International Business Machines Corp.

Computers by the Dozen fill the testing center of a computer manufacturer. Here, specialists test new *programs* (sets of instructions) which computers follow when solving problems.

COMPUTER

COMPUTER is a machine that handles information with amazing speed. It works with such information as names and addresses, book titles, lists of items sold in stores, mathematical problems, and weather forecasts. A computer handles information in the form of numbers. It solves problems dealing with words by changing them into problems dealing with numbers. The fastest computers can do millions of problems in a few seconds.

Businessmen use computers for bookkeeping and accounting. A computer keeps track of sales, customer payments, and the amount of stock in warehouses. It figures out employees' wages and prints their paychecks. Many banks have computers to record the amount of money deposited or withdrawn by each customer. Engineers use computers to check the design of buildings, bridges, and dams. Astronauts use computers to keep their spaceships on course. Computers make the connections between telephones in some areas.

Because of the widespread use of computers, the computer industry has become one of the largest industries in the United States. The computer industry consists of companies that manufacture, sell, and *lease* (rent) computers. It also includes companies that supply various products and services used by specialists who work with computers.

In some industries, computers control machines that make products. A computer turns the machines on and off, and adjusts their operation when necessary. Machinery controlled by computers is used in making bakery goods, chemicals, steel products, paper, and many other items. Computers also set type for printing newspapers and books. For more information on the use of computers in industry, see the article on AUTOMATION in WORLD BOOK.

Evan F. Linick, the contributor of this article, is Assistant to the President, MARK IV Systems Company, an operating unit of Informatics Inc., a computer software company.

Computers have been called "electronic brains." But a computer cannot think. A human operator must put *data* (facts and figures) into a computer. Then he must tell the computer what to do with the information.

Special machines are used to put information and instructions into a computer. One of the most important of these machines is similar to a tape recorder. It records information in the form of tiny magnetic spots on a plastic tape. This machine "reads" the tape and sends the information to the computer in the form of electric signals. A piece of magnetic tape about 1 inch (2.5 centimeters) long could hold the names, addresses, and telephone numbers of 15 persons.

A computer has a *memory* that stores information, and an *arithmetic* (pronounced *AR ith MEHT ick*) *unit* which performs mathematical operations. These parts contain most of the electronic equipment that makes the computer work. A computer is connected electrically with tape machines, automatic typewriters, and printing machines that record the information it produces.

A computer operator sits at a desklike unit called a *console*. On parts of the console are tiny lights that flash when the computer is operating. These lights tell what operation the computer is performing at any moment. A computer works noiselessly most of the time. But when the high-speed printing machines operate, they sound almost like machine guns. Some of these printers can print enough information in one minute to fill four pages of a telephone directory.

A computer that does many kinds of jobs may include enough equipment to fill a room, or it may be as small as a table radio. The small computers that do many jobs are often called *minicomputers*. Other kinds of small computers are designed to do only one job, such as guiding a spacecraft.

COMPUTER/*Kinds of Computers*

Computers may be classified according to the jobs they can do. A *general purpose computer* can perform many kinds of jobs. General purpose computers may be used in banks, department stores, libraries, or schools. A *special purpose computer* is designed for just one job, such as helping to guide a space vehicle.

Computers also may be classified into two types according to the way they work. These types are: (1) *digital computers* and (2) *analog computers*. Each type operates in a different way. The operation of these computers is explained in the following two sections.

Digital Computers solve problems by counting *digits* (numbers). These machines can add, subtract, multiply, and divide. Electronic digital computers differ from adding machines and other ordinary figuring machines because they can automatically do many problems, one after the other. For example, a computer may first add two numbers, then subtract a third number from the sum of the first two, and finally multiply the result by a fourth number—all in one continuous operation. A digital computer also can compare two numbers to find if both are equal or if one is larger than the other.

Before a digital computer can solve any problem, it must be given two kinds of information. First, it must have all the numbers to be used in solving the problem. Second, the computer must have a set of instructions, called a *program*, that tell it what to do with the numbers. The numbers and the instructions are stored in the memory of the computer.

A human operator puts the necessary numbers and the program into the computer. The machine then performs a series of operations with the numbers, according to the instructions of the program.

Most digital computers are general purpose computers. Manufacturers produce a variety of standard models, each of which can do many basic jobs in almost any business or industry. These computers are so widely used that the word *computer*, when used alone, usually means a general purpose, digital computer.

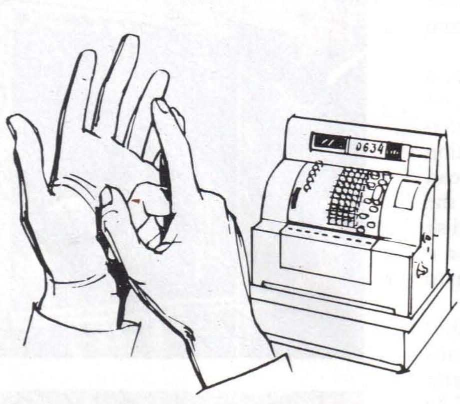
The rest of this article, except for the following section on analog computers, describes the parts and operation of general purpose, digital computers.

Analog Computers solve problems by measuring one quantity in terms of some other quantity. Most well-known instruments operate on this principle. For example, a thermometer measures temperature in terms of the length of a thin line of liquid in a glass tube. The longer the line, the higher the temperature. An automobile speedometer measures speed by means of a pointer moving across a dial. The faster the car is going, the farther the pointer moves. An analog computer might use electrical hookups to represent the speed and direction of an airplane, and to measure the effect of wind on the plane. The computer's electrical hookups act as an *analogy* (likeness) of the flying airplane. The analogy gives an analog computer its name.

Crewmen learning to pilot airplanes or spacecraft are trained in machines controlled by analog computers. Guided by a computer, a training machine duplicates situations that might occur on a real flight.

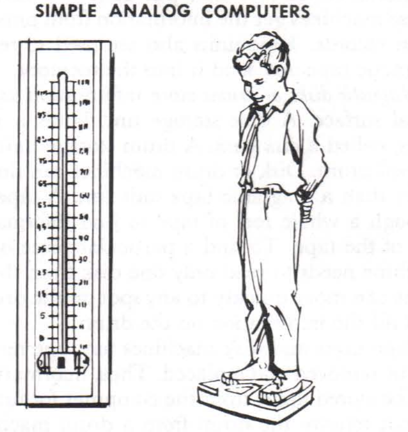
Quantities such as electrical voltage cannot be measured exactly. As a result, analog computers are not so exact as digital computers, which work with numbers digit by digit. Most analog computers are special purpose computers. They may solve their special problems faster than a digital computer could.

SIMPLE DIGITAL COMPUTERS



Digital computers solve problems by counting, just as a person does when he counts on his fingers. A cash register is a mechanical digital computer. It contains wheels that turn to certain positions to represent numbers. The register adds by counting the turns that the wheels make.

SIMPLE ANALOG COMPUTERS



Analog computers measure one quantity in terms of another quantity. A thermometer indicates temperature in terms of the length of a thin line of liquid. The line gets longer as the temperature rises. A bathroom scale indicates weight by the distance a dial moves.

A general purpose, digital computer consists of five main parts. Each part does a special job. (1) *Input equipment* sends data and instructions into the memory. (2) The *memory* stores data and instructions until they are needed. (3) The *control unit* gets instructions from the memory and tells the arithmetic unit what to do with the data. (4) The *arithmetic unit* gets data from the memory and performs the operations ordered by the control unit. (5) *Output equipment* records the desired information and delivers it from the computer.

The memory, control, and arithmetic units may be grouped in a single unit called the *central processing unit* (CPU). Input equipment and output equipment, often referred to as *peripheral* equipment, may be connected with a CPU or work independently of it. When connected with a CPU, peripheral equipment is said to be *on-line*. When working independently, it is *off-line*. Cables or telephone wires may connect a CPU in one city with peripheral equipment located in another city. Such peripheral equipment provides *remote terminals* for the CPU.

Certain types of peripheral equipment called *auxiliary storage units* function as both input and output devices. An auxiliary storage unit can store more data and instructions than the memory unit of a CPU.

Input Equipment works with punched cards, magnetic tape, magnetic disks or drums, and other kinds of records that contain data and instructions.

Punched cards carry information in the form of patterns of holes. Operators put the holes in the cards with *key punch* machines similar to typewriters. A common type of card has room for holes that represent 80 letters or numbers and other symbols.

Machines called *card readers* take information from the punched cards. These machines can "read" more than a thousand cards a minute. They put the information from each card into the form of electric signals. The signals are sent to the computer's memory. Then they are usually recorded on magnetic tape for storage.

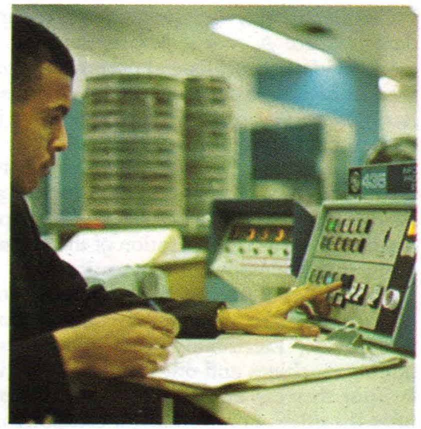
Magnetic tape used in computers is similar to that used in tape recorders. Computer tape carries information in the form of small magnetic spots. Spots representing more than a thousand letters and numbers can be recorded on 1 inch (2.5 centimeters) of tape. Machines called *tape units* put data and instructions on the tape. These machines get the information from punched cards and other input records. Tape units also are used to read information from magnetic tape and send it into the memory.

Magnetic disks or drums store information as magnetic spots on a metal surface. A disk storage unit holds a stack of shiny metal disks, called a *disk pack*. A drum storage unit contains a cylinder-shaped drum. Disk or drum machines can find stored information faster than a magnetic tape unit can. A tape machine must read through a whole reel of tape to find information stored near the end of the tape. To find a particular piece of information, a disk machine needs to read only one disk from the pack. A drum machine can move quickly to any spot on the drum without having to read all the information on the drum.

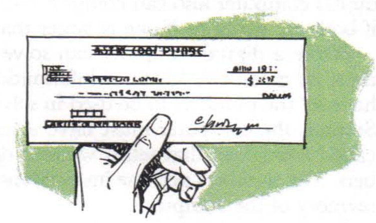
Tape units and disk machines use tape reels or disk packs that can be removed and replaced. Thus, information put on these units can be stored apart from the computer for future use. An operator cannot remove the drum from a drum machine. Therefore, if he wants to save information already on the drum, he must first transfer the data to a tape or disk.

A device called a *data entry machine* records information on magnetic disks or tapes. An operator uses the device in much the same way as a key punch machine.

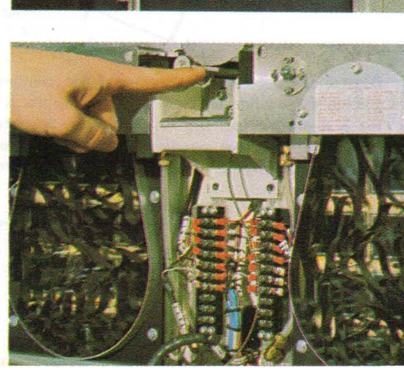
Other kinds of input equipment handle information that has been stored in various other ways. *Paper tape* equipment reads



Operator's Console, *above,* keeps track of the basic operations performed by the computer equipment shown on these pages.



Input. Just as a bookkeeper reads a check, *above,* to put information into his head, a tape unit, *below,* reads magnetic tape to put information into a computer. The bottom photo shows the part of the machine that reads the tape.

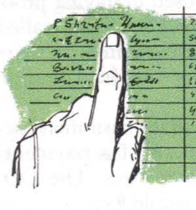


information stored as a pattern of holes in a roll of paper tape. An *optical scanner* works somewhat like the human eye. The scanner "looks" at handwritten or printed information and produces electronic signals that represent the information. Some equipment uses a process called *magnetic ink character recognition* to read data printed with special ink. The ink contains a metal powder that can be magnetized and then read by the equipment. Telephones with *Touch-Tone* buttons also may be connected to a computer. By pressing the buttons, a person can put information into the computer.

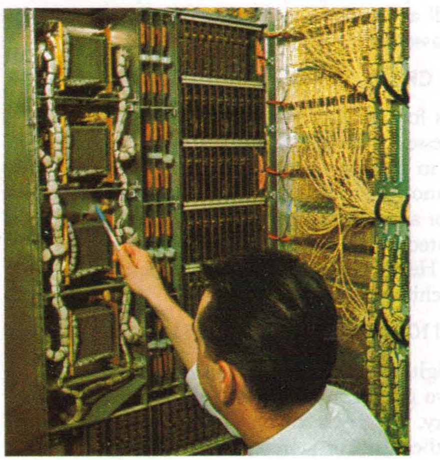
Memory receives information from input machines and holds it until needed by other parts of the computer. One kind of memory consists mainly of thousands of small rings called *cores*. Each core can be magnetized in either a clockwise or counterclockwise direction. When magnetized one way, a core stands for a 1. When magnetized the opposite way, it stands for a 0. The memory "remembers" any number by magnetizing a group of cores in a certain combination of 1's and 0's. This method of using 1's and 0's to represent any number is called the *binary numeration system* (see NUMERATION SYSTEMS [The Binary System]). The memory also remembers words by substituting numbers for letters.

A single memory core can store one *binary digit* (a 1 or a 0), also called a *bit*. Many cores are needed to represent most numbers or words. The memory is divided into sections with a certain number of cores. A number called an *address* identifies each section so that the computer can find stored information when it is needed.

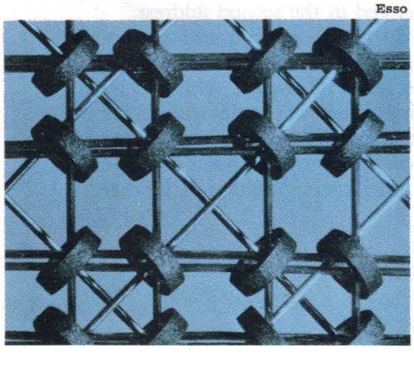
Control Unit guides the computer in performing operations with stored data. This unit selects *instructions* from the memory. An instruction consists of a series of numbers. It includes a code number that tells what operation is to be performed, such as addition or subtraction. The instruction also includes addresses that tell where data for the operation are stored in the memory. After the control unit selects an instruction, it commands the arithmetic unit to perform the proper operation. Then it selects another instruction and gives the arithmetic unit another command. The control unit repeats these operations until the job is finished.

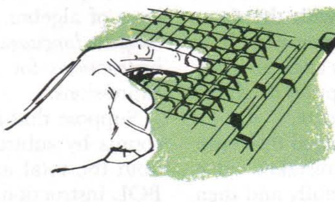


Memory. A bookkeeper stores data in an account book, *above*. Similarly, a computer stores data in its memory, *below*. Rings in the memory, *bottom*, are magnetized to represent numbers.

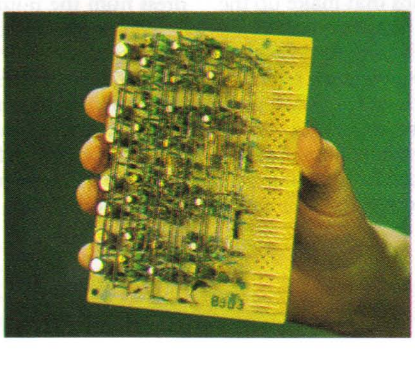


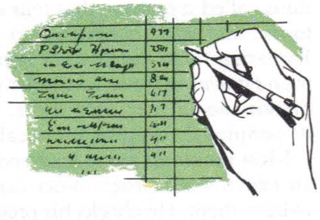
Esso





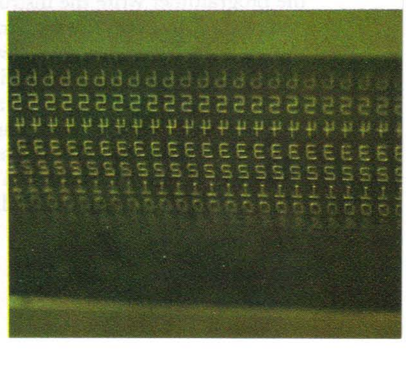
Processing. A bookkeeper uses a calculator, *above*, to do mathematical operations. A computer's arithmetic unit, *below*, performs similar operations with data stored in its memory. Thousands of electronic circuits, *bottom*, do the job.





Output. A bookkeeper writes his answers in an account book, *above*. A computer may print its data on a long sheet, *below*. A row of printing wheels, *bottom*, prints a line at a time.

WORLD BOOK photos by Edward F. Hoppe



Arithmetic Unit gets data from the memory. It stores the data temporarily in its own storage devices, called *registers*. The registers connect with electronic circuits that perform mathematical operations according to commands from the control unit. After an operation has been completed, the answer appears as new data in the registers. The answer is transferred to the memory for storage until it is needed for another operation or is sent to output equipment.

Output Equipment includes card and tape punches, magnetic tape units, magnetic disk or drum units, automatic typewriters, high-speed printers, cathode ray tubes that display information, and voice response units.

Card and tape punches put information on punched cards and punched paper tape. Magnetic tape, disk, or drum units record data in magnetic form. Output information is put on punched cards; paper tape; and magnetic tape, disks, or drums so it can be put back into the computer easily when needed. Generally, automatic typewriters are used to print only small amounts of information because they can type only one character at a time. High-speed printers can print a whole line of more than 100 letters and numbers at a time, and 1,000 lines a minute. A cathode ray tube (CRT) displays information on a screen similar to a television screen. Some CRT's show only letters and numbers. Others display such information as drawings and graphs. A voice response unit sends data as spoken words through a telephone. To make such a response, the computer selects words and phrases from a collection of human-voice recordings.

COMPUTER/*Programming a Computer*

A computer by itself cannot solve any problem. A computer specialist called a *programmer* must tell the machine exactly what to do. He writes a set of instructions called a *program* that tells the computer what data to use and what operations to perform with the data. Preparing these instructions is called *programming*. The term *software* refers to computer programs and the information used in preparing them. The computer itself and its peripheral equipment are called *hardware*.

Most programs are so long and complicated that even an experienced programmer can make mistakes when writing them. He checks his program carefully and then tests it on the computer. If the computer does not work properly, the programmer must find his mistakes and correct them. Programmers refer to mistakes as "bugs," and call the testing procedure "debugging."

Planning a Program begins with a detailed description of the job the computer is to do. The programmer might get the job description from scientists and engineers who want to solve mathematical problems. Or he may get it from *systems analysts* (experts who plan information handling systems). The job description tells what input information is necessary, what processing must be done, and what the output should be.

A programmer or a systems analyst uses the job description to prepare a diagram that shows how all the parts of the job fit together systematically. This diagram is called a *systems flow chart*. The chart maker uses symbols to show how information will flow from input equipment, through the computer, to output equipment.

The systems flow chart helps the programmer prepare another diagram called an *operations flow chart*. In this chart, he breaks the job down into detailed steps that show the exact operations the computer must perform.

Writing a Program. The operations flow chart helps the programmer write the instructions that make up the program. The programmer writes the instructions on special forms called *coding sheets*. For most jobs, key punch operators then put the instructions on punched cards. Machines read the cards and send the program to tape units that record it on magnetic tape.

The programmer writes the program in a "language" consisting of certain words and symbols. The language he uses depends on the particular computer he is working with and on the job to be done. Computer languages include COBOL (COmmon Business Oriented Language), used in processing business data, and FORTRAN (FORmula TRANslation), used in solving problems of algebra. COBOL and FORTRAN are called *compiler languages*. They allow the programmer to write instructions for the computer using simple, common expressions.

Suppose that a computer is to update customers' accounts by subtracting a *credit* (amount of a payment) from the total amount each customer owes. The COBOL instruction for this operation would be:

SUBTRACT CREDIT FROM TOTAL

Programmers also use another kind of language called an *assembly language*. Assembly languages are somewhat harder to use than compiler languages because they involve symbols as well as words. The instruction above, when written in an assembly language, might be:

S CREDIT, TOTAL

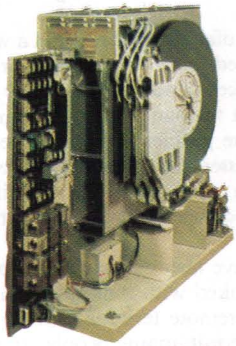
The symbol *s* stands for *subtract*. The words *credit* and *total* represent addresses that tell where data for the operation are stored in the memory.

The computer cannot work directly with instructions written in compiler or assembly languages. The instructions must be translated into a *machine language* consisting of binary digits. Here is how the above instruction might appear in machine language:

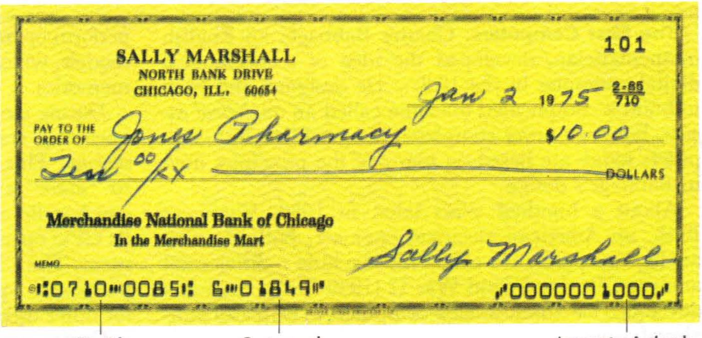
011111 011110100010 000000101110

The first group of digits is an operation code meaning *subtract*. The next two groups are addresses of numbers stored in the memory. To perform the operation, the computer subtracts the number stored in the first address from the number stored in the second address.

Computer operators do not have to translate compiler and assembly languages into machine language. The computer does the translation itself with special programs written for this purpose. It usually records the program in machine language on magnetic tape. When the job is to be performed, the computer reads the tape and stores the program in its memory, along with other input information.



Burroughs Corp.


SALLY MARSHALL
NORTH BANK DRIVE
CHICAGO, ILL. 60654

101

Jan 2 1975

2-85
710

PAY TO THE ORDER OF Jones Pharmacy $10.00

Ten 00/xx DOLLARS

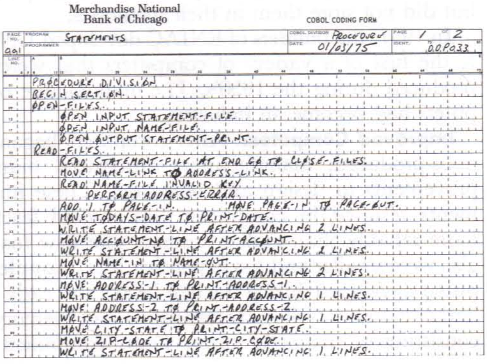
Merchandise National Bank of Chicago
In the Merchandise Mart

MEMO

Sally Marshall

⑆0710⑈0085⑆ 6⑈01849⑈ ⑈0000001000⑈

A Personal Check, *above right*, has numbers printed in magnetic ink in the lower left-hand corner. These numbers identify the check writer's bank and account. After a check has been cashed, it goes to the bank, where a clerk uses a machine to print in magnetic ink the amount written on the check. These numbers go in the lower right-hand corner of the check. Numbers printed in magnetic ink are read by another machine. It reads thousands of checks in a few minutes and records their numbers as magnetic spots on a magnetic disk machine, *above left*. A disk machine holds several rapidly spinning disks and can store the numbers from thousands of checks.


Merchandise National
Bank of Chicago

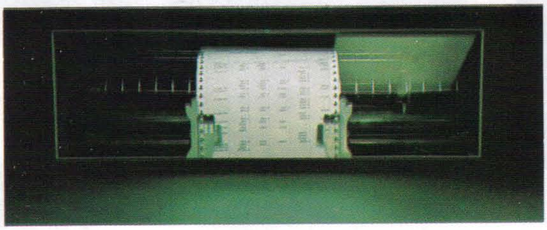
COBOL CODING FORM

PROGRAM: STATEMENTS | COBOL DIVISION: PROCEDURE | PAGE 1 OF 2
PAGE NO. 001 | DATE: 01/03/75 | IDENT. 00P033

```
PROCEDURE DIVISION.
BEGIN SECTION.
OPEN-FILES.
    OPEN INPUT STATEMENT-FILE.
    OPEN INPUT NAME-FILE.
    OPEN OUTPUT STATEMENT-PRINT.
READ-FILES.
    READ STATEMENT-FILE AT END GO TO CLOSE-FILES.
    MOVE NAME-LINK TO ADDRESS-LINK.
    READ NAME-FILE INVALID KEY
        PERFORM ADDRESS-ERROR.
    ADD 1 TO PAGE-IN.        MOVE PAGE-IN TO PAGE-OUT.
    MOVE TODAYS-DATE TO PRINT-DATE.
    WRITE STATEMENT-LINE AFTER ADVANCING 2 LINES.
    MOVE ACCOUNT-NO TO PRINT-ACCOUNT.
    WRITE STATEMENT-LINE AFTER ADVANCING 2 LINES.
    MOVE NAME-IN TO NAME-OUT.
    WRITE STATEMENT-LINE AFTER ADVANCING 2 LINES.
    MOVE ADDRESS-1 TO PRINT-ADDRESS-1.
    WRITE STATEMENT-LINE AFTER ADVANCING 1 LINES.
    MOVE ADDRESS-2 TO PRINT-ADDRESS-2.
    WRITE STATEMENT-LINE AFTER ADVANCING 1 LINES.
    MOVE CITY-STATE TO PRINT-CITY-STATE.
    MOVE ZIP-CODE TO PRINT-ZIP-CODE.
    WRITE STATEMENT-LINE AFTER ADVANCING 1 LINES.
```

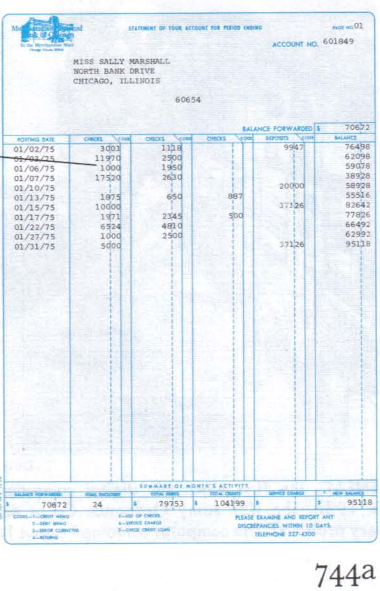
The Bank's Computer, *above*, reads the numbers from the disks and subtracts the amounts of cashed checks from the customer's account. A computer program, *above right*, tells the computer how to handle the numbers from the disks. The program also tells the computer how to prepare the customer's statement.

Customer's record of the check shown above



A High-Speed Printer, *above*, is controlled by the computer. It prints a monthly statement for each customer. This statement, *right*, lists cashed checks, deposits, and the amount remaining in the account.

Merchandise National Bank (WORLD BOOK photos)


Merchandise National Bank of Chicago
In the Merchandise Mart

STATEMENT OF YOUR ACCOUNT FOR PERIOD ENDING

PAGE NO. 01

ACCOUNT NO. 601849

MISS SALLY MARSHALL
NORTH BANK DRIVE
CHICAGO, ILLINOIS

60654

BALANCE FORWARDED $ 70672

POSTING DATE	CHECKS	CHECKS	CHECKS	DEPOSITS	BALANCE
01/02/75	3003	1118		9947	76498
01/03/75	11970	2500			62098
01/06/75	1000	1950			59078
01/07/75	17520	2630			38928
01/10/75				20000	58928
01/13/75	1875	650	887		55516
01/15/75	10000			37126	82642
01/17/75	1971	2345	500		77826
01/22/75	6524	4810			66492
01/27/75	1000	2500			62992
01/31/75	5000			37126	95118

SUMMARY OF MONTH'S ACTIVITY

BALANCE FORWARDED	ITEMS ENCLOSED	TOTAL DEBITS	TOTAL CREDITS	SERVICE CHARGE	NEW BALANCE
$ 70672	24	$ 79753	$ 104199	$	$ 95118

CODES—1—CREDIT MEMO 2—DEBIT MEMO 3—ERROR CORRECTED 4—RETURNS 5—LIST OF CHECKS 6—SERVICE CHARGE 7—CHECK CREDIT LOAN

PLEASE EXAMINE AND REPORT ANY DISCREPANCIES WITHIN 10 DAYS. TELEPHONE 527-4500

The First Computers. Charles Babbage, an English mathematician, developed the idea of a mechanical digital computer in the 1830's. He designed and tried to build a complicated machine called an *analytical engine*. Babbage never completed his machine. But computers today are based on many of the principles used in Babbage's design.

About a hundred years later, in 1930, Vannevar Bush, an American electrical engineer, built the first analog computer. He called his machine a differential analyzer. During World War II (1939-1945), engineers developed electronic analog computers to help aim antiaircraft guns.

The first digital computer, called Mark I, was completed in 1944 by Howard Aiken, a Harvard University professor. Mechanical and electrical devices controlled the operation of Mark I. In 1946, engineers at the University of Pennsylvania built the first digital computer controlled by vacuum tubes. They called it the Electronic Numerical Integrator and Computer (ENIAC).

Perhaps the most important computer advancement during the 1940's was the work of John von Neumann, an American mathematician. Von Neumann developed the idea of storing the computer program in the machine's memory. Early computers had used programs, but did not store them in their memories.

In 1951, the builders of ENIAC developed UNIVAC I, the first of a variety of computers that were mass-produced during the 1950's. The manufacture of computers had become an industry.

Improved Computers. After computers began to be mass-produced, manufacturers introduced many improvements in design and operation. These improvements resulted in computers that worked faster and more reliably than earlier models. The new machines also were smaller and less expensive. For example, computers developed during the late 1950's and early 1960's had circuits controlled by transistors and memory units consisting of magnetic cores. These computers could perform operations in one-tenth the time it took earlier models, which used vacuum tubes and magnetic-drum memories.

During the 1960's, manufacturers developed a way of operating computers called *multi-programming* or *time-sharing*. This method makes it possible for many users to "share" a computer at the same time. A computer can handle more than one problem at a time because its CPU operates much faster than its peripheral equipment. The CPU works on one user's problem while the peripheral equipment processes input and output data for other users.

Computer engineers have also developed peripheral equipment that can be linked with a distant computer by telephone lines. Such remote terminals, along with time-sharing methods, permit many people at widespread locations to use a single computer.

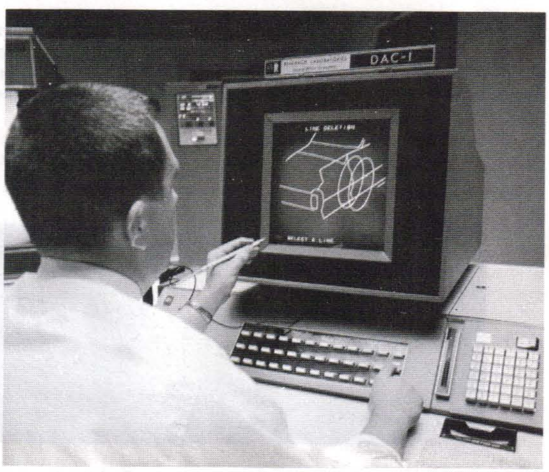
By 1970, about 75,000 computers were in use in the United States. Computer experts predict that this number will grow to more than 300,000 by 1980.

Computers of the Future will operate more and more as parts of "networks"—groups of several computers linked by communications lines. Network computers exchange data directly among one another. A network might also include terminals in banks, department stores, and homes. A store's customers could use their private terminal to do their shopping at home. If desired, the computer could then immediately deduct the cost of the purchases from the customer's account at a bank connected to the network.

Legal and social problems may arise as more and more information is put into computers. For example, *data banks*—large collections of facts—will grow as businesses and the government collect personal and business information. The existence of such data banks makes it difficult to protect a person's right to privacy. Various groups, including legislators and computer designers, are working to prevent the unauthorized use of information in data banks.

University of Pennsylvania

ENIAC, the first electronic digital computer, began operating in 1946. The U.S. Army Ordnance Corps used it to solve artillery problems. This computer contained about 18,000 vacuum tubes.



General Motors Corp.

Computerized Drawing Board, *above*, displays drawings stored in its memory. A designer can change a drawing by touching the screen with a device called a *light pen*.

COMPUTER/Careers

The development of computers has created career opportunities in such fields as automation, electronic data processing, and systems analysis. These fields deal with general principles of information handling and management that apply to all businesses. Computer specialists use their skills wherever computers help do a job. These experts can choose from an almost unlimited variety of jobs in education, government, industry, or science.

A computer specialist is basically a problem solver. He must have imagination so he can visualize difficult situations and find solutions to problems. He also should be creative so he can suggest new ideas and methods.

Above all, a computer expert needs training. This training may begin with a high school course in computer programming or with similar introductory courses. It should include at least a strong background in high school mathematics.

A college degree is desirable for almost every job in the computer field. College students may take courses in computer programming, computer languages, data processing, and systems analysis. At a university, these courses may be offered by the department of computer science, or by the departments of business, engineering, or mathematics. Many engineering schools include computer programming as a standard part of second- or third-year studies. A computer specialist may spend several months in on-the-job training to complete the preparation for his particular job.

Jobs associated with computers include: (1) computer operator, (2) computer sales representative, (3) data processing manager, (4) design engineer, (5) key punch operator, (6) programmer, (7) service engineer, (8) systems analyst, and (9) tape and disk librarian.

Computer Operator controls the computer and its input and output equipment. This specialist works at a control unit called a *console.* The computer operator keeps records telling what jobs the computer does and how long each job takes. The operator also may schedule new jobs.

Computer Sales Representative sells computers and related equipment, products, and services. He must have training in marketing and in computer applications, and must be familiar with the customer's business.

Data Processing Manager directs the people who program and operate a computer. The manager must have experience in using computers, and must be skilled in dealing with people.

Design Engineer works on the research and development of computers and of their input and output equipment. The designer tries to create new machines that are faster and smaller than existing machines, but able to do even more work. The design engineer also tries to improve machines to make them easier for programmers and operators to use. The job of computer design engineer requires at least a bachelor's degree in a field such as electronics. Many design engineers have master's or doctor's degrees.

Key Punch Operator uses a machine resembling a typewriter to prepare data for computer handling. The machine may punch holes in cards or paper tape. A key punch operator may also operate a data entry device that puts the information directly onto magnetic tape or disks. A high school graduate may learn to operate either machine with two or three weeks of training.

Programmer writes the instructions that the computer follows in doing a particular job. For a detailed description of the programmer's job, see the section on *Programming a Computer* in this article.

Service Engineer keeps computers in working order. Most service engineers are employed by computer manufacturers to work with their customers.

Systems Analyst determines how a computer will fit into the overall picture of the people and machines that do a particular job. The analyst must know everything about the job and about the equipment that is to do the job. The systems analyst not only serves the persons who want a job done, but also helps the programmers and operator who actually do it. See SYSTEMS ANALYSIS.

Tape and Disk Librarian supervises the storage of a computer's magnetic tape reels and disk packs. The librarian also keeps records of what information is stored on the tapes and disks.

EVAN F. LINICK

COMPUTER/Study Aids

Related Articles in WORLD BOOK include:

Abacus	Electronics
Adding Machine	Guided Missile (diagrams)
Aircraft Instruments (Flight Director)	Gyropilot
Automation	Information Retrieval
Bush, Vannevar	Printing (Electronic Computers)
Cash Register	Space Travel (Piloting a Spacecraft; Aiming at the Moon)
Cybernetics	Typewriter (History)

Outline

I. Kinds of Computers
A. Digital Computers
B. Analog Computers

II. Parts of a Digital Computer
A. Input Equipment
B. Memory
C. Control Unit
D. Arithmetic Unit
E. Output Equipment

III. Programming a Computer
A. Planning a Program
B. Writing a Program

IV. History

V. Careers

Questions

What is a computer *program?*

How do computer memory rings store information?

What common computer language is used in processing business data?

How do analog computers represent numbers?

How do electronic digital computers differ from adding machines and other figuring machines?

What information does each instruction of a computer program include?

What is "debugging"? Who performs this job?

How do *compiler languages* differ from *machine language?*

How do magnetic disk and drum units differ from magnetic tape units?

What are the main parts of a general purpose, digital computer?

Reading and Study Guide

See *Computer* in the RESEARCH GUIDE/INDEX, Volume 22, for a *Reading and Study Guide.*

COMPUTER-ASSISTED INSTRUCTION. See EDUCATIONAL PSYCHOLOGY.