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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 digital computer technology. It is published by the Office of Naval Research, Mathematical Sciences Division.

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

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Gordon D. Goldstein, Editor

July 1961

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## EDITORIAL NOTICES

### NEW CIRCULATION POLICY - DIGITAL COMPUTER NEWSLETTER

The NEWSLETTER is circulated without charge to interested military and government agencies, and to the contractors of the Federal Government. Also for the many years it had been reprinted by the Association for Computing Machinery within their Journal and more recently in their Communications.

The Association decided that the Communications could better serve its members by concentrating on ACM editorial material. Accordingly, effective with the January-April 1961 issue, the NEWSLETTER is available only by distribution from the Office of Naval Research.

Requests to receive the NEWSLETTER regularly should be submitted to:

Gordon D. Goldstein, Editor  
Digital Computer Newsletter  
Information Systems Branch  
Office of Naval Research  
Washington 25, D. C.

Contractors of the Federal Government should reference applicable contracts in their request.

### EDITORIAL POLICY - DIGITAL COMPUTER NEWSLETTER

The NEWSLETTER, although a U. S. Navy Department publication, welcomes contributions from any source. Page limitations do, however, prevent publication of some of the received material. Items which are not printed are kept on file and are made available to interested personnel within the Navy Department, and other government agencies.

Publication of information on commercial products does not—in any way—imply Navy approval of said products; nor does it mean that the Navy vouches for the accuracy of the statements made by the various contributors. Since we do not have space to print all of the worthwhile and newsworthy items, what does appear in each issue should be considered only as being representative of the state-of-the-art and not as the sole product or technique available.

### CONTRIBUTIONS FOR DIGITAL COMPUTER NEWSLETTER

The Office of Naval Research welcomes contributions to the NEWSLETTER. Your contributions will assist in improving the contents of this newsletter, and in making it an even better medium of 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 this Office for future issues. Because of limited time and personnel, it is often impossible for the editor to acknowledge individually all material which has been sent to this Office for publication.

The NEWSLETTER is published quarterly (January, April, July, and October), and material should be in the hands of the editor at least one month before the publication date in order to be included in that issue.

The NEWSLETTER is circulated without charge to interested military and government agencies, to the contractors of the Federal Government, and contributors.

Communications should be addressed to:

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Washington 25, D. C.

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## COMPUTERS AND DATA PROCESSORS, NORTH AMERICA

### 160-A COMPUTER - CONTROL DATA CORPORATION - MINNEAPOLIS, MINNESOTA

Control Data Corporation has announced a considerably expanded version of the 160 (see DCN April 1960), called the 160-A. This new computer is packaged in an office desk, as is the 160. A number of orders already have been received and first deliveries will be made this June (1961). The basic 160-A is priced at \$90,000, and is leased at \$2250 per month.

The basic 160-A computer is equipped with a magnetic core memory of 8192 12-bit computer words (double the memory of the 160), buffered input and output, program interrupt, and an unusually large and powerful list of 91 instructions. The 160-A basic magnetic core memory can be expanded in modules up to 32,768 words. Such capabilities ordinarily are associated only with large-scale computers such as the Control Data 1604.

A variety of peripheral equipment can be added to the 160-A according to the user's requirement. For example, to the 160-A can be added a magnetic tape system, high-speed line printer, card reader/punch, and electric typewriter. The Control Data 350 Paper Tape Reader and the Teletype Paper Tape Punch are standard equipment.

An almost unlimited number of applications will be served with the 160-A, including some that previously demanded much bulkier and more costly computer equipment. A few examples are: commercial data processing, engineering problem solving, off-line data conversion, scientific data processing, and real time data acquisition/data reduction and complex industrial control applications.

With the 160-A Computer, Control Data provides an extensive package of programming aids for many different applications. These include Systems & Service Programs, Interpretive Systems, Compilers, assemblers, commercial programs and General Scientific Programs. The 160-A computer will also be used in Control Data's Satellite Computer System.

### IBM STRETCH - INTERNATIONAL BUSINESS MACHINES CORP. - WHITE PLAINS, N. Y.

The IBM STRETCH computer is one of the most powerful and versatile data-processing systems ever built. It was designed and constructed over a five-year period at IBM's laboratories in Poughkeepsie, N. Y., for the Los Alamos Scientific Laboratory under contract to the U. S. Atomic Energy Commission. The Los Alamos laboratory is operated for the commission by the University of California.

The computer features speed, memory capacity, input-output flexibility, checking, and multiprogramming capability. This solid-state system is extremely fast and efficient in solving large technical problems. Its general purpose design also provides facilities for high speed, flexible handling of variable field length data and decimal arithmetic.

**Speed.** Working with fourteen-digit numbers, the system can make an addition in 1.5 microseconds; a multiplication in 2.7 microseconds; a division in about 10 microseconds. The speed makes possible solutions to problems for which equations are known, but which previously were too large or complex for solution at a reasonable cost or in a reasonable length of time.

**Simultaneous Operation.** STRETCH technology attains its high speeds through the use of ultra-fast circuits, transistors, and circuit components. But it is the principle of simultaneous operation that provides the really large increase in performance over previous systems. The computer is organized like an assembly line. As each part completes a task, it passes the work on to another machine element and immediately starts its next task, while the other parts continue with theirs. As a result, the main arithmetic unit is free for almost continuous, top-speed calculation. Facilities within also provide new concepts in multi-programming—having a number of problems available to the computer so that its various

elements can work on different problems at the same time. As many as nine programs have been run simultaneously in this fashion during test periods.

**Memory.** Operation of internal core storage is overlapped, to vastly increase the effective data flow. The Los Alamos Scientific Laboratory system has six magnetic core storage units of 16,384 words each—a total core storage of 98,304 words. This is equivalent to more than 1,500,000 decimal digits, with data retrieval from any unit in 2.1 millionths of a second. Instruction addresses allow a capacity of up to 262,144 words for future expansion.

Since the system is organized to operate several of these storage units at the same time, a continuous flow of more than a million words a second can take place, with a peak flow rate capability of about three million words a second.

A feature of core storage is the large word size—seventy-two bits per word. Of these, sixty-four are information bits and eight are for error checking and correcting. The use of words of this size, the largest available in any computer today, provides greater precision in solving complex mathematical problems. Multiple precision procedures often may be avoided in working with numbers of this size, simplifying programming operations.

A further simplification can be achieved because of the unique addressing features of STRETCH's variable field length operations. These operations allow a single instruction to address any sequence of up to sixty-four bits, regardless of their position—even if it crosses a word boundary. On the major data paths, the eight error checking and correcting bits in each word provide automatic correction of single bit errors.

**Disk Storage File.** Since the Los Alamos computer will use information at a high rate, even its large internal storage may not be sufficient for many of the problems to be encountered. Accordingly, the system has been equipped with a new large-capacity magnetic disk storage file to supplement internal core storage.

This unit will store 2,097,152 words, each comprising sixty-four information bits. The equivalent of 1,200,000 digits of information can be transferred from the file to the core storage units, or back, in one second. It would take less than half-a-minute to read the entire disk file's capacity to or from core storage.

The file includes a stack of fifty magnetic disks which rotate continuously at 1750 rpm. Information is stored on seventy-eight of the 100 disk faces. The information disks are arranged in two modules, or sets, with a comb-like arrangement of forty arms extending over each module to write information on or read information from the disks. The arms move in and out over the disk faces, but no vertical motion is required.

Even numbered tracks of information are located on one disk module, odd numbered tracks on the other. Information is stored on the disks in such a manner that they are read out in half words, in parallel. The file reads thirty-two information bits and seven error checking and correcting bits, then repeats the process for the other half of the word. The information is sent to a synchronizer to generate a word with sixty-four information and eight error checking and correcting bits.

Because of the use of two modules, approximately two-thirds of the track-to-track record seeking time is overlapped when the file is used in sequential operations. Each comb of arms can position while the other is reading.

The disk file will be used at Los Alamos to store—for rapid accessibility—programs commonly used as sub-routines, as well as for data storage. Information may be entered, through core storage, onto the disks from magnetic tape, punched cards or the operators console.

**Input-Output.** The system utilizes a wide variety of input-output equipment. Multiple units may be in operation simultaneously, sending information to storage or receiving it from

storage. Included as on-line input-output units are IBM 729 Model IV magnetic tape units; a 1000 card-a-minute card reader; a 250 card-a-minute card punch, and a 600 line-a-minute alphameric printer. The operator's console, described below, also functions as an input-output unit.

**Operator's Console.** A new approach is employed in this console, which is logically separated from the main computer and functions as an input-output device. The keyboard, switches, lights, digital display and console printer all are subject to programmed interpretation and control. The interpretive program, therefore, may endow this console with as much sophisticated control function as a programmer may wish to devise, permitting a close man-machine relationship that would be quite uneconomical in previous systems.

On the console are ninety-six binary keys and switches, each of which can be programmed to perform any specific function desired. A flick of a switch, for example, could be used to initiate a transfer of storage from memory to disks, cards or tape; to initiate a trace of instructions within the system for display on the console printer; to change programs; to utilize different information in running a program than was used in previous runs.

The interpretive approach of the console offers exceptional flexibility and makes possible console facilities that will not be outmoded as new operating techniques are developed. Program control of console functions also permits monitoring and logging functions which would be uneconomical as built-in equipment.

The console's digital display has a capacity of sixteen positions, in which the operator can see numerals or special characters representing a number of factors. These could include a display of the contents of any storage location; a count of how many times a program loop has been run, or the result of successive iterations to show the approach to a final answer of a problem. The digital display eliminates the need for reading a complex of console lights.

**The Exchange.** A new peak of efficiency in handling input-output devices is provided by a specialized computer within the system. It is called the Exchange. This acts as a switching center, routing information between the internal core storage of the system and eight channels--each able to handle up to eight tape units, a card reader, a card punch, console or printer. The Exchange is capable of controlling the flow of 800,000 characters a second from the input-output equipment. Processing may proceed without delay within the central processing unit simultaneously with the operation of the various input-output units.

**Central Processing Unit.** Completely new concepts have been built into the central processing unit to provide a high degree of overlapped operation. Thus, maximum utilization of the various sections of the central processing unit is assured at all times. Specifically, the arithmetic unit is provided with a pre-processed flow of instructions and data ready for execution. This substantially increases its efficiency.

The central processing unit may be considered functionally as three sections, each contributing to the high degree of overlapped operation and each able to function simultaneously during program executions. The three are:

**The Instruction Processor.** The instruction processor is a small computer within the central processing unit, having its own storage and arithmetic unit. Its function is to obtain instructions from core storage, pre-process them for execution in the arithmetic and logical unit and forward them to the Look-Ahead, described below. As they are transferred to Look-Ahead a request is made for their execution. Some instructions actually may be executed entirely within the instruction processor. This preliminary processing may be performed for as many as ten instructions in advance of the instruction currently being executed in the arithmetic unit.

**The Look-Ahead.** A new concept in processor design is incorporated in this unit. The Look-Ahead serves as a "reservoir" of pre-processed instructions together with their data, for the use of the very high-speed arithmetic unit. By providing a flow of information to the arithmetic unit, Look-Ahead effectively increases the storage speed many times; to fully utilize the tremendous speed of the arithmetic circuitry.

The Arithmetic and Logic Unit. The arithmetic and logic unit includes two high-speed arithmetic units, both of which may be operating during the execution of an instruction, providing yet another degree of overlap in instruction execution. One of these units utilizes ninety-six-bit parallel adder to perform high-speed floating point arithmetic. The other unit operates in serial fashion in variable field-length processing and adjusts its mode of operation between decimal, binary or logical operations as specified by the instructions.

All of the above functions of the central processing unit are carried on concurrently with the operation of this high-speed disk file and the various input-output units.

Automatic Interruption. The system has the ability to put aside what it is doing to turn to special conditions requiring immediate action. These may be conditions completely outside the computer's sphere of operations. The computer could interrupt its work upon a major problem to make priority calculations on another problem presented to it for rapid solution. All other parallel functions in the system would continue without pause. After the priority problem is completed, the interrupted elements of the system would continue their previous work. This "interrupt" feature is vital in allowing many users quick access to the computer.

In addition, automatic interrupts may be based on conditions within the computer--conditions recognized by the computer itself as requiring special action. As many as forty-seven separate interrupt conditions are possible. This ability to selectively and automatically monitor so many machine or program conditions frees the programmer from tedious and time-consuming testing. It provides a positive signal should some exceptional condition arise so that corrective or alternative action may be initiated at once.

Accuracy and Reliability. The use of solid-state components throughout makes system inherently more reliable than its vacuum tube predecessors. In addition, it incorporates more self-checking features than any other computer. All data transfers and calculations are checked for accuracy and many errors are corrected automatically.

The reliability was indicated during pre-shipment tests at Poughkeepsie. The tests covered five consecutive days of 12-hours-a-day operation and were conducted with a series of programs written by personnel from the Los Alamos Scientific Laboratory. The system's functional capability, as well as its reliability and serviceability, were tested during these program runs. During the five-day period, the machine averaged 90% "good time" to "total time" well above the 80% which had been established as the test criterion.

#### NCR 315, 304, 390, AND 310 - NATIONAL CASH REGISTER COMPANY - DAYTON, OHIO

The National Cash Register Company has a fully-developed line of electronic data-processing equipment including four separate solid-state systems, each with its unique set of features.

Three of the systems are designed to solve general business and accounting problems; each of these systems has distinct advantages under different conditions. The fourth system, the NCR 310, is designed specifically for use in conjunction with the National Post-Tronic and the Pitney-Bowes National magnetic character sorter in the banking industry.

NCR 315. The new Class 315 electronic data processing system is a solid-state, low-cost computer expandable from a basic system of limited capacity to a powerful full-scale system. The computer accepts and delivers large volumes of information in all common business-machine media at high speeds.

The main memory, the random access file, the magnetic tape file, and the input and output systems are all variable in size or capabilities to fit closely the requirements of the user.

The processor is available with five different memory sizes capable of storing 6000 to 120,000 decimal digits or 4000 to 80,000 alpha-numeric characters.

Up to sixteen Card Random-Access Memory (CRAM) units may be incorporated in a 315 system. Each unit contains an easily removable cartridge of 256 magnetic cards. Each card can store up to 21,700 alpha-numeric characters in the seven magnetic "tracks" running down one surface of the card; each track can be addressed separately. Any card (or track) in the system is accessible within 170 milliseconds. Access time may be shared. There is no rewinding. With this magnetic-card file, the 315 system can process any number of special transactions in random order at any time.

The system may include from one to eight magnetic tape files, each containing 3600 feet of 1/2-inch magnetic tape and capable of storing 21 million alpha-numeric characters or 31 million decimal digits of information.

The input system for the 315 may include up to four magnetic character sorter-readers, a punched card reader, a paper tape reader, and the console typewriter as well as the magnetic tape handlers.

The output system may include up to four high-speed line printers and card punches in any combination, a paper tape punch, the console typewriter, and the magnetic tape handlers.

Any input, output or memory components not incorporated in the original system may be added as required. To permit maximum efficiency in the use of input and output units (time sharing), the peripheral units can interrupt a program automatically.

#### Sorter-Reader

Sorting speed	750 documents per minute
Sorting pockets	12 pockets
Document dimensions	2-1/2 to 4-1/2 inches wide 5-1/4 to 10 inches long .003 to .007 inches thick
Type font	E-13B (American Bankers Association specifications)

#### Paper Tape Reader

Reading speed	1000 characters per second
Tape width	5-, 6-, 7-, or 8-channel tape
Acceptable code	Any code

#### High-speed Printer

Printing speed	680 lines per minute
Line length	120 characters per line
Form width	4 to 22 inches
Skipping rate	5040 lines per minute

#### Card Reader

Reading speed	400 or 2000 cards per minute
Acceptable codes	Any code

#### Paper Tape Punch

Punching speed	120 characters per second
Tape width	5-, 6-, 7-, or 8-channel tape
Acceptable code	Any code

#### Card Punch

Punching speed	250 cards per minute
Acceptable code	Any code

#### Card Random-Access Memory (CRAM)

Transfer rate	100,000 alpha-numeric characters per second
Storage	21,700 alpha-numeric characters per card; 5.6 million alpha-numeric characters per cartridge
Access time	170 milliseconds
Re-access time	14 milliseconds to card already selected
Reading time	32 milliseconds per track

#### Magnetic Tape File

Transfer rate	40,000 or 80,000 alpha-numeric characters per second
Storage density	500 alpha-numeric characters per inch
Tape length	3600 feet
Record length	Variable from two to 16,000 alpha-numeric characters

**NCR 304.** The Class 304 Electronic Data Processing System is a solid-state, medium-cost computer designed specifically for business and comparable large-volume applications. Features of the system include provisions for simplified programming, a large-capacity memory, and high-speed input and output machines which together can handle all common types of business-machine media.

The magnetic core memory of the 304 may have either 24,000 or 48,000 memory positions. The computer, also, accommodates up to 64 magnetic tape units, each containing 3600 feet of fully-utilized tape. The magnetic tape records information at a density of 250 characters per inch.

The system employs a basic three-address command structure for programming economy in large-volume applications. However, there is also available a single-address command list for scientific computation. This single-address mode of operation, which allows fixed or floating point arithmetic, is called Micro-Flow. The programmer can switch easily from one command list to the other to obtain maximum results in any application.

The 304 permits use of National's Electronic Autocoding Technique (NEAT), a method for simplifying the programming of instructions for such complex procedures as merging, sorting, summarizing, and editing.

High-speed input machines take information from punched cards, punched paper tape, magnetic tape, and media imprinted with magnetic characters. Limited information may also be fed into the system through a typewriter at the console.

Other high-speed machines record input information by punching cards or tape, or by printing on paper a line at a time.

To assure accuracy, all data moving through the system is checked at every step from the initial input to the final report.

Semi-conductors and printed circuits are used throughout the system to keep space, cooling, and maintenance requirements at a minimum.

#### Magnetic Tape File

Transfer rate	30,000 alpha-numeric characters per second
Storage density	250 alpha-numeric characters per inch
Tape length	3600 feet
Record length	Variable from 100 to 1000 alpha-numeric characters



#### Card Reader

Reading speed	2000 cards per minute
Acceptable code	Any code

#### Tape Reader

Reading speed	1800 characters per second
Tape width	5-, 6-, 7-, or 8-channel tape
Acceptable code	Any code

#### Sorter Reader

Sorting speed	750 documents per minute
Sorting pockets	12 pockets
Document dimensions	2-1/2 to 4-1/2 inches wide 5-1/4 to 10 inches long
Type font	.003 to .007 inches thick E-13B (American Bankers Association specifications)

#### High-speed Printer

Printing speed	680 lines per minute
Line length	120 characters per line
Form width	4 to 22 inches
Skipping rate	5040 lines per minute

#### Paper Tape Punch

Punching speed	3,600 alpha-numeric characters per minute
Tape width	5-, 6-, 7-, or 8-channel tape
Acceptable codes	304 code and any other code

#### Card Punch

Punching speed	250 cards per minute
Acceptable code	Any code

**NCR 390.** The Class 390 electronic data-processing system (see DCN July 1960) consists of a central processor, a console, units to read punched paper tapes or punched cards used as input media, and auxiliary equipment to create punched paper tape or punched cards and to control other peripheral equipment.

The 390 is a solid-state, magnetic core, fully transistorized processor that may be integrated into all existing data-processing systems.

Two important features of the 390 provide a low-cost system for general business use: the first is a unique magnetic ledger card which stores data in magnetic tape strips on the back of the form, yet carries all necessary printed information for reference and auditing on the front of the form. The second feature is a programmable printer capable of printing final results in any columnar arrangement on multiple forms and reports.

In general, commercial data-processing systems have the same basic requirements: the system must have the ability to perform arithmetic calculations; the ability to classify, summarize and distribute transactions and entries; the ability to print and maintain accounting records and files for reference purposes; the ability to create payroll, billing, and other documents; and the ability to organize all of this information into statistics and reports for management. The 390 can perform all of these operations.

The system has two kinds of memory, external and internal.

The external memory is data stored in machine language in magnetic ledgers, punched paper tape, or punched cards. The external memory is used to store detailed accounting information and programs.

The internal memory is of magnetic core design and consists of 200 twelve-digit memory cells. The internal memory is used to accumulate totals during processing, and for storage of program instructions.

The internally stored program may be modified at will by the monitor. The monitor may also extract information or insert new data or new instructions at any time without disturbing the computer program.

#### Paper Tape Reader

Reading speed	400 characters per second
Acceptable code	390 code
Tape width	5-channel tape

#### Card Punch

Punching speed	250 cards per minute
Acceptable code	Any code

#### Magnetic Ledger Card

Magnetic storage	200 digits or more
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**NCR 310.** The Class 310 controller-computer, designed primarily for the banking industry, permits full automation of all paper handling, sorting, listing, and posting when used in conjunction with a Pitney-Bowes National sorter reader.

For banks using the automated POST-TRONIC, the 310 automatically punches the account number, transaction code, and amount of each check and deposit into paper tape while these items are being processed by the sorter. Simultaneously, all items are tested for validity of account number, transaction code, ABA number, and presence of a dollar amount digit.

As items are being qualified and fine sorted, the 310 directs the documents to specific pockets based on entire account number identification. High volume accounts can, therefore, be immediately sorted without modification of the account number.

#### Paper Tape Punch

Punching speed	110 characters per second
Tape width	8-channel tape
Acceptable code	NCR POST-TRONIC code

#### Paper Tape Reader

Reading speed	350 characters per second
Tape width	5, 6, or 7
Acceptable code	Any code

#### Sorter Reader

Sorting speed	750 documents per minute
Sorting pockets	12 pockets
Document dimensions	2-1/2 to 4-1/2 inches wide 5-1/4 to 10 inches long .003 to .007 inches thick

Type font	E-13B (American Bankers Association specifications)
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## ORACLE - OAK RIDGE NATIONAL LABORATORY - OAK RIDGE, TENNESSEE

Oak Ridge National Laboratory's general purpose computer ORACLE (see DCN October 1957) was shut down on May 22, 1961 for the purpose of installing a new magnetic tape unit. This unit is being integrated into the ORACLE utilizing existing unused order combinations in the input-output list.

There is a two-fold purpose in adding this tape unit: first, it will provide a needed additional auxiliary memory for internal use; second, it will provide a means of direct communication of IBM BCD format between ORACLE and IBM's 7090 or its peripheral equipment.

The tape itself is a modified Potter 906 Mod. II with Potter's transistorized servo and transport control, and Potter's dual read-write head for checking while writing.

The transistorized read and write amplifiers were designed and constructed at Oak Ridge National Laboratory. The control logic was designed and constructed utilizing commercially available "ECCO" transistor logic modules.

The order list is as follows:

### Oracle Mode

- 83 - Write one record of n words (10 Hex characters per word)
- 93 - Read one record

### IBM BCD Mode

- 8B - Write one record of n words (6 BCD characters per word)
- 8F - Write end of file
- 9B - Read one record

### Common Mode

- 87 - Rewind to load point
- 97 - Hunt back one record
- 9F - Hunt forward one record

It is expected that the ORACLE will be back in operation within one month of the shutdown date.

## PHILCO 2400 - PHILCO CORP. - WILLOW GROVE, PENNA.

The new Philco 2400 is a low-cost, high-capacity data-handling system. Designed as an adjunct to the Philco 2000 Electronic Data-Processing System (see DCN April 1957 and April 1959), the 2400 eliminates the need for buffer-controllers in a 2000 System, as well as the need for individual controllers for each input-output unit. Controls for input-output units are built right into the 2400. In addition, the 2400 relieves the 2000 of all time-consuming input-output and data-preparation workloads. This leaves the 2000 System free to perform computational work at peak efficiency.

A 2000 and a 2400 can be coordinated to operate in parallel on portions of a job best suited to each computer, thereby reducing problem time and increasing system capacity.

The 2400 contains 8192 characters of random-access core storage, simplified controls, and stored-program processing which permits editing, searching and selecting, sorting, and data translating. The console has convenient monitoring and control features designed for the operator who is servicing input-output devices. These features include automatic load control and program control. Inquiry typewriters are available as options for operator control and direct access to memory locations. The basic 2400 system provides for additional input-output devices and future memory expansion. Reduction of required floor space, maintenance, and power are just a few of the economical features of the compactly designed 2400.

With its asynchronous organization of memory, processor, program control, and independent input-output channels, the 2400 gives users the maximum amount of simultaneous input-output operations. High-speed core storage of up to 32,768 directly addressable characters meets individual user's needs.

**Input-Output Functions.** In its performance of all input-output functions for 2000 Systems, the 2400 uses standard Philco input-output devices. However, controller units and programmed plugboards are replaced by the stored-program processing of the 2400, in combination with minimum control circuitry for each input-output device.

The 2400 accommodates a complete selection of Philco 2000 input-output devices on eight autonomous channels. Since these channels are character oriented, they are readily adaptable to high-speed data links, mass storage files, character reading devices, and output displays.

Up to eight Magnetic Tape Units can be addressed by each input-output channel selected for magnetic tape use. Two magnetic tape channels can be operated simultaneously for a read-write speed up to 180,000 characters per second.

The selection of input-output operations is controlled by a combination of operator inputs, program, and controls which are coded into the data itself. The operations which can be selected include the control of information to be punched and/or printed, the determination of end of information, the accumulation of control totals, and the selection of mode or printing.

**Processing Functions.** Valuable computer and data transfer time are saved by the performance of the translating, packing, and editing phases of data preparation on a 2400. As a result, the 2000 deals only with preprocessed and verified data. Savings in excess of 15% of storage space and access time are realized, as well as an average saving of 25% of available computer time.

In addition to input-output processing, the 2400 can also function as a powerful auxiliary processor to the 2000. Typical operations which can be shared by the 2400 for over-all system economy include information retrieval and data select, sorting and merging, binary and decimal arithmetic, and computations.

Search functions of the 2400 are designed for fast and efficient information retrieval. Data-streams from high-speed devices are scanned at the full speed of the devices. As a result, the continuous flow of input data is not interrupted.

For economical preparation of reports, the 2400 recognizes data codes, then selects the program and format required. The 2400 is, therefore, completely compatible with existing 2000 data select features.

Fast sorting is accomplished on the 2400 by expanded memory, simultaneous tape operations, extra tape stations, and special sort instructions.

General data-processing instructions include binary and decimal arithmetic, logical decisions, transfers, and shifts. Processing ability may be expanded by the addition of multiply and divide functions.

**Expanded Processing Ability.** The basic 2400 system can be expanded in modular fashion and remain balanced. For this reason, a system can be designed to give a customer as much data-processing power as he now needs and can later be expanded to fill his future needs. To extend this idea, as many 2400 systems as necessary can connect and coordinate a number of on-site or remote locations with a 2000 System.

**System Reliability.** Complete data accuracy for the entire 2000 - 2400 operation is assured by the built-in checking features of both systems. Incoming data may be audited, and the validity of each item may be checked by program. Step-by-step checking through the entire machine cycle is performed as follows:

Input-output devices are field proven and have built-in parity checking. Punched-card operation includes double-read-and-compare.

Data Parity is carried through internal processing.

Additional program checking may be tailored to the user's needs.

Preventive maintenance and diagnostic routines assure complete machine reliability.

Philco 2000 and 2400 tape units provide immediate readback for lateral and longitudinal checking.

Data characters found to be in error can, in many cases, be automatically corrected by program.

#### UNIVAC 1107 THIN-FILM MEMORY COMPUTER - REMINGTON RAND UNIVAC - NEW YORK, N. Y.

The Remington Rand Univac 1107 Thin-Film Memory Computer, the first of the third generation of commercially available electronic computers and the first computer to employ thin magnetic film memory, is an advanced solid-state data-processing system. It was designed and developed to solve both complex problems off-line and real-time problems on-line.

The system employs a separate thin magnetic film control memory with several internal features which enable the user to gain additional speeds beyond those built in by electronic circuitry. These features include 16 arithmetic registers, 15 index registers with automatic incrementation, and partial word transfer capabilities. The new 1107 accesses its film memory more than 1,000,000 times per second in normal operation. Its two large banks of core memory are accessed up to 500,000 times per second.

In addition to the film memory, the system employs a ferrite-core memory of from 16,384 to 65,536 words, depending on the requirements of the user.

The thin magnetic film memory, a 7 year intensive research and development of Remington Rand Univac, represents a breakthrough in the field of electronic data processing. It enables the 1107 to attain internal referencing rates of speed measured in billionths of a second, as compared to the millionths of a second for previous computer systems. For example, the cycle time from the thin-film memory is only 0.6 microseconds, as compared with the cycle time of ferrite-core memories (most advanced previous memory design) of 1.5 microseconds.

The thin film is a ferro-magnetic film (a few millionths of an inch thick) made by depositing vapors of iron, nickel, cobalt, or other ferro-magnetic metals or their alloys, on a suitable sub-strate such as thin glass plate. The film has very unusual properties when deposition is made under controlled conditions. For example, if a magnetic field is applied parallel to the surface of the sub-strate during deposition, the thin film then becomes easier to magnetize in the direction of the field in which it was applied than it is at right angles to that direction. This property permits the magnetic state of such a film to be switched in as little as 1 billionth of a second. In a computer memory, this means that information can be stored in and retrieved from the memory with a speed directly related to the speed required for switching the magnetic state of the memory. All of the older types of memories, such as electric relays or vacuum tubes, mercury delay lines, magnetic drums, and ferrite cores, were capable only of much slower speeds. Ferrite cores, the fastest of the previous types, could be rated only as high as millionths of a second. Thin magnetic film memories may ultimately permit a thousandfold increase in computer memory speed.

To fabricate arrays of ferro-magnetic film for computer use, the metal must be deposited in the presence of a magnetic field onto the sub-strate using an evaporative process in a vacuum of the order of  $10^{-5}$  or  $10^{-6}$  mm of mercury.

A very delicate operation is employed to connect these deposits of film to the computer circuitry. Since ordinary wires cannot be used, a multi-layer printed wiring on plastic

material is required. Ferro-magnetic film arrays are laid onto the printed circuit. The arrays, made up of individual circular ferro-magnetic film elements about 1/32 in (1/80-inch) in diameter, are placed on the multi-layer circuit etched in a grid pattern. When the copper matrix is covered with the arrays, it is closed to connect the circuit, and the memory is then completed.

In addition to the high-speed switching-time, Thin-Film has other unique and valuable properties:

1. Thin-Film memory is of the catalogue type, that is, its store of information can be interrogated and read-out millions of times without destruction.
2. It requires less electric power for energization than do other memories.

Ferro-magnetic film elements can now be produced which are so small and have such fast switching speeds that they make possible computers of smaller size and much greater capability than have been available to date.

A Thin-Film memory built with non-destructive read-out properties will make computers more reliable than they have been to date, since the memory cannot be destroyed or affected by use. In addition, the production of thin magnetic film lends itself well to automation and, therefore, computers should be produced far more economically in the future.

When Thin Magnetic Film begins to be used for performing logic as well as for memory functions, computers will have even greater capabilities and will be well on their way to self-adaptive functions, i. e., organizing themselves to do a job in the best possible way, and even to program themselves.

The net result is to provide the 1107 with capabilities found only in much costlier large-scale systems, and to enable it to efficiently and economically process a wide range of commercial, scientific and military applications.

Typical applications that can be processed on the 1107 are scientific computation; data reduction and analyses; digital communication and switching systems; tactical data and control systems; simulation; logistics and intelligence systems; traffic control; reservation systems; and inventory and scheduling systems.

The 1107 has a highly versatile input-output section which can accommodate a wide range of peripheral equipment. External units can be used to provide a hierarchy of auxiliary storage, such as drums, discs, and tapes. Others, such as card units, printers and document-sensing devices, serve as input and output equipment.

The 1107 can also communicate with many other real-time devices, such as analog-to-digital and digital-to-analog converters, key sets, printing telegraph equipment, digital communication, radar and tracking systems, display systems and other data-processing devices.

In spite of its ability to perform so wide a range of applications, the 1107 computer requires comparatively small floor space. A typical configuration actually occupies only 150 square feet, exclusive of passageways, work areas, etc. The system is appreciably lower in cost than less advanced equipment. Rental charges range from \$40,000 to \$80,000 per month, depending on configuration. Delivery is 18 months to 2 years following acceptance of contract.

## COMPUTING CENTERS

### BENDIX G-20 INSTALLATION - CARNEGIE INSTITUTE OF TECHNOLOGY - PITTSBURGH, PENNA.

A Bendix G-20, (see DCN April 1960, and January-April 1961) which can be operated by remote consoles 1500 feet away, is being installed in the Carnegie Institute of Technology Computation Center. Installation of the basic units of the G-20 was begun following removal

of the old computer from the Graduate School of Industrial Administration. Certain of the remote consoles and storage units will be installed this summer.

The new G-20 was selected because of its high speed, the capacity and information exchange rate of its storage units, its time-sharing ability, and its low cost—about \$850,000. The needs for and uses of a computer on the Carnegie Tech campus are wide and varied. Some examples are:

1. Teach the use of the computer.
2. Implement research projects of graduate students and staff in the university's general research program.
3. Discover new uses of the computer. Two of the major research projects in this area are devising new means for the computer to serve as an aid in management decision making and developing methods to study human thought processes through simulation.
4. Play the management game by the businessmen enrolled in the Program for Executives and by students in the Graduate School of Industrial Administration.
5. Ease the teaching load by grading problems.
6. Act as a teaching machine for students in mastering certain drill problems in the areas of mathematics, engineering, and physical sciences.
7. Apply data-processing procedures to university administration functions.

The computer also will serve as the central element in a new doctoral program in systems and communications sciences which Carnegie Tech will offer this fall.

The availability of low price in-out stations for the G-20 computer is another great advantage of this system.

If people can request access to the computer from a distance—and the computation center plans to have several of these remote stations—this will increase the usefulness of computers. The computer will become a natural part of the educational process and merge into the dynamics of research in progress in a much more direct way than it is at present.

The remote consoles will be used by students and faculty. Through the consoles they will directly request execution of their programs kept permanently recorded by the central computer.

A unique quality of the computer is its control buffer system which by performing many functions formerly assigned to the machine's central processor serves to break an operational log jam that limits the performances of many computers. The G-20 buffer once ordered into action by the central computer can under its own control proceed to read punched tape or punched cards, look up data stored on magnetic tape, and print or punch required output. Meanwhile, the central computer is left free to handle additional computation work.

The new G-20 is a completely transistorized system that can do up to 83,000 additions or subtractions per second and reads and writes on magnetic tape at 240,000 decimal digits per second. The G-20 magnetic tape system can read information equal to a 400 page book in less than 11 seconds and one high-speed G-20 printer could reprint the same book in just 12 minutes.

#### HIGH-SPEED ANALOG-TO-DIGITAL CONVERTER SYSTEM - PACIFIC MISSILE RANGE - POINT MUGU, CALIFORNIA

A high-speed analog-to-digital converter system is now operational at the U. S. Naval Missile Center, Pacific Missile Range, Point Mugu. The system will accept three types of telemetry data: pulse amplitude modulated data (PAM), pulse duration modulated data (PDM), and frequency division multiplex type data (FM). The FM data is processed at a sampling rate of 6666 samples per second. All data is output in a binary format.

The system consists of analog tape reproduce units, FM discriminators, a range-time tape search unit, and a Microsadic digitizer system. The microsadic system is made up of an electronic commutator, for multiplexing up to 12 FM signals; an 1800-bit core buffer; and a digital tape recorder. For time-data correlation, the 1KC range-time carrier is counted

and accumulated from a known starting point by the time accumulator. The 1800-bit core buffer allows writing PDM and FAM data in standard IBM tape format.

FM data is written in a gapless tape format. In this way, FM data is not lost between records. In the gapless format all data is contained in tape Channels 1, 2, 4, 8 and A. A 1-bit in Channel B is used exclusively to indicate an end-of-record, and at all other times the contents of Channel B are zeros. Upon sensing a "B-bit" transmission is terminated and the tape, upon stopping, backspaces past the B-bit and stops again. To read the next record, the tape is set in motion and attains reading speed before the B-bit is read. Transmission commences on the first tape character following the B-bit. Recently a 36-bit buffer was placed between the Microsadic and the computer enabling the unpacking to be handled external to the computer and permitting direct entry of data to the computer. Transistorized, printed circuit, modular construction is used throughout the Microsadic system.

In summary, this system provides the following capabilities:

1. Analog-to-digital conversion of time and telemetry data with recording on magnetic tape in a form compatible with the computer format.
2. Direct entry of time and digitized data, via the buffer, into the IBM 709 or 7090 computer.
3. Playback of digital telemetry tapes through the buffer into the computer. In addition, the use of the buffer provides limited computer word format controls and the ability to increase the rate of entry of data in the computer.
4. Digital FM telemetry tapes prepared by the system can be placed on a standard type 729 magnetic tape unit and read directly into the 709 through a modified type 755 tape control unit, at standard IBM tape speeds.

#### COMPUTATION CENTER - U. S. NAVAL WEAPONS LABORATORY - DAHLGREN, VIRGINIA

The Automatic Digital Data Assembly System (ADDAS), a part of the Naval Space Surveillance System, has been constructed to the state where data transmitted by phone line from one of the remote sources is being assembled on magnetic tapes suitable for input to the NORC or the IBM 7090. Automatic equipment for the other remote sources is under construction. Installation of a computer to be devoted to space surveillance work is planned for late 1961, and the ADDAS will ultimately be connected as an on-line input to this computer. A more detailed description of the ADDAS was given in the April 1960 Digital Computer Newsletter.

## COMPUTERS AND CENTERS, OVERSEAS

### ARGUS - FERRANTI, LTD. - LONDON, ENGLAND

In recent years there have been fundamental changes in the characteristics of industrial plants and in the functions of the human beings who run them. Plants have become larger and processes enormously more complex, so that very difficult control problems have arisen. The work of the human operator has become little more than supervisory—the actual plant operation being regulated by automatic control systems under the operator's command.

Computers have been used for some time for logging industrial data to produce additional information for the plant operators. Now the stage has been reached when the local automatic control devices themselves are being supervised by a central digital computer. As a result the human operator becomes even more remote—though he still stays in full command.

Latest technique in computers for plant control is represented by the Ferranti Argus digital computer (see DCN April 1959), a machine developed specifically for this type of work. It possesses the flexibility normally associated with digital computers, but also incorporates features which distinguish it from general-purpose machines and make it particularly well suited to process-control applications.



The Argus is a fast and powerful digital computer with a time-sharing facility which makes it capable of storing and working on several programs at once and dealing with several different plants and processes concurrently. A comprehensive range of input and output equipment is available for connecting the computer to a large variety of instruments and devices in industrial plants. Both the computer and its associated equipments are of exceptional reliability.

Information can be read into the computer from as many as several hundred instruments in a plant, subjected to any necessary mathematical operations, and then used to generate any required number of output signals. These output signals may be for direct control of the plant, for plant supervision or for operating logging devices. Because of the time-sharing system the input and output signals need not all be concerned with the same process. The electronic design of the Argus computer is based on circuits constructed entirely from solid-state components. The machine uses binary serial/parallel fixed-point arithmetic and has a word length which may be either 12 or 24 binary digits. With 12-digit numbers, addition operations are carried out in 20 microseconds, multiplication in an average of 100 microseconds and division in 200 microseconds.

Programming the machine is done manually, by inserting small pegs of magnetic material into holes drilled in printed circuits which are arranged in trays. Reading-out of the stored information is done by energizing the printed conductors on the one face of a tray, and the pegs cause currents to be induced in certain of the conductors on the other face, depending on the pattern in which the pegs are inserted.

The high-speed working store is a magnetic core matrix type. Backing-up storage of 50,000 words can be provided by a magnetic drum.

The time-sharing feature of the design mentioned earlier is achieved by a system which enables the main program to be interrupted at regular intervals to allow a special routine of instructions to be carried out—as may be required for regularly examining some quantity in the controlled process and taking necessary corrective action. Another useful facility allows for direct writing into or reading out of the magnetic core store by independent equipment, such as magnetic tape units, which cannot be synchronized with the computer.

The individual computing elements from which the Argus is built up are versatile units constructed as printed-circuit packages, with 36 packages in a box. These boxes can, in fact, be assembled very quickly to form different types of digital control systems. Recently a special control computer using them was designed and built in three months, while a variety of data logging systems designed on this principle are currently being assembled to meet specific requirements.

Because of its flexibility and reliability the Argus computer system can be used in many industries, at all levels of application between data logging and direct 'on-line' control.

Financial justification for installing a computer for control purposes can be found in increased efficiency and productivity of the plant, in lower costs of labor or material, in increased safety, and in improved consistency of output—particularly in plants where satisfactory control is difficult to achieve by other means. On the large plants of today even small increases in efficiency can produce enormous savings.

Alternatively there is the consideration that a single computer can control, by time-sharing techniques, several small plants of completely different characteristics. Thus in cases where it might be difficult to find financial justification for applying computer control to only one process, the savings obtained on several small units could be as beneficial as for a single large plant.

For certain processes with the right kind of characteristics it is possible to replace all conventional control devices by an Argus system. An example of this is the system which has been ordered from Ferranti by Imperial Chemical Industries for the direct control of one of their chemical plants at Fleetwood in Lancashire.

When the installation of new instrumentation became necessary for this chemical plant it was decided to centralize all the control loops in a digital computer rather than to install a large number of individual analog controllers in a conventional system.

The installed price of the digital control system is slightly higher than that of the conventional analog system but the central availability of all process data in the digital computer offers many benefits which could not otherwise be achieved.

For example, the process variables will be logged on magnetic tape in such a way as to facilitate mathematical analysis of the plant characteristics on a Ferranti Mercury computer (until recently one of the fastest digital computers in Europe). The knowledge gained in this way will gradually be incorporated into the Argus program so that, ultimately, the independent control loops which are built into it will be subject to over-all supervision by a master section of the program.

About 100 individual control loops in the I. C. I. plant will be replaced by the Argus computer, which will have a program capacity of 1024 instructions and core storage for 1024 words. Over 300 analog signals of six different types are to be read in, one group of 100 points being selected in a total time of 1/16-second. Outputs for controlling the settings of nearly 100 pneumatically operated valves are also being provided.

The fact that the computer operates directly on the process is the most important feature of this application of Argus. A more orthodox approach would have been for the computer to operate through the agency of conventional controllers or in parallel with them, to guard against the possibility of equipment failure.

The reliability of the Argus equipment, however, coupled with the docile nature of the I. C. I. process, makes such precautions unnecessary. Furthermore, the Argus is one of the few process computers anywhere in the world which are sufficiently fast to carry out this form of direct control of a large number of loops.

In addition to the Argus system ordered for the control of a chemical plant, another Argus system is being considered for control operations on a large boiler.

#### SIRIUS - FERRANTI, LTD. - LONDON, ENGLAND

The Sirius computer (see DCN July 1959) is a small transistorized general-purpose digital machine which can be installed in a medium-sized room and plugged into the domestic mains supply. Costing only £18,450 (basic price), it has been designed for establishments which have a definite need for a versatile stored-program computer but cannot justify the purchase of a large installation.

Being a general-purpose machine, it is suitable for a wide variety of uses in industry, commerce, science, and technical education. Commercial data processing, industrial data logging and process control are as much within its ambit as scientific and technical calculations. The machine is easy to use, as numbers are represented in decimal form and can be displayed to the operator in this form at any time. An automatic programming language, or Autocode, allows it to be used by people who are not trained as programmers.

Thus the Sirius does not need a staff of computer specialists permanently in attendance to operate it. And, being small and relatively inexpensive, it does not have to be kept permanently occupied to justify itself economically. It is an ideal machine for "do-it-yourself" computing. Present users include small and medium-sized establishments as well as individual departments of much larger organizations.

The computer is constructed as an upright cabinet, fronted by a flat steel desk at which the operator sits. The cabinet, which contains the transistor electronic circuitry, measures 6 feet, 9 inches wide by 4 feet, 9 inches high by 10 inches deep. The desk measures 6 feet, 6 inches wide by 2 feet, 10 inches deep. Together they occupy a floor space of 25 square feet. Not part of the basic computer, but requiring some additional floor space, are the paper-tape editing desk and output punch.

All of this equipment can be installed comfortably in a room of about 150 square feet. Most establishments will have no difficulty in finding a place for the computer that is conveniently situated for the people who have to use it. The total weight is 13 cwt., and as no special power supplies are necessary the machine can be moved from one room to another without undue trouble. Power consumption is actually 600 watts for the computer itself, or about 2 kilowatts for a full installation. With such a small dissipation of electrical power no special cooling or ventilating facilities are necessary.

What, then, are the main operating characteristics of the Sirius? As already mentioned, numbers are represented in decimal form inside the machine (actually binary-coded decimal), the length of a computer word being 10 decimal digits.

The same system is used in the punched paper-tape input and output equipment, so the computer's task of reading-in data and writing out results is greatly simplified.

Decimal numbers can also be entered manually by pressing rows of ten keys on a keyboard unit while the contents of certain registers in the machine are presented on two monitor displays, each consisting of a row of ten illuminated numerals (level with the operator's eyes). One of the displays always shows the instruction which has just been obeyed. The other shows the contents of a register selected by the operator.

Sirius operates in the serial mode and is therefore not as fast as parallel computers, but nevertheless a word, consisting of 10 decimal digits, takes only 80 microseconds to pass through the arithmetic unit. The time taken to perform instructions in a program varies with the nature of the instructions, but ranges from 0.24 milliseconds (for operations involving only the arithmetic unit) to about 8 milliseconds (for multiplication or division). Average programs are performed at a speed of about 1000 instructions per second.

An important feature of the machine is that it has multiple accumulators for performing arithmetic operations—eight in all. This makes it easier and quicker to write programs and also increases the speed with which the computer performs them. The contents of any accumulator can be used to modify the address of an instruction, for example, so that repetitive procedures can be easily written in the programs.

A single level of storage is used in the machine. In other words there is no distinction between a working store and a main store, so that no time is wasted on transfers of numbers from one to the other. The basic computer has a storage capacity of 1000 words, provided by torsional delay lines of great reliability. This can be readily extended in multiples of 100 words by adding extra storage units, making possible a total storage capacity of 10,000 words.

The normal input and output medium for the Sirius is punched paper tape. The tape readers operate at 250 characters per second and the output tape punch at 60 characters per second. Other input/output equipment may, however, be fitted. Fast tape punches (110 characters/second) or direct output printers (10 characters/second) may also be supplied, while analog/digital and digital/analog converters can be fitted for data logging and process-control applications.

Error detecting facilities are provided in Sirius for guarding against errors introduced by the operator, or by faults in the equipment, or by mischances such as numbers getting too big for their storage registers. Automatic checking procedures are applied to the paper-tape input/output equipment and to the storage system while the computer is in operation, and any such errors cause the machine to stop. An "overflow register" notes when any numbers get too large for the capacity of their storage registers.

Considerable experience, gained from the whole range of Ferranti computers, has gone into the design of the programming system. Over 60 different functions are made available by the instruction code. Each instruction occupies one computer word of 10 decimal digits. A typical example, as displayed on the instruction monitor mentioned earlier, might be 000372/11/53. The first six digits, 000372, are a store address or a constant, the next two digits, 11, are a code number identifying the order to be performed, while the last two digits, 523, are the identification numbers of two accumulators.

In this case the instruction literally means: "add the contents of accumulator 3 to the contents of storage location 372 and subtract the sum from the contents of accumulator 5, which will store the result."

Since one of the decimal monitors shows the instruction which has just been obeyed and the other is used to display the contents of any accumulator, it is easy to demonstrate in readily understood decimal terms the effect of each instruction on the operation of the computer.

An automatic programming system is also provided for the Sirius. This is normally used with the Sirius Autocode compiled for the machine but has the special feature that it will also accept programs written in the well-established Pegasus Autocode. Since there are now a great many Pegasus Autocode programs in existence this facility gives the Sirius user the benefit of a large number of ready-made programs. Autocode programs are actually performed twice as fast on Sirius as they are on Pegasus.

Arithmetic and other operations in the machine are performed by majority-decision logical elements consisting of circuits built up from semiconductor diodes, transistors and transformers.

The circuits are constructed in the form of plug-in packages, of which there are some 700 of ten different types. This form of construction, allied with robust electronic components working under conservative conditions, ensures great reliability in the operation of the machine.

Since the latest model of Sirius computer was introduced last year, ten of these machines have been ordered.

#### SIEMENS 2002 INSTALLATION - GUTENBERG UNIVERSITY - MAINZ, GERMANY

In August 1960, a medium-size digital computer Siemens 2002 was installed at the Institute of Applied Mathematics, Gutenberg University, Mainz. The Computer has been in operation since October 1, 1960.

#### ISTITUTO DI FISICA TEORICA - UNIVERSITY OF NAPLES - NAPLES, ITALY

A new laboratory for the construction of self-organizing machines and other brain models is being organized in Naples under Prof. E. R. Caianiello in the Scuola di Perfezionamento in Fisica Teorica e Nucleare of the University of Naples. Some of the ideas which will be leading into the program are to be found in E. R. Caianiello's "Theory of thought processes and thinking machines" in the 2nd issue of the Journal of Theoretical Biology.

Prof. Norbert Wiener, who spent 4 months in Naples during the present academic year, intends to join the Scuola di Perfezionamento in Fisica Teorica e Nucleare again for one year beginning next February to work on brain waves and cybernetical theory.

#### ELEA 6001 - C. OLIVETTI & C. S. p. A., LABORATORIO DI RICERCHE ELETTRONICHE - MILAN, ITALY

The Olivetti Elea 6001 is a medium-size, fully transistorized digital computer designed for scientific applications. Since, generally, in scientific computations internal speed and flexibility are more important than input-output capacity, the Elea 6001, following a widely accepted practice, has adopted punched paper tape as the main input-output medium, while at the same time variable length words and instructions allow complete exploitation of the magnetic core storage.

In addition to the magnetic core memory, there is a magnetic tape unit, which can handle reels with a capacity of four million characters. This magnetic tape unit, which is directly connected with the high-speed storage acts as an auxiliary memory and allows computation of large equations systems without any limitation in the number of unknowns, since the intermediate results can be easily stored on magnetic tape and thence transferred back to the main storage when required.

**Machine Coding.** A four-bit decimal-binary code is used in the Elea 6001.  $2^4$  or 64 different characters are therefore possible. The numerals, and six arithmetic and special symbols are thus represented by a single digit, while the alphabetic characters, together with other special symbols, are expressed by a two-digit code.

The punched paper tape, which is the usual medium for input and output, uses a six-channel code. The translation for six-bit digits to four-bit digits and/or to two-digit characters is completely automatic and does not require a conversion program.

No fixed length words are adopted. The end of each word, instructions or data, can be sensed by the machine in two ways: by a word-mark bit, which is recorded on a sixth memory plane, under the last digit of the word, or by a key-character, chosen by the programmer.

**The Central Processing Unit.** - The Elea 6001 central processing unit contains in a compact cabinet the main storage, the logic circuits, and the control devices for the input and output equipments.

**Memory.** The main storage of the Elea 6001 can store 10,000 decimal digits on a four-bit code. It is made with magnetic ferrite cores, assembled on five planes of 100 x 100 cores. The fifth plane is used to record a parity bit for checking purposes. A sixth plane stores the end-of-the-word bits.

The magnetic core memory can also perform the functions of the accumulators and of index registers, in addition to storing data and instructions. Any location of the memory can be selected for this purpose by a special instruction, and reset to its previous storage when necessary.

Up to nine supplementary matrices of 100 x 100 cores can be added to the basic storage, thus increasing the capacity to 100,000 digits.

**Microprogramming Technique.** The arithmetical and logical functions in the Elea 6001 are performed through a magnetic core device, called "logical sequence matrix". This matrix, which is built as a small magnetic core memory, permanently stores a number of elementary instructions, which are selected according to the operation code of the machine instructions, and executed one or several times until the actual machine instruction has been performed.

A basic Elea 6001 has one logical sequence matrix, which provides for 121 actual machine instructions.

Three supplementary matrices can be added to the system: The first supplementary matrix gives the Elea 6001 a set of direct machine instructions for floating point arithmetic, and  $\sin x$ ,  $\cos x$ ,  $e^x$ ,  $\log_n^x$  etc. computations. The two other matrices can be built according to the customer's special requirements and so microprogrammed to give the system a set of direct machine instructions most frequently needed by its scientific users.

**Control Devices.** A set of interconnection registers, nineteen of which are small magnetic core buffers, and six are flip-flops, controls the interconnection between the main storage and the input-output units. A console is provided for the usual operator functions, with a keyboard and a set of lamps which display the internal machine operations.

**Input and Output.** The basic unit is a photoelectric punched paper tape reader which reads the tape at a rate of 800 characters per second. The punched tape is read twice, and information from the first reading is stored and checked against that of the second reading.

In case of misreading—which is signaled by the console display lamps—branch instructions contained in the program provide for error correction.

A paper tape punch, with a punching rate of 50 characters per second, is the main output unit of the basic system.

The basic Elea 6001 has also a teletypewriter connected, which can be used both as a low speed input-output unit and as an inquiry station. The teletypewriter, in addition to printing, can at the same time be coupled to a punch thereby simultaneously preparing a tape suitable for future input.

The Elea 6001, being a modular system, can also use magnetic tape units for input and output and for file storage purposes. Up to six magnetic tape units, with a reading speed of 22,500 characters per second, can be connected to the system.

An on-line printer, printing 360 lines of 102 characters per minute, can also be connected to the system as an output unit when large volumes of data are handled.

Upon request of the user, the Elea 6001 can also be connected to a card reading unit (500 cards per minute), and to a card punching unit (150 cards per minute). These punched cards units can be used as input-output equipment instead of the punched paper tape units, or as auxiliary input-output devices.

All input and output units, whether card, paper tape, or magnetic tape units, are completely buffered, so that overlapping of input and output operations with internal processing is thoroughly possible.

Instruction Coding. - The instruction repertoire, made available by the first logical sequence matrix (which is standard on all Elea 6001 systems), contains 121 instructions for arithmetic operations, logical operations, comparisons, character transmission between high-speed storage zones, single-bit operations, handling of constants, search of characters whose location in high-speed storage is unknown, table look up, branching on external as well as on internal conditions, input-output instructions and many others.

Because of the particular logic of the Elea 6001, and since all arithmetic operations can be performed in the main storage, the instructions, while containing only one explicit address, are actually two or three-address instructions.

Relying on the interconnection registers for storing partial or even complete addresses, it is possible not to write the address of the operand in many instructions. Moreover, there is no need of indicating the length of the information affected by the instructions, since the machine will automatically sense the end-of-the-word bit stored on the sixth memory place.

Thus, the full instruction is composed of three parts:

OP	I	<u>AAAA</u>	address
			index register
			operation code

If, in a program, we have to operate on address 1231, write the instruction

OP	I	1231
----	---	------

and immediately after we want to operate on address 1235, we can write the second instruction thus:

OP	I	5
----	---	---

since the first three digits of the address (having remained unchanged) had been previously stored in one of the interconnection registers. In case many consecutive instructions are acting on the same address it is sufficient to write the address only the first time, thus:

OP I 1231 O'P' I' O''P'' I'' . . . .

The machine will automatically complete the instructions which follow the first one picking up the address which had been automatically stored by an interconnection register.

It must be noted that many instructions have a single-digit operation code, thus even less memory space is required for the program.

**Operations Time.** In the Elea 6001 the execution time for each instruction varies according to the program in which the instruction is contained: an optimized program does the same job of a non-optimized one, but in a shorter time, since all the coding and programming facilities have been used efficiently.

Thus, only average execution times can be indicated. In microseconds, memory accesses included, they are, for 10-digits operand, the following:

	Fixed Point	Microprogrammed Floating Point	Floating Point Subroutine
Addition	364	2198	9400
Multiplication	3804	3428	8900

The transmission of one digit requires 24 microseconds and the memory access time is 6 microseconds. The basic time of the logical sequence matrix is 4 microseconds.

**Programming Service.** A full programming service is available for the Elea 6001 user. Pre-tested programs for standard mathematical computations like, for instance, matrix calculus, solution of integral and differential equations, etc., and diagnostic and monitor programs are provided.

**A P S.** Two automatic programming languages are available to users of the Elea 6001, thus enormously improving the performance of the system while easing programming effort.

The first one, which is called APS (Assemblatore Programmi Scientifici-Scientific Programs Assembler), is a simple symbolic language which provides for writing a program but avoids most of program coding troubles. The APS is based on a translator program which compiles a program written in symbolic language into a machine language program through the assembling of standard subroutines.

**PALGO.** A more advanced automatic programming language, named PALGO (Programmazione Algoritmica-Algorithmic Programming) is available, which uses the main symbols and phases of the ALGOL 60 symbolic language.

PALGO is a slightly reduced version of ALGOL 60. This reduction has been suggested by the size of the machine and for allowing a speedier compiler. However, any compiler which can translate into machine language programs written in ALGOL 60 can also translate programs written in PALGO.

#### DIGITAL STORAGE FOR ANALOG COMPUTER - REDIFON LTD. - CRAWLEY, ENGLAND

Combining a small analog computer with a digital storage unit is a new approach to computing equipment opening up fields of application which cannot be tackled economically by conventional computing machines. Introduced by Redifon Ltd., as an addition to their RADIC (Redifon Analogue Digital Computing) system, this combined equipment offers large computing capacity and a high degree of flexibility at low cost. The equipment, demonstrated at the international exhibition of measurement, control, and automation techniques (MESUCORA) in Paris on 9th - 17th May, showed how a small analog computer with only ten operational amplifiers

can become the equivalent of a much larger computing assembly when equipped with a digital storage unit.

The two parts of the new equipment are being made available separately, so that organizations already possessing analog computers need only obtain the digital storage unit in order to greatly extend the capabilities of their present machines. The storage unit incorporates analog/digital and digital/analog converters to enable it to be linked with any existing analog computer.

The use of digital input and output facilities for analog computers is now well established on the larger machines, and the advantages arising from the technique are mainly of a practical nature: ease of setting-up, automatic checking of parameters, and so on. With the aid of digital storage facilities, however, the capabilities of analog computers can be extended far beyond the range of conventional machines.

A general-purpose analog computer, when equipped with a digital memory unit, can deal with:

stochastic function generation  
finite variable time delays  
partial differential equations  
correlation analysis.

The type of digital memory unit adopted by Redifon, Ltd., for these applications is basically a magnetic tape transport device which moves the tape past the recording and reading heads in small separate steps instead of continuously. The tape transport mechanism uses 35-mm tape with sprocket holes like cinematograph film, and this is moved past the recording and reading heads by two driving sprocket wheels.

In conventional systems of magnetic data recording, the tape is moved forward continuously at a uniform speed. In the Redifon system, however, the tape is moved forward in discrete, intermittent steps during both recording and read-out operations. This is done by stepping motors, actuated by successive electrical impulses, which drive the sprocket system and thus advance the tape in steps past the recording or read-out heads. This drive system operates in such a way that the tape is quickly started, advanced at a uniform speed during most of the step, and then quickly stopped.

The 35-mm tape is wide enough to accommodate 16 recording tracks side by side. The recording heads are fed with current pulses from an analog/digital converter in some applications and from a digital keyboard in others.

Coincidentally with the arrival of a digital data pulse at the input, an operating pulse is applied to the stepping motor to advance the tape one step. At the conclusion of the motor movement a clear and reset pulse is fed back to the digital/analog converter. Thus the original analog data is converted into the equivalent binary data and recorded in parallel in the various recording tracks spaced across the tape width.

Read-out heads are spaced laterally across the tape in the same way as the recording heads, and these feed into a digital-analog converter. The analog output resulting from the sets of recorded binary data takes the form of a discrete voltage varying with time. Each level of the varying voltage corresponds to one set of recorded binary data across the width of the tape and one forward step of tape movement.

To obtain the variation in tape transit time between the recording and reading heads the mechanism uses a differential system based on two sprocket drive wheels.

**Stochastic Function Generation.** Considerable theoretical work has been done on the analysis of industrial plants under typical operational conditions. In general these plants have nonlinear characteristics and in practice their inputs contain random variations. To investigate such systems on an analog computer the following approach has been evolved.



The random variations may be pre-programmed from a table of random numbers on the digital memory unit, using a digital keyboard input. Two such memory units are used. One unit determines the amplitude while the other determines the frequency by pulsing the first unit. The resulting output is then a well-defined probability distribution in frequency and amplitude.

This output may be added to an analytic analog signal such as a sine wave or ramp function, thereby giving a closely defined signal-to-noise ratio. The resulting composite signal may then be used as the forcing function to an analog simulation of the plant under investigation.

A suitable function of the error—say integral of error squared—may be continuously computed, and parameters of the analog varied in the conventional manner until minimum error function is obtained.

**Simulating Time Delays.** For the accurate simulation of process plant, one cannot go very far with the need to simulate finite time delays. To achieve an accuracy comparable with conventional analog computer components, Redifon have made use of digital techniques. This is easily achieved with the digital memory unit by utilising the known delay of data passing from the recording heads to the reading heads.

**Solving Partial Differential Equations.** By using a digital store with a general-purpose analog computer, the solution of partial differential equations can be tackled in two ways.

The first method involves a straightforward approximation to achieve accurate and stable integration and differentiation with respect to variables other than time. This is accomplished in a similar manner to that used in the digital differential analyser.

The second method involves the use of an iterative process. By this means a relatively small computer may be used to simulate only one section or "finite difference" of a flow problem—as typified by the transfer of heat along a metal conductor. Here it is only necessary to simulate one section of the flow process. The final values of a section—call it the  $n^{\text{th}}$ —are stored on the digital memory unit and used to reset the same integrators, which then compute values on the  $(n + 1)^{\text{th}}$  section for a small period of time. If this system is operated on a fast time scale, compared with the rest of the simulation, the whole problem may be treated as a pure analog.

As an example of a practical application, this "finite difference" method will allow a small analog computer to be used for the analysis of a large multi-plate distillation column, since only one plate of the column need be simulated by the computer.

**Correlation Analysis.** Another important application of digital storage to an analog computer is for system analysis by correlation techniques.

Where the transfer function of an actual plant unit (for example, a heat exchanger) is unknown, we may have access to records of typical operational values of the input and output data of the unit. In such a case the input and output data may be recorded on two memory units, either directly (if the information is available as dc voltages from appropriate transducers) or via the digital keyboard input (if the information is available in graphical or tabular form).

Having recorded the input and output data on two tapes, these are replayed, and, using both heads for read-out, the outputs are multiplied together and averaged (or integrated). The delay between the two read-out heads can be simply altered (that is, decreased or increased) by a timing mark on one of the spare channels on the endless loop. This same timing mark can be arranged to print out the value from the integrator once per cycle of the tape.

Thus a complete record of the auto-correlation function of the input, and the cross-correlation function of input and output, can be easily obtained. Using these two functions, and an approximate simulation of the unknown unit, it is possible to reach an accurate simulation from which the transfer function of the unit can be obtained. With the auto-correlation function used as a forcing function, the parameters of the approximate simulation are adjusted

until minimum error is obtained between the output of the analog and the empirical cross-correlation function.

Redifon are now investigating the application of the self-optimising techniques of linear programming to enable the analog parameters to be adjusted automatically. If this can be achieved it will indeed provide a most powerful tool for the analysis of process plants in general.

#### WEATHER FORECASTING RESEARCH - REMINGTON RAND-CHARTRES PTY. LTD. - SIDNEY, AUSTRALIA

Remington Rand, in cooperation with Melbourne University, Department of Meteorology, is training a research officer in Univac Solid State programming, for a large project on numerical weather forecasting (Barotropic forecasts). This work was started on CSIRAC, the computer developed at the Commonwealth Scientific and Industrial Research Organization and later required the English Electric 'Deuce' machine at the University of New South Wales, but now requires, in the final development, the Univac Solid State with Magnetic Tapes.

#### MAILÜFTERL - TECHNISCHE HOCHSCHULE - VIENNA, AUSTRIA

A description of this computer was given in the Digital Computer Newsletter January 1958. A slight change in the arithmetic unit made it possible to use both binary (45 digits) and decimal (11 digits) arithmetic. An input-output device for on-line logical control has been added. It has been used for the analysis of external hardware switching circuits. The output device comprises a 16-bit relay buffer store which can be operated at a repetition rate of 50 per second. 16 input lines can be sampled at the same rate.

In the course of research work on logical data processing, which was sponsored by the European Research Office, a method for the minimization of Boolean functions has been developed, which is an extension of the method given by Quine-McCluskey. Boolean functions with up to 16 variables, given in formulas, can be translated to a normal form and then minimized automatically. Results are printed in the form of Boolean expressions.

An ALGOL-translator corresponding to the standard of the European ALGOL group ALCOR has been designed and is now in use.

Several learning structures have been programmed and simulated on the machine: the plastic neuron (Willis), the conditional probability computer (Uttley), the learning matrix (Steinbuch), a model for the conditioned reflex (Zemanek, Kretz and Angyan). A new conditional probability scheme for the automatic generation of classes (Kudielka) has been developed.

A result in music theory: Hauer and Schönberg have based their composing rules on series of tones, in which either each tone within an octave or each interval within an octave occurs only once. The so-called "all tone series" fulfill both these conditions. A program generated all the 3856 existing series.

#### DEPARTMENT OF SUPPLY - WEAPONS RESEARCH ESTABLISHMENT - SALISBURY, SOUTH AUSTRALIA

On the 2nd February, 1961, the Weapons Research Establishment Mathematical Services Group accepted an IBM 7090 electronic data-processing machine. The machine configuration consists of a 32,768 word store, two data channels, eight 729-II tape units, card reader, punch, and printer. At present the card reader, printer, punch, and four tape units are connected to channel A, whilst the remaining four tape units are connected to channel B. This arrangement has been adopted in order to conform with the standard 32K FORTRAN Monitor system. However, the cable layout has been left sufficiently flexible to allow for any configuration of tape units from 2 on channel A and 6 on channel B to 2 on channel B and 6 on channel A, with room for expansion in either case.

The machine is housed in a room approximately 50 feet by 30 feet and occupies about half of the total area. A false floor for free running of cables was provided as well as a false ceiling for insulation sealing and flush fitting of lighting. Air conditioning has been achieved by the use of packaged units of the refrigerated type. Two of these, with 8-hp compressors, provide air flow under the false floor, and two, with 5-hp compressors, provide room cooling. A common water cooling tower is used for all four units.

Since Australia has a 50 cps 240 v standard for mains power, it was also necessary to install a 50/60 cycle English Electric Co. converter to provide the required 204-v 3-phase power for the machine. The converter has automatic phase and voltage control with over-voltage protection.

In order to provide flexible programming facilities, the FORTRAN/FAP Monitor system has been adopted as the basic compiler assembler for programming operations. However, it is also proposed to carry out some work with the 9PAC business data-processing compiler and the General Motors dynamic analyser program Dyana. As a result of the FORTRAN system, it was possible to arrange for a number of basic programs to be tested by Weapons Research Establishment programmers in the USA before the machine arrived at Weapons Research Establishment. It has also been much simpler to convert programmers from WREDAC coding (see DCN January 1960) than might otherwise be expected.

In order to adjust the remainder of the WRE Data-Processing System to the IBM 7090, it has been necessary to modify the Ampex FR400 tape units and associated equipment of the Automatic Data Converters and the WREDAC Output converter for off-line printing and plotting. Complete success has been attained in this project by replacing the 8-track heads with single-stack, 7-track heads, and in addition, providing standard Ampex photo electric reflective spot sensing mechanisms and IBM type reel hold down assemblies. Detailed modifications were also made to the converter units to provide for the correct parity checking as required in the operation of the IBM-729-II tape units. At present, writing and reading is carried out in the low-density mode of 200 bits/in. However, tests have shown that high-density operation is possible by using a 37-1/2 ins/sec tape speed and a 20-Kc/sec writing rate, but further checks are required in order to establish the reliability of this operating rate.

Future developments envisage the modification of the Ampex FR 400 tape units on WREDAC and the input/output circuits to provide magnetic tape compatibility between the two machines. In addition, a new set of Automatic Data Converters is being planned for more efficient preparation of magnetic tapes for input to the IBM 7090.

## MISCELLANEOUS

### COMPUTER SPEECH SIMULATION - BELL TELEPHONE LABORATORIES - NEW YORK 14, N. Y.

A simulation method of producing synthetic speech in response to the typing of phonetic symbols on a keyboard was disclosed by Bell Telephone Laboratories. The actual "speaking machine" would be of the tandem resonant type in which novel principles are used. Before actually building it, however, a high-speed, general-purpose computer was used to simulate it.

The computer is programmed to accept in sequence on punched cards the names of the phonetic speed sounds which make up an English sentence. The computer then processes this information the way an actual speaking machine would, and produces an output like the output of the speaking machine.

The program has two parts. One simulates the speaking machine; the other consists of rules, derived from previous research, for combining the individual speech sounds into connected speech and producing control signals for driving the speaking machine.

Nine control signals corresponding to voice pitch, buzz intensity, hiss intensity, plus the center frequencies and bandwidths of three speech formants, are continuously generated.

The speech of the simulated talking machine comes out of the computer on digital magnetic tape. It is then converted to a variable magnetic sound track suitable for playing on an ordinary tape recorder.

A semblance of natural inflection and phrasing was obtained by specifying on each punched card, the changes in pitch and timing. By specifying the pitch of the sounds they were also able to make the computer sing.

The simulation samples obtained are early results of a research project to obtain a better understanding of the nature of speech. Ultimately this knowledge may be useful in devising new ways of transmitting speech efficiently over communications systems.

For example, a person may, in the future, be able to sit at a keyboard and by typing, cause a talking machine thousands of miles away to speak for him. There is also the possibility that talking machines, like the one simulated in the computer, could be built for use by people who are unable to speak. By typing the phonetic symbols on a keyboard they could direct a talking machine to speak for them. Also, in the future, a blind person may be able to have a speaking machine read to him from books which have previously been encoded on a punched tape.

#### INFORMATION RETRIEVAL - U. S. PATENT OFFICE - WASHINGTON 25, D. C.

A system to store and search the information content of a collection of transistor circuit patents has been developed by a team in the Office of Research and Development of the U. S. Patent Office. The system permits rapid searching of topological, structural, and functional features of a rapidly expanding group of documents, now numbering some 1500. The patents are largely in the field of pulse technology, including gating circuits, counters, logic circuits, and other transistor circuits.

An inverted file, coordinate-index system with 1000 terms is employed with each patent being assigned an average of 100 terms. Over 400 patents have been analyzed and encoded, and are being operationally searched by patent examiners. The system employs specially-designed tables of terms to represent systems and topological circuit configurations.

A system of superimposed punched cards based on coincidence of holes (peek-a-boo) is used in the search, and an accompanying microfilm reader to display the patents.