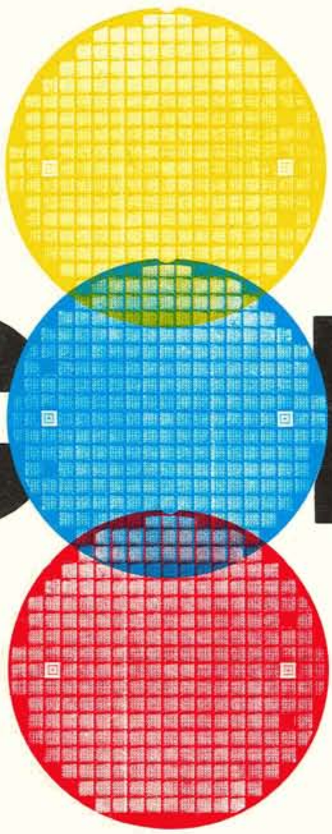
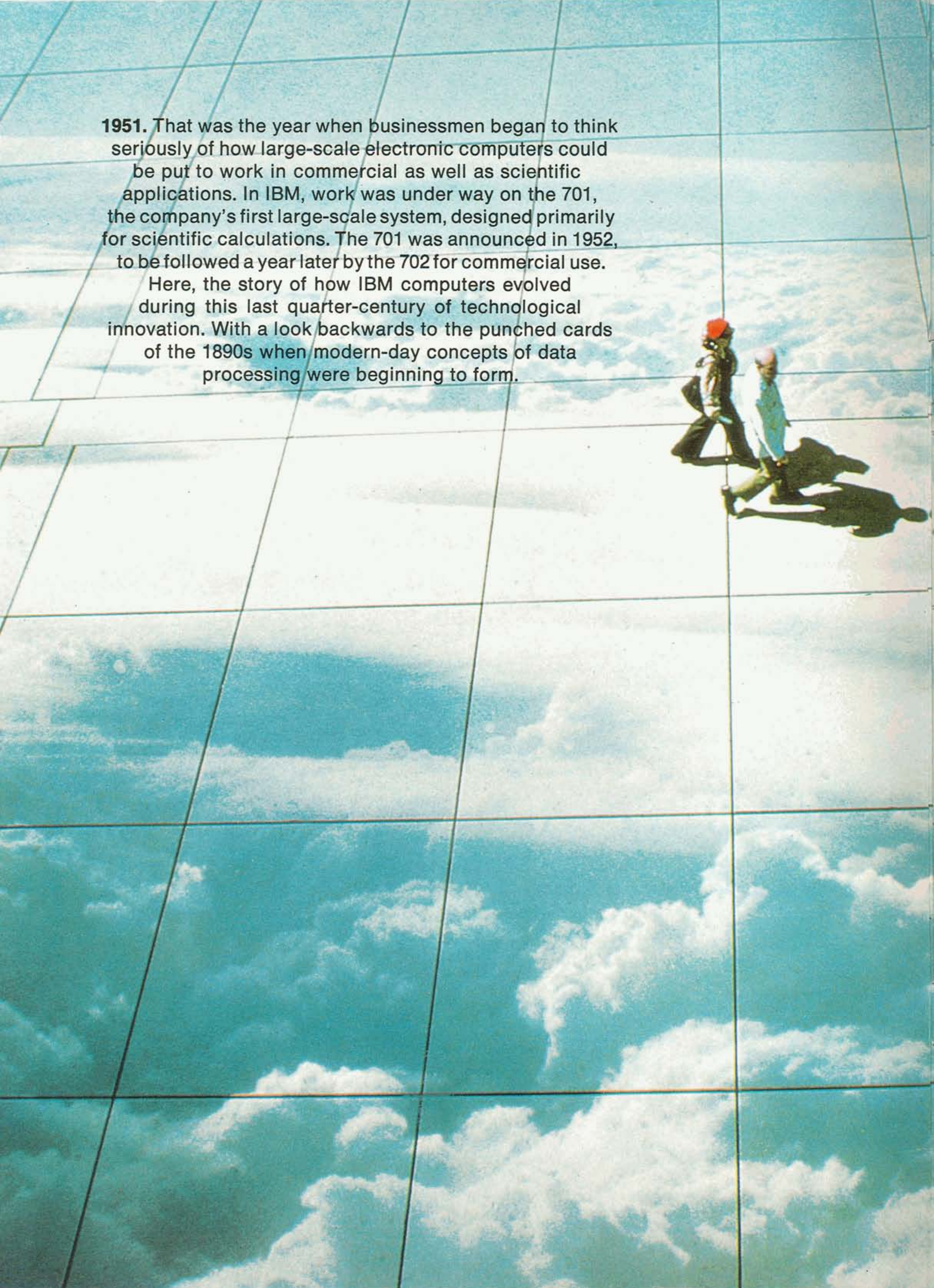
IT WAS TO
HAVE BEEN THE
NUCLEAR AGE.
IT BECAME...

THE COMPUTER AGE



THE EVOLUTION OF IBM COMPUTERS

1951. That was the year when businessmen began to think seriously of how large-scale electronic computers could be put to work in commercial as well as scientific applications. In IBM, work was under way on the 701, the company's first large-scale system, designed primarily for scientific calculations. The 701 was announced in 1952, to be followed a year later by the 702 for commercial use. Here, the story of how IBM computers evolved during this last quarter-century of technological innovation. With a look backwards to the punched cards of the 1890s when modern-day concepts of data processing were beginning to form.



It was to have been the nuclear age.
It became the computer age.

Fastest 25 Years

In the past quarter-century, the computer has moved from the margins of our existence into the center of our lives.

Few technologies have come so far so fast.

By 1951, the computer had been developed and introduced into commerce. But even those closest to it were unprepared for what would follow. The computer's spectacular growth—in numbers, in power and capability, in the variety of things it does—came as one of the great surprises of modern times.

What may not be surprising, but can be heartening, is that the success of the computer appears to be the result of many people trying to solve many problems in many fields—as a natural consequence of getting on with the business of life in general.

The success of the computer is based upon its ability to store and process vast quantities of information. It can add to, update, and retrieve that information, and transmit it across continents via communication satellites and telephone lines. It can calculate, make comparisons, simulate events, and monitor ongoing industrial and scientific operations. It can do all those things reliably with great ease and speed.

All these functions flow from the basic faculty of the computer to manipulate and store data in the form of numerical codes.

The computer has evolved naturally through the centuries from early counting devices like the abacus. But today, instead of manipulating beads on a wire, we rely on electronic impulses to accomplish the same goals.

And most important, as a result of technological innovations in these last 25 years, the costs of computing have come down from $1.26 for 100,000 multiplications in 1952 to one cent today. It has become feasible to use computers for applications today that would have been uneconomic only a few years ago.

Like the telephone, television, the automobile, and the airplane, the computer has transformed our world. And like so many of those other inventions, it is built upon know-how that emerged quite rapidly, especially (in the case of the computer) after the end of World War II. In quick succession the computer went from electromechanical counters to vacuum tubes to magnetic storage and memory to microscopic solid-state circuits.

Conceptually, the computer came into its own when two groups of scientists, engineers, and mathematicians—one working at the University of Pennsylvania and the other at IBM—implemented the idea that the machine's instructions could be stored and manipulated in the same manner as data. The computer's subsequent development flowed from the practical application of innumerable new technologies in both hardware and software. Over the past quarter-century, IBM introduced hundreds of new products, and many of these represented advances in the state of the computer art.

The following pages tell the story of IBM's entry into data processing, and the computer revolution that followed.

1890–1946

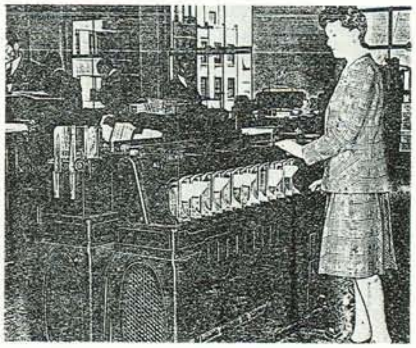
Wheels and levers

The beginning of data processing

An original Hollerith keypunch. This mechanical device, along with a tabulator and card sorter, enabled the U.S. Government to count the 1890 census twice as fast as the 1880 census even though the population had grown by 25 percent. The Hollerith concept, while improved upon through the years, remained the basis of the information processing industry through World War II.

'This apparatus works unerringly as the mills of the gods, but beats them hollow as to speed.' —Electrical Engineer November 11, 1891

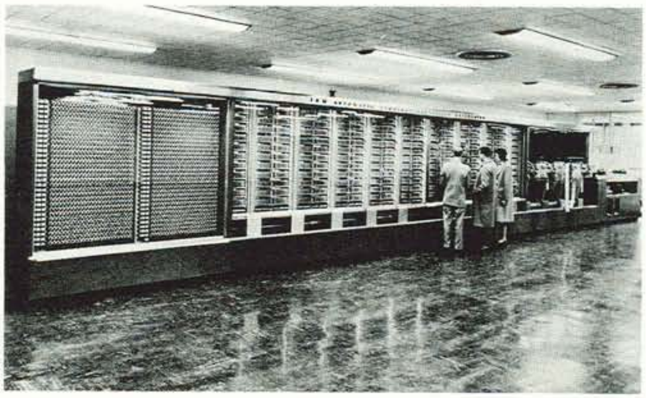
In the 1880s, the U.S. Census Bureau faced a crisis. It was clear that by the time it could count the 1890 census the data would be obsolete. So the Bureau held a contest to see if it could find a faster way to tabulate the results. Dr. Herman Hollerith, a young engineer in the Census Bureau, won hands down. He invented an electromechanical machine activated by punched cards. The holes in the cards represented vital statistics. Hollerith said the idea occurred to him when he saw a railroad conductor use a ticket punch. In 1896, Hollerith founded the Tabulating Machine Company, one of three firms which later became International Business Machines Corporation.



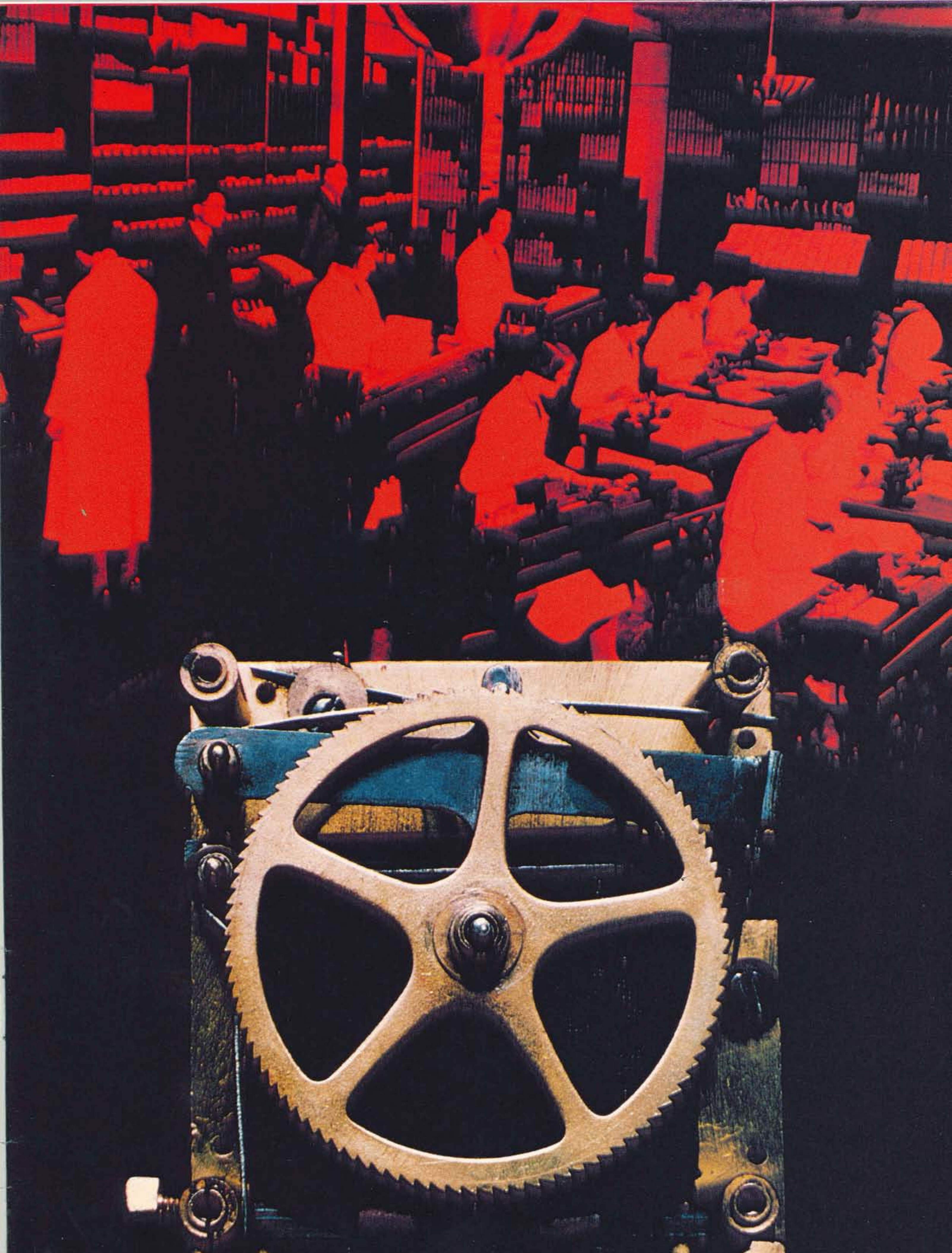
The IBM 080 card sorter was a familiar object to four decades of office workers. It was still being manufactured in the 1950s.

In 1941, this IBM 040 unit converted telegraph paper tape directly into punched cards. It was the first machine to do so. With the 040, the U.S. Air Corps obtained summary totals of equipment in inventory at its depots daily instead of annually.

→ The Hollerith tabulator relied on electromagnetically operated counters. From that central invention emerged progressively faster tabulating and companion machines. Introduced in 1925, the IBM 080 card sorter processed 400 punched cards per minute. The IBM 031 keypunch, introduced in 1933, was one of the first machines to permit punching of letters as well as numbers into cards. The IBM 405 tabulator, introduced in 1934, could add or subtract 150 punched cards per minute.



In 1944, Harvard's Dr. Howard Aiken and IBM completed five years of work on the Mark I, the largest electromechanical calculator ever built. It had 3,300 relays and weighed 5 tons. It could multiply two 23-digit numbers in six seconds.



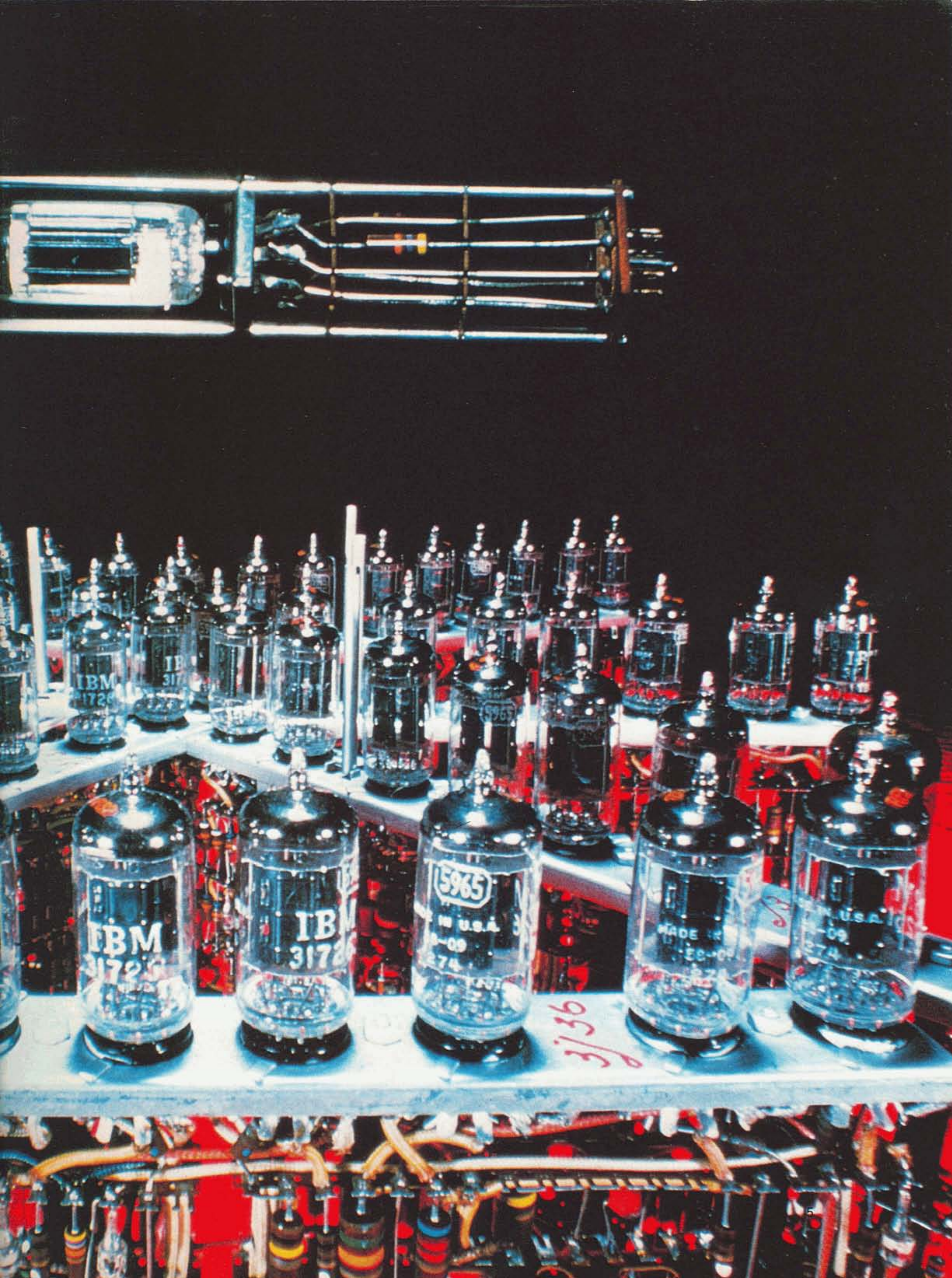
1946
The vacuum tube

With electronics, thousands of times faster

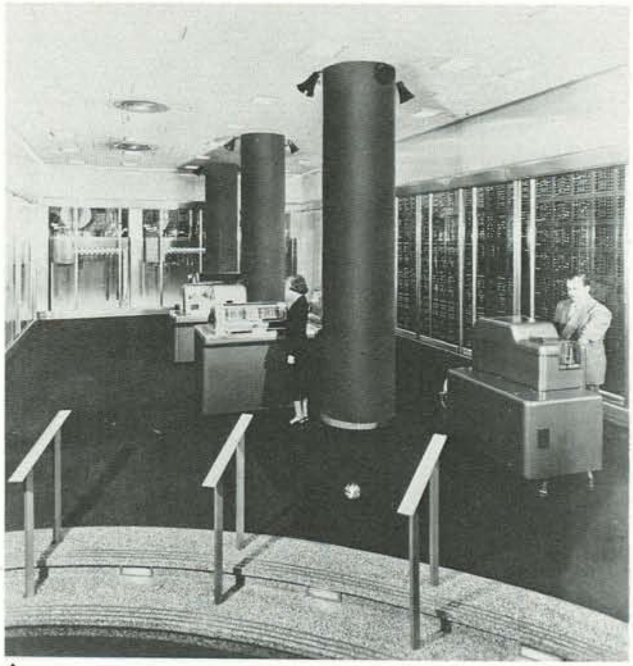
Electromechanical machines were too pedestrian for the swift-paced postwar world. Users wanted speed, and the vacuum tube responded to their demand. Vacuum tubes, flipped on and off like switches, could count thousands of times faster than moving mechanical parts. But the story doesn't lie in vacuum tubes alone. It lies in the creation of computer systems that incorporated not only vacuum tubes, but also other advancing technologies. Between 1946 and 1952, a series of electronic calculators and computers emerged in rapid succession: ENIAC at the University of Pennsylvania, the IBM Selective Sequence Electronic Calculator, The Institute for Advanced Study computer, UNIVAC for the Census Bureau, and the IBM 701—to name a few.

In 1946, IBM vacuum tube machines could multiply two 10-digit numbers in 1/40 of a second; by 1953, in 1/2000 of a second.

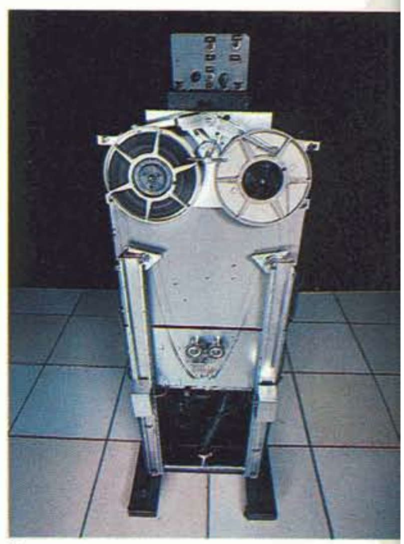
The IBM 604 was the first electronic calculator to supplant electromechanical office equipment on any scale. It was also the first electronic machine that could be easily repaired. Without tools, service engineers could remove one tube and its associated parts (shown at top) and plug in another. The array of tubes (below) were used in a later computer.


IBM
5965

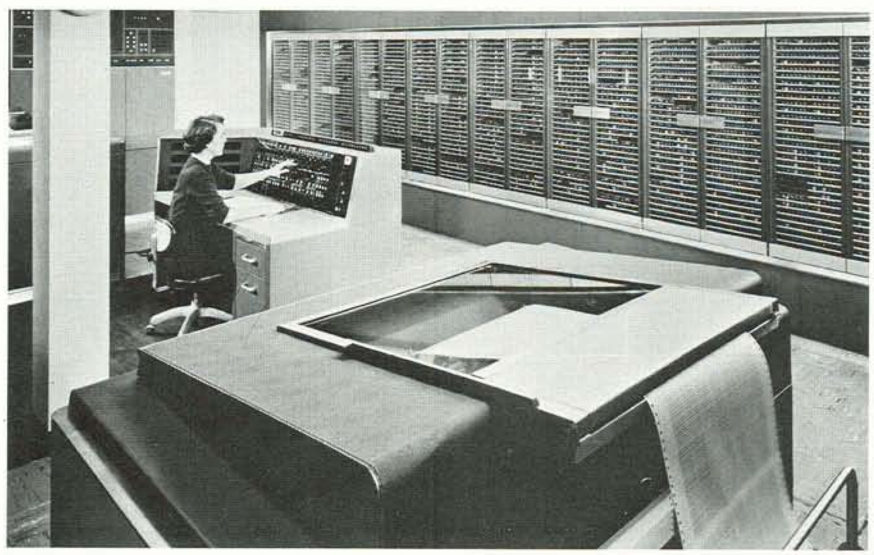
←
The IBM 701 could add a typewritten column of 10-digit numbers as tall as the Statue of Liberty in about one second. In one hour it could solve a problem in aircraft wing design that might have taken an engineer seven years with a desk calculator. Announced in 1952, the 701 was a portent of the larger, faster machines yet to come.



↑
The IBM Selective Sequence Electronic Calculator, completed in 1947, contained both vacuum tubes and relays. It was more than 100 times faster than the Mark I. It was the first IBM stored program machine, and it could select its own calculating sequence by modifying its own stored instructions—thus, its name.



↑
The vacuum tape column, invented by IBM in 1950, controlled the reeling and unreeling of tape and kept it from snapping. Vacuum columns are at left and right, under reels.



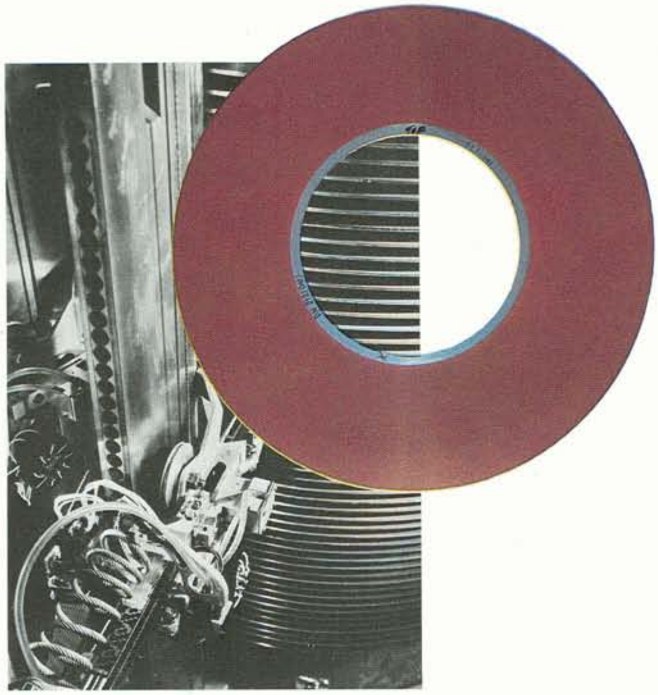
→
IBM's Naval Ordnance Research Calculator was the most powerful computer of its day back in 1954. It had 9,000 vacuum tubes.

1953

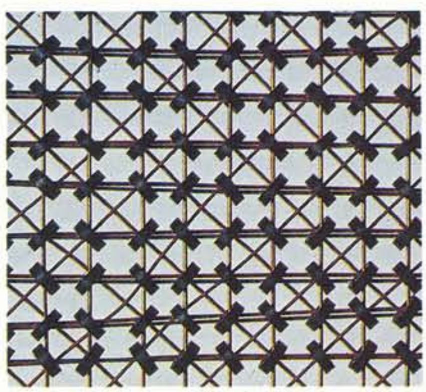
Magnetic storage

Better ways to find information fast

The vacuum tube vastly increased the computer's calculating speed. But it did little to improve the efficiency of two other critical aspects of the computer's configuration: storage and memory. The early vacuum tube computers stored data on punched cards or tape and drums and relied on cathode ray tubes or drums for active memory. Punched cards were slow and not rewritable. Tape could be inefficient because of the time taken in reeling and unreeling. Cathode ray tubes were expensive and unreliable. The urgent demand for faster and cheaper storage and memory devices stimulated research and development in magnetics — magnetic disks and drums for storage, magnetic cores for memory, and better materials for better magnetic tapes.



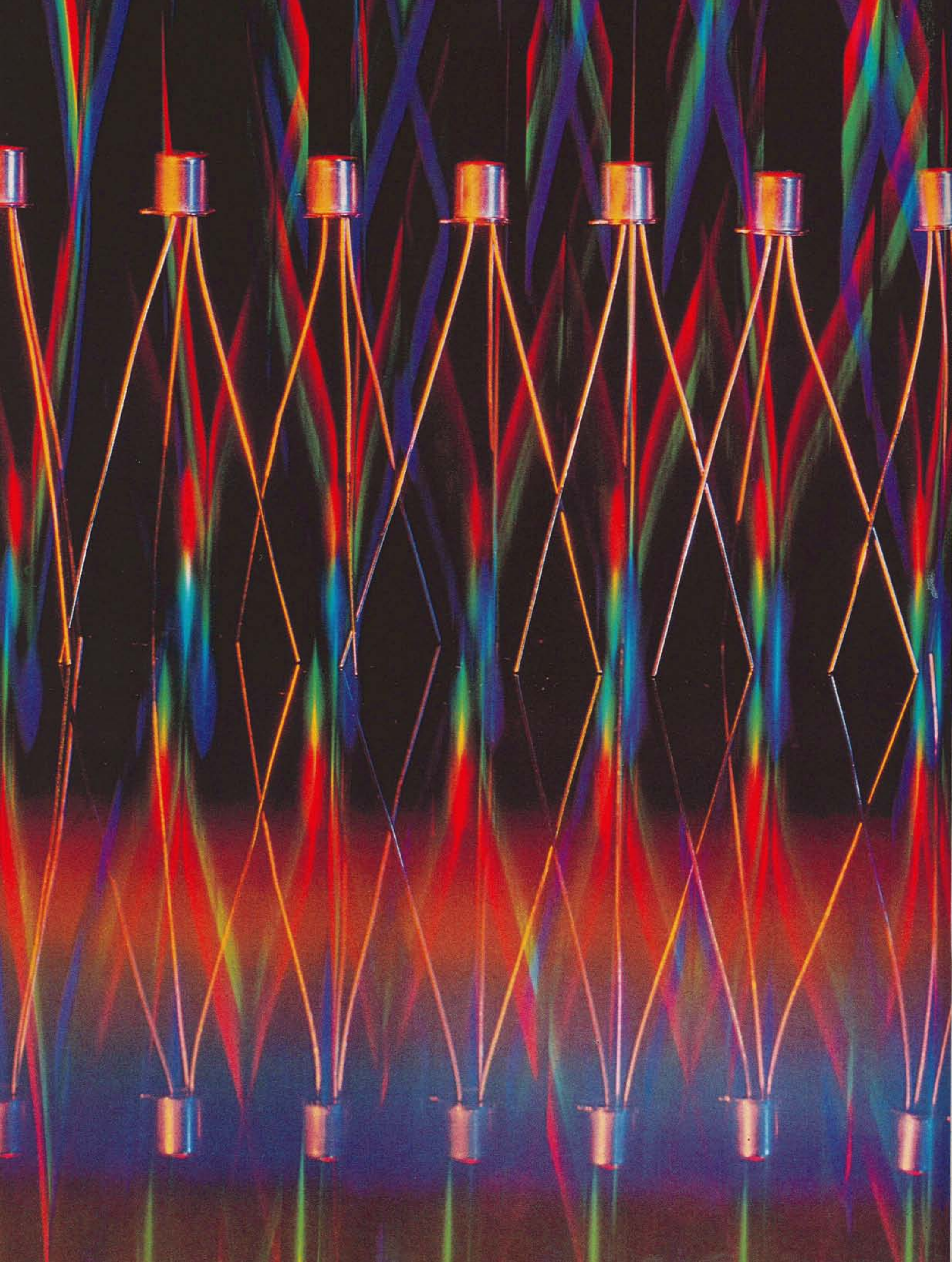
← When IBM introduced its 305 RAMAC (for random access) in 1956, data processing leapfrogged into the future. Magnetically coated aluminum disks (such as miniature replica at left) stored volumes of data on concentric tracks. In a fraction of a second, a read/write mechanism found the right magnetic spot and retrieved data from any point on the disk. The RAMAC's 50 spinning disks contained five million characters of information.

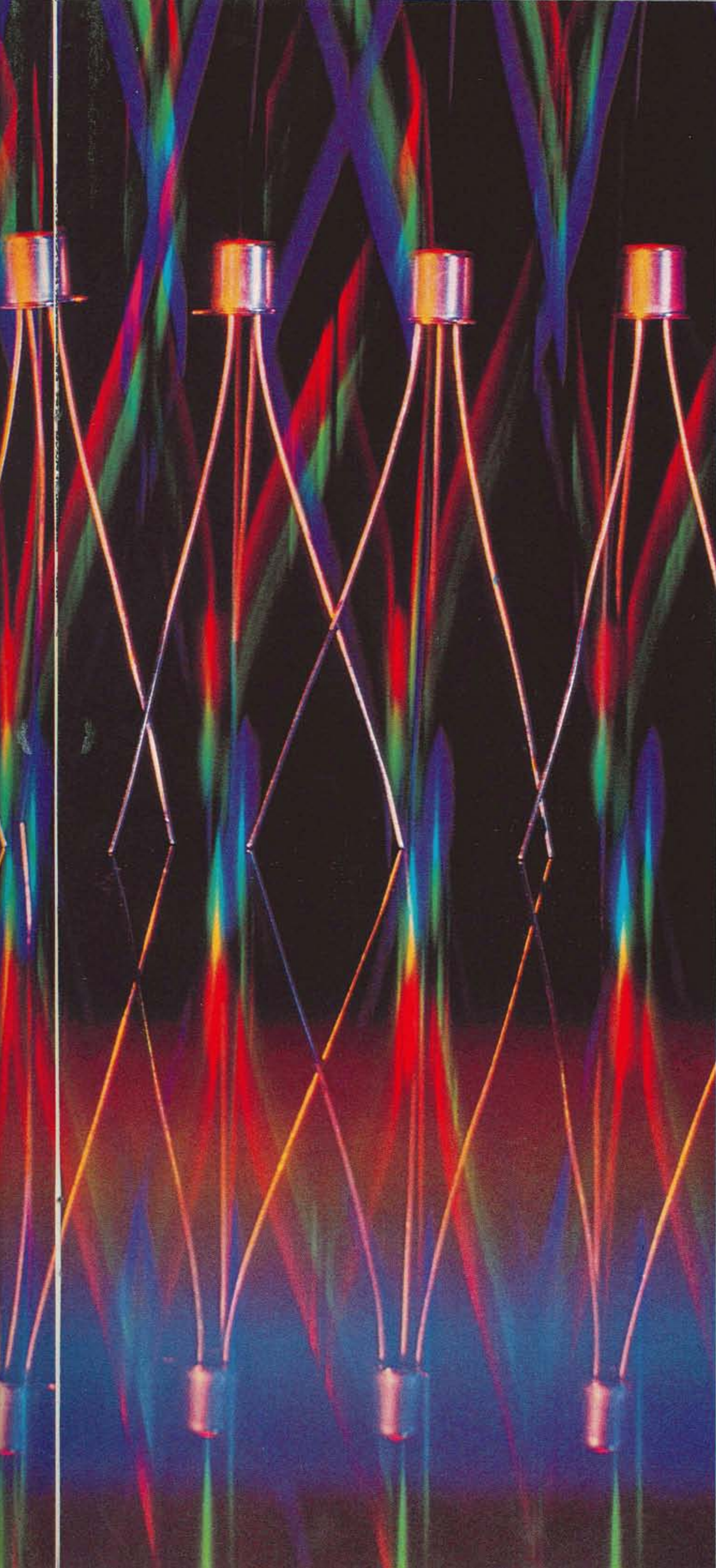


↑ Current-carrying wires that pass through iron oxide cores magnetize them clockwise or counterclockwise. Cores switched from one magnetic state to the other in millionths of a second. One magnetic direction represents a zero, the other, a one in the computer's binary code. Inventors outside IBM originally developed the donut-shaped cores for memory, and IBM perfected the method for making them. The company adapted pill-making machinery to produce them by the millions.

← Vacuum tubes and core memories were combined in the mammoth computer, SAGE, built by IBM under the direction of M.I.T. SAGE was used as part of the U. S. air defense. The 113-ton computer, containing 58,000 tubes, processed data transmitted from a radar network in real-time. That is, the data was processed as rapidly as it was received.

The IBM 650 was a widely used general-purpose computer for business, industry, and universities. When introduced, it processed data on punched cards. Later users could add magnetic tapes and disks. The 650 had a magnetic drum memory.

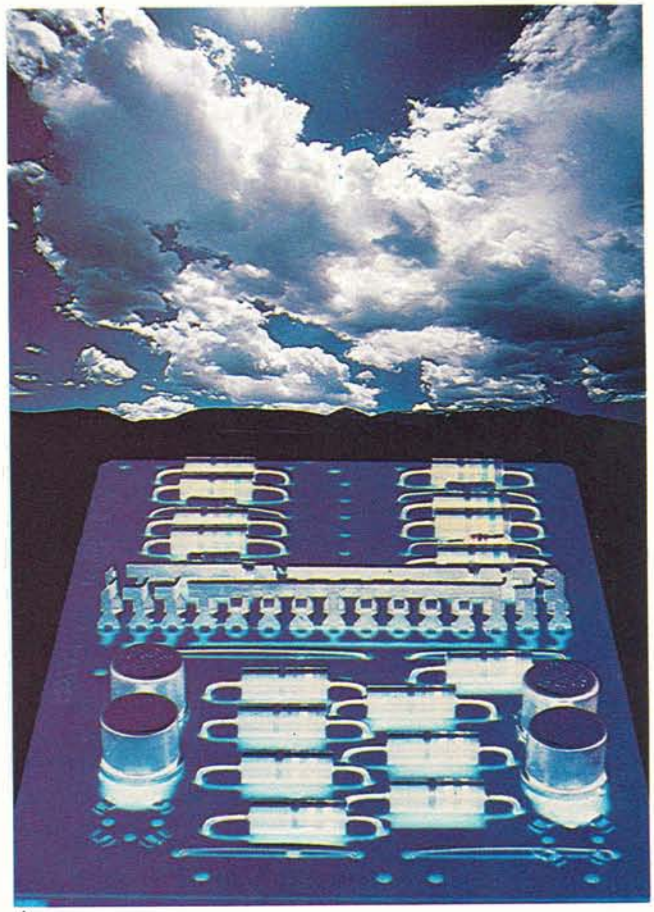




1959
Transistors
Smaller, faster, more reliable

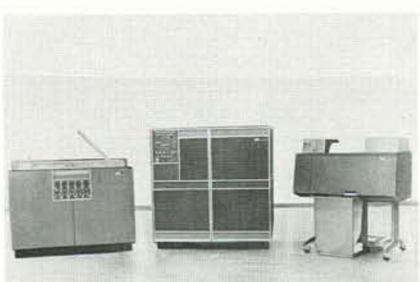
The transistor was invented at Bell Laboratories in 1947. But it's often a long road from invention to application. IBM and the semiconductor industry invested nearly a decade in research to perfect a mass production and testing process and to incorporate the solid-state technology—which the transistor represented—into the computer. The transistor was only 1/200 the size of the bulky vacuum tube. It was smaller, faster, and could be packaged tightly—an electrical impulse had less distance to travel. And because it was composed of a solid substance, it was far more rugged and reliable. In operation, it generated much less heat than a vacuum tube. In the late 1950s, more sophisticated computers arrived—ones that employed transistors for arithmetic, ferrite cores for memory, and magnetic disks or tapes for storage. Now the computer could multiply two 10-digit numbers in 1/100,000 of a second.

IBM built the industry's first fully automatic transistor production line at its Poughkeepsie plant in 1959. Holding to tolerances as close as 1/2000 of an inch, the line produced and tested 1,800 transistors per hour.

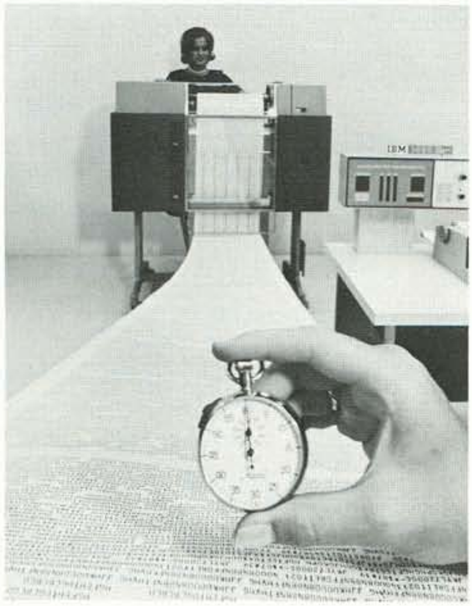


↑
Transistors and printed circuits were combined on cards like this. The cards were plugged into large frames, or gates, which swung out for maintenance.

→
STRETCH, built by IBM in 1960, was the most powerful computer of its day. Its 150,000 transistors could execute 100 billion instructions per day. It could cope with more than one instruction at a time and prepare itself for future work.



Introduced in 1959, IBM delivered more than 10,000 of these transistorized IBM 1401 computers, many to small and medium-sized users—making it by far the most popular computer up to that time.

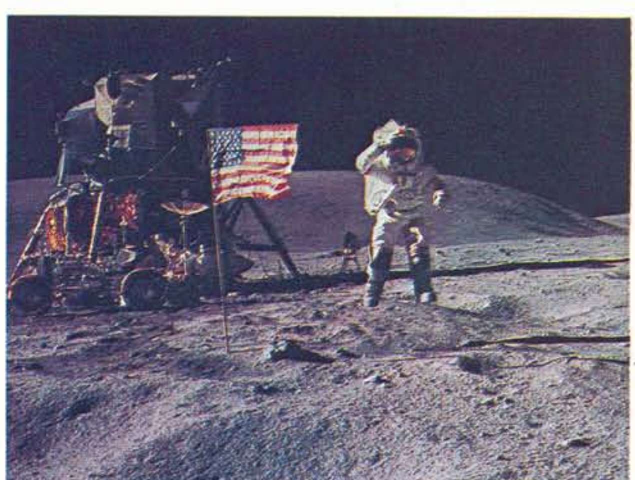


The disk pack. IBM introduced storage units with such removable disks in 1962. Each disk pack contained well over 2 million characters, and the user could switch packs with ease. At about the same time, one IBM tape reel could store 17 million characters of information. A tape unit could read and store the equivalent of 1,100 punched cards per second.

As computing speeds increased, so did printing speeds. The "chain" printer produced 600 lines per minute in 1959, a fourfold increase over the earlier most widely used IBM printing method.

In 1963, the "train" printer boosted printing speeds to 1,100 lines per minute. Rather than riding on a chain, typefaces now rode on a steel track.

SABRE, the airline reservation system, was the first large commercial computer network that operated on-line in real-time. That is, changes in schedules and reservations were recorded as they occurred. SABRE significantly reduced the time needed to make reservations. SABRE was developed by IBM for American Airlines after six years of joint research. It went into operation in 1962.



The Apollo moonshot was simulated many hundreds of times on an IBM System/360 Model 75 before actual flight. This solid-state electronic computer provided the speed necessary to prove trajectory calculations and to train the flight crew.

1964

System/360

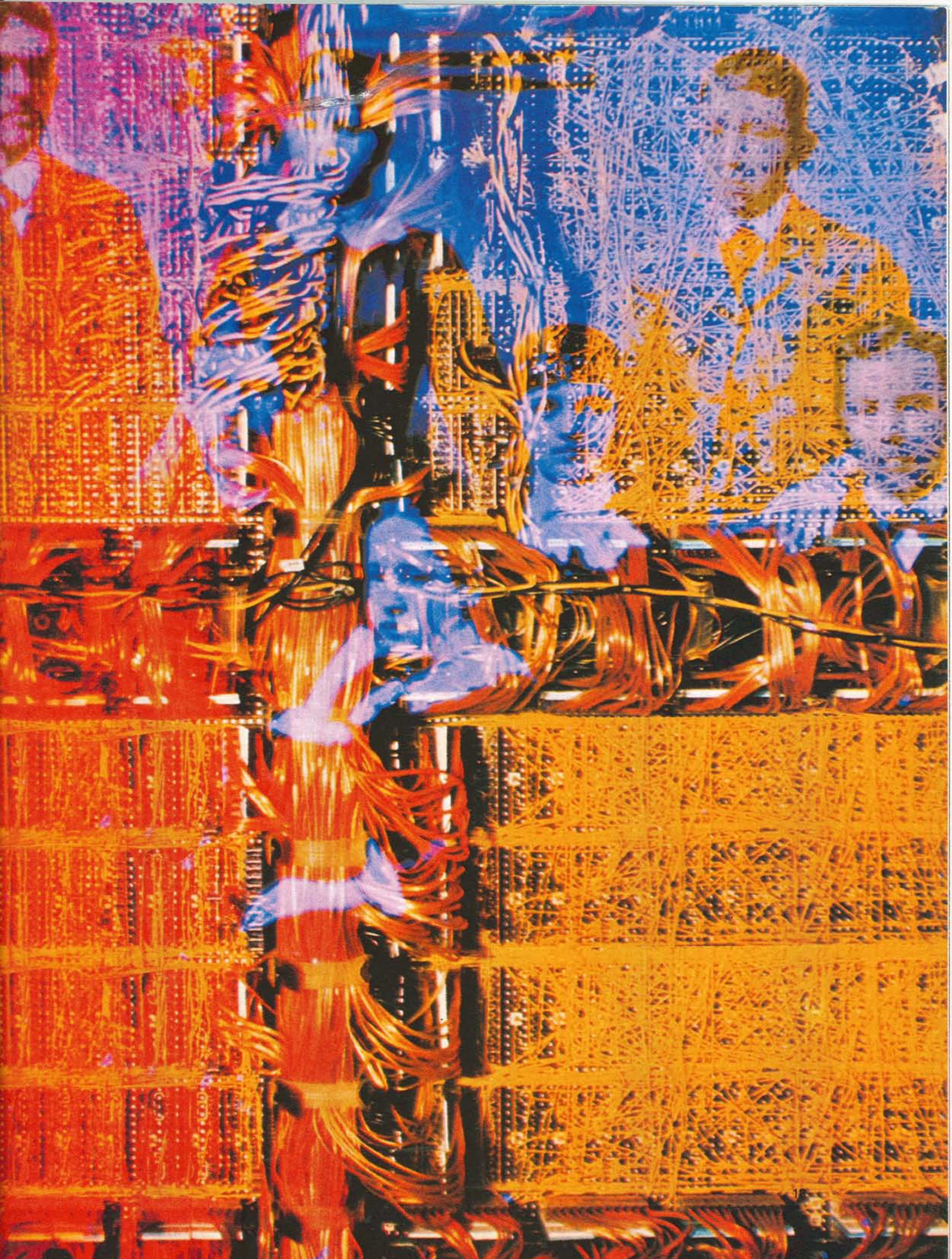
First 'family' of computers

The early transistorized computers advanced the state of computing technology. But they had one important drawback: They weren't compatible. Users often had difficulty switching from one type of computer to another without rewriting their programs. Peripheral devices designed for one computer often wouldn't work with another. What users really needed was a family of compatible computers in which peripherals and programs could be interchanged. Realizing this, IBM—at considerable risk—replaced its computer product line. In 1964, the company came out with System/360—the first family of compatible computers, ranging from small to large.

As first delivered to users, there were five central processing units. The smallest processor could perform 33,000 additions per second; the largest, 2,500,000 per second.

Variations among processors gave users 19 combina-

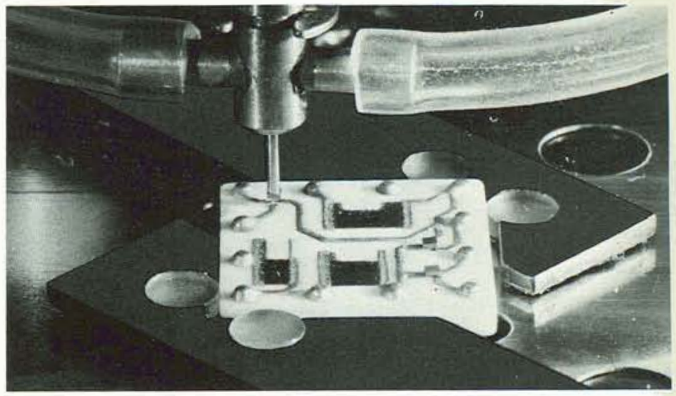
(Continued on page 14)



tions of graduated calculating speeds and memory capacity.

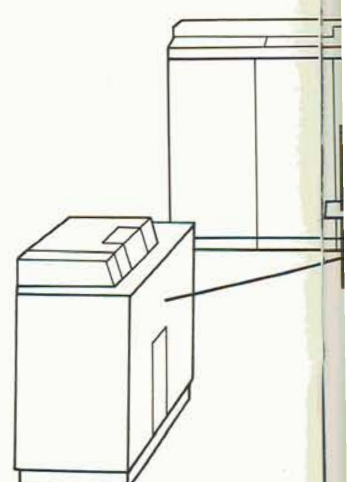
As users added applications, they could add or replace processors without rewriting programs. With certain limitations, instructions for one model ran on the others.

All five processors worked with most of the 44 attachments. Users could select the combination of disk or tape units, printers, communication devices, and other attachments that best served their needs.

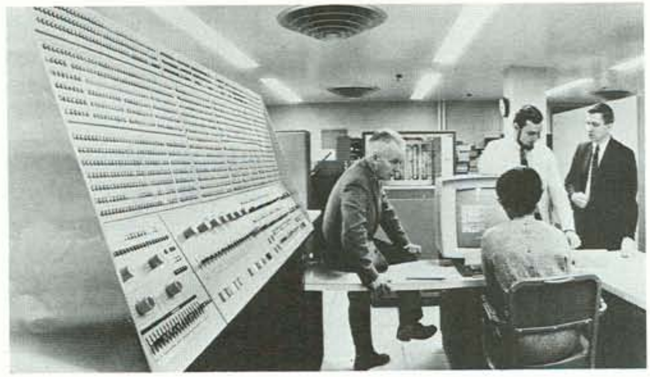


How the computer

A computer may be a single machine, but is often a configuration of machines designed and programmed to work together, as a system. When we think of a computer system, we should think of the conversion of data into electronic signals sent back and forth among the particular machines that compose the system. The machines are connected by cables and often linked with telephone lines to distant locations.



← With System/360 came Solid Logic Technology (SLT). IBM developed techniques for placing tiny circuits on half-inch ceramic modules. Some System/360 circuits could switch on and off in 6-billionths of a second. One problem: positioning transistors 28/1000-inch square on the module. Vacuum needles did the job. SLT was highly reliable. Statistically, an SLT module would run 33 million hours on average without failure.



← The Model 91 was IBM's most powerful computer when delivered in 1967. Its speed ranged up to 16 million additions a second.

works

Input

We can enter data directly into the computer with the keyboard of a typewriter terminal similar to those used by bank tellers and airline reservation clerks. Or we may enter data through a card reader that converts holes in punched cards into electrical impulses. Did you ever notice those oddly shaped numerals at the bottom of checks? They're printed in magnetic ink, and another kind of input device can sense those shapes and convert them into electronic signals.

Storage

Once we enter data, we need a place to store it so that it's readily available when we want to use it. The punched card itself is a permanent storage device. It holds information that can be used over and over again. But today we store most data magnetically on disk or tape. We can pack data quite densely in this manner—as many as several million "bits" of data per square inch.

Central Processing

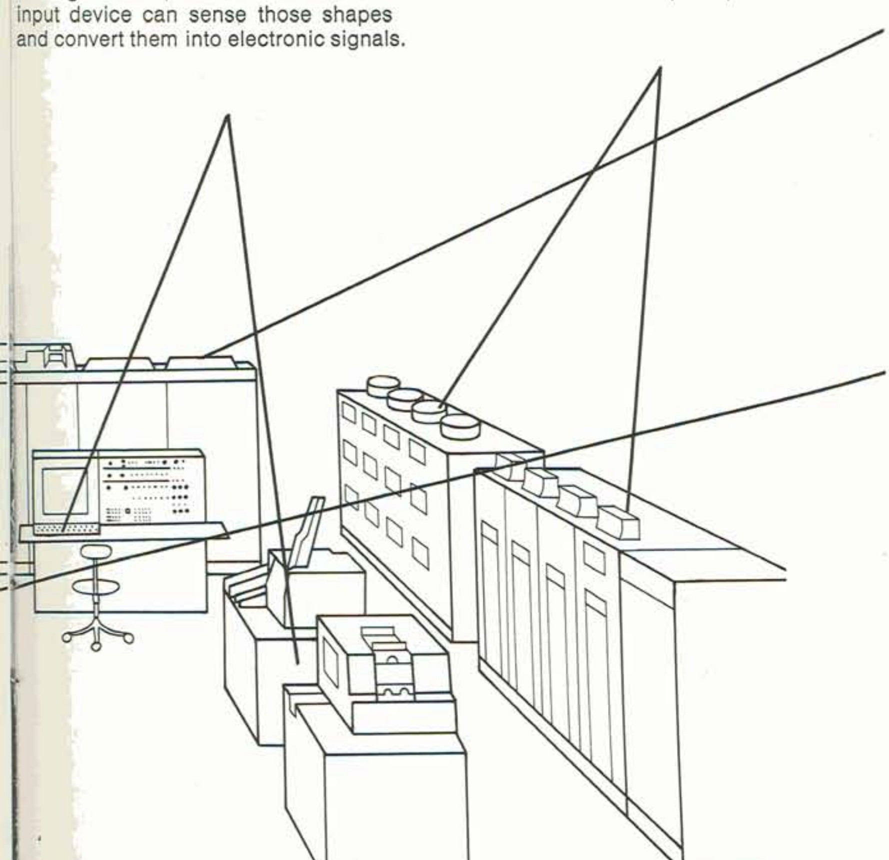
Suppose a stack of magnetic disks contains a complete company payroll. To make out the payroll checks, each in the proper amount with the proper deductions, we must transfer data from the disks to the central processing unit (CPU), which consists of memory and arithmetic/logic circuits.

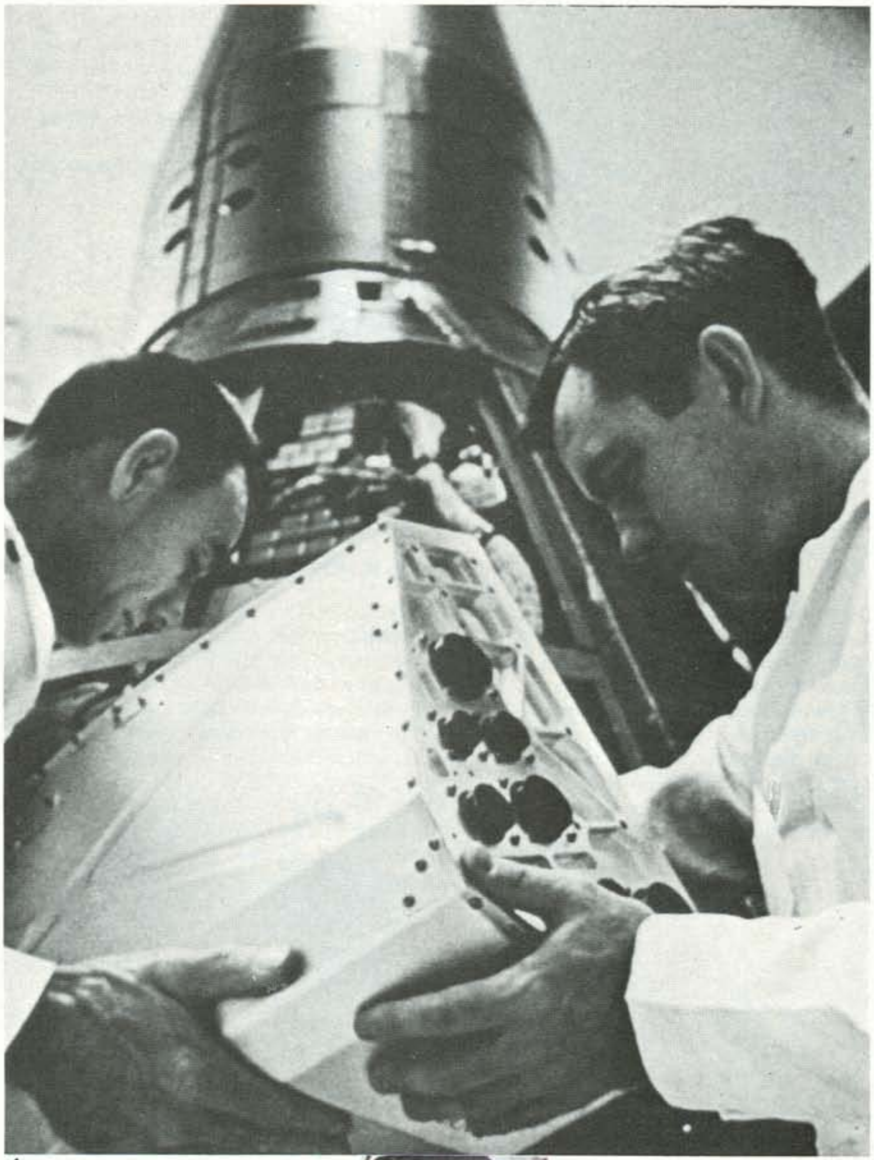
A device called a channel automatically moves payroll data and related application programs from disk storage to active memory. Once the data is in memory, the arithmetic/logic section takes over and performs the necessary steps in proper sequence to make out the paychecks. Once the payroll transactions are completed, the data is sent back from memory to disk storage. There is a constant transfer of data between memory and storage.

Output

High-speed printers—activated by electronic impulses— can print checks, invoices, tables, even report cards at up to 2,000 lines per minute on impact printers.

A student sitting at a remote terminal can "converse" with the computer; that is, query the computer and obtain a typewritten answer in seconds—provided, of course, the proper information and instructions were entered in the first place. We can also obtain output on screens similar to television sets.





↑
Small and rugged, this onboard 59-pound computer helped guide Gemini spaceflights through rendezvous, docking, and splashdown. For guidance and navigation, IBM developed another family of computers, called 4 Pi. In many applications, magnetic drums were used for storage because of durability, size, and quicker access time.

←
IBM programmers wrote programs that contained 1.5 million instructions for the ground-based computers that controlled the Apollo space flights.

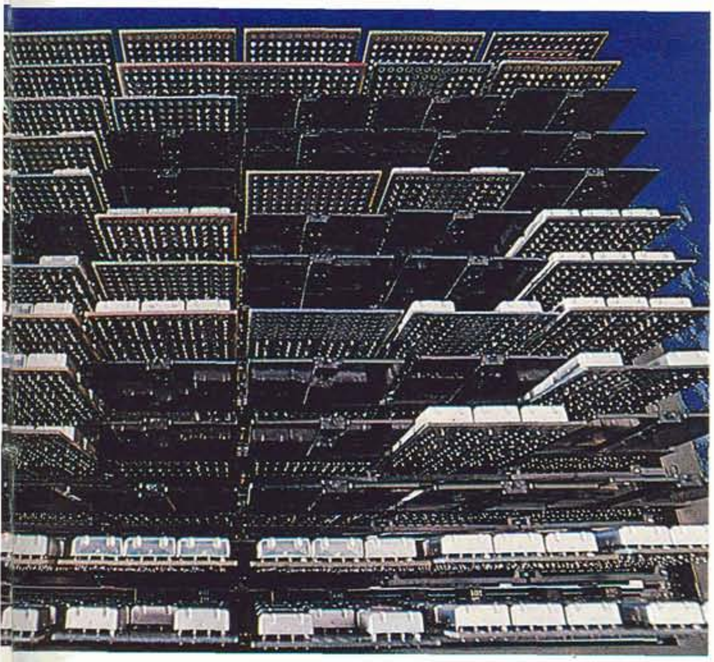
→
Solid Logic Technology simplified production and maintenance. Laminated cards holding half-inch modules were plugged into foot-long circuit boards. Boards, in turn, were mounted on "gates" on the computer framework.

The evolution of pro

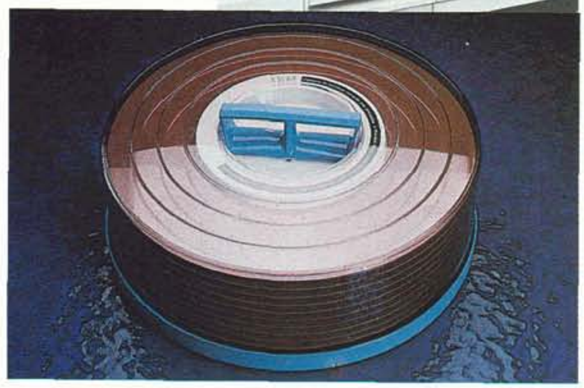
When a computer makes out a payroll or calculates the orbit of a satellite, it appears to have accomplished something remarkably complex. Actually, it has merely executed in sequence a large number of simple steps as directed by a set of instructions called a program, which is written by a person called a programmer. The computer has no mind of its own. It only does what the programmer tells it to do.

In the early days, we had to rearrange the wiring in the computer every time we wanted it to perform a different task. Subsequently, computers were designed so that operating instructions could be stored and manipulated within the computer itself.

Today's computer handles many operations concurrently. Consequently, it must be programmed so that it can calculate, transfer data, record input, and generate output—all at the same time. For that reason, control programs—which coordinate the work as it flows through the computer—grow in importance as computing speeds rise. They have been called the "glue" that holds the system together. When IBM introduced its System/360, the operating software was



→ Timely data became as important as capacity and speed. With the IBM 2314 disk storage system, any record on file could be updated in a fraction of a second.



gramming

every bit as critical as the Solid Logic Technology.

0111010111000100111101001110I

To understand programming, it helps to understand how computers count. When people process data, they use 10 digits and 26 letters. But when computers process data, they use only two digits—a zero and a one. Why only two? Mainly because an electrical impulse exists or does not exist. Either a switch is on or it's off.

Think of the computer's vacuum tubes or transistors in terms of light bulbs. If the light is on, that represents a one. If the light is off, that represents a zero. Thus, in one binary code, the capital letter *J* is represented by a string of eight light bulbs in the following order: 11010001. All numbers, letters, and symbols in common usage can be represented in this way.

These zeroes and ones constitute machine language. During the early 1950s, programmers had to communicate with the computer in machine language—that is, in terms of zeroes and ones. Thus, if they wanted the computer to calculate how far a train would travel at 60 miles per hour in 3 hours, the instructions might look like this:

```
1001 0000 1110 1100 1101 0000 0000 1100
0000 0101 1100 0000
0101 0000 1101 0000 1100 0000 0101 0110
0100 0001 1111 0000 1100 0000 0101 0010
0101 0000 1111 1101 0000 0000 0000 1000
0001 1000 1101 1111
0100 0101 0001 0000 1100 0000 0001 0110
1000 1111
0000 0000 0000 0001 0000 0000
0000 1010 0001 0011
0101 1000 0010 0000 1100 0000 1001 1010
0101 1000                1100           1110
```

By the mid-1950s, symbolic coding reduced the programmer's task to more workable dimensions. For example, with Speedcoding, a complex set of instructions might look like this:

```
0100  RFTPJ  0200  0201  ----  ----  ----
0101  MPY    0200  0201  0202  ----  ----
0102  PRINT  0202  0202  0999  TRMN  0104
0103  NOOP   0000  0000  0000  STOP  0100
0104  NOOP   0000  0000  0000  STCH    0
```

Gradually, programmers devised languages that more closely resembled English statements. A translation program, simultaneously fed into the computer, called a compiler, converted the statement written in a programming language into machine language.

FORTRAN (an acronym for Formula Translation) was one of the first high-level programming languages. Developed largely by IBM, it was based on algebra plus a few rules of grammar.

```
  RATE=60
  TIME=3
  DISTNC=RATE*TIME
  PRINT 1, DISTNC
1 FORMAT(12 DISTANCE = ,F5.0)
```

FORTRAN was developed mainly to solve scientific problems. Subsequently, a group of languages for business applications—COBOL, RPG, BASIC, and others—appeared. Another significant advance occurred with the development of APL (A Programming Language), which can be learned in a few days.

```
RATE←60
TIME←3
' DISTANCE = ' ; TIME x RATE
```

Today researchers are busy trying to perfect techniques that will allow laymen to instruct the computer in their own words.

1970

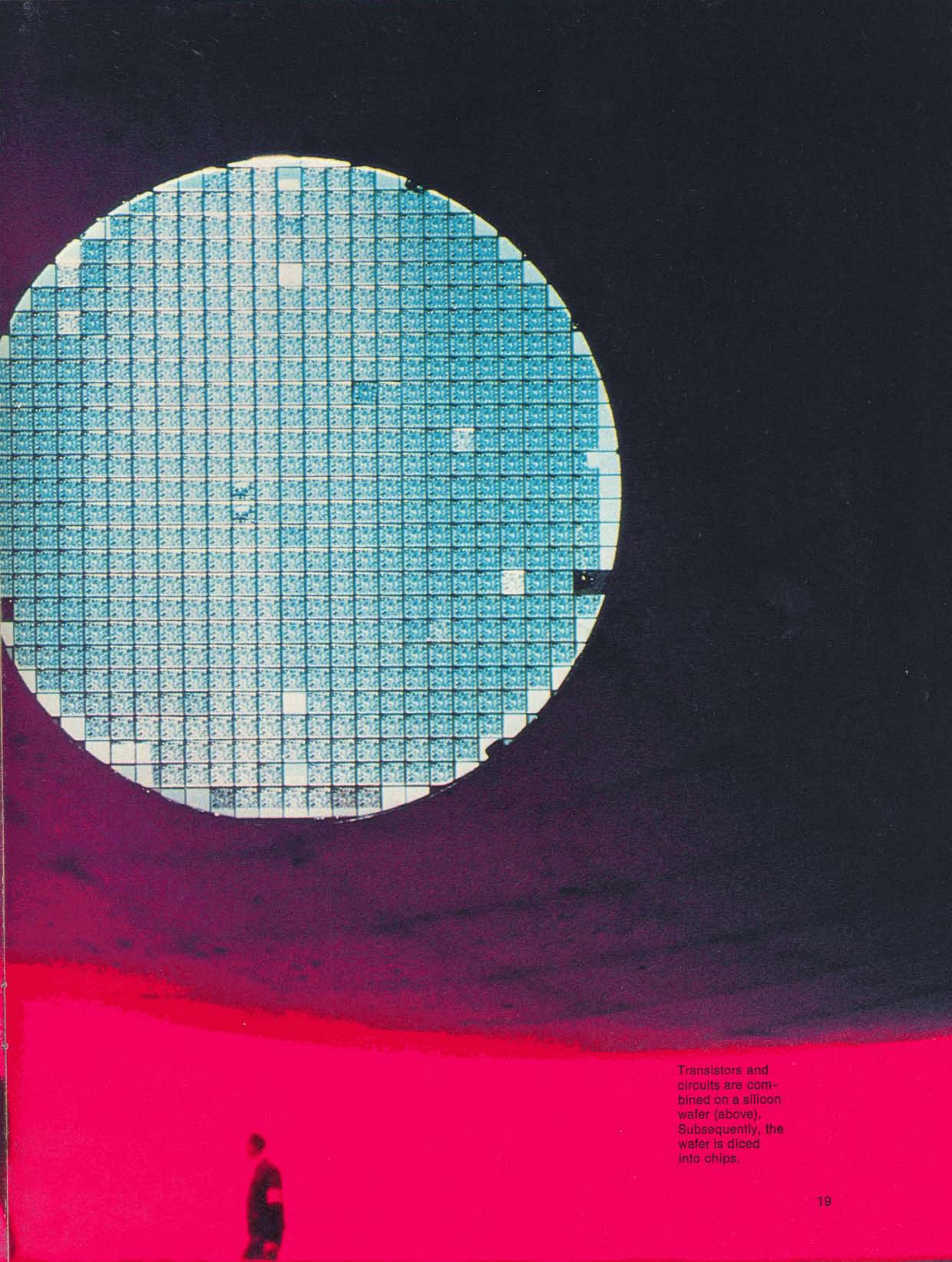
System/370

Technology makes the difference

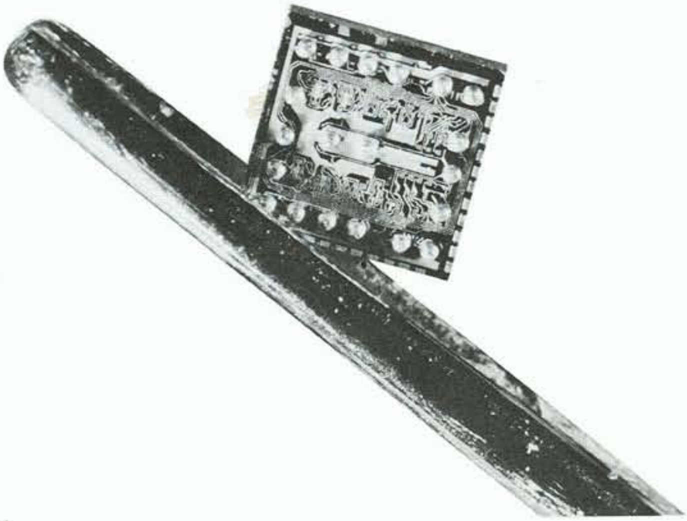
From System/360 to System/370—that denotes not only a long technological step, but also a logical one. Like its predecessor, System/370 embraces a family of compatible computers. But the technology that makes it tick is more advanced. The most obvious difference lies in memory. In System/360, the central processing unit consists of magnetic cores for memory and Solid Logic Technology for calculating. In most System/370 models, both memory and arithmetic/logic consist of integrated circuits. But that long step forward doesn't depend upon transistors alone. It rests also upon what the industry calls 'monolithics' and Large Scale Integration—that is, the compression of transistors and circuits onto minute silicon chips. This is the new world of micro-miniaturization. With monolithic circuits come other advances in storage and terminals. Most System/370 models, for example, have 'Virtual Storage' capability that magnifies the capacity of main memory many times, and enables users to work economically with millions of characters of information.

Before Virtual Storage, a user had to plan carefully the placement and movement of programs and data between main memory and auxiliary storage. With Virtual Storage, as parts of programs stored in auxiliary storage are needed for processing, they are quickly and automatically interchanged with information in main memory.

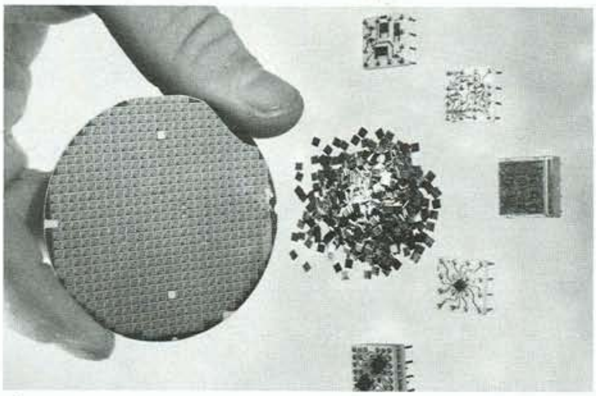
From System/360 to System/370—not only a long technological stride, but also another large gain in productivity at lower cost.



Transistors and circuits are combined on a silicon wafer (above). Subsequently, the wafer is diced into chips.

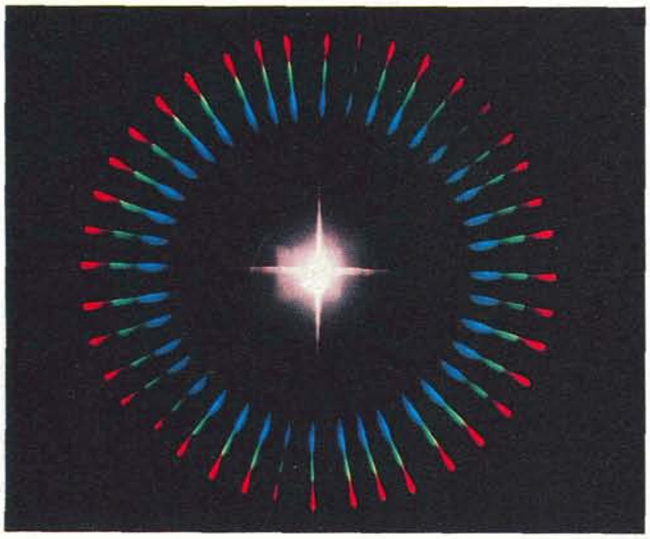


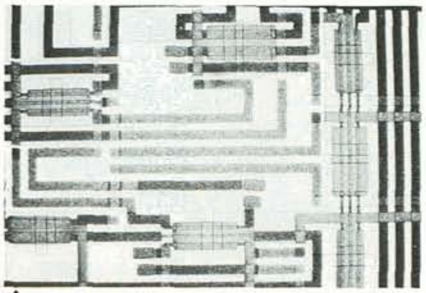
↑
In the eye of a needle, a chip magnified approximately 500 times, contains 25 circuits for performing arithmetic. With monolithic technology, System/370 computers can make millions of calculations a second.
In 1972, System/370 main memory used tiny silicon chips mounted on $\frac{1}{2}$-inch modules, each pair of modules containing more than 4,000 bits of data—the same as 4,000 cores. This monolithic memory was more reliable and four times faster than the core memory it replaced.



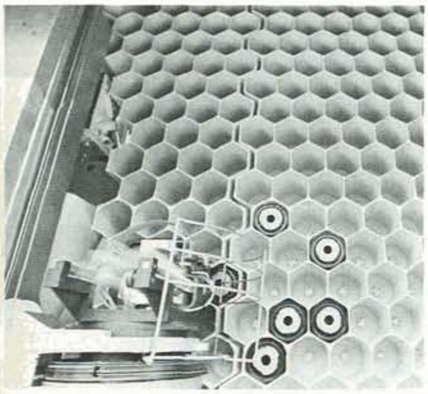
↑
Just as IBM developed advanced manufacturing methods for magnetic core memories and early transistor computers, so it also was one of the pioneers in developing production methods for monolithic circuitry. The technique begins by slicing a $2\frac{1}{4}$-inch diameter wafer from a silicon ingot. Then thousands of tiny electronic devices are formed on the wafer by repeating various photographic, etching, and chemical processes. Next, the wafer is diced into chips measured in fractions of inches. Finally, chips are mounted on single- or double-stacked ceramic modules and encapsulated in a protective aluminum cover for placement in logic/arithmetic or memory.
Today, the engineer designs the circuitry with the aid of a computerized cathode ray tube display. The computer checks the engineer's design and drives the photographic system.

←
The virtue of monolithic circuitry is clearly evident in the IBM 5100, introduced in 1975. It weighs only 50 pounds. Portable, it can be plugged into a wall socket.



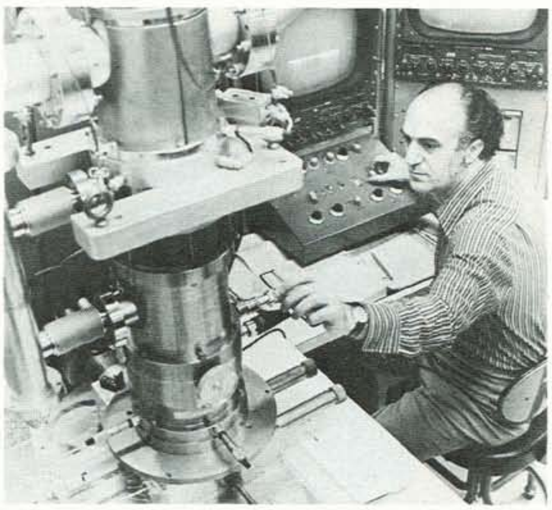


↑
How fast is fast? IBM scientists have fabricated an experimental electronic device that can be switched on and off in 10 trillionths of a second . . . far faster than current computer devices. The switch is called a Josephson tunneling junction.



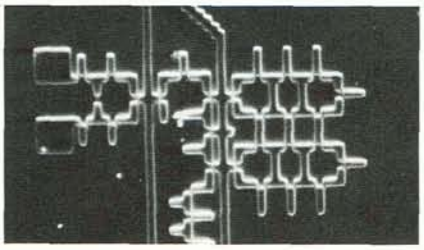
←
The IBM 3850 Mass Storage System—a beehive of electronic activity. It contains up to 472 billion characters of information. Cartridges in each honeycomb cell contain magnetic tape. On signal, data on tape is transferred to disks, then to computer memory. Introduced in 1975, the 3850 gives quick and inexpensive access to vast files of data.

↑
The laser, a unique source of pure and coherent light, and electrophotographic printing are combined in the IBM 3800 Printing Subsystem, six times faster than the company's fastest system to date. The printer can print 13,000 lines of computer output per minute.



↑
How small is small? Current fabrication methods rely on ultraviolet light to draw the circuit lines. With the process, one can print the entire Bible—all 1,250 pages of the Old and New Testaments—on a wafer $1\frac{1}{2}$ inches square. IBM scientists are now utilizing a technique to replace light with electron beams—an even finer instrument for drawing circuit lines.

←
System/370 Model 145—the first computer with monolithic technology for a full-sized main memory. Up to 262 memory cards held 262,000 characters of data. Like other System/370 models, it can act upon programs written for earlier System/360s. Late System/370 models possess virtual storage. Composed of innovations in hardware and software, virtual storage enables a programmer to feel he has the entire machine at his disposal.



How dense is dense? When magnetic disks were first introduced, it was possible to pack 1,000 bits of data per square inch. Today the number is several million. But another technology called magnetic bubbles—still in the research stage—may increase density even further. Bubbles are tiny magnetic regions found in certain thin magnetic materials.

Computers help get things done

In the years ahead, we can expect computer usage to grow apace. Processors and data storage devices will have instant access to a vast storehouse of information and computing power via remote terminals linked to data centers via telephone lines or radio waves. This is the new growing world of data networks and data communications—of computing on-line and in real-time. Indeed, significant examples are already evident.

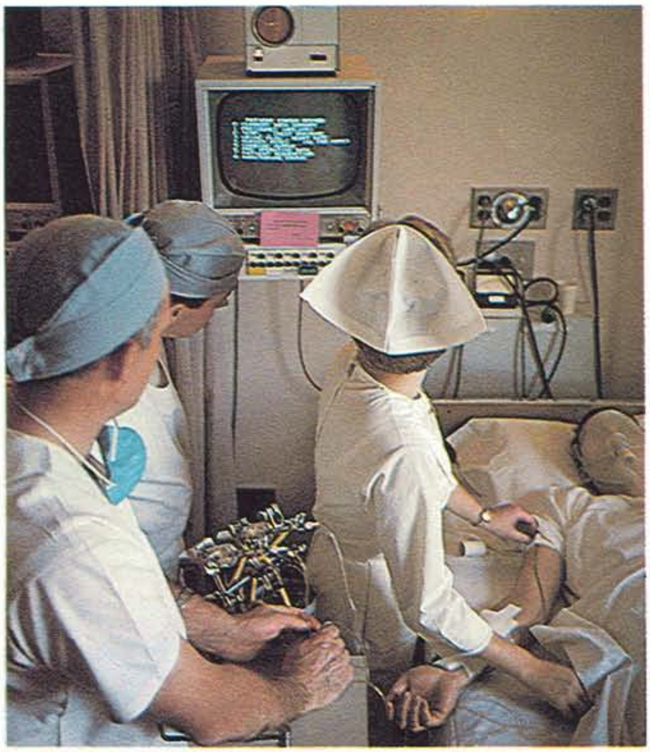
A warehouse contains millions of items. But inventory information is kept up-to-the-minute with terminals and computer files that record what has been shipped in and out.

Time-sharing allows many terminal users to share the same data in the same computer system. Scientists and students can gain access to the computer from their own terminals as if each were the only user at a given time.

The investment advisor checks the current status of customer portfolios against market quotations. With updated data, he can make prudent and timely investment decisions.

→
Hospital administrators and doctors can now obtain patient information and process records with ease.

←
Running a chemical processing plant calls for instant information, fine control. An IBM System/7 responds to stimuli—heat, light, humidity, weight. Thus, a plant engineer can monitor the entire ongoing operation from a remote site.



↑
Special banking terminals enable banks to clear checks, update customer accounts, even transfer funds electronically.

Faster, Smaller, Cheaper

The chart shows how data processing costs and time have declined during the past two decades. It represents a mix of about 1,700 computer operations, including payroll, discount computation, file maintenance, table lookup, and report preparation. Figures show costs of the period, not adjusted for inflation.

	1955	1960	1965	Today
Cost	$14.54	$2.48	$.47	$.20
Processing time	375 sec.	47 sec.	37 sec.	5 sec.
Technology	Vacuum tubes Magnetic cores Magnetic tapes	Transistors Channels Faster cores Faster tapes	Solid Logic Technology Large, fast disk files New channels Larger, faster core memory Faster tapes	Monolithic memory Monolithic logic Virtual storage Larger, faster disk files New channels Advanced tapes
Programming	Stored program	Overlapped input/output Batch processing	Operating system Faster batch processing	Virtual storage Advanced operating systems Multiprogramming Batch/on-line processing

Today. Tomorrow

A desk-size computer today can often produce the same amount of work as a computer that once occupied an entire room. The secret lies largely in the integrated circuits. We can pack thousands of microscopic circuits on a silicon memory chip smaller than a tiny pencil eraser.

As circuits become smaller, their ability to process information grows. With smaller circuits, calculating speeds also rise. And as density and speed increase, computing costs go down. The result: many times faster processing at a fraction of the cost.

The same technology that drives down costs also improves reliability. Statistically speaking, some computer components today can run continuously for millions of hours without failure.

Meanwhile, progress in programming languages is making the computer easier to use. Someday people may be able to tell the computer in their own words what they want it to do.

What's ahead? Many more users at terminals linked to computers. Electronic machines being used in many more ways to help people work better together in an ever more complex world.

Produced by the editors and staff of *Think*, the IBM employee magazine, in collaboration with Will Hopkins as art director. Special-effects photography by Mitchell Funk. Text by Richard Bode. Cover design by Herb Lubalin.

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