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THE WHIRLWIND I COMPUTER

I. General Description

Until late 1951 the Digital Computer Laboratory at MIT operated as a division of the Servomechanisms Laboratory, which was established in 1940 to develop automatic control systems and military fire control. The work in servomechanisms led naturally into digital computers for real-time control applications, where the logical nature and performance requirements of the job are often beyond the capability of analog systems. In 1951 the Digital Computer Laboratory became an independent laboratory in the Electrical Engineering Department for research and development in digital computers and their application to engineering, both industrial and military.

Project Whirlwind, sponsored by the Office of Naval Research in the Digital Computer Laboratory, effected the successful operation of the Whirlwind I digital computer in November 1950. The basic logical plans of the machine had been published in 1947. During the intervening three years, components were developed, basic circuits were established, and the mechanical and electrical details designed.

Whirlwind I is a high-speed electronic digital computer in which numbers are represented by groups of short electrical impulses. Computations are carried out in the binary-number system, with a basic register length of sixteen binary digits (equivalent to about 5 decimal digits). For general mathematical work, it is possible for the computer to handle numbers having a length which is a multiple of the standard 16-digit register.

Instructions and data are transferred from Flexowriter perforated paper tape via a Ferranti photoelectric tape reader into an internal high-speed magnetic core storage. Each digit of each storage register consists of a particular magnetic core; whether a '0' or a '1' is stored depends on the direction of magnetization of the core. Since readout of the cores is destructive, each storage access cycle includes a read and a rewrite or write, depending on whether the old information is to be left in the register or new information is to be inserted. Time is not a coordinate of the information; therefore,

every memory location is accessible in an equal length of time. External magnetic tape and magnetic drum systems supplement the internal core storage.

Whirlwind I uses parallel-digit transmission over a bus system which provides one channel for each binary digit of the 16-digit register. Each major unit of the computer can transmit digits to and receive digits from this bus. The operation of the various output and input gates between the bus and units of the computer is controlled in the proper sequence by a central control element.

The basic impulse rate (pulse-repetition frequency) for general operation of the computer is 1 mc; pulse duration is 0.1 μsec. Within the arithmetic element, the impulse rate for multiplication and shifting is 2 mc.

Terminal equipment consists of Flexowriters for direct typing and paper tape punching and for delayed (via magnetic tape) typing and paper tape punching, photoelectric and mechanical devices for reading from punched paper tapes, five magnetic tape units, two magnetic drums, oscilloscopes and a camera.

II. Summary of Whirlwind I Specifications

STORAGE (16-DIGIT WORDS)

Magnetic Core Storage (MS):

2 banks, each having 1024 cores per digit plane; access time, 8 μsec.

Auxiliary Drum Storage:

12 groups each of 2048 registers on magnetic drum; single word or block transfer to and from MS; average access time to single word or block: 8.3 msec within a group, 67 μsec to select new group; block transfer rate, 32 μsec/word.

Buffer Drum Storage

The buffer magnetic drum is used both for auxiliary storage and as buffer storage for special input data. The programmer is permitted to use only 6 groups each of 2048 registers (groups 2, 3, 4, 5, 6, and 7) for auxiliary storage. The buffer drum is similar to the auxiliary drum in physical structure.

Test Storage:

32 toggle-switch registers; 5 flip-flop registers (interchangeable with any 5 toggle-switch registers).

SPEED (IN MICROSECONDS)

Addition:

To get one number from MS, add it to one already in AE.....24

To get two numbers from MS, add them, and transfer answer to MS.....72

Multiplication and Roundoff:

To get one number from MS, multiply it by one already in AE.....36-43

To get two numbers from MS, multiply them, transfer product to MS.....84-91

TERMINAL EQUIPMENT

Punched Paper Tape and Typewriters:

Flexowriter 7-hole tape (6 information, 1 index); 6-binary-digit code for letters and decimal numbers, 10 lines/inch. Input to computer: mechanical tape reader (106 msec/line, 318 msec/word), Ferranti Photoelectric Tape Reader - PETR (5 msec/line, 15 msec/word); output: tape punch (93 msec/line, 279 msec/word), printers (about 135 msec/character, up to 900 msec for carriage return). After PETR is deselected, the tape moves less than .04 inch.

Magnetic Tape:

Parallel-serial storage of binary digits in 3 pairs of nonadjacent channels (2 information pairs, 1 index pair) across the $\frac{1}{2}$ inch wide tape. Redundant recording in pairs minimizes tape-flaw errors. Maximum density, 100 lines (200 binary information digits) per inch; speed, 30 inches per sec. Coded tape recording of computations enables printer to operate independently of computer.

Flexowriter: Delayed Output Via Magnetic Tape:

Flexowriter characters for delayed output can be recorded at the rate of 133 per second. A 1000-foot reel of magnetic tape can store 53,000 characters, which can be recorded in a minimum of 6.7 minutes, and which can be printed in about 90 minutes or punched in about 63 minutes.

Five Raytheon magnetic tape units are used with WWI. Of the five tape units (called 0, 1, 2, 3A, and 3B) a maximum of four may be actually connected to the computer at any time. One of the Units 3A or 3B is connected to delayed output reading equipment, the other to the computer. These connections may be exchanged by throwing a toggle switch. Unit 2 is connected either to the computer or to delayed output reading equipment (which condition is controlled by the position of another toggle switch).

Oscilloscope Display:

Two 16-inch magnetically deflected CRT's (one with visible face, the other with a computer-controlled Fairchild camera) are available for displays. X and Y axes each have 2048 discrete positions. Points may be plotted at a maximum rate of 6250 points/sec. Digits may be displayed as point-by-point arrays (3 x 5) taking approximately 1.8 milliseconds per digit. Approximately 320 five-digit numbers can be recorded on a single frame (in about 6 seconds). By altering the settings of the oscilloscope amplifiers, it is possible to display vectors (197 μsec/vector) and special characters that can be generated by intensifying selected lines in a rectangular figure eight (357 μsec/character).

Buffer Drum:

Magnetic drum acts as temporary storage of input and output data arriving at computer in random and asynchronous manner from multiple sources and leaving for various output devices.

The information on these pages will be revised and included in the new WWI Brochure, DCL-68.