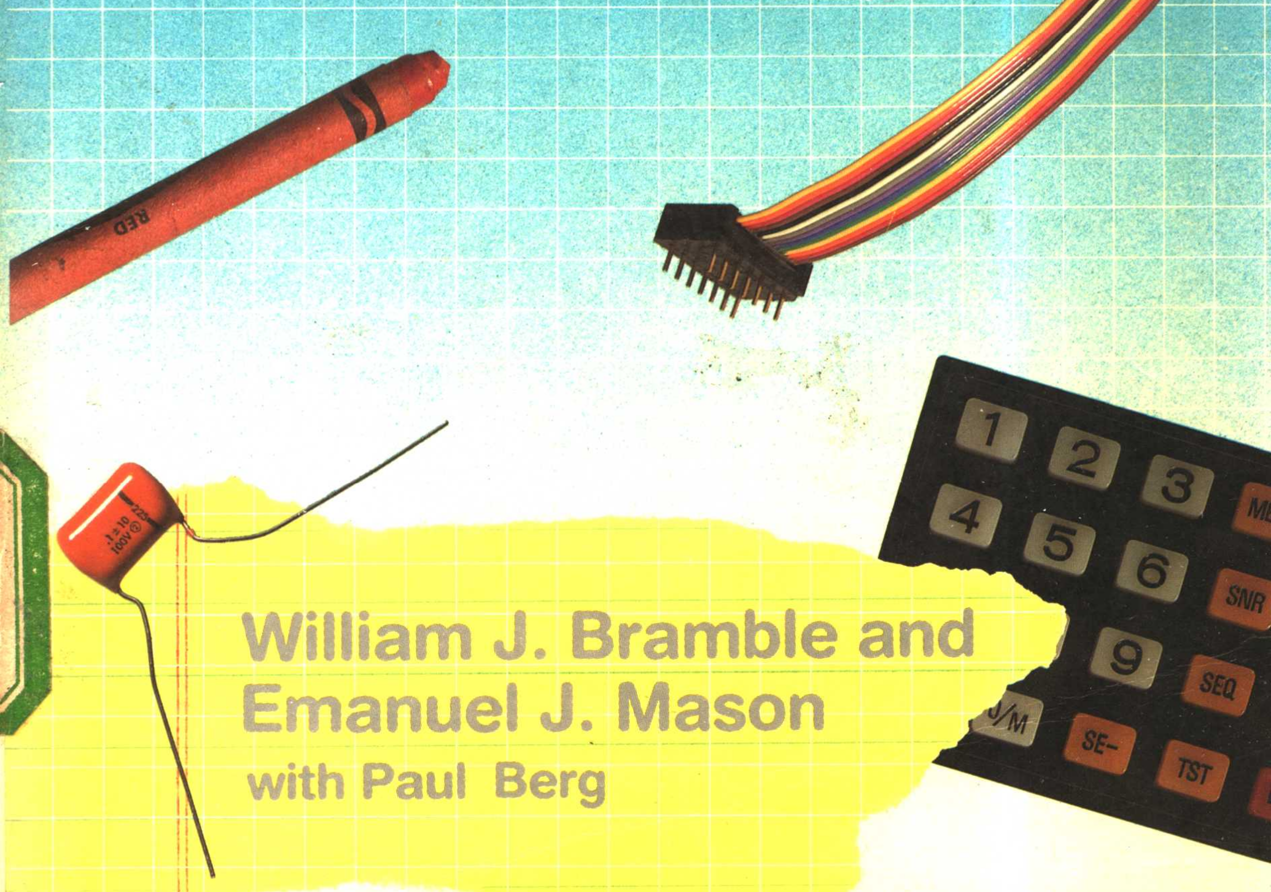
Computers in SCHOOLS



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PREFACE

In recent years educators have become increasingly aware of the need to know how to use computer technology in educational settings. The availability of computers at relatively low prices and in forms that are usable even by young children has opened educators' eyes to the potential of the technology. However, educators must increase their familiarity with this technology in order to realize its potential.

With new innovations, the people who do the initial developing often fail to recognize that practitioners require information and training. Thus, it often seems that when training materials and information are most needed, they are most lacking. Only after many users have "learned the hard way" do the needed resources become available. Educational computing has not been immune to this kind of discrepancy between the available technology and the information necessary to enable educators to use it. If training materials in educational computing had been keeping pace with the developing technology in the last few years, educational computing would be much more pervasive than it currently is.

In addition to training in how to operate and use computers, educators need an understanding of how computers relate to what we know about education. Scientific research, theory, and philosophy concerning schools, learning, and instruction cannot be overlooked when computerized education is developed and applied. A computer, in the final analysis, is an extremely capable instructional aid. Its successful use must be governed by sound educational principles. In this book, the computer is placed within the context of educational practice, research, and thought, in order to bridge the gaps between the hardware designer, the educational program developer, and the practicing educator.

This book focuses on the role of the microcomputer in education. Microcomputers are relatively inexpensive, easy to use, and capable of performing many useful functions in instructional settings. Topics covered include the history of computing, instructional hardware and software, determination of needs, development and evaluation of instructional materials, small-scale data processing, sources of assistance to educators who use computers, techniques of applying computerized instruction in the classroom, the social and economic impact of computers in society, and the future of educational computing. With this coverage, the book should be extremely useful to those interested in education and technology (parents, school board members, educational researchers and planners, and so on). The administrator who must organize and manage educational programs should find this an interesting book. However, the book should be of particular value to educators in training, as well as to experienced classroom teachers and administrators, who require some basic knowledge of instructional computing. In addition, those interested in computerized training within a business or industrial setting should also find the book worthwhile.

Technological change has occurred rapidly in recent years. Educational computing is also developing at a rapid pace. The present authors had to be cognizant of these rapid changes as the book was being developed. The manuscript was prepared on a microcomputer with word processing capabilities, so that changes resulting from new innovations could be incorporated easily.

During the preparation of the manuscript, useful insights and other assistance were provided by numerous people. The most notable contribution was by Paul Berg, an experienced educational computing specialist, whose assistance in drafting chapters in the second half of the book was critical to the completion of the project. Many of Paul's insights and conceptualizations, particularly those in Chapter 12, were extremely significant.

Ed Obie, of the Alaska Department of Education's Office of Educational Technology and Telecommunications (OET&T), provided a summary for Chapter 4 (for which he has been duly credited) and various critical comments regarding other sections of the book. Bea Tindall, also of OET&T, provided comments and ideas along the way. Critical reading of various sections and helpful recommendations were provided by Gary Anglin, Susan Mason, and William E. Stilwell. Lamar Abalahin assisted with library research. Assistance with text entry was provided by Susan Mason, Virginia Berg, and Billy Bramble. Ellen Bramble proofread much of the manuscript. Finally, the timeliness and high quality of the critiques of the early drafts provided by William H. Sanders, Indiana University; Ronald Hunt, San Jose State University; Vicki Blum Cohen, Columbia Teachers College; and John D. Davis, Sr., Northern Illinois University, were appreciated by the authors throughout the project.

William J. Bramble
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CHAPTER 1

COMPUTERS IN EDUCATION: EVOLUTION OR REVOLUTION?

CHAPTER CONTENTS

Events are taking place in education that many are saying will ultimately be considered revolutionary. Despite a great deal of excitement, however, the revolution is not yet visible to everyone. What is precipitating the revolution is the fact that computers which a short time ago were available only to large institutions with highly trained technical staffs are now becoming as common as chalkboards and audiotape recorders in classrooms across the United States. How has this affected education?

Consider the following examples:

- At an elementary school in North Carolina, students previously had little opportunity for tutorial assistance in learning mathematical facts. With more than two dozen students in the class, there simply wasn't time for the teacher to give the students individual attention. Further, the task of grading daily mathematics assignments for that many students was nearly overwhelming. Today compact and sophisticated computers in the classroom give automated mathematics tutorials and drills for the students who need them. The machines that provide this instruction are tireless and infinitely patient. They score students' performance and keep records for the teacher. The teacher now has a great deal more time to directly address the special problems particular students may experience as they learn mathematics, and to provide warmth and support for children engaged in the learning process.[1]
- Students in a social studies class in Minnesota learn about how the settlers went westward from Missouri along the Oregon Trail. In their textbook, readings describe the passage of settlers over this trail during the mid-nineteenth century and briefly mention the great distance involved and the problems encountered by the travelers. Now this trip, with all its hazards and difficulties, comes alive for the students on a classroom microcomputer. Using this device and a program about the Oregon Trail, they are able to plan and participate in a trip along the trail. Along the way they are presented with problems similar to the ones that confronted the settlers. The students experience the consequences of their solutions and decisions, and may or may not make it to the end of the trip "alive."[2]
- In isolated communities in Alaska, students attend schools reminiscent of the little red schoolhouses once common throughout America. A typical school may only have two teachers, and about 20 students with a broad age range. The teachers face major challenges. During the school day, a teacher is expected to respond to a wide variety of students' needs. For example, a kindergarten student may need work with reading readiness, first- and second-grade students with basic language arts instruction, a sixth-grader with computations involving fractions, and six high school students with algebra, language arts, history, earth science, and health education. With microcomputers recently purchased by the school, and programs furnished by the state department of education, individualized courses of study are possible for the high school students; at the same time supplemental instruction in readiness and basic skills is

available for the students in the primary grades, and drill and practice in computations involving fractions can be given to the sixth-grader.[3]

- Students in an elementary school in Colorado are not concerned about the card catalog in the school library. In fact, they don't use a card catalog at all, in the traditional sense. Yet they engage in a systematic process of finding books in the library, and they're good at it. At their school, library resources are now catalogued on a microcomputer. With a few simple commands, students can search for books by subject, author, or title. The computer and the student communicate in plain English. Instructions are patiently provided by the computer, and students can find books more quickly, more easily, and with far less frustration than with a traditional card catalog method.[4]
- In an elementary school in Texas, and another in New York, students use a program developed for classroom computers by a professor from the Massachusetts Institute of Technology. The program enables students to instruct the computer using simple English commands rather than complicated scientific codes. This innovative approach to education allows students to learn new concepts in mathematics by instructing the computer to form and move shapes on a television screen. Thus, the student learns by doing. Learning experientially is not a new idea, of course; it was part of John Dewey's theory of progressive education, proposed around the turn of the century. However, the computer now makes it more practical for students to experience learning individually. Instruction occurs as children initiate actions in the context of their environment, rather than in response to actions by the instructor. For the students in these Texas and New York schools the classroom environment has been expanded to include the computer.[5]

Around the country—and, for that matter, around the world—computers have captured the imagination of educators. The promise of computers in education has been recognized for several decades, but their actual use in schools was meager until quite recently. Since the mid-1970s, sales of relatively small computers called *personal computers,* or *microcomputers,* to individuals, businesses, and schools have shot skyward. For example, according to figures provided by the National Center on Educational Statistics the number of microcomputers used for instructional purposes in schools increased from about 102,000 in the school year 1981-1982 to 156,000 at the start of 1982-1983.[6] These microcomputers are comparable in size to small portable typewriters and can easily fit (with their associated hardware) on a desk top. Some are even small enough to fit in a small attaché case or a coat pocket. They are relatively reliable and inexpensive, and they are capable of an amazing variety of educational applications.

EDUCATION AND THE MICROCOMPUTER

During the 1960s computers were believed to have significant potential for education. In fact, tremendous growth in the use of computers for direct instruction was expected. But conditions were not yet right. The computers of that day were huge, costly machines, usable and affordable only by large corporations, government agencies, universities, and research centers. Large, highly trained staffs were required to operate, maintain, and program these computers. Therefore, educational uses of computers were expensive to develop and even more expensive to implement. Further, the design of the learning activities was based primarily on the programmed instruction approach, in which students progress through highly structured steps toward clearly specified behavioral goals. In this kind of instruction, correct answers are reinforced by allowing the student to progress to a new activity; typically, incorrect answers are discouraged by showing the question again with the correct answer. Mechanical or electronic devices had been designed to present materials in this way as early as the 1950s. Such devices could be produced and operated at a much lower cost than a computer. The approach had also been economically and successfully built into programmed textbooks and workbooks.[7]

Successful gains were demonstrated by the few students given computer instruction during this period; but designs emphasizing programmed instruction did not fully utilize the instructional capabilities of the computer. In addition, the proponents of computerized instruction were, of necessity, highly trained people associated with research or model demonstration projects. In sum, computers were not an efficient way to use funds for instructional materials, nor were they affordable or practical for most educational agencies or schools.

The more recent history of computers in education is quite different. The small computer – the microcomputer – is being touted as a potentially revolutionary tool for the modern educator because, in addition to its low cost, it is generally designed to be easier to use than larger machines. In fact, to use most microcomputers, the educator does not have to be a computer expert or even to know anything about programming. A few days of training will usually enable a complete neophyte to benefit from the exciting new technology. The low cost and ease of operation of the microcomputer have allowed classroom teachers, counselors, librarians, resource teachers, school administrators, and other educators to make immediate and successful use of this powerful tool.

Universities and research centers were largely caught unprepared as this revolution in the use of computers began. They were lulled by the belief that computers had been found impractical and too costly for use in education. Further, the universities were beset by a myriad of problems of their own, ranging from inability to compete with industry for computer experts to inability to maintain their existing programs in the face of dwindling funds. As a result, universities and training institutions have been slow to respond to the demands of educators for more training in instructional computing. Nowadays, educators at all levels are showing interest in learning about computers in education. Superintendents ask, "What can computers do for our school district? How can we plan our staff development so that we will be able to use computers effectively?" Teachers ask, "What should I look for in instructional software to determine if it is appropriate for my classroom?" Special education teachers ask,"What should be taken into account in using computers with physically impaired children?" University professors ask, "What do prospective classroom teachers need to know about the use of computers for instruction?"

All these questions, and many others, point to the need for more information about computers in education. This book was written to meet this need, and to point out ways to obtain additional information about this remarkable technology. This book will focus on the microcomputer and its application in educational settings.

LARGE AND SMALL COMPUTERS

Computers are electronic machines capable of reading, processing, and storing information and providing some output. Figure 1.1 shows the basic functions computers can perform.

Microcomputers are small computers. In order of increasing size, they are followed by *minicomputers* and large *mainframe* computers. The concept of size may be deceptive with regard to computers. In general, the size of a computer has to do more with its capacity than with the physical space it occupies. Some of the early computers, which were enormous machines that filled large rooms, were not as capable as many of today's microcomputers. You will see as you read further in this book that even microcomputers can store a surprising amount of information and perform complex calculations with amazing speed. Microcomputers are distinguished from larger minicomputers and mainframe computers on the basis of size, cost, complexity, amount of memory, and processing speed. More will be said about this in Chapter 2.

Figure 1.2 shows a typical microcomputer found in a school. By way of contrast, Figure 1.3 shows a large mainframe computer. The larger computer can perform larger and more complex tasks that would be impractical, or even impossible, for the microcomputer. Many instructional applications do not require such computing power. Therefore, a mainframe computer is simply not practical or justifiable in terms of cost for many educational applications.

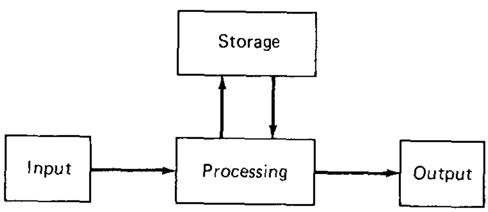
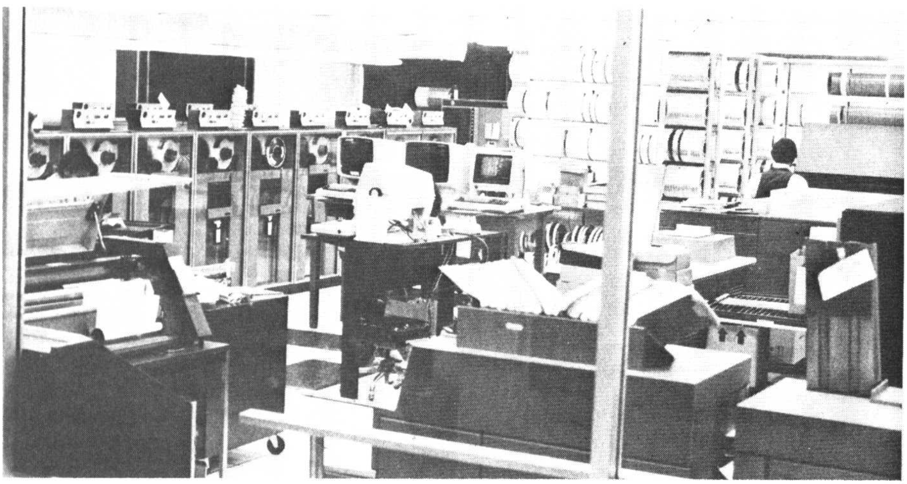


FIGURE 1.1
Basic computer functions.

FIGURE 1.2
Above: A student working at a microcomputer.

FIGURE 1.3
Below: Operations room of a modern mainframe computer.



A BRIEF HISTORY OF COMPUTERS

People often ask when the first computer was developed. That is a difficult question to answer precisely. Actually, the human mind is considered by many to be the first, and still the best, computer. The flexibility and powers of reasoning of the human mind have not yet been equalled by even the most sophisticated computers. In fact, people got along without computers for many thousands of years, and yet managed to perform calculations precise enough to build pyramids, navigate the globe, and predict the positions of the stars in the sky. Further, instances of fairly accurate census records appeared several thousand years ago. Obviously, then, computers are not necessary for such achievements. However, the usefulness of devices that aid in calculating is also obvious; and attempts to develop such devices began early in human history.

Early Developments

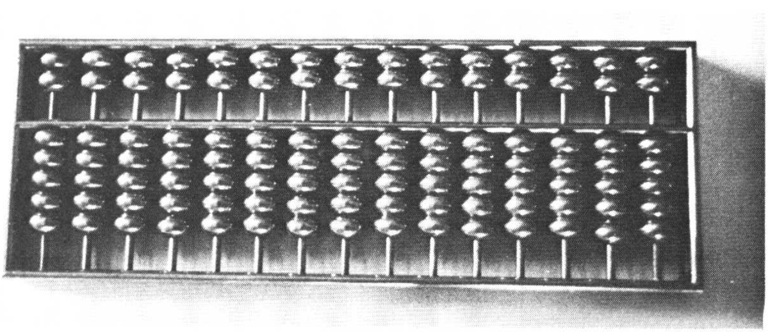
A variety of calculating aids were available in early civilizations. The first calculator was developed by the Chinese about 4000 years ago. This device, the abacus, is familiar to many schoolchildren (Figure 1.4). It is still in use in many parts of the world for making everyday calculations.

Before computers existed, there were two main problems in performing large-scale projects such as census studies: (1) storage and (2) summarization of the data.

To solve the first problem, several millennia ago humans invented a remarkable method of storing records and figures—writing things down. Information was first stored on clay tablets and later on parchment or paper-like substances. In this form, records were fairly permanent. They could be read and interpreted consistently by various readers and stored for later use.

Summarization of records was a problem because many classifications and calculations of data were required to combine and simplify data into concise figures. Originally, summarization was approached by brute force. That is, summaries were made by working on a problem for a long time. With some luck, the values calculated were correct. It didn't take people very long to figure out, however, that brute force was both tedious and time-consuming. It was also

FIGURE 1.4
An abacus.



very expensive. These disadvantages led to the search for technological aids for performing calculations.

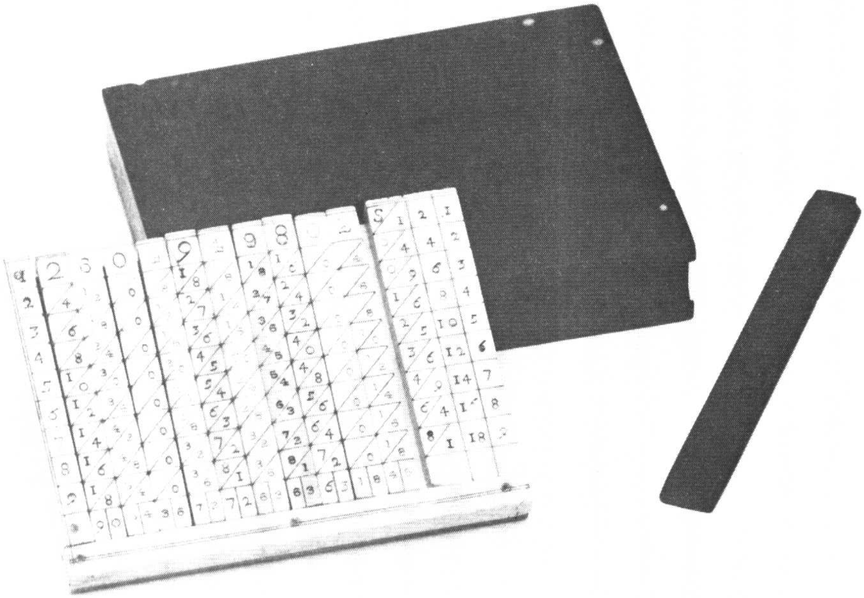
From Mechanical Calculators to Mechanical Computers

In the early 1600s in Scotland, John Napier developed a calculator to assist with multiplying, using a system of rods that could be moved about on a pattern (Figure 1.5*a*). About 25 years later (that is, in the middle of the seventeenth century), a Frenchman, Blaise Pascal, made another significant contribution to computation technology. When he was only about 18 years old, Pascal developed a device with gears that worked much like the mileage indicator in an automobile. It was designed to assist Pascal's father, a government official, in performing financial calculations. Later in the century, a machine invented by Gottfried Wilhelm von Liebniz improved on Pascal's device. By using repeated additions, it could multiply. It could not be made to work very accurately (the technology of the time was insufficent); but the ideas on which it was based contributed to later developments in calculating.

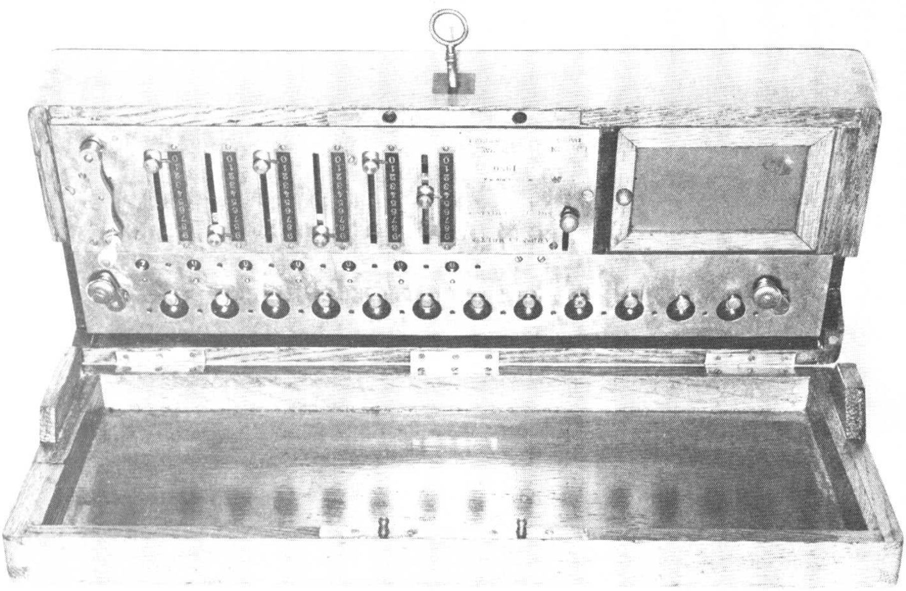
During the industrial revolution, inventions appeared which helped control manufacturing processes. One example is a technique developed by Joseph-Marie Jacquard, in which holes punched in cards to represent weaving patterns were used to automatically control weaving machines. This procedure is considered the direct ancestor of the punched card as a medium for storing information in more recent data processing operations.

In the early 1800s Charles Xavier Thomas, also known as Thomas de Colmar, invented the arithmometer (Figure 1.5*b*), a device that multiplied and divided effectively by repeated addition and subtraction, using the ideas of Leibniz. However, the work of an Englishman, Charles Babbage, was more significant to the later development of computers. In 1823 Babbage began to develop a calculation machine which he called the *difference engine* (Figure 1.6). About ten years later, he tried to develop a more sophisticated machine that operated more like a computer than a calculator. This machine he called the *analytical engine.* The two machines were steam-driven and were designed to perform their functions by converting instructions from punched cards into the precise turning of gears. Despite years of effort, neither of these machines ever worked; the technology of the time did not allow Babbage to build them with the necessary precision. However, many of the ideas incorporated in the design of Babbage's engines were later used in the design of mechanical calculators, and ultimately in electronic calculators and computers.

Lady Ada Byron Lovelace worked with Babbage. She was a skilled mathematician and is considered by many to be the first computer programmer. While she worked with Babbage on the operational procedures for the analytic engine, she developed many ideas that were basic to modern programming. Her career was shortened by illness and by popular notions of the time about the suitability of mathematics as an occupation for women.



(a)



(b)

FIGURE 1.5
Early computing machines: (*a*) Napier's rods; (*b*) Thomas's arithmometer. *(IBM Corporation.)*

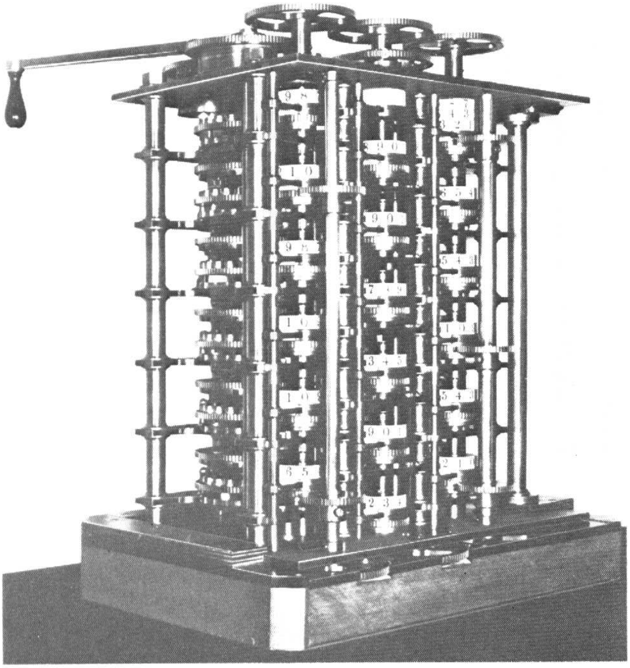


FIGURE 1.6
Babbage's difference engine. *(IBM Corporation.)*

Electronic Solutions to Calculating and Data Processing

The search for better ways to store and process information began almost as soon as people began to keep records and do calculations. This search has led more recently into the realm of electronics. From the late 1890s into the first quarter of the twentieth century, various advances were being made in electronics that were ultimately to have a major impact on computers. Among these were the transmission of telegraph messages by radio waves, the first cathode-ray tube, and the vacuum-tube diode. During this period, most of the developmental activity in electronics was directed toward radio and television. By 1920, sufficient progress had been made to begin the first commercial radio broadcasts.

In the late 1800s, Herman Hollerith was perfecting a method for processing data along the lines of Jacquard's punched cards. Hollerith eventually developed this technique to the point where he was able to get a contract to tabulate the data collected in 1890 by the U.S. Bureau of the Census. Hollerith's machine (Figure 1.7) used electronic impulses to read punched cards. The impulses were sent through rods on one side of the card as it was fed through the machine. If a rod encountered a hole, it touched a metal plate on the other side of the card

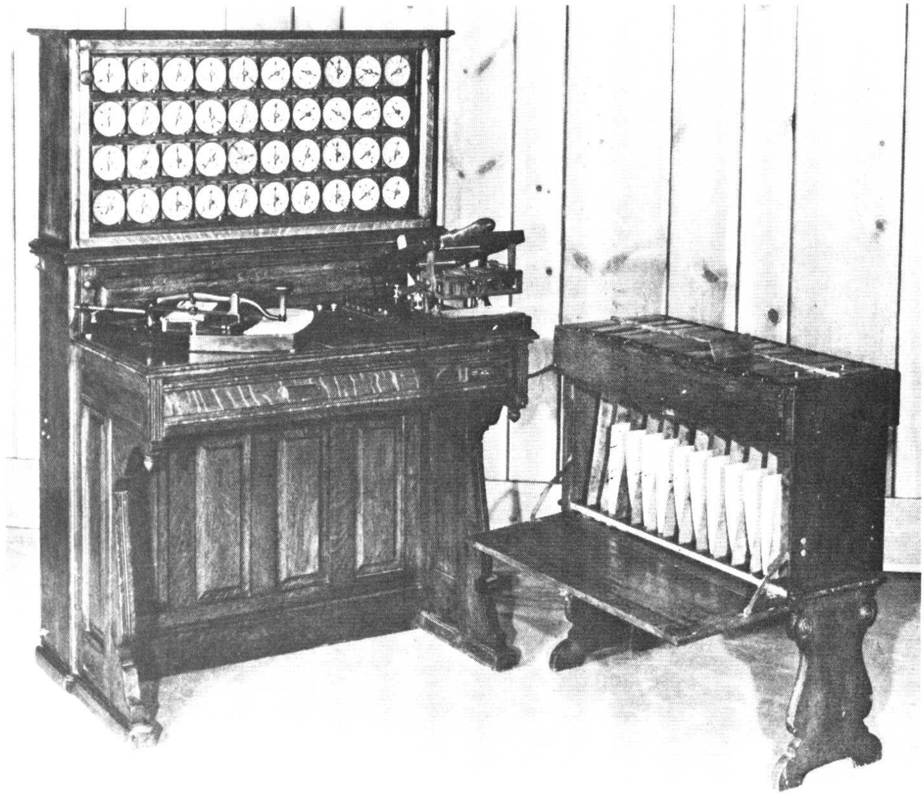


FIGURE 1.7
Hollerith's tabulation machine. *(IBM Corporation.)*

and completed the circuit. Thus, the operation was analogous to an on-off switch in which the paper in the card kept the switch off, and a hole allowed the switch to be momentarily turned on. In 1896 Hollerith formed a company that was later to become International Business Machines (IBM), a giant in the computing industry.

During and immediately after the Second World War the first electronic computers were developed. These machines had been preceded by an electromechanical computer, the Mark 1 (Figure 1.8*a*). The electronic computers were made with vacuum-tube circuits similar to those found in older radios and television sets. In many cases they were based on advances in electronic circuit design developed to improve weapons guidance systems and devices used to encode messages during the war. Computers were assembled using great numbers of these vacuum tubes interconnected by miles of electrical wiring. One such computer was ENIAC (Electronic Numerical Integration and Calculator),