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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TABLE OF CONTENTS

GENERAL PURPOSE COMPUTERS

The OARAC

The Flight Research Laboratory (formerly Office of Air Research) Automatic Computer, being built by the General Electric Company, Syracuse, New York, is to be delivered to Wright Field in the spring of 1952.

It is a coded decimal, single address, serial machine using a 10,000 word magnetic drum memory, magnetic tape input and output and typewriter input and printing.

*The information contained in this issue was gathered in early December 1951.

It can be programmed in the majority of cases to carry out some 110 instructions per second. Division and multiple accuracy operation are built in. Operation can be performed on both numbers and instructions.

Emphasis was placed on simplicity of maintenance. The computer contains approximately 1400 tubes with all of the circuits in the main body built on plug-in units. Each plug-in "turret" contains one tube or none with a number of passive elements; seven different types of such turrets were sufficient to build up all of the required functions.

The machine has been completely wired and full scale testing is under way.

The CADAC

A new electronic, automatically-sequenced digital computer, called the CADAC, has recently been constructed by the Computer Research Corporation, 3348 W. El Segundo Boulevard, Hawthorne, California, for the Cambridge Air Force Laboratories. In addition to the usual arithmetic instructions (add, subtract, multiply, and divide) the operations extract, print, shift, test, and test for overflow are included in the design. A third address code is employed.

The memory consists of a magnetic drum with a capacity of 1023 words grouped in 16 channels of 64 words each. Since the drum rotates at 40 rps, the average three-address command requires about one sixteenth (1/16) sec. corresponding to about two and one-half (2-1/2) turns. During computation, the numbers and addresses are held in three one-word registers on the drum.

In the design of the computer, small size and minimization of the number of tubes were stressed. In all, there are about 195 tubes and 2500 crystal diodes in the computer. The word length is 36 binary digits, numbers being expressed as magnitudes and sign, lying between 1 and -1. Input and output are by electric typewriters, with numbers being expressed in octal form.

The SEAC

As an outgrowth of the collaborative program now under way to produce several modified SEACs, revised designs have been developed for the physical form of the basic building elements in the machine. A single, plug-in package has been designed for all of the basic tube and diode functions, another package for the electrical delay lines, and, finally, one for the specialized delay line terminations.

Almost all of the machine circuitry will be constructed out of these three packages. The packages have been tested and are now in hand production. Typical circuits are being assembled and proved in on the present SEAC. For example, internally the lock-out counter of the Williams memory is composed of packages, and in the auxiliary equipment the same packages are used in the outscriber.

An external selector has been put into regular operation on the SEAC by means of which automatic selection may be made from among any of 10 different input-output units.

The SWAC

Since the last report in this Newsletter, the accelerating voltage in the cathode ray tubes of the memory system has been lowered, with a consequent improvement in flaw conditions but an accompanied increase in spillover. Under these circumstances, the stock of cathode ray tubes had to be resorted in order to obtain the best useable tubes. Several 3KP1 tubes have been delivered and have been put into use with good performance with respect to spillover.

The introduction of the magnetic drum into the computer system is well under way. Both a new small single and a new double tube plug-in unit have been designed. The initial circuitry on the drum will utilize a pulse frequency of approximately 60 to 70 kc, which will give a distinct advantage in that it will simplify the circuit design. The system as now being constructed will give a maximum memory of about 5000 words with an average transfer time of approximately 500 microseconds per word, which is obtained by transferring from the drum to the Williams tube memory a sequence of numbers during one revolution of the drum, starting the actual transfer at any arbitrary word and stopping at the end of one revolution.

Whirlwind I

Approximately 35 hours a week of scheduled application time is being divided equally between military and general applications. The aim in connection with general applications is to make the Whirlwind computer available for the solution of worthwhile problems by research workers at MIT and in other academic and industrial organizations. By eliminating any manually set switches and by using one operator to run all programs, it appears to be practical, without loss of efficiency, to use the computer for problems requiring only a few minutes of machine time. The computer has enough time available so that problems can be run without appreciable delay. Computer availability and the number of experienced programmers are about in balance and growing at an equal rate.

Present plans are to attempt to make the preparation of programs an easily learned and readily performed task so that a prospective user can without difficulty set up his own program rather than require the services of an experienced programmer. As steps in implementing this plan, a well-catalogued and easily-used library of subroutines is being built up; explanatory texts describing methods of programming are being developed; and effective methods of having experienced personnel provide advice and assistance to the user are being worked out.

A number of people interested in such diverse problems as digitally-controlled milling machines, missile trajectories, oil reservoir production, ambipolar diffusion, and optical constants of thin metal deposits have already set up successful programs of their own. Further development of the subroutine library and the forthcoming expansion of the present limited (348 registers) storage capacity will greatly facilitate such work.

A second bank of 16 storage tubes has been added to the computer and will soon be available for use. This will at least double the storage capacity used up to the present.

Moore School Automatic Computer (MSAC)

The final design of the basic circuits for the MSAC have been completed. Preparation of schematic and layout diagrams was initiated, and standardization of circuits and layout techniques was accomplished through the use of technical design memoranda describing the basic circuits. Over 50% of the schematics for the MSAC have been completed.

Construction of a single unit, the Dispatcher Memory Loop, is now under way. This unit contains most of the typical circuits of the MSAC and will occupy one rack of the machine. Tests will be conducted on this rack to determine the final operating characteristics of the circuits before the remainder of the machine is constructed.

Procurement of components is continuing, and fabrication of units, such as pulse transformers, delay lines, and germanium diode clusters, is planned in the near future.

The Burroughs Laboratory Computer

Enhancements have been made in the Burroughs Laboratory Computer to increase its memory capacity, to increase the flexibility and capacity of the teletype input-output system, and to incorporate automatic multiplication and division.

The memory capacity has been increased from 800 nine-decimal-digit words to 5300 nine-decimal-digit words. The storage is divided into 10 bands of 500 words per band plus 300 words that are common to all bands. The desired band is selected by a programmed instruction. Addresses from 100 through 399 are common to all bands, but addresses from 400 through 899 require that the proper band switch be set up. This change required the addition of 90 read-write heads on the drum plus the necessary circuitry. The computer was shut down 31 hours and 35 minutes for this enhancement.

Multiplication is accomplished by repeated addition, and division is accomplished by direct subtraction. Both operations require an average of 50 milliseconds for their execution. This change required two magnetic shift registers and the necessary Pulse Control Equipment used for the control circuits. The factors are stored in the shift registers to obviate making reference to the drum during the operations. An eighteen-digit product and the quotient plus the remainder are

available following the operations. Because of the ease in manipulation and the flexibility of the Pulse Control Units only 58 hours were required to make the change.

The re-design of the teletype input-output system is nearly completed. The system will include the following:

3 transmitter distributors,
2 page printers, and
2 reperforators.

Any combination of the above can be programmed to allow better control of the format of the printed page and to allow the inclusion of an input word with output words on a perforated tape.

The problems solved on the computer include the following:

solution of simultaneous equations,
inversion of matrices,
cam design,
parameter calculations of computer circuits,
simulation of logical networks,
random number generation, and
sample production control problem.

The Naval Proving Ground Calculators

The Aiken Relay Calculator (Mark II) continues to operate six days a week, 24 hours a day. During the past three months it has been occupied with various items relating to ballistic research as well as the preparation of general ballistic tables for bombs and rockets. Experience with a new experimental checking circuit for automatically checked results has thus far proved to be a valuable asset, especially in helping to locate the sources of many machine errors. The results of the computation have also been more reliable.

The Mark III Calculator is also being operated six days a week, 24 hours a day. The relative percent of good running time is under that of Mark II, but significant progress has been made during the last month. During this report period, the Calculator has been used entirely for the integration of trajectories in connection with the preparation of a general ballistic table.

Aberdeen Proving Ground Computers

The ENIAC

A new function table control panel of 4 switch set and 96 plug board controlled lines was put in operation with the Eniac in September. The new table was designed and constructed by the Computer Research Branch and has performed satisfactorily. The new unit increases the program capacity of the Eniac by 30%, and since it is plug board controlled, it shortens somewhat the set-up time required for changing problems on the machine.

During the period 1 August through 31 October 1951, the Eniac has completed computations for 27 different problems (which involved 56 changes of program) dealing with such varied topics as:

a. bomb drag studies,
b. guided missile flight path trajectories,
c. reduction of yaw and swerve data from transonic missile firings,
d. gamma ray and neutron transmission through various thickness of matter by Monte Carlo techniques, and
e. firing tables and bombing tables.

The ORDVAC

The Ordvac has been completed and testing is in progress. During the test period the Ordvac has carried out test operations which used all of its orders for periods frequently reaching four to five hours and on one occasion reaching twelve hours without error. At present, it appears that the

safe read around ratio is of the order of twenty, but tests are continuing for the purpose of determining this constant more accurately and lead to its increase.

The EDVAC

The first large-scale problem, involving the determination of the proper values of matrices up to the twelfth order was satisfactorily completed on the Edvac, signifying that the machine is ready for production.

A number of testing and computational routines, essential for the treatment of large-scale problems, are presently being developed.

SPECIAL PURPOSE COMPUTER

MADDIDA

Recent engineering changes in the MADDIDA digital differential analyzer have produced such radical improvements in the computer's efficiency and mathematical flexibility that earlier models are now considered as obsolete. Northrop Aircraft is recalling all MADDIDAs previous to Serial No. 6 and bringing them up to date.

The most significant advancement has been the installation of a test panel for marginal checking, which enables the operator to examine quickly the operating margin of all parts of the computer. Operating experience has shown that through the use of this check panel virtually trouble-free operation can be obtained. On a recent test run of MADDIDA No. 9, covering a period of 300 operating hours, scheduled and emergency maintenance totalled less than 2% of total time.

A large number of circuitry changes have been made to increase the margin of reliability of the computer and several new features have been added. Among these are a time reversal switch which permits the computer to halt and "back up" in the middle of a problem, an overflow alarm which automatically halts the computer and notifies the operator if a variable starts to exceed its expected range, and on the latest machines a logical change which permits the coder to multiply any variable by a constant without increasing the number of integrators used.

In the line of auxiliary equipment, a drum type digital graph plotter has been developed recently by the Engineering Research Company of Los Angeles. Thorough testing has shown this plotter to be well engineered and extremely reliable. Northrop Aircraft has recalled all early models of the decimal tabulating equipment for MADDIDA due to the fact that they were difficult to maintain in operating condition. A new model decimal tabulating output device is now under test and is expected to be in production within 30 days.

A new MADDIDA installation has recently been completed for the Air Force 3151st Electronics Group at the University of Utah. According to present schedules, six more MADDIDA installations will be made in the next few months.

DATA PROCESSING AND CONVERSION EQUIPMENT

The Charactron

The Charactron is a special-purpose cathode-ray tube, developed by engineers of Consolidated Vultee Aircraft Corporation, Los Angeles, California.

A matrix containing character-shaped openings is located between the electron gun and the fluorescent screen. A stream of electrons directed through the matrix openings results in a shaped beam that provides a presentation of characters on the screen of the tube where they can be read or photographed. An electrostatic deflection system is utilized for character selection in the matrix, and either electrostatic or electromagnetic deflection is used for positioning character images on the screen. Thus, the proper sequence of applied deflection voltages selects and positions matrix characters so that input signals are translated into visual intelligence.

Among the more general applications of the Charactron are (1) data conversion and tabulation of analogue or digital information, (2) computer read-out, (3) high-speed printing, (4) high-speed communications, and (5) monitoring and message display equipments.

One possible type of data converter is one that will measure physical quantities in the form of electrical potentials and present them as three-place numerals on the Charactron screen. In such a device, the voltage levels can be converted to decimal number values within a few milliseconds and with an accuracy of one part in one thousand. Another possible type of converter will be used in combination with high-speed printers of coded information. This equipment (referred to as a Charactrontype Printer) will have printing rates ranging from 1000 to 10,000 characters per second, thus satisfying the needs of voluminous printing at high speeds. Printing can be done on ordinary paper, using a dry photographic process.

Wallind-Pierce Equipment

The Wallind-Pierce Corporation, 109 Bond Street, Redondo Beach, California, which was formed in January 1951, is now completing work on two contracts for the Naval Electronics Laboratory, San Diego, California. In the course of this work the following pieces of equipment are being developed:

(1) A digital-to-analogue translator having an accuracy of .1%. Sixteen serial, ten-place binary numbers are translated into 16 output voltages having a range from +50 volts to -50 volts.

(2) An analogue-to-digital translator which converts the angular outputs of 16 shafts to 16 ten-place binary numbers and transmits this information serially in less than one second.

(3) A digital pick-off which senses shaft rotations to less than .1% (ten binary places) with negligible load on the shaft being sensed. Sampling rate is 50 times a second.

Aurex Magnetic Wire Storage

Some years ago, the Aurex Corporation, 1117 N Franklin Street, Chicago, Illinois, developed a new magnetic wire recording device, after which special prototypes were developed and built under an Office of Naval Research contract.

It is essentially a cartridge containing two opposite cavities in which the wire may be coiled naturally on the inside of one and drawn from the center of either cavity to the other by means of a revolving shaft and a controlled pinch roller unit which is positioned between the cavities when the cartridge is mounted on the unit.

The cartridge may be made in different forms to accommodate a small amount or up to many thousand feet of wire. The smallest cartridge need be not over one and one-half (1-1/2) inches in diameter. The wire has been run without any difficulty, whatever, up to 27 feet per second, and can be run faster. Recording experiments indicate considerably greater efficiency than is now obtainable with wire. Since the cartridge is stationary and only a few inches of wire are in motion, inertia is no problem and the starting and stopping of the wire is practically instantaneous.

CRC Ferro-Resonant Flip-Flop

The CRC Ferro-Resonant Flip-Flop, which utilizes the principle of ferro-resonance to produce bi-stability in a simple series LC circuit, has been placed on the market by the Computer Research Corporation.

With the establishment of the basic flip-flop design, laboratory work is now going forward on packaging and embodiment in counting and other devices. A decade ring counter has been constructed which employs no tubes or diodes and functions up to 20 kcs. The counting unit proper (exclusive of neon read-out) occupies a space 1" x 2" x 3". Actually, it is feasible to combine the flip-flops in rings of twenty or more elements. Thus, it also becomes possible to divide incoming pulse rates by any integer between two and twenty. Further development has been in the direction of increased speeds and the most recent flip-flop (Model MC) functions at the rate of 100 kcs.