canvassers prepared their own verification books by copying on separate slips of paper the names and addresses of all voters listed in precinct registration records, arranging them according to street names and house numbers, and then re-copying them into the books.

Judge Adesko said the pre-printed verification books will permit canvassers to spend more time in the house-to-house check of voters and are expected to result in greater accuracy of printed precinct poll lists.

Although machine-printed verification books have already been used in some areas while the conversion was in process, they will be used in all 3842 precincts under the election board's jurisdiction for the first time during the registration and canvass preceding the June 14 primary election.

All precinct polling places were opened on May 17 for registration of voters and the canvass was conducted on May 18 and 19.

The board keeps registrations and conducts elections in Chicago, Berwyn, Chicago Heights, Cicero, Lyons, and Stickney.

Suspect voter affidavits and post card suspect notices to registrants who cannot be found – formerly prepared by canvassers – will also be machine-processed under the new method.

In addition, all records pertaining to about 20,000 judges of election have also been converted to punch cards and data processing equipment is used to prepare payrolls for judges and for rental of polling places. All mailings to election judges, including identification cards and certificates, are now prepared by machine. Lists of judges for publication in newspapers are similarly processed.

In order to keep the cost of equipment rental to a minimum, IBM computers, already installed in various city departments, will be used to prepare the verification books. The election board now pays $2,562 a month for rental of equipment. Twenty-five board employees have been trained to operate the machines.

Judge Adesko said the conversion of voter registration records was the first step in a continuing program for adapting modern data processing methods to operations of the election board in all areas where it is possible to do so under existing election laws.

"We cannot stand still in an age in which data processing systems and computers are performing spectacular feats in business, industry and science," Judge Adesko said. "We must study all developments which hold promise of streamlining our election procedures without endangering the franchise of the voter or the sanctity of the ballot. If the election laws prevent the use of more modern, efficient procedures then we should move to change them."

The Board of Election Commissioners began exploration of the possibility of converting its

operations to business machine methods in 1962 and several engineering studies were made. Because of signature and other requirements of the election code, however, none of the engineers could devise a workable plan for a complete conversion.

When Judge Adesko was elected to the County bench in 1960 he urged the board to develop a program for partial conversion to data processing methods which would not conflict with the election laws or require a great investment in equipment. The present program is the result of that plan.

Experiments with machine processing of data for canvassing were first carried out during the October 1962 registration in four precincts which were selected to provide a cross-section of Chicago neighborhoods. During the January 1963 registration and canvass, the plan was expanded to cover one whole ward with approximately 40,000 voters in 66 precincts.

When this also proved successful, the plan was extended to cover six wards during the March 1964 registration and canvass, and a total of 14 wards were converted in time for the November 1964 general election.

New Computer Plans

Eastern Airlines
New York, New York 10020

Plans for a $34 million expansion of its electronic computer facilities to meet the increasing demands of air travel were announced in January by Eastern Airlines.

The principal component of Eastern's move into what it calls a "new generation" of airline data processing will be the acquisition from the International Business Machines Corporation of a 1-1/2 billion character electronic reservations system controlled by dual System/360's to be installed in a new Data Services Building to be erected at the airline's operating base at Miami International Airport.

The computers and the huge electronic storage system containing travel itineraries of a million passengers will be linked to more than 1600 reservations agents in 8 cities where individual passenger records will be electronically displayed on television-like screens at a speed of more than 3000 words per minute.

The eight reservations offices now located in Atlanta, Charlotte, Chicago, Houston, Miami, Montreal, New York City, and Tampa, handle telephone calls from customers in the 103 United States and Canadian cities served by Eastern's flights. Other reservations offices in Bermuda, Mexico City, and San Juan, Puerto Rico, will be connected to the system by overseas teletype circuits.

When the new computers and their 1600 associated "agents sets" (television-like display screens with typewriter keyboards) in these cities, are placed in service beginning late next year, it will be the first such use of cathode ray tubes for reservations and flight information purposes by any airline. Eastern will also have at that time one of the largest commercial data processing systems in the world. The new IBM system is expected to be completed by the fall of 1968.

The announcement of Eastern's plans to proceed with a long-range program of improvement in its electronic computers and data processing equipment was made by Todd G. Cole, Eastern's senior vice president-finance and administration, at a press conference here following a meeting of the company's board of directors.

In addition to the new IBM System/360 equipment for Miami and the cathode ray tube "agents sets" at Eastern's principal cities, plans include the purchase of two new Sperry Rand UNIVAC 494 "Real-Time" computers to be installed at Charlotte early in 1967. These will be more than six times as powerful as the "second generation" UNIVAC 490 computers they replace. The "first generation" computers which were introduced by Eastern at New York City in 1958 were the first general purpose "Real-Time" computers in the airline industry.

At Miami the new Reservations Data Center, besides storing reservations and information on flight numbers, classes of accommodation available on different flights, times of departure and arrival at airports, meal service, and fares, will provide full automation of reservation clerical functions.

The new IBM system will monitor the preparation of each passenger's itinerary to assure

that all details are in order, automatically reserving seats on Eastern and other airlines. Each time there is a change in the schedules of Eastern or one of its connections, the computer will search out the records of passengers affected and report the facts to the appropriate reservations office. In most cases the computer will make alternate arrangements for the passenger.

The advanced IBM reservations system will be in constant communication with the reservations systems of other airlines to transmit and receive records of interline travelers. An additional innovation will be the printing of tickets for transmission to customers by mail or teletype.

Most of the IBM data processing equipment – valued at $13 million – will be located in the new Miami Reservations Data Center, including the two IBM System/360 Model 65's, each capable of executing 750,000 instructions per second and storing more than 5 million characters in their magnetic core memory files. They will permit storage in duplicate of detailed reservations records for up to 1 million passengers at any time, far more detailed reservations records than are possible with the present system.

Computer instructions for Eastern Airlines reservations and ticket system will be based on IBM's Programmed Airline Reservations System, a set of more than 600 programs. Used together, these programs constitute a fully operative system for handling passenger reservations, flight inventory and related functions.

With the shifting of reservations responsibilities from the present electronic computer complex in Charlotte, the latter facility, with its new and more powerful UNIVAC equipment, will become Eastern's Operational Data Center. This will provide up-to-the-minute records on location, status, and availability of the airline's fleet of nearly 200 aircraft and some 5000 flight officers and cabin attendants who man them. It may also be used for storing the records on the nearly 100,000 air freight shipments which move over Eastern's routes each month.

Charlotte will also continue to serve the reservations needs of such local service carriers as Allegheny, Mohawk, North Central, and Ozark Airlines and to be the home of Eastern's Message Switching Center. The "second generation" computers performing this service since last March have responsibility for the receipt and transmission of more than 3-1/2 million messages interchanged each month between some 150 locations around the Eastern system.

In discussing the new computers, Mr. Cole said, "Improved technology in both data processing and data communications now makes it economically practicable to employ these new devices for further improvement of our reservations service, which is even now unsurpassed in the transportation industry. By taking over tedious and routine tasks, the computers will make it possible for our agents to answer more promptly and give more highly personalized service to the traveling public who now talk to us with over 2 million calls per month."

"The new system," he said, "will cause no serious displacement of employees. On the contrary, despite the improved efficiency of the new system, we will not only guarantee continued employment to our present reservations staff, but we will need to recruit additional skilled men and women to handle the ever-increasing travel demands of our customers."

WHEN A CUSTOMER CALLS
(in the future system)

Most Eastern reservations are made by telephone. When a customer telephones a local Eastern Airlines number for flight information and a ticket, his call is automatically routed to the nearest regional Reservations office and is answered by a sales agent who uses a 2915 airline reservations unit to get up-to-the-second flight information.

Upon receiving a call, the agent discusses itinerary plans with the customer – origin, destination, date, and approximate time of departure. The agent enters this information into the system on the typewriter-like keyboard of the airline reservations unit, and it goes by high-speed data circuits to the computer center in Miami for processing.

The computer compares a passenger's request with the stored flight information at the center – information which is constantly changing and being updated by the computer as new information is fed in.

Data in a Second

Within 1 second, detailed information on available flights is displayed automatically on the television-like cathode ray tube of the agent's airline reservations unit. The display shows at a glance the flight number, classes of service available, number of seats available, airport and time of departure, airport and time of arrival, meal service, and

fares for flights which could satisfy a customer's needs.

When travel involves a change to another Eastern flight or to another airline, this information is also displayed in detail. Only flights with at least one available seat are displayed.

As soon as information is displayed, the agent discusses it with the customer who has been on the telephone for only a few seconds. The customer makes his choice of flight and the agent enters it into the computer with the airline reservations unit's keyboard.

The computer instantly responds to this entry by displaying information pertaining to the selected flight. This confirms the reservation. The computer then automatically signals the agent to enter the passenger's name, telephone number, and how and when he wants to receive his ticket.

The computer automatically checks the completeness, validity, and logic of each transaction. If mistakes are made or information is left out, the computer signals the agent and identifies the error or the missing data.

If, for any reason, a customer should need special service or equipment – a wheel chair, for instance – this information is also entered into the computer. It is then automatically printed out and forwarded to the proper location at the proper time.

In effect, an agent holds a two-way conversation during a transaction – he "talks" to the computer while he is talking to the customer. This computer technique is called the "conversational mode."

RECORDS AND TICKETS

When an agent has entered all necessary information and finishes his conversation with the customer, the computer indexes the passenger's name on a record and places it into an IBM 2314 direct access storage facility at the computer center for reference and ticket preparation. If the passenger's itinerary requires notification-of-sale to another airline, the computer prepares and transmits the necessary message automatically – a task now done by hand.

Any passenger's records can be displayed at any of Eastern's more than 1600 agent sets, so that no matter where a traveler is and what information or changes in his itinerary he requests, they can be easily handled.

A significant percentage of tickets will be prepared automatically by the central computer from reservation information entered by sales agents. Depending on time considerations, automatically-prepared tickets will be either transmitted by teletype to appropriate Eastern Airlines offices or mailed to customer addresses.

In addition to automatically processing reservations and preparing tickets, Eastern's System/360 Model 65's will be used to:

* Identify unticketed passengers whose time-limits have expired;
* Prepare boarding manifests;
* Receive teletype messages from other airlines and adjust files and records when required;
* Assign cancellation space to passengers on waiting lists;
* Develop, on a demand or scheduled basis, a variety of management reports including projected load factors, sales analyses, agent activity reports and work back-log reports for supervisors;
* React to schedule changes by identifying affected passengers, rebooking them on substitute flights and notifying reservations offices to contact affected passengers;
* Print schedules for external ticket agents and as back-up references for Eastern offices; and
* Maintain up-to-the minute inventory, space availability, and flight information records.

600 DATA PROCESSING PROGRAMS

Computer instructions for Eastern Airlines' reservations and ticketing system will be based on IBM's Programmed Airline Reservations System, a set of more than 600 programs. Used together, these programs will constitute a fully operative system for handling passenger reservations, flight inventory, and related functions.

The programs have been developed by IBM through its experience with airline reservation systems. The program package will be used by Eastern with only slight modifications.

In addition, the Eastern system will be able to make use of a full line of programs for the IBM System/360, including the

operating system, sort, merge, and utility programs, and assembly and compiler languages.

DATA PROCESSING EQUIPMENT

Key equipment in Eastern's system will consist of the System/360 Model 65's in Miami and the IBM 2915 airline reservations units located in Eastern reservations offices. Initially, 1600 of these display units will be connected to the central processor.

A complex system such as Eastern's also requires the services of many other data processing machines – communications control units, storage units, units to get data into and out of the system, and control the flow of this data. Following is a brief description of some of the more important equipment:

The IBM System/360 Model 65 is designed to solve very large information processing problems. Initially, each of Eastern's System/360's will have a minimum memory capacity of 262,000 bytes of information (a byte is equal to one character or two digits). This capacity easily can be doubled if and when it is required. The Model 65 requires only 750 nanoseconds (billionths of a second) to retrieve eight characters of information from its memory.

The IBM 2915 airline reservations unit provides a rapid and efficient method of man-machine communication with System/360. Alphameric data (numbers, letters, and special symbols) entered through the keyboard and messages sent from the central processing unit are projected on the direct-view cathode ray tube display screen. Messages from the computer are displayed at a speed of 3000 words a minute.

The IBM 2361 core storage provides auxiliary high-speed, directly accessible bulk core storage for Eastern's System/360 Model 65's. Eastern's 2361's will provide 4 million bytes of additional core storage which can be accessed by the central computer in 3 microseconds (millionths of a second).

The IBM 2314 direct access storage facility provides high-capacity, extremely fast on-line storage for System/360. Initially, Eastern's system will use six 2314's, each capable of storing up to 207 million bytes of information. Computer access time averages 75 milliseconds (thousandths of a second).

The IBM 2703 transmission control unit regulates the flow of data between the Miami computer and the reservation office terminals. It forms the connection between telephone and teletype communications lines and the IBM processing equipment.

SYSTEMS SCHEDULE

Begin installation of central site equipment
July 1, 1966
Initial cutover of central site equipment
October 1, 1967
Cutover of first reservations office for tests
December 1, 1967
Cutover of other reservations office begins
February 1, 1963
Cutover of final reservations office
September 1, 1968.

Logistics Research Project
The George Washington University
Washington, D.C. 20037

In January 1966 the first increment of a data processing system designed and developed at the Logistics Research Project was delivered to the Maintenance Support Office in Mechanicsburg for employment in support of the mission of that organization of the central data processing activity for the Navy's Maintenance and Material Management Information System. This initial increment consisted of about 80 data processing entities.

An object time compiler called the DMC (Decision Module Compiler) has been programmed, tested, and is being employed as a production tool at both the Logistics Research Project and at the Maintenance Support Office as a part of the 3M data processing system. It constitutes a material enhancement of the basic capability of the IBM 7080 for decision making and for the assembly and distribution of data fragments.

Remote Computer Use

Harvard University
Cambridge, Massachusetts 02138

A small group of students in Cambridge is learning mathematics from a computer in Santa Barbara, 3000 miles away.

The computer, employing a systems program worked out by Prof. Glenn Culler of the University of California, solves a problem in calculus or statistics, step-by-step, for the Harvard class.

The mathematical process appears on a device similar to a television tube.

Prof. Anthony Oettinger at Harvard opens his class by turning, not to a blackboard, but to the signalling device. On a keyboard, he types out the problem, thus programming the Santa Barbara computer.

The steps to solution appear almost instantaneously on the Cambridge screen.

Professor Oettinger is using the system experimentally for instruction in a seminar on "Technological Aids to Creative Thought," as well as in other classes. The communication, over 3000 miles, is made by telephone and microwave.

Three universities are now using the systems program developed by Professor Culler at Santa Barbara: UCSB, UCLA, and Harvard.

At Harvard, the Santa Barbara computer is being used in a program of experiments in the process of teaching and learning. Research aspects are supported by the Advanced Research Projects Agency of the Department of Defense.

Professor Oettinger foresees similar displays in many classrooms, all linked to the computing center.

"For the first time, relatively inexpensive display devices can be installed in classrooms without regard to where a relatively more expensive computer is located. This means literally hundreds of schools and laboratories are now possible participants in a system of this kind."

Essentially, this method involves translating computer calculations into graphic terms which dramatically illustrate a problem and its successive steps to solution. "It's a case of a picture being worth a thousand words. Besides that, there are some problems you simply cannot describe in words," he said.

"Basically, students are given a better feel for problems, given a better intuitive grasp of very abstract notions. This establishes a strong complement to abstract learning. Many students are therefore able to increase their learning speed, probe more deeply into problems, and attack others they might never even attempt."

Harvard is currently expanding its computer facilities. Eventually, the computer center will be connected with terminals at various places in the University, available to scholars in diverse disciplines.

An IBM system 360 model 50 will be installed, and larger and smaller computers will be installed over the next 2 years.

Computerized Braille Printer

Honeywell Inc.
Wellesley Hills, Massachusetts 02181

A computerized Braille printer said to be 100 times as fast as any standard device currently being used to produce single-copy "written" material for blind persons has been announced here by the electronic data processing division of Honeywell Inc.

The first unit, according to J. Ernest Smith, Honeywell EDP vice president, has been donated to the University of Southern California's computer sciences laboratory in Los Angeles and is now in operation there.

Smith said the Honeywell Braille printer is also more than twice as fast as any competitive computer-driven unit yet devised and is more than 12 units as fast as an automatic Brailler, which produces single-copy Braille from punched paper tape.

Standard computer printers, Smith e[illegible], are being used to a limited degree by blind computer programmers to produce Braille "printouts" of the programs they develop, "but do not print a grade of Braille acceptable to

blind people for permanent use." A strip of rubber-like material is laid over the "print hammers" and the "period" symbol is used to emboss lightweight paper. Standard printers produced by Honeywell and other manufacturers are being used in this fashion, he said, but not extensively.

"The main problems in using a standard computer printer for Braille," he said, "is that interdot spacing within a Braille 'cell' is poor, the height above the paper of the embossed dots is insufficient for good 'reading' and the lightweight paper that must be used does not last as long as a Braille document should. This method also produces Braille 'face down' on the printer, which means a blind person operating the printer has to remove the printout before it can be read."

He said the new Honeywell Braille printer produces Braille "face up," making it possible to read the printout while it is still in the machine.

Standard methods used to produce single-copy Braille are the "slate and stylus," a manual device with which a person can write two to three cells per second, and the typewriter-like Braillers, which can produce about three or four cells a second. Special methods include the automatic, single-character Brailler, which produces 16 cells per second, and the stereograph, a seven-character-per-second device that embosses metal plates used for high-volume production of Braille material.

Modified H-222

The Honeywell Braille printer, Smith said, is a modified H-222 high-speed printer; a standard peripheral device in Honeywell's Series 200 product line and used with computer systems such as the H-200. Honeywell, in the past few years, has also donated complete H-800, H-400, and H-200 computers to USC; the latter system having the Braille printer as one of its peripherals.

The printer produces 300 Braille cells a second on standard Braille paper (although other paper types can also be used) by replacing the normal "hammers" and "print rolls" used in the standard H-222 printer with a "ball-and-cavity" assembly. Its speed is equivalent to approximately 400 lines of 44 cells each per minute.

When the computer instructs the printer to produce a Braille cell – six embossed dots in two columns of three each – the correct hammers are activated and the balls mounted on them strike the paper and drive it through into the matching cavities.

The modified H-222 printer can be easily converted in a few minutes between Braille and regular "ink print," Smith said, making it possible for one printer to handle both types of printing. The conversion kit to do this will be available to Series 200 computer users on a special order basis.

PLATO

Coordinated Science Laboratory
University of Illinois
Urbana, Illinois

INTRODUCTION

The purpose of the PLATO project 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) provision of a prototype for multi-student teaching machines; (3) learning and teaching research. Under the first category has come the development of three successive versions of the PLATO equipment with PLATO IV, which includes an audio facility, now under construction. The 20-student station classroom provides the prototype for multi-student teaching machines mentioned in the second category.

The learning and teaching research, the third area of PLATO research, has covered curriculum studies, college teaching, and behavioral science research. Cooperative work with

the University of Illinois Committee on School Mathematics is now in its fourth year. Professor W. E. Montague of the Department of Psychology is a half-time member of the PLATO group and is directing two behavioral-science studies. Cooperative work with three university departments (electrical engineering, library science, and business administration) has resulted in three credit courses offered this semester. Other interactions of the PLATO group with various disciplines at the University have suggested experiments and studies in negotiation (Guetzkow), health education (Creswell), evaluation of teaching materials in many fields (The SIRA Project), language analysis (Myers), comparative psycholinguistics (Osgood), and many other areas. The demands on the PLATO staff and the computer facility have resulted in the gift of the use of a 1604 computer from the Control Data Corporation which was installed in the spring of 1966, and which is for the sole use of PLATO research.

The plasma display discharge-tube research, another important part of research in category one, is offering definite promise for the possibility of a less expensive PLATO display. Small display holes of approximately ten-thousandths of an inch in diameter have been constructed and tested. The light from these holes is sufficiently bright to be clearly visible in a lighted room. It has been shown that the display spot can be turned on, erased, or read, to see if it is on or off, all within 2 microseconds. The light emitted from the hole occurs in bright pulses, each of which lasts less than 20 nanoseconds.

PLATO III SYSTEM EQUIPMENT

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

Student-station circuitry constructed to date includes all that required for the full operation of 20 student stations. Construction of the remaining required to update 10 stations that have been in use over the past 2 years continues and is expected to be complete during the coming quarter. Due to slowness in processing of requisitions and the delivery of components requested, construction has been somewhat delayed. As a consequence, checkout has resulted in only 12 stations being fully operational. The check out of the remaining station circuitry is expected to be complete by the end of the coming quarter.

Developmental circuitry required to update the present system or to provide new system facilities continues to be under study. Included are transistor deflection circuitry that will replace vacuum-type tubes operating in existing flying-spot scanner equipment, and audio-storage equipment to provide for random-access audio readout capability for all student stations in the PLATO system.

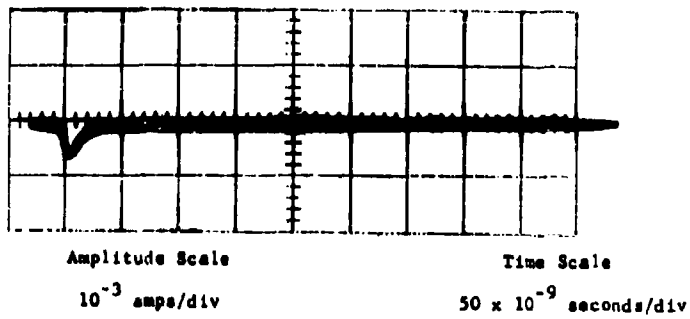
PLASMA-DISCHARGE DISPLAY-TUBE RESEARCH

Development of the plasma display tube has been motivated by the need for a simple display that responds directly to the digital signals from the computer and that retains its images without the need for regeneration. The basic element in the display is a bistable gas discharge cell in which charge storage on insulating walls provides the memory.

This paper is a discussion of the circuit properties of the cell, a technique for changing the state of a selected cell, and a new transistorized generator for driving the display.

A rectangular array of gas-discharge cells can, in principle, provide a simple, effective display for the PLATO teaching system, and for the many other multiple-access systems now under development. These cells provide adequate light, they can be separately addressed, and because the firing voltage can be made larger than the sustaining voltage they possess a memory. Unfortunately, when many cells are fired to form a pattern, the discharges can couple the selecting electrodes together in a way that makes addressing of the cells ambiguous.

At CSL, the direction of research on this device stems from the idea that if these electrodes are separated from the gas discharges by glass walls, the discharges can still be controlled by alternating voltages, but they will be isolated from each other by the capacitive reactances through the glass. With this arrangement, however, the behavior of each gas cell is entirely different from that of a direct-current discharge. In an efficient discharge, transfer of charge to the walls rapidly reduces the exciting field and completely extinguishes the discharge. Figure 1 shows, for example, that in a neon-nitrogen gas the discharge extinguishes only 20×10^{-9} seconds after it begins. The upper trace shows the current pulse on a time scale of 50×10^{-9} seconds per division. The lower trace shows the same pulse superimposed on the displacement current, in this case, on a



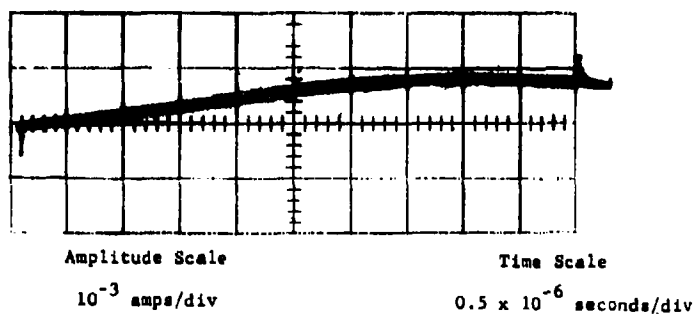


Fig. 1--Discharge current in the gas discharge display cell

time scale of 0.5×10^{-6} seconds per division. The driving signal in each case is a sinusoidal voltage with a frequency of 100 kHz. Although the duty cycle for light output is only 1/250, the discharge provides enough light for the display.

The memory in these cells actually resides in the charges which remain on the wall from pulse to pulse. To ignite a cell with wall charges, the driver need apply a voltage that may be as small as one-half the voltage needed to fire the cell in the absence of the wall charges. Unlike the dc discharge whose "memory" is inherent in the distribution of charged particles in the volume, the discharge functions simply as a switch to transfer charge to the cell walls.

Figure 2 shows an equivalent circuit in which C is the capacitance across the unfired cell, C_1 is the capacitance between an electrode and the adjacent cell wall, and G is a spark gap which represents the discharge itself. With a signal V' between the electrodes A and B, the voltage across C consists of two components, a voltage V_d proportional to V_o' and a voltage V_o proportional to the charge Q on the cell walls. More precisely

$$V' = V_d + V_o \ ,$$

$$V_d = C_1 V/(C_1+2C) \ ,$$

and

$$V_o = Q/C \ .$$

Whenever the gas breaks down, charge flows to the walls to change V_o. Between firings, however, the cell "remembers" the value of V_o.

To initiate a discharge, V must exceed the firing voltage V_f. When the cell walls are uncharged, the external signal must supply the entire voltage and V_d must exceed V_f. With charged walls, however, the external signal need supply only the difference between V_f and V_o.

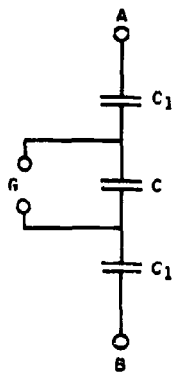


Fig. 2--Equivalent circuit of gas discharge display cell

Assume now that the amplitude of the sinusoidal sustaining voltage is such that V_d does not exceed the firing voltage V_f. In the "0" state $V_o = 0$ and, since V_d never exceeds V_f, the cell cannot fire. No charge is transferred and the cell remains in the zero state. In the "1" state, on the other hand, the cell fires when V_d just exceeds $(V_f - V_o)$. In this case, V_o is equal to one-half the voltage change V_c produced by the transfer of charge,

$$V_o = \tfrac{1}{2}V_c.$$

After the discharge

$$V_o = \tfrac{1}{2}V_c.$$

On the negative excursion of V_d the cell fires again when $V_o = -(V_f - V_o)$. The charge transfer this time restores V_o to its original value, and the cell remains in the "1" state.

A cell in a "0" or "off" state does not respond to the sustaining signal, shown in Fig. 3A, whose amplitude is less than the firing voltage. When a bias is superimposed on the sustaining voltage, however, as in Fig. 3B, the cell eventually fires, and because of differential charging in the next few cycles, the firing points reach a symmetrical phase condition. If now

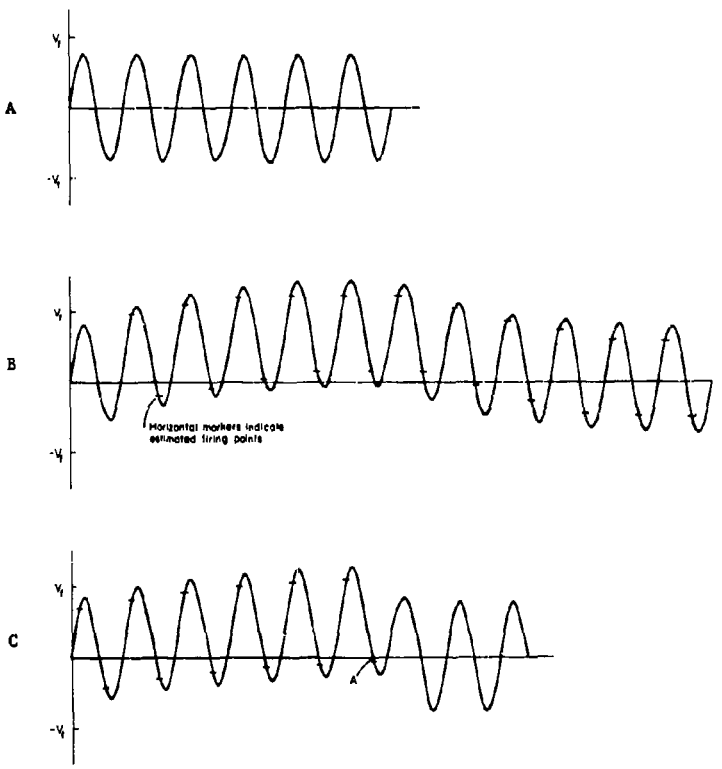


Fig. 3--Turn-on and turn-off signals for plasma display tube

the bias voltage is slowly reduced to zero, the firing times on the positive excursions are delayed slightly and the firing times on the negative excursions are advanced slightly. The greater slope on the negative half cycle results in an increased charge transfer during the discharge, and, when the bias voltage is 0, the cell is in a "1" or "on" state, and the firing points are symmetrical in phase.

When, as in Fig. 3C, the bias voltage is gradually increased on a cell that is "on," the positive firing points are advanced in time, the negative firings are retarded, and the differential charging compensates for the change in bias. When the bias voltage finally reaches a steady value, the only effect is a change in the steady voltages in the circuit. In fact, if the bias voltage is equal to half the charge transferred in the cell during normal firing, then, just after the firing at time A, the voltage due to the wall charge in the cell is zero. If the bias voltage is now removed within one-half cycle, the cell cannot refire, and it will be in the "0" or "off" state.

The slow voltage changes were produced by charging a 100 pF capacitor through 0.33×10^6 ohms, and the rapid changes were produced by discharging this capacitor through a 6BG6 vacuum tube. Figure 4 illustrates several stages in the "turn off" of a single cell. For the upper pair of traces, the bias voltage was zero. The pulses on the second trace are amplified photocell signals produced during the discharge. The middle pair of traces shows the voltage and the light signal after the bias is added to the cell, and the lower traces show that, after the bias has been removed (at a controlled time), the cell no longer fires.

The ability to turn selected cells on and off through high impedance circuits should simplify addressing problems, and in particular, should allow the use of gas switches in the selection circuits.

An experimental transistorized generator has been built which can drive the plasma display tube through a 50-to-1 step-up transformer. The signals consist of positive and negative pulses alternating with one another, and separated by a period in which the voltage is zero. The slopes of the wave forms are essentially uniform throughout the rise or fall time, and the time intervals between pulses are controllable.

The generator delivers 1500 volts; the rise time is about 1.0 microsecond, and the fall time time about 1.5 microseconds. These figures hold for all ranges of repetition frequency up to about 200 kHz. An adjustable threshold detector provides a means of smoothly varying the output amplitude over its entire range.

A block diagram of the generator is shown in Fig. 5. The circuit is push-pull, and each half of the primary is driven alternately by means of a monostable multivibrator and a driver. When the voltage on the collector of transistor T_1 or T_2 reaches a preadjusted level, the monostable multivibrator flips and turns the driver off, thereby limiting the output to the desired value. The transistor T_3 or T_4 then drives the output voltage to zero. Furthermore they prevent oscillation in the time interval between pulses. The symmetry and the frequency of an external square wave generator determines the time delay between positive and negative pulses and the frequency of the generator output.

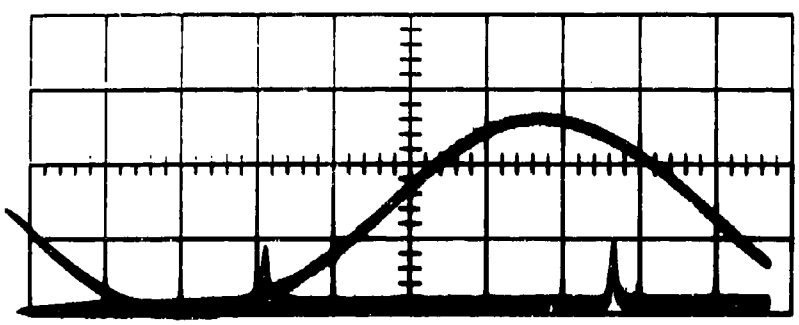
PLATO LEARNING AND TEACHING RESEARCH

University Courses

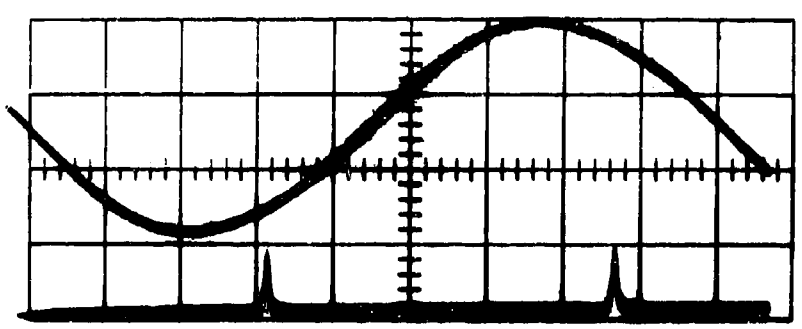
Electrical Engineering 322 – Circuit Analysis. Two types of teaching logic are to be used during the spring semester to teach a 3-week session of EE 322; during this time the lesson material is to be presented only by PLATO (i.e., the PLATO sessions are not being supplemented with regular class sessions). One-half of the students involved will use the tutorial logic and the EE 322 lesson material described in previous reports. The remaining half will use a modified version of the tutorial logic which was designed to present the new inquiry-oriented type of lesson material. The new logic and lesson material were developed during this quarter. Although the logic is highly specialized at this time, there are plans to develop a generalized logic of this type which will be able to present both the tutorial and inquiry types of lesson material.

The students described above have been given a pre-test to obtain an indication of previous knowledge; a post-test will be given to determine the relative effectiveness of the two methods of teaching used. The results of this work and a description of the modified logic will be included in a later report.

FORTRAN Programming for Business Students. During the past semester, nine students were processed using the logic for



Amplitude Scale (sine wave)
500 volts/division



Time Scale
0.5 microseconds/division

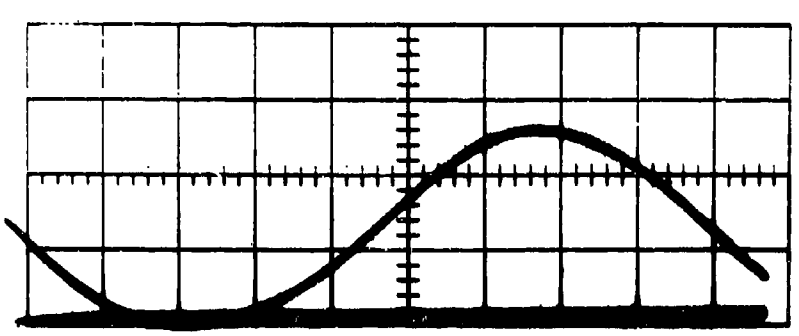


Fig. 4--Stages in turn-off of single cell in plasma display tube

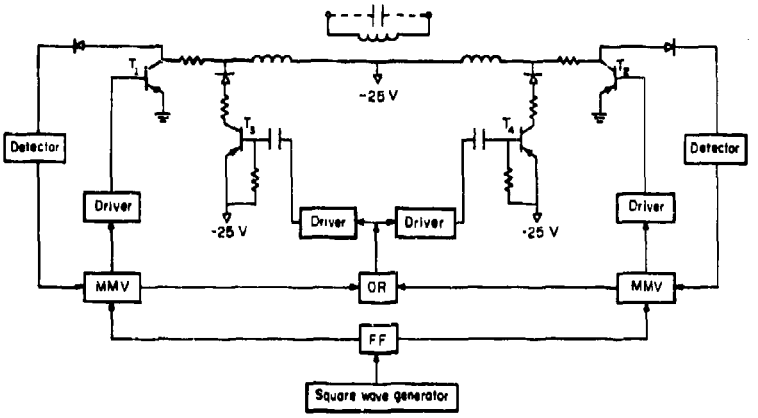


Fig. 5--Experimental generator for plasma display tube

teaching FORTRAN computer language developed during the summer of 1965. These students were also being given traditional classroom lectures dealing with the rules of the FORTRAN II language. A similar group received only the traditional lectures. Comparative measurements were obtained with respect to (1) the ability of the students to identify incorrect statements, (2) the ability to compose correct statements, and (3) the average number of attempts made by the students before their programs run successfully.

Plans are being made for two modifications in the project. One modification will allow for the fact that students make more keying errors as they proceed through the lessons. The errors have been traced to a difference between the PLATO keyset and the ordinary keypunch keyboard which is being used simultaneously for the preparation of programs. The other modification will involve the incorporation of on-line compilation capabilities into the PLATO logic. This will provide immediate feedback to the student regarding the grammatical validity of the individual statements and the logical validity of the program as a whole.

Library Science 195. The 12 students who took the introductory course in library science during the fall semester using the PLATO system completed the course. From all evaluations these students did just as well as those students taught by the conventional lecture method. Comments received from the students show that they enjoyed learning on the PLATO system.

It was decided to allow another group of students to take the PLATO version of the course during the second semester. Thirteen students enrolled in the class. More detailed analyses of the students' work will be made at the end of the second semester. The computer program for examining the students' responses has been written.

Methematics Instructional Projects

ARITHDRILL. The teaching logic for ARITHDRILL has been completed and debugged. The logic includes several new parameters of practice and provision for assigning values to these parameters individually for each student from a master "teacher's" keyset. The most important capability provided by the new parameters is that of supplying prompting information to the student according to five different sets of contingencies.

An exploratory 2-week trial has been completed which indicates that the basic program is effective, with most students, in maintaining learning behavior at the keyset for 50-minute sessions. This would appear to be an important result, since the "attention span" of these low-achievers is usually considered to be 15 minutes or less.

A program for reducing data from ARITHDRILL has been written and is being debugged. Student sessions on a regular basis will begin when time on the computer becomes available.

Man-Computer Interface Study. Student communication with PLATO is achieved by a keyset. Data are being collected to assess the relative efficiency of different configurations of keys and to compare keyset input with input by a more useful method, namely, longhand writing. An annotated bibliography of the relevant literature on similar research is also in preparation.

A Language-Free Test of Interpersonal Norms. This project, directed by Dr. Charles Osgood, involves the use of the PLATO system in the production of short, animated films. Each film strip, or scenario, will portray an interpersonal intention composed of discrete sequences of visual events (which are, in turn, identified with abstract, theoretical components). For example, size differences will be used to indicate power differences, speed will represent levels of activity, etc. Subjects' reactions to the films will provide information on the relative importance of these components in the interpretation of interpersonal behavior. Since the research material is language-free, it will also have fruitful application to the study of cross-cultural differences in normative behavior.

An initial program has been compiled in which the size, movement, location, and speed of the characters is controlled. A fine resolution CRT is being adapted for use with the PLATO system. Direct filming of the displays from the CRT should begin in late March.

Interaction Studies Group. A general PLATO program has been written that will facilitate group-interaction studies. Its first use will be in the Inter-Nation Simulation (INS) studies of Guetzkow, et al., on the PLATO system. The program provides for the following activities with regard to messages: writing and editing, sending, reading, and retrieving. The sending and retrieving are controlled by communication rules that in INS studies help define the roles of up to 20 decision-makers. The structure of the simulations and of the communications roles can be set in any way desired by the experimenter, or, if he so desires, by one or more of the players.

The program has been compiled and will be debugged in the next quarter. Decision forms and economic models can be inserted easily in the program as needed.

Project SIRA (System for Instructional Response Analysis)

Work has begun on a program to interpret requests for information about student responses in the form of a multiple-stage sorting routine which will select and store information from PLATO dope tapes needed to answer requests. It is expected that this program will form the central element in the developing system.

Work is nearly finished on the program called TEXT DOPE, which processes dope tapes and then, on request, plots graphs of time and errors against question number and lists student answers to questions in the lesson.

A new teaching logic has been designed and coding is nearly finished. This program, TEXT EDIT, plots questions for the student on the PLATO blackboard and has an author mode which permits on-line editing of these questions. This program also provides for auxiliary input devices, such as a Braille typewriter or apparatus (not yet available), on which a student can trace simple diagrams. It is expected that this logic will also form a part of the developing system.

THE CATO MANUAL

The CATO manual for use with the PLATO system has undergone a major revision and augmentation. It is organized in four major parts with an appendix and is written as an aid to all users of the system from the non-technically-oriented to the experienced programmers. Part I contains a brief general description of the functions of the PLATO hardware (electronic equipment), its relationship to the PLATO software (computer program), the operation of the system by student input, the relationship of the teacher and/or programmer to the system, and remarks on the preparation of material for the system. Part II describes the general operating procedures for the PLATO system. Part III is a section designed for the PLATO teacher or programmer who is writing his own PLATO program using the PLATO compiler (CATO). It is written in two parts, the first being detailed programming instructions, the second detailed compiling and editing instructions. Part IV discusses "doping" (student response records) procedures and analysis. The appendix, Part V, contains seven sections of more detailed information which might be desired by the experienced PLATO programmer. Preliminary copies have been distributed to present users of the system, and after revisions based on their reactions have been made, the CATO programming manual will be ready for general distribution.

Least Squares Calculation Computer Program

Aeronautical Materials Laboratory
Naval Air Engineering Center
Philadelphia, Pennsylvania

The Aeronautical Materials Laboratory, Naval Air Engineering Center, has been using a computer program for least squares calculation with probable errors after a method described by Birge.* The program is not unique, however, this particular application is. The subject of dilute solution of oxygen in alloys has been studied over a period of several decades and has a profound impact on the iron and steel industry. In the past, investigators drew a line through their data points with the best apparent fit. In order for the resulting conclusions to be valid, the lines must accurately reflect the true relationship between the data points. After this is done, additional calculations should be made to assess its statistical significance, to establish the precision of its slope, and to obtain a measure of the accuracy with which it predicts the dependent variable from the independent variable.

A routine was established whereby the data points for a series of runs were programmed into a computer which read out the equation for the least squares line with probable errors. This permitted the engineer to place real significance on all the sources of errors and compare them with the probable errors. This has been done with all thermodynamic studies made to date and the Aeronautical Materials Laboratory was one of the first to utilize a computer for applications of this type in published papers.

As an example, many investigators have reported that Henry's Law is not obeyed in dilute solutions of oxygen in pure liquid iron. The available information on the equilibrium constant versus oxygen concentrations was programmed into the computer for a least squares plot with probable errors and it was found that the slope that investigators claimed existed was less than the probable errors in the system. It was proved conclusively that Henry's Law was obeyed** and had an important influence on dilute solution studies.

Plans are underway to consider certain areas where computers could augment the attainment of objectives particularly in the area of solving engineering and scientific problems, systems engineering, and management. The main reason for considering scientific and engineering problems is to reduce the time spent by the scientific personnel solving problems and allow them to spend more time in interpreting the results and planning future experiments. The systems engineering will require more imagination, but the primary reason for thinking about this area is to be able to have rapid correlation and retrieval of information.

*R.T. Birge, "Least-Squares' Fitting of Data by Means of Polynomials," Rev. Mod. Phys., 19, 298-348 (1947)

**E.S. Tankins, N.A. Gokcen, and G.R. Belton, "The Activity and Solubility of Oxygen in Liquid Iron, Nickel, and Cobalt," Trans AIME, 230, 820 (1964)

Consolidated Data Processing

State of Nebraska
Lincoln, Nebraska 68509

Installation of a new computer system which will "assure continued efficiency and economy in Nebraska state government" was announced by Gov. Frank B. Morrison during March 1966.

The initial tasks of the IBM System/360 Model 30 will be State Accounting and Budgetary Control (ABC), coordination of welfare and medical assistance programs and more than 150 central accounting department jobs.

The Governor noted that installation of the new computer was one of the first major steps in implementing Legislative Bill 173, an act establishing the Department of Administrative Services for the purpose of consolidating the data processing tasks of 66 separate state agencies.

"This act is perhaps the most significant development in our state government since the Unicameral legislature was established in 1935," Gov. Morrison said.

According to the Governor, the new department's primary objective is to save tax dollars through efficient use of modern data processing technology.

"However, an equally important benefit is better utilization of human resources," he continued. "State agencies employ many highly qualified specialists who spend much of their time on administrative jobs. The new Department of Administrative Services will free these specialists from clerical routines."

Mr. Willard Townsend, director of the new state department, said the most efficient use of the System/360 depends on advanced programming support provided by IBM. He explained:

"When a computer must perform hundreds of different tasks, there is the time-consuming problem of switching manually from one job to the next. We must have a 'master program' that does this job automatically. This is where IBM's Basic Operating System comes into the picture.

"The Basic Operating System (BOS) makes possible efficient computer processing of many small jobs by storing computer instructions for each on a magnetic tape or disk. When each job comes up, a specially coded 'header' card calls the appropriate program from storage and transfers it in a split second to the computer's central processing unit. Once there, the program directs the processing of the current job and then is returned to storage, freeing the computer for its next task."

The director detailed the department's electronic data processing application areas. They include:

* Payroll for all 20,000 state employees. This involves 22 sub-applications, taxes, insurance, social security, and the like.

* State Accounting and Budgetary Control (ABC). This will be one of the nation's most advanced systems for integrated management of budgetary and fiscal matters. Included are all state warrant (check) writing (60,000 per month); expenditure management, assuring that appropriated money is properly spent; and receipt and disbursement accounting on a daily basis. Periodic summary reports also will be generated.

* Coordinating the welfare and medical assistance programs now handled separately by the 93 counties. This will involve writing on additional 25,000 checks each month. The result will be decreased state and county costs and, because of better accounting procedures, increased federal participation.

* Converting for the computer more than 150 jobs now performed on punched card equipment by the central accounting office. These include licensing, real estate transfers, health statistics, and so forth.

Mr. Townsend said that he envisions a statewide Tele-processing network linking selected agencies directly to the computer system.

Each agency, through its data communications terminal, will have direct access to the system to get answers or to have work performed," he said.

Governor Morrison concluded: "The real importance of the Department of Administrative Services and its computer will be their contribution to a better managed, more economical state government for Nebraska."

Emergency Bed Request System

Downstate Medical Center
State University of New York
Brooklyn, New York 11203

In March 1966 a computerized pediatric bed assignment system, to provide better distribution of patients in Brooklyn's hospital beds, was put into operation on an experimental basis.

Known as EMBERS (Emergency Bed Request System) the system, thought to be the first of its kind in the nation, electronically links nine Brooklyn medical centers. Its aim is to prevent delays in hospitalization of ailing infants and children and to distribute patients among the cooperating hospitals so that pediatric facilities are neither overcrowded nor underutilized.

The Computing Center for EMBERS is located in the Basic Sciences Building of the State University of New York Downstate Medical Center, 450 Clarkson Avenue, Brooklyn, Brooklyn-Cumberland Medical Center, The Jewish Hospital of Brooklyn, The Long Island College Hospital, Greenpoint Hospital, The Bedford-Stuyvesant Health Center, and Kings County Hospital Center.

Initial impetus for the bed request system came from Dr. Jonathan T. Lanman, Chairman of the Department of Pediatrics at Downstate

and Chief of Pediatrics at Kings County, one of Downstate's affiliated hospitals.

More than a year ago, he observed that while Kings County's pediatric wards often were seriously overcrowded, other hospitals affiliated with Downstate had underutilized pediatric beds.

Last summer a study committee consisting of representatives of each participating hospital was set up. It worked out the present system, which provides for assignment of each patient to an available bed within a matter of seconds.

Each of the participating medical institutions is "connected" by telephone lines to the Downstate Computer Center. Each time a pediatric patient is admitted to, or discharged from, any of the hospitals, the information is transmitted to the Computer Center from a terminal in the hospital.

A computer, in turn, stores in its "memory bank" the exact patient census information for all of the participating hospitals so that any any point it knows exactly where beds are available.

When a patient appears at a hospital which has reached 90 percent of pediatric bed capacity, the hospital reports to the computer and makes a "bed request," so that the patient may be admitted to another hospital.

With the bed request, the computer receives a "message" about the patient which includes identification information, his address, and whether he requires a medical or surgical bed.

This data is fed into an IBM 1440 computer at Downstate, which transfers it to an IBM 1410 computer. The latter has all the data stored concerning bed availability in each of the participating hospitals.

Within 10 seconds, the computer matches the patient's address with the nearest hospital that has an available bed. The computer then sends a message to the overcrowded hospital telling it where the patient should be sent. Simultaneously, the receiving hospital gets a similar message.

When the patient appears at the receiving hospital, the hospital informs the computer so that the computer can keep its data absolutely current. The computer then supplies the receiving hospital with an up-to-date recapitulation of its patient census, including this latest admission.

The pediatric EMERGENCY BED REQUEST SYSTEM operates on a 24-hour basis. Training for personnel at each hospital who use the necessary typewriter terminals and other equipment was supplied by Downstate Computing Center authorities. Director of the Downstate Computing Center is Stephen J. Siegel.

Dr. Lanman pointed out that pediatric bed demands in the past have created serious problems for many Brooklyn hospitals. While some hospitals, notably Kings County, have operated at up to 125 percent of capacity at times, other hospitals in the area have had only 50 or 60 percent of their pediatric beds filled.

He pointed out that between 1960 and 1965 pediatric outpatient visits at Kings County increased from 85,000 to 155,000 per year, and inpatient loads from 3300 to 4000.

Dr. Lanman said that pooling of pediatric beds had been tried successfully in England and in Germany. A number of Downstate staff members had seen the British and German programs in operation and provided valuable information about how to set up such a system.

Dr. Vincent Larkin, Chief of Pediatrics at Methodist Hospital, who was instrumental in launching the new service, is the medical coordinator of the system.

Dr. Joseph K. Hill, Vice President at Downstate, said that if EMBERS proves successful Downstate would consider the feasibility of setting up a system for adult medical and surgical beds with a group of Brooklyn Hospitals which could benefit most from computerized bed assignment.

Zip Code Reader

Post Office Department
Washington, D.C. 20260

In November 1965, Postmaster General Lawrence F. O'Brien inaugurated the Post Office Department's first high-speed optical "reading" machine.

The machine, unveiled at a ceremony in the highly mechanized Detroit post office, began reading printed or typed ZIP Codes on letters and sorting them at the rate of 36,000 an hour.

"We have entered a new era with the development of a high-speed optical ZIP Code 'reader'," the Postmaster General said, and "its capabilities

are phenomenal. It is the newest link in our chain of improved mail service."

Citing the present mail volume of more than 72 billion pieces annually, he said the new scanner "arrived at a crucial moment in our postal program." By 1980, he predicted, mail volume will reach 100 billion pieces a year.

The new ZIP Code reader, attached to an existing letter sorter machine, is 15 times faster than hand sorting.

In addition, the equipment ultimately will read the second line of the address and sort incoming local mail directly to the letter carrier delivery routes.

Mail that can be processed by the scanner may vary in size from 3 inches to 5 inches in height, and from 5 inches to 11-1/2 inches in length; thickness permitted is up to 1/4 inch.

In tests with live mail passing through the Washington, D.C. post office, a prototype reader installed in the Postal Engineering Laboratory accepted and read standard envelopes as well as envelopes with address windows and addresses affixed with gummed stickers with 99 percent accuracy. The machine does not read handwritten addresses, nor does any other machine in the world today. Postal engineers, however, are doing research in this area.

The reading machine unveiled is the first of four which will be installed in the Detroit post office. On order are two more to be installed in the new Buffalo, New York, post office by September 1966. Each reader system costs about $260,000. Following evaluation of the system in Detroit and Buffalo, plans are to install the equipment as soon as possible in other major mail processing centers where it is deemed justified in terms of cost and productivity.

The Post Office Department's reading machine is the first to be used by any postal service in the world.

The reader was developed in order to process more rapidly and accurately the millions of ZIP Coded letters that are now passing through post office daily. The system, attached to an existing letter sorter, is designed to sort incoming and outgoing machine-printed, ZIP Coded mail to 300 separations at a rate of 36,000 per hour. Also it has the capability of reading the second line of the address and sorting incoming and outgoing mail directly to the letter carrier delivery routes.

The "readers" are 15 times faster than hand sorting. They operate at about the same speed as 12 individuals operating the most sophisticated console-type letter sorting machine now in use.

A contract totalling $1.8 million was awarded to the Philco Corporation, a subsidiary of the Ford Motor Company, to build the ZIP Code "reader" and maintain it for a period of 24 months. The readers, including maintenance, cost about $260,000.

No postal employees are expected to lose their jobs. With a present mail volume of 72 billion annually and growing at a rate of about 2.3 billion a year, the Postal Service will need even more employees to move the mail.

The system now in use in Detroit is the first in the world. Other countries are, however, engaged in similar research, and our "know-how" is being provided to those countries upon request.

Adaptive and Self-Optimizing Control

Automatic Control Center
Purdue University
Lafayette, Indiana 47907

Two books by Professor Rufus Oldenburger, Director of the Automatic Control Center at Purdue University, Lafayette, Indiana have appeared this spring. Dr. Oldenburger is the principal investigator for ONR Contract Number Nonr-1100(20) on "Adaptive and Self-Optimizing Control." Various research results obtained under this contract are covered in these books. One volume is entitled "Optimal Control," and the publisher is Holt, Rinehart, and Winston.

In adaptive control the two major problems are identification and optimization. Once the system to be controlled is identified the problem is to adjust the controller to yield satisfactory and preferably optimal performance automatically. To obtain optimal performance, the problem of optimality must be solved. Thus given the system to be controlled and inherent limitations on the controller, such as the power available for control, the problem is to determine what "best"

control is possible and to build the controller to yield this best control. In the sense of the control engineer best in the case of one controlled variable means that the maximum error in the controlled variable is kept at a minimum, after a sudden disturbance the error dies out in minimum time, and so forth. In the Holt book the problem of the optimal control of a single variable is solved. As is normally the case, it is assumed that the power element of the controller is a servomotor whose speed is bounded. The output of the servomotor is the manipulated variable. Each controller is composed of "brain" and "brawn." The brain or computer part of the controller takes the measurement of the controlled variable, performs computations on this measurement and instructs the servomotor, or brawn, of the controller to vary the manipulated variable so as to give desired control. The manipulated variable is the controller output and at the same time the input to the system to be controlled. The time rate of change of this manipulated variable is bounded in practice. The control engineer has little or no control over this rate of change, that is servomotor speed. He must accept this, the system to be controlled, and the element that measures the controlled variable. With these as given entities the brain of the controller must be designed so as to give acceptable, or preferably optimal control. It is vital to solve the problem of optimality because the engineering scientist with the knowledge of what is best can then seek a practical compromise that is suboptimal, that is, as near to optimal as practical. In the Holt book it is proved that optimal control exists for systems of as high order as are of practical interest to industry. It is further shown that a single control function will do. With the present state of the art of digital computing techniques the reproduction of this function in actual equipment is feasible. Engineering compromises that have been employed in successful hardware are given in the volume. Work done on the ONR contract to extend the theory for optimal response to step disturbances to arbitrary disturbances is covered. Results for the case of the simultaneous control of two or more variables done on the ONR contract are included. The maximum principle of the Russian mathematician Pontryagin is covered in the volume.

The second book entitled "Optimal and Self-Optimizing Control" is a collection of leading papers on the subject published in the United States and abroad. The Massachusetts Institute of Technology Press is the publisher of this volume. Under the ONR contract Dr. Oldenburger compiled a survey of the existing literature on the subject, comprising over 300 published contributions. The volume begins with this survey. The survey is followed by 38 papers grouped into chapters entitled "Optimal Control of Systems with Unbounded Inputs," "Optimal Transients for Systems with Bounded Inputs," Minimization of a Functional for Systems with Bounded Inputs," "Statistical Methods in Optimal Control," and "Self-Optimizing Control." Optimal and self-optimizing control is the major area of research in automatic control today. The papers on optimal control are of two types. One is that treated in Dr. Oldenburger's Holt book where optimal is in the sense of the control engineer who wishes to keep the controlled variable at a fixed value or varying in some prescribed manner. The second type is optimal control from the viewpoint of guidance. Here the brain of the computer is chosen so as to minimize some functional, such as the fuel required in attitude control in bringing a satellite from one position in space to another. Here one is not looking at the error in the controlled variable or errors in the controlled variables, but rather a secondary property expressed as a mathematical functional. The errors may turn out to be very great. Nevertheless for analysis and design it is important to know the nature of the controller that will optimize the value of a secondary quantity. If necessary a compromise may then be made. The theory for optimal guidance in the case where controller outputs or their rates of change are bounded is a logical extension of the case where these quantities are unbounded.

The statistical approach to optimal control was largely inspired by the work of the late Norbert Wiener. Here the system disturbances are assumed to be random and defined by statistical functions, and optimality is stated in some average sense.

Self-optimizing control is concerned with the automatic search for the minimum or maximum or a function. Thus one may wish to control a gasoline engine so as to achieve maximum efficiency and hence essentially minimum cost of operation. In the search for an optimum point of operation digital computer techniques play an important role. At each instant during the search process the controller must decide how next to proceed. Included among the papers on self-optimization are a series by the Russian control expert A. Feldbaum on his dual control theory, which have been largely overlooked by American workers in the field. Dual control is adaptive control where the controller must first investigate and learn the characteristics of the system to be controlled or ways of controlling it, and in the second place it must direct the

system to the desired state, deviation from this state being measured by a loss function.

The M.I.T. volume is intended to show the beginner as well as control expert how the the area covered by the volume developed historically and mathematically and to bring the reader up to date on the present state of the field.

ADP Progress

U.S. Treasury Department
Internal Revenue Service
Washington, D.C. 20224

The automatic data processing (ADP) system of the Internal Revenue Service produced over $35 million in additional revenue during 1965, and offset $33.6 million in potential refunds of 178,000 business and individual taxpayers against unpaid tax balances of the same taxpayers.

A total of $70 million in additional revenues is credited to the ADP system since it became operational in 1962.

Business returns were processed on a nationwide basis for the first time in 1965, and processing of individual returns under ADP was introduced into a second IRS region.

In addition, 1965 saw activation of the IRS Data Center in Detroit, Mich. to handle centrally such Revenue Service programs and activities as payroll preparation, taxpayer compliance measurement, statistics of income, tax forms distribution, and management information reports.

Reporting on the highlights of the fourth year of operation of the ADP system, Internal Revenue Commissioner Sheldon S. Cohen said, "Some accomplishments were 'firsts,' but in the main we consolidated and capitalized on our previous gains."

A continuing byproduct of the Revenue Service's ADP system, voluntary disclosures, was noted again during 1965, when nine taxpayers filed 92 Federal tax returns covering $694,000 in previously unreported taxes, and indicated they were filing in anticipation of detection by the government's computers. One case involved a taxpayer who had failed to file income tax returns for more than 10 years. On advice of counsel, this individual filed his returns, and paid in excess of $450,000 in delinquent taxes, penalties, and interest.

Mr. Cohen cited other areas where revenue gains are expected to be substantial. These include mathematical verification, validation of estimated tax credits, duplicate return follow-up, and delinquency checks. These programs encompass both business and individual returns.

While it is difficult, before the ADP system is fully installed for every taxpayer in the country, to put a precise dollar tag on results, the programs now in operation and others being tested or planned indicate very tangible and substantial benefits ahead, Mr. Cohen reported.

The IRS experience with computers in 1965 continued to demonstrate that checking by high speed machines is faster, easier, and more comprehensive than the manual routine followed before the advent of ADP.

COMPUTERS BENEFIT TAXPAYERS AND GOVERNMENT

As a result of a delinquency check of individual returns by computer process in the southeast in late 1964, IRS has secured 14,000 delinquent returns and is investigating 80,000 other cases.

The individual returns secured were about equally divided between balance due and refundables, Commissioner Cohen reported. Over $600,000 in additional taxes due was reported and over $500,000 was claimed for refund. Consequently, both the government and the taxpayer benefited from this aspect of computer action last year. In 1966, a similar delinquency check for detecting failure to file by individuals is being extended to include the states of Pennsylvania, New Jersey, Delaware, Maryland, Virginia, and the District of Columbia.

The ADP system verifies the arithmetic on all returns filed, before they are placed in the master file. During 1965, net additional revenue from mathematical verification of Forms 1040 by service centers in the southeast and mid-Atlantic regions alone, is estimated at $9.5 million.

This figure is lower than normal, according to Mr. Cohen, due to unfamiliarity of many taxpayers with the minimum standard deduction which went into effect in 1964. About two out of three taxpayers who erred mathematically on their returns, did not claim the standard deduction which gave them the greatest tax advantage and reported more tax liability than they should have. IRS, however, through its ADP verification process detected the errors and refunded the overpaid amounts to the taxpayers.

Another taxpayer benefit from ADP applies to refund checks returned by the Post Office, generally because the taxpayer has moved and left no forwarding address. These checks are not redeposited by IRS and credit is restored to the taxpayer's account for offset against current liabilities or for refund upon receipt of a correct address.

During 1965, individual income tax returns filed by taxpayers in the southeast and mid-Atlantic regions were checked for audit selection under the ADP system. The computers were programmed to pass over the returns of taxpayers where the questionable items had been examined the previous year and found acceptable.

This means that generally a taxpayer will not be contacted from year to year for the same reason. Some 15,000 taxpayers whose returns were audited in 1964 were not audited in 1965 as a result of the innovation. This computer application to audit is being extended to the central, southeast, and western regions of the country this year.

OTHER DELINQUENCY LEADS GENERATED

A check on business returns in 1965, matching entries against the entities on the business master file, generated 1.2 million notices of non-receipt of tax return. From these were secured 465,000 delinquent business returns, with a tax potential of $93.5 million.

The delinquency check continues as a valuable means of keeping the business master file current and up-to-date. Entities no longer in business are removed from the file, information pertaining to class of tax liability is corrected, and elimination of multiple employer identification numbers to a single tax entity is now possible. This purification process reduces posting errors, and generally improves the accuracy of output. This all adds up to improvement of service to the business taxpayer.

SYSTEM CATCHES MISTAKES BEFORE REFUNDS ARE PAID

The $33.6 million from 177,000 overpaid tax returns which was offset during 1965 against other taxes owed by these taxpayers represented an increase of $16.9 million over the preceding year. The increase is due principally to the increased scope of the Revenue Service's ADP system.

The ADP system has a great potential for detecting and preventing duplicate refunds before the refunds are paid. Maximum results will not be fully realized until the individual master file covers the entire country. But the system's present ability to detect cases of duplicate filing before refunds are made is demonstrated by the 75,000 cases involving duplicate returns uncovered in the southeast and mid-Atlantic regions in 1965.

Approximately 30,000 of these cases represent unidentified amended returns or filing errors. But about 22,000 cases involved individual taxpayers filing a return for each of their withholding statements, Form W-2, obtained because they held more than one job during the year. An additional 23,000 cases were identical duplicate returns.

The Revenue Service estimates that $6.3 million in additional revenue came from disallowed refunds and increases in tax liability. Of this amount, $5 million was attributable to the multiple W-2 and identical duplicate cases.

VERIFICATION OF ESTIMATED TAX CREDITS

In the southeast region the ADP system provided an effective means to verify estimated tax credits claimed by taxpayers. In 1965 increased revenue from underpaid estimated tax and penalties is estimated at $11.4 million. This verification system, which can only be performed to a limited extent by manual methods, will also be operational under ADP in the mid-Atlantic area this year.

NATIONAL IDENTITY FILE

Recovery action on erroneous refunds issued is possible through existency of an interim file, the national identity file, being used until the individual master file of all U.S. taxpayers is complete. Duplicate filings detected by the computers, using the interim individual file

covering tax year 1963 and reported on in 1965, yielded an estimated $3.4 million in excessive refunds. IRS is now reviewing the file for tax year 1964, and expects similar results.

When the individual master file of all taxpayers is complete, each taxpayer will have a consolidated tax account reflecting his current tax status at any given point in time. This objective was accomplished last year with respect to business returns. For individuals, it is complete in two regions, and by 1967 will be complete for every individual taxpayer.

ADP operations in 1965 resulted in the identity of six substantial fraud cases currently being investigated, and three more cases whose additional taxes, penalties, and interest are expected to exceed $132,000.

DIRECT FILING PROMISES ECONOMY - SPEEDIER REFUNDS

Taxpayers in the southeast region in 1965 were offered the option of filing returns claiming refunds direct with the IRS service center in Chamblee, Ga. Nearly 4.5 million taxpayers exercised this option, thereby eliminating double handling for about 55 percent of all individual tax returns, which saved processing time as well as an estimated $50,000 to the government.

The option to file directly with a service center has been extended to taxpayers in the mid-Atlantic region in the current filing period. Taxpayers in Pennsylvania, New Jersey, Delaware, Maryland, Virginia, and the District of Columbia, who expect refunds, may file with the IRS service center in Philadelphia.

Legislation has been introduced which would enable the IRS to require direct filing of all returns with the service centers in all regions of the country. The economies expected from such legislation have been projected to about $3.8 million annually on a national basis. If the legislation is enacted, direct filing will be phased in over several years, much as the ADP system itself is being installed.

MAGNITUDE OF ADP OPERATIONS

The nationwide business master file now consists of 5.3 million accounts. Individual master file accounts now total 19.3 million, for both southeast and mid-Atlantic regions.

In 1965, the ADP system processed a total of 17.4 million business returns, and filed a total of 19.2 million individual returns and estimated tax declarations.

Commissioner Cohen emphasized one of the ADP system's principal benefits as that accruing to the taxpayer. "The expanding processing capabilities of the system not only enable us to insure that the taxpayer pays his fair share of the tax burden, but permit us also to detect and initiate corrective measures in those instances where he has erred to his own disadvantage."