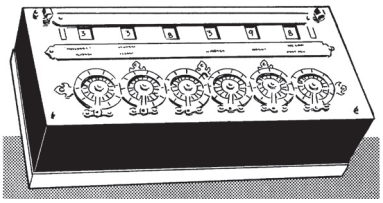
The Generations of Computers

The development of computers started with mechanical and electromechanical devices (17th through 19th century) and has progressed through four generations of computers.

Mechanical Devices

Blaise Pascal
1623 – 1662

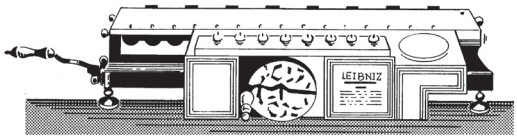
One of the earliest mechanical calculating devices was the Pascaline, invented in 1642 by the French philosopher and mathematician Blaise Pascal. The Pascaline was a complicated set of gears that operated similarly to a clock. It was designed to only perform addition. Unfortunately, due to manufacturing problems, Pascal never got the device to work properly.



The Pascaline was a mechanical calculating device invented by Blaise Pascal in 1642

Gottfried Wilhelm von Leibniz
1646 – 1716

Later in the 17th century Gottfried Wilhelm von Leibniz, a famous mathematician, invented a device that was supposed to be able to add and subtract, as well as multiply, divide, and calculate square roots. His device, the Stepped Reckoner, included a cylindrical wheel called the Leibniz wheel and a moveable carriage that was used to enter the number of digits in the multiplicand. However, because of mechanically unreliable parts, the device tended to jam and malfunction.



The Stepped Reckoner was another early attempt at creating a mechanical calculating device

Charles Babbage
1792 – 1871

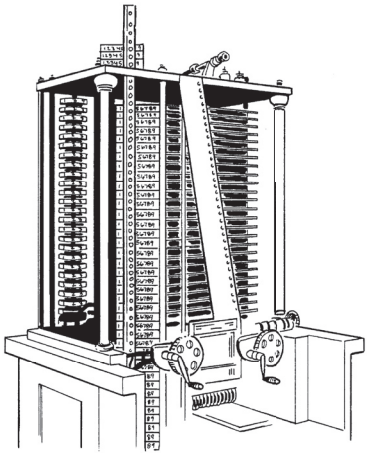
In 1822 Charles Babbage began work on the Difference Engine, which was intended to calculate numbers to the 20th place and then print them at 44 digits per minute. The original purpose of this machine was to produce tables of numbers that would be used by ships' navigators. At the time, navigation tables were often highly inaccurate due to calculation errors and a number of ships were known to have been lost at sea because of these errors. Although never built, the ideas for the Difference Engine led to the design of Babbage's Analytical Engine.

The Analytical Engine, designed around 1833, was supposed to perform a variety of calculations by following a set of instructions, or program, stored on punched cards. During processing, the Analytical Engine was planned to store information in a memory unit that would allow it to make decisions and then carry out instructions based on

The History of Punched Cards

Punched cards originally provided instructions for weaving looms. In 1810 Joseph Jacquard, a French weaver, placed punched cards in his looms so that as the cards passed through the loom in sequence, needles passed through the holes and picked up threads of the correct color or texture.

those decisions. For example, when comparing two numbers, it could be programmed to determine which was larger and then follow an appropriate set of instructions. The Analytical Engine was also never built, but its design served as a model for the modern computer.



Babbage's Analytical Engine was designed as a calculating machine that used punched cards to store information

Ada Byron
1815 – 1852

Babbage's chief collaborator on the Analytical Engine was Ada Byron, Countess of Lovelace, the daughter of Lord Byron. Interested in mathematics, Lady Byron was a sponsor of the Analytical Engine and one of the first people to realize its power and significance. She also wrote of its achievements in order to gain support for it. Ada Byron is often called the first programmer because she wrote a program based on the design of the Analytical Engine.

Babbage had hoped that the Analytical Engine would be able to think. Ada Byron, however, said that the Engine could never "originate anything," meaning that she did not believe that a machine, no matter how powerful, could think. To this day her statement about computing machines remains true.

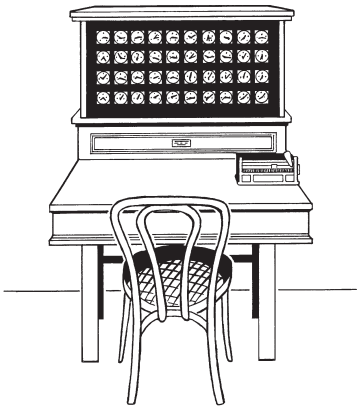
Herman Hollerith
1860 – 1929

Based on the success of his tabulating machine, Herman Hollerith started the Tabulating Machine Company in 1896. In 1924, the company was taken over by International Business Machines (IBM).

Electro-Mechanical Devices

By the end of the 19th century, U.S. Census officials were concerned about the time it took to tabulate the continuously increasing number of Americans. This counting was done every 10 years, as required by the Constitution. However, the Census of 1880 took nine years to compile which made the figures out of date by the time they were published.

In response to a contest sponsored by the U.S. Census Bureau, Herman Hollerith invented a tabulating machine that used electricity rather than mechanical gears. Holes representing information to be tabulated were punched in cards, with the location of each hole representing a specific piece of information (male, female, age, etc.). The cards were then inserted into the machine and metal pins used to open and close electrical circuits. If a circuit was closed, a counter was increased by one.

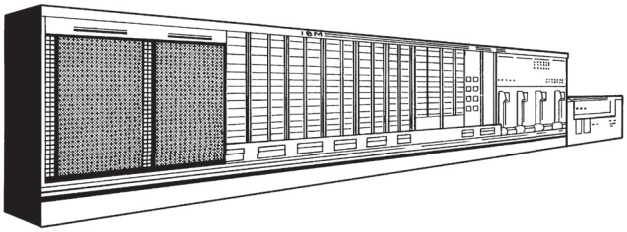


Herman Hollerith's tabulating machine, invented for the Census of 1890, used electricity instead of gears to perform calculations

Hollerith's machine was immensely successful. The general count of the population, then 63 million, took only six weeks to compile. Although the full statistical analysis took seven years, it was still an improvement over the nine years it took to compile the previous census.

Howard Aiken
1900 – 1973

In 1944, the Mark I was completed by a team from International Business Machines (IBM) and Harvard University under the leadership of Howard Aiken. The Mark I used mechanical telephone relay switches to store information and accepted data on punched cards. Because it could not make decisions about the data it processed, the Mark I was not a computer but instead a highly sophisticated calculator. Nevertheless, it was impressive in size, measuring over 51 feet in length and weighing 5 tons. It also had over 750,000 parts, many of them moving mechanical parts which made the Mark I not only huge but unreliable.

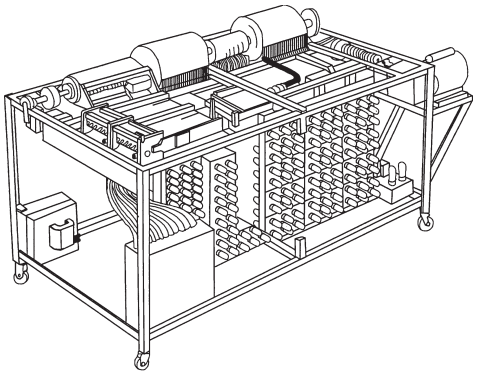


The Mark 1 was over 51 feet long and weighed over 5 tons The First Generation of Computers

John Atanasoff
1903 – 1995

The first electronic computer was built between 1939 and 1942 at Iowa State University by John Atanasoff, a math and physics professor, and Clifford Berry, a graduate student. The Atanasoff-Berry Computer (ABC) used the binary number system of 1s and 0s that is still used in computers today. It contained hundreds of vacuum tubes and stored numbers for calculations by electronically burning holes in sheets of paper. The output of calculations was displayed on an odometer type of device.

Clifford Berry
1918 – 1963



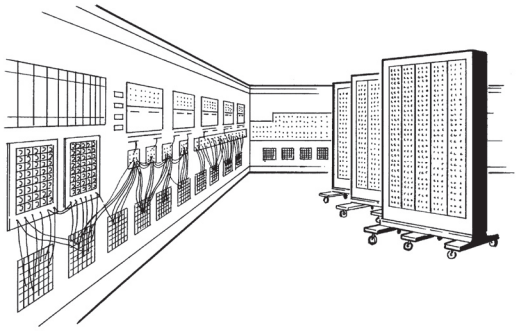
The Atanasoff-Berry Computer used the binary number system used in computers today

The patent application for the ABC was not handled properly, and it was not until almost 50 years later that Atanasoff received full credit for his invention. In 1990, he was awarded the Presidential Medal of Technology for his pioneering work. A working replica of the ABC was unveiled at the Smithsonian in Washington, D.C. on October 9, 1997.

John Mauchly
1907 – 1980

In June 1943, John Mauchly and J. Presper Eckert began work on the ENIAC (Electronic Numerical Integration and Calculator). It was originally a secret military project which began during World War II to calculate the trajectory of artillery shells. Built at the University of Pennsylvania, it was not finished until 1946, after the war had ended. But the great effort put into the ENIAC was not wasted. In one of its first demonstrations, ENIAC was given a problem that would have taken a team of mathematicians three days to solve. It solved the problem in twenty seconds.

J. Presper Eckert
1919 – 1995



The ENIAC was originally a secret military project

The ENIAC weighed 30 tons and occupied 1500 square feet, the same area taken up by the average three bedroom house. It contained over 17,000 vacuum tubes, which consumed huge amounts of electricity and produced a tremendous amount of heat requiring special fans to cool the room.

The ABC and the ENIAC are first generation computers because they mark the beginning of the computer era. A computer is an electronic machine that accepts data, processes it according to instructions, and provides the results as new data. A computer can also make simple decisions and comparisons.

Colossus

Built two years before the ENIAC, the Colossus was a special-purpose computer designed by Tommy Flowers, an engineer at the Post Office Research Station in England. The Colossus was designed to break codes during World War II. Its effectiveness played a major role in ending the war.

The Stored Program Computer

The ABC and ENIAC required wire pulling, replugging, and switch flipping to change their instructions. A breakthrough in the architectural design of first generation computers came as a result of separate publications by Alan Turing and John von Neumann, both mathematicians with the idea of the stored program.

Alan Turing
1912 – 1954

In the late 30s and 40s, Alan Turing developed the idea of a "universal machine." He envisioned a computer that could perform many different tasks by simply changing a program rather than by changing electronic components. A program is a sequence of instructions written in a code that the computer understands.

John von Neumann
1903 – 1957

In 1945, John von Neumann presented his idea of the stored program concept. The stored program computer would store computer instructions in a CPU (Central Processing Unit). The CPU consisted of different elements used to control all the functions of the computer electronically so that it would not be necessary to flip switches or pull wires to change instructions.

Together with Mauchly and Eckert, von Neumann designed and built the EDVAC (Electronic Discrete Variable Automatic Computer) and the EDSAC (Electronic Delay Storage Automatic Computer). These computers were designed to solve many different problems by simply entering new instructions that were stored on paper tape. The instructions were in machine language, which consists of 0s and 1s to represent the status of a switch (0 for off and 1 for on).

Francis "Betty" Holberton
1917 – 2001

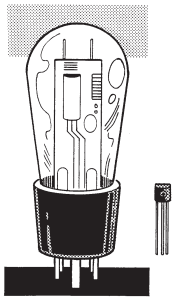
The third computer to employ the stored program concept was the UNIVAC (UNIVersal Automatic Computer) built by Mauchly and Eckert. With the UNIVAC came the first computer language called C-10, which was developed by Betty Holberton. Holberton also designed the first computer keyboard and numeric keypad in an effort to make the computer more user-friendly. The first UNIVAC was sold to the U.S. Census Bureau in 1951.

These first generation computers continued to use many vacuum tubes which made them large and expensive. They were so expensive to purchase and run that only the largest corporations and the U.S. government could afford them. Their ability to perform up to 1,000 calculations per second, however, made them popular.

Second Generation Computers

John Bardeen, William Shockley, and Walter Brittain

In 1947, William Shockley, John Bardeen, and Walter Brittain of Bell Laboratories invented the transistor. A transistor is a semiconductor device that could replace a vacuum tube. Transistors were much smaller than vacuum tubes, less expensive, and allowed computer to process up to 10,000 calculations per second:



Transistors made computers smaller, less expensive, and more reliable than those with vacuum tubes

In the early 1960s, IBM introduced the first medium-sized computer named the Model 650. It was expensive, but much smaller than first generation computers and still capable of handling the flood of paperwork produced by many government agencies and businesses. Such organizations provided a ready market for the 650, making it popular in spite of its cost.

Second generation computers also saw a change in the way data was stored. Punched cards were replaced by magnetic tape and high speed reel-to-reel tape machines. Using magnetic tape gave computers the ability to read (access) and write (store) data quickly and reliably.

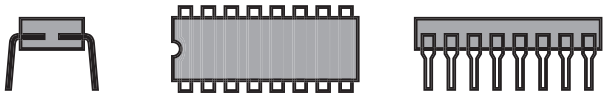
Robert Noyce
1927 – 1990

Noyce developed the integrated circuit while working at Fairchild Semiconductor. In 1968, he formed the company that is now Intel Corporation.

Third Generation Computers

The use of integrated circuits (ICs) began the third generation of computers. In 1961, Jack Kilby and Robert Noyce, working independently, developed the IC, also called a chip. Hundreds of transistors, as well as other electronic components and wiring could be housed within a single IC, which allowed computers to process information at a rate of millions of calculations per second.

ICs are created from silicon wafers which are then etched with intricate circuits and then coated with a metallic oxide to allow the circuits to conduct electricity. The silicon wafers are housed in special plastic cases that have metal pins. The pins allow the ICs to be plugged into circuit boards that have wiring printed on them.



A typical chip is about 1 cm wide by 2.5 cm long

In 1964, the IBM System 360 was one of the first computers to use integrated circuits and was so popular with businesses that IBM had difficulty keeping up with the demand. Computers had come down in size and price to such a point that smaller organizations such as universities and hospitals could now afford them.

Jack S. Kilby
1923 – 2005

Working for Texas Instruments, Kilby developed the first integrated circuit. He used this new technology to create the first electronic handheld calculator.

Marcian Hoff
1937 –

Stephen Wozniak
1950 –

Steve Jobs
1955 –

Fourth Generation of Computers

In 1970, Marcian Hoff, an engineer at Intel Corporation, invented the microprocessor, an entire CPU on a single chip. The replacement of several larger components by one microprocessor made possible the fourth generation of computers.

The small microprocessor made it possible to build a computer called a microcomputer, which was small enough to fit on a desktop. The first of these was the Altair built in 1975. In 1976, Stephen Wozniak and Steven Jobs designed and built the first Apple computer. The Apple Macintosh set new standards for ease of computer use with its graphical user interface. In 1981, IBM introduced the IBM–PC. The computer was an instant success because of the availability of spreadsheet, accounting, and word processor software. Desktop computers are referred to as either PCs or Macs.

Advances in technology made personal computers inexpensive and therefore available to many people. Because of these advances almost anyone could own a machine that had more computing power and was faster and more reliable than either the ENIAC or UNIVAC. As a comparison, if the cost of a sports car had dropped as quickly as that of a computer, a new Porsche would now cost about one dollar.

Fifth-generation of computers are still in development and are based on artifical intelligence.