DIGITAL COMPUTER NEWSLETTER

The purpose of this newsletter is to provide a medium for the interchange, among interested persons, of information concerning recent developments in various digital computer projects

OFFICE OF NAVAL RESEARCH · MATHEMATICAL SCIENCES DIVISION

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THE ERA 1101 COMPUTER

The first 1101 Electronic Computer was delivered by Engineering Research Associates, Inc., to the United States Government in late 1950 and was in operation eight days after delivery. The magnetic drum memory, which stores 1280 bits of information per square inch, has a maximum storage capacity of 16,384 24-binary digit words. For introducing information into the computer, photoelectrically read punched tape is employed. Input data may be converted from decimal or octal to binary form in the computer and output data may be converted from binary to decimal form and sent to an electric typewriter for typing, or to a paper tape punch if the data are to be reused.

In order to increase flexibility of control, the commands which the computer can carry out are stored in the magnetic drum memory and can be altered by arithmetic operations. Control is of the single address type with provision for 38 built-in commands. If required, multiple precision operations can be programmed.

Complete loading of the storage drum can be accomplished in less than eight minutes. Although minimum access time to the arithmetic unit from the drum is 32 microseconds, the maximum time is determined by the time required for one complete drum revolution, which is 17 milliseconds. By proper programming, the time required for the addition of two numbers can be as low as 96 microseconds, and for multiplication, 352 microseconds, including procurement of both operands and the next command. However, where the problem requires random access to the memory, the speed of calculation is dependent upon the time for the complete drum revolution. By using care in the mapping of the program on the drum, the speed of operation may be obtained which approaches maximum operational speeds.

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The computer has been very reliable. By spending approximately 10% of each day for routine preventive maintenance, the Government has operated the original 1101 for the first 500 hours with only 16 hours of unscheduled maintenance.

MOORE SCHOOL AUTOMATIC COMPUTER (MSAC)

Work is continuing in the design and testing of the basic circuits. The main categories are flip-flops, pulse transformers, gating circuits, and delay line and transmission line studies.

A preliminary modification of the logic based on the capabilities of the new circuits has been completed and timing studies have been conducted.

Prototype chassis have been constructed and used in the testing program. The cabinets and holders for the mercury-acoustic high speed memory tanks are being assembled. The physical lay-out of the MSAC and methods of interconnection are being studied. Construction of the first chassis is scheduled for the month of June.

THE INSTITUTE FOR ADVANCED STUDY COMPUTER

Since the publication of the last Newsletter the memory organ for the Institute for Advanced Study computer has been completely integrated into the system and various tests have been made involving the interplay of the arithmetic and memory organs. These tests are proceeding satisfactorily.

During the same period extensive life tests of the multiplier were completed. These tests were carried out with the unit operating at a high duty cycle and fully covered all aspects of the situation.

Various input-output organs are being built and tested at the present time.

ABERDEEN PROVING GROUND COMPUTERS

The ENIAC

The ENIAC completed its fifth year as an operating machine in February 1951. Gradual improvements have been made since the adoption of the converter code, the most recent being a change in the address terminology and an addition of a small unit to make automatic the switch between control from the function tables and control from cards.

During a recent period (November 1950 to March 1951), the ENIAC completed the computations for the following problems: (a) an investigation of some of the properties of interior ballistics, (b) an evaluation of error in axially symmetric supersonic airflow, (c) two additional programs for the determination of the equilibrium composition of a four component system of fuel elements, (d) two complete bombing tables, (e) the reduction of data for 9,950 points of guided missile data, and (f) two programs involving normal trajectory computations.

The EDVAC

During the period covered by the current report the EDVAC system has been brought to the condition of satisfactory operation with the exception of the memory amplifier assemblies. The original amplifiers are not considered satisfactory and new ones have been under construction and have just been delivered. It is hoped that the installation of the new memory amplifiers will conclude the construction and testing of this unit.

The ORDVAC

Test work on the ORDVAC memory system (electrostatic tubes) has indicated that exceptional reliability may be expected from this equipment. It has run for periods of the order of tens of hours without error. The University of Illinois is exerting every effort to be sure that the elements of this machine will be exhaustively tested before the system is completed. It appears that this policy will yield a finished machine and a more satisfactory device in less time than would otherwise be possible. It appears that the completion date (October 1951) originally anticipated will be met.

NATIONAL BUREAU OF STANDARDS WESTERN AUTOMATIC COMPUTER (SWAC)

Improvements have been made in the testing techniques and methods of adjusting the memory, resulting in more efficient maintenance of the SWAC. General testing is still being carried on interspersed with the running of problems.

Two optical reader units for input are under construction, a large one for handling 1000 foot reels of paper tape and a smaller one for handling shorter pieces of tape.

A magnetic tape unit has been delivered from Raytheon Corporation and work is proceeding on its integration into the SWAC input-output system.

Progress is also being made on the necessary circuitry to enable the magnetic drum memory to be used as an auxiliary memory for the SWAC.

NATIONAL BUREAU OF STANDARDS EASTERN AUTOMATIC COMPUTER (SEAC)

Statistics were compiled on the operating performance of the SEAC for the months October through December 1950. During the time which was set aside for the solution of problems (76 hours per week), the machine was in good working order for 64 per cent of the time in October, 70 per cent of the time in November, and 86 per cent of the time in December. During the last week in December, the machine was in good working order for 96 per cent of this time. A wide variety of problems have been run on the SEAC, including the following:

Problem	Total Hours on the Machine	Brief Description
Linear Programming, OAC	525	Solution of large systems of linear algebraic equations pertaining to program planning for the Air Force.
Number Theoretical Problems	200	Computation of factorization tables, tables of primes, primitive roots of primes, diophantine equations, and Haupt exponents.
Subsampling Design, Census	68	Determination of sample sizes corresponding to minimum variance in a census, using sampling methods.
Relative Abundance of Elements	48	Solution of a 27th-order system of ordinary differential equations relating to the neutron capture theory of the formation of the elements in the universe.
Electron Trajectories	40	Solution of a second order nonlinear differential equation describing the passage of electrons through a cavity.
Laplace Equation by Monte Carlo Method	26	A test of the Monte Carlo Method by solving a known problem in two dimensions.

Use has been made of two models of the new magnetic tape transport mechanism which require no reels or servos (the tapes are held between parallel glass plates). In this mechanism the only inertia to be overcome, when starting or stopping, is that of the tape passing over capstan heads. Reading, writing, and reversal operations have been performed completely under the machine's control. Equipment to provide selective erasure under machine control is now being developed.

The Williams tube memory, designed for 1024 spots per tube, is currently being proved in with 256 spots in order to obviate possible difficulties of splash (read-around ratio). The full Williams system was operated successfully on test routines for over five hours, on two occasions. It has also worked successfully for several hours in integrated operation with the complete machine, on a prime number routine. This particular routine stores orders and temporary results in the electrostatic memory and does most of the basic computation there, in order to achieve increased speed. With the electrostatic memory, it took 12 minutes and 8 seconds to compute that 99,999,999,977 is a prime number; with the acoustic memory, the corresponding computation time was 36 minutes, or three times as long. A problem of significance is now being tried, using both the acoustic and electrostatic memory in combination.

PROJECT WHIRLWIND

During January, February, and March the Whirlwind computer has been operating usefully with electrostatic storage. One third of the time, about 30 hours a week, is divided between scientific and engineering computation and the study of real-time control problems. During these assigned application periods, computer operation is now satisfactory about 85 per cent of the time. The other two-thirds of the time is devoted to improving reliability, extending the terminal facilities, and routine maintenance.

Whirlwind is at present using 256 registers of electrostatic storage. Input is by means of punched paper tape. A photoelectric tape reader has been received and will shortly be connected to the computer to increase the speed of reading in programs and data. An output typewriter is in use for printing computed results. An oscilloscope display is available for problems more readily studied by this means. A magnetic tape drive has been received, and circuits are being built for its incorporation into the computer.

RELAY DIGITAL COMPUTER, IMPERIAL COLLEGE, UNIV. OF LONDON

K. D. Tocher is building an automatically sequenced digital computer at the Imperial College of Science and Technology. The operation of the computer is serial and a three-address code, similar to the one originally devised for the National Physical Laboratory ACE pilot model, is used. Addition of two ten-binary-digit words takes approximately a quarter of a second; round-off multiplication takes approximately three seconds. Exact multiplication and double length operations on words can also be performed. Division will be automatic.

Approximately 1800 high-speed relays and 1200 slow-speed relays are used in the computer, both for the erasable memory elements and for the gating elements. This rather large number of relays is due to the inclusion of several special facilities, which can be called for automatically, and not to the size of the erasable memory store, which can hold only twelve words of ten binary digits each. A slower, auxiliary store is provided by punching equipment and Hollerith tape. Standard Hollerith punched card machines are used in the input and output equipment. (From 1 February 1951 ONR European Scientific Notes.)

ZUSE COMPUTER MODEL IV AT ZURICH, SWITZERLAND

In July 1950, a sequence-controlled computer was installed at the Institute for Applied Mathematics of the Swiss Federal Institute of Technology at Zurich. It was constructed by Konrad Zuse of Neukirchen, Germany, in consultation with E. Stiefel and A. Speiser of the Institute. It is a relay computer with 2200 telephone relays and 20 step switches and employs mechanical storage elements developed by Zuse. Although the storage capacity is now only 64 numbers, it is hoped that it can be increased to 1024 numbers. Access time to the memory is one-half second.

The machine operates in the binary system, employing a floating binary point with exponent ranging from 63 to -64. Translation from decimal to binary numbers and vice-versa is fully automatic. Numbers are fed in by means of keyboard or punched 35-mm movie film, whereas the output goes to a typewriter or punched film which can be fed back to the film-read unit, thus providing external storage.

For introducing instructions into the computer, a coded sequence is punched into movie film, each instruction having 8 binary digits, which is fed into one of two stations. The computer executes the following orders: Add, subtract, multiply, divide, take the square root, form the absolute value, call conditionally, stop conditionally and unconditionally, and skip conditionally. The skip order causes all the following orders up to a starting order to be disregarded and thereby enables several subsequences to be punched on one loop of tape.

The time for addition and subtraction is approximately 1 second, for multiplication 2.5 sec, for division and square root 6 sec, all including transfers from and to storage. To skip an order takes 0.2 sec.

DATA HANDLING AND CONVERSION EQUIPMENT

Stavid Engineering Data Conversion Equipment

Stavid Engineering, Inc., 312 Park Avenue, Plainfield, N. J., has developed a data conversion recording and play back equipment which permits the measurements of servo orders to be made to an accuracy of .01°. To maintain this accuracy the information contained in the servo order is converted into digital form at a pulse repetition rate of 60,000 pulses per second. Two ring counters serve as both counters and memory circuits in order to slow the pulse repetition rate down to a frequency which is recordable on magnetic tape. Nine servo orders are monitored and sequentially sampled at the rate of one order per twentieth of a second. The measurements of the servo order are recorded on three-channel tape in the form of pulses. On the first track, one pulse is the equivalent of .01° of servo orders. On the second track, one pulse equals .25°, and on the third track, one pulse equals 10°. Thus no more than 40 pulses are required on any track to fully define the measurement of the order.

Equipment is now being developed which will automatically accept the information from the magnetic tape and transcribe it into IBM punch cards where one card contains one measurement of each of the nine input orders.

Signal Corps Angular Position Encoders

An angular position encoder to generate a 15-digit binary number, which is a measure of the angular position of an input shaft to .01°, has been designed at the Signal Corps Engineering Laboratories, Fort Monmouth, New Jersey, and construction of two models by a contractor is expected to be completed in March 1951. The heart of this device is a special code pattern consisting of transparent and opaque areas laid down on a glass disk 9-1/2 inches in diameter. The pattern is made by photographic contact printing from a suitable master. The disk is carefully mounted between bearings and rotates with the input shaft. An optical reading system, consisting of a high intensity stroboscopic light source, a narrow defining slit, and fifteen miniature photocells, will be used to "read" the shaft position at regular intervals, using a binary number sequence which provides freedom from transition errors and which is easily converted to the standard sequence. The complete encoder, including lamp, photocells, and photocell preamplifiers, will be about 12" in diameter and 6" deep, and will mount on any flat surface. A ring-shaped flange is provided for centering with respect to the mount. All delicate surfaces will be protected from dust, etc., and the whole assembly is expected to be sufficiently lightweight and rugged for contemplated uses.

One application for this encoder is in connection with a digital servo for remote shaft positioning with very high accuracy. In preparation for the construction of such a servo, an experimental pilot model, operating with 10-digit optical encoders, was constructed at the Signal Corps Engineering Laboratories and completed in June 1950. Studies are now being made of the dynamic behavior of the 10-digit servo.

The major components of the 10-digit pilot model accommodate fifteen binary digits, permitting their reuse as components of the high-accuracy servo, after completion of the 15-digit encoders.

Zatocoding

Zatocoding is the name given by the Zator Company, 79 Milk Street, Boston 9, Massachusetts, to its system of coding punched information cards for efficient machine selection by subject. The process employs the technique of superposition of random subject codes (indentations on the edge of the card). It is not necessary to store the cards in any alphabetical or other subject order or to select references according to a definite classification scheme. Copies of an occasionally published journal, dealing with the problems of the organization of knowledge, can be obtained from the Company upon request.

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