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# DIGITAL COMPUTER NEWSLETTER

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

**OFFICE OF NAVAL RESEARCH · MATHEMATICAL SCIENCES DIVISION**

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# Editorial Policy Notices

## 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 precent publishing all the material received. However, items which are not printed are kept on file and are made available to interested personnel within the Government.

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

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

## CONTRIBUTIONS

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

## CIRCULATION

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

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

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

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All communications pertaining to the Newsletter should be addressed to:

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# Computers and Data Processors, North America

## B300 Multi-Processing

*Burroughs Corporation*
*Detroit, Michigan 48232*

In July 1965 Burroughs Corporation conducted a successful series of demonstrations emphasizing the power and versatility of an unusual two-processor B300 computer system in multi-processing and time sharing.

The random access data communications configuration of Burroughs new B300 series—the industry's first moderately-priced multiple-processor computer system—simultaneously handled continuous on-line teller transactions and on-line integrated inventory and accounting. While these applications were running, the system also processed input from punched paper tape produced by an E2190 electronic direct accounting computer.

At the heart of the on-line applications was a Burroughs random access electronic disk file shared by the two-processor system. Actually, in both on-line and general purpose computer configurations, as many as four B300 processors can share a disk file.

For the demonstrations, the twin B300/disk file system stored more than a million characters of memory, showing the feasibility of utilizing the disk file as a practical extension of the processors' core memories. Each processor has 9.6 thousand characters of core memory.

Access to any record throughout the file is by electronic switching in an average time of 20 milliseconds. The "head-per-track" design of the random access file eliminates mechanical arm positioning, card drops, and all other mechanical accessing movements that have been responsible for the previous slowness of disk file access.

In the on-line teller system demonstration, the B300 was used as the central processor and the on-line disk file as storage for account records and programs. Located some distance from the computer was the Burroughs on-line teller console, where transactions were originated and where processed information was printed out.

The other major application performed by the processor/disk file system was a data communication network of two dial TWX units and a Teletype typewriter. Visitors were invited to operate the equipment, sending inquiries and transaction information into the disk file and receiving printed results.

Here is a listing of transactions and inquiries demonstrated by the two-processor B300/disk file system:

### MULTI-FILE INVENTORY AND ACCOUNTING TRANSACTIONS

Product Sale (this single input transaction from a remote source causes up to 20 accesses to related records in the disk file)

- Updates inventory file, reducing quantity on hand and quantity reserved
- Applies standard cost to issue quantity to give extended value at cost
- Posts cost value of the inventory reduction transaction to the accounting files
- Applies sales price to issue quantity to give extended value of the sale
- Posts the sale transaction to the accounting files
- Updates the management reporting files reducing total inventory value on hand and reserved
- Posts the sale to the customer's record in the accounts receivable file

Stock Receipt—Purchase

- Updates inventory file, increasing quantity on hand and reducing quantity on order
- Extends quantity received by standard cost
- Posts the receipt transaction to the accounting files
- Updates the management reporting files, increasing total inventory value on hand and reducing total value on order
- Posts the receipt to the vendor's record in the accounts payable file

Payment Received From Customer

Records payment received in the customer's record in the accounts receivable file
Posts the payment transaction to the general accounting files

Payment Made to Vendor

Records payment made in the vendor's record in the accounts payable file
Posts the payment transaction to the general accounting files

Journal Entry Posting

Debits designated account and department; credits designated account and department

Stock Reservation

Increases the quantity of stock reserved in the inventory file
Updates the quantity of stock available in the inventory file
Applies standard cost to the quantity reserved to give extended value of the reservation
Updates the management reporting files, increasing the total value reserved and adjusting the value of the available stock

Stock Issue

Updates inventory file, reducing quantity on hand and quantity reserved
Applies standard cost to issue quantity to give the extended value at cost
Posts the inventory reduction transaction to the accounting files
Updates the management reporting files reducing total inventory value on hand and reserved

Stock Order—Purchase or Production

Updates the inventory file, increasing quantity on order and adjusting the quantity available
Applies standard cost to the purchase or production quantity to give extended value of the order
Updates the management reporting files, increasing the total on order value by the value of the order commitment, and adjusting the total value of the available stock

Stock Order Deletion—Purchase or Production

Updates the inventory file, decreasing quantity on order and adjusting quantity available
Applies standard cost to the order deletion quantity to give extended value of the order cancellation
Updates the management reporting files, decreasing total on order value by the value of the order cancelled and adjusting the total value of the available stock

Stock Receipt From Production

Updates the inventory file, increasing quantity on hand and reducing quantity on order
Extends the quantity received by standard cost
Posts the receipt transaction to the accounting files
Updates the management reporting files, increasing total inventory value on hand and reducing total value on order

INVENTORY INQUIRIES

Full stock status with price and location
On hand quantity
On order quantity
Description
Reserved quantity
Price
Available quantity
Location
Show record

ACCOUNTING INQUIRIES

Department expense totals
Account balance
Selected account balance for a given department
Account description

MANAGEMENT INQUIRIES

What is total value of inventory
What is total open order balance
What is total demand value
What is total available inventory value

REMOTE PRINTOUT REQUEST

Print financial reports
Print department expense reports for a designated department

Print inventory dollar value report
Print customer statements
Print accounts payable reference
Print accounts receivable reference
Print departmental expense reference

ADDITIONAL ACCOUNTING TRANSACTIONS

Add new accounts to accounting file
Add new departments to accounting file
Add new customer record to accounts receivable file; inquire into customer record for name, address, credit rating, balance, or entire file
Add new vendor to accounts payable file; inquire into vendor record for name, address, terms, balance, or entire file

ON-LINE TELLER SYSTEM TRANSACTIONS

Cash deposit
Withdrawal
Deposit, with automatic passbook updating of dividend
Withdrawal, with automatic passbook updating of dividend and previous no-book transaction
Check deposit with automatic computer hold for uncollected funds
Withdrawal attempt against uncollected funds, with computer enforcement of hold
Supervisory removal of hold, and override withdrawal
Detection of teller errors: incorrect account number, incorrect passbook balance, incorrect passbook alignment
Automatic spacing of passbook over centerfold
Passbook mortgage payment

ON-LINE TELLER SYSTEM INQUIRIES AND TOTALS

Request for abbreviated account status: account balance, available balance, net deposits, hold status, and previous transaction information showing type, date, and teller
Request for detailed account status: abbreviated status information plus dividend loan amount, unposted dividends, and amounts held for local and out-of-town checks
Monthly analysis balances: account balance, dividend loan amount, four dividend dollar-month balances
Teller totals from mechanical accumulations in the Teller Console and from computer accumulations

## B8500 Modular Data Processing System

*Burroughs Corporation*
*Detroit, Michigan 48232*

The B8500 is a dynamically modular, very large scale information processing system which utilizes the latest technological advances in monolithic integrated circuitry and thin film memory to achieve extremely fast and versatile computing power.

The system is intended for the user whose computational and communications needs are more complex and demanding than can be effectively solved by a conventional approach to electronic data processing, or even by dispersed multi-computer installations.

Inherent in a system which can accomplish this goal is the necessity for efficient multiprocessing, time sharing, and true modularity. The practicality of these features, thoroughly proved in scientific, commercial, and management data processing applications by Burroughs D825, B5000, and B5500 information processing systems, has been extended and translated into the advanced design of the B8500 system; see Figs. 1-3. A typical small B8500 System might include 1 computer, 3 memory and 1 input/output module to service 2 disk files, 13 tape units, as well as other random access equipment, and a console. The data transfer rate for such a system would be approximately $71.5 \times 10^3$ characters per second. The I/O is capable of handling many more peripheral devices as shown by the 466 spare channels.

The unique modular system organization, developed by Burroughs Corporation and proved in use by B5500 commercial (see DCN, January 1965) and D825 military data processing systems (see DCN, April 1964), has been extended to the very large scale B8500. This organization permits multiple computer and I/O modules to share fully in the memory, making effective multi-processing practical. In the B8500, as

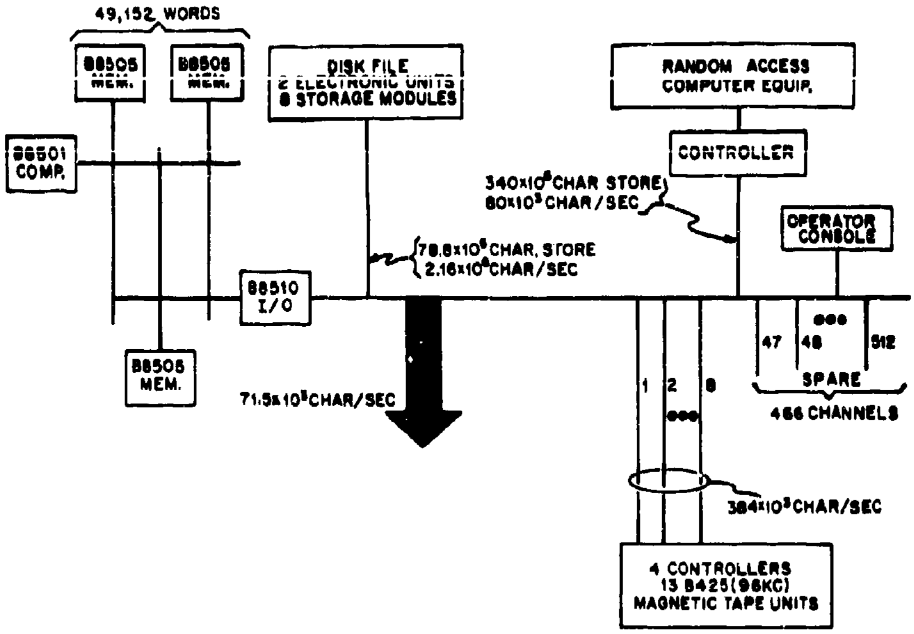


Figure 1—Typical B8500 system

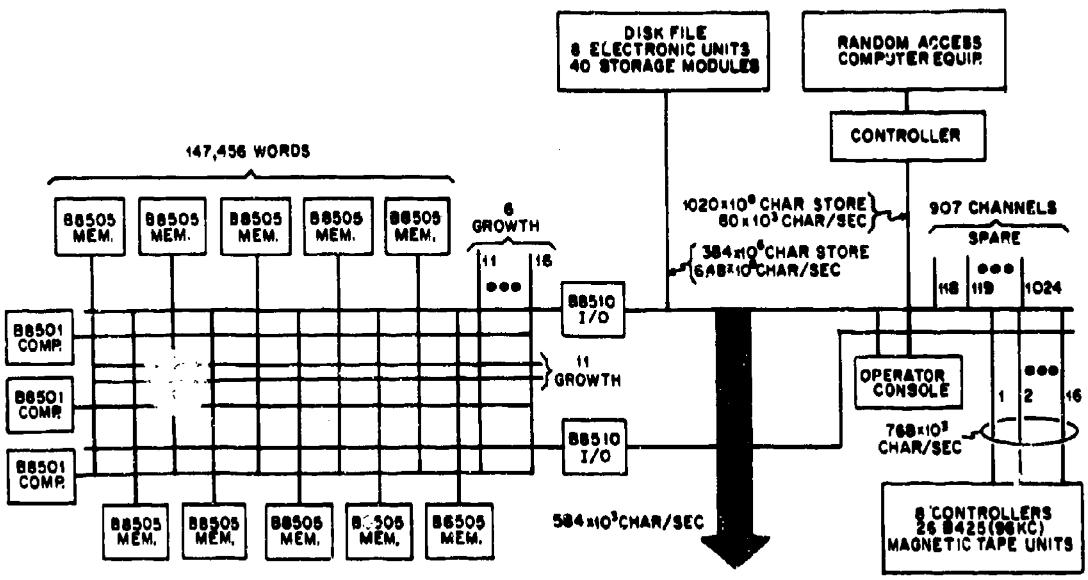


Figure 2—Further expanded B8500 system

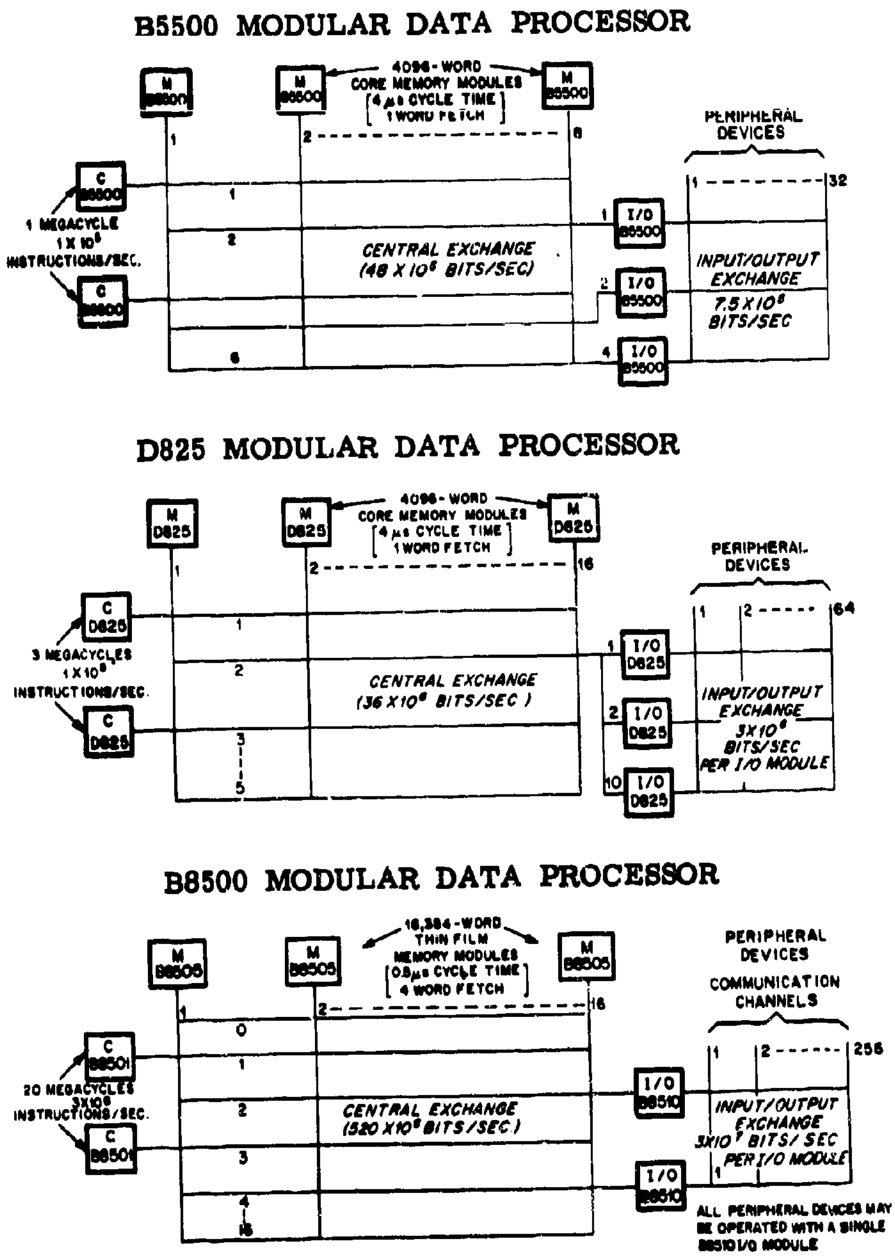


Figure 3—Modular data processors

many as 16 memory modules and a combination of up to 16 computer and/or I/O modules can be interconnected to provide a data transfer rate of $520 \times 10^6$ bits per second.

Typical of applications for which the B8500 can be used effectively are centralized management information processing, large time-sharing requirements, real-time communications, store and forward message processing, centralized or decentralized scientific and engineering communications, and military command and control.

In order to handle these requirements effectively, certain system capabilities are necessary. These are:

- System flexibility for growth and modification
- Real time response to external stimuli
- High system reliability with minimum module down time
- Dynamic responsiveness to human operators and users at dispersed locations

These capabilities are realized in the B8500 through the inter-relation of hardware, software, and organizational concepts embodied in these features:

- Extensive executive program
- Modular software
- Multi-programming and multi-processing for increased throughput
- Capability for multiple, simultaneous, high speed input and output
- System expansion
- High system reliability and availability
- Extensive interrupt and external request capability
- Efficient use of storage

## EXTENSIVE EXECUTIVE PROGRAM

The executive program supervises the compilation of all programs to generate data and program objects in a format that permits the most efficient handling by the executive program. Memory bounds and dynamic storage protection permit programs to be debugged while production programs are being executed.

The executive program is written to handle the maximum B8500 system configuration (16 memory modules and 16 processor or input/output modules). This approach permits automatic self-regulation as configurations change and provides the basis for automatic scheduling around any malfunctioning module.

## MODULAR SOFTWARE

Modular software makes it easy to add or modify functions in order to advance to new modes of controlling and processing problems. The segmentation of a job—organizing it into a number of data and program objects which do not need to be in main memory at the same time—permits jobs to be run with much less memory than would normally be required. This is particularly important in on-line real time applications where the sequence of jobs is constantly changing, and where multi-programming is essential to achieve the greatest equipment utilization.

## MULTI-PROGRAMMING AND MULTI-PROCESSING FOR INCREASED THROUGHPUT

Multi-programming in the B8500 is essential for making the most effective use of the system's high-speed processing capability. Programs are run when all necessary information has been assembled on the high-speed disk file, but while any given program is waiting for additional input from disk, other jobs can be activated. Waiting time is therefore not wasted time. Multi-programming also occurs when programs are shared by more than one user program. During periods of extensive compiling, for instance, two or more compile jobs might be multi-programmed at the same time from a single copy of the compiler in main memory.

Multi-processing occurs at many levels in the B8500. I/O operations occur almost completely independently of the processor module, and in parallel with processor module operations. Multi-processing occurs in multiple processor installations, so that two processor modules almost double the throughput of the system. In addition, its unique internal organization permits multi-processing within a single processor module and gives more efficient execution of single and multiple programs. Memory processor operations can also occur independently of the other system operations. The B8500's instructions facilitate such operations as list searching.

## CAPABILITY FOR MULTIPLE, SIMULTANEOUS, HIGH SPEED INPUT AND OUTPUT

Up to 512 simplex peripheral channels may be buffered and controlled by a single input/output module, handling peripheral devices such as card readers, magnetic tape units, teletype equipment, display devices, and so on. Additional devices can be handled if the I/O channels are multiplexed. The I/O module contains an independent processing capability which minimizes the amount of computer monitoring. One of the primary functions of the I/O module is to enter automatically into high speed disk files the low speed data coming from external peripheral devices. The central processor thus services peripheral devices from the high-speed disk file, thereby increasing the total efficiency of the system.

## SYSTEM EXPANSION

The B8500 computing system was designed for easy expansion as needed. Processor, memory, and I/O modules can be added and begin operation immediately without interruption to the system. All software is written to utilize the equipment available at a given moment in any system configuration. If more equipment is made available through expansion, greater throughput is realized.

The B8500 system might typically be further expanded to include 3 computers, 10 memory, and 2 input/output modules which service 8 disk files, 26 tape units, as well as other random access and console equipment, Fig. 2. The data transfer rate for such a system would be $584 \times 10^3$ characters per second with 907 I/O still available. Any combination of 11 I/O modules or computer modules and 6 more memory modules could still be added to achieve a maximum configuration.

## HIGH SYSTEM RELIABILITY AND AVAILABILITY

The highly advanced circuit and memory techniques, in conjunction with the unique interconnection network in the B8500 computing system, provide extremely high availability and reliability. The interconnection network permits the various functional modules to communicate simultaneously without restriction. This network is distributed among the units it services and exists as part of the functional module. The system, therefore, adjusts to any change in its configuration. Thus, if there are at least two modules of the same type in the system, the system will remain operative even though one module is not available. Throughput will continue, but at a proportionally reduced rate.

## EXTENSIVE INTERRUPT AND EXTERNAL REQUEST CAPABILITY

The B8500 has a comprehensive interrupt system utilizing condition and mask registers to control interrupt conditions. An interrupt processor program determines what action is to be taken for each of the interrupt conditions.

External requests for service are specially encoded for fast recognition by the I/O module. I/O service programs communicate directly with peripheral equipment and begin the necessary response to the request. If the request requires processing in the computer module, an interrupt is passed on to the processor for the proper scheduling of the request for service.

## EFFICIENT USE OF STORAGE

The B8500 system utilizes a hierarchy of memories ranging from the 0.1 microsecond cycle thin film memory in the computer modules, through the high speed disk file system, to tape storage. Throughput is maintained at a high level by balancing the flow of information among these various memories. The B8500 executive program manages this information flow so that data is available in high speed (0.5 microseconds) main memory storage when required by the operational program.

Look-ahead logic transfers data and instructions from 0.5 microsecond memory to 0.1 microsecond memory for execution. The 0.5 microsecond main memory communicates with the next level in the hierarchy, namely the fast disk file system, which has an average transfer time of 5 microseconds per word. In general, the executive routine collects programs and data in the disk file before initiating their execution. As much data as is needed at any one time is then brought into the 0.5 microsecond main memory by the executive program.

## HARDWARE CHARACTERISTICS

The flexibility inherent in the modular organization of the B8500 enables Burroughs to offer a system tailored to meet specific computational requirements. The growth potential of a minimal B8500 results in an increase in productivity by a factor of at least ten. This balanced growth is accomplished with no changes to existing programs or operating procedures. The economical expansion achieved provides greater throughput and lower cost per unit of computation.

Advanced system and hardware techniques are implemented in the B8500:

The unique concept of modular system design provides an inherent ability to extend the useful life of the equipment due to the flexibility of application through reconfiguration of the system by modules, and the modest cost to modify system modules to incorporate proven technological developments as the need arises.

The B8500 is fabricated with integrated circuits. The circuits themselves are integrated versions of the discrete circuit which has been the Burroughs standard in the past. The integrated version of the circuit retains its high speed characteristics plus the inherent greater reliability of an interconnected monolithic array. The system maintenance and reliability is greatly enhanced.

Thin film memory is used for the main computer store. The thin film memories have been field-proven since their introduction by Burroughs and have the unique advantage of extremely high-speed performance along with high reliability.

B8501 Computer Module

The B8501 computer module is the latest and most powerful of the Burroughs family of modular systems. It represents the most recent state of the art techniques in system, circuit, and memory design.

The computer module, in employing multiprocessing and look-ahead techniques to greatly increase processing speeds, remains consistent with the fundamental design principles of previous Burroughs computers. In this regard, the computer has retained such features as:

- An arithmetic stack for automatic call-up of operands
- A variable syllable instruction format and a 48-bit operand
- Independent computer, I/O, and memory modules
- The incorporation of a local scratch pad memory

To this traditional and proven procedure of program execution, the concept of multiprocessing has been judiciously applied, effectively eliminating many of the time-consuming procedures of data and instruction fetches, stores, address modifications, etc. Paramount among these features are the following:

- Instruction Look-Ahead—A fast-access (35 nanoseconds) buffer area in local memory
- Associative Indexing—Permits any memory word to be used as an index word rapidly and completely automatically
- Stack Extension—Permits the arithmetic stack to be pushed down in local memory to a depth of 16 words without recourse to main memory storage.

B8510 Input/Output Module

The input/output module provides the necessary interface control and buffering between the peripheral equipments and the memory and computer modules. Up to 512 simplex peripheral channels may be buffered and controlled by a single I/O module.

I/O module functions include:

- Independent and interlacing channel operations
- Storing or fetching to or from main memory
- Accumulating a word in a variety of byte sizes
- Testing for word count and character coding
- Modifying the main memory address field
- Sequencing descriptors for extended I/O operations

The combination of descriptor word flexibility, and a rapid channel servicing cycle have made the I/O an outstanding channel of the B8500 system.

It is important for the descriptors to control the flow of data into and out of the system minimizing the amount of computer monitoring. In this respect, the I/O is semi-autonomous. Thus, data is neither slowed down for lack of I/O response nor is the computer hampered by a continuing need to supervise every detail of each of the many I/O transactions.

B8505 Memory Module

The B8505 Memory Module is a 16,384 word memroy, 52 bits per word, with a full cycle time of 500 nanoseconds. Words can be stored or fetched in four-word groups so that the maximum data rate possible for a single memory module is $416 \times 10^6$ bits/second.

The speed of main memory is the result of Burroughs continuing development and progress in the field of thin film memories. The basic thin film stack and electronic circuits have been used in the D830 Developmental Computer System, a B8500 predecessor. Every phase of the memory fabrication from the film deposition process to electronic circuit design is performed at the Defense, Space, and Special Systems Group facilities of Burroughs Corporation.

In addition to the raw speed capabilities of the memory, a selection of powerful logic operations have been installed in the memory module.

The B8500 system permits expansion up to 16 of these modules for a total of 262,144 words, each of which is randomly and directly addressable.

### B8500 Disk File System

The average access time of the disk file is 20 milliseconds. The transfer rate is 10.4 million bits per second. Two important design features of the disk file system have made such speeds possible.

- A head-per-track organization, eliminating the need for mechanically positioned head assemblies.
- A paralleled read/write operation which accesses eight tracks simultaneously.

The disk file storage modules that are utilized in the B8500 disk file system are mechanically identical to the highly successful commercial disk storage unit used in the Burroughs B5500 and B200/B300 series computers. Up to 50 storage modules may be included with each B8500 system for a total of 60 million 52-bit words of storage.

The disk file is very important to meet economically the total system requirements because of the speed and ease with which data and programs may be made available to main memory. Without the disk system, main memory would have to be prohibitively large.

## SOFTWARE CHARACTERISTICS

The B8500 Operating System consists of an Executive Scheduling Program (ESP), service programs (such as I/O procedure), and compilers for ALGOL, FORTRAN, and COBOL. Modularity makes the basic software design and construction much easier, but more important is its flexibility for changing to new modes of controlling and processing computing requests. The dynamic and diverse environment of on-line systems prohibits the use of an operating system whose functions are inextricably interwoven in a monolithic block of code. The B8500 operating system is therefore designed so that an independent module of code and its relation to other modules is well defined so a function can be changed easily without affecting other functions.

The total software package is composed of a collection of small segments or modules. At any given time in the execution of the program, only the active segments need to be in memory; large contiguous areas are not required. Therefore, programs can be run with varying amounts of memory.

Program segments operate independently of their location in memory so that during the course of a job, program segments may be executed from several different places in memory. This movement of program segments in memory requires no modification of the segments. This flexibility in the utilization of memory is especially important with on-line systems where there are many concurrent users.

### Executive Scheduling Programs

The principal function of the ESP is to allocate dynamically equipment modules, such as processors, memory, and I/O channels, to a constantly changing set of jobs. This achieves a high degree of utilization of the total system. Sharing equipment modules among many programs is generally called multiprogramming. The ESP goes a step further by multiprogramming a set of jobs that consist of both user requests and operating system functions.

All of the operating systems, including the compilers, are written in extended ALGOL. The advantages of using ALGOL are speed of writing program, ease in making modifications, provision of good documentation and reduced programming time, all of which contribute to concise source programs.

Memory protection and an extensive file system are also included in the operating system. This filing system provides reference to files and file items by name rather than absolute location or storage medium.

### Compilers

The B8500 Extended ALGOL compiler uses the compiling technique known as recursive descent syntactic analysis. This technique, proven in the B5500 ALGOL compiler, compiles quickly, makes modifications easier and produces good object code. B8500 extended ALGOL implements virtually all of ALGOL 60 and provides extensions for I/O operations, partial word operations, string manipulation, and diagnostics.

The B8500 FORTRAN IV compiler implements the A.S.A. FORTRAN IV language. The compiling is done in one pass using conventional precedence scan techniques. The hardware stack in the B8500 makes this type of analysis very fast. Library programs written in EXTENDED ALGOL can be called in FORTRAN making it unnecessary to include any assemble language coding.

The B8500 COBOL compiler implements D.O.D. COBOL 61, Extended. All the additional features in B5500 COBOL are also included in B8500 COBOL. In addition, data segmentation and the ability to compile program segments independently are also included. The character operations in the B8500 are well suited for working with character fields as required in COBOL.

## Automatic Drafting with Expandable Stored Program Control

*Airborne Instruments Laboratory*
*Division of Cutler-Hammer*
*Deer Park, New York 11729*

A numerically controlled drafting machine that automatically translates complex mathematical formulae within minutes into precise detailed engineering drawings is now being manufactured in a joint program between the Universal Drafting Machine Corporation, Cleveland, Ohio and Cutler-Hammer's AIL Division, Deer Park, New York.

The automatic drafting machine called ORTHOMAT, together with the numerical control system called DECAMATIC, Expandable Stored Program (ESP) Control, is the newest equipment in the field of numerically controlled engineering drafting systems.

This automatically controlled drafting system produces detailed graphical presentations within minutes or hours. Prior to the development of a numerically controlled automatic drafting system, engineers had to plot designs and layouts manually; this took days, weeks, and even months before making a final decision on design suitability. An error in the initial design criteria meant that the entire design process had to be repeated.

The application of numerically controlled engineering/drafting machines has been expanding rapidly since their first application in the aerospace field in 1962. The use of these machines has extended to the automotive industry, architectural, and civil and marine engineering fields, and is becoming an essential element in a wide variety of computer-aided design applications. With its high-speed capability of accurately reproducing engineering data and designs in a wide variety of applications, the use of the automatic drafting machine is already a "must" in the highly competitive aerospace and automotive fields.

This increasing scope of applications has resulted in tremendous demands on the drafting machine control system in the direction of increased versatility and faster operation. Economy of computer time in the preparation of input data for an automatic drafting machine is becoming a significant item in the cost justifications for the drafting machine and its control system.

The availability of this new system has expanded on the versatility of all other automatic drafting machines without sacrificing line quality or accuracy. The overall numerically controlled drafting system has a built-in Expandable Stored Program Control designed to provide versatility of operations because of its ability to store a wide variety of operating programs and subroutines.

The DECMATIC-ESP Control system translates all of the built-in commands into a continuous flow of orders to the ORTHOMAT which automatically responds with an accuracy and speed never realized before by any other means.

### HOW THE SYSTEM WORKS

An operator can now sit at a typewriter keyboard and directly request engineering details from a large library of stored programs in the memory of the ORTHOMAT drafting machine. The same keyboard permits the operator to change programs, revise operating subroutines and insert additional commands into the control memory. Punched paper tape, punched cards, or high-speed magnetic tape can be used to supply input data to the system.

Flexibility of operation is further enhanced by the ability of the DECAMATIC's ESP Control to accommodate almost any input format. As applications for the drafting machine expand with user experience, the stored program can be flexibly updated to keep pace with the new applications.

The Expanded Stored Program controls provide linear interpolation based on line end-points, circular interpolation based on the co-ordinates of the center of a circle and its radius and end points, parabolic interpolation based on end points and mid point, and supply feedrate control to the drafting machine based on line length and direction with automatic acceleration and deceleration of the pen carriage. Automatic generation of dashed lines, automatic generation of center lines, and variable axis scaling are some of the standard features available with this control. Its mirror-image capability permits both halves of a symmetrical part to be drawn from a definition of one half alone, or permits the drawing of a part that is a mirror image of the part defined in the control information. The computational capability of the control provides a facility for figure rotation by trigonometric means.

While the primary purpose of the DECA-MATIC-ESP Control system is the control of the ORTHOMAT drafting machine stylus, it also provides an output to the typewriter, paper tape punch, or magnetic tape. The flexibility of the stored program control permits the drafting machine to be used as a digitizer without any duplication of equipment. For this use, the machine is provided with optical accessories that let the operator control the position of the ORTHOMAT carriage so that the line being digitized is centered in a precision reticle.

The following illustrations, Figs. 1-3, are examples of automatic drafting.

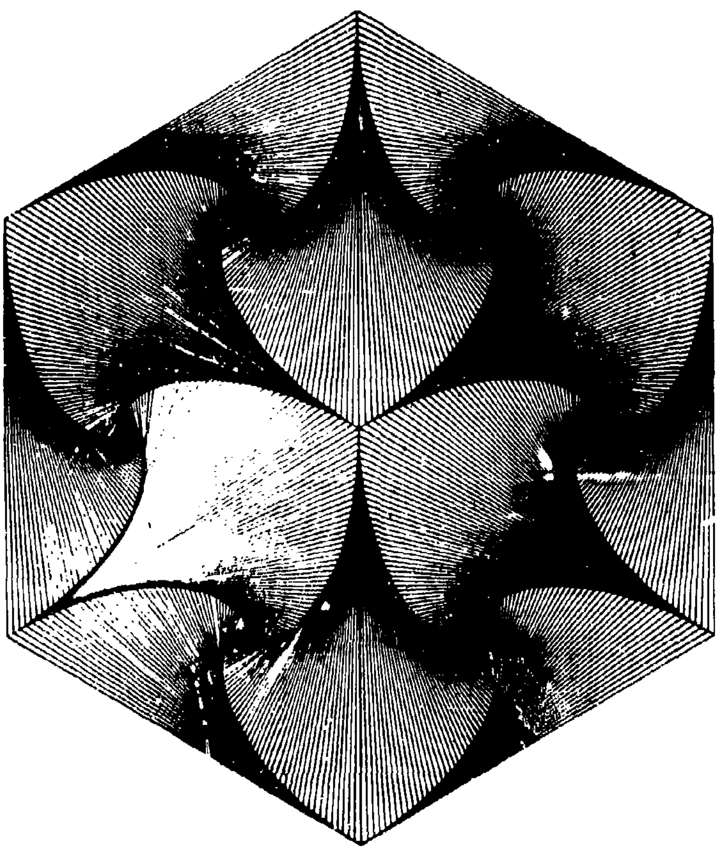

Figure 1—Computerized automatic drafting produced this drawing of a computer check study

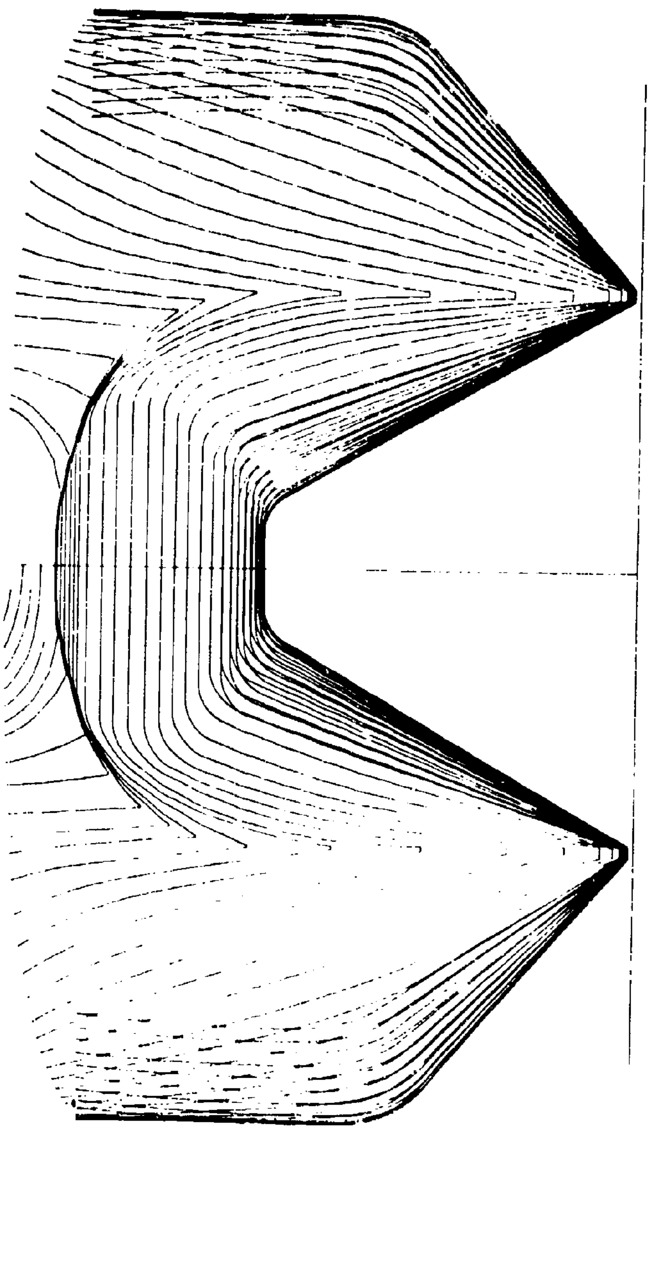

Figure 2—Computerized automatic drafting produced this drawing of a twin hull for Boeing

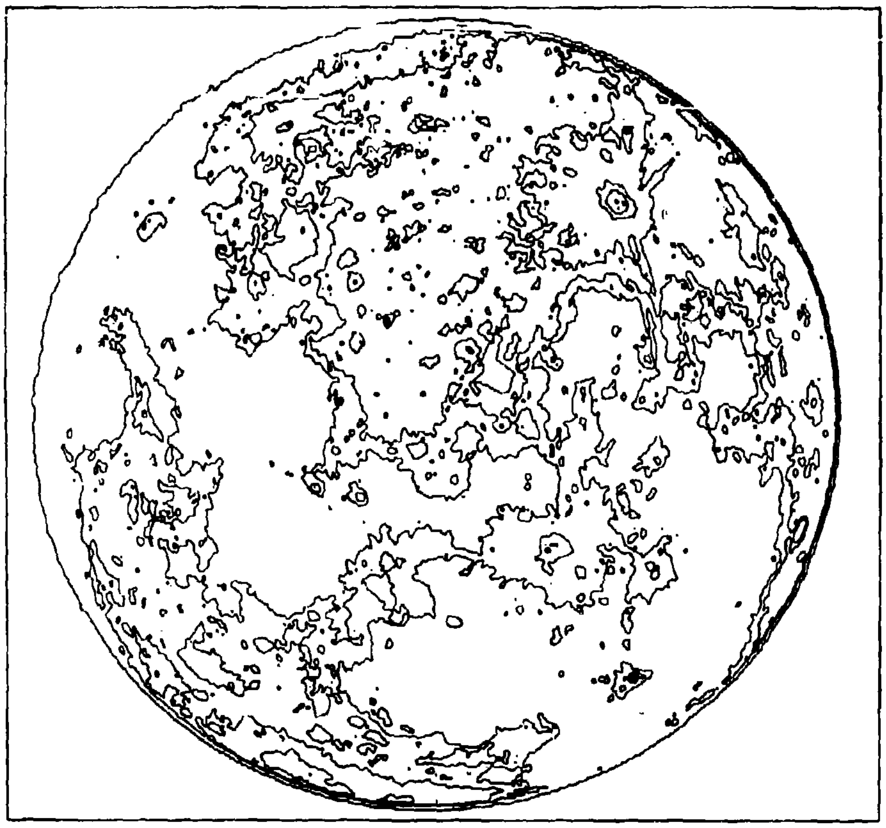

Figure 3—Computerized automatic drafting produced this drawing of a lunar scan for Boeing for the Lunar Scan Program 37G-PM

## CLOSED-CIRCUIT TELEVISION

To fill the low-volume, occasional requirements for a digitizer a direct-viewing telescope is used. For high-volume digitizing operations, a high resolution closed circuit television system provides the operator with an enlarged view of the line being digitized centered in the reticle, displayed at a convenient angle on an operating console. Seated at this console, the operator has precise vernier control of the position of the television vidicon tube mounted on the ORTHOMAT carriage. The operation is made faster and easier by an automatic incrementing facility that duplicates the previous increment. An operator can digitize up to 40 or more points per minute for extended periods of time without eye strain or fatigue.

## HIGH-SPEED CONTROLS

With its high-speed operation and powerful computational ability, Cutler-Hammer's new DECAMATIC-ESP Control produces tapes complete with machine tool feed-rate numbers, machine tool preparatory and miscellaneous function codes, cutter offsets, and verifies the machine tool control tape by drawing the cutter path. When the drafting machine is equipped with accessory equipment for digitizing, complete control of the tape preparation for many machine tools is provided by the DECAMATIC-ESP Control System.

## DEVELOPMENTAL HISTORY OF MARK II UDM ORTHOMAT

In 1962, the Universal Drafting Machine Corporation (UDM), Cleveland, Ohio, introduced the N/C-controlled ORTHOMAT drafting machine to provide fast, accurate, large scale drafting from punched tape. The N/C systems used were essentially modified machine-tool control units, and the superiority of the concept of a drafting machine working with standard N/C

# DECAMATIC EXPANDABLE STORED PROGRAM CONTROL

## SPECIFICATIONS

### CONTROL OPERATIONS

| | STANDARD | OPTIONAL |
|---|---|---|
| CORE MEMORY | 4096 12-bit words | 32,768 12-bit words |
| INPUT DEVICES | Teletypewriter Model ASR 33<br>(10 characters per second)<br>High-speed paper tape reader<br>(300 characters per second) | Magnetic Tape Reader<br>Punched card reader |
| INPUT FORMATS | Word address | Tab sequential |
| INPUT CODES | Binary-coded decimal | Straight binary<br>ASCII |
| OPERATING MODES | Incremental<br>Absolute | |
| BUILT-IN PROGRAMS | Interpolation:<br>Linear<br>Circular<br>Alphanumeric<br>FRED I (a compact new program requiring minimum memory) | Parabolic<br>APT lettering deck<br>ALADDIN |

### DRAFTING MACHINE OPERATIONS

| | STANDARD | OPTIONAL |
|---|---|---|
| THREE BASIC CAPABILITIES: | 1. Continuous path drafting<br>2. Point-to-point plotting<br>3. Digitizing (with auxiliary optical equipment) | |
| THREE OPERATING MODES: | 1. Automatic (by tape, card, etc. input)<br>2. Semi-automatic (by typewriter keyboard entry or panel controls)<br>3. Manual (by jog pushbuttons) | |
| NUMBER OF LINEAR AXES | Any 2 of 3 | Any 2 of 4 to 6 |
| MATHEMATICALLY DEFINED CURVES | By linear or circular interpolation | By parabolic interpolation |
| DASH LINES | Selectable spacing | |
| CENTER LINES | Selectable or variable spacing | |
| MIRROR IMAGE | Either axis or both | |
| SCALING | 4 digits selectable from 1000-1.000 and 1.000 to 0.001 in steps of least significant digit, each axis independently | |
| ZERO OFFSET | Anywhere on the table; off table zero offset range: 999.9999 inches | |
| CONTROLS PROVIDED | Turret index<br>Pen/stylus up/down<br>Automatic return to table zero<br>Emergency stop<br>Optional stop<br>End-of-program stop<br>End-of-tape stop and rewind | Sequence number search |
| SPEED | Automatically variable 0-400 inches per minute, control system computes automatic optimum with automatic control of acceleration and deceleration. A manual override variable from 0-100% is provided. | |
| PRINTOUTS AND INDICATORS | Via typewriter:<br>Command printout<br>Position printout<br>Automatic identification of cause of stoppage (program stop, optional stop, parity error, etc.)<br>Via panel indicator light:<br>Tape parity error | Via panel display:<br>Command readout<br>Position readout<br>Sequence number readout |

### DIGITIZING OPERATIONS

| | STANDARD | OPTIONAL |
|---|---|---|
| OUTPUT DEVICES | Teletypewriter Model ASR 33 (types or punches tape at 10 characters per second) | High-speed tape punch<br>(110 characters per second)<br>Magnetic tape encoder<br>Card punch |
| OUTPUT FORMATS | Typed copy<br>Word address (1-inch 8-level punched tape) | |
| OUTPUT CODES | Binary-coded decimal | Binary<br>ASCII |
| OPERATING MODES | Incremental<br>Absolute | |
| INTERPOLATION | Linear | Cutter centerline by direct digitizing |
| DIGITIZING CAPABILITY | Point plotting, singly or consecutively<br>2-axis punching (2 variables) | 2 variable axes, 1 constant axis |
| MISCELLANEOUS TAPE COMMANDS | EOB<br>Optional stop<br>EOR | Special identification, starting, or letter codes<br>Auxiliary machine tool command codes<br>Sequence number code:<br>Automatically adds 1 count for each digitized point |
| COMPUTED OUTPUTS | | Feedrate entered as inches per minute and automatically converted to:<br>MAGIC 3<br>computed FRN |

control systems was recognized and accepted by industry.

Although the original ORTHOMATS were N/C machines, the basic concept of the ORTHOMAT was designed to keep step with technological advances in general purpose computers.

For the past three years, UDM and Cutler-Hammer's AIL Division, Deer Park, New York have been investigating and developing a mature drafting/digitizing machine with true computer control. This joint development has resulted in the manufacture of the Mark II UDM ORTHOMAT with a DECAMATIC EXPANDABLE STORED PROGRAM (ESP) Control system.

The new system provides all the benefits of the N/C system plus the long-awaited benefits of computer used: much greater adaptability, versatility, and lower cost than N/C machines. The ORTHOMAT table, heads, and servomechanical system remain unchanged. The DECAMATIC-ESP Control portion of the new system accepts an almost infinite combination of inputs, codes, and formats, and provides the benefits inherent in a computer's stored memory. It is expandable—readily and inexpensively modified and enlarged by the addition of hardware and software. In short, the new system provides greater speed and versatility than any N/C operated system, costs less, has lower operating costs, yet retains the same accuracy and reliability.

The ORTHOMAT (built by Universal Drafting Machine) portion of the system consists of two elements: (1) the drafting machine and its servomechanical system and (2) the drafting/digitizing heads and related equipment. The DECAMATIC ESP (built by the AIL Division of Cutler-Hammer) has the third element, the Expandable Stored Program Control (ESP).

## UDM ORTHOMAT MARK II MECHANICAL AND SERVO-MECHANICAL SYSTEM

The ORTHOMAT portion of the Mark II ORTHOMAT Drafting/Digitizing Machines consists of two elements: (1) the drafting machine and its servomechanical system, and (2) the drafting/digitizing heads and related equipment.

ORTHOMAT's building-block design concept offers maximum versatility at minimum cost:

- It can be integrated to any control system which can supply X and Y pulses in 1-mil increments at a controlled rate, plus the auxiliary signals needed for stylus control.

- The identical table and servosystem is used for the drafting machine, the digitizing machine, or the combination drafting/digitizing machine. Thus, either of the former can be readily converted to the latter at any time.

- A variety of drawing and digitizing heads and stylii are interchangeable to provide maximum ability to handle a wide range of assignments. Buy only what is needed now, with assurance that there are "add-on" capabilities as requirements change or increase.

### The Table

The ORTHOMAT table is available with standard drawing area sizes from 4 × 4 to 6 × 20 feet, exclusive of parking area. The table combines unusually lightweight with extremely high precision and rigidity. It is of a prestressed design which assures an extremely flat working surface. The carefully engineered design provides an excellent combination of precision, long life, and light weight. All work is done with the table horizontal for optimum servo performance.

### Vacuum Chuck

The drawing surface of the table is a vacuum chuck with a continuous anodized aluminum surface. A set of flexible vacuum masks is furnished for isolating a portion of the chucking surface to allow holding small sheets. Vacuum supply is by a pump system in a movable cabinet, usually located under the table.

An optional feature is reverse float, which is useful for positioning large sheets on the chucking surface—particularly heavy metal loft plates. Also available as an option is valving for applying vacuum to selected portions of the chuck surface, rather than using the vacuum masks. Locating and positioning of drawing media and metal loft plates is simplified by the use of locating stops, offered as an accessory.

### Media

The ORTHOMAT allows a broad selection of drawing media. Its vacuum system holds any media from thinnest paper to heavy metal loft plates. Among the media widely used on the ORTHOMAT are:

| | |
|---|---|
| tracing paper | scribe-coat Mylar |
| vellum | steel loft plates |
| frosted Mylar | aluminum loft plates |

Carriages and Servomechanical System

An extremely accurate anodized-aluminum beam is mounted on each longitudinal edge of the ORTHOMAT table. Each beam has integral way surfaces, precision machined and hard coated. The X carriages move along these beams and support the traveling (Y) beam. Ball-bearing rollers, preloaded for extreme accuracy, support the carriages. Mounted on the traveling beam is the Y carriage, complete with its servo drive unit. This carriage has a faceplate area to which are fastened the various drafting/digitizing heads. All three carriages are driven by electrically synchronized servo-drive motors fed by the servosystem in the computer control.

The carriage servo-drive motors engage one edge of a wide precision rack mounted on each beam. Precise closed-loop feedback is provided by a system which compares the actual position attained with the position ordered and makes any necessary adjustment. This is accomplished by UDM patented Digiducers—measuring transducers completely independent on the servo-drive motors—which measure ACTUAL position (not command pulses or ordered position) to 0.001 inch. Feedback accuracy is completely divorced from any inaccuracy in the servo-drive motors. Furthermore, wear in the drive racks will not affect feedback accuracy because the drive-motor pinions and the Digiducer pinions engage separate positions of the wide racks.

Drawing Heads

Single Stylus Holder. The single stylus holder is standard equipment. Changeover from one stylus to another is made by manually lifting the one out and putting the other in place in the stylus-holding head.

An optional Optical locater mounts on the Single Stylus Holder. A telescopic magnifier arrangement, it is useful for aligning a drawing and locating starting reference points.

Indexable Hex Turret. An optional ORTHOMAT drawing head is an indexable turret which can hold six different stylii. These may be any of the drawing or scribing stylii described below. Only one stylus is in operation at any given time; selection can be programmed or made manually. The stylii are spring-loaded in the turret so that they may follow any minute irregularities in the drawing surface. The indexable turret is also available with an optical locator, similar to that described above.

Rotary Scribing Head. An accessory, the rotary scribing head consists of a 6-position indexable turret carrying six separate rotating stylii for making wide lines on scribe-coat Mylar, as for electronic printed circuit masters.

Stylii

Capillary Pens. Capillary pens can be used with colored ink for line widths from 0.008 to 0.040 inch; available with either steel or long-wearing jewel nibs.

Ball Point Pens. Available in a selection of colors, ball point pens provide a line 0.005 or 0.006 inch wide, depending upon the media.

Diamond Scribe Stylii. Extremely long wearing, diamond stylii provide lines 0.003 to 0.007-inch wide on materials such as Scribe-coat Mylar and metal. Special stylii are available for wider lines.

Rotary Scribe Stylii. Power-driven by the Rotary Scribing Head, these stylii have a concave center, so that a terminal with a land can be made by bringing the stylus down to the work and withdrawing it without carriage movement. Rotary stylii are made to order for any required line width from 0.020 to 0.170 inch.

Digitizing Heads

The Telescopic Viewer. The Telescopic Viewer used consists of a microscope system which focuses the image of a portion of the drawing onto a reticle pattern, magnifies the combined image, and projects it to a remote viewing telescope mounted at one end of the Y beam. The Telescopic Viewer is mounted on the Y-beam carriage and can be accurately positioned over the drawing. Any point on the drawing can be found by observation through the telescope eyepiece, which is located conveniently for the operator working along side the table. A remote control panel which can be positioned anywhere along the edge of the table provides the operator with X-Y movement controls so that he can locate the reticle accurately.

Closed Circuit TV Camera. For volume requirements, a machine equipped specifically for digitizing is necessary, since sophisticated techniques are involved. The telescopic viewer described previously is inadequate and inconvenient for continuous use. Production ORTHOMAT digitizing machines are equipped with a special UDM-designed closed circuit TV camera to pick up the reticle image of the optical system and present it on a TV monitor screen.

With this system, the operator sits before a low-silhouette console with the TV monitor and manual controls conveniently located before him. The TV screen constantly displays a magnified image of the work area and finding reticle so that the operator can conveniently monitor the operations for long periods without fatigue. He does not need to observe through an eyepiece as with the Telescopic Viewer, or to stand and move alongside the table as the carriage and reticle travel over the drawing.

The operator is provided with very sensitive, rapid, and precise positioning controls. For high-speed traversing, an omni-directional joystick is used. This provides rough positioning of the TV head anywhere on the table at speeds up to 400 inches per minute. Two large diameter hand wheels (one for each table axis) are then rotated for fine, positive positioning over the desired point. The combination of TV viewing, rapid manual positioning controls, and high-speed tape punchout provides exceptional working speeds and accuracy with minimum operator fatigue.

The operator's console also has controls for rapid and easy manual insertion of auxiliary function codes on the tape, control of the tape leader, and all of the necessary system controls. With the ORTHOMAT Mark II digitizing machine, complete two-axis N/C machine-tool control tapes can be prepared in one step without further processing. The operator can even instruct the DECAMATIC ESP Control to output the feedrate commands for the machine control system along with the coordinate data. Either Magic 3 or a computed feedrate number may be used, depending on the requirements of the machine-tool N/C control unit.

Automatic Line Follower. Where volume warrants, an automatic line following head can be added which results in very fast digitizing, yet with all of the manual control required. In this system, the TV camera head and an automatic optical line follower head are used in combination, both heads simultaneously viewing the same point on the drawing. Operation can be carried out manually with the TV arrangement or automatically where the lines on the drawing permit.

In use, the operator finds and records the start point, using the TV monitor and manual controls. He then manually locates the first point along the line to be digitized. After setting the system to automatic mode, the line follower head moves automatically along the selected line without further operator effort. The line follower and DECAMATIC ESP Control work together to output points along the line automatically at a speed and point density best suited to the radius of curvature, according to tolerances preselected by the operator. Line following is fully automatic and continues wherever the line leads without further attention. The output enjoys full ORTHOMAT accuracy at all times.

In certain ambiguous situations, the ESP requires that the operator take over manual control. For example, if the line follower comes to very close parallel lines or intersecting lines, the computer recognizes that a choice exists; it stops the head and waits for operator direction. The same thing occurs at sudden, sharp corners. During the manual portion of the operation, the DECAMATIC continues to select point spacing automatically. If, however, the line follower comes to a small break in the line, it will actually look ahead for continuation, but without outputting data. If it finds the line again, the line follower automatically resumes outputting and continues as if the line had been unbroken. If it has reached the end of a line it will also search ahead to see if the line continues. After searching a preselected distance (e.g., 1/4 inch) without finding a continuation, it will then stop and wait for operator direction.

This equipment combination provides maximum output rate and accuracy with minimum operator effort. Speeds to 100 inches per minute and accuracies to ± 0.003 inch are completely practical.

Engineering Design Features

Every ORTHOMAT incorporates many significant engineering design features which contribute to its accuracy, speed, precise control, long life, low maintenance, and operator safety and convenience. The design assures you of a rugged, long-lived, trouble-free, extremely precise machine which provides the best combination of mechanical, electromechanical, electronic, and computer design features.

Accuracy.

1. ORTHOMAT MARK II machines with DECAMATIC ESP control provide standard

accuracy over the entire table surface of ±0.005 inch. Repeatability is within ±0.002 inch. For less demanding applications, ORTHOMATS are also available with an optional overall accuracy of ±0.010 inch and repeatability of ±0.003.

2. Patented Digiducers provide detection of actual carriage position to within 0.001 inch for control feedback and for position readouts.

3. The DECAMATIC ESP Control reads and issues commands in pulses of 0.001 inch value, but accumulates any 0.0001 inch bits to eliminate cumulative errors.

4. No overshoot or undershoot.

5. Prestressed design of aluminum table assures stable flat working surface.

6. Vibration isolators built into table legs.

7. Machined and hard-coated ultra precision carriage ways are integral with rigid beams.

8. Precision, preloaded ball bearings in carriage rollers.

9. Servo-drive pinions are permanently lubricated for long life.

10. Digiducer pinions are anti-backlash design.

11. Custom precision racks are specially made to unusually exacting, UDM specifications and are permanently lubricated for long life.

12. Both ends of Y-beam driven by electrically synchronized high-torque servo motors.

13. Dead zone compensation is provided to prevent errors due to changes of direction.

14. Solid state ESP circuitry assures long life and reliability.

15. Temperature control of ESP enclosure (by blower fans) protects transistors and other circuit components and assures accurate functioning.

Speed. Buffer storage and servo design combine to minimize elapsed time per job. Drafting time is determined by two elements: stylus-movement speed and reading speed of the ESP control system. Stylus speed of the ORTHOMAT is 0-400 ipm. The tape reader feeds a block or several blocks of commands into the ESP memory where the information is held until the machine is ready for it. Then the required command is transferred instantaneously to the execution area. Since new information is available in advance, the machine normally need not decelerate and accelerate unless abrupt changes of direction are called for. The design provides finished work in minimum elapsed time, a vastly more important consideration than even the high stylus speed.

Low Maintenance Cost.

1. Comprehensive maintenance training course for service personnel.

2. Test Panel on control system for fast, easy testing, trouble-shooting, and repair.

3. Modular circuit boards speed trouble-shooting and replacement.

4. Motors, synchros, transducers, and other mechanical components are easily replaced.

5. Fan cooling of ESP enclosure protects components.

6. Permanent, dry film lubrication on racks.

7. Complete Maintenance Manual with circuit explanations and trouble-shooting guides.

Operator Safety and Convenience.

1. Electrical transmission system is enclosed within special plastic "conduit" and is located underneath the beams so that the operator is protected from electrical shock.

2. Low noise level—the ORTHOMAT is an office machine.

## DECAMATIC EXPANDABLE STORED PROGRAM CONTROL SYSTEM

The DECAMATIC subsystem portion of the overall Mark II UDM ORTHOMAT system is an Expandable Stored Program Control (ESP) real-time process control computer which operates at a speed compatible with the needs of the ORTHOMAT's servomechanical system,* and

*Prior to this development of the real-time process control, the servomechanical system was driven by the capability of the then existing numerical control systems, which did not take advantage of the ORTHOMAT's built-in speeds.

which provides the 0.001-inch positioning pulses, servo drive and feedback correction signals, and signals for operation of the ORTHOMAT heads, stylii, and so on. The principal advantage of the DECAMATIC-ESP Control lies in its ability to fit designers' needs simply by adding stored routines. The DECAMATIC-ESP has internal memory storage capacity and is addressed through a teletypewriter keyboard or other input readers.

DRAFTING WITH ESP CONTROLS

For drafting, a tape reader is added to the basic DECAMATIC-ESP Control system. The system provides manual selection of usual control functions, by means of the teletypewriter keyboard, such as: mirror image of each axis, selection of any two of three axes for drafting, manual pen down and pen up, and so forth. All basic software necessary for standard drafting operations are provided with the system. Included in the system are routines to accomplish the following:

- Accept punched paper tape input coded in standard EIA code, word address format, BCD, absolute or incremental position data.
- Perform linear, circular, and parabolic interpolation.
- Automatic optimum or selected maximum feedrate, with automatic acceleration and deceleration, up to 400 ipm.
- Automatic generation of dash and center lines of variable length.
- Separate 4-digit scaling of each axis between 0.001X and 100.0X, in steps of the least significant digit.
- Figure rotation by trigonometric methods.

MEMORY

High-speed and reliable operation of Mark II ORTHOMAT system are assured with the use of a directly addressable core memory to store its instructional programs and operating parameters. The core memory of the DECAMATIC-ESP controller has a capacity of 4096 12-bit words, and is expandable to a capacity of 32,788 12-bit words.

MAN AND MACHINE

To enable the operator to keyboard-control the drafting machine, and to simplify the revision and up-dating of the programs stored in the core memory, the DECAMATIC-ESP is supplied with a Model ASR 33 Teletypewriter. With an operating speed of 10 characters per second, it can either print "hard copy" or produce punched paper control tapes. A high-speed paper tape reader, with a capability of 300 characters per second, is used as the normal input device for control of the drafting machine. Its high-speed capability lets the drafting machine work at its maximum speed for normal operation. An optional magnetic tape reader and transport system is available with a speed of 900 characters per second for those applications requiring this capability. The DECAMATIC-ESP Control system can be programmed to decode any standard magnetic code format and is IBM compatible. As an optional input device for application in overall systems using punched cards for data transmission, a punched card reader with a capability of handling 100 cards per minute can be provided.

TAPE INPUT

While the normal input is in the form of the standard 1-inch 8-track punched paper tape using a word address format and binary-coded decimal information, the versatility of the DECAMATIC-ESP lets it handle input data in tab sequential format and to accept straight binary input data. By a simple programming change, the DECAMATIC-ESP Control decodes ASCII input information.

INCREMENTAL AND
ABSOLUTE COMMANDS

While most continuous-path contouring control systems operate only on an incremental basis, the DECAMATIC-ESP operates on either incremental or absolute position data. A built-in capability provides linear, circular, or parabolic interpolation.

THREE OPERATING MODES

Under ESP Control the drafting machine is provided with three basic operating capabilities: continuous path drafting, point-to-point plotting, and digitizing (with auxiliary optical equipment). Three basic operating modes are available: fully automatic, by tape or card input and so on; semiautomatic, by typewriter keyboard entry or panel controls; and manual by jog pushbuttons.

MULTIAXIS CAPABILITY

The standard DECAMATIC-ESP has been designed to accept multiaxis input information, and draw in any two of the axes selected by either tape or manual control. The ability to plot or draw the information contained in any two of six input axes is available if required.

INDEPENDENT AXIS SCALING

A wide-range scaling facility has been incorporated into the DECAMATIC-ESP. Each axis can be scaled independently over a range selectable from 100.0 to 0.001 in steps of the least four significant digits. While the conventional wired control system provides a few selected scales, the wide scaling range of the variable stored program control provides almost unlimited capability in this desirable feature.

NEW AND FAST ALPHANUMERIC PROGRAM

Alphanumeric characters can be drawn, scaled large or small to suit the drawing, in any direction on the paper or other media. Both tape controlled lettering and keyboard lettering can be used. Requiring only a minimum memory, FRED I (a fast and compact alphanumeric program) was developed specifically for this application. Optionally, by a software change, the control has been designed to accept and decode the alphanumeric input from the APT lettering deck, and the ALADDIN program.

AUTOMATIC DASH AND CENTER LINES

The control system will generate dashed lines with selectable spacing and line lengths and selectable or variable center lines. It has a complete mirror image capability, capable of reversing the input information in either or both axes.

ZERO OFFSET, CAPABILITY

A full range zero offset capability is available in the stored program control, one that lets the zero be set not only anywhere on the table, but to any point off the table within the control range of 999.999 inches.

CONTROL FUNCTIONS

All the conventional control functions for drafting machine operation are provided: turret index; pen/stylus up/down/automatic return to reference; emergency stop; optional stop; end of program stop; end of tape, stop and rewind, and sequence number search.

Drawing speed is always controlled to the optimum for minimum drawing time and best line quality. The control automatically varies carriage speed with automatic control of acceleration and deceleration to the optimum speed as computed. The drafting machine and control are capable of operating up to 400 inches per minute. Line length, in the case of straight lines, and increment length and curvature in the case of curved lines, are the two parameters that determine the drawing speed. A manual speed override is provided on the panel that permits the operator to limit the speed when working on drafting media that cannot be used at maximum carriage speeds.

DATA DISPLAYS

Several supplementary outputs in addition to the drafting machine control signals are available to facilitate operation and to diagnose system or programming errors. A position printout, in both X and Y, are provided in typed form by the typewriter. In addition, the typewriter prints an automatic identification of the cause of stoppage, for example: program stop, optional stop, input data parity error, and so forth. As an option, high visibility in-line readout displays can be provided on the panel. Both command and position readout in each axis are available. The input block sequence number can be provided as a panel display, similar to the command and position readouts as described above. This option is of particular value in machine tool control tape verification, and in digitizing operations.

DIGITIZING WITH DECAMATIC-ESP

The versatility of the DECAMATIC-ESP enables the drafting machine to be used as a high-precision digitizer. Limited only by table size, the digitizing capability provides a control resolution of 0.001 inch. The drafting machine can be provided with two alternate optical accessories to convert it for digitizing operations. For low-volume digitizing, a direct viewing telescope is mounted on the machine. The digitized output of the line is output by the Teletypewriter as either typed "hard copy" or punched paper tape, or both. Ten characters per second can be typed or punched by this machine. Positioning of the object line in the telescope reticle is done by jog pushbuttons.

When the volume of digitizing work is substantial, an indirect viewer made up of a closed circuit television system enhances accuracy and minimizes operator fatigue. The object line is magnified and displayed on a large television tube mounted in an operator's console. Seated at this console the operator sees the image of the line superimposed on a fixed reticle. A manually operated positioning control moves the carriage for perfect centering of the image on the reticle. Convenient panel-mounted controls permit the operator to select automatic incrementing one axis so that he uses his vernier control only on the other. The system also controls increments in the dependent axis by providing a linear extrapolation from the last two digitized points to minimize the amount of correction necessary by the operator with his vernier control. Up to 40 points per minute can be accurately digitized using this method. The availability of an optional high-speed tape punch with a capability of 110 characters per second is recommended for the high-volume digitizing system to ensure that the punching speed does not limit the operation. Outputs to encode magnetic tape or to operate a card punch are available as optional equipment.

## PRODUCES CONTROL TAPES FOR MACHINE TOOLS

The stored program control can produce tapes with the same format and coding choices available as standard or optional inputs, that is, word address or tab sequential, BCD or binary, absolute or incremental, EIA or ASCII. The computational ability of the controller is adequate for the computation of machine tool feedrates. Inputs in inches per minute are converted to MAGIC 3 or computed FRN. Any auxiliary machine tool command codes (g, m, s, t, or other functions) can be added to the output tape. A sequence number code that automatically adds one count for each digitized point can be generated. Combining these capabilities produces complete control tapes for many numerically controlled machine tools, and minimizes the need for large-scale general-purpose computer time in preparing control tapes for most other machine tools.

## FRED I, A NEW ALPHANUMERIC PROGRAM

FRED I is a fast and compact alphanumeric program especially developed for use in the DECAMATIC-ESP. FRED I is novel in several respects. First, its name: it is the current fashion in today's world to coin an acronym for computer programs, administrative routines, and new products. PERT (Program Evaluation Review Technique), LEM (Lunar Excursion Module), APT, ADAPT, CLTAPE, FORTRAN, and a host of others come quickly to mind. Scientific advances, on the other hand, are usually associated with the name of their discoverer or originator. Einstein's theory, Planck's constant, Poisson's ratio, Newton's laws, and many others memorialize the person who first clearly stated or revealed the scientific law or principle that bears his name. FRED I, while not as earth-shaking a revelation as Newton's exposition of the laws of motion or Einstein's theory of relativity, in name, at least, bridges the gap between past and present. Like the popular acronyms, it rolls easily off the tongue. Like the second set of examples above, it is named for its developer, Fred C. Hallden, an AIL Engineer whose specialties include the development of control systems.

FRED I is novel in another more important respect: its compactness. The laws of present-day economics demand maximum capability at minimum cost. These inexorable demands require that a maximum alphanumeric capability be programmed and stored in a minimum memory, thus making available additional capabilities without increasing the memory size. Mr. Hallden developed FRED I to provide an alphanumeric capability that includes all letters, numbers and standard symbols in an easy-to-read conventional form using minimum memory. The wide-range scaling capability of the DECAMATIC-ESP control can enlarge and reduce the alphanumeric characters. When enlarged, as in the title information on a drawing, aesthetic considerations ruled out by alphanumeric program that generates deformed letters and numbers. Flattopped "A's," square-cornered "S's," deformed "7's," and so on, while not too objectionable in small sizes, radically offend the senses when enlarged. Fred I draws conventional Gothic characters and pleasing Arabic numerals capable of being greatly enlarged or reduced without losing their good looks.

## L-304 Militarized Computer

*Litton Industries*
*Guidance and Control Systems Division*
*Woodland Hills, California*

The first in a series of microelectronic general purpose militarized computers, designated the L-300 and L-3000 series, was unveiled by Litton Industries Data Systems Division, September 15-17 in Washington.

The unique capabilities and applications of the Litton computer in a military systems environment was demonstrated then at the Air Force Association's 1965 Aerospace Development Briefings at the Sheraton Park Hotel.

The initial computer in the series, the L-304 which was presented at the AFA Briefing, is the only computer of its weight and size that offers militarized real time data processing with multiple program and multiple computer capability, according to George T. Scharffenberger, Litton senior vice president and head of its Systems Group.

The L-304 with 4096 32-bit words of memory resembles a pair of cigar boxes in size. It weighs 27 pounds and is contained in 0.3 cubic feet, including power supplies. Through added drawers, memory is expandable to 32,000 32-bit words and with the addition of a memory allocator, it can be increased to 262,000 32-bit words.

Memory also is expandable through a multiple computer configuration with up to eight computers sharing memory and connecting with one another through shared memories and/or input/output channels.

The computer's compactness is made possible by unique multi-layer boards and interconnecting techniques and a series of miniaturized power supplies developed by the Litton Systems Division.

Scharffenberger said the L-304 is the first computer built and operating to offer such reduced packaging and multiple capability.

While organized as a general purpose computer, the L-304 includes special features that make it effective in real time command and control and intelligence data processing.

These features include special instructions, multiple program capability with automatic priority control, and an extensive and flexible input/output system—allowing for communication with up to 64 I/O devices.

Efficient design and unusual production techniques provide extensive capability at minimum cost and maximum reliability, according to Scharffenberger.

He said prices for the L-304 are below what might be expected for a computer of this capability—even for those not fully militarized.

## RCA Variable Instruction Computer

*Radio Corporation of America*
*Defense Electronic Products*
*Burlington, Massachusetts*

The RCA Aerospace Systems Division at Burlington, Massachusetts, is under contract to the Air Force to construct a model of the RCA Variable Instruction Computer (VIC). This VIC will embody a new variable instruction concept in which the machine algorithms are not fixed but may be varied by altering the bit content of the control words. By providing a versatile set of arithmetic and logical functions in the arithmetic and shift unit, a virtually unlimited set of machine orders can be executed. This provides an exceptional degree of flexibility which can be a great advantage in complex applications and provides a basis for real-time, on-line reliability through automatic alternative modes of operation.

The VIC model being constructed is a 36-bit parallel machine with two 4096 word, 3-microsecond main memory modules and two 256-word, 0.6-microsecond high-speed memory modules. Multiple programs can be handled simultaneously to achieve an average order rate of 300,000 operations per second with a peak of 1,000,000 operations per second. Four parallel input/output channels are being provided. The VIC will operate on one's and two's complement, sign and magnitude, and hexadecimal numbers.

## UNIVAC 490 Modular Real Time Systems

*UNIVAC Division*
*Sperry Rand Corporation*
*New York 19, New York*

In June 1965, three general purpose computers, designed for orderly growth and expansion of real-time data processing, were announced by the Sperry Rand Corporation's UNIVAC Division.

Known as the UNIVAC 490 Modular Real-Time Systems, the new series consists of three highly expansible computers of various capabilities: the low-cost, medium scale UNIVAC 491; the intermediate UNIVAC 492; and the large scale UNIVAC 494, a super-speed real-time system that is six to ten times faster than the present UNIVAC 490 Real-Time Computer.

The new compatible series is available in a wide range of systems configurations that allow users to increase power, speed and storage capacity gradually to meet the changing real-time and batch processing needs of a business.

In a real-time data processing system, information is transmitted to a central computer from many activities of a business. This information is processed and the results are obtained in time to influence the activities being monitored or controlled.

In announcing the new series, Carl J. Knorr, Vice President, Marketing of the UNIVAC Data Processing Division, said, "The inherent power and flexibility of the UNIVAC Modular Series tailors these systems to grow with the increased real-time demands of many users in business and industry. This growth can be applied when needed and in the appropriate increments required. Ultimately, this means greater data processing throughout per dollar by offering the customer only the amount of processing power he can efficiently use."

The new series is a powerful successor to the UNIVAC 490 Real-Time Computer, introduced by Sperry Rand UNIVAC in 1962 as the world's first commercial real-time data processing system.

Basic units of the 490 Modular Series are the UNIVAC 491 and 492 Real-Time Systems. These models are available in a wide choice of expandable internal memory capacities, input/output channels, and mass storage systems that provide the flexibility to adjust the systems to fill higher or lower volume requirements. Both the UNIVAC 491 and 492 can handle extremely large quantities of data concurrently in real-time and batch processing modes.

Largest and most powerful of the 490 Modular Series is the super-speed UNIVAC 494, a large scale system operating as fast as 375 nanoseconds (billionths of a second). The 494's standard 12 input/output channels can be increased in groups of four to a maximum of 24, providing the input/output capability to meet the processing requirements of many of the largest businesses.

Multiple processing enables the 494 to handle vast quantities of converging data concurrently in real-time, batch processing and scientific applications.

A comprehensive software library will be available for the UNIVAC 490 Modular Real-Time Systems. Hardware compatibility is a feature of the 491 and 492; software compatibility will be provided throughout the new series.

Monthly rental prices range from $8,200 for the basic UNIVAC 491 to $14,000 for the UNIVAC 494. Purchase prices are $328,000 for the 491 to $588,000 for the large-scale 494.

Deliveries of the first UNIVAC 491 and 492 Real-Time Systems began in the fourth quarter of 1965, and first deliveries of the large-scale 494 are scheduled for the first quarter of 1966.

### UNIVAC 491 AND 492 REAL-TIME SYSTEMS

The UNIVAC 491 and 492 Real-Time Systems are medium scale data processing systems in a new series of modular real-time computing systems. They are designed to serve in many types of business, industrial, and scientific purposes including [illegible] as financial, insurance, production, and inventory control, branch plant control and general management control application.

### Central Processors

<u>UNIVAC 491 Processor Technical Specifications.</u> Memory cycle time per 30-bit word 4.8 microsecond; 16,384 word standard memory, expandable in increments of 16,384 word modules up to 32,768, and then increased in 8192 words to a maximum of 65,536 words; 8 input/output channels which can be increased by six to a maximum of 14; memory lockout reserves 1024 word increments for concurrent programs; uses a repertoire of 62 basic instructions that produce over 25,000 programming operations.

UNIVAC 492 Processor Technical Specifications. Memory cycle time per 30-bit word 4.8 microsecond; 16,384 word standard memory, expandable in increments of 16,384 word modules up to 32,768, and then increased in 8192 words to a maximum of 65,536 words; 14 input/output channels; memory lockout reserves 1024 word increments for concurrent programs; uses a repertoire of 62 basic instructions that produce over 25,000 programming operations.

Externally Specified Index (E.S.I.) is available in both the 491 and 492. E.S.I. provides a unique address for incoming data.

Peripheral Subsystems

Random Access Storage. FH 880 Magnetic Drum—786,432 words per drum of 3,932,160 alphanumeric characters per drum; up to 8 units per computer channel; 17 milliseconds average access time; word addressable.

Modular Fastrand Mass Storage—10,813,440 alphanumeric characters per unit; up to 16 units per computer channel; 67.5 milliseconds average access time; sector addressable.

Fastrand IA Mass Storage—64,880,640 alphanumeric characters per unit; up to 8 units per computer channel; 92 milliseconds average access time; sector addressable.

Fastrand II Mass Storage—129,761,280 alphanumeric characters per unit; up to 8 units per computer channel; 92 milliseconds average access time; sector addressable.

Magnetic Tapes. Uniservo VI C—8500, 24,000, and 34,000 characters/second transfer rates; 200,556 and 800 6-bit characters/inch recording densities; 42.7 inches/second tape speed; up to 16 Uniservo VIC units per computer channel connected through a channel synchronizer.

Uniservo VIII C—24,000, 66,700, and 96,000 characters/second transfer rates; 200,556 and 800 6-bit characters/inch recording densities; 120 inches/second tape speed; up to 16 Uniservo VIII C units per computer channel connected through a channel synchronizer.

Communications Terminal Module Controller. CTM functions as a link between the processor and the communications terminal modules; includes up to 64 CTM positions; available in the following transfer rate capabilities:

| | |
|---|---|
| Low speed: | Up to 300 bits per second |
| Medium speed: | 300 to 1600 B.P.S. |
| High speed: | 1600 to 4800 B.P.S. |

Data Communications Terminal. Complements the Communications Module Terminal Controller. Provides single line high-speed communications capabilities at low cost: connects broadband stations by leased Telpak line; dial circuit at 2000 bits/second; leased voice circuit at 2400 bits/second; leased broadband circuit at 40,000 bits/second or higher.

800/900 Cards Per Minute Reader
300 Cards Per Minute Punch
700/922 Lines Per Minute Printer
Paper Tape Subsystem

UNIVAC 1004 Card Processor. UNIVAC 1004 is a versatile data processing unit which reads 80 or 90 column punched cards and prints hard copy. The UNIVAC 1004 can be used online with all UNIVAC 490 series systems. It also functions off-line as a satellite, providing extensive computing under plugboard control and communications through its own capabilities.

UNIVAC 494 REAL-TIME SYSTEM

The UNIVAC 494 is a very large capacity, high-speed real-time data processing system in a new series of modular real-time computers. It processes several real-time programs concurrently with multiple batch processing applications. The UNVIAC 494 has an effective memory cycle time of 750 nanoseconds, or 375 nanoseconds overlapped, or less than three-quarters of a microsecond per 30-bit computer word.

Central Processor

UNIVAC 494 Processor Technical Specifications. 750 nanosecond memory cycle time, 375 nanoseconds overlapped; 16,384 standard memory; expandable in a 16,384 word increment to 32,768, and then in 32,768 word modules to a maximum of 131,072 words; 12 input/output channels which can be increased in groups of four to a maximum of 24; 14 index registers; Externally Specified Index provides a unique address for incoming data; decimal arithmetic; double precision floating point arithmetic; memory lockout reserves 64-word segments for concurrent programs; employs 99 instructions which can be combined with contents of instruction word to expand to a flexible repertoire of almost unlimited programming functions.

Peripheral Subsystems

All peripheral subsystems used with 491 and 492 are available for 494. Additionally available for 494 is:

Mass Memory. FH 432 Magnetic Drum--262,144 words per drum or 1,310,720 characters per drum; 786,432 words per three drum minimal subsystem; nine drum subsystem on a single computer channel through 432 drum control unit; 4.25 millisecond average access time; word addressable.

## LOCI-1, LOCI-2

*Wang Laboratories, Inc.*
*Tewksbury, Massachusetts*

Wang Laboratories, Inc., now is offering several LOCI LOgarithmic Computing Instruments. These are the first in a family of compact electronic computers which can be used on desk tops or tables for "off-line" or "on-line" applications.

The LOCI-1 is a keyboard controlled electronic computing instrument capable of performing all of the operations found in ordinary calculators, but in addition can easily raise a number to any integer or fractional power or take its root, which can be any integer or fractional power. With the unique principle of generating logarithms digitally, the computer functions with enormous flexibility and unparalleled power, reducing the steps needed for many types of complex calculations.

For example, with merely a single keystroke, it is possible to square a number, take the reciprocal of the square, take its square root, or the reciprocal of the square root, as normal operations functions of the computer. Exponential and logarithmic operations are accomplished with equal ease. Very briefly, LOCI-1 has a logarithmic register which accumulates the algebraic sums of the logarithms of numbers much as an ordinary accumulator stores the results of additions and subtractions. The logarithms are automatically generated when the appropriate function keys are pressed. Anti-log of a number in the logarithmic register is also obtained with a single keystroke command.

Answers of 8 to 10 digit precision are instantly available at electronic speeds, on the clearly legible in-line display. Although it is simple to operate, the LOCI-1 is more flexible than a slide-rule and more accurate than most mathematical and engineering tables.

The LOCI-2 is an advanced model in the LOCI family of desk-top computers. In addition to having all of the features of the LOCI-1, it has a static card reader for programmed operation and extra storage registers. Operated as an extended calculator, in the manual mode, the LOCI-2 is capable of performing additions, subtractions, multiplications, division, and exponentiation as well as taking logarithms and extracting roots. All these basic functions are completed in approximately 80 milliseconds, faster than many general purpose computers. For programmed operation in the automatic mode, the LOCI-2 has a powerful and flexible repertoire of commands with which iterated procedures are easily and compactly coded. In particular, there are commands for making decisions, and for constructing loops in a program. It is very simple, for example, to program a Taylor series. No equipment is needed to punch a program upon a card, merely push a pencil through the pre-scored positions.

Orders have already been received for several varieties of "on-line" applications. These are for controlling process variables in a feed-back loop, converting encoder readings to position coordinates, and automatically reducing nuclear scaler readings, to mention a few representative examples. The instruments are available to provide outputs for conventional peripheral equipment, such as the Teletype Model 33 combined output writer, tape-reader and tape punch. In addition, multiple inputs can be multiplexed into the LOCI so that it is possible to take the outputs of several digital voltmeters and convert the readings to engineering units.

Many problems are too tedious to attempt on a desk calculator, but too small to justify the expensive effort of using a large general purpose computer. By switching back and forth between the manual and automatic modes, the LOCI-2 combines the versatility of a calculator with the powers of a computer. The LOCI-2 opens up this entire class of problems for quantitative analysis at your desk without requiring the frustrations of time requests, priority requests, key-punch delay, and a queue at the large general purpose computer.

All LOCI instruments are carefully constructed from completely solid-state components, assuring the most reliable and long-term performance. They are truly compact in size for personal desk-top operation—being only 17" wide × 16" deep × 11-3/4" high. The LOCI-1 is priced at only $2750.00 while the price of the LOCI-2 starts at $4750.00. Delivery of either type of instrument has been running about two months.

## LOCI APPLICATIONS

Due to its unique features, the LOCI is the only desk-top computer capable of performing many types of complex computations. Consider some of the examples below:

### Vehicle Performance

$$M = \left\{\frac{2}{r-1}\left[\left(\frac{P_t}{P}\right)^{\frac{r-1}{r}} - 1\right]\right\}^{0.5} \qquad (1)$$

$$W = 3.190\left(1 - 0.375\,\frac{\Delta P}{P}\right)\left(\frac{P\Delta P}{T}\right)^{0.5} \qquad (2)$$

$$W_a = \frac{.08487\,(P_1 + 14.5)}{T^{0.5}} \qquad (3)$$

$$h_f = \left[\frac{.1851\,(P_o + 14.5}{W_a}\right]^{2.2515}$$

### Quality Control (Failure Rate Coefficient)

$$\beta = \frac{\ln\ln\left(\frac{1}{1-P}\right) - \ln\ln\left(\frac{1}{1-P_1}\right)}{\ln T_2 - \ln T_1} \qquad (4)$$

### Microwave λ Calculation

$$\lambda_x = \frac{1}{\sqrt{\frac{1}{\lambda 2} - \left(\frac{1}{2a}\right)^2}} \qquad (5)$$

### Structural Analysis

(Solve for $C_{g1}$ and $C_{g2}$ given $P_1$, $P_2$, $T_1$, $T_3$ and incremental values of $W_1$.)

$$W_1 = \frac{C_{g1}\,P_1\left(\frac{\Delta P_1}{P_1}\right)^{0.45}}{2000\sqrt{T_1}} \qquad (6)$$

$$W_2 = \frac{C_{g2}\,P_2\left(\frac{\Delta P_1}{P_2}\right)^{0.45}}{2000\sqrt{T_2}}$$

$$\Delta P_1 = 200 - \frac{W_1\sqrt{T_1}}{15}$$

$$\Delta P_2 = 200 - \frac{W_2\sqrt{T_2}}{15}$$

$$W_1 + W_2 = 60$$

### Runway Visual Range

$$U^2 - e^{KU} = 0, \qquad (7)$$

solve for U. (Reduced from

$$E = \frac{IT^{V/R}}{V^2},$$

solve for V.)

### Gear Center Calculation

(Solve for X and Y, given A, B, G, H.)

$$E = \sqrt{A^2 + B^2} \qquad (8)$$

$$P = \frac{G^2 + E^2 - H^2}{2E}$$

$$Q = \sqrt{G^2 - P^2}$$

$$X = \frac{PA - QB}{E}$$

$$Y = \frac{PB + QA}{E}$$

### Thermocouple Calibration

$$R_t = aR_o\left[t\left(1 - \frac{\delta}{100}\right)\left(\frac{t}{100} - 1\right)\right] + R_o \qquad (9)$$

## LIBRARY OF PROGRAMS SUPPLIED FREE WITH LOCI-2

The standard LOCI programs are all very easy to operate; generally the user only needs to push one key after entering a variable.

**Statistical Programs**

Variance - Standard deviation

Least Square Fit $(y = bx + c)$, any x

Least Square Fit $(y = bx + c)$, fixed x interval

Least Square Fit for exponential decay $(y = Ae^{ax} + B)$, fixed x interval

T - test for significance

$N!$, $\ln[\Gamma(X+1)]$ - Stirling's approximation to $N!$ for large N

Mean

Moving average

Root-mean-square

$$\mathrm{Erf}(X) = \frac{2}{\sqrt{\pi}} \int_0^X e^{-t^2}\, dt,$$

$$N(x) = \frac{2}{\sqrt{2\pi}} \int_0^X e^{-\frac{t^2}{2}}\, dt$$

**General Mathematical Programs**

SIN - COS

TAN

ARCTAN

SINH, COSH

$\mathrm{SINH}^{-1}$, $\mathrm{COSH}^{-1}$

Bessel Functions

$a^x$, $\sqrt[x]{a}$, $\log_x a$ for any values of a and x.

Solution of transcendental equation

$xe^x + c = 0$

Solution of cubic equation

$x^3 + a_2x^2 + a_1x + a_0 = 0$

**Other Programs**

Resonant frequency

Triangulation

Traverse

# Computing Centers

## New Computer Center

*University of California, Irvine*
*Irvine, California*

Under a joint research agreement with the International Business Machines Corp., the new Irvine campus of the University of California will become a unique computer laboratory.

University and IBM experts are joining forces to make UC Irvine a computerized model for American institutions of higher education which today are struggling with twin crises of knowledge and enrollment explosions.

Chancellor Daniel G. Aldrich, Jr., announced the signing of the agreement at the 1500-student campus, 40 miles south of Los Angeles.

Symptomatic of the higher education crisis, UC Irvine is scheduled for rapid growth, at a rate of about 1,000 additional students a year, to an ultimate enrollment of 27,500. It is destined by 1990 to become one of the giant campuses of the nation in the heart of a new population center.

"Much ill-informed criticism has been directed toward the 'inhuman' aspects of computers, but the same criticisms would have applied when the printed book was first introduced several centuries ago," Dr. Aldrich said.

"Those who work with the computer now believe it will have a greater impact on education than the book. It is evident that universities must quickly resort to these electronic aids if students and professors are to keep from literally being buried by the 'inhuman' mass of technical and scientific information which is being developed today," he said.

"The rapid increase in numbers of qualified students applying to universities and colleges across the nation also has presented higher education with a crisis in administration," the chancellor said.

"The mass of paper work involved in registration alone is staggering. Universities are in the same position as the banks were a decade ago. If they had not computerized their handling of paper, half the work force would now be employed as bank clerks. The only alternatives to computers for universities would be to limit enrollments and to limit the access to knowledge. These alternatives are unacceptable to American society today," Dr. Aldrich stated.

Although many universities now have access to computers, IBM officials said the UCI installation is the first in the nation to be devoted to extensive computerization of all aspects of a university campus.

The UC Irvine project will tie in with nation-wide programs by scientists, educators and information system firms such as IBM to bring the current explosion in knowledge under the powerful control of electronic computers. These programs envisage the day when the total knowledge contained in libraries will instantly be available anywhere through electronic systems.

The UC Irvine project also will be the first major plan to apply recently announced IBM computer research to systems of programmed instruction on the university level.

Professors in the various divisions and schools at UCI will assist in the project by helping to develop automated lessons which will help students to assume responsibility for individual learning at their own pace.

"With the assistance of computers and other teaching technology," Dr. Aldrich said, "we can free the professor of some of the essential but routine inculcation of basic information, and save the student from deadly 'canned' lectures.

"These objectives also fit in with our plans to bring professors and students together more frequently in small groups for intellectual interchange and inspiration of the sort which cannot be gained from books or computers or any device," he said.

The initial UCI computer facility will allow more than 20 students at a time to participate at their own pace in programmed instruction.

Seated at typewriter-like consoles, located at various places on campus, including the library, classrooms, laboratories, and dormitories, the future student will be able to engage via computer memory banks in richly programmed lessons. Advancing at his own pace, he will be able to stop at any time and start again where he left off by entering his personal lesson code number.

As the currently installed 1410-1440-1448 computer facility moves from primarily experimental to more general applied use on campus, plans call for installation of more powerful computers designed to accommodate as many as several hundred students simultaneously.

Professors will be able to use the facility by remote console for developing complex classroom problems, for direct access to library materials, or for solving weighty research problems.

The administration, meanwhile, will be able to keep track of and evaluate each student's progress from time of entrance to final graduation, budget for future buildings, take inventory, order and catalog books for the library and tabulate and issue personnel paychecks—all by remote console.

Irvine's faculty is being encouraged to develop imaginative new uses in computers in conjunction with television, language laboratories, and other new electronic and mechanical instruments in their instruction and research.

Chancellor Aldrich noted that the computer facility is only a part of UC Irvine's overall commitment to the exploration and exploitation of information and communications sciences, ranging from basic research on brain functions in the biological sciences to sophisticated engineering and administrative systems.

"Students and professors at Irvine—perhaps as nowhere else in the nation—will have the advantages of the most advanced education, research, and administration technologies," Dr. Aldrich said.

## 6000 Series Computers for AEC

*Control Data Corporation*
*Minneapolis, Minnesota 55440*

The U.S. Atomic Energy Commission has approved orders for the following Control Data 6000 Series computer systems for the Lawrence Radiation Laboratories at Berkeley and Livermore, Calif. which are operated for the AEC by the University of California:

(a) A 6600 system for the Berkeley facility.
(b) A 6600 system for the Livermore facility.
(c) A 6800 system for the Livermore facility.

The Control Data 6800 will be delivered to the Livermore facility in the last quarter of 1967. At that time, Livermore's present 6600 computer, which was installed in September 1964, will be exchanged for the 6800.

These computer systems will be used to increase the capacity of existing large-scale systems for performance of complex scientific studies relating to basic nuclear research for peacetime and weapons development programs.

The Lawrence Radiation Laboratory has one of the largest automatic data processing computer capabilities in the world, with a total computer investment, including the above orders, of approximately $49 million.

It was the same office of the AEC that ordered the first Control Data 6600 in July 1962. The AEC has traditionally obtained the fastest and most advanced computer systems available in order to handle their massive computational and data processing requirements.

The Control Data 6600 and 6800 computer systems have problem-solving power far beyond any manufacturers' present or announced design. For example, the 6800 with an execution speed of 12,000,000 instructions per second exceeds by a factor of four the speed of the 6600 which is presently the fastest and most powerful computer installed in the world.

## IBM Computer Time Sharing System for NIH

*National Institutes of Health*
*Bethesda, Maryland*

The National Institutes of Health—a major hub of medical research in the United States—has taken its first step toward placing the power of the computer at the fingertips of its 3500 scientists.

International Business Machines Corporation announced in August 1965 that it has received a contract for the first of a planned three-phase installation of a time-sharing computer system on the 48-building, 350-acre, NIH "campus" here.

Time-sharing, which makes the power of a large computer available virtually simultaneously to many individuals, will enable the NIH computer to serve scientists in many of these buildings where multi-million dollar medical research is being conducted. Terminals in various buildings will be connected to the computer through communications lines.

Concerning the contract award, NIH Director Dr. James A. Shannon said, "The computer is bringing medical research to a new era of discovery. Ingenious mathematical models can project theories into the future. Data analysis can find clues to medical problems of the past that have been too big and complex to solve in any other way. Plans are proceeding at NIH to establish a new Division of Computer Research and Technology so that we can use this tool most effectively."

Operations at NIH encompass a federation of nine independent research institutes, four service divisions and a 500-bed hospital. One of three operating bureaus of the U.S. Public Health Service, it not only conducts research against disease but also provides research grants to approved institutions and facilities across the country.

NIH's time-sharing system will be the first used by an organization devoted solely to medical research.

Under the $1.8 million contract announced, IBM will install a medium-scale System/360 Model 40 in January 1966. The system's auxiliary equipment will include direct access storage devices capable of housing some 87 million numbers and of pinpointing informations in 85 milliseconds.

The plan calls for a Model 65 as a second-step replacement in August 1966. This will ultimately be expanded to an IBM System/360 Model 67 time-sharing system.

First of the remote terminals tying the Institutes into the system will be installed late next year. Scientists will employ these typewriter-like terminals to converse directly with the Model 67. Because of the computer's great speed, each scientist will have the impression that he is using it alone. Answers will be printed, visually displayed on TV-like screens or recorded on punched cards.

In addition to time-sharing, the Institutes will be able to use the IBM System/360 in applications ranging from accounting and research to an important role in information retrieval.

## IBM Time-Sharing Computer Complex

*Computation Center*
*Massachusetts Institute of Technology*
*Cambridge, Massachusetts 02139*

In August 1965, the plan to install a $6-million IBM System/360 time-sharing computer complex at the M.I.T. Computation Center to serve M.I.T. and 51 other cooperating colleges and universities in New England was announced jointly by IBM and M.I.T.

The time-sharing IBM System/360 Model 67, to be installed in February 1967, will meet the diverse and expanding computational needs of students, faculty and staff drawn from virtually all research and educational activities of M.I.T. The computer complex will also be available to the 51 other New England colleges which now have access to the Computation Center.

The new computer, designed specifically for time-sharing, will be capable of serving simultaneously more than 200 people working with different programs from remotely located terminals. The present IBM 7094 installation only allows 30 people to use the Center's computer at the same time from remote terminals; while the new System/360 computer complex is expected to be approximately 15 times more powerful.

Time-sharing was pioneered at the Computation Center 7 years ago and has been pushed forward at M.I.T. under the continuing leadership of Professor Fernando J. Corbato, Deputy Director of the Computation Center, and his colleagues. Time-sharing basically is a technique which allows a computer to switch from one problem to another so rapidly that to each person it appears as if he alone is using the computer.

The current time-sharing method used with the IBM 7094 at the Computation Center allows up to 30 users—located at remote typewriter consoles and connected to the central machine by telephone lines—to use the 7094, simultaneously.

As a practical matter, since all remote terminals will not be used at any one time, more than 120 terminals already have been installed throughout the M.I.T. campus and elsewhere in the Cambridge area so that the computer's capabilities are accessible as demands may require. The terminals are connected both to the Computation Center IBM 7094 and to another IBM 7094 at M.I.T.'s Project MAC (for multiple access computer) where advanced research on time-sharing itself is being carried forward (DCN, July 1964).

Since the IBM System/360 will be capable of handling more than 200 simultaneous users, the Center's effectiveness to the academic community will be correspondingly increased.

The impact of such an increase with the System/360 can be seen by examining the ways in which several M.I.T. courses are already being taught using the time-shared 7094 in the Computation Center. Students in numerous courses in several departments have access to the central computer through remotely located consoles and regularly carry out course assignments using the machine.

In the Civil Engineering Department, for example, a special classroom has been established containing an IBM 1620 computer connected to the 7094 in the Computation Center. Classes being held in this room utilize both the 1620 computer—which plays the role of a sophisticated remote console—and the more powerful machine in the Computation Center to design solutions to engineering problems. With the aid of graphical and visual display devices, students and staff can complete actual visual designs of complex engineering work directly in the classroom. Typical problems might be design of a super highway interchange or a large steel structure.

In the Department of Electrical Engineering alone, approximately one-third of the Institute's undergraduate students received basic instructions in the use of electronic computers last year in three courses utilizing the 7094 in the Computation Center. This indicates that students consider instruction in computation of great importance. Although this instruction is elective, substantially all M.I.T. students elect it at some point in the 4-year curriculum.

The Computation Center is also playing a vital role in a wide variety of M.I.T.'s research programs. Studies of cosmic rays, of genetic phenomena, of the crystal structure of matter, of the design of ships, of nuclear physics, of systems of industrial management, and of the political and social behavior of man—to mention only a few—are all using the Computation Center. The installation of the System/360 will greatly increase the computing power available to these instructional and research projects and will enable the computer to become a more effective tool of the research worker, the professor and the student.

The goals of the M.I.T. Computation Center always have been to advance the state of the art of computer science, to foster the use of computer techniques in all areas and to provide a computing service to M.I.T. students and faculty, as well as to members of the participating colleges and universities.

Although the original IBM 704 installed at the Center in 1957 did satisfy what were then the needs of many users, the growing demands for machine time soon resulted in an average delay of a day or more in obtaining solutions. An early attempt at solution was the batch processing technique in which users would submit problems—in the form of decks of punched cards—to the Center. The Center staff would collect the problems in batches, transfer them to magnetic tape and feed them through the computer as rapidly as possible. But even batch processing did not reduce the delay significantly as demand continued to grow. What's more, it meant that the Computation Center had a virtual monopoly on access to the computer.

in an effort to keep pace with the increasing computational load and to eliminate the monopoly of access, time-sharing was developed. This put the user in direct and personal contact with the computer. The original 704 was replaced by an IBM 709 in 1960. Later the 709 was replaced by the larger and faster 7090 which M.I.T. upgraded last year to the present 7094.

Despite upgrading the center with consistently more powerful computing equipment, the demand for computational service expanded more rapidly. It is estimated that computational needs at M.I.T. and the New England colleges and universities served by the Center have doubled just about every 2 years.

The 7094 computer at the Computation Center presently operates as a time-sharing system for only a part of each day. The new System/360 will operate in the time-sharing mode 24 hours a day. It will process batch jobs during the free time available between calls from remote terminals or computing. It is expected that the System/360 will be capable of handling virtually simultaneously several times the number of problems that the 7094 does now.

The IBM System/360 for the Computation Center will consist of two central processing units and two memory units each with access times as short as 150 to 200 nanoseconds (a nanosecond is a billionth of a second). Supporting this equipment will be IBM 2314 direct access storage facilities, each of which can store up to 207 million characters (a character is 8 data bits of information). The 2314 can transfer information to the central processing unit at a rate of 312 thousand characters a second. High speed magnetic tape units, printers, IBM display terminals and other peripheral devices also will be included in the new System/360 time-sharing computer complex.

## CDC 3200

*McDonnell Aircraft*
*St. Louis 66, Missouri*

The McDonnell Automation Center, a division of McDonnell Aircraft Corporation, in August installed the area's first Control Data Corporation digital computer.

The computer, a Control Data Model 3200, will be the new digital part of McDonnell's hybrid computing facility—a vast complex of analog and digital computers which allows the Automation Center to achieve the unique benefits of each machine-type for particular applications.

The McDonnell 3200 system has 32,768 words of core storage, and two disk packs which extend the mass storage by 1,000,000 words. This Control Data computer, with 24-bit fixed-point and 48-bit floating-point word length and 1.25 microsecond cycle time, provides greater speed and precision for the hybrid operation.

The increased storage capacity allows larger and more complex problems to be solved. The increased speed and precision allows more accurate computations by permitting shorter sample time, and allows larger problems by permitting more calculations per given sample interval.

New software and arithmetic hardware, available on the computer, permits more rapid programming of hybrid studies. Special purpose hybrid software now being jointly developed by Control Data and the McDonnell Automation Center will further increase the efficiency of the hybrid operation.

"Man-in-the-loop" simulation of the Gemini missions is one use of the hybrid complex. The astronauts and McDonnell engineers have used the hybrid simulator to test control concepts and procedures used in the space flights. The computer system simulates the operation of the control systems and the on-board computer. The simulator, utilizing live instrumentation, produces electronically the visual displays and instrumentation responses the spacecraft will encounter in flight—from lift-off through orbit and rendezvous to re-entry.

The Control Data 3200-analog hybrid system will be used in the design and development of all McDonnell aircraft and spacecraft. In addition to McDonnell work, the hybrid system, including the Control Data 3200, is available to Automation Center clients.

Although accelerating requirements of the Gemini program will require extensive use of the 3200 for some time, multi-programming—a technique made possible by the machine's greater flexibility—will soon permit other Automation Center and commercial jobs to be processed even while the computer is busy with hybrid simulation. This feature of the machine is expected to be in operation by 1 January 1966.

The Automation Center provides the complete range of management consulting, systems design, programming, and data processing and computing services to industry, science, and business as well as to other McDonnell divisions. The Center is one of the largest data processing service organizations in the country. Drawing on a quarter century of experience in the automation field, 850 employees utilize over $22 million worth of equipment to serve clients from coast to coast.

## OMNITAB Made More Useful for the Scientist

*National Bureau of Standards*
*Washington, D.C. 20234*

Expansion and improvement of the OMNITAB general purpose computer program (see DCN, January 1964), which now includes almost 100 subroutines, has made it an even more useful scientific tool than when first announced in 1963.[1] New features, developed by Joseph Hilsenrath and his associates of the NBS Institute for Basic Standards (U.S. Department of Commerce), make it possible to write shorter programs, to incorporate text material along with tabular results in such a way as to produce a finished report, and to utilize any of the fundamental physical constants or atomic masses in a calculation by use of the appropriate OMNITAB word in the program.[2]

OMNITAB is an NBS-developed computer program that permits scientists and others who are unfamiliar with programming, to communicate with a 7094 computer using simply written sentence commands. The program can be used for the calculation of tables of functions, for solutions of nonlinear equations, for curve fitting, and for statistical and numerical analysis of tabular data. Because of the ease with which certain experimental data may be directly adapted to the OMNITAB input for processing, the OMNITAB program is gaining wide acceptance in both university and governmental laboratories.

Some of the new commands which have been added to the program and which make it possible to write even more concise programs than before are: MOLWT, which computes the molecular weight of any molecule from the empirical formula; CTOF, which converts a column of temperatures from degrees Celsius to degrees Fahrenheit; and FTOC, which converts Fahrenheit to Celsius. Other single-sentence operators compute the translational partition function for a given atomic weight and list of temperatures, and the electronic partition function at a given temperature for a set of energy levels or for a set of temperatures at a fixed energy level.

For convenience, the current best values for the fundamental physical constants and atomic masses of the elements have been incorporated in the program so that by use of the appropriate OMNITAB word, the proper number will be used. A typical one-sentence command employing this feature would be:

MULTIPLY COLUMN 2 BY
*PLANCK* STORE IN COLUMN 4.

Thus all users obtain the current accepted values for the constants. More accurate values can be substituted in the program as they become available.

New commands which permit format flexibility now make it possible to produce a finished report on OMNITAB. Text material may be incorporated interchangeably with computed results; the command NOTE and certain synonyms enable the program to differentiate between OMNITAB instructions and bibliographic or editorial comment.

The inclusion of a complete set of instructions for matrix operations has greatly expanded the range of problems which OMNITAB handles. Furthermore, these instructions contribute brevity by providing, in addition to compact matrix operators such as INVERT, others which can operate on entire rectangular arrays of numbers at a time. For example, the following instructions are all that are needed to evaluate the 22 expressions in Fig. 1.

[1] OMNITAB: A second generation general purpose computer program, NBS Tech. News Bull. 47 (Jan. 1963).

[2] For further details, see A general-purpose interpretive program for the calculation of tables of functions and statistical and numerical analysis, by Joseph Hilsenrath, Guy G. Ziegler, Carla G. Messina, Philip J. Walsh, and Robert J. Herbold, NBS Handbook 101 (1965) (to be published).

| | |
|---|---|
| 1 | $2a + a^2$ |
| 2 | $2b + b^2$ |
| 3 | $2b + a^2 + 2b^2 - 2ab$ |
| 4 | $2c + .5a^2 + 1.5c^2 - ac$ |
| 5 | $-2a + 4d + a^2 + 4d^2 - 4ad$ |
| 6 | $-a + 2e + f + .5a^2 + 2e^2 + .5f^2 - 2ae$ |
| 7 | $2c + 2b^2 + 3c^2 -4bc$ |
| 8 | $2d + b^2 + 2d^2 - 2bd$ |
| 9 | $-2b + 4e + 2b^2 + 4e^2 + f^2 - 4be - 2bf$ |
| 10 | $-b + 2g + h + b^2 + 2g^2 + h^2 - 2bg - bh$ |
| 11 | $-2b + 4i + b^2 + 4i^2 - 4bi$ |
| 12 | $2e + 1.5c^2 + 2e^2 + .5f^2 - 2ce - cf$ |
| 13 | $-2c + 4g + 3c^2 + 4g^2 + 2h^2 - 4cg - 4ch$ |
| 14 | $-2c + 1.5c^2$ |
| 15 | $2f + 4d^2 + 4e^2 + f^2 - 8de$ |
| 16 | $2h + 2d^2 + 2g^2 + h^2 - 4dg$ |
| 17 | $-4d + 6j + 4d^2 + 9j^2 - 12dj$ |
| 18 | $-2d + 2d^2$ |
| 19 | $2f + f^2$ |
| 20 | $4e - 2f + 4e^2 + f^2 - 4ef$ |
| 21 | $2h + 4e^2 + f^2 + 4g^2 + 2h^2 - 8eg - 2fh$ |
| 22 | $-f + 2e^2 + .5f^2$ |

Figure 1

ARAISE (B) IN ROW 1 COL 21, R=101, C=10 TO (A) IN 1,1 START STORING IN 1,21

PRODUCTS OF COLS 20 THROUGH 30, STORE IN COL 20

COALSCE ON THE FIRST COL, THE MATRIX IN 1,19, R=101, C=2, STORE IN 1,32

In this example matrix (A), 10 ×101, contains the exponents of the ten variables (a, b, ... j) for each term of each expression. Missing variables of course have zero exponents so that the row in (A) representing the term (-4)ad from expression 5 is written

1,0,0,1,0,0,0,0,0,0

Matrix (B), 10 × 101, is formed by duplicating a row of numerical values for a, b, ... j 100 times. The ARAISE instruction raises every element in (B) to the power of the corresponding element in (A); results are stored over "old" (B). Next, the product is taken of eleven columns (column 20 contains the coefficient of each term); results are stored in column 20. Finally, the terms belonging to the same expression are added together on the basis of an identification number in column 19; expression number and answer are stored in columns 32 and 33, respectively.

The OMNITAB operating procedure, the complete list of commands, and a discussion of the variety of problems for which OMNITAB can be used are available in a user's manual soon to be published as NBS Handbook 101. An abridged version of this manual is already included as a subroutine in the program; the print-out of this abridged version may be called for by use of the word MANUAL. Similarly, the OMNITAB instruction set can be called for by use of the word, COMMANDS. As additional instructions are added to supplement the manual and keep it up to date, they may be called for by use of the word, WATSNU.

The repertoire of OMNITAB operations and subroutines exceeds that which can be stored at one time in a 32K (about 32,000 storage locations) machine. Consequently, the subroutines have been arranged in a compatible system operating under the IBSYS monitor.[3] Under this system, which was designed at the University of Maryland Computer Science Center, frequently used parts of the program are always in the core and less used portions are read into the core as needed from system tape.

[3]International Business Machines Corporation System monitor.

## Honeywell 200 Computer to NRL

*Naval Research Laboratory*
*Washington, D.C. 20390*

The U.S. Naval Research Laboratory has acquired a medium-size computer that will help it keep track of the $60 million it spends annually on basic and applied research in electronics, physics, chemistry, metallurgy, and underwater sound.

A Honeywell 200 business computer—able to perform 500,000 operations a second—will be devoting about 70 percent of its time to financial management, cost reporting, and inventory and production control. It will also handle the payroll and personnel records for NRL's 3500-man staff.

"Another interesting project for the computer," according to John P. Donovan, NRL comptroller, "will be direct support of NRL's research activities by maintaining library records. It will control the journal holding, renewal, and check-in procedures, as well as the cataloging and loaning of more than 50,000 hard-bound volumes and 1400 periodicals used by our research staff—and will notify library users when a book or periodical is overdue."

Donovan indicated that the H-200's speed and capacity will enable it to grow with NRL's continuously expanding work load and to handle other new applications, such as automatic budget reporting and extrapolation.

The H-200, valued at approximately $215,000, includes a central processor with 8192 characters of main memory, 3 magnetic tape drives able to transfer 20,000 characters of information a second, a high-speed printer, and a card reader/punch unit.

## Computing Facility

*Oak Ridge National Laboratory*
*Oak Ridge, Tennessee 37831*

The Mathematics Division of the Oak Ridge National Laboratory operates and maintains a computing facility, which until September 1965 operated with a CDC 1604-A computer using 14 CDC 606 magnetic tape drives, a CDC 160-A computer using three 606 magnetic tape drives. Other equipment included two 1612 printers, a 405 reader, a 415 punch, and two Calcomp 580 plotter systems.

The 1604-A uses the COOP monitor; the 160-A uses a peripheral processor developed here with capabilities for simultaneous read and print. In fact, the processor allows full speed on one printer and a card to tape or tape to card; it also allows full speed on two printers. An 80-percent full speed capacity is obtained with two printers plus card to tape or tape to card.

The above facility had been completely saturated with work since July 1965 (it was turning more than 400 jobs per day), so in September 1965 an IBM System/360 Model 2060 was rented on a temporary basis. This was done to relieve, in part, the CDC 1604-A. This system will have four IBM 2311 disks, five magnetic tape drives (two IBM 2402's and one 2403), two 1403-N1 printers, and one 2540 card read-punch. The model 2050 will have 32K of fast memory.

On February 1966, the IBM System/360 Model 2050 central processor will be replaced by the Model 2075, and 128K of bulk memory will be added.

The computing facility operates on a closed shop basis, but programming is open to all members of the Laboratory. Because of the open shop policy the Mathematics Division has among its responsibilities that of making the computers accessible to as wide a variety of people in the Laboratory as possible. To this end, a FORTRAN 63 compiler was written for use in the IBM System/360. This permits the exchangeability of programs in the CDC 1604-A and IBM System/360. For use with the latter computer a simple problem oriented language for use on remote facilities was designed. A compiler has been written for it.

Among problems of interest to the Laboratory are space shielding (SNAP) problems, reactor development, isotope separation, nuclear safety programs, and desalination of water.

## Educational Computer Center

*Sacramento Regional Educational Data Processing Center*
*6011 Folsom Boulevard*
*Sacramento, California*

The first data processing center in the United States devoted specifically and completely to education was opened in Sacramento during July. California educators and government officials took part in the dedication ceremonies held at the Sacramento Regional Educational Data Processing Center.

The Sacramento center, located in offices of the county superintendent of schools, 6011 Folsom Blvd., is one of the largest of 12 such centers that ultimately will operate in the state, providing computer services to hundreds of school districts.

Through the Sacramento regional center, complete pupil personnel services will be offered in the fall to 44 school districts in 16 Northern California counties. Included in the services "package," which will cost participating schools $2.50 a year per pupil, will be student scheduling, attendance reports, grade reporting, and test scoring.

A Honeywell 200 computer system has been installed and will be used until December when a Honeywell 2200 computer will become operational. The H-2200 will handle all student scheduling for the Ventura County Regional Educational Data Processing Center, which also will begin operations in the coming semester.

The Sacramento center's H-200 system includes a central processor with 65,536 characters of memory, a console, six magnetic tape drives, two 650-line-per-minute printers, a card reader/punch, and random access drum storage that can hold up to 2.6 million characters.

The Ventura regional center will also operate a Honeywell 200, which includes a console, central processor with 16,384 characters of memory, four magnetic tape drives, a high speed printer and card reader.

Through a communications system the Ventura center, and ultimately the other locations, will have direct access to the larger computer in the Sacramento facilities.

A master processing schedule already has been prepared for the coming year for the Ventura regional center and for vocational education, with computer time scheduled for all participating districts.

Vocational education will be the use of the computer by junior college students enrolled in a special advanced computer class. The students will work at the Sacramento center on programming, use of machine languages, and actual operation of the H-200.

The junior college course and a beginning computer class at the high school level will be run on a test basis during the coming year to determine the feasibility of expanding computer course offerings to the secondary school level.

Both the Sacramento and Ventura County centers are working partly under development grants from the California State Department of Education and its Research and Development Center in Educational Data Processing.

Scheduled to begin operation a year from now are regional centers in Los Angeles County, Orange County (also serving Riverside County), Fresno County (serving the central area), and Santa Clara County (also serving San Mateo and Monterey Counties).

Tentatively scheduled for centers later are San Diego, San Mateo-San Francisco, Sonoma, San Bernardino, and Contra Costa. A second center also is planned for Los Angeles.

With the opening of the new centers, portions of the area now covered by the Sacramento regional center will be reassigned.

The center in the capitol city now handles counties ranging in size from Calaveras, which has a population of just over 10,000, to Santa Clara and Sacramento, both with populations over one-half million.

Other counties served are Colusa, El Dorado, Placer, Butte, Sutter, Solano, Yolo, Stanislaus, Tulare, Yuba, Fresno, Nevada, and San Joaquin.

Nearly all work handled by the regional center the first year for districts in these 16 counties will be for high schools, with a few elementary schools contracting for attendance accounting and test scoring. Services offered this year will cover more than 100,000 students. The current computing system is capable of handling services for 300,000 students.

The initial year also will find the center handling complete payroll operations for 4500 teachers and school personnel in Sacramento and Placer Counties.

The Ventura regional center, which services Santa Barbara, San Luis Obispo, and Ventura Counties, will handle records of some 100,000 students and payroll operations for 8000 teachers and school personnel during the coming year. It also will use the computer "packages," developed in Sacramento through the cooperation of the State Department of Education and Honeywell EDP.

State education officials who have been studying the feasibility of regional cooperation in data processing have cited several advantages of such a program. These include:

- Expenses reduced by furnishing and operating one regional center, consisting of a number of school districts, rather than furnishing and operating separate installations for each district.
- Experience, developments and improvements that take place at the regional center can be applied to a large number of schools, not just one or a few.
- A high degree of central staff competency is more likely to be realized in a regional system than in a local district system.
- There is a greater uniformity of procedures and products in a regional venture than can be found among separate district systems.
- Various districts cooperating in a regional system can contribute valuable suggestions to the total effort because of the large number of schools participating and because of the differences existing in the districts.

## Beckman 420 Installation

*University of Southern California*
*Los Angeles, California 90007*

Beckman Instruments, Inc., has given an $80,000 Model 420 digital computer to the Communication Systems Laboratory at the University of Southern California's School of Engineering. Installation of the computer was completed during August in USC's Olin Hall of Engineering.

The new computer will be used initially in a project aimed at developing a more efficient television system—a system which would transmit pictures over long distances with little power.

Digital codes are used to transmit pictures from such far away places as Mars or the Moon. A computer is used to translate these series of received impulses into an actual picture. The Mariner IV program used this type of system. The new Beckman 420 computer will be used in a similar but more efficient coding and decoding process.

The 420 is a fixed point, binary, simple address computer which handles real-time data continuously and efficiently. A powerful command list, together with a flexible indirect addressing capability, including cyclic indirect address and a flexible stem of interrupts, allows the computer to perform complex routines at high speed.

If a more efficient television system can be developed, it will have great commercial and military value. The project is partially under Air Force Support and directed by Dr. William K. Pratt, assistant professor of Electrical Engineering.

## GE 635 Computer Systems Installation

*TRW Systems**

*Redondo Beach, California*

TRW Systems has completed an agreement with the General Electric Company for the leasing of a large GE computer system, Frederick W. Hesse, TRW Vice President - Operations, announced in August 1965.

The system, which includes two GE series 635 computers and peripheral equipment, will double TRW Systems' present data-handling capacity. It will also permit the company to consolidate its scientific and business data processing into a single facility. Resultant cost savings for TRW will ultimately total more than $2 million per year. GE expects to have its equipment installed by July 1966, and in operation at full capacity by December 1966.

The selection of the GE system was the culmination of a 9-month TRW task group study of the company's expanding computer requirements for the next few years. A thorough survey was made of major computing systems now available or expected to be available within the next 2 years.

Within the past year, TRW Systems has won a number of contracts which will significantly increase the company's computation workload. This workload includes scientific/engineering functions and business data handling.

The two model 635 computers initially will have a disc storage capacity of 200 million characters, a main core memory capacity of 131,000 words, a high speed drum capacity of 1 million words, 14 seven-track tape units, 2 nine-track tape units, 4 high-speed printers, 2 card readers, and 1 card punch unit.

Provision has been made for directly tying in remote terminals to the 635 system. That is, off-site laboratories and business operations may have control stations from which they can place data and instructions over telephone lines directly into the storage and memory units and control subsequent operations of the computers.

TRW's computing centers now operate on a three-shift basis and produce the equivalent of more than a million and a half lines of printing a day. Over the past 10 years TRW Systems has accumulated probably the largest library of mission and trajectory computer programs of any company in the industry.

The company's computation work includes the analysis of data from ballistic missile tests, spacecraft performance, and experiment data and design criteria for complex electronic, aeronautical, astronautical, and mechanical systems and subsystems.

TRW Systems' scientific computation and data reduction center (CDRC) is under the direction of Dr. Eldred C. Nelson. The business data management is directed by Mr. W. Stewart Hotchkiss. TRW Systems' equipment now consists of two IBM 7094-Mod II, an RCA 501 and two RCA 301 computers, an analog computing facility, analog-to-digital and digital-to-analog conversion equipment, and an on-line computing center designed to be operated by design engineers rather than computer programmers. The GE system will replace the IBM and RCA equipment.

TRW systems is an operating group of TRW Inc., a widely diversified manufacturer of products in the aerospace, electronic, and automotive fields. TRW Systems has been prime contractor since inception of the United States Space Program for a large number of satellite and space probe projects, including several spacecraft in the Pioneer series, the Explorer series, the Nuclear Detection Satellites (Vela), the Orbiting Geophysical Observatory (OGO), and a family of environmental test satellites. The company is currently developing and manufacturing the rocket engines which will land the Apollo astronauts on the moon, as well as a wide array of electronic and mechanical systems for the United States military and civilian space agencies and for other industrial companies. It has been responsible for the past decade for overall systems engineering and technical direction of the U.S. Air Force Ballistic Missile Program.

Headquarters for TRW Systems is in Redondo Beach, California. Other TRW Systems facilities are located in San Bernardino and San Juan Capistrano, California; Houston, Texas; Cape Kennedy, Florida; Huntsville, Alabama; and Washington, D.C.

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*Formerly TRW Space Technology Laboratories - STL.

## Computation and Analysis Laboratory

*U.S. Naval Weapons Laboratory*
*Dahlgren, Virginia*

### STRETCH

A number of additional language facilities have been made available to STRETCH users at NWL. These included SIMTRAN, which is a version of SIMSCRIPT prepared by IBM for STRETCH, and AUTOCHART, a program prepared at NWL for use in the preparation and maintenance of flow charts. The latter is modeled after the system of the same name prepared by IBM for the 7070 computer.

The STRETCH continues to be the major facility of the Laboratory with an average utilization of 120 to 140 productive hours per week.

### NORC

A FORTRAN compiler (NORCTRAN) has been completed and is in use on the NORC. A sort generator has been included as part of this system.

The NORC completed its tenth year of operation in June 1965 and continues to be used approximately 40 hours per week. No significant engineering problems have developed with the NORC, in spite of its age.

### DIRECT ACCESS COMPUTING

An IBM System 360 Model 40, with a 131K Memory, the universal instruction set, and other appropriate special features, was installed in August 1965 for support of Naval Weapons Laboratory research and development efforts in direct user access computing and time sharing. Primarily emphasized in this program is the study of the effects on scientific manpower productivity and overall problem solving time created by direct, immediate, and convenient access to a powerful computer by individual scientists and programmers, particularly by means of console terminals which include sophisticated graphical capability. The terminals used in the Naval Weapons Laboratory study include two IBM type 2250 buffered display systems.

Additional studies in this general area have also been made over the past several months using an IBM 1050 System with both the IBM Mohansic Laboratories Time Sharing Monitor System and the commercially available QUIKTRAN System.

### POLARIS COMPUTER SYSTEMS

A POLARIS Target Card Computer System Mark 148 (PTCCS) was installed in the Laboratory during July 1965. The PTCCS was developed for installation in the earlier POLARIS submarines which require missile presettings in punched card form, and which originally carried a large file of punched target data cards. The Laboratory also has a POLARIS Digital Geoballistic Computer (DGBC) of the type used for fire control in later POLARIS submarines. At the Naval Weapons Laboratory, the DGBC and the PTCCS are employed for development of computer programs for POLARIS shipboard use.

# Computers and Centers, Overseas

**The Foundation for Management Training**
*Graduate School of Business Administration*
*Goteborg C, Sweden*

The Graduate School of Business Administration is currently pursuing the following research projects:

- EDB-simulation of planning processes in the textile industry. The different models cover three levels from the spinning mill to the clothing factory. One of the objectives is to connect these intra-firm models to each other in order to get an inter-firm model.

- Development of a planning model for integrated order production within the heavy mechanic industry. The objective is to find better planning rules by simulating several different strategies.

- Development of a simulation model to study the effect of the change from left to right hand traffic in Gothenburg. The model can also be used to find better rules for traffic control during the peak hours of the day.

- Development of a model for budget simulation in a complex organization.

- Development of validation methods for simulation models.

- Construction of systems for information handling and information retrieval in decision intensive organizations.

- Development of methods for representation of ill-structured problems. This research has a very clear connection with the work for construction of programming languages for handling such problems.

**University of London**
*Institute of Computer Science*
*44 Gordon Square*
*London, W.C.1. England*

An ICT Atlas I computer has been in operation at the Institute since May 1964. Details of the installation are:

Storage:

| | | | |
|---|---|---|---|
| Main Store | Cores | | 32,768 words |
| | Magnetic drums | | 98,304 words |
| Fixed Store | | | 8,192 words |
| Subsidiary working store | | | 1,024 words |

Words are 48 bits or 8 characters of 6 bits.

Magnetic tape:

14 Ampex tape units connected, of which 8 can be in simultaneous use.

Input and output:

5-, 7-, or 8-channel paper tape (four tape readers) or 80-column punched cards (two card readers). Output may be on line printer (two Anelex printers), paper tape (three tape punches) or punched cards (one card punch).

On-line data links:

Three on-line GEC data links to colleges of the University are already in use. A high-speed on-line link (television cable) is installed to Imperial College (London University) and will be used in addition to normal computing service work for experiments in adaptive control work.

The computer is now fully loaded on a 24-hour day, 5-day week schedule, and 7-day working will be introduced by the end of 1965.

During the 12 weeks commencing 31 May 1965, 975 hours of computing time were available, 30,720 jobs were done, and the computer carried out $520 \times 10^9$ instructions.

## H.M. Nautical Almanac Office

*Royal Greenwich Observatory*
*Herstmonceux Castle*
*Hailsham, Sussex, England*

An ICT 1909 computer system (see DCN, April 1965) will be installed in H.M. Nautical Almanac Office, England, in March 1966. The system will comprise a central processor with 16,384 words of core storage and a cycle time of 6 microseconds, together with four magnetic-tape units, a line printer (1350 lines per minute), a card reader, card punch, two paper tape readers and punches, and a graph plotter.

The computer will have three principal fields of use: firstly, for the computation of ephemerides for astronomy and space research, and for the preparation of almanacs and tables for navigation and surveying; secondly, for the analysis of astronomical observations and for theoretical research in celestial mechanics and astrophysics; and thirdly, for other work for the Hydrographer of the Navy (for example, for Decca-lattice charts). In addition, time on the computer will be made available to the University of Sussex, and possibly also to other establishments under the control of the Science Research Council.

## Technical Centre

*Supreme Headquarters Allied Powers Europe*
*The Hague, Netherlands*

A CDC 3600 has been installed at SHAPE Technical Centre (STC), The Hague, Netherlands. The 3600, which replaces an IBM 704, operates under the Drum Scope system. The model installed at STC has a core storage of 64K words with 48 data bits and 3 parity bits each. Auxiliary storage of 1,000,000 words is provided by two magnetic drums (average access 17 ms, transmission 2 Mc). Peripheral equipment includes six tape units (200, 556, 800 bpi, max. 120 kc), card reader (1200 cpm), card punch (250 cpm), two printers (1000 lpm each), CRT display. There are two data channels. Access to the drums and tape units can be effected through either channel. The STC installation is the first 3600 system in Europe to be equipped with drums.

## Basser Computing Department

*The University of Sydney*
*Sydney, New South Wales, Australia*

The current expanded configuration of the English Electric KDF 9 (see DCN, January 1965) in the Basser Computing Department, School of Physics, University of Sydney, is as follows:

16K core memory (was 8K)
2 readers (was 1)
1 punch
1 line printer
4 magnetic tape units (was 3)
1 monitor typewriter.

There is a plotter on order, and interconnection of the KDF 9 with the laboratory's older machine, SILLIAC (a copy of the ILLIAC I with four magnetic tapes attached) is almost complete.

## Miscellaneous

### Unattended Transmission of High Speed Data

*Bell Telephone System*
*New York, New York*

Bell System Data-Phone service now enables business machines transmitting at speeds up to 2000 bits per second (about 2700 words per minute) to converse with one another without any human intermediary. Operating in conjunction with Bell System 801-type Automatic Calling Units, the 201A Data-Phone data set now is compatible with computer-to-computer transmission as well as with machines that transmit punched paper tape, magnetic tape, and card media.

With this new feature of the 201A Data-Phone data set, organizations with several branch offices will be able to poll these offices automatically over the regular telephone switched network for sales, production, and other information. By making such polls in off-hours, they will be able to take advantage of lower evening telephone rates and also reduce the transmission traffic which their telephone service must handle during regular hours.

The typical equipment configuration would consist of an automatic calling unit and a data set at the headquarters location and a data set at each branch, along with the business machines. The telephone numbers of the locations to be polled would be stored in the computer system. At a pre-determined time the computer would begin to feed the numbers in sequence to the automatic calling unit. The calls would then be placed automatically to the location being polled.

The transmitting unit at the branch would then be activated and would start sending data to the central office. This data would have been loaded into the transmitter sometime earlier, perhaps at closing time.

### Computer Programmed Telemetry System

*Systems Division*
*Beckman Instruments, Inc.*
*Fullerton, California*

INTRODUCTION

The Beckman Model 420 Digital Computer has been incorporated into the Beckman Model 8420 Telemetry System as a processor/controller.

The inclusion of a medium-sized digital computer into a telemetry ground station has brought to this system the intrinsic flexibility required in processing many different and widely divergent formats. This innovation has proved to be both effective and economical.

The Model 420 Computer contains a core memory with a capacity of 4096 to 32,768 18-bit computer words. There are eight bi-directional I/O channels which are processed on a priority basis. These eight channels are divided into four standard channels with a word transfer time of 9.6 microseconds and four high-speed channels with a word transfer rate of 3.2 microseconds. Each channel can accept data from a maximum of 16 input/output devices.

Detailed analysis of the data on first pass is not required by most telemetry ground stations. Therefore, the function of the computer is to perform sync strategy, editing, merging of multiple input, data compression, decommutation, display of data, engineering unit conversion, and gapped computer formatting of the data for wording on a magnetic tape unit.

Detailed analyzing of the data may be made on a second pass operation by the Model 420 Computer.

## HARDWARE AND SOFTWARE PROGRAMMING

A Beckman Model 8420 Telemetry System consists of a Model 420 Computer, plus whatever subsystems or peripheral equipment is required to handle the input and output needs. Standard input subsystems include these needed for PCM, PAM/PDM, FM, and range-time signals. A Simulator Subsystem is also available for checkout and test.

Output subsystems consist of digital tape transports, digital displays, digital-to-analog converters for driving strip-chart recorders or oscillographs, and tape printers or card punches.

The programming of all these elements is a balance of hardware and software. To conserve computer time and memory, program events that take place more frequently than once a telemetry frame are built into the peripheral hardware. Thus, all bit slip correction and primary synchronization is performed in the Telemetry Subsystems.

This frees the computer to handle the control of data on input, frame synchronization, processing routines, and output formatting.

The input control of data is accomplished by a unique device called a List Control. This device has its own I/O instruction list that gives the computer the ability to: edit channels on input; sort or decommutate data on input by specifying different areas of the core memory for each channel; and specify incoming word length (PCM) or commutation pattern (FM).

The sorting of data on input by I/O control relieves the computer processor program from having to perform a decommutation routine before operating on the data. Since telemetry data is by nature cyclic, then the Instruction List can be iterative with a branch instruction to loop the list. The bit remains in synchronism with the incoming data on a word-for-word basis. That portion of the list instruction word which defines the specific buffer where the data word will be placed is called Externally Specified Buffer (ESB). A maximum of 512 buffer locations may be specified. These buffer locations are in addition to the standard 4 buffer locations per channel.

If the incoming data is to be from a number of FM discriminators, the instruction list is used to sequence the FM channels to be digitized so that a commutation pattern can be generated via program control. The data will be commutated and decommutated by the list word.

## PROGRAM ORGANIZATION

Telemetry Processing Programs for the Model 8420 are generated with the use of a special telemetry oriented compiler (FORGE). The compiler aids the operator in writing a specific operational program by printing out a series of questions on the system typewriter. The answers to these questions, entered on the same typewriter, consist of information required to complete the program, i.e., bit or pulse rate, LSB or MSB format, channels per frame, processing required per channel, and output format.

## SORTING PCM DATA

A simplified example will illustrate the flexibility and high throughput capacity of such a system. The basic objective is an on-line sort of PCM data recorded on an analog magnetic tape. The sort is to be performed at an input word rate of 25,600 eight-bit words per second. The data is to be sorted into eight output buffer areas, each buffer area connected to a digital magnetic tape for recording in a gapped format.

While the data is being sorted, other functions to be performed are tape search, data editing (inhibit certain words), quick-look, data compression (inhibit output if within high-low limits), and merging of time and fixed data. The overall flow of data is shown in Fig. 1.

The system required to perform these functions would consist of a Model 420 Computer, a PCM Bit and Frame Synchronizer, a Time Code Translator, a DAC and Display Subsystem, eight digital tape transports, and one analog tape transport (it is assumed that both the PCM data and the time data are on a single tape).

Figure 2 illustrates the sort operation. The PCM main frame contains 25,000 words and cycles once each second. Within the frame are 50 minor frames of 512 words each, repeating once each 20 milliseconds. The ESB address list is synchronized with the incoming

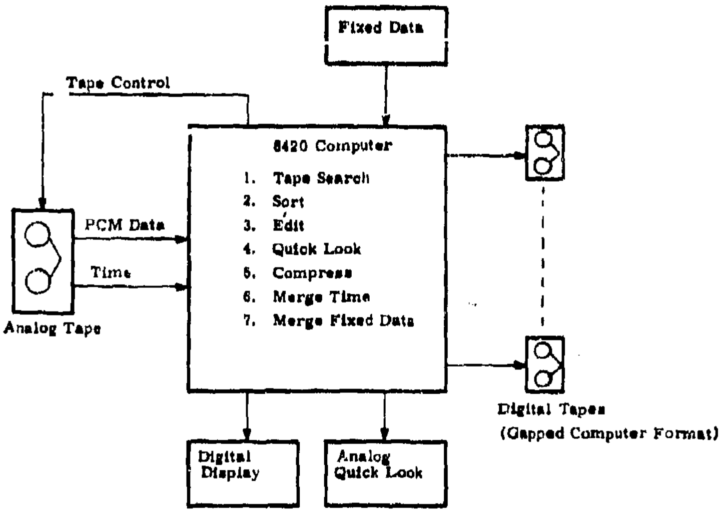


Figure 1—Overall data flow

telemetry minor frames. As each PCM word is transferred from the PCM synchronizer subsystem into the computer memory, an associated ESB address is extracted from the list and used to specify a set of buffer control words, A through H. The actual destination of the data word is the current address in the control-word set that has been specified.

As each output buffer area is filled, the output tape associated with that particular buffer area is started. For simplicity of organization, each output tape record contains a multiple of words contained in the minor frames and is started at the conclusion of a minor frame. Each of the buffer areas may be of any desired size, independent of the other areas.

The inputting of PCM data and outputting of data to the digital tape recorders is through normal I/O channels. The outputting of the ESB address is through a high-speed direct memory access channel. Together, these three functions consume 57.2 percent of the memory time, on average. This leaves 42.8 percent of the time for the additional functions of edit, time merge, quick-look output, sync maintenance, and data compression.

## OTHER PROCESSING FUNCTIONS

The time-merge function consists of placing a time word with each output record. The time word, derived from the serial time record on the analog tape, can be programmed to represent the first word in the output record or the last.

The quick-look function involves the stripping of one channel of data and presenting it to the system operator in decimal format. In addition, up to eight other channels may be stripped out for conversion to an analog voltage for driving strip-chart recorders.

The computer also checks on the minor frame sync once per frame to determine if the PCM subsystem is still synchronized. If and when sync is lost, a flag is inserted in the header of all records and the record itself is filled out with all zeros. This guarantees that all of the records on the output tapes are of the same length, whether or not they contain usable data. A similar procedure is used to determine and flag main-frame sync.

Three types of data compression may be programmed. In one case, the system flags data that exceeds the preset high-low limits. In the second case, only the data that exceeds the limits is recorded. In the third case, the high-low limits are adjusted or reset at fixed intervals, with only the data falling outside the limits being recorded. The effect is to pace the frequency of the recording with the stability of the signal. There is only an occasional record when the data words are varying slowly, with more frequent recording during transient periods.

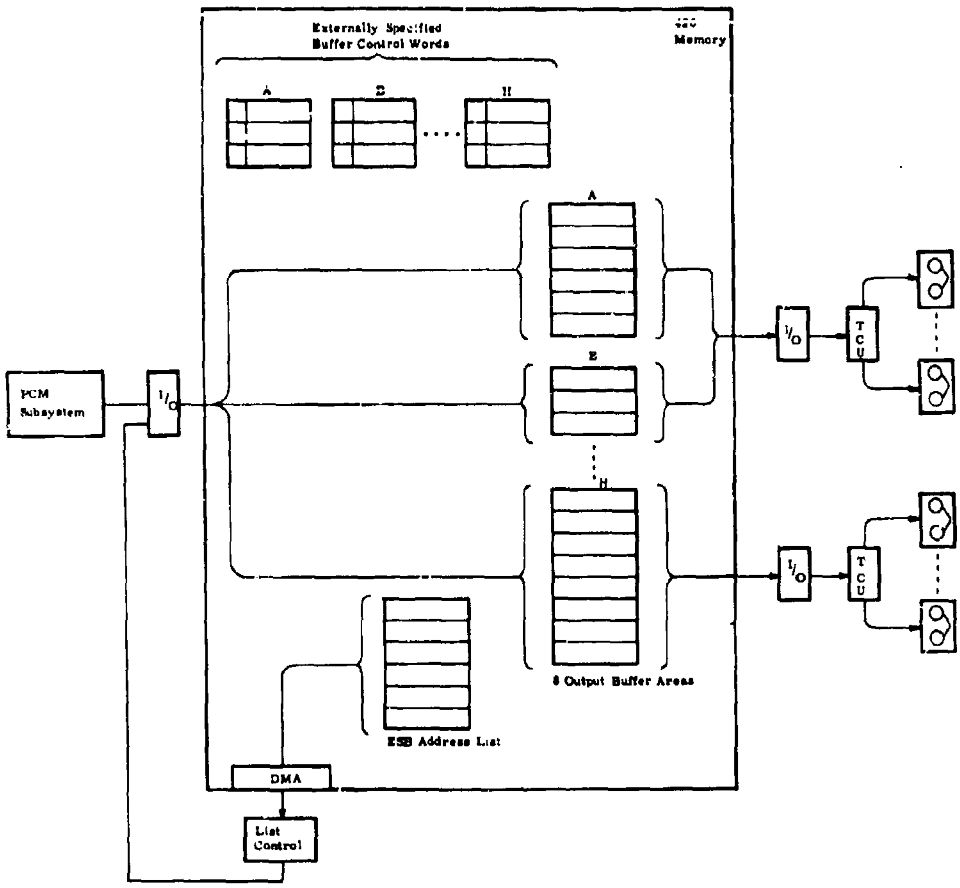


Figure 2—On-line sort

## SYSTEM LOADING ANALYSIS—TIMING

### PCM Input

The PCM input word rate is 25,600 words per second. Each word takes 9.6 microseconds. The percent of available time used for PCM input is:

$$9.6 \times 10^{-6}\ \text{sec/word} \times 25,600\ \text{words/sec} = 0.24486\ \text{sec/sec} \cong 24.5$$

### Time Input

One complete time word (two computer words) are entered every minor frame or once per 20 milliseconds. This is 100 words per second. Required capacity:

$$9.6 \times 10^{-6}\ \text{sec/word} \times 100\ \text{words/sec} = 0.00096\ \text{sec/sec} \cong 0.1\ \text{percent}$$

### List Output

One list word (containing ESB address) is associated with every PCM input word. Each list word (through DMA) takes 3.2 microseconds. Required capacity:

$$3.2 \times 10^{-6}\ \text{sec/word} \times 25,600\ \text{words/sec} = 0.08192\ \text{sec/sec} \cong 8.2\ \text{percent}$$

### Magnetic Tape Output

The total output rate is approximately 52,000 char/sec, or 26,000 words per second since there are two characters per word. Required capacity:

$$9.6 \times 10^{-6}\ \text{sec/word} \times 26,000\ \text{words/sec} = 0.2496\ \text{sec/sec} \cong 25\ \text{percent}$$

### Quick-Look Output

In the worst case, one digital display and eight DAC are updated every 20 milliseconds. This is a word rate of 450 words/sec. Required capacity:

$$9.6 \times 10^{-6} \text{ sec/word} \times 450 \text{ words/sec} = 0.004325 \text{ sec/sec} \cong 0.4 \text{ percent.}$$

### Processor Operations (Performed once every 20 milliseconds)

Time Processor. This routine causes a set of time words to be entered and checks against preset stop time. Required capacity (worst case):

$$\frac{63.8 \times 10^{-6} \text{ sec/frame}}{20 \times 10^{-3} \text{ sec/frame}}$$

$$= 0.00319 \text{ sec/sec} \cong 0.3 \text{ percent.}$$

Sync Maintenance. This routine determines if the minor frame and major frame are still in sync. Required capacity:

$$\frac{390.4 \times 10^{-6} \text{ sec/frame}}{20 \times 10^{-3} \text{ sec/frame}}$$

$$= 0.01952 \text{ sec/sec} \cong 2.0 \text{ percent.}$$

Output Control. This routine starts the output tapes if required during a minor frame interrupt routine. Worst case is starting two outputs per frame. Requires capacity:

$$\frac{80 \times 10^{-6} \text{ sec/frame}}{20 \times 10^{-3} \text{ sec/frame}}$$

$$= 0.004 \text{ sec/sec} \cong 0.4 \text{ percent.}$$

List Update. The list contents (ESB address) vary from minor frame to minor frame due to subcommutation. In this problem, the average number of ESB addresses that must be updated is limited to 50 per minor frame. Required capacity:

$$\frac{1091.2 \times 10^{-6} \text{ sec/frame}}{20 \times 10^{-3} \text{ sec/frame}}$$

$$= 0.05456 \text{ sec/sec} \cong 5.5 \text{ percent.}$$

Data Compression. In most tests the data being checked against limits falls within the limits. This requires 72.0 microseconds per check. When the data falls outside limits, it takes 183.6 microseconds to reestablish limits and prepare data for output. A reasonable average time is 83 microseconds per-channel-per-frame. For two channels per frame the required capacity is:

$$\frac{166 \times 10^{-6} \text{ sec/frame}}{20 \times 10^{-3} \text{ sec/frame}}$$

$$= 0.0083 \text{ sec/sec} \cong 0.8 \text{ percent.}$$

Quick-Look Processor. Every minor frame it is possible to process one channel for digital display (binary-to-BCD) and eight channels for the DAC outputs. Required capacity:

$$\frac{402.4 \times 10^{-6} \text{ sec/frame}}{20 \times 10^{-3} \text{ sec/frame}}$$

$$= 0.02012 \text{ sec/sec} \cong 2.0 \text{ percent.}$$

### Summary of Timing Analysis

The total loading is tabulated below:

| Operation | Percent Time |
|---|---|
| PCM Input | 24.5 |
| Time Input | 0.1 |
| List Output | 8.2 |
| Tape Output | 25.0 |
| Q. L. Output | 0.4 |
| Time Processor | 0.3 |
| Sync Maintenance | 2.0 |
| Output Control | 0.4 |
| List Update | 5.5 |
| Data Compression | 0.8 |
| Quick-Look Processor | 2.0 |
| TOTAL | 69.2 percent |

This leaves 30 percent of the processing time available for other on-line functions.

## SYSTEM LOADING ANALYSIS—MEMORY

### Output Buffers

Each output tape requires a double buffer area so that data can be unloaded from one area while being loaded into the other area. The average buffer length is 400 words (800 tape characters). Required memory:

$$8 \text{ tapes} \times 2 \times 400 \text{ words} = 6400 \text{ words.}$$

List

The list is twice the length of a minor frame. Required Memory:

2 × 512 = 1024 words.

List Update

The Memory required to update the list is (64 + words/frame updated) × 50 frames. Required memory:

114 × 50 = 5700 words.

Program

It is estimated that the program plus associated registers are contained in 1000 words of memory.

Summary of Memory Requirements

| Operation | Memory Required |
|---|---|
| Output Buffers | 6,400 |
| List | 1,024 |
| List Update | 5,700 |
| Program | 1,000 |
| TOTAL | 14,124 |

## GE 635 Systems for Bell Telephone Laboratories, Inc.

*General Electric*
*New York 22, New York*

Bell Telephone Laboratories, Incorporated, has leased three advanced time-sharing computer systems valued at more than $23 Million from General Electric's Computer Department.

The computers are advanced GE-635 systems modified to handle the time-sharing operations at the three Bell Laboratories locations at Holmdel, Murray Hill, and Whippany, N. J. They contain a combined total of almost four million characters in core memory.

Time-sharing computers allow many users to work simultaneously with the system because they can switch rapidly from problem to problem. Thus, engineers and scientists would be able to use the G-E computers on complex computation problems without programming them on cards and tape, and waiting in line for answers. This is made possible by the G-E computer's real-time, multi-programming capabilities.

Several hundred users can get on line to computers of this type, depending on the size of the problems and the types of terminals used.

The computers can be linked together, so that users at any location can gain access to the G-E computer at another site by employing a technique known as multiprocessing.

In addition, users can reach the G-E computers from remote locations, such as offices or homes by use of teletype and telephone lines.

Shipment of the advanced GE-635 systems to Bell Laboratories will begin in early 1966.

## High Speed Hybrid Circuits

*Department of Computer Science*
*University of Illinois*
*Urbana, Illinois*

The Circuit Research Group has investigated the use of mixed digital-analog circuits in pattern processing. In the so-called PARAMATRIX system a line drawing is electrically rotated, magnified, and repositioned, such deficiences as gaps and blurs being automatically corrected. The set of circuits used accepts signals from -10 v to +10 v and includes current amplifiers (precision: ± 10 mv) and voltage amplifiers (precision: ± 0.33 percent ± 20 mv) working from DC to 10 MC. The incoming information is taken from a slide and the end result is displayed on a matrix of lights.

## IITRAN Program

*IIT Computation Center*
*Illinois Institute of Technology*
*Chicago, Illinois 60616*

A new educational and scientific computer language designed specifically for student use was described in August at a SHARE meeting of computer users. Written under the auspices of Illinois Institute of Technology, the new system of simplifying mathematical and logical statements in English for use with computers has been dubbed "IITRAN," a combination of the university's initials and "tran" for translator.

As described by William S. Worley, Jr., a staff member of the IIT Computation Center and chief developer of IITRAN, the new language enables computers to process relatively simple problems, in quantity, much faster than the older computer languages which were designed primarily for use in advanced scientific research or for commercial or industrial purposes. The effectiveness of the new language together with the improved efficiency of large advanced computers makes feasible the routine use of advanced computers by undergraduates and even secondary school students.

Dr. Peter G. Lykos, director of the IIT Computation Center, has stated that, with IITRAN, the cost of undergraduate use of the Center's computer facilities is now approximately that of student use of a library; that is, using IITRAN, a student can have enough time on IIT's IBM 7040 computer to handle a typical student problem for less than the cost of circulating a book from the public library.

IITRAN, like other computer languages, is essentially a means of translating a few complex statements in English into an equivalent set of very many simple instructions which are comprehensible to a computer. IITRAN can be used by students with no background in computer programming after about 1 hour of instruction.

## Industrial Test of Computer Assisted Instruction

*IBM*
*White Plains, New York 10601*

The first test of its kind using the computer as an aid to the industrial training of employees at locations thousands of miles apart was initiated in June 1965 by International Business Machines Corporation.

The pilot study conducted by the company's Field Engineering Division is designed to test the feasibility of using a computer and remote terminals to help train IBM customer engineers, who service IBM's information handling systems.

The experiment, in which student terminals at IBM offices in Philadelphia, Los Angeles, San Francisco, and Washington, D. C. are connected to a central computer at Poughkeepsie, N. Y., will help to determine the effectiveness of computer assisted instruction as a method of teaching complex technical subject matter in an actual field environment.

Mr. O. M. Scott, IBM vice president and president of IBM's Field Engineering Division, said, "As the pace of technological advancement quickens, we are increasing our educational activities and continually exploring new instructional techniques to enable our customer engineers to meet the service requirements of our advanced computer systems. The pilot study has potential as a highly effective supplement to conventional classroom methods and laboratory work at our education centers. We hope this experiment will help us to individualize instruction and reduce the amount of time a customer engineer needs to spend at a central training location. However, computer assisted instruction certainly isn't intended to replace all centralized education for customer engineers."

IBM's Field Engineering Division designed the experiment which employs an IBM 1440 data processing system to store and present instructional material prepared by divisional training specialists. IBM 1050 data communications systems serve as the links between the students and the computer. Course material is entered into the system through the typewriter-like keyboards of the 1050 terminals linked to the computer by telephone lines. The value of computer controlled graphic display devices to computer assisted instruction is also being explored in the study at IBM's San Francisco and Washington, D.C. offices.

After storage in the computer's direct access disk files, the course material can be presented to the student through the same or another 1050 terminal. At present, twelve 1050 terminals can communicate with the 1440 computer at the same time. The maximum number of terminals, however, is still be be determined.

Should guidance be required, voice communication between students and an instructor located at the central computer or another terminal is handled by means of telephone subsets.

The course material is presented in printed form on the same terminals which the students use for responses. The computer in Poughkeepsie analyzes these responses, checks their accuracy, and retains and stores student performance data. The pace and content of instruction is set by the individual student in accordance with his grasp of the material and speed of response to questions.

The group of IBM customer engineers, experimenting with computer assisted instruction courses for the balance of 1965 will attempt to maintain a reasonable schedule of instruction while on call at their respective offices. This will enable a test of the effectiveness of the system amid normal job pressures.

## COMPUTER ASSISTED INSTRUCTION

Computer assisted instruction is a relatively new educational technique presently undergoing investigation. In IBM's Field Engineering Division, each customer engineer, working at a student terminal, is questioned and responded to individually by the centrally located computer. The speed and memory capacity of the computer enables it to accommodate many students in various stages of many courses simultaneously. This permits each student to proceed at his own rate so that the slower student does not become lost or retard others. The faster student is not bored by material below his level of capability.

The Field Engineering Division experiment will be conducted under the direction of H. S. Long, manager of Instructional Devices at the division's Advanced Maintenance Development facility in Poughkeepsie, N.Y. "The logical capabilities of the central computer," Mr. Long said, "permit it to make numerous decisions based upon each student's background and progress in the course. Thus, for a given course, there are numerous possible paths."

Students can, at a given point in the course, be sent on to the next question, sent ahead to a later section of the course, given remedial or enrichment material, directed to a textbook or to reference material, or directed to consult with an instructor or counselor on a specific topic.

The student is kept informed, at every step along the way, of the accuracy of his response. The student may also be permitted considerable freedom of choice. For example, at various points during the course he may ask to see a glossary of terms, request help, skip an area by demonstrating proficiency, or even express his satisfaction or dissatisfaction with the course by typing his comments on the terminal. The author of the course can obtain from the computer a complete record of each student's responses, as well as the student's personal comments, at any time. This information provides feedback to the course author so that he can identify points of error or ambiguity in the course and make the appropriate corrections.

The terminal, in addition to its educational function, also serves as the instrument for course construction and revision. Courses are written for computer assisted instruction in a fairly simple language known as Coursewriter, which requires no computer programming experience. Thus, the author of a course need undergo no extensive training and, furthermore, need not be located near the central computer. Coursewriter was originally developed by IBM's Instructional Systems Development Department and has been made available to educators interested in experimenting with computer assisted instruction.

The ability to revise courses quickly and from remote terminals makes this instructional technique extremely well suited for courses in rapidly changing areas of technology, where the time, expense, and trouble of reprinting and redistributing more conventional course materials would be prohibitive.

## IBM'S FIELD ENGINEERING DIVISION

The Field Engineering Division has responsibility for installing and maintaining IBM information-handling systems and equipment.

Thus, when a new product successfully completes all manufacturing tests and is delivered, IBM customer engineers located throughout the United States are responsible for machine installation and maintenance. These men, who are members of IBM's Field Engineering Division, are selected for a unique blend of aptitude, technical background, and personal characteristics. They have grown with the industry through three generations of technology—electro-mechanical, electronic, and solid state—and have consistently provided highest quality service for IBM machines ranging from the vertical sorter to the modern data processing system.

Early in their career, customer engineers undergo a 14-week initial training period, which enables them to maintain a basic complement of machines. As they develop experience, and the need arises, they receive advance training courses varying in length from a few days for a simple machine or feature, to 5 months for a large system. Some complex system configurations may require that a group of men undergo a 2-year training program which equips them to service that specific system. In addition to a functional knowledge of the machine, the training of these men may include the use of diagnostic programs, programming systems, test equipment, process simulators, and experience on the final test line. Thus, as the initial machines are being delivered, experienced customer engineers are prepared to accept this additional responsibility.

To assure quality at all levels of a product's development, the Field Engineering Division offers its field experience through service planning representatives located at each manufacturing plant. Early in a product's life, the service planning representatives provide information which influences reliable design, performance objectives, component feasibility, cost estimates, and provide customer reaction to certain technical situations. At the same time, plans are made for the physical location of the machine in the customer's office. Customer engineers in the field gather experience on prototype models installed within IBM. They check power, space and other environmental factors. This experience is fed back to development engineering, and used as input for decisions on design characteristics, size specifications, power requirements, and other related factors.

When the machine is installed at a customer location, and during subsequent visits, detailed records are kept of time spent on each unit, on component performance, on system diagnosis, and other pertinent sub categories. These records are forwarded to 1 of 10 IBM data processing centers throughout the United States. There the information is edited and forwarded to a central computer, which compiles the data into a meaningful form. Reports generated from this data are analyzed to determine overall machine performance, as well as trouble encountered on specific units. This analysis, together with personal contacts with customer engineers, assures rapid correction of items which may not have been included during development or testing. This process is a continuous one throughout the life of the product.

To assist customer engineers in the most rapid and efficient diagnosis of a machine failure, the division has established technical information centers at strategic geographic locations. Technical specialists, reference material, and the latest service techniques are a phone call away from most customer engineers. Field seminars, plant forums, and specialist training programs combine with the latest in diagnostic and maintenance techniques to assure maximum life and usage of every product.

## Advances in the Algebraic Theory of Machines

*Krohn-Rhodes Research Institute*
*Washington, D.C. 20013 and*
*Berkeley, California 94702*

Within the Krohn-Rhodes Research Institute study to advance the algebraic theory of machines, the institute has developed a new method for generating Boolean Functions.

1. A fixed simple non-abelian group machine* M is used, and any Boolean function B can be realized by M with the aid of a storage sequence depending on M and B. This means

*A group machine is a finite state machine such that (1) every input permutes the states, and (2) the collection of permutations of the states given by all input sequences is a group. The adjectives "simple, non-abelian" refer to the group defined by the machine.

that one finite state machine can be used to realize all Boolean functions involved in a given operation with only a storage unit need for each Boolean function. This could lead to significant new techniques in the optimization of design of computer components.

The details of this method will soon appear in "Realizing Complex Boolean Functions with Simple Non-Abelian Groups," by W. D. Maurer, Kenneth Krohn, and John Rhodes. The method is an outgrowth of "A Property of Finite Simple Non-Abelian Groups," by W. D. Maurer and John L. Rhodes, Proceedings of the American Mathematical Society, 16(3), June 1965, pp. 552-554.

2. Dr. W. D. Maurer has written a system in MAD at Project MAC for performing computations of the theory of finite groups and semigroups. Typical programs written using his system give ways to determine ideals of a semigroup from its Cayley table or from a representation by functions acting on a set of states. A particularly interesting program is described in "Computer Determination of Semigroup Isomorphism," by W. D. Maurer. An algorithm in MAD with certain subroutines in FAP is given to determine when two semigroups, given by Cayley (multiplication) tables are isomorphic. Both Cayley tables and scratch space for another of the same size must fit simultaneously into core. Some pushdown storage is also used.

The basic idea of the algorithm is to construct a sequence of increasingly fine partitions on the semigroups, checking at each state to see if they still correspond. If at any state they fail to correspond, they are judged non-isomorphic and the program stops. If they are isomorphic, the algorithm yields an isomorphism between them.

The first partition on each semigroup is given by regarding as equivalent any two elements which have the same index and period. (The index of an element is the smallest power of it which is equal to some higher power, and the period is the number of distinct powers of the element which occur beyond (and including) this smallest repeated power.) Each subsequent partition is obtained from the preceding by regarding as equivalent all elements which are equivalent in the preceding and remain equivalent in the preceding under multiplication on the right or left by any element of the semigroup. If this process terminates and corresponding classes remain with more than one element, a pair of individual elements in corresponding classes are arbitrarily assigned to corresponding one-element classes and the refinement procedure continued. The process continues until the semigroups are judged non-isomorphic or an isomorphism is found. The program required 20 seconds to find an isomorphism of the cyclic group of order twelve with the direct product of the cyclic groups of orders three and four.

3. A state-input model has been developed for multienzyme biochemical systems in which the algebraic theory of machines is of great use. The model essentially regards substrates as states and coenzymes as inputs, and will be described in a forthcoming paper by R. Langer, John Rhodes, et al. The model poses very interesting and difficult computing problems. The problems are similar to those solvable by the methods of Maurer described above and essentially reduce to the problem of finding the maximal subgroups of a semigroup of about $2^{150}$ elements, a problem which is clearly impossible without the use of very powerful mathematical techniques to simplify the necessary computations.

4. "Complexity of Finite Semigroups" by Kenneth Krohn and John Rhodes will soon appear. In "Algebraic Theory of Machines I," soon to appear in Transactions of the American Mathematical Society, these authors showed that every finite state machine can be decomposed sequentially into simple group machines and "combinatorial" machines, i.e., machines which can be built sequentially from copies of a three state machine with the following state-input table:

Table: Basic Inputs

| States | 1 | a | b |
|---|---|---|---|
| 1 | 1 | a | b |
| a | a | a | b |
| b | b | a | b |

In the sequential construction of a finite state machine from group machines and combinatorial machines it may be necessary to alternate group machines and combinatorial machines several times. This paper shows that finite state machines exist for which arbitrarily many alternations are necessary, and a method is given for determining the minimal number necessary (the "complexity" of the machine) in terms of the associated semigroups. An explicit but possibly quite complicated method for sequentially decomposing a finite state machine into group and combinatorial machines is given.

5. In "Algebraic Theory of Machines II," by W. D. Maurer, Kenneth Krohn, and John

Rhodes, soon to appear, a method is given to reduce any sequential decomposition of a finite group machine to a decomposition using the simple groups arising as factors in some composition series of the group of the machine. The reductions are of three kinds: (1) discarding unused states or inputs of one or more of the machines in the decomposition; (2) discarding unused machines; (3) changing the wires connecting the machines in the decomposition. The third reduction is equivalent with the algebraic operation of conjugating in the associated semigroup by an element which fixes the starting state of each machine of the decomposition.

6. In "Complexity of Grammars by Group Theoretic Methods," by John Rhodes and E. Shamir, a statistical method using the Mangus transform is developed to decide whether a given sentence belongs to a language. The sentence is expanded in terms of commutator subgroups of a free group. It is then judged to be in the language if, for some preassigned n, its first n coordinates in the commutator expansion agree with those of some sentence in the language. A further check is then performed by using a certain finite state machine associated with the language. This may be able to provide a practicable preliminary check on computer programs.

## IBM 360 Computer

*Meredith Publishing Company*
*Des Moines 3, Iowa*

Meredith Publishing Company has enlisted a computer, the first of its kind installed in the printing industry, to help in its continuing battle to meet ever narrowing production and distribution deadlines. The first of two such computers ordered by Meredith was put into operation in September at Meredith Printing, the company's manufacturing division.

Fred Bohen, board chairman and the company's chief executive officer, said the computer, IBM's new System/360 Model 30, would be applied to one of the publishing industry's most complicated problems—integration of production and distribution requirements for mass distribution magazines.

"Better Homes & Gardens, for example, has a coast-to-coast circulation of 6,750,000," he said. "A single issue may have as many as 70 regional editions, each of which may be divided into two slightly different publications, one for home delivery and one for newsstand sale, with 140 different products resulting.

"The problem is assuring that each edition arrives at its proper destination—whether it's a newsstand in Seattle or a home in Miami—on the same day; and that it arrives with the right regional advertising and the right regional editorial material printed in the issue received."

John Gregg, general manager for the company's Meredith Printing Division, said proper distribution of the magazines has its roots in the earliest production processes.

"Each press run for the 12 million magazines Meredith Printing produces each month must be meticulously scheduled so that the completion of each edition dovetails with binding, shipping, and mailing requirements," he said. "There is just not enough lead time to accomplish this task satisfactorily using manual methods."

Gregg said the plant had experimented on several occasions by giving two men all the time they required to draw up an optimum labor and equipment schedule for a given issue after it already had gone to press. "In every case, it required 3 to 4 weeks to prepare," he added, "and while considerable savings would have been effected, that kind of time is just not available."

He estimated that the system when fully operational will be able to schedule labor and equipment for an entire issue in a matter of minutes. "In addition to the time saved, and the greater efficiency generally, this will give us an added margin for last minute advertising and editorial changes," he said.

Bohen said a second System/360 Model 30 is scheduled for installation at Meredith later this year. This machine is slated to take over and expand applications now being handled on three 1401 systems at the company's Locust Street building.

"The biggest use of this second system will be in the area of subscription fulfillment for the more than eight million copies of Better Homes & Gardens and Successful

Farming magazine which Meredith publishes each month," Bohen said. "System applications will include billing, subscription analysis, and preparation of Audit Bureau of Circulation reports."

In addition, the Model 30 will handle the company's normal financial jobs—payroll, accounts receivable and payable, inventory, and management reporting.

Meredith Publishing Co., parent organization with headquarters in Des Moines, has a total of six operating divisions: Magazine Publishing, responsible for Better Homes & Gardens and Successful Farming; and Meredith Printing, contract printers of magazines and catalogs, both located in Des Moines; Meredith Press, consumer book division, New York and Des Moines; Meredith Educational Division, New York and Chicago; Replogle Globes, Inc., Chicago; and Meredith Broadcasting, four AM radio, two FM radio, and four television stations with headquarters in Omaha.

## Direct Communication Between Man and Computer

*National Bureau of Standards*
*Washington, D.C. 20234*

ACCESS, a data-processing system developed by the NBS Institute for Applied Technology (U.S. Department of Commerce), represents an advance in communication between man and computers. This system will receive and process data from local and remote sources and can present its output in a form immediately intelligible to the human operator.

ACCESS (so-called for Automatic Computer Controlled Electronic Scanning System) was developed for use by the Office of Emergency Planning to help provide rapid access to digital and pictorial data. The ready availability of these data will aid the OEP in evaluating situations during a national emergency.

ACCESS accepts input information directly from microfilm records of hand-marked documents and digital information either from other machines or directly from its keyboard. It has been used in experimental work at the Bureau to accept such graphical material as specially prepared maps and charts. It will store the information, perform a variety of operations on it, and present outputs either in digital form for use by other machines or in a form requiring no further translation for man. The system includes an X-Y plotter which prepares such output displays as maps, charts, and diagrams.

### The ACCESS System

ACCESS is primarily a data-gathering and data-preparation system, accepting marked documents which it scans by means of an advanced version of FOSDIC. The subsystem, Film Optical Sensing Device for Input to Computers, was initially developed jointly by NBS and the Bureau of the Census for machine reading of census documents.[1] The supervisory function of ACCESS was derived from the AMOS IV (Automatic Meteorological Observation Station) System[2] developed by NBS and the Weather Bureau for storing and processing weather data from remote stations.

ACCESS is intended to control not only the FOSDIC scanner, but also the communications facilities, displays, pen plotters, and multiple tape units serving the system. Although the processor is a relatively slow computer, it is useful because of its varied operations, such as table lookup and memory intertransfer. These make it adaptable for code conversion, verification, editing, reorganizing, screening, control of input-output devices, and preparation of output messages.

ACCESS is a single-address, serial binary system containing in its addressable memory over 25,000 words, each of 13 binary bits and 1 parity bit used for a quick check of the accuracy of transfer and recall. A double-length word can be used if longer ones are desired.

Four different types of memory are used in ACCESS. Transistorized registers, each containing one or two words, give fast access to a small amount of data during arithmetic and other operations; a core memory gives

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[1] FOSDIC II reads microfilmed punched cards, NBS Tech. News Bull. 41, 72-74 (May 1957), and FOSDIC III to assist in 1960 census, NBS Tech. News Bull. 43, 106-107 (June 1959).

[2] The AMOS IV computer for a prototype automatic weather station, NBS Tech. News Bull. 45, 13-15 (January 1961).

fast access to about 1000 words of information; a magnetic drum memory stores up to 24,000 words; and finally, four magnetic tape units store large volumes of information to which extremely fast access is not required. Five octal characters, composed of 15 binary bits, are used to address words in the drum, core, and register memories.

OPERATION OF ACCESS

The FOSDIC scanner is an integral part of the ACCESS system. Although originally designed to detect the presence of marks on census forms at specified positions, it is used by ACCESS to read pictorial material as binary information and to read, selectively, specified areas on the film image. The Bureau in its predelivery experimentation extended ACCESS's reading ability to microfilms of map tracings on coordinate paper. It matched the map symbols against those of a blank master map, previously entered in the memory, to assemble frames of county maps into the state map.

Tracing the lines on a map is accomplished by a line-following program which searches for a point on a line and, when it finds one, analyzes the eight surrounding points on a fine grid to find the direction of the line. One of the two peripheral points then becomes the central point, and the process is repeated to establish the line in the computer memory. At junctions the search follows the rightmost path, returning to its starting point for closed shapes. The search reverses when it comes to the end of a line in the field, so that such a line is sensed as a collapsed contour.

The line-following techniques was used in the NBS experimentation to read closed contours (such as are seen on weather maps), county boundaries, and state outlines. The data are stored on magnetic tapes as X and Y coordinates of the lines and can be produced as a trace on a display oscilloscope or as a permanent record on an X-Y digital plotter. Symbols and map contours on microfilm frames were produced on a large X-Y plotter in such positions that a complete map was assembled from microfilmed portions of it.

NBS is still experimenting with aspects and variations of the line-following program. Bureau scientists are studying recognition of the middle and junctions of lines and directing search into untried line branches. They are also looking into the effects of varying such operational parameters as the level of recognition threshold, type of instructions, and characteristics of the search area.

## ADP Resource Sharing

*Office of Management Information*
*Department of the Navy*
*Washington, D.C.*

The Department of the Navy, within its program to foster and facilitate the systematic exploitation of ADPE and associated scientific techniques, has established procedures for or Navy participation in the Government-wide ADP Resources Sharing Exchange Program.

POLICY

The practice of offering available ADPE time and related services in accordance with the applicability provisions is to be followed as a means of increasing ADPE utilization.

Sharing is to be considered a principal means for performing essential ADP work where adequate ADP Resources are not on board a given activity.

Activities in need of ADP Resources are to exhaust sharing possibilities with other contiguous or proximate Government or Government Owned Contractor-Operator (GOCO) activities, and are encouraged to avail themselves of the services of Sharing Exchanges, where such exist, prior to initiating proposals for new or additional ADPE.

Negotiations, arrangements, and agreements for sharing are the responsibilities of the participating activities; and, in addition to economic aspects, should consider proximity, deadlines, communications, transportation, security, command pre-emption prerogatives, and staffing needs.

Sharing arrangements may be made on either a reimbursable or nonreimbursable basis. Until a uniform rate structure for Government-wide application becomes available, the cost of reimbursable services will be a matter of direct negotiation by the activities concerned. In determining cost, consideration should be given to such factors as operator and supervisory salaries, overhead, cost of supplies, maintenance, machine rental, and depreciation.

Nonexistence of a formally established Sharing Exchange in a particular area does not absolve or exempt local management from its responsibility to assure that it has exhausted all possibilities of Sharing in its own immediate geographical environs, prior to initiating proposals for new or additional ADPE.

PROCEDURES

Sharing Exchanges are to:

1. Maintain current records of all available Government, GOCO and commercial (available on a contract basis) ADP Resources within their respective geographical areas.

2. Publish a consolidated listing of such available ADP Resources quarterly, and as significant changes occur.

Regional offices for the sharing exchange are located in: Washington, D.C. (National Bureau of Standards), Boston, New York City, Philadelphia, Atlanta, Chicago, Kansas City, Dallas, Denver, San Francisco, and Seattle.

## John Sealy Hospital

*Computerized Hospital Care*
*Galveston, Texas*

Streamlining patient care and reducing hospital paperwork, both with the use of a computer, is the object of a joint project announced in August 1965 by the University of Texas-Medical Branch and International Business Machines Corporation.

As part of the project, doctors and nurses at the John Sealy Hospital here will use an IBM data processing system to order drugs, schedule operating room time, and plan patient's diets.

Dr. T. G. Blocker, Jr., executive director and dean of the University of Texas Medical School (with which the John Sealy Hospital is associated) said: "Considerable progress is being made toward a hospital information system in which vital information is provided by a computer, not by a flood of paper forms and reports."

Key jobs performed by this system—ordering drugs, performing laboratory analyses, and reporting laboratory results—were demonstrated by IBM at the August American Hospital Association's annual meeting in San Francisco. Communications terminals at the AHA demonstration were linked to an IBM 1410 computer used by the John Sealy Hospital in Galveston, more than 1600 miles away.

The University of Texas, Medical Branch, already is using several such terminals linked to its 1410 for developmental and educational purposes. The Medical Branch has announced that it plans to replace the 1410 computer late next year with IBM's most advanced computer, System/360, which ultimately will be connected to a total of 60 remote terminals.

There are two parts to a hospital or medical information system. The first is the computer complex itself—remote terminals, communications lines, direct-access memory devices, and the central processing unit. The second is the formidable series of instructions—the program—which runs this complex.

D. J. Bobbitt, general director of Texas University's hospitals, explained that a hospital information system is designed to achieve greater efficiency and provide better patient care, in both large and small hospitals.

With such a system, the computer, for the first time, will be able to link a hospital's nursing stations, clinical laboratories, pharmacy, blood bank, admitting office, medical records unit, business office, and other departments.

With this network, the computer will be able to help admit patients; find beds for them; order drugs; schedule X-rays; schedule and report results of lab tests and plan special diets. It also will schedule the use of the operating room and other test and therapeutic facilities, and furnish doctors with up-to-the minute records showing the treatment given and the progress made by their patients.

Hospital information is transmitted over communications lines linking remote terminals to the computer. An IBM 1092 data entry terminal, used at John Sealy Hospital, utilizes interchangeable plastic overlays so that the symbols on the keys can be changed depending on whether a drug is ordered or X-rays are scheduled.

The memory capacity and communications ability of the System/360; which the Texas University hospitals plan to install, makes possible a continuous flow of requests and information within the hospital, each of which can be monitored, recorded, routed, and sped to various locations by the system.

HOSPITAL $R_x$ — HOW IT'S DONE WITH A COMPUTER

Before the computer was brought into the process of administering drugs, 12 steps were needed to accomplish this simple, routine procedure.

The doctor wrote his prescription. The nurse transcribed it to a requisition—with a carbon for her records. She then posted the order on her medication card. The requisition went to the pharmacy. The pharmacist filled the order, costed the requisition, typed a label, and sent the drug back to the nursing station. The nurse took out a medication ticket, administered the drug, and recorded it in her notes on the patient's record.

Efficiency studies on this and other hospital routines, conducted at one hospital, showed that 40 percent of a nurse's time was spent in clerical work.

Here is how drugs are ordered using a computer:

The nursing station is linked to the computer through a remote terminal (IBM 1092) equipped with pushbuttons whose symbols can be changed, by use of plastic overlays, to fit different routines.

To order drugs, the nurse selects the "Medication Orders" keymat and places it over the keys. Working from the doctor's order sheet, she enters the prescription. By pressing seven keys, she tells the computer who the patient is, what drug is prescribed, the dosage, frequency, duration, when it's to begin and how it's to be administered.

The system decodes the order and types it back in English on a printer so that the nurse can recheck her order. If the order is correct she flashes it to the computer. Or she changes it.

The computer posts it on the patient's profile—a listing of all medical activities concerning the patient. If the drug has to be filled by the pharmacy, the computer transmits the prescription—complete with label—to a printer there. If the drug is stocked at the nursing station, the computer keeps inventory records.

A half hour before the drug is to be administered, the computer reminds the nurse by printing out a medication schedule containing all the details. If the nurse fails to respond to the computer, it will repeat the reminder every 15 minutes.

Another safeguard in the system is that it virtually eliminates the possibility of overdoses. Stored in the computer's memory are "safe limits" of drugs for patients of different ages and weights. If the prescription exceeds these limits, the computer will question it.

Finally, when the nurse verifies to the computer that the drug has been administered, charges are automatically posted to the patient's account.

**Overseas Flight Planning**
*TWA*
*New York, New York*

Trans World Airlines plans and tests two million flights a week across the Atlantic to assure maximum schedule dependability and the smoothest ride for passengers.

Applying the advances of computerization to flight planning, TWA "flies" the Atlantic 2,100,000 times a week by computer, an IBM 1620, preparatory to dispatching its Boeing 707 StarStream jets on 210 weekly transatlantic flights.

The computer's job is to plot the fastest fairest-weather route in advance of each flight departure. It flies the Atlantic 10,000 times in the process.

TWA in August 1965 also applied computerized flight planning to its nonstop polar operations between the West Coast U.S.A. and Europe, the first in airline history.

The computer analyzes every mile of weather, radio aids, air traffic control procedures, aircraft performance, payload, and a host of other factors. Several minutes later, it prints a detailed flight plan which assures the speediest trip in the greatest comfort for passengers.

"Computerized flight planning comes as an assist to safety too, because it provides dispatchers and flight crews unprecedented accuracy of expected aircraft performance and flight progress, much added information, and swift revision of flight plan for alternate routings," says J. E. Frankum, TWA vice president—transportation.

"Computerization of flight planning comes as another major application of electronic data processing to improve customer service in many areas," said James W. Smith, TWA vice president—data services. "TWA has instituted computerization to provide instantaneous passenger reservations service, improve its worldwide inventory control, provide high-speed United States and international communications, monitor aircraft performance in flight, and improve maintenance and inspection capability."

TWA commissioned its computer flight planning center at New York's Kennedy Airport in June 1965 after more than a year of development and testing by TWA's Transportation Division and Data Services department. Eastbound transatlantic flight planning for east coast departures is performed by TWA's dispatchers at New York and Mid-West non-stop departures by dispatchers at Kansas City. Westbound flights from Europe are handled by the airline's dispatchers at Shannon airport, Ireland. Interrogation by TWA's stations in Europe, computation in New York and teletype return of a completely detailed plan to Shannon, as well as gateway terminals anywhere in Europe—all within minutes—marked another first in bringing the continents closer together.

TWA is the only transatlantic airline with in-house capability for computerized flight planning.

How good is it? The captain, taxiing on the ground in New York, can announce to his passengers that their flight to Paris will take 6 hours and 27 minutes for the 3738-mile flight, and 6 hours and 27 minutes later Paris Orly airport should be in view.

Here's how it works: The computer is continually informed by TWA's Meteorological Winds Analysis Group of present and forecast weather across North America, the North Atlantic, and Europe. Dispatchers feed into the computer operational data, such as aircraft weight, fuel capacity, payload, and Air Traffic Control instructions. After analyzing all its data through as many as 10,000 electronic trials across the Atlantic, the computer determines the optimum weather track for a specific scheduled flight, avoids turbulent areas, and prints a detailed flight plan.

It shows how much fuel should be on board; it indicates route and altitudes leg by leg, rate of fuel consumption, flight time and distance between radio check points, and temperatures aloft. It even tells the crew how many ground and air miles they will have flown, the weight of their aircraft, the amount of fuel and the time upon arrival at destination—all this before take-off.

Take TWA's nightly Flight 800 New York to Paris. Although it is 3738 miles over the ground and sea, the flight plan on a given night may tell the captain that his air miles (miles flown through moving air) will be only 3421 and that 93,600 pounds of fuel will be required. Should it route him over Gander, Newfoundland, one of about 15 check points along the way, the following typical data is provided for Gander:

| | |
|---|---|
| Ground Miles (N.Y. to Gander) | 1,123 |
| Air Miles (N.Y. to Gander) | 993 |
| Altitude | 33,000 feet |
| Wind Speed | 93 mph |
| Wind Direction | 220 degrees |
| Outside Air Temperature | - 51 degrees F |
| Wind Component | + 90 mph |
| Air Speed | 554 mph |
| Ground Speed | 644 mph |
| Fuel | 73,300 lb |
| Time (N.Y. to Gander) | 1:52 |

(Note: all miles indicated are statute miles)

Flight 800's flight plan probably won't take him on the straightest route to Paris, it's too long in terms of flight time. A pioneer in "pressure pattern" navigation, TWA will plan its flights far off the shortest great-circle course, if necessary, to take advantage of jetstreams which are high altitude tail winds with velocities up to as much as 150 miles an hour. Conversely, coming the "other way" avoidance of the jetstream can reduce flying time. This is known as "Minimum Time Track" flight planning.

The flight plan is fed into Doppler, an airborne electronic system for over-ocean navigation which is more precise than the human navigator. TWA pioneered Doppler, which gives the crew continuous position readings as opposed to the hand method, with sextant, that takes as long as 15 minutes to get a fix.

"Pilots hail the computerized flight plan," says Mr. Frankum. "It gives them more information more swiftly than ever before." It also facilitates speedy change in flight when desired. If for some reason a route change is requested, the pilot radios TWA flight dispatch, and within a few minutes a revised flight plan is received in his cockpit.

"Dispatchers recognize the computer as an aid to accuracy in their profession, a tool to examine many variations and at the same time end tedious hand calculations," he noted. "And to the air traveler, it means further assurance of the fastest, safest, most comfortable routing possible—and a new measure of schedule dependability."