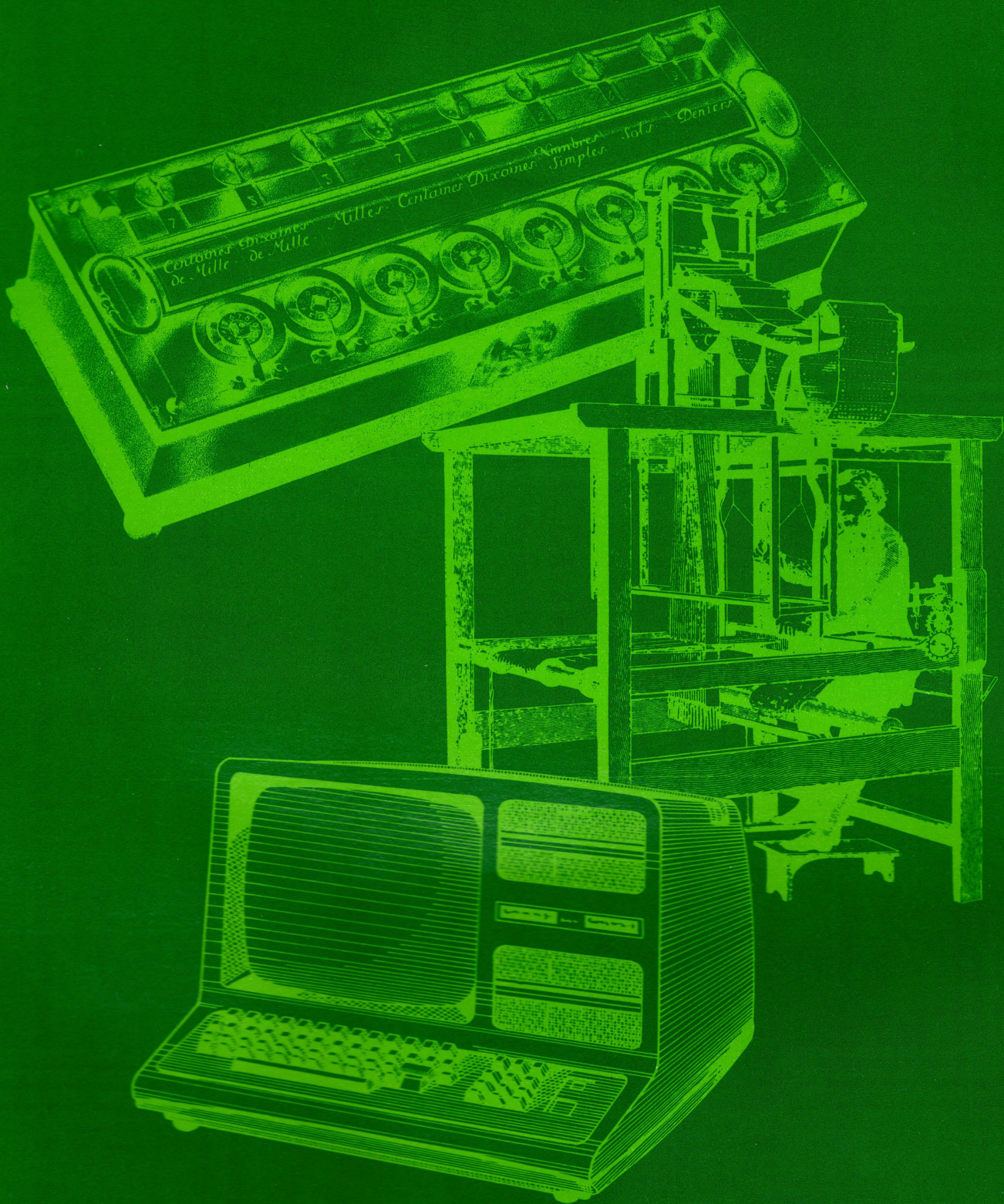


TEACHER'S GUIDE



Radio Shack®

COMPUTERS
PAST & PRESENT

AN EDUCATIONAL PROGRAM ON THE HISTORY OF COMPUTERS





Dear Teacher,

This educational program traces some major historical events in the development of computers and describes a modern computer system—what it is and how it operates. The background material in this guide will help you teach the unit effectively, no matter how much or how little you know about computers.

This program assumes that neither you nor your students have direct access to a computer. All of the unit's activities can be effective without the use of computer equipment.

Components of the program include a wall chart for classroom display and six activity masters, each of which can be used to produce up to 200 student activity sheets. The file folder, in addition to containing the teacher's guide, can store the wall chart and masters between uses.

In the teacher's guide you'll find a background survey of computers and computer history plus a bibliography. Lesson plans for the student activities are printed on the face of each activity master.

® BACKGROUND

The history of computers is a fascinating story, only the most important characters and events of which can be presented here. In the same way, the outline given here of how computers work is necessarily oversimplified. The bibliography lists a number of books and articles you can use to fill in the gaps in this brief survey.

What Is a Computer?

Defining a computer in terms that young students can understand is more difficult than you might think. Computers are basically simple machines and, at the same time, very complex ones. They perform simple operations—as simple as turning a switch on or off—but they perform these operations so quickly, in such great quantity, and in such small space that they seem incredibly complicated. To the layman they may seem mysterious and almost magical.

The mystery and magic are illusions created by the efficiency with which computers perform the tasks we devise for them. Computers are, after all, simply machines that depend on us completely for instructions and guidance. A computer can do only what its human masters have instructed or programmed it to do. When an error occurs, it is almost always the fault of the program—developed (and to be corrected) by human operators. (In rare cases, errors result from a problem with the computer itself.)

This capacity for storing and following instructions is the crucial element in a working definition of computers. Computers are programmable, that is, they can store and follow instructions given to them by human operators. You and your students, however, can probably think of other less sophisticated devices that are programmable in some sense. (An alarm clock is a familiar example.)

What distinguishes computers from other programmable devices is their ability to calculate. Computers are

essentially counting machines. When a computer prints out a paragraph in English or another language, or when it produces elegant and sophisticated designs on its screen, what we see is the result of the computer's internal manipulation of numbers, translated into visual displays or common language. At its heart, the computer understands only numbers.

So, we can define a computer as a powerful calculator that can store and follow instructions or programs. This definition is not perfect, but it may help you and your students talk about computers in non-technical language.


Some Computer History

Our definition of computers includes two elements, each of which has its own history: calculating machines and programming. Not until about 1951 did the two historical developments merge in a machine that fits our definition.

The first devices used for counting were probably our fingers and toes. Our early ancestors counted and perhaps even multiplied using their fingers, then marked their results on cave walls, pottery, and clay tablets. The Latin word *digiti* means "fingers" and was also used for the numbers that were counted on fingers. And from *digiti* comes our term *digital* computers.*

Long ago Egyptian merchants substituted pebbles for fingers. They made three grooves in the sand and placed pebbles in each to represent amounts of money and merchandise. Each pebble placed in the right hand groove represented one unit, one piece of money, or one item of merchandise. Each stone in the middle groove meant 10 units, and each one in the left groove meant 100 units. As trade increased and transactions became more complex, merchants replaced this sand calculator with the abacus.

*Digital computers are the most common type. *Analog* computers, on the other hand, use physical quantities such as voltage or weight to represent numbers.



"Abacus" comes from the Arab word for dust and the Greek word for platter. It seems that the first abacus was simply a portable sand calculator, a board with sand on it in which to make grooves for the pebbles. Soon beads strung on wires in a rectangular frame replaced sand, platter, and pebbles. This kind of abacus has been used throughout the world and is still in use in Far Eastern countries. An abacus allows its user to manipulate numbers and to carry from one column to the next. The size of an abacus depends on its task. The Romans used a hand-held abacus, but Pope Sylvester II (940-1003 A.D.) constructed one with 72 columns, including three for fractions.

The abacus was the only practical mechanical calculator until two or three hundred years ago. Many experimenters of the 17th and 18th centuries tried to come up with a better calculating machine. In nearly every case the result worked on paper, but the limited technology of the time made the calculator difficult or impossible to manufacture.

One such calculator was *La Pascaline*, invented by the Frenchman Blaise Pascal (1623-1662). Pascal was talented in many fields, but it was his special interest in mathematics that led him, at the age of nineteen, to an idea for a new kind of calculating machine. Pascal's idea was to line up a series of gears side by side, one gear for each number place (ones, tens, hundreds, etc.). Each gear had ten teeth (for the numerals 0 to 9), with the tenth one longer than the others. The numerals were imprinted on the gear teeth, which were then mounted inside a brass box. Small windows in the box allowed one tooth of each gear to be seen. As each gear was rotated with a stylus, the numbers 0 through 9 appeared in turn. As the ones gear reached 9, the long tooth would engage the tens gear and advance it one notch. For every complete revolution of the ones gear, the tens gear advanced by one numeral.

When the tens gear revolved completely, the hundreds gear advanced one numeral and so on.

This action allowed *La Pascaline* to "carry" numbers from one column to the next, something any calculator must be able to do in order to add or subtract. *La Pascaline* worked well and impressed everyone who saw it. But at the time there was no way to make one except by hand, and *La Pascaline* could only add and subtract efficiently. To multiply or divide meant laborious repeated additions or subtractions and could be done more quickly with pen and paper. Pascal's calculator was an interesting experiment, but it had almost no practical use.

Still, *La Pascaline* was an important first step in mechanical calculators. The idea behind it is the basis of many modern counting devices from small plastic calculators used to count balls and strikes, keep golf scores, or add up the grocery bill to large mechanical adding machines and even your automobile's odometer.


Another visionary inventor, who was never to see his best invention leave the drawing board, was the Englishman Charles Babbage (1781-1871). Babbage tried to expand the idea of a geared mechanical calculator into a device that could multiply, divide, and print mathematical tables. His first attempt, called the Difference Engine, got as far as a successful scale model, but was never built in full-size working form. At the time it was not possible to manufacture gears and other parts to the precise tolerances necessary for a working machine.

Not discouraged, Babbage began work on the designs for his Analytical Engine, an enormously complicated calculator that could perform all arithmetic functions, solve math problems, and do sixty additions per minute.

Even though the Analytical Engine was never built, it was an important step toward the computer. Babbage's designs included many of the features of modern computers, features that were not to be perfected until a hundred years later. One of these features was that the Analytical Engine could be programmed. That is, it could store and follow instructions from its operators.

With Charles Babbage the history of mechanical calculators overlaps another historical development crucial to the modern computer: that of stored instructions or programming. Babbage's Analytical Engine was designed to accept instructions coded onto punched cards, much like modern computer cards. The Analytical Engine would "read" these cards, store the instructions they contained, and perform its functions as the instructions dictated. Modern computers work very much the same way. The idea of storing a machine's instructions on punched cards, though, was not original with Babbage.

Joseph Jacquard (1752-1834), a French weaver, was actually the first person to use punched cards for this purpose. His invention, the Jacquard loom, represents another important step toward the modern computer. Patterns are woven into fabric on a loom, where the operator lifts certain threads of the fabric as it is woven to allow a colored thread to show through. Jacquard's goal was to program the loom to lift the right threads at the proper time so that the pattern would be produced automatically. First, he coded the sequence of lifted threads onto a series of perforated cards. Each perforation represented a certain thread to be lifted. Then Jacquard modified his loom so that when a perforated card was inserted an array of needles pressed against it. Where there was a perforation, the needle passed through and caused one particular thread to be lifted.



As the loom operated, the cards caused the correct pattern to be woven into the fabric over and over again. An identical pattern could be woven into many separate pieces of fabric, and changing the pattern simply meant changing the sequence of punched cards. Although the Jacquard loom couldn't calculate anything, it was an important predecessor of the modern computer because it could be programmed. That is, it could be given a set of instructions (a program), and then could follow it step by step.

Another milestone on the road to the computer was reached in 1890 when Herman Hollerith (1860-1924) used similar punched cards to record information for the United States census. Hollerith got his idea for recording data on punched cards by watching a railroad conductor. As the conductor punched each ticket to identify a passenger's route and destination, Hollerith realized that he could punch a card to identify an individual by name, address, occupation, and other factors. He also developed an electrical tabulating machine that counted individuals by responding to the holes in the cards. Just like Jacquard's loom, Hollerith's census machine pressed pins against each card. Pins that went through holes made electrical contact and caused a dial to move, thus recording the information. Hollerith's punched card system produced preliminary results of the 1890 census in just six weeks, results that had previously required years of hand calculation.

In the years between 1890 and the middle of the 20th century, many advances were made in mechanical calculators. The common mechanical adding machine (used so widely up until the recent development of the electronic calculator) was perfected during this period. IBM (International Business Machines) became the largest company in its field. IBM's first

president, Thomas Watson, provides the link between mechanical calculators and the earliest modern computers.

During World War II, Watson and IBM financed the production of Mark I, a giant calculator to produce tables for aiming artillery shells. Mark I had 760,000 parts and could add or subtract in one-third of a second. Mark I thus symbolized a leap in the size and power of calculating machines.

The next major step, ENIAC (Electronic Numerical Integrator and Calculator), was developed by John W. Mauchly, physicist, and J. Presper Eckert, Jr., electrical engineer. Designed to produce weather forecasts, design wind tunnels, and produce ballistic tables for army and air force weapons, ENIAC became operational in 1947. It weighed thirty tons, occupied 1500 square feet, stood nine feet high, and contained 18,000 vacuum tubes, 70,000 resistors, and 10,000 capacitors. It used about as much electricity as three radio stations. ENIAC was able to add, subtract, multiply, divide, and take square roots and could do as much work as 20,000 people. A problem that had required a person 20 hours to compute was solved by ENIAC in 30 seconds.

ENIAC is often considered the first electronic computer. Yet it fails to meet one important criterion set by our definition. ENIAC was programmable only in a very primitive sense. Preparing ENIAC to solve a problem required hours of plugging, unplugging, and connecting many bulky wires and cables. Each time a new problem was attacked, the process had to be repeated. Perhaps it is more accurate to think of ENIAC as a highly sophisticated calculator, as its name implies, rather than as a true computer. ENIAC was, however, an important advance, because it functioned not through the mechanical action of gears and levers but through the quiet and speedy operation of electronic circuits.


The honor of being the first true computer, by our definition, belongs to Eckert and Mauchly's next accomplishment: UNIVAC (Universal Automatic Computer), put into service in 1951. UNIVAC was a great improvement over its predecessors. It was faster and more powerful, able to add 237,000 five-digit numbers in one minute, check for errors in its own problems, and handle information other than numbers. Yet it was less bulky, weighing four tons and occupying 575 square feet.

But the most important attribute of UNIVAC in historical terms was its ability to use programming. The new idea of mating a high-speed calculator with punched card programming belonged to John von Neumann, who thus combined the two historical developments described in this survey.

Since UNIVAC, computers have rapidly become more powerful and more compact than Eckert and Mauchly could have imagined. At the same time, computer costs have gone down dramatically. In the 50's, computers were as big as a room, used hundreds of vacuum tubes, computed in milliseconds (thousandths of a second), and cost hundreds of thousands of dollars. In the early 60's transistors replaced vacuum tubes, making computers smaller and faster. Computers of this period computed in millionths of a second and cost tens of thousands of dollars.

In the late 60's and early 70's another major step took place. Scientists and engineers learned how to miniaturize electronic components into what are called integrated circuits. These miniature components led to minicomputers, the size of a large suitcase, that could compute in billionths of a second and that cost as little as \$25,000.

Since about 1975, a technique known as large-scale integration has allowed major components of a computer—made up of thousands of circuits—to be manufactured in the



form of a silicon chip less than a centimeter square. The resulting microcomputers, no larger than an electric typewriter, cost about the same as a color TV set. The 80's will see this trend continue, with pocket-size computers more powerful than ENIAC and UNIVAC of just 35 years ago.

Throughout its evolution from abacus to silicon chip, the computer has given humans greater power to solve problems. Early electronic computers, large and expensive, were limited to government, research, business, and industry. Today's inexpensive microcomputers are extending computer capabilities into schools and homes. We may soon reach a time in history when computers will be as accessible and as easy to count on as our fingers.

How a Computer Works

The basic function of a computer is processing: the operations a computer performs on the information we give it. At the heart of any computer is its **central processing unit** (or CPU), the component that performs and controls the processing function.

The CPU has three units, which we can call control, arithmetic, and memory. The **control unit** is something like a policeman directing traffic. It coordinates all the operations taking place within the computer and directs information from one unit to another at the proper time. In doing so, the control unit follows the program of instructions supplied by a human operator.

The **arithmetic unit** (sometimes referred to as the logic unit) is the calculating part of the computer, performing the mathematical operations required by the program under the direction of the control unit. The complicated tasks computers perform are really combinations of basic arithmetic operations, executed at extremely high speeds.

The **memory unit** of a computer is a storage area for information. The control unit takes information from memory to process it, then returns the results to memory until the program specifies what is to be done with it. The computer's program is also stored in memory for the control unit to consult at each stage of its operation. Every item of information in memory is assigned to a location with a specific numerical address, where it can be retrieved easily if needed.

Together, the control, arithmetic, and memory units allow the computer to process information according to the program we provide. But this processing ability is worthless unless we have the ability to put information *into* the computer and to get answers and results *out*. Thus all computers include **input** and **output** units.

Any instructions or information we want to put into the computer is called **input**. Different computers have different kinds of devices for accepting input. Punched cards were frequently used with early computers. Today's microcomputers often rely on a simple keyboard like that of a typewriter and on cassette tapes or disks made of magnetic tape.

Information that the computer produces for us to examine—the answer to a calculation or the solution to a problem—is called **output**. Sometimes output devices are the same as input devices; output can be automatically recorded on the same cassette tape or magnetic disks. Most modern microcomputers use television screens to display output or print it on paper.

A computer, then, can be thought of as a combination of an **input unit**, a **central processing unit** (made up of control, arithmetic, and memory), and an **output unit**. In operation, the computer follows these general steps:

1. Input the program.
2. Input the information to be processed.


3. Store program and information in memory.
4. Control unit selects information from memory, routes it to arithmetic unit, and returns the results to memory, all according to the program's instructions.
5. Arithmetic unit performs the required calculations.
6. Results are output from memory as the program directs.

This is not really very different from how our mind works when we solve a problem. Information we need is taken in by our senses as **input**. Our brain keeps track of the problem-solving process through its **control** function and performs calculations just as an **arithmetic** unit does. Instructions for adding and multiplying or thousands of other skills are stored in our **memory**. And the answer is presented through speech or writing as **output**.

The equipment that performs these functions in a computer system is often called *hardware*. The directions and instructions, or programs, we give the computer are referred to as *software*.

Without software programs a computer is useless. Every computer must have a program that tells it what operations to perform. The program, written by a human programmer, is a step-by-step set of directions for the computer that deals with a specific application.

Programmers must learn special programming languages that allow them to communicate with computers. Each computer has the ability to translate the programming language into the numbers it understands. There are many different programming languages for different computer applications. Some of these languages (especially those used in school and home computers) use common English words and are very easy to learn.



What Computers Can Do

What can computers do? They seem to be in every part of our lives and now even in our homes. Computers can calculate a path for a spaceship to the moon, and they can play checkers. They can tell a grocery store owner the best location for a new warehouse, and they can help doctors save lives through accurate and speedy diagnostic procedures. Computers can compose music, direct city traffic and help people learn. The list is endless.

Education offers new possibilities. Perhaps most important is the computer's ability to free the teacher from drill work and provide students with individualized instruction. The microcomputer is a major factor in the increase in computer assisted and computer managed instruction. With it, the teacher can individualize drills to fit the achievement level of each student. The computer can also do clerical work for a teacher. It can analyze a student's weaknesses and strengths instantly and provide records of achievement and mastery.

As increasing numbers of teachers and students realize how microcomputers can make learning more efficient and more enjoyable, their use in schools will probably increase. Perhaps one day microcomputer programs will be as common and as widely used as library books or filmstrips. We may actually get to know computers as well as the fingers on our hands.

Using the Wall Chart

The wall chart is meant to serve as a reference for your students, a colorful motivational device, and a permanent classroom decoration. Its attractive graphics illustrate the historical development of calculators, stored instructions, and computers—up to modern microcomputers like the TRS-80™ microcomputer.

Using the Activity Masters

Each preprinted, spirit-duplicating activity master will produce as many as 200 copies. Attach the master to a standard spirit-duplicating machine and run the copies you need. Then replace the tissue backing and store the master in this folder for future use.

Answers to the various activities and suggestions for using each activity are printed on the face of the master. This information will not reproduce when you make copies, and student information will appear full size.

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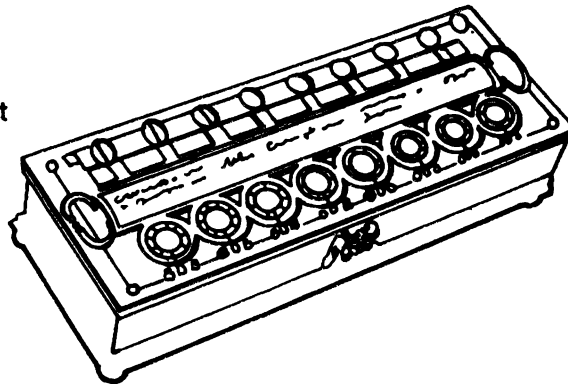
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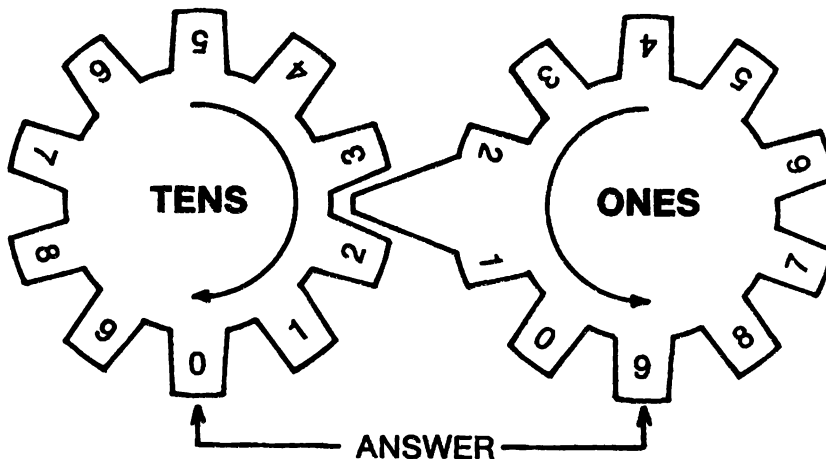
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•MACHINES THAT ADD•

La Pascaline was the name of one of the first mechanical calculators. It was invented in France, in 1842, by Blaise Pascal.



This calculator has gears like *La Pascaline*. The gear on the right represents the ones (or units) column. The gear on the left represents the tens column.



Our calculator is set at 9. What will happen if we move the ones gear one step counterclockwise?

How would you use this calculator to add $5 + 27$? The steps for doing this problem are listed below. But they may not be in the right order. Put them in the right order by placing 1, 2, or 3 in the blanks.

- _____ Turn the ones gear to 5.
- _____ Read the answer: 32 (ones gear reads 2 and the tens gear reads 3).
- _____ Turn the ones gear 7 steps counterclockwise and the tens gear 2 steps clockwise.

Discussion Questions

1. What is the purpose of the long tooth on the ones-gear?
2. How could you use this calculator to subtract?
3. Can you multiply on this calculator? How?
4. Name other machines that use gears to add.

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ACTIVITY MASTER 1

MACHINES THAT ADD

OBJECTIVES: Students will learn how an early mechanical calculator works. They will identify the steps involved in solving an addition problem with the calculator.

La Pascaline, the first mechanical calculator, was invented by Blaise Pascal in 17th-century France. Explain to students that this machine performed addition and subtraction just like the abacus. But Pascal's calculator used gears and dials in a box instead of beads on wire in a wooden frame.

Each of the dials on top of *La Pascaline* represents a specific number place. From right to left, the first two dials represent French coins: *sous* and *deniers*. The third dial is units, the fourth is tens, etc. Each dial is connected to gears inside. Each decimal gear has ten teeth plus a protruding piece called the carry ratchet. When a dial makes one revolution, the ratchet moves the next dial to the left one space.

Additional Activities

You or a student might try making a calculator based on the simple diagram shown on the student activity sheet. The gears and base can be made of heavy cardboard or thin plywood.

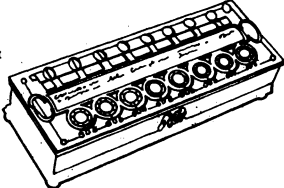
Answers to Discussion Questions:

1. To move the tens gear from 10 to 20, 30, 40, etc. each time the units gear makes one revolution.
2. Yes, by turning the gears in the opposite directions.
3. Yes, by adding the multiplicand as many times as the value of the multiplier.
4. Odometer, pocket adding machine for shoppers or golfers, mechanical desk calculator, plastic student adding machine.

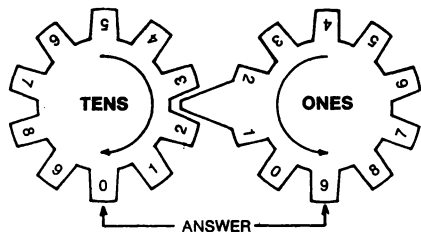
ACTIVITY MASTER 1

•MACHINES THAT ADD•

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This calculator has gears like *La Pascaline*. The gear on the right represents the ones (or units) column. The gear on the left represents the tens column.



Our calculator is set at 9. What will happen if we move the ones gear one step counterclockwise?

How would you use this calculator to add $5 + 27$? The steps for doing this problem are listed below. But they may not be in the right order. Put them in the right order by placing 1, 2, or 3 in the blanks.

- ① Turn the ones gear to 5.
- ③ Read the answer: 32 (ones gear reads 2 and the tens gear reads 3).
- ② Turn the ones gear 7 steps counterclockwise and the tens gear 2 steps clockwise.

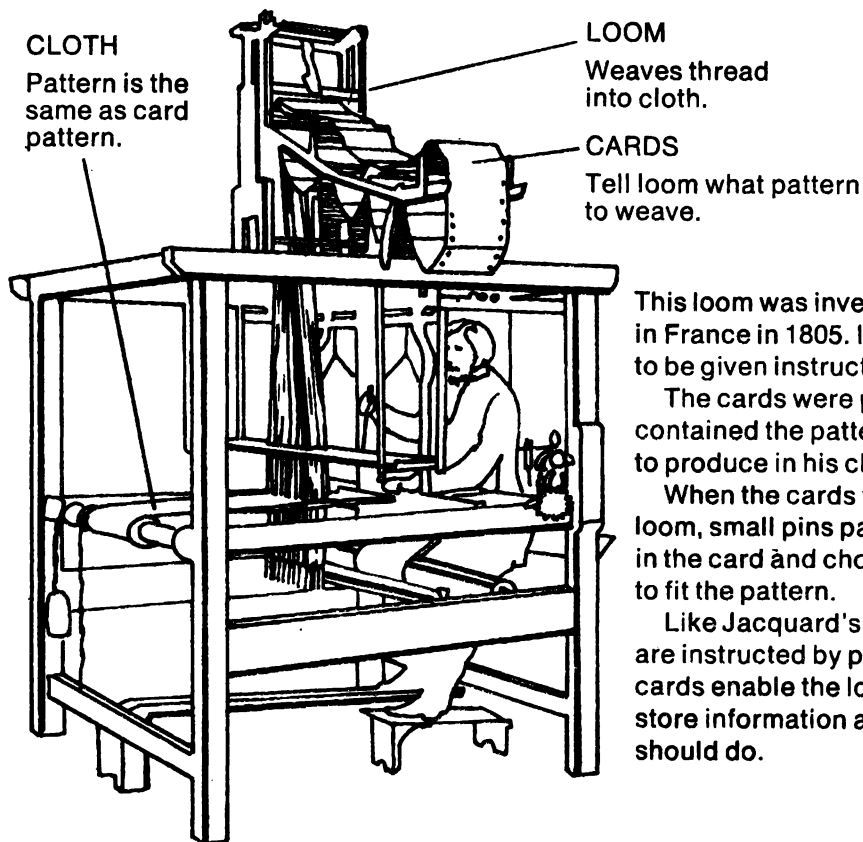
Discussion Questions

1. What is the purpose of the long tooth on the ones gear?
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3. Can you multiply on this calculator? How?
4. Name other machines that use gears to add.

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MACHINES THAT REMEMBER WHAT TO DO



This loom was invented by Joseph Jacquard in France in 1805. It was the first machine to be given instructions by punched cards.

The cards were punched so that they contained the pattern the weaver wanted to produce in his cloth.

When the cards were attached to the loom, small pins passed through the holes in the card and chose the colored threads to fit the pattern.

Like Jacquard's loom, some computers are instructed by punched cards. Punched cards enable the loom and computer to store information and remember what they should do.

Discussion Questions

1. How did punched cards help a weaver?
2. Why might a weaver worry about Jacquard's loom?
3. What would you do to change patterns on Jacquard's loom?
4. What would you do to repeat the same pattern?
5. What other modern tools or devices can you name that store information? Does an alarm clock, for example, do so?
6. Which would cost more, a hand-woven scarf or a scarf produced on Jacquard's loom? Why?
7. Why are stored instructions important for a computer?

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MACHINES THAT REMEMBER WHAT TO DO

OBJECTIVES: Students will learn how punched cards were first used to program a machine. They will learn how the cards on Jacquard's loom were the forerunners of computer punched cards.

Memory is one important element in a modern electronic computer. A computer can store programs that tell it what to do. It can also store data—facts that it uses in solving a problem.

Ask students to recall *La Pascaline*. What happens to the answer to one problem when it calculates a second problem? Show them that simple calculators do not have the ability to store information. When a mechanical calculator starts a new problem it erases the old one.

Tell students how in 1805, Joseph Jacquard, a French weaver, introduced the first machine operated by instructions stored on punched cards. The machine was a loom, not a calculator.

Point out to students that computers of the fifties and sixties used punched cards to store programs and information, but that modern computers use more compact methods like magnetic tape or disks. Microcomputers often use small chips to store information inside the computer and ordinary cassette tapes for storage outside the computer.

Additional Activities

1. Have students bring other devices to class that store information. Discuss why and how they store information.

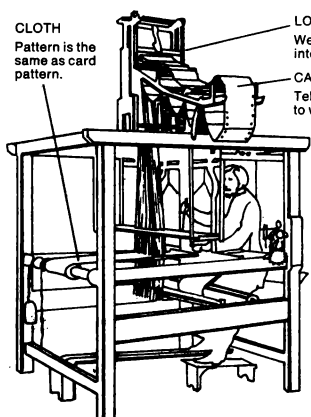
2. Have students research and report on Jacquard or Herman Hollerith.

ACTIVITY MASTER 2

MACHINES THAT REMEMBER WHAT TO DO

CLOTH
Pattern is the same as card pattern.

LOOM
Weaves thread into cloth.



CARDS
Tell loom what pattern to weave.

This loom was invented by Joseph Jacquard in France in 1805. It was the first machine to be given instructions by punched cards. The cards were punched so that they contained the pattern the weaver wanted to produce in his cloth. When the cards were attached to the loom, small pins passed through the holes in the card and chose the colored threads to fit the pattern. Like Jacquard's loom, some computers are instructed by punched cards. Punched cards enable the loom and computer to store information and remember what they should do.

Discussion Questions

1. How did punched cards help a weaver?
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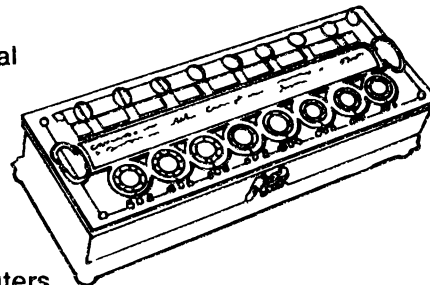
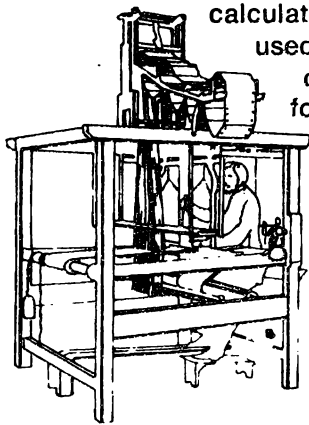
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Answers to Discussion Questions:

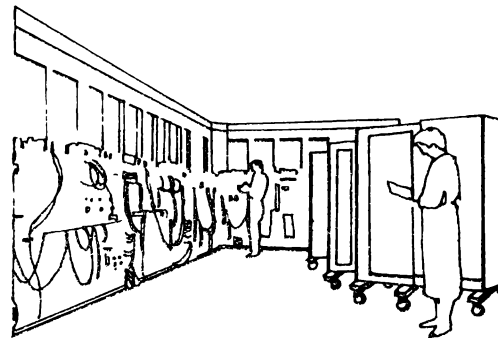
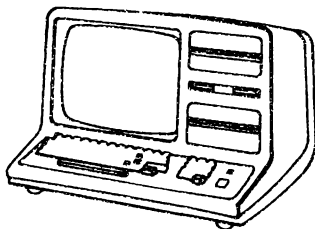
1. Faster production, greater accuracy and uniformity, machine supervision.
2. Job loss, less personal care and individual craftsmanship in products.
3. Use new set of cards with prepunched pattern.
4. Use same set of cards again.
5. Scoreboards, calculators, clock radios, thermostats, elevators, phonograph records, audio and video tapes.
6. Hand-woven costs more; skill is required and more hours of work.
7. The computer can store data to solve problems. Stored programs can be recalled and followed when needed.

CALCULATOR + PROGRAM = COMPUTER

Computers combine the best features of mechanical calculators with the stored instructions used by Jacquard's loom to make a decision-making, instruction-following machine – A COMPUTER!



Early computers were very big compared to today's microcomputers. Below is a list of features. See if you can pick out those that apply to each kind of computer.



weighs 30 tons
weighs 30 pounds
occupies 3 square feet
occupies 1500 square feet
9 feet high
1 foot high
thousands of tiny transistors

1800 vacuum tubes
adds 5000 times each second
adds 100,000 times each second
remembers up to 48,000 items of information
remembers 1 item of information at a time
uses as much energy as a locomotive
uses as much energy as a 40 watt light bulb

Discussion Questions

1. What operations can a computer perform that make it like a calculator?
2. What do punched cards or other memory devices help a computer to do?
3. Why do you think computers are getting smaller?
4. In what ways is a smaller computer better?
5. Why is high speed important for a computer?
6. Why is low energy use important for a computer?
7. What can a computer remember with its memory?

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ACTIVITY MASTER 3

CALCULATOR + PROGRAM = COMPUTER

OBJECTIVES: Students will learn that computers combine calculating ability with programming. They will see how computers have increased in speed and power and decreased in size and energy needs since the 1950's.

Computers combine the arithmetic ability of a mechanical calculator with the stored instructions feature of machines like Jacquard's loom. A computer can follow the instructions given on punched cards or other information-storing devices, then carry out these instructions by performing mathematical operations. Together, these features equip the computer to make decisions—something no calculator can do.

Computers have changed since Mark I and ENIAC appeared in the 1940's. Size is the most visible change. Show students the illustrations on the activity master and discuss the significance of the size difference. Early computers cost millions of dollars and were operated by trained specialists. Modern home microcomputers can cost less than \$500 and be operated by a child.

In 1944, Mark I, a large electronic digital calculator, could add or subtract in one second. Today, microcomputers can execute nearly a million instructions in one second.

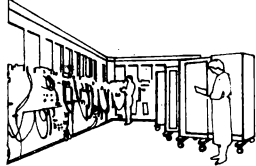

Additional Activity

Ask groups of students to find pictures of early calculators and early computers. (The bibliography contains sources that have such pictures.) Make a display to show size, shape, and speed differences.

ACTIVITY MASTER 3

CALCULATOR + PROGRAM = COMPUTER

Computers combine the best features of mechanical calculators with the stored instructions used by Jacquard's loom to make a decision-making, instruction-following machine — A COMPUTER!



Early computers were very big compared to today's microcomputers. Below is a list of features. See if you can pick out those that apply to each kind of computer.

<p><i>weighs 30 tons</i> <i>weighs 30 pounds</i> <i>occupies 3 square feet</i> <i>occupies 1500 square feet</i> <i>9 feet high</i> <i>1 foot high</i> <i>thousands of tiny transistors</i></p>	<p><i>1800 vacuum tubes</i> <i>adds 5000 times each second</i> <i>adds 100,000 times each second</i> <i>remembers up to 48,000 items of information</i> <i>remembers 1 item of information at a time</i> <i>uses as much energy as a locomotive</i> <i>uses as much energy as a 40 watt light bulb</i></p>
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Discussion Questions

1. What operations can a computer perform that make it like a calculator?
2. What do punched cards or other memory devices help a computer to do?
3. Why do you think computers are getting smaller?
4. In what ways is a smaller computer better?
5. Why is high speed important for a computer?
6. Why is low energy use important for a computer?
7. What can a computer remember with its memory?

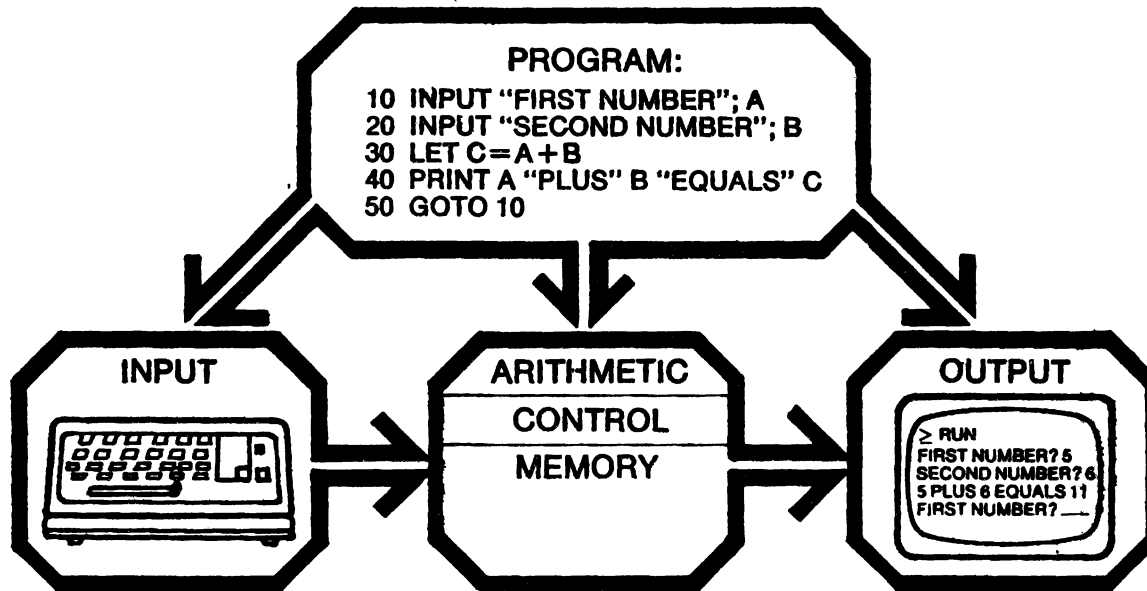
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Answers to Discussion Questions:

1. Addition, subtraction, multiplication, division, square root, etc.
2. Computers store programs and information in memory. Memory devices help a computer operate like a calculator with a memory.
3. Microelectronics enables computers to use smaller parts, allowing some parts of a computer to be put on a silicon chip smaller than a thumbnail.
4. More portable, cheaper.
5. The faster a computer, the more problems it can solve. When the computer saves time, it saves human energy.
6. The first computers required a room full of air conditioners to cool them and burned out vacuum tubes frequently. Low energy use makes today's computer much more efficient.
7. Information and programming.

• HOW DOES A COMPUTER WORK? •



Match each part shown in the boxes above with the correct description below. Write the name of the part in the blank beside its description.

- | | |
|--|--|
| <p>1. _____ tells the computer what to do and how to go about it.</p> <p>2. _____ puts information into the computer, usually on a keyboard that looks like a typewriter.</p> <p>3. _____ can add, subtract, and solve other kinds of problems.</p> <p>4. _____ controls all the operations in the computer.</p> | <p>5. _____ stores information within the computer or on cassette tapes or magnetic disks. Information (including programs) can be recalled from here by the computer when needed.</p> <p>6. _____ produces the answer to a problem, usually on a screen that looks like a television.</p> |
|--|--|

Discussion Questions

- | | |
|---|--|
| <p>1. What part of a microcomputer is largest? What part is the smallest? Why?</p> <p>2. Which part of a computer corresponds to <i>La Pascaline</i>? To the abacus?</p> <p>3. What can you do with your brain that a computer cannot do?</p> | <p>4. How is computer memory like yours? How does it differ from yours?</p> <p>5. Which can do a multiplication problem faster: your brain or a microcomputer?</p> |
|---|--|

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ACTIVITY MASTER 4

HOW DOES A COMPUTER WORK?

OBJECTIVES: Students will study the basic parts of modern computers. They will learn how each part works and how it relates to other parts to perform the functions of a computer.

Computers vary in size and shape, but the basic operating parts are the same, whether the computer fills a room or is smaller than a briefcase.

a. **Memory.** Ask students to recall *La Pascaline* and Jacquard's loom. What do they remember? Not all of them will remember the same details, but a computer remembers information exactly. A computer also follows remembered instructions. When do students do the same?

b. **Arithmetic.** Ask students to do a simple multiplication problem. What basic processes did they carry out? (Recording the problem, multiplying, adding.) Did they all get the same answer? Computers perform arithmetic operations and get the same answer every time.

c. **Control.** What would happen if students tried to solve a math problem without controlling the order in which they went through the steps? A computer's control unit makes sure every step is done at the right time and in the right order.

d. **Input/output.** Ask students how they take in information. How do they express information? Computers follow instructions exactly and produce accurate results, but it is up to humans to be sure the instructions are explicit and to interpret the results.

e. **Programming.** Ask students to make up a program for themselves as they prepare to take part in some activity. What are the steps in the program? Is the order of the steps important?

ACTIVITY MASTER 4

•HOW DOES A COMPUTER WORK?•

Match each part shown in the boxes above with the correct description below. Write the name of the part in the blank beside its description.

<p>1. _____ tells the computer what to do and how to go about it.</p> <p>2. _____ puts information into the computer, usually on a keyboard that looks like a typewriter.</p> <p>3. _____ can add, subtract, and solve other kinds of problems.</p> <p>4. _____ controls all the operations in the computer.</p>	<p>5. _____ stores information within the computer or on cassette tapes or magnetic disks. Information (including programs) can be recalled from here by the computer when needed.</p> <p>6. _____ produces the answer to a problem, usually on a screen that looks like a television.</p>
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Discussion Questions

<p>1. What part of a microcomputer is largest? What part is the smallest? Why?</p> <p>2. Which part of a computer corresponds to <i>La Pascaline</i>? To the abacus?</p> <p>3. What can you do with your brain that a computer cannot do?</p>	<p>4. How is computer memory like yours? How does it differ from yours?</p> <p>5. Which can do a multiplication problem faster: your brain or a microcomputer?</p>
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Additional Activities

- Show students pictures of different kinds of computer hardware. Discuss how each piece is used for input, output, processing, or storage.
- Visit an operating computer at a local business or institution. Talk with your host ahead of time so that he or she will describe the system in terms that correspond to those used in this unit.

Answers to Exercise:

- Program (Stored Instructions)
- Input
- Arithmetic
- Control
- Memory
- Output

Answers to Discussion Questions:

- Input and output components must be large enough for a human to control. Arithmetic, control, and memory components are sometimes smaller than a thumbnail.
- The arithmetic unit corresponds to problem-solving ability of both.
- Think, dream, imagine, create, etc.
- Both store information for later. A computer remembers everything; your memory is selective. Computer memory is controlled by program through control unit; yours is controlled by your brain.
- A computer can do 500 additions in 1/10 of a second. It can do a problem that you would need a year to do in 30 seconds.

TELLING A COMPUTER. WHAT TO DO

Imagine that you have a computer and you want it to solve a problem for you. Before the computer can help you, you must **program** it for your problem. In other words you

must tell it exactly what to do to find the answer.

Here is a program that will tell the computer to add two numbers together:

10 INPUT "FIRST NUMBER"; A

Every line in a program starts with a number, so the computer can follow its instructions in order. This line tells the computer to put FIRST NUMBER? on its screen. When you type in a number and press **[ENTER]**, the computer stores it and labels it "A."

20 INPUT "SECOND NUMBER"; B

SECOND NUMBER? appears on the screen. You type in another number and press **[ENTER]**. The computer stores it and labels it "B."

30 LET C=A+B

The computer adds A and B and labels the answer "C."

40 PRINT A "PLUS" B "EQUALS" C

The number labeled A appears on the screen, then the word PLUS, then the number labeled B, then the word EQUALS, then the number labeled C — the answer.

(A and B are the numbers you typed in. C is the number the computer got when it added A and B together.)

50 GOTO 10

The program goes back to line 10 and starts over again. Now you can type in different numbers for A and B.

When you type in RUN and press **[ENTER]**, the computer will "run" through the program, following your directions step by step.

If you run this program, typing in 5 for A and 6 for B, here is what will appear on the screen:

```
> RUN
FIRST NUMBER? 5
SECOND NUMBER? 6
5 PLUS 6 EQUALS 11
FIRST NUMBER? ___
```

Study this program carefully and then talk with your teacher and classmates about these questions:

1. What will appear on the screen if you type in two different numbers for A and B?
2. How would you change the program so the computer would *subtract* two numbers?

(Hint: change one thing in line 30 and one thing in line 40.)

3. How would you change the program so that the computer would add *four* numbers instead of two? (Hint: this program will have more lines.)

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ACTIVITY MASTER 5

TELLING A COMPUTER WHAT TO DO

OBJECTIVES: Students will study the steps in writing a computer program and practice writing a simple program.

Computers won't work until they are told what to do by a human. A computer program is a step-by-step set of instructions that tells the computer what operations to perform and in what order. Programmers are persons who write programs.

A programmer first analyzes the problem to be solved. Then he or she constructs a flow chart that lists all the steps in the solution arranged in proper order. The programmer uses symbols to indicate when the computer should start, stop, and make a decision. (See the bibliography for sources of information about flowcharting.)

The next step is to translate the flow chart into a language the computer understands. Computer programming languages have names like BASIC, PASCAL, FORTRAN, or COBOL. Some languages are better for use in business, some for science, and some for educational or home use. BASIC is the most common microcomputer language for educational or home use.

Additional Activities

1. Ask students to construct a flow chart for some activity they have done recently or do regularly: clean the garage, watch television, get ready for school, clean their room. Have they included every step? Have they shown where they made decisions in the activity?
2. Visit a Radio Shack computer center and ask to see some program listings.

ACTIVITY MASTER 5

TELLING A COMPUTER, WHAT TO DO

Imagine that you have a computer and you want it to solve a problem for you. Before the computer can help you, you must program it for your problem. In other words you must tell it exactly what to do to find the answer.

Here is a program that will tell the computer to add two numbers together:

```
10 INPUT "FIRST NUMBER"; A
20 INPUT "SECOND NUMBER"; B
30 LET C = A + B
40 PRINT A "PLUS" B "EQUALS" C
50 GOTO 10
```

Every line in a program starts with a number, so the computer can follow its instructions in order. This line tells the computer to put FIRST NUMBER? on its screen. When you type in a number and press **[ENTER]**, the computer stores it and labels it "A."

SECOND NUMBER? appears on the screen. You type in another number and press **[ENTER]**. The computer stores it and labels it "B."

The computer adds A and B and labels the answer "C."

The number labeled A appears on the screen, then the word PLUS, then the number labeled B, then the word EQUALS, then the number labeled C—the answer.

(A and B are the numbers you typed in. C is the number the computer got when it added A and B together.)

The program goes back to line 10 and starts over again. Now you can type in different numbers for A and B.

If you run this program, typing in 5 for A and 6 for B, here is what will appear on the screen:

```
> RUN
FIRST NUMBER? 5
SECOND NUMBER? 6
5 PLUS 6 EQUALS 11
FIRST NUMBER? _
```

Study this program carefully and then talk with your teacher and classmates about these questions:

1. What will appear on the screen if you type in two different numbers for A and B?
2. How would you change the program so the computer would subtract two numbers?
3. How would you change the program so that the computer would add four numbers instead of two? (Hint: this program will have more lines.)

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Answers to Discussion Questions:

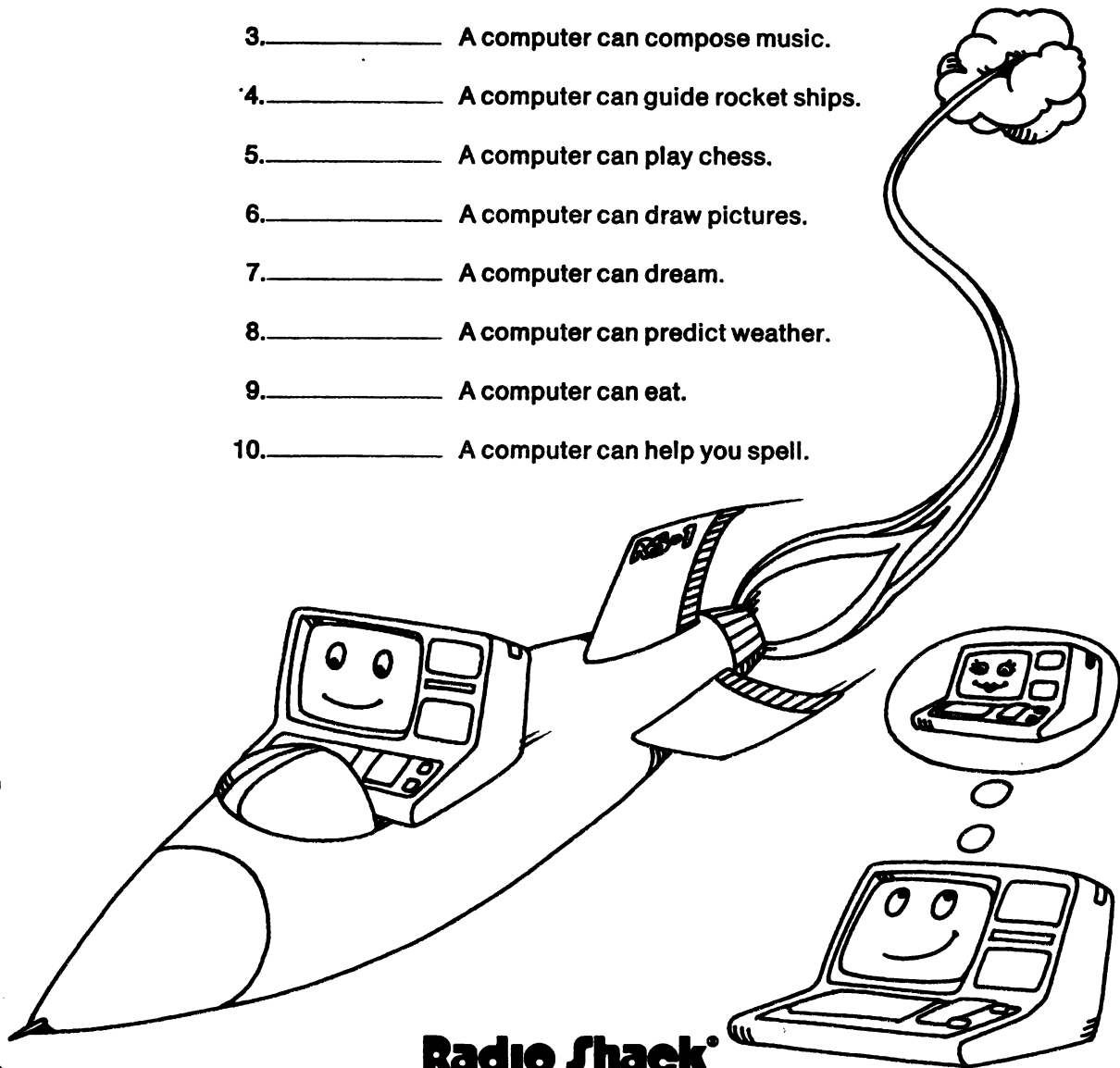
1. New numbers would appear in lines 2, 3, and 4 on the screen, and the new correct answers would appear after "EQUALS."
2. Change line 30 to:
30 LET C = A - B
Change line 40 to:
40 PRINT A "MINUS" B "EQUALS" C
3. Add lines 21 and 22:
21 INPUT "THIRD NUMBER"; C
22 INPUT "FOURTH NUMBER"; D
Change line 30 to:
30 LET E = A + B + C + D
Change line 40 to:
40 PRINT A "PLUS" B "PLUS" C "PLUS" D "EQUALS" E

WHAT COMPUTERS CAN AND CANNOT DO

Below are ten statements. Some describe what a computer really can do, and some describe what a computer cannot do. Write "yes" in front of each activity you think a

computer can perform. Write "no" in front of those you think a computer cannot perform.

1. _____ A computer can think.
2. _____ A computer can help your teacher.
3. _____ A computer can compose music.
4. _____ A computer can guide rocket ships.
5. _____ A computer can play chess.
6. _____ A computer can draw pictures.
7. _____ A computer can dream.
8. _____ A computer can predict weather.
9. _____ A computer can eat.
10. _____ A computer can help you spell.



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ACTIVITY MASTER 6

WHAT COMPUTERS CAN AND CANNOT DO

OBJECTIVES: Students will read a series of statements describing various activities, and they will decide whether a computer can or cannot perform each such activity. Then they will make their own list of microcomputer applications in school and at home.

Ask students to list the specific activities that they are sure computers perform for us. Put some of their responses on the board as a starting point for using the Activity Master.

When everyone finishes filling in the blanks, discuss the answers and add to the list on the board. Let this list be the beginning of group or individual projects about microcomputer applications in the school and at home.

Additional Activities

1. Invite a computer operator or salesperson to demonstrate a microcomputer to your class.
2. Have students write a poem or story about how computers might affect them in the future.

Answers to Exercise:

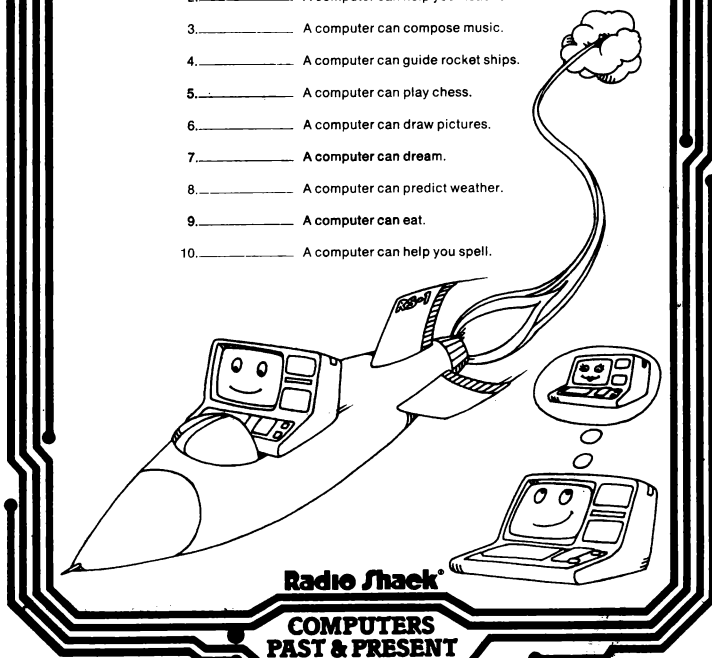
1. **No:** Computers cannot think, although they perform many of the processes the brain performs. They cannot think original thoughts and are subject to programs written by humans.
2. **Yes:** Especially in keeping records and controlling paperwork.
3. **Yes:** An early piece was the *Iliac Suite for String Quartet*, written in the 1950's.
4. **Yes:** The Pioneer and Voyager spacecraft had computers aboard instead of human pilots.

ACTIVITY MASTER 6

WHAT COMPUTERS CAN AND CANNOT DO

Below are ten statements. Some describe what a computer really can do, and some describe what a computer cannot do. Write "yes" in front of each activity you think a computer can perform. Write "no" in front of those you think a computer cannot perform.

1. _____ A computer can think.
2. _____ A computer can help your teacher.
3. _____ A computer can compose music.
4. _____ A computer can guide rocket ships.
5. _____ A computer can play chess.
6. _____ A computer can draw pictures.
7. _____ A computer can dream.
8. _____ A computer can predict weather.
9. _____ A computer can eat.
10. _____ A computer can help you spell.



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5. **Yes:** Computers have beaten some of the world's experts.
6. **Yes:** Artists use computers to see their ideas instantly.
7. **No:** A computer cannot dream, because it operates purely on logic and has no subconscious or imagination.

8. **Yes:** Computers are good predictors, because of their ability to compile, store, and compare.
9. **No:** It doesn't eat like humans, but it does take in and process information.
10. **Yes:** Microcomputers have programs to help anyone spell better.