The IBM 7070 Data Processing System

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THE INTERNATIONAL Business Machines Corporation (IBM) *7070* is a high-speed solid-state data processing system designed for both commercial and scientific applications. Its versatility and range enables easy expansion from a basic card system to a tape or tape RAMAC system which incorporates the speed and capacity of many large-scale data processing systems.

In both commercial and scientific applications, it is becoming essential that the data processing system be flexible to meet both current and future requirements of the application. The IBM *7070* system has been designed with such flexibility in mind. A wide variety of configurations can be utilized to meet increasing customer needs.

Description of a Typical 7070 System

A typical *7070* system is composed of the machine units shown in Fig. 1. These units are:

Console: This is a separate unit which includes the console typewriter and a small operator's panel. The console unit is designed to simplify and expedite the operator's tasks and insure maximum productive machine time.

The typewriter is the principal operator's tool, and replaces many of the indicator lights and control switches of previous data processing machines.

Operator errors should be minimized by the computer's ability to audit operator commands by a stored program, and by the existence of a printed record from the console typewriter.

Magnetic Tape Units: Two different magnetic tape units are available. The Model *729*II reads or writes tape at a rate of 15,000 characters per second, while the Model *729*IV reads or writes at a rate of up to 62,500 characters per second. Any combination of up to 12 of these units can be employed in the *7070* system.

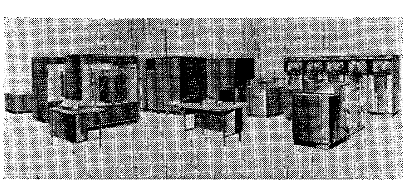

Fig. 1. Typical IBM 7070 system

Each tape unit is attached to one of two independent tape channels. This enables the system to simultaneously read-write compute, read-read compute, or write-write compute.

To insure that the tape record is properly written, an additional set of magnetic reading heads is mounted in the tape drive adjacent to the writing heads, providing an immediate validity check of the written record.

Disk Storage Units: The *7300* disk storage units consist of a magnetic disk storage array with a capacity of six million digits. Each record is 60 words in length, making a total of 600 digits and 60 signs.

Records are read or written by a mechanical access mechanism containing a magnetic recording head. This mechanism moves rapidly to any record in the file. Three of these mechanisms are provided in each disk storage unit to minimize access time by overlapping the operation.

Up to four disk storage units can be utilized in the system, providing a total storage capacity of up to twenty-four million digits. These units are attached to the system by the same two data channels as the magnetic tape units. Each of these data channels is connected to a disk storage unit by program control, thus enabling simultaneous read-write compute, read-read compute, or write-write compute on different disk storage units.

Manual Inquiry Station: The *7900* manual inquiry station permits fast interrogation of the status of data stored in core storage, in a disk storage unit, or on magnetic tape. The station consists of a special typewriter equipped with a solenoid-driven key-board and transmitting contacts. A 16 - channel punched Mylar tape provides format control.

Up to ten manual inquiry stations can be attached to the system, each one separately buffered, and designed for connection to the system by cable up to 2,500 feet long.

Card Reader: The *7500* card reader operates at a rate of 400 cards per minute, with format control by means of a control panel mounted on the reader. Data from a full 80-column punched card may be transferred into the computer.

The card reader is equipped with a front-attended tray-feeding hopper and stacker.

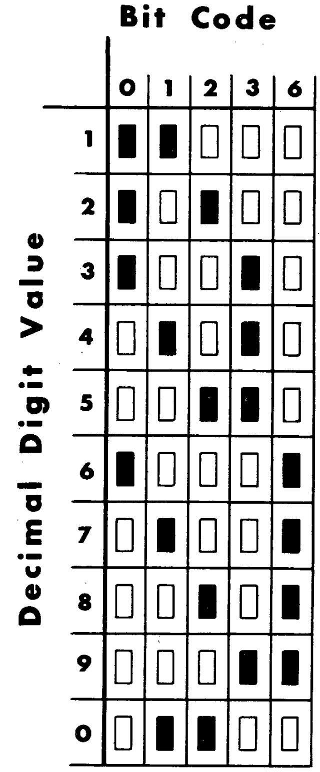

Fig. 2. Two-out-of-five code

As many as three *7500* card readers can be utilized for card input. Selected cards may be offset in the stacker as desired.

Card Punch: The *7550* card punch operates at a punching speed of 250 cards per minute, with format controlled by control panel wiring. Front-attended hopper and stackers are used. Selected cards may be offset in the stacker.

As many as three *7550* card punches can be utilized for card output.

Printer: The *7400* printer operates at a speed of 150 lines per minute, with format control provided by the control panel. The printed line output consists of a span of 120 characters, spaced ten to the inch.

As many as three *7400* printers can be utilized for printed output.

However, as printed and/or card output, a maximum of three *7550* card punches and *7400* printers can be used in any combination.

Main frame: The main frame of the *7070* system contains most of the system electronics and consists of the following elements:

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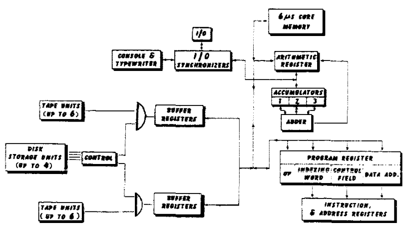

Fig. 3. Major IBM 7070 functional elements

1. Arithmetic registers and core adder.
2. Indexing hardware.
3. Space for optional floating decimal arithmetic.
4. Main core storage consisting of 5,000 or 10,000 words of magnetic cores.
5. Two data channels, code translators, data registers and controls for magnetic tape and disk storage units.
6. Buffers and controls for card input/output and printer.

Machine Characteristics of the 7070 System

Storage address and arithmetic registers are of fixed length of ten digits. However, the execution times of arithmetic operations and data transfers are completely variable.

Digit Code: A word in machine code is composed of 55 bits consisting of ten digits plus sign, each digit of which is represented by five bits in a two-out-of-five code. Fig. 2 illustrates this code.

Modes of Data Transmission: Parallel modes of data transmission include data transmitted to or from core storage via:

1. The program register.
2. The arithmetic register.
3. The tape synchronizing transmission registers, and
4. The auxiliary registers.

Serial modes of data transfer include data moved to and from the tape units. Accumulators, arithmetic registers, and auxiliary registers all have serial paths connecting them to and from the core adder. There is also a serial data path to and from the input/output synchronizers.

Rates of Data Transmission: The *7070* system operates at a 250-kc digit rate, with data transmitted to or from core storage at a 6-microsecond (μsec) rate. Data is transmitted to or from the core shift registers within the main frame at a 4-μsec rate.

On the disk storage unit, access time varies from a minimum of approximately 105 milliseconds (track to adjacent track of the same disk) up to approximately 850 milliseconds (track to track of different disks).

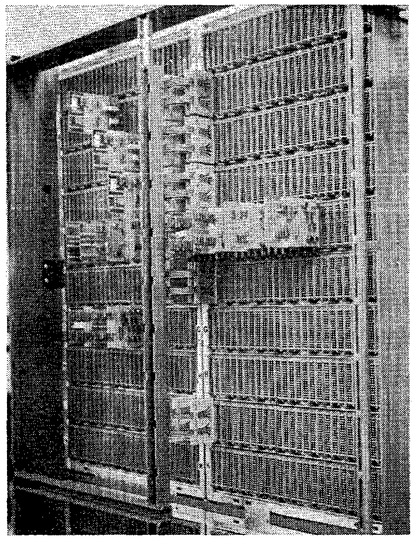

Fig. 4. One of the sliding gate cabinets housing the system electronics

Instruction Format: All operations performed by the *7070* are controlled by numerically coded instructions consisting of 10 decimal digits and sign.

The instruction format is shown in Table I.

Internal Organization of the 7070 System

Fig. 3 illustrates the major functional elements in the machine organization.

Storage: Main Storage consists of 5,000 or 10,000 words of magnetic cores operating on a 6-μsec cycle.

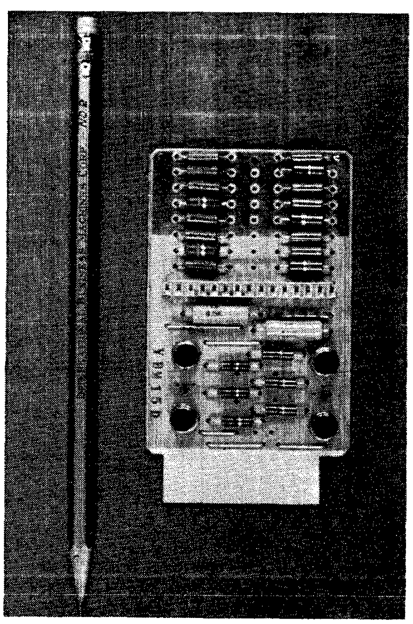

Fig. 5. Sample IBM 7070 printed circuit card

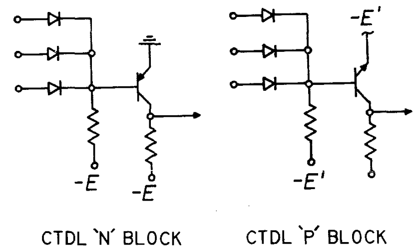

Fig. 6. CTDL transistor circuits

The 55 bits of a word are read into or out of core storage in parallel under control of priority circuits. These parallel data channels interconnect all of the major elements of the system, including arithmetic registers, instruction register, control registers, and input/output registers.

Arithmetic Registers: Arithmetic is performed by three registers with the adder and its controls. A sum is obtained by adding the contents of any two registers serially by digit, with the sum transferred to the specific arithmetic register.

In multiplication, the multiplicand is stored in accumulator 3, the multiplier in accumulator 2, and the product is generated in accumulators 1 and 2.

In division, the divisor is stored in accumulator 3, the dividend in accumulators 1 and 2, and the quotient is transferred to accumulator 2. The remainder is located in accumulator 1.

Program Registers: The program section contains the instruction register, address register, and program register and an arithmetic register (not shown).

Indexing makes use of the main adder and controls.

Up to 99 index words stored in core memory are available for automatic indexing during instruction interpretation.

Magnetic Tape Control: The two magnetic tape channels are buffered by time-sharing main core storage through a tape buffer register of ten digits. When this register is filled, its contants are transferred in parallel into core storage at a location specified by a special control feature called scatter read-write. The scatter read-write feature provides, by means of a sequence of stored control words, the format in memory of the record read from tape. This feature is also used in other input/output operations, including disk storage operations.

In a data processing system containing a multiplicity of input/output devices, there has been a need to provide an effective means of running two or more applications simultaneously. The *7070* solves this problem by a mode of operation known as "automatic priority processing" in which a given input/output device interrupts the sequence of the main routine, temporarily stores machine status information, and causes a program branch to the new routine.

After completion of priority processing routine, the machine returns to the original program.

This mode of operation is provided for in the control of magnetic tape as well as all other input/output devices.

Disk Storage Control: Control of the data format of disk storage records is very similar to the format employed in magnetic tape. Scatter read-write and priority processing are employed.

Card Input/Output and Printer Synchronizers: Each card input/output device is attached by means of a separate synchronizer to permit operation of all these units in parallel with computing. All synchronizers are connected to core storage by a parallel data channel to permit scatter read-write and priority processing functions.

Physical and Electrical Characteristics of the 7070 System

Printed Circuit Cards: The system electronics are housed in a group of sliding-gate cabinets, one of which is illustrated in Fig. 4. These cabinets are designed to accommodate printed circuit cards of a type shown in Fig. 5. These printed cards, which mount up to six transistors, are designed for automated fabrication. The number of different card types utilized is held to a minimum. Approximately 14,000 cards are employed in the *7070* system shown in Fig. 1. A total of 30,000 alloy-junction germanium transistors, and 22,000 germanium diodes, are used in this system.

Chassis intercard signal wiring is provided by jumper wires which are connected to the card socket by wire-wrap connections. This wiring is designed to be accomplished automatically by wire-wrap machinery.

Distribution of power supply voltages to the transistor cards is accomplished by printed circuit strips. This enables a major portion of the electronic system to be fabricated by automatic equipment.

CTDL Transistor Circuits: The logic and control sections of the *7070* utilize complementary-transistor diode logic (CTDL) to provide economical logic circuitry for the system. These circuits are illustrated in Fig. 6. The basic building blocks can be described as using two circuits in each system; each block comprising a p-n-p (N-block) inverter and n-p-n (P-block) inverter. Each inverter has an input circuit that in combination controls the "on" and "off" states of the transistor and, therefore, performs the logic. In addition, outputs can be wired so that logical switching functions are also performed by transistors. Thus, two logical operations may be performed in a single stage with various block connections.

Table I. Instruction Format

S	0 1	2 3	4 5	6 7 8 9
Sign	Op	IW	C	D

Position S	Contains the sign: 6 minus; 9 plus.
Positions 0–1	Contain the operation code.
Positions 2–3	Contain the indexing word designation. Positions 2–3 of the instruction word specify the indexing word to be used with the instruction. Value 00 indicates no indexing; values 01–99 are directly related to core memory words 0001–0099.
Positions 4–5	Contain the control information, field definition, index word to be operated on, or an extension of the operation code. Position 4 specifies the starting position of the field (high-order position of the field). Position 5 specifies the last position of the field (low-order position of the field). The field specified may not extend beyond the limits of one word to the adjoining word. If the start position is greater than the last position, an error stop occurs. The sign of the specified field is the sign of the word which contains the field.
Positions 6–9	Contain the data address (address of the operand), control information, or branch address.

Current Mode Circuits: Current mode transistor circuitry is used in the timing storage and core storage portion of the *7070* system. Current mode logic provides a building block in which the flow of sufficient current rather than the voltage levels affects the logical operation. Here, the transistor is considered as a current amplifier. Thus, when X milliamperes of a base current flows, KX milliamperes of collector current will flow, K being the current gain of the transistor. These circuits are employed to represent a "logical 1" when they do not supply base current, and a "logical 0" when they do supply base current. A typical circuit is illustrated in Fig. 7.

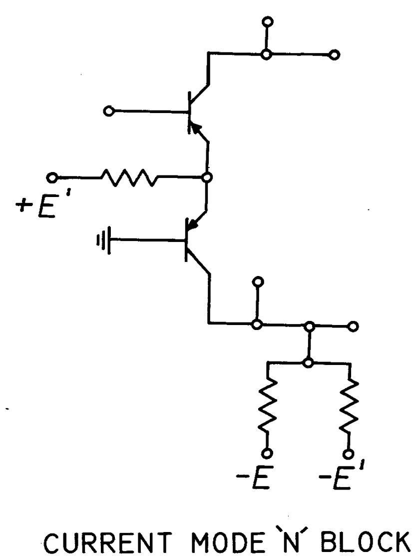

Fig. 7. Typical current mode transistor circuit

Magnetic Core Registers and Translators: Magnetic devices are used in several *7070* units in addition to the core memory.

These units are:

1. Arithmetic registers.
2. Adder.
3. Code Translators.
4. Validity check circuits.

The registers utilize magnetic core shifting registers.

The adder and code translators are coincident current core arrays in the form of truth tables.

Summary and Conclusions

The IBM *7070* system offers facilities required for complete data processing according to the most modern concepts. In addition, by utilizing recent developments in transistor and magnetic technology, the *7070* provides these functions at a minimum cost.

An equally new and modern approach to the manufacture of data processing machines is an important part of this product.

Discussion

H. P. Peterson (Lincoln Laboratory, Massachusetts Institute of Technology): Is arithmetic done in the 2-out-of-5 code?

Mr. Avery: Arithmetic is done in the 2-out-of-5 code using a serial by digit adder.

Mr. Peterson: How long is a full carry time?

Mr. Avery: 4 microseconds.

T. J. Beatson (General Electric Company): How are alphabetic or non-numeric data handled in the 2-out-of-5 code structure?

Mr. Avery: Alphabetic data are represented in the machine by two numeric digits. Alphabetic input-output is automatically translated to and from this code representation.

Alphabetic words in memory are identified by a special symbol in the sign position.

F. B. Pace (Bell Telephone Laboratories): How many different modular types are used in the IBM *7070*?

Mr. Avery: One printed-circuit card design is used for all circuits. About 10 different printed patterns are used. A total of 73 different circuits may be achieved by the manner in which circuit components are mounted on the card.

Mr. Ottollanch: When will IBM make the first commercial installation?

Mr. Avery: The first commercial installation will be in the Spring of 1960.

Mr. Ottollanch: What are add, multiply, and divide time for minimum and full system?

Mr. Avery: Arithmetic times are not dependent upon system size but are dependent upon field size of the record.

A 5-digit add requires 60 microseconds.

Multiply time in microseconds is: 192+48. (No. of 1's, 2's and 4's in multiplier) + 2 (No. of 3's, 5's, 6's, and 8's in multiplier) + 3 (No. of 7's and 9's in multiplier) + (No. of zero groups in multiplier)

Divide time in microseconds is: 264 + 48 10 + quotient digits.

H. F. Sherwood (Touche, Niven, Bailey & Smart): Is use of a high-speed printer planned with the *7070* system, and if so, what type?

Mr. Avery: The type *720A* printer with the *760* buffer and *727* tape unit may be used off-line with the *7070*.

The system is designed to be compatible with new IBM printers when available.

W. R. Haber: In the card punch machine, what is the maximum number of holes allowable for punching?

Mr. Avery: A maximum of 80 columns may be punched in each card. Each column may contain all allowable numeric, alphabetic, and special characters together with special control punches in the zone portion of the card.

J. H. Waite (Radio Corporation of America): What are some representative times for matrix inversion?

Mr. Avery: Information on matrix inversion times will become available at a later date.

J. H. Waite: What are program running times for sine, arctan subroutines?

Mr. Avery: Sine routine: 7.7 milliseconds minimum
10.3 average
12.9 maximum
Arctan routine: 9.9 minimum
14.1 average
17.2 maximum

Performance Advances in a Transistorized Computer System: The TRANSAC S-2000

R. J. SEGAL J. L. MADDOX P. PLANO

THE THEME of this 1958 Eastern Joint Computer Conference is "Modern Computers." It is significant that all of the new computers described at this conference are transistor machines. In order for a particular transistor machine to be properly described as a "modern computer" it should satisfy the following three criteria:

1. Performance of the transistor machine should be notably better than currently available vacuum-tube machines in the same class. An increase in the speed of arithmetic operation by a factor of 3 (or more) to 1 is an example of this type of performance advance.

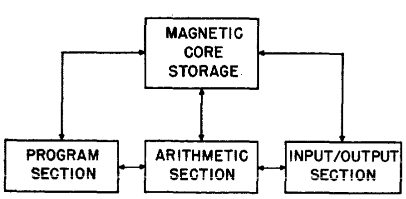

Fig. 1. Magnetic-core storage unit is time shared by other sections of the S-2000 system

2. Performance characteristics should be obtained from a working model of the transistor machine. More than one finely conceived system has been unable to overcome the difficult technical and economic obstacles between the initial concept and its realization in the form of hardware.

3. The existence of a single working model still does not imply the ability to produce many machines with the same performance characteristics. The design specifications, the equipment components, and the production organization must make it possible to produce and deliver many machines on schedule before a particular "modern computer" can be said to truly exist.

In the field of large-scale data processing systems the TRANSAC *S-2000* is a "modern computer" which meets the criteria just outlined. The first *S-2000* system was delivered to the field in November 1958. The Philco production organization is now producing both transistors and additional *S-2000* systems on schedule. As of December 1958, three systems of the *S-2000* class exist in the form of hardware and additional systems are in production. The performance advances of the *S-2000* stem from the versatility of the computing sections, the particular organization of the input-output system with relation to the computing and memory sections, and the new and sophisticated implementation of the *S-2000* logic by mass-produced units of hardware which incorporate the transistor as the active logical element.

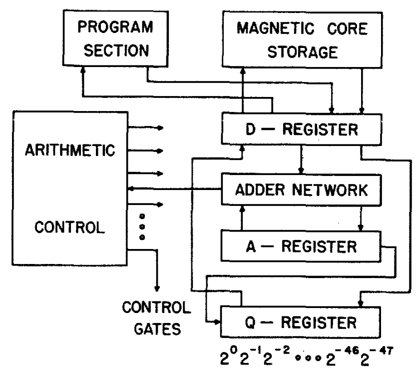

Fig. 2. Arithmetic section block diagram, fixed point

S-2000 System Organization

The TRANSAC *S-2000* organization centers around a magnetic-core storage unit. To the memory are connected the other three essential computer sections:

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