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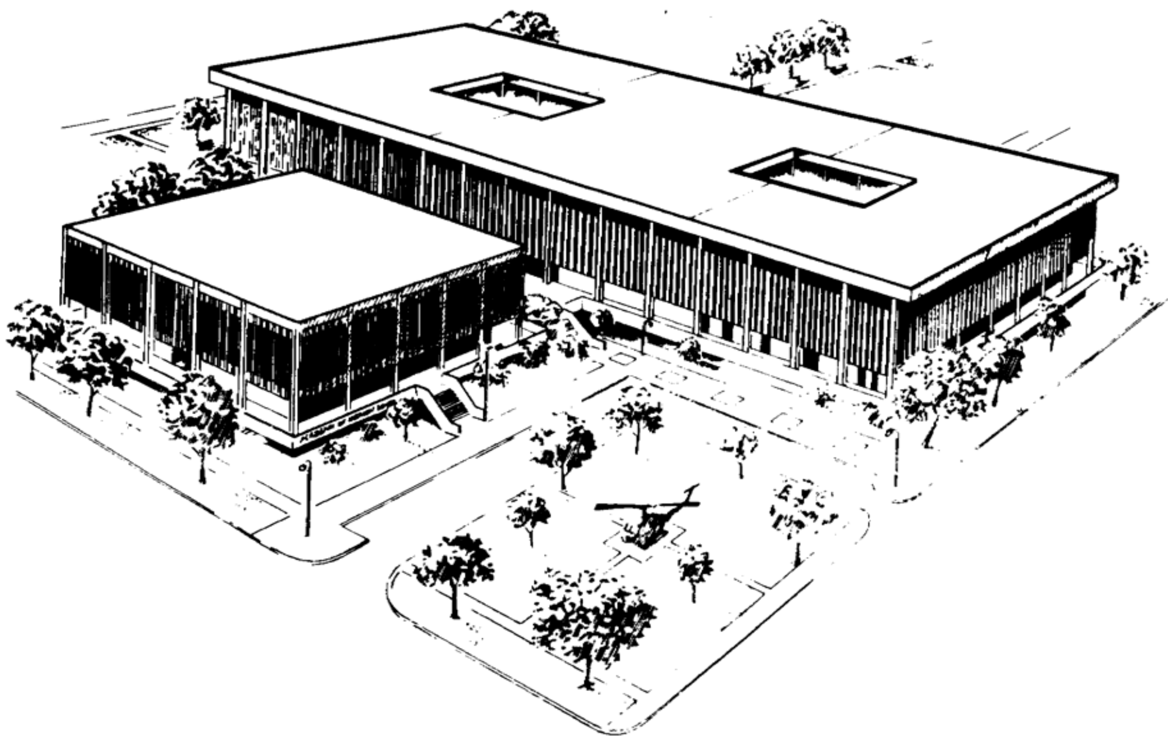

AMEDD COMPUTER LITERACY I

SUBCOURSE MD0057 EDITION 200

DEVELOPMENT

This subcourse is approved for resident and correspondence course instruction. It reflects the current thought of the Academy of Health Sciences and conforms to printed Department of the Army doctrine as closely as currently possible. Development and progress render such doctrine continuously subject to change.

ADMINISTRATION

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Approved students whose enrollments remain in good standing may apply to the Nonresident Instruction Branch for subsequent courses by telephone, letter, or e-mail.

Be sure your social security number is on all correspondence sent to the Academy of Health Sciences.

CLARIFICATION OF TRAINING LITERATURE TERMINOLOGY

When used in this publication, words such as "he," "him," "his," and "men" are intended to include both the masculine and feminine genders, unless specifically stated otherwise or when obvious in context.

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CORRESPONDENCE COURSE OF THE
U.S. ARMY MEDICAL DEPARTMENT CENTER AND SCHOOL

SUBCOURSE MD0057

AMEDD COMPUTER LITERACY I

INTRODUCTION

Computers have become such a pervasive and indispensable feature of the work setting, that it is hard to imagine functioning efficiently without them. While some have embraced computerization whole-heartedly, others have remained aloof, even hostile, to the changes computers have brought about.

This subcourse and its sequel (AMEDD Computer Literacy II) will not teach you how to use and operate a computer. (Those skills are best learned on the job, in circumstances, which permit constant and repeated practice.) But, it will help you to become computer-literate. That is, you will gain a working knowledge of how computers evolved, what the components do, and how computer systems work. In the sequel (AMEDD Computer Literacy II) you will learn how the computer translates digital messages into the binary code, how a program is designed, how computers are used in business, in health care, and in the x-ray department, and finally future trends, safety, personal comfort, and other issues. With this foundation, you should be able to use the computer more intelligently and master the actual operations more quickly.

Do your best to achieve the objectives of this subcourse. Make sure to read the captions of the illustrations and the definitions of new terms that appear throughout the text. New terms are presented in the body of text, and again in a glossary at end of the subcourse. These are devices designed to help you retain the subject matter more easily. Good luck and good reading.

Subcourse Components:

The subcourse instructional material consists of the following:

Lesson 1, The History of Computers.
Lesson 2, Computer Hardware.
Lesson 3, Computer Fundamentals.
Glossary

Study Suggestions:

Here are some suggestions that may be helpful to you in completing this subcourse:

--Read and study each lesson carefully.

--Complete the subcourse lesson by lesson. After completing each lesson, work the exercises at the end of the lesson, marking your answers in this booklet.

--After completing each set of lesson exercises, compare your answers with those on the solution sheet that follows the exercises. If you have answered an exercise incorrectly, check the reference cited after the answer on the solution sheet to determine why your response was not the correct one.

Credit Awarded:

To receive credit hours, you must be officially enrolled and complete an examination furnished by the Nonresident Instruction Branch at Fort Sam Houston, Texas. Upon successful completion of the examination for this subcourse, you will be awarded 10 credit hours.

You can enroll by going to the web site http://atrrs.army.mil and enrolling under "Self Development" (School Code 555).

A listing of correspondence courses and subcourses available through the Nonresident Instruction Section is found in Chapter 4 of DA Pamphlet 350-59, Army Correspondence Course Program Catalog. The DA PAM is available at the following website: http://www.usapa.army.mil/pdffiles/p350-59.pdf.

LESSON ASSIGNMENT

LESSON 1 The History of Computers.

LESSON ASSIGNMENT Paragraphs 1-1 through 1-26.

LESSON OBJECTIVES After completing this lesson, you should be able to identify (by selecting from alternatives):

1-1. Early aids to manual computation and their uses.

1-2. Distinctive features of machine-assisted, electromechanical, and electronic data processing devices.

1-3. Key points of the stored program theory of computers.

1-4. Differences among first-, second-, and third-generation computers.

SUGGESTION After reading the lesson over several times, complete the exercises at the end of the lesson. These exercises will help you to achieve the lesson objectives.

LESSON 1

THE HISTORY OF COMPUTERS

Section I. MANUAL PHASE

1-1. INTRODUCTION

a. We tend to think of the computer and activities like **data processing** as a phenomenon of recent times. In fact, the computer is as ancient as prehistory. The position of the stones at Stonehenge in England and the arrangement of the windows in the Mayan temples of Central America represent means of computing celestial movement. In 1901, divers exploring an ancient shipwreck off the coast of Antikythera, an island in the Aegean Sea, found a mechanical device with bronze cogs and wheels, an elaborate mechanism for determining celestial events for navigation. Based on this shipwreck, the device dates back to 100 BC.

data: facts, unevaluated messages, the raw material of information.

data processing: operations performed on data to derive information: originally done manually, later mechanically, and more recently by electronic means.

Figure 1-1. Stonehenge, in England. The positions of the stones were used to compute celestial movement,

b. Computing and record-keeping aids have been around for as long as people have been counting and keeping track of their affairs. Early forerunners to the modern computer, though crude by comparison, have served the same purpose: to facilitate the storage and processing of data.

1-2. MAKESHIFT AIDS

a. For a long time, our distant fore-bearers managed without keeping records. However, as society grew more structured and people organized into tribes, daily life grew too complex to function without records. When people began to collect animals, and engage in commerce, when families entered into social relations with one another, they began using the ten fingers and then stones, sticks, scratches on a rock, or knots in a string. These manual devices made it easier to account for sheep in a flock, days between cycles of the moon, or the number of successful hunts.

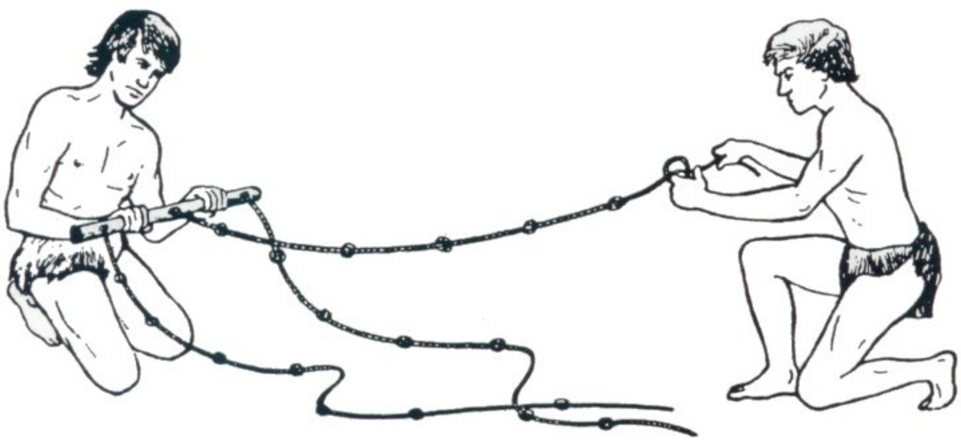

Figure 1-2. Knots on a string used to keep track of day-to-day affairs.

b. By about 4,000 years ago, early civilizations had developed sophisticated numbering systems to keep track of commercial transactions. At the Ashmolean Museum in Oxford, England, there is a royal Egyptian staff dating back to the year 3400 BC. Indentations in the wood make record of 120,000 prisoners taken, a booty of 400,000 oxen and 1,422,000 goats.

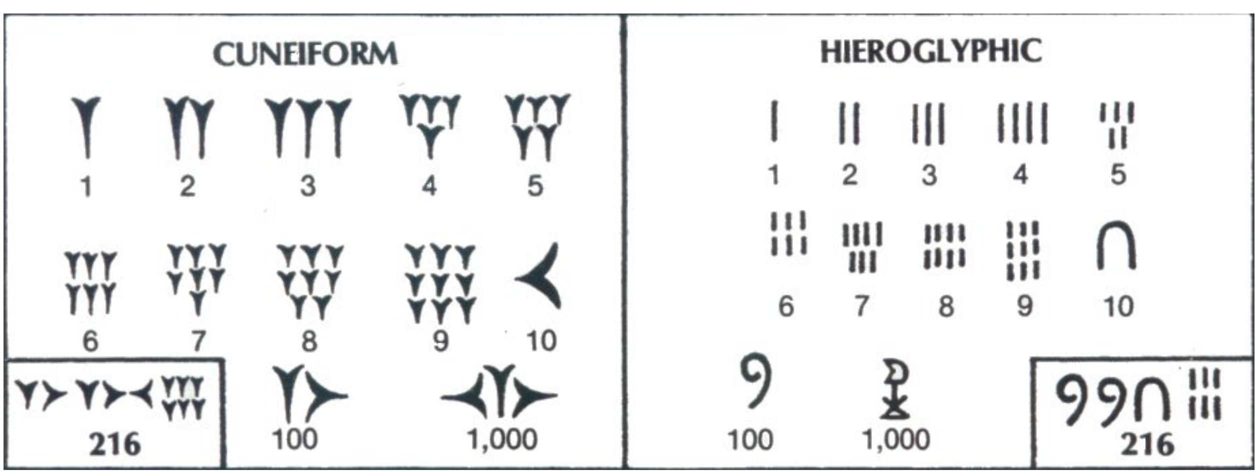

Figure 1-3. Ancient numbering systems used the additive method. The number "216" is shown in the corner insets, as written in cuneiform and hieroglyphics.

1-3. CUNEIFORM TABLETS

With the advent of nations and commerce, manual aids to memory proved inadequate. Around 3000 BC, well before the ancient Greeks and Romans, Babylonian merchants began using cuneiform tablets to record their transactions. Cuneiform symbols were cut into damp clay with a stylus and then baked. These tablets served as permanent records, and specimens have been unearthed reasonably intact in modern times.

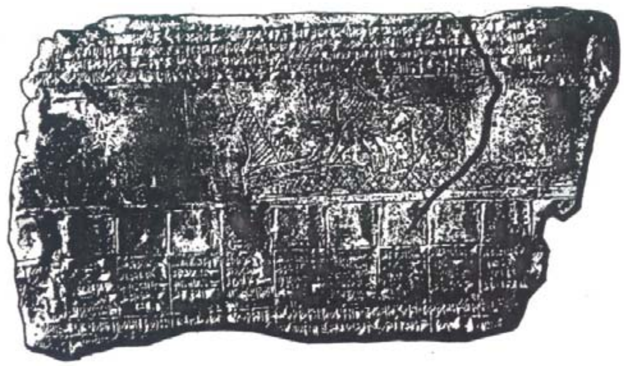

Figure 1-4. A cuneiform tablet used by Babylonian merchants.

1-4. HIEROGLYPHICS ON PAPYRUS SCROLLS

In the same period (circa 3200 BC), the Egyptians developed papyrus, a paper-like material made from the center layers of the papyrus plant. A sharp-pointed pen, known as a calmus, was used to make hieroglyphic inscriptions on the papyrus. Like the cuneiform tablets, papyrus scrolls permitted a more permanent means of record keeping. Scrolls, found in Egyptian tombs, have provided valuable information on Egyptian life.

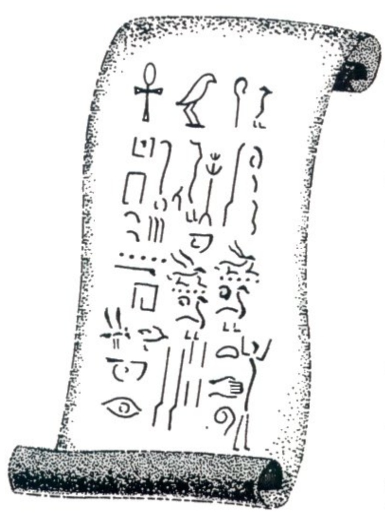

Figure 1-5. Egyptian hieroglyphics on a papyrus scroll.

1-5. EARLY DATA PROCESSING

The cuneiform tablets and papyrus scrolls represent an early form of data processing (facts recorded for subsequent use and manipulation). A more formal definition describes data processing as the storage and processing of discrete facts through one or more operations (recording, classifying, sorting, calculating, summarizing, storing, retrieving, reproducing, and/or communicating). In ancient times, all of these data processing operations were accomplished, but manually rather than electronically. Cave drawings, dating back to 2000 years BC, can be viewed as art. They also represent early attempts at data storage: a recording of the hunt, or other important events of daily life.

Figure 1-6. Cave drawing of a hunt as data storage.

1-6. THE ABACUS

a. The **abacus** is perhaps the most important early computing instrument, since it has been known and widely used for more than 2,000 years. All ordinary arithmetic operations can be performed by moving heads along a wire according to rules ("a program") that the user memorizes.

> **abacus**: an ancient calculating device composed of a frame of rods representing decimal columns, and beads that are moved on the rods to form digits.

b. In arithmetical terms, the rods of an abacus act as place columns. Each bead on the rod is worth one, those on the 10s rod are worth 10 apiece, and so on. The abacus is so efficient that not until the 17th century did it meet significant competition as a computational device. Still widely used in the Orient, skilled users have been known to perform computations more quickly and accurately than clerks using mechanical desk calculators.

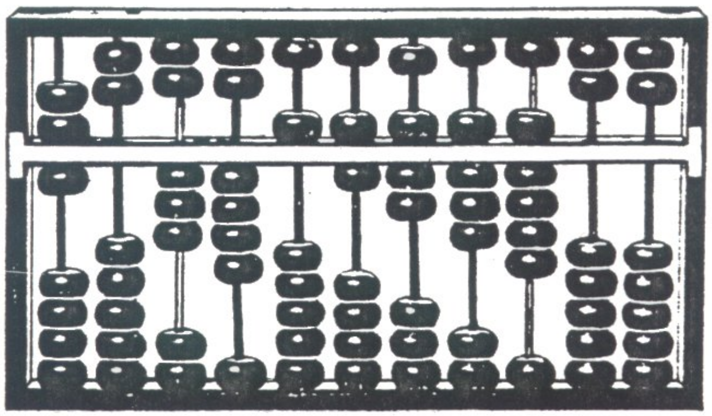

Figure 1-7. The abacus, the most widely used computing device.

1-7. THE AZTEC CALENDAR AND OTHER UNNAMED DATA PROCESSING TECHNIQUES

The Aztec calendar, used around 1000 AD, in Mexico and Central America, was based on the 52-year cycle of the planet Venus. Once deciphered, it was found to be a calendar of amazing accuracy. The Aztec calendar could, in a manner of speaking, be considered the world's first hard disk. This brief survey of early data processing is by no means comprehensive. It is only intended to give you a feel for the fact that data processing did not suddenly occur in modern times. In the next section, we take a quantum leap into the 17th century and the machine-assisted phase.

Figure 1-8. The Aztec calendar, a calculating device of amazing accuracy.

Section II. MACHINE-ASSISTED MANUAL PHASE

1-8. THE TECHNOLOGY GAP

a. **Introduction**. By the 17th century, significant progress in record keeping techniques had been achieved. The ancient Greeks had invented record audits; the Romans, banking systems and budgets; the medieval Florentines, Genoans, and Venetians of Italy, double bookkeeping entries. Despite these breakthroughs, manual recording remained essentially a tedious task performed by overworked clerks. There was a real technology gap. Available methods had not kept pace with population growth and the rapid increase in information. Tax collection, census taking, engineering, and astronomy were just a few of the areas that would have benefited from machine-assisted recording and computing devices at the time.

b. **Shickard's Digital Calculating Clock (1623).** Efforts to create mechanical computing aids date as far back as the 17th century. Though Blaise Pascal is commonly credited with the first digital calculator, it is, in fact, Wilhelm Schickard, a German astronomer, who actually holds this distinction. Schickard invented the first mechanical calculator that could add, subtract, multiply, and divide. He developed it as an aid to astronomers who, until then, had to do lengthy and tedious computations to develop their mathematical tables. (Shickard is little known because his work was destroyed during the Thirty Year's War. It was not recovered until 1957, when his correspondence with Johannes Kepler, the astronomer, was found).

digital: the representation of data for transmission by discrete signals.

digital calculator: a machine, like the abacus or adding machine, that essentially does counting operations.

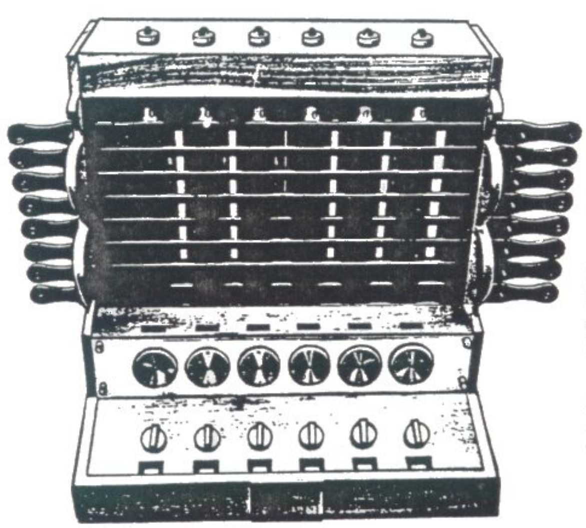

Figure 1-9. Shickard's digital calculating clock was the first mechanical calculator.

c. **Pascal's Adding Machine (1642).** Blaise Pascal, a French philosopher and inventor, was only 19 when he began work on an adding machine in 1642. He was inspired in the attempt by the computational drudgery of his father's job as regional tax official. Pascal's machine, the "Pascaline," was a boxed wheel-and-cog device; he built more than 50 versions of it over the course of a decade. The operator fed it the figures to be added by dialing them on a series of wheels. Each wheel, marked with the digits 0 through 9, stood for a particular decimal column (is, 10s, 100s, and so on). A wheel carried a total greater than nine by executing a complete turn and advancing the higher order wheel to its left by one digit. Pascal's principal of interlocking wheels remained central to the operation of most adding machines for the next 300 years. His machine could perform simple addition by carrying over, with relative ease. It performed other operations by a cumbersome system of repetitive additions. The machine was widely praised and the young Pascal presented a copy to King Louis XIV. It never made him rich.

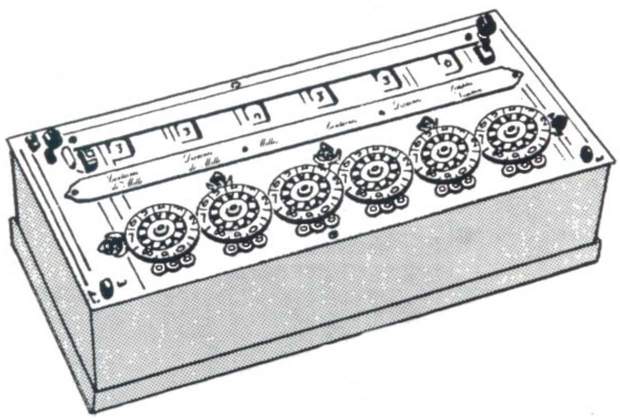

Figure 1-10. Pascal's adding machine used interlocking wheels, which remained central to most calculating devices for the next 300 years.

d. **The Von Leibniz Calculator (1673).** The next advance came in 1673, when Gottfried Wilhelm Von Leibniz attached a multiplication/division device to Pascal's basic machine. His was the first machine that could do subtraction, multiplication, and division easily. The device actually multiplied and divided through a process of successive adding and shifting, made automatic by a special component that speeded up the repetitive additions and subtractions involved in multiplying or dividing. Von Leibniz, an eccentric genius and mathematician, built the device as an aid to himself. For, though he understood calculus, he could not multiply, having failed to learn the multiplication tables. Of the tedious computations astronomers had to do, he wrote" it is unworthy of excellent men to lose hours like slaves in the labor of calculation which could be relegated to anyone else if machines were used."

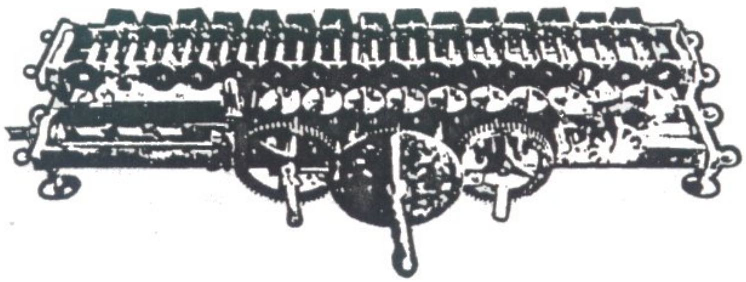

Figure 1-11. The Von Leibniz calculator could do all basic operations easily.

e. **The Colmar Commercial Mechanical Calculator (1820).** The prototypes built by Von Leibniz and Pascal was not widely used. The engineering techniques of the period could not produce the precision required to make these machines reliable. They remained curiosities until more than a century later, when Charles Xavier de Colmar developed the first commercially successful mechanical calculator that could add, subtract, multiply, and divide.

f. **The Bollee Calculator (1887).** Leon Bollee of France designed the first machine to perform multiplication successfully by a direct method instead of through cumbersome repeated additions.

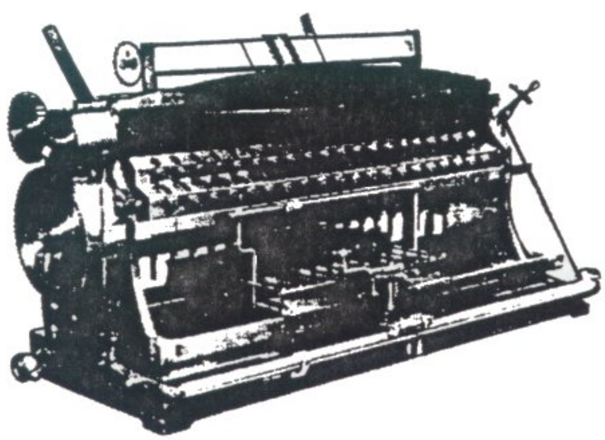

Figure 1-12. Bollee's calculator used the direct method of multiplication.

g. **Subsequent Advances (1890).** A succession of improved "desk-top' mechanical calculators followed, so that by 1890 the available built-in operations included: accumulation of partial results, storage, reintroduction of past results, and printing of results, each requiring manual application.

1-9. PUNCH-CARD DEVELOPMENT: JACQUARD'S PUNCH CARD-CONTROLLED LOOM (1800).

The punch card, a key feature of the early computers of the 1930s, was first applied to a mechanical loom, used for weaving damask patterns on table linens. Through out the 18th century, French silk weavers had experimented with schemes for guiding their looms by perforated tape, punch cards, or wooden drums. In all these systems, the presence or absence of holes created patterns in the fabric by controlling the way the yarns were raised or lowered. In 1804, Joseph Marie Jacquard built a fully automated loom that could handle enormously complicated designs. The loom was programmed by a mountain of punch cards, each card controlling single throws of the shuttle. To produce a new pattern, the operator simply replaced one set of cards for another. It could measure flower designs or pictures of men and women as easily as other looms could weave plain cloth. The Jacquard loom revolutionized the weaving industry and, in its essential features, is still in use today. What Jacquard did with punch cards was, in essence, to provide an effective means of communicating with the loom. The language was limited to just two "words," "hole" or "no hole." The same binary or two-based system is quite universal in today's modern computer. And though punch cards were important for weaving, they were destined to have their greatest impact on the development of computers.

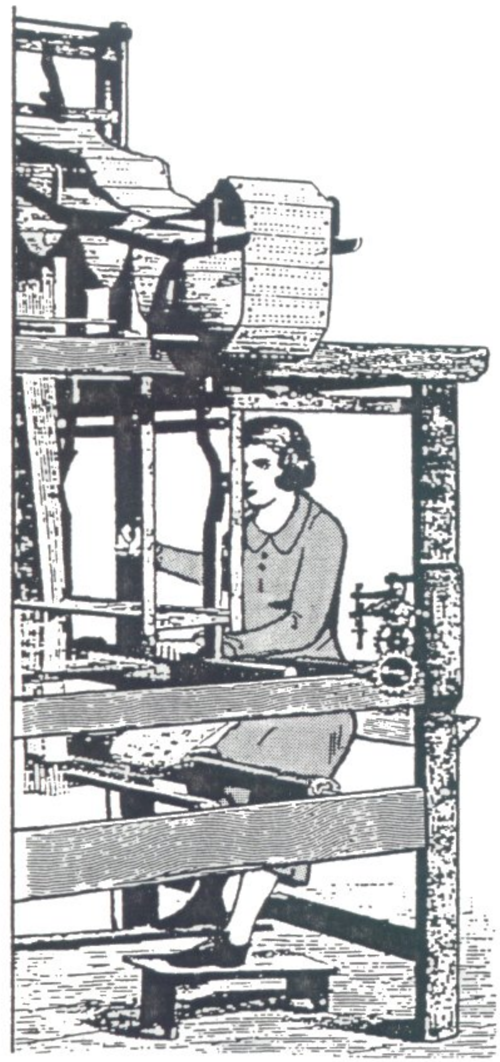

Figure 1-13. Jacquard's loom used punch cards to weave tablecloths.

1-10. AUTOMATIC MECHANICAL COMPUTERS

a. **The Babbage Machines**. The next breakthrough occurred in the early 19th century, when Charles Babbage set out to automate the lengthy computations used by astronomers in preparing math tables. Babbage, a math professor and eccentric genius, occupied the same Cambridge University chair of math once held by Sir Isaac Newton. Mathematical accuracy was a personal crusade with Babbage; he took pleasure in spotting errors in the logarithm tables of astronomers, mathematicians, and navigators. Observing that such calculations consisted of routine operations that were regularly repeated, he envisioned a machine that could do the computations automatically.

b. **Babbage's Difference Engine (1823).** In 1822, Babbage wrote a scholarly paper describing an automatic mechanical calculating machine that could prepare astronomers' math tables. It would be steam-powered, fully automatic, commanded by a fixed instruction program, and even equipped with printouts of the resulting tables. Babbage enlisted the support of the Royal Society, a prestigious association of scientists, to obtain government grants, and spent the next 10 years wrestling with his idea. By 1833, however, he abandoned it in favor of his next brainchild, the Analytical Engine.

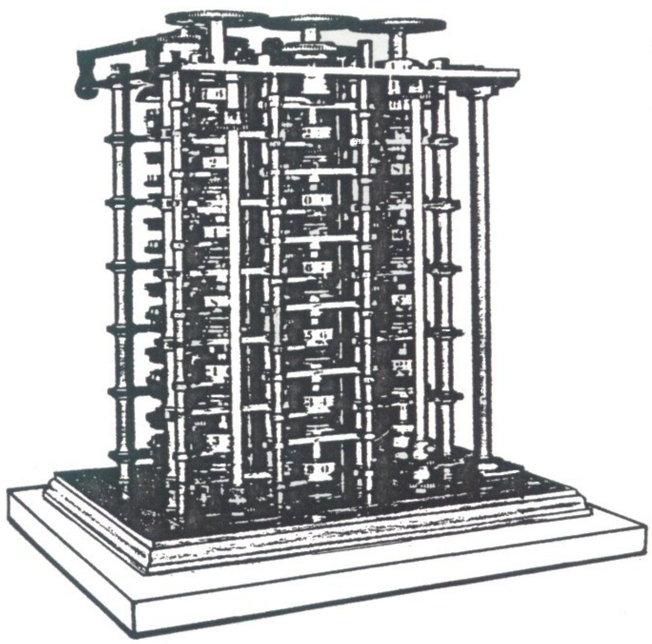

Figure 7-14. Babbage's Difference Engine, designed to calculate mathematical tables, never left the drawing board.

c. **Babbage's Analytical Engine (1833).**

(1) In 1833, Babbage went on to develop ideas for an even more ambitious machine. The Analytical Engine, unlike its predecessor, was designed not just to solve one type of math problem but to carry out a wide range of calculating tasks according to instructions supplied by its operator. It was to be "a machine of the most general nature," nothing less than the first general-purpose programmable computer. Babbage was at least 100 years ahead of his time in designing his Analytical Engine: a general-purpose, programmable, automatic mechanical digital computer. It was Babbage's great glory and lifelong frustration to have conceived the fundamental principles of the modern computer a century before the technology existed to build one. He spent many decades, much government money, and a good deal of his private fortune in the attempt.

(2) The Analytical Engine was to have a "mill" and a "store," both composed of cogs and wheels. The store would hold up to 100 forty-digit numbers at a time. Numbers would be kept in the store until their turn to be operated on in the mill. Results would then be moved back into the store to await further use or to be printed out. Instructions would be fed into the machine by means of punch cards.

(3) Lord Byron's daughter, Lady Ada Lovelace, assisted Babbage in the development of the Analytical Engine and actually designed and refined some of its internal characteristics. A brilliant mathematician in her own right, she helped to document some of Babbage's efforts. One of the few who actually comprehended the machine's methods and its vast potential for application, she wrote: "We may say most aptly that the Analytical Engine weaves algebraic patterns, just as the Jacquard loom weaves flowers and leaves." Regarding the Analytical Engine, Babbage declared that Lovelace "seemed to understand it better than I do." What she understood was the machine's radical conception. It was indeed a mathematical Jacquard's loom, essentially empty, but capable of executing any pattern or program that could be translated on punch cards. The Analytical Engine was never built. All that exists are plans and drawings of a small portion of the mill and printer built by Babbage's son. But Babbage's ideas set the stage for later developments.

d. **Post-Babbage Stagnation.** Between 1850 and 1937, little progress was made in automated digital computers. The advent of steam power and the great engineering feats of the period, leading to the development of railroads, steamships, textile mills, and bridges, created a strong need for machines that could perform many repetitive calculations quickly.

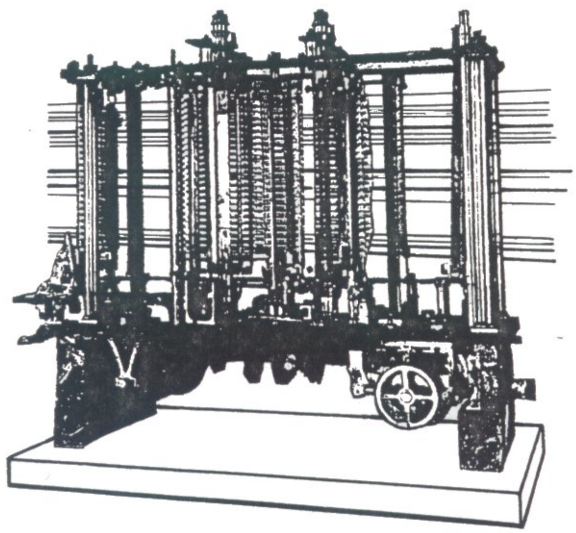

Figure 1-15. Babbage's Analytical Engine, conceived to “weave algebraic pattern as Jacquard's loom weaves flowers.”

Section III. ELECTROMECHANICAL PHASE

1-11. INTRODUCTION

Early calculators were, basically, mechanical devices using gears, levers, and pulleys. But they were generally unreliable, bulky, heavy, and slow. And so, by the post-Civil War era, record keeping and computing in the United States (US) continued to be largely manual, with pen, pencil, ruler, worksheet, and ledger still the primary tools. Less than one percent of record keeping was machine assisted. The gap between volume of information and available methods of capturing data was so great that the 1880 census took 10 years to complete. It was finally completed in 1890, in time for the 1890 census! This state of affairs gave the impetus for the development of electromechanical aids.

electromechanical: composed of both electrical and mechanical parts.

1-12. HOLLERITH'S PUNCH CARD-CONTROLLED CENSUS MACHINE (1890)

a. **The Need for Automation.** The excessive time required for the 1880 census placed Congress in violation of its own laws. By law, Congressional seats were supposed to be reapportioned every 10 years, based on census results. Therefore, the Census Bureau commissioned Herman Hollerith, an engineer and statistician, to design a machine that would automate the 1890 census.

b. **Hollerith's Vertical Sorter.** It was not until 20 years after Babbage's death that punch cards were finally applied to data processing. Dr. Herman Hollerith, an engineer and statistician assigned to the Census Bureau, had watched hundreds of clerks go through the laborious exercise of tabulating the 1880 census by hand. He spent the 1880s working to develop a punch card system. By 1890, he had perfected his vertical sorter, a machine-readable punch card that could handle 50 to 80 cards per minute. With tabulating reduced to one-eighth the previous time, Hollerith's vertical sorter was adopted as the official census machine. The 1890 census was completed in only 3 years, for a population of 63,000,000. By contrast, it had taken 10 years to hand-count the records of the 53,000,000 citizens participating in the 1880 census.

c. **The Workings of the Vertical Sorter**. The cards in Hollerith's tabulator were the size of dollar bills. Each card had 12 rows of 20 holes to be punched for the data on age, sex, number of children, occupation, marital status, and everything else the census wanted to know about the U.S. population. Canvassers in the field recorded the information on forms. These were sent to Washington, where the information was transferred to the cards by punching the appropriate holes. Fed into another device hooked up to the tabulating machines, the punch cards were pressed into ranks of fine pins, one for each of the 240 items on the card. When a pin found a hole, it pushed through to dip into a small cup of mercury, thereby completing an electromagnetic circuit and causing an indicator on a bank of recording dials to move forward one place.

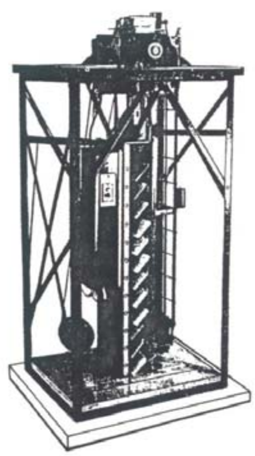

Figure 1-16. Hollerith's vertical sorter tabulated data for the 1890 census using punch cards.

d. **Facts vs Information.** The raw, discrete, and unevaluated facts on age, sex, etc., were input into the sorter, and useful information, summarizing population totals by Congressional district, average number of children, and so forth, was compiled.

information: data arranged in useful ordered form; the output of manipulated data.

NOTE: Although facts and information are used interchangeably in common usage, the above distinction does exist, and is important in terms of computers and what they do.

e. **Significance of the Vertical Sorter.** With this new use of the punch card, Hollerith made an important step toward automated computation. Earlier applications of the punch card had been uniquely for process control. In Jacquard's loom, the punch card controlled the weaving pattern (a process). Hollerith was the first to use the punch card as a medium for data processing. So just 19 years after Charles Babbage's death, an element of his Analytical Engine, punch cards, appeared in a functioning machine.

f. **Features of the Vertical Sorter.** Hollerith's census machine or vertical sorter could automatically "read" the information that had been punched into cards, without human intermediation. The card passed through a reading station equipped with special brushes and a contact roller to convert the holes in a card into electric impulses. The electric impulses were then processed by the machine to obtain the desired output.

g. **Advantages of the Vertical Sorter.** With automation, reading errors were greatly reduced, workflow was increased and, most important, stacks of punch cards could be used as an accessible memory store of almost unlimited capacity. In addition, different problems could be stored on different batches of cards and worked on, as needed.

h. **Later Implications.** Hollerith won prizes, praise, and a doctorate from Columbia University for his invention. "The apparatus, marveled 'The Electrical Engineer,' works as unerringly as the mills of the Gods, but beat them hallow as to the speed.` Hollerith went on to form his own company to promote the commercial use of his machines, successfully adapting his census machine for commercial use. He sold his inventions to the railroads, government offices, and even Czarist Russia. The company was immediately and lastingly successful. Over the years it passed through a series of mergers, to eventually become IBM.

1-13. OTHER PUNCH CARD APPLICATIONS

a. **Business and Science.** For the next 50 years, punch card machines did the bulk of the world's business computing and a considerable portion of the computing work of science. With Hollerith's success, improved punch card machines were developed by IBM, Remington-Rand, Burroughs, and other corporations.

b. **Features of Electromechanical Punch Card Machines**. Electromechanical devices used electrical power to provide mechanical motion to do such things as turn the wheels of an adding machine. Such systems could automatically feed in a specified number of cards from a "read-in' station. They could also add, multiply, and sort and feed out cards with punched results. By modern standards, the punch card machines were slow, processing 50 to 250 cards per minute, with each card holding up to 80 decimal numbers. And the need for manual intervention between processing stages was a major drawback. But, nonetheless, punch cards marked a significant step forward, providing a means of input, output, and memory storage on a massive scale.

electromechanical: composed of electrical and mechanical parts.

1-14. PUNCH CARD EQUIPMENT VS LATER COMPUTERS

Punch card equipment was effective in performing many of the individual steps necessary to process data, e.g., sorting, calculating, and summarizing. But it still required people to handle trays of cards between each step. Separate machines had to be fed, started, and stopped. The limited intercommunication between processing stages and the need for manual intervention are the major disadvantages of punch card equipment. Ultimately, with modern computers, manual interference between data input and information output would be eliminated. Alterable instructions directing the machine to perform automatically would be stored within the machine itself.

computer: any automatic device capable of performing calculations without human intervention.

1-15. AIKEN'S MARK I AUTOMATIC DIGITAL COMPUTER (1937-1944)

a. **Introduction.** In 1944, Howard Aiken of Harvard University completed the Mark I automatic digital computer, the first in a series of automatic calculating machines that he built. The Mark I combined established technology with Hollerith's punch card techniques. Besides arithmetic operations, these new machines had special built-in programs or subroutines to handle logarithms and trigonometric functions. In a sense, this was the realization of Babbage's unrealized Analytical Engine (though Aiken was unaware of Babbage's work until the Mark I was near completion).

program: a sequence of detailed instructions for performing an operation on a problem by computer.

routine: ordered set of general instructions.

subroutine: a routine that can be part of another routine or program.

b. **Features of the Mark I.** The Mark I was 51 feet long and B feet high and contained 760,000 parts. It was an electromechanical computer. Electromagnetic relays automatically controlled internal operations, while 78 mechanical adding machines and desk calculators performed arithmetic operations. The relays automated the calculating machines, so that long calculations could be done without human intervention.

c. **Use of the Mark I**. During World War II, Allied intelligence discovered that the Nazis were experimenting with an electronically directed cannon. The Mark I was used to evaluate many complex mathematical formulas and resulted in the discovery that such a cannon would never function. While the Nazis wasted valuable research time on this project, the Allies were able to ignore it as a military threat.

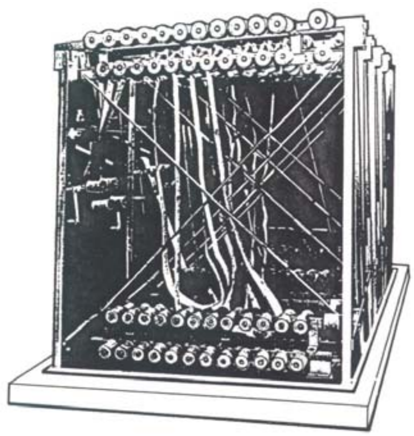

Figure 1-17. The Mark I computed complex ballistics tables using vast quantities of punched paper. After World War II, it was used for 15 more years at Harvard University.

Section IV. ELECTRONIC PHASE

1-16. THE IMPETUS: WORLD WAR II

From the outbreak of World War II, the War Department's Ballistic Research Lab at the Army's Aberdeen Proving Ground in Maryland had been trying to prepare artillery firing tables for gunners in the field. Gun crews desperately needed these trajectory tables so they could adjust their aim according to range, altitude, wind, temperature and other conditions. Gunners in North Africa, for example, had been complaining that the soft ground there caused unpredictable recoil of their cannon and threw off their aim. With 750 different multiplications required to calculate a single trajectory path, and at least 2000 trajectories per table, human operators (assisted by an inefficient Mark I) fell increasingly behind. Therefore, the Army awarded $400,000 to the nearby University of Pennsylvania's Moore School of Engineering to develop a computer that could handle these trajectory calculations.

1-17. ELECTRONIC NUMERICAL INTEGRATOR AND COMPUTER. (1939-1946)

a. **Importance of the Electronic Numerical Integrator and Computer**. Between 1939 and 1946, engineers John P. Eckert and John W. Mauchley headed a team of 50 at the Moore School to work on the Army's secret project. By 1945, they built the Electronic Numerical Integrator and Computer (ENIAC), the first high-speed, all-electronic computer. The Electronic Numerical Integrator and Computer could effectively track the trajectory of rockets and missiles. However, with the war nearly over, ENIAC was used to evaluate the feasibility of the hydrogen bomb and it continued to be used in the cold war years (1946--1955) to test new systems.

b. **The Cumbersome Decimal-Based the Electronic Numerical Integrator and Computer**. The Electronic Numerical Integrator and Computer was a terribly complicated computer. Because it handled numbers in decimal form, it needed about 17,468 vacuum tubes. Mauchley preferred the familiar decimal approach because he wanted "the equipment to be readable in human terms." However, this meant frequent breakdowns. With so many tubes operating at a rate of 100,000 pulses per second, there were 1.7 billion chances every second of a tube failing.

> **vacuum tube**: electronic circuits used in first-generation computers, eventually replaced by transistors and then by integrated circuits.

c**. Key Drawback: Wire-Your-Own Programming**. The Electronic Numerical Integrator and Computer's main drawback was the difficulty in changing its instructions or programs. Reprogramming involved an awkward process of rewiring. Someone who wanted to switch from calculating artillery-firing tables to designing a bridge had to plug and unplug hundreds of wires, and depending on the program's complexity, rewiring could take anywhere from 4 hours to 2 days. This wire-your-own programming drawback resulted from the fact that ENIAC had only enough internal memory to handle the numbers involved in the computations it was performing. Programs had to be literally wired into the complex circuitry. (EDVAC, Eckert and Mauchley's next project, would feature a stored program, which was central to the concept of the modern computer.)

d. **Size, Space, and Heat**. By today's standards, ENIAC seems primitive, occupying 2800 square feet and requiring over 17,000 vacuum tubes. Vacuum tubes took up space, gobbled electricity, generated heat, and burned out rapidly. If one tube went out, the whole system went down. The Electronic Numerical Integrator and Computer 's 17,468 tubes gave off so much heat that, despite fans intended to cool the machine, the temperature in the room sometimes reached 120ºF. Vacuum tubes, wrote one historian, “afflicted the early computer with a kind of technological elephantiasis.”

e. **The Electronic Numerical Integrator and Computer vs. Previous Generations of Computers.** For its time, ENIAC represented a marked improvement over previous generations of computers. It was 1,000 times faster than earlier computers. The Electronic Numerical Integrator and Computer could do in one day what a manual operation would require 300 days to perform. It could do 300 multiplications in one second, whereas the fastest electromechanical devices could perform only one multiplication per second. Most importantly, ENIAC served its intended purpose of performing the calculations necessary for World War II weapons systems. There were a number of disparaging stories about ENIAC. (It was said that all the lights in West Philadelphia would dim when ENIAC was turned on, and that three or more tubes would always burn out when it was started.) But those anecdotes notwithstanding, ENIAC was so successful that it marked the end of the pioneer stage of automatic computer development. The success of ENIAC led Eckert and Mauchley to eventually form the Remington-Rand Corporation.

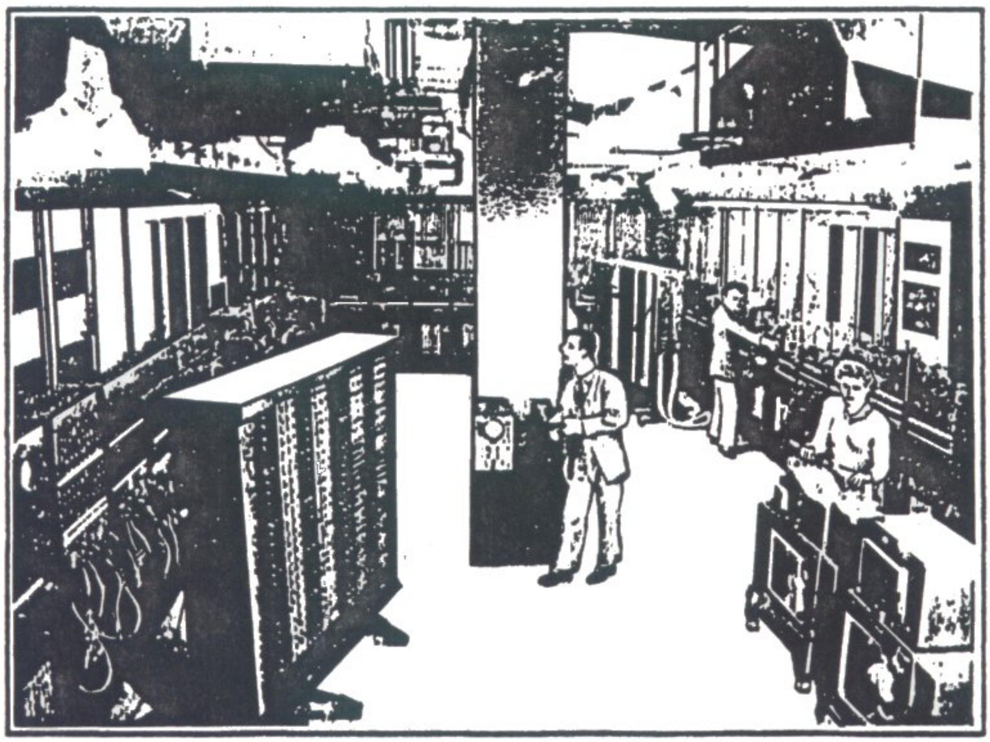

Figure 1-18. The Electronic Numerical Integrator and Computer, the first electronic digital computer, was hard to program for other purposes.

1-18. VON NEUMAN SUMMARIZES KEY CONCEPTS OF THE MODERN "STORED PROGRAM" COMPUTER (1945)

a. **Von Neuman Translates Abstract Theory into Practical Terms**. Hungarian-born, John Von Neuman was a mathematical genius and a member of the prestigious Institute of Study in Princeton. He was hired as a special consultant to help Eckert and Mauchley on the hydrogen bomb testing and ongoing work on EDVAC, one of the first stored program computers. Von Neuman had the vision to realize the modern computer could be an all-purpose tool, not just a high-speed calculator. He also had a knack for translating abstract mathematical theory into practical terms. In June 1945, less than a year after joining the Eckert and Mauchley team, he wrote a 101-page memorandum summarizing the team's plans for EDVAC. His clear description of the machine and its inner logic drew the attention of Herman Goldstine, the Army liaison officer who had sought him out for the project. Goldstine was so impressed with the memo that he sent it to scientists and professors in both the U.S. and England (committing a breach of military secrecy). In the memo, Von Neuman outlined the key concepts of the modern stored program computer. His prestige lent credibility to computer research. Many of the readers erroneously assumed that all the ideas in the memo, especially the proposal to store programs in the computer's memory, were Von Neuman's. This angered Eckert and Mauchley, who had not been able to publish anything about EDVAC because of the military secrecy of the project. This led to the eventual dissolution of the team,

b. "**Von Neuman's First Draft of a Report on EDVAC**." Von Neuman described a computer that would have a very simple, fixed physical structure. It would not need changes in hardware like ENIAC, and yet it would be able to perform any kind of computation effectively. The means would be a properly programmed control. Although, all of the ideas were not uniquely his own, Von Neuman did contribute to a new understanding of how practical fast computers should be organized and built. These ideas, often referred to as the "stored-program theory," which became fundamental for future generations of high-speed digital computers and were universally adopted.

c. **Features of the Stored Program Computer.** The stored program technique involves many more features than the one named which, in combination, make very high-speed operations, such as 1,000 arithmetic operations per second, feasible.

> **stored program computer model:** A design theory upon which most modern computers are based. It holds that instructions as well as data should be stored internally in the machine in magnetic form, so they can be altered as the program progresses.

(1) Binary system. Von Neuman was the first to suggest the use of a binary numbering system represented by only two digits (0 and 1) to build computers, rather than the 10 digits (0 to 9) of the decimal system. He suggested that equipment design lent itself to the binary system since electronic components are either "on" or "off," conducting or not conducting, magnetized or not magnetized. Thus, computer instructions could be coded as numbers and stored internally in the machine along with data.

(2) Data and instructions stored together. The storage of instruction programs with data in the same memory unit made it possible to arithmetically modify instructions in the same way as data.

(3) Alterable instructions. Alterable instructions provided the capability to alter instructions, as needed, during a computation to make them behave differently.

(4) Conditional control transfer. Conditional control transfer was a type of machine instruction that permitted the program sequence to be interrupted and reinitiated at any point.

conditional control transfer: a machine instruction that transfers control to a designated instruction if some condition is true and continues in sequence to the next instruction if the condition is not true.

(5) Programs in the subroutine library. With this innovation, frequently used subroutines did not have to be reprogrammed for each new problem, but could be kept intact in libraries and read into memory when needed. Thus, much of a given program could be assembled from the subroutine library.

library: a collection of statement routines or executable programs, normally residing on disk, that may be readily accessible for use by a computer. Most systems have several libraries.

(6) The memory an assembly place for instructions. The all purpose computer memory was like the assembly place in which parts of a long computation were stored, worked on piecewise, and assembled to form the final results.

(7) Control as assembly place. The computer control served as an errand runner for the overall process.

(8) Read and write memory (RAM) is designed to provide almost constant access to any particular piece of information. Contents can be retrieved and altered by the user at will.

RAM: a form of temporary internal storage whose contents can be retrieved and altered by the user; also called "read and write memory." (The acronym, RAM, remains in common usage, although the term "random access memory" does not.)

d. **First-Generation Stored Program Computers (1947).** The first generation of modern programmed electronic computers appeared in 1947. These machines had punched-card or punched-tape input and output devices and RAMS of 1,000-word capacity. Physically, they were more compact than ENIAC; some were about the size of a grand piano and used 2,500 electron tubes, far fewer than required by the earlier computers. They needed considerable maintenance, attained perhaps 70 to 80 percent reliability, and were used for 8 to 12 years. This group of machines included EDSAC, EDVAC and UNIVAC.

(1) Electronic Delay Storage Automatic Computer (EDSAC) (1949) was the first computer to incorporate the ideas outlined by Von Neuman. Von Neuman's historic report caused a furor in the computing world. ENIAC, the world's first high-speed calculating device, had just been developed and now, at essentially the same time, or. Von Neuman proposed an entirely new machine. Built at Cambridge University in 1949, EDSAC was no faster than ENIAC, but it did utilize the binary number system and instructions that were stored internally. These instructions were called a program, thus the name "stored program."

(2) Electronic Discrete Variable Automatic Computer (EDVAC) (1952), a computer similar to EDVAC, was the second machine designed by the Eckert-Mauchley team. EDVAC was smaller, faster, more versatile, and more flexible than ENIAC.

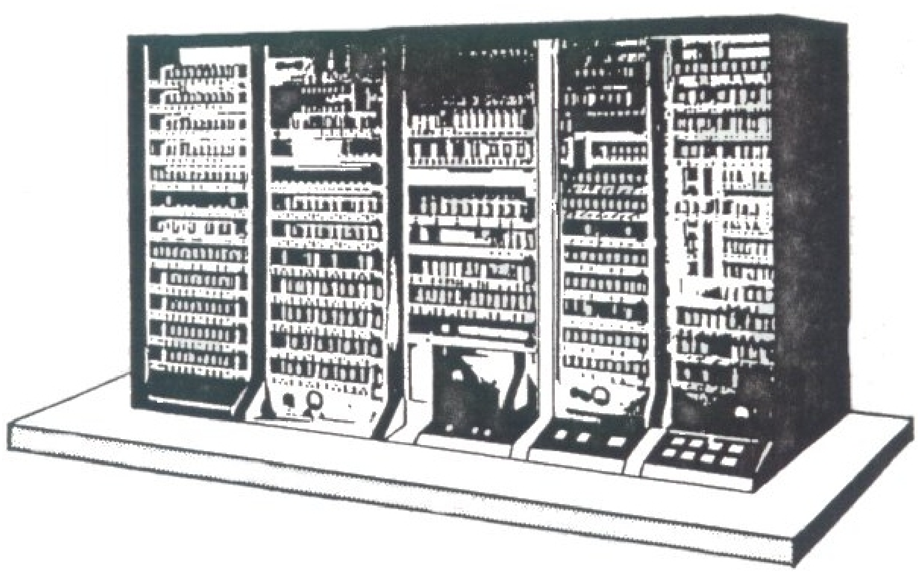

Figure 1-19. EDSAC, the first computer that stored its own programs.

(3) Universal Automatic Computer (UNIVAC) (1952). Eckert and Mauchley built UNIVAC, the first computer offered as a commercial product. In early 1951, the Census Bureau acquired the first UNIVAC, which remained operational until 1963. The first computer acquired for data processing and record keeping by a business was another UNIVAC, which was installed in 1954 at General Electric's Appliance Park in Louisville, Kentucky.

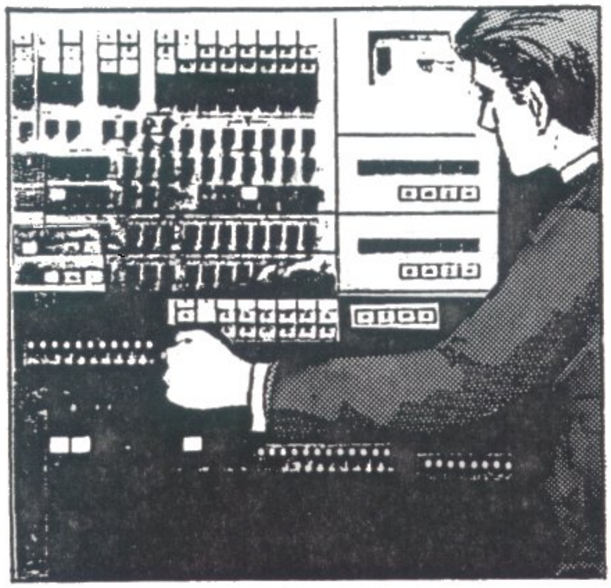

Figure 1-20. UNIVAC, the first computer offered commercially.

1-19. SECOND-GENERATION SOLID-STATE COMPUTERS (1959)

The transistor was invented at Bell Laboratories in 1947. It took nearly a decade of research to perfect the solid-state technology that the transistor represented. When transistors were applied to computers in 1959, another milestone was achieved. Second-generation solid-state computers were better, faster, and more efficient because of transistors.

transistor: a type of electronic circuitry found in second generation computers; smaller, faster, and more reliable than vacuum tubes, but inferior to third-generation integrated circuits.

solid state: pertaining to electronic devices, transistors or crystals that can control current without the use of moving parts, heated filaments, or vacuum tubes.

a. **Reduced Size.** When transistors replaced vacuum tubes, computers got smaller. You will recall that first-generation computers, such as ENIAC, were as large as silos and weighed about 30 tons.

b. **Increased Speed.** Early transistors were only 1/200th the size of the bulky vacuum tubes. Because of this, an electric impulse had a shorter distance to travel within it and was, therefore, much faster than a vacuum tube.

c. **Reduced Heat and Increased Reliability.** Vacuum tubes gave off so much heat that, despite air conditioning, the heat generated affected the reliability of the machines. Since the transistor was a solid one-piece unit, it was far more rugged and reliable and produced much less heat.

1-20. THIRD-GENERATION INTEGRATED CIRCUIT COMPUTERS (1964)

Third-generation computers, introduced in 1964, made use of microelectronic or integrated circuits on a large scale. This technology compressed hundreds of thousands of transistor circuits into minute silicon microchips. A single silicon microchip, smaller than a baby's fingernail, could hold hundreds of thousands of electronic components. Microchips and other advances resulted in expanded speed, efficiency, and memory capability.

> **integrated circuit:** electronic circuit whose components are etched on a single piece of semiconductor material, usually a silicon chip, less than 1/8 inch square; permits faster, cheaper processing than with transistors.

Section V. REVIEW

1-21. MANUAL PHASE

a. Computing and record-keeping devices used increasingly as people organized into tribes and began engaging in commerce.

b. Earliest manual aids to memory: fingers, stones, sticks, scratches on a rock, knots in a string.

c. Early manual data processing (facts recorded for later use and manipulation), circa 3000 BC.

(1) Cuneiform, clay tablets used by Babylonian merchants.

(2) Papyrus scrolls, paper-like parchment used by Egyptians to inscribe hieroglyphics.

d. The abacus: the most important early computing device known. It was widely used since 2000 BC, .and is still used a lot in the Orient.

1-22. MACHINE-ASSISTED MANUAL PHASE

a. By the 17th century, overworked clerks could not keep up with the need for fast, accurate record-keeping and computing in such areas as: astronomy, engineering, census-taking, and tax collection.

b. Various machines to assist in manual computation were designed and/or developed in this period.

(1) Digital calculating clock--Shickard, 1623. (His adding machine preceded Pascal's, but his work was lost until 1957.)

(2) Adding machine--Pascal, 1642. Commonly credited as the first, because Schickard's work was lost. Could add and subtract by carrying over. Other operations performed through a cumbersome process of repetitive additions. System of interlocking wheels central to most adding machines for the next 300 years.

(3) Von Leibniz's calculating machine, 1673. A multiplication and division device was attached to Pascal's basic machine so that these operations were accomplished through a process of successive adding.

(4) Colmar's calculator, 1820. The first commercially successful mechanical calculator.

(5) Bollee's calculator. 1887. Eliminated the need for repeated additions.

1-23. PUNCH CARD DEVELOPMENT

a. Jacquard's punch card-controlled loom, 1801.

B. First application of punch cards to control a process: weaving patterns for damask tablecloths.

1-24. AUTOMATIC MECHANICAL COMPUTERS, 19TH CENTURY

Charles Babbage--100 Years Ahead of His Time. Conceived of modern programmable computer with printout and memory before the necessary technology existed.

a. Difference engine, 1823. Automatic mechanical calculating machine, designed to prepare astronomer's math tables; never completed.

b. Analytical engine, 1833.

(1) General-purpose, programmable, automatic mechanical digital computer.

(2) Had features of modern computer: punch card input, memory unit, automatic printout, sequential program control, and 20-place accuracy.

(3) Wrote the Countess of Lovelace, "We may say most aptly that the Analytical Engine weaves algebraic patterns just as the Jacquard loom weaves flowers and leaves."

(4) Designed, but never completed.

1-25. ELECTROMECHANICAL PHASE

a. It took 10 years to tabulate results of the 1880 census by hand. The inadequacy of manual data collection and manipulation triggered the creation of Hollerith's vertical sorter or census machine in 1890.

b. Hollerith's punch card-controlled machine automated the 1890 census.

(1) Hollerith used punch cards as a medium for data processing, whereas Jacquard's loom had used punch cards to control a process (weaving).

(2) Automatic reading of information punched into card without human intermediation; this reduced reading errors and increased workflow.

(3) Accessible memory store of almost unlimited capacity provided by stacks of punch cards.

(4) The 1890 census was completed in only 3 years with the use of Hollerith's vertical sorter or census machine.

c. Features of punch card equipment:

(1) Electromechanical machine: electric power provided mechanical motion, that is, to turn the wheels of an adding machine.

(2) Automatic reading: cards fed into a read-in station, results fed out on punch cards.

(3) Sorted, calculated, and summarized (individual steps of data processing).

(4) Drawbacks of punch card equipment:

(a) Manual intervention between processing stages, that is, people handling trays of cards between each step. Separate machines to be fed, started, and stopped.

(b) Limited intercommunication between processing stages. (Later computers had alterable instructions within the machine itself that directed the machine to perform automatically.)

d. Aiken's Mark I Automatic Digital Computers, 1944.

(1) Established technology and punch card techniques combined.

(2) Electromechanical: electromagnetic relays automatically controlled internal operations, while 78 mechanical adding machines and desk calculators performed arithmetic operations. The relays automated the calculating machines, so that long calculations could be done without human intervention.

(3) Built-in programs or subroutines to handle logarithms and trigonometric functions (in addition to capability for handling arithmetical operations).

1-26. THE ELECTRONIC PHASE (ELECTRONIC DIGITAL COMPUTERS)

a. **Need for a Computer to Produce Trajectory Tables Generated by New World War II Weapons Systems--ENIAC. Eckert and Mauchley (1939-1946)**.

(1) First high-speed all electronic computer.

(2) Tracked the path of new rockets and missiles.

(3) "Wire-your-own" instruction technique: not easily reprogrammed. For each new problem, connections had to be redone.

(4) very large: about the size of a silo (1800 square feet).

(5) Required over 17,000 vacuum tubes. If one vacuum tube went out, the whole system went down. It also generated a lot of heat and had a short life-expectancy.

(6) One thousand times faster than the previous generation of computers. It could do 300 multiplications in one second, whereas the fastest electromechanical devices could do only one per second.

b. **The Stored Program Theory of Modern Computers**.

(1) John Von Neuman spread the word about the concepts necessary for devising modern stored program computers, though he didn't develop the ideas single-handedly.

(2) Through a properly programmed control, a computer could have a very simple fixed physical structure, without the need for changes in hardware. Yet, it could be perform any kind of computation effectively.

(3) The stored program theory was fundamental for future generations of high-speed digital computers. This theory encompassed a number of related ideas.

(a) Binary system. Equipment design lent itself to a binary system since electronic components are either "on" or "off," conducting or not conducting, magnetized or not magnetized. Thus, instructions could be coded as numbers and stored internally in the machine along with the data.

(b) Data and instructions stored together. With instruction programs and data in the same memory unit, instructions could be modified in the same way as data.

(c) Alterable instructions. Instructions could be altered during a computation to make them behave differently.

(d) Sequential program control. A type of instruction that permitted the program sequence to be interrupted and reinitiated at any point.

(e) Subroutines. Instructions that can be used repeatedly according to the way the computation progresses.

(f) Programs in the subroutine library. Frequently used subroutines kept intact in "libraries" and read into memory when needed.

(g) The memory as assembly place for instructions. Parts of a long computation were stored, worked on piecewise, and subsequently assembled.

(h) Read and write memory . A type of memory that provides almost constant access to any piece of information so that the contents can be retrieved and altered, at will, by the user.

c. **First-Generation Stored Program Computer (1947)**.

(1) The first programmable stored program computer to incorporate Von Neuman's ideas is EDVAC.

(2) Another programmable computer with a stored program is EDSAC.

(3) The first commercially available computer was the UNIVAC.

d. **Second-Generation Solid State Computers (1959)**.

(1) Transistors made computers better, faster, smaller, and more efficient.

(2) Elimination of the vacuum tubes reduced amount of heat generated, which reduced wear and tear, and increased reliability.

e. **Third-Generation Integrated Circuit Computers (1964)**.

(1) Silicon microchips, the size of a baby's nail, replaced transistors.

(2) Increased speed, efficiency, and memory capability.

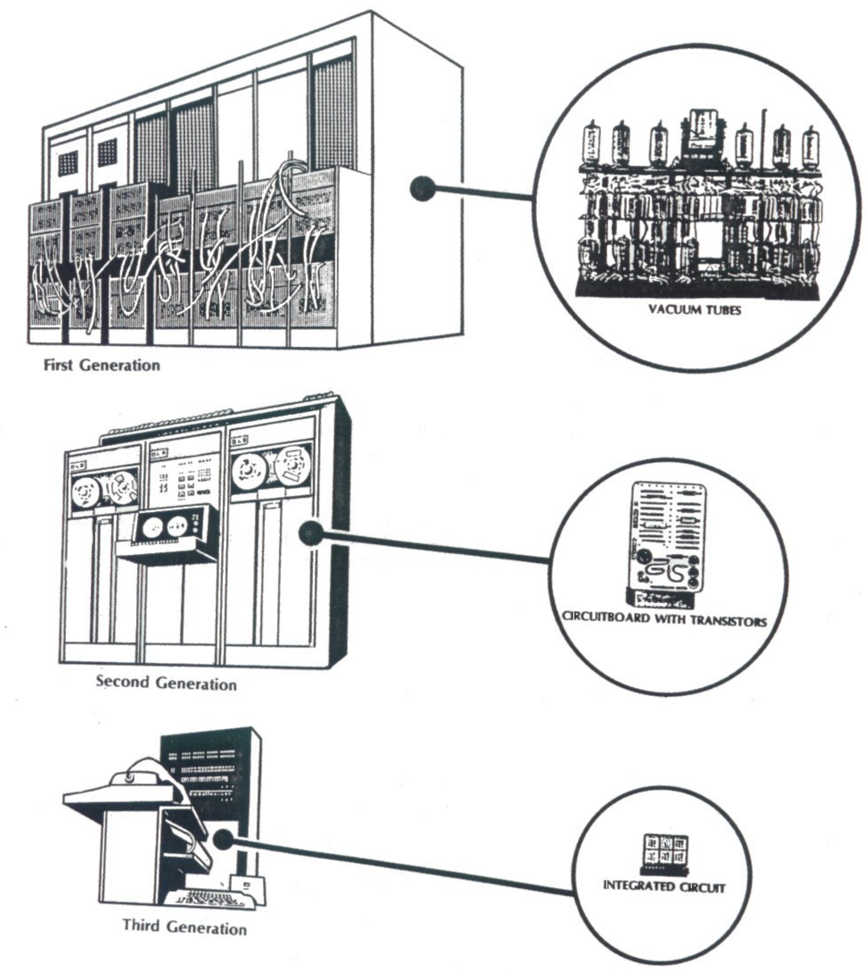

Figure 1-21. The progressive miniaturization of computer circuitry.

Continue with Exercises

EXERCISES, LESSON 1

INSTRUCTIONS. Circle the letter of the response that best answers the question or best completes the incomplete statement or write the appropriate term in the space provided.

After you have completed all the exercises, turn to "Solutions to Exercises" at the end of the lesson and check your answers. For each exercise answered incorrectly, reread the material referenced after the solution.

SPECIAL INSTRUCTIONS. For exercises 1 through 6, match each device (left-hand column) with its description (right-hand column). Enter the appropriate letter in the space provided. (One of the lettered statements in this exercise will not be used.)

1. ____ Shickard's digital calculating clock, 1623.
2. ____ Pascal's adding machine, 1642.
3. ____ Von Leibniz's calculating machine, 1673.
4. ____ Jacquard's loom, 1801.
5. ____ Colmar's calculator, 1820.
6. ____ Bollee's calculator, 1887.

a. Featured a multiplication/division device that performed operations through successive adding.

b. The first commercially successful mechanical calculator.

c. Could add and subtract by carrying over numbers through a system of interlocking wheels.

d. The first adding machine invented. Little known because the inventor's work was lost for several hundred years.

e. A computing device used for navigation.

f. Eliminated the need for repetitive addition method to multiple and divide.

g. Used punch cards to make damask patterns on table linens.

SPECIAL INSTRUCTIONS. For exercises 7 through 12, match each device (left-hand column) with its description (right-hand column). Enter the appropriate letter in the space provided. (One of the lettered statements in this exercise will not be used.)

7. ___ Jacquard's loom, 1801.

8. ___ Babbage's Analytical Engine

9. ___ Hollerith's vertical sorter or census machine, 1890.

10. ___ ENIAC, 1946.

11. ___ EDSAC, 1949.

12. ___ UNIVAC, 1951.

a. First high-speed all electronic computer; hard to reprogram for other uses, though.

b. First stored program computer.

c. First computer offered as a commercial product.

d. Used punch cards as a medium for data processing.

e. Blueprint for a general-purpose automatic mechanical computer with printout and memory; never developed, 100 years ahead of its time.

f. Used punch cards to control the weaving process.

g. Used transistors in lieu of vacuum tubes.

13. As people organized into ________________and engaged in _______________ computing and record-keeping devices were used with increasing frequency.

14. The first manual aids to memory included: fingers, stones,_______________ on a rock, and _________________in a string.

15. An early form of permanent record-keeping, developed around 3000 B.C. by Babylonian merchants, was the ____________________tablet.

16. Around the same time (3200 B.C.), the Egyptians developed papyrus scrolls, and used _________________to record events.

17. The __________________ has been used to perform arithmetic operations since 2000 B.C. and is still used in the Orient.

18. The hand tabulation of the 1880 _____________________, which took 10 years to complete, led to the creation of Hollerith's punch card-controlled vertical sorter.

19. Hollerith's machine featured automatic reading of information punched into cards without _______________________intermediation.

20. The _________ reading feature in Hollerith's sorter meant that cards could be fed into a read-in station and results fed out on punch cards.

21. The use of punch cards in Hollerith's sorter reduced __________________ and increased workflow.

22. The stacks of punch cards used in Hollerith's sorter provided a ______________ of almost unlimited capacity.

23. With the use of Hollerith's vertical sorter, the 1890 __________________ was completed in only 3 years.

24. Punch cards could do many of the steps needed to process ________________ like sorting, calculating, and summarizing.

25. A drawback of punch card equipment was the need for ___________________ intervention between processing stages to handle trays and to start and stop machines.

26. Punch card machines could not perform automatically, like later computers, because they lacked alterable instructions built into the machine, and had limited ____________________ between processing stages.

27. The Mark I, developed by Howard Aiken in 1944, was an automatic __________ computer that used punch card techniques.

28. The electromechanical Mark I featured electromagnetic _________________ which automatically controlled internal operations and automated 78 mechanical adding machines.

29. A computer was developed during World War II to calculate the paths of new ____________________ systems for the Army.

30. ENIAC, the first high-speed all _________________ computer, was developed by Eckert and Mauchley between 1939 and 1946.

31. ENIAC's "wire-your-own" instruction technique made it hard to _____________ for other purposes.

32. ENIAC was frequently out of commission, because if one of its 17,468 _____________ _______________ went out, the entire system was down.

33. In 1945, John Von Neuman spread the word about the stored program theory, a set of concepts necessary for developing the __________________________.

34. According to the stored program theory, a computer could have a very simple fixed physical structure and yet perform any computation without requiring changes in __________________________.

35. The stored program theory stated that equipment design lent itself to the _________________ system, as electronic components were either “on” or “off.”

36. According to the stored program theory, instructions could be coded as _____________________ and stored internally.

37. With instructions and data stored together in the modern computer, instructions could be ______________________________ in the same way as data.

38. Conditional control transfer, another aspect of the stored program theory, meant that program sequence could be interrupted and _______________ at any point.

39. Modern computers feature RAM (read and write memory), which provides almost ________________ access to information.

40. In modern computers frequently used instructions are kept intact in libraries, as ______________________________ and read into memory when needed.

Check Your Answers on Next Page

SOLUTIONS TO EXERCISES, LESSON 1

1. d (para 1-8b)

2. c (para 1-8c)

3. a (para 1-8d)

4. g (para 1-9)

5. b (para 1-8e)

6. f (para 1-8f)

7. f (para 1-9)

8. a (para 1-10c(1))

9. d (para 1-12b)

10. a (para 1-17)

11. b (pare 1-18d(1))

12. c (para 1-18d(3))

13. tribes, commerce (para 1-2)

14. scratches, knots (para 1-2)

15. cuneiform (para 1-3)

16. hieroglyphics (para 1-4)

17. abacus (para 1-6)

18. census (para 1-12a)

19. human (para 1-12f)

20. automatic (para 1-12f)

21. errors (para 1-12g)

22. memory (para 1-12g)

23. census (para 1-12b)

24. data (para 1-14)

25. manual (OR human) (para 1-14)

26. intercommunication (para 1-14)

27. digital (para 1-15a)

28. relays (para 1-15b)

29. weapons (para 1-16)

30. electronic (para 1-11a)

31. program (or reprogram) (para 1-17c)

32. vacuum tubes (para 1-17d)

33. modern computer (para 1-18a)

34. hardware (para 1-18b)

35. binary para 1-18c.(1))

36. numbers (para 1-18c.(1))

37. modified (OR altered OR manipulated) (para 1-18c.(3))

38. reinitiated (para 1-18c.(4))

39. constant (para 1-18c.(8))

40. subroutines (para 1-18c.(5))

End of Lesson 1

LESSON ASSIGNMENT

LESSON 2 Computer Hardware.

LESSON ASSIGNMENT Paragraphs 2-1 through 2-11.

LESSON OBJECTIVES After completing this lesson, you should be able to identify (by selecting from alternatives):

2-1. Distinguishing features of digital and analog computers.

2-2. The five components of a computer and their functions.

2-3. Peripherals (input, output, and storage devices) and their capabilities.

2-4. Differences between direct and sequential access, main, and auxiliary storage.

2-5. The concept of storage addressing and associated terms.

2-6. Limitations of the computer.

SUGGESTION After completing the assignment, complete the exercises of this lesson. These exercises will help you to achieve the lesson objectives.

LESSON 2

COMPUTER HARDWARE

Section I. THE MAJOR COMPONENTS

2-1. INTRODUCTION

The computer is actually a system of interrelated components. These components, known collectively as hardware, are the machines that make up a functioning computer. Although, it is not necessary to have a detailed knowledge of computer technology to perform data processing activities, knowing about the components and its functions will give you a better appreciation of a computer's capabilities and limitations.

hardware: the physical apparatus of a computer system.

2-2. DIGITAL VS ANALOG COMPUTERS

a. Digital computers are by far the most widely used type of computer. Most modern electronic computers are digital, and, for the most part, this book focuses on this type of computer. But, there are, in fact, two ways in which data may be sent over communications channels. These two methods correspond to the two types of computers: digital and analog. A digital computer operates directly on numbers expressed as digits and responds to the discrete "on" and "off" states of electronic circuitry. These 'on" and "off" states can be represented by 1's and 0's, called binary digits, which can be counted. Digital computers operate by counting, but vary in precision with those used for scientific applications achieving accuracy to the hundredth or even thousandth place. Computers used for business applications are generally accurate to only a few decimal places.

digital computer: computer capable of performing calculations by counting is and Os; data is represented as discrete digital "on-off' states.

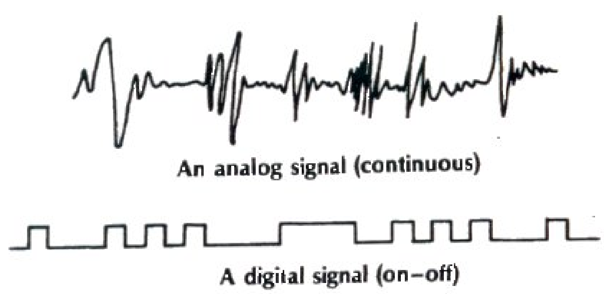

Figure 2-1. Data may be sent over communications lines as "on-off" (digital) or continuous (analog) signals.

b. Analog computers do not count. They measure continuous physical or electrical magnitudes such as pressure, temperature, current, voltage length, or shaft rotations. Analog devices have been in existence longer, a slide rule being one example. Another is a gasoline pump, a device that measures the quantity and price of gasoline. Yet another example is a car speedometer, with drive shaft rotations converted to a number that indicates the speed. Analog devices are not as accurate as the digital variety. Under ideal conditions, they function only within 0.1 percent accuracy. It is important to note that while numerical results are obtained from an analog computer, they are arrived at indirectly.

analog computer: used primarily in engineering and scientific computing, it measures continuous physical or electrical magnitudes, such as pressure, temperature, current voltage, and so forth.

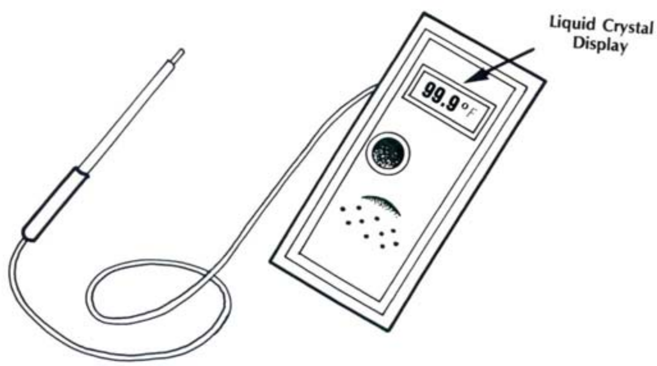

Figure 2-2. This thermometer is an analog device. It perceives temperature as a continuous function. A microprocessor converts the reading into digital terms and advances the liquid crystal display (LCD) 2/10 of a degree at a time. When the temperature stabilizes, the reading is locked in and a beeper sounds.

2-3. DIGITAL COMPUTER FUNCTION

All digital computers, no matter what size or shape, have certain similarities in the way they are organized. A computer must be able to read or accept instructions and data, remember the problem solved and the data to use, perform arithmetical calculations and logical manipulations on the data, read out the results, and control the entire operation. The five functions of a computer are given in figure 2-3.

1. **Input**
2. **Control**
3. **Calculation/symbol (arithmetic/logic) manipulation**
4. **Storage**
5. **Output**

Figure 2-3. The five functions of a computer.

2-4. COMPONENTS

Like the human body, the computer is composed of various peripheral "limbs" and central organs that perform diverse functions. Peripherals or peripheral devices include input-output units, secondary storage devices, and other auxiliary equipment. Just as humans use their eyes to read information and send it to the brain, a computer uses an input device that reads or accepts the information into a computer "brain," the central processing unit (CPU). The information is read by the CPU and logical action is taken according to a preset plan (program) that provides step-by-step instructions. These components interact to solve problems, with numerical data instructions constantly being sent back and forth between components. The entire process is controlled by instructions provided in a software program. When the task is complete, the results can be “memorized” into the computer memory. They can also be written or punched on cards or tape by output devices.

read: to accept or obtain data from some source, as, for instance, a storage device.

write: to record or deliver data to a storage device, for example, to punch data on cards in the form of a pattern of holes.

1. The input device

2. The central processing unit (CPU)

- **a. Control unit**
- **b. Arithmetic logic unit**
- **c. Core memory**

3. The output device

Figure 2-4. Computer components.

software: programs used to direct computer problem-solving and oversee operations.

2-5. THE CENTRAL PROCESSING UNIT

a. **The Central Processing Unit.** Also known as the central processor or CPU, this is the heart of the computer system. It selects, interprets, and executes program instructions, stores data temporarily, maintains order, and directs overall functioning. It does not perform actual processing operations on data. The CPU consists of three parts: the arithmetic unit, the primary storage unit, and the control unit. The CPU is often quite simply referred to as the computer.

central processing unit (CPU): the computer nerve center, coordinates and controls the activities of all the other components, performs arithmetical and logical processes to be applied to data, and stores data.

b. **The Arithmetic/Logic Unit.** The arithmetic/logic unit (ALU) performs the four arithmetic operations (addition, subtraction, multiplication, and division) which are, in turn, used to perform logical operations. An example of a logical operation might be comparing one data item to another to see which is less. Since the bulk of internal processing involves calculations or comparisons, the capabilities of a computer often depend on the design and capabilities of the ALU.

c. **The Primary Storage Unit.** Also known as the internal storage, core memory, or main storage, this is a temporary storage. It stores the program and data, for immediate use, while they are being worked with. The program and data are inserted into the storage area, often called the memory, through the input unit. While the computer is solving a problem, the program instructions and data continually run back and forth between the arithmetic/ logic unit, the control unit, and the storage unit.

(1) <u>Magnetic core storage system</u>.

(a) The information stored in the core memory or main storage is stored in a series of "cubbyholes." Each cubbyhole (location) has an address. The information at the address consists of binary digits or bits stored by an ingenious system of magnetized "doughnuts" suspended on a wire network.

bit: short for binary digit; the smallest unit of information recognizable to a computer.

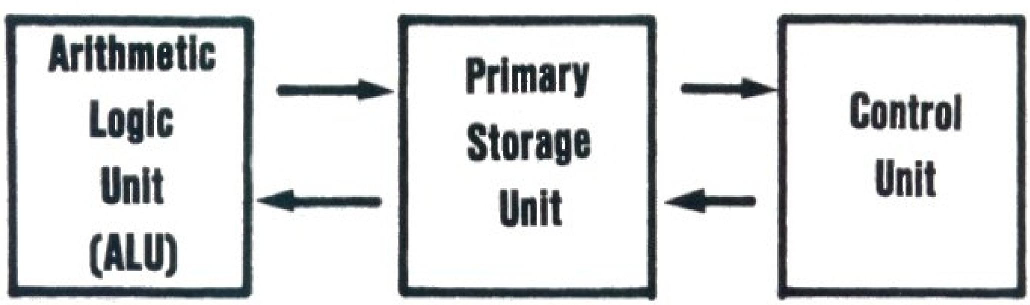

Figure 2-5. The central processing unit (CPU).

(b) The magnetism in the magnetic core is induced by a current in the wire network (clockwise magnetism representing a 1 bit and counterclockwise magnetism, a 0 bit). The direction can be sensed when the information needs to be read. The 1 or 0 bit is the part of the electronic code that the computer uses to process letters, numerals, or symbols, and the bits are grouped to form a particular code for each letter or numeral.

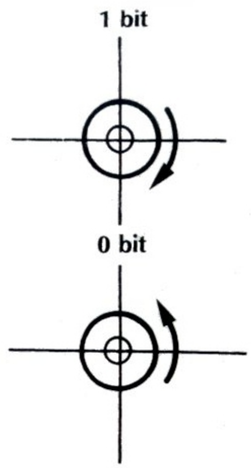

Figure 2-6. Iron core doughnuts or bits. Clockwise magnetism represents a 1 bit; counter clockwise magnetism, a 0 bit..

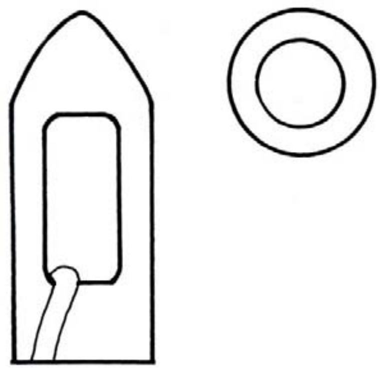

Figure 2-7. Size comparison: Bit vs eye of a needle.

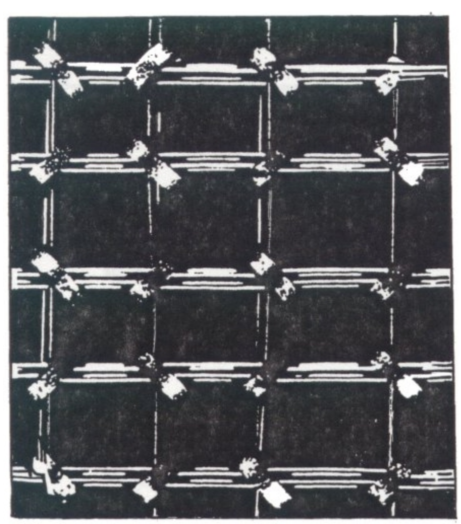

Figure 2-8. Magnetic core "doughnuts' threaded on wire matrix.

(2) <u>Semiconductor (silicon chip) storage</u>.

(a) More recent developments have led to the use of semiconductors in primary storage units. Semiconductor memory is composed of circuitry on silicon chips. One silicon chip, only slightly bigger than one core, can hold as much as thousands of cores. The speed of processing with semiconductors is also significantly faster.

(b) Semiconductors are designed to store data in locations called bit cells, which are capable of being either "on" or "off." Bit cells are arranged so that they can be written to or read from, as needed. They can be accessed directly, rather than having to go through all the memory in sequence. This is referred to as random access memory (RAM); a concept introduced in Lesson 1. Another term for this is direct access, covered later in this lesson. (See para 2-Bc.)

(c) Final results remain in the core memory until the control unit causes them to be erased, normally after the results are transferred to an output device. After all computations and manipulations are completed, the results are recorded in peripheral memory, which takes the form of magnetic tape or disk.

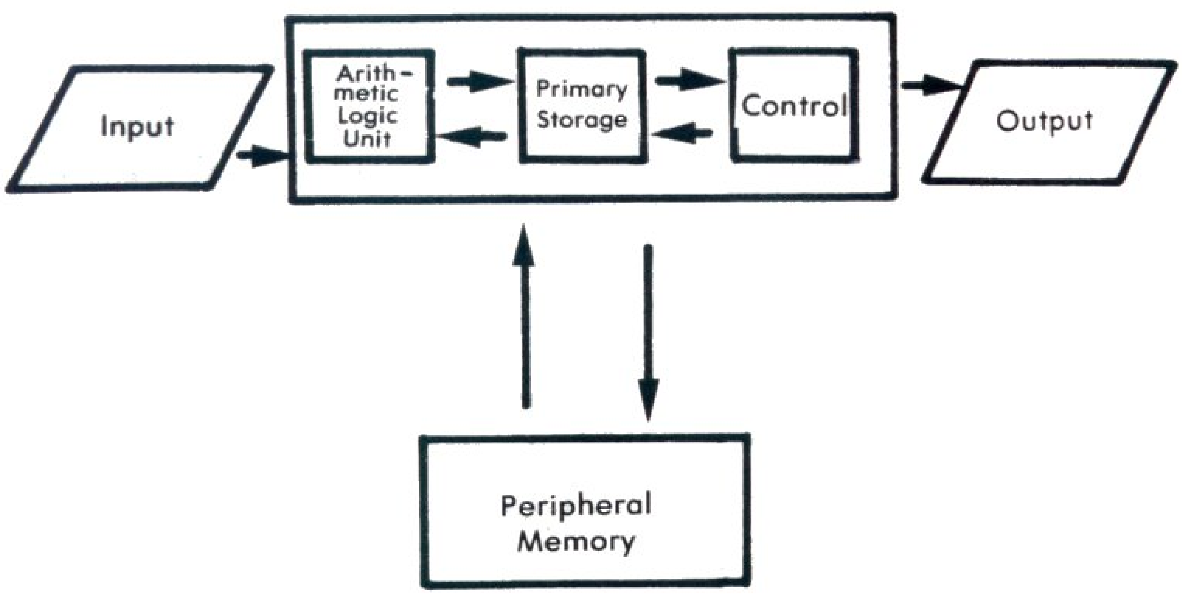

Figure 2-9. Relationship of peripheral input-output devices and memory to the CPU.

d. **Control Unit.** The control unit is the most crucial element of the computer. It does not process or store data. Rather, it directs the overall functioning of the other units and controls data flow. It interprets the instructions of a program in storage and produces signals. These signals act as commands to circuits directing them to execute the instructions. In addition, the control unit communicates with the input and output devices to initiate the transfer of data, instructions, and results to and from storage.

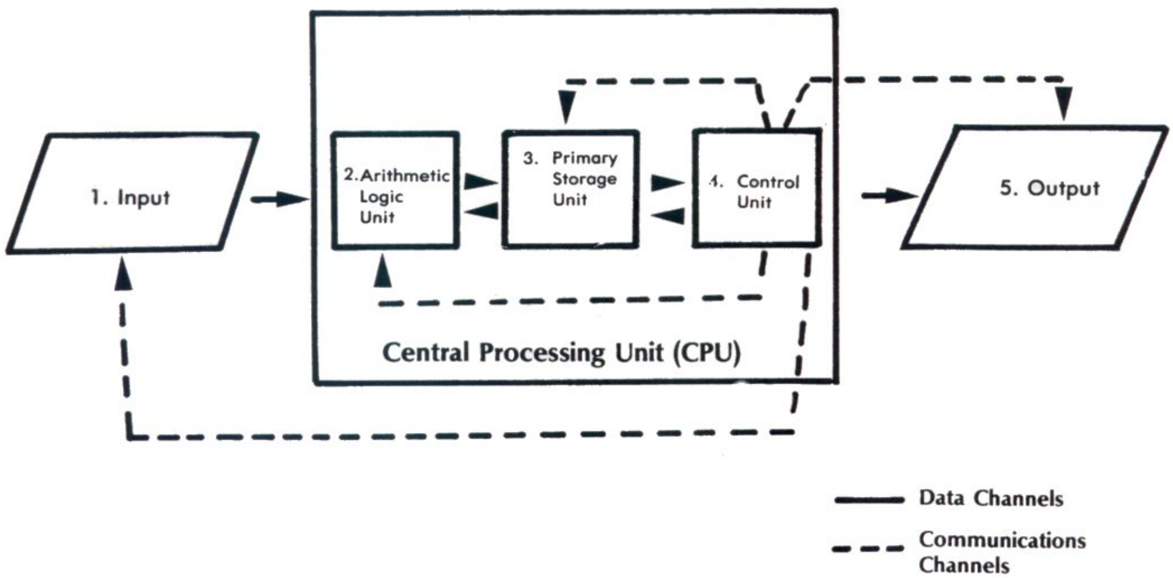

Figure 2-10. The five parts of a computer.

Section II. PERIPHERALS (INPUT, OUTPUT, AND STORAGE DEVICES)

2-6. THE INPUT UNIT

a. **Overview.** Although the central processing unit (CPU) is the brain of a computer system, input (and output) devices or peripherals are important because they are the communications link between people and machines. If the people/machine interface is weak, the overall performance of the system will suffer. The input unit is the component that reads previously recorded data from a variety of data entry input media. An integral part of the computer system, the input unit operates under the control of the CPU, as directed by the program. As data are accepted or read by the input device's sensing mechanism, they are converted through electronic pulses to magnetic recorded form, since data and instructions must be in a form the computer can use.

peripherals: input-output units, secondary storage devices, and other auxiliary equipment.

b. **Data Entry/Input Devices.** Data can be entered on and then read from a variety of input devices.

(1) Punch cards or paper tape readers are still used as input for some minicomputers and mainframe computers. Punch card systems require mechanized movement and have many limitations. These devices record data in the form of the absence or presence of punched holes. Punch cards had been used in data processing long before the digital computer was developed, dating as far back as 1890 to Hollerith's census machine. Data are most commonly recorded on punch cards through the use of a keyboard. An operator reads a source document and transcribes the data from the

document onto cards by pressing keys on the keyboard. Keying data in this manner can be costly and time-consuming, with punch-in rates of 120-150 cards per minute. Once the data are keyed in, punch cards can be handled quite fast, with reading rates of over 1,000 cards per minute being possible for optical readers. A light source on one side activates a photo detector if there is a hole (a binary 1) to run through. The detector is not activated if the card face is present (no hole, a binary 0). The brush type card reader unit is slower, with rates of only 200 cards per minutes. If the brush goes over a hole, it makes contact with a metal plate and passes this on as a signal of a binary 1 being read.

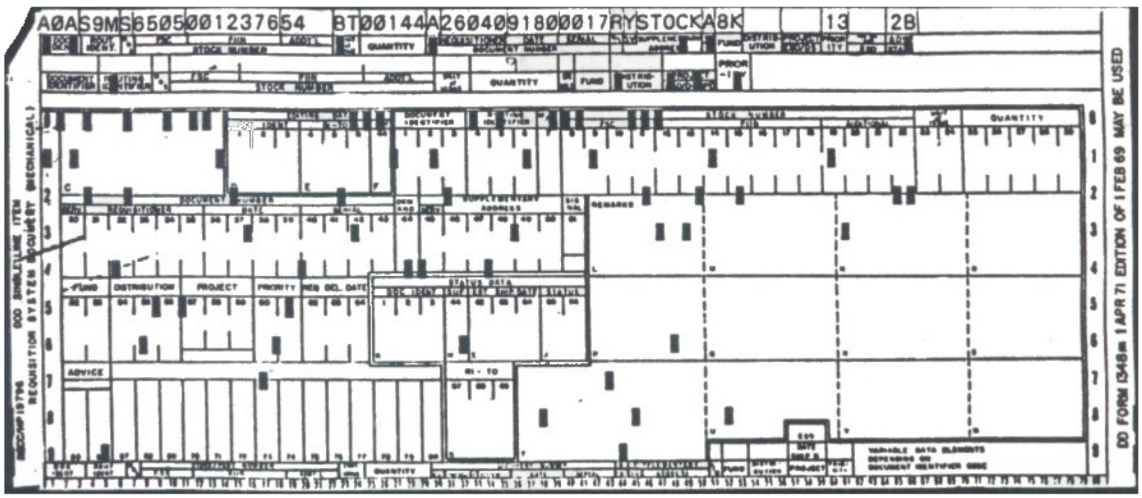

Figure 2-11. Punch card ('field' and "record" are explained in figure 3-2 of AMEDD Computer Literacy II).

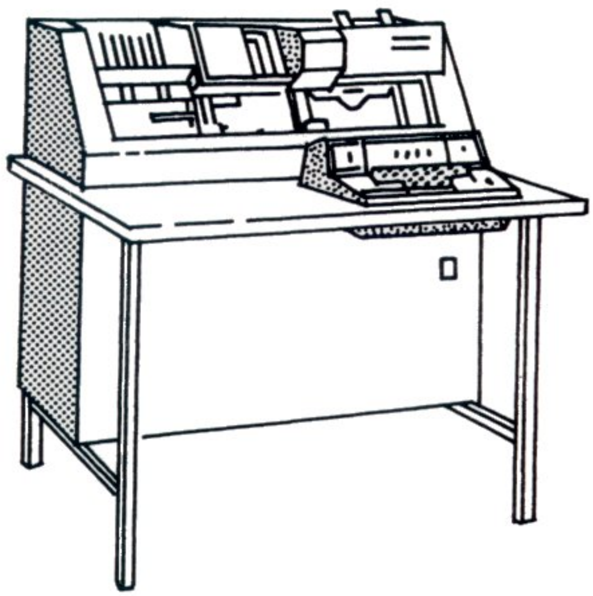

Figure 2-12. A keypunch machine.

(2) Paper tape readers. With punched paper tape, data are again stored in the form of the absence or presence of punched holes. These entries are permanent and not reusable. Paper tape readers operate at approximately 100 characters per second for mechanical readers and 1,000 per second for optical readers. Punched tape can store small amounts of data in a more compact form than cards. It is relatively inexpensive and the data can be seen (not so with magnetic tape, see next page). Paper tape is most practical for use on small or time-shared terminals.

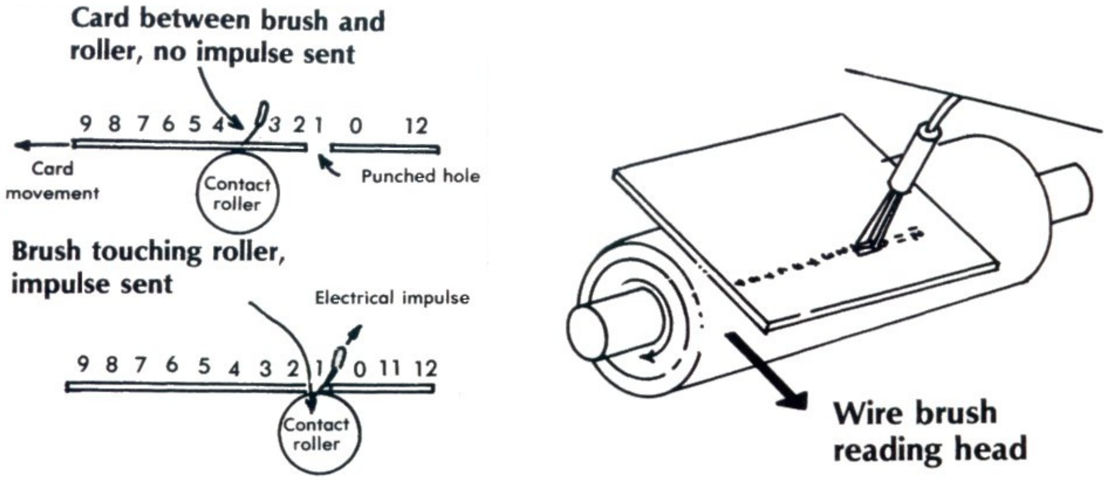

Figure 2-13. Reading head detects the presence or absence of a hole.

(3) Magnetic tape or magnetic disks. When magnetic media such as tape or disks are used, data are entered in much the same way as with the keypunch. But it is stored as magnetized spots on the surface of a tape or disk instead of punches on a card. This is referred to as a key-to-tape system. The data can be stored indefinitely because the spots retain their magnetism. Unlike punch cards, data can be replaced with new data. Tape and disks can also store more data in a smaller space (6,250 characters per inch). Since data can be read into the CPU hundreds of times faster, key-to-magnetic-tape-entry methods are more efficient than punch cards or paper and are suitable for large volume, high-speed applications.

(a) Key-to-tape. Most key-to-magnetic tape systems are being replaced by disks (hard disks) and diskettes (floppy disks) as a result of advancing technology. Key-to-magnetic media represent an improvement over the slower punch card and paper tape feeders. Speed has always been a concern because input (and output) equipment has been a restraining factor on high speed computers since the beginning. This is because data can be processed much more quickly than it can be entered or written out.

(b) Key-to-disk systems. Atypical key-to-disk setup consists of several keying devices, connected to a minicomputer. Data to be recorded onto magnetic disks are usually first edited by a minicomputer. This editing is directed by the minicomputer's stored-program instructions. The corrected data is then stored on the magnetic disk for input to the computer.

hard disk (disk): a round magnetized plate, usually made of plastic or metal, organized into concentric tracks and preshaped sectors for storing data. (Usually faster than a diskette (floppy disk), holding 20 megabytes of data or more, but also more expensive.)

floppy disk (diskette): a flexible platter covered with magnetic recording material that permanently stores programs and data. Floppy disks come in two basic sizes: 5 1/4-inch and 3 1/2-inch and hold 360K to 1.4 megabytes of information. Most users need at least 1 to 2 floppy disks or a hard drive.

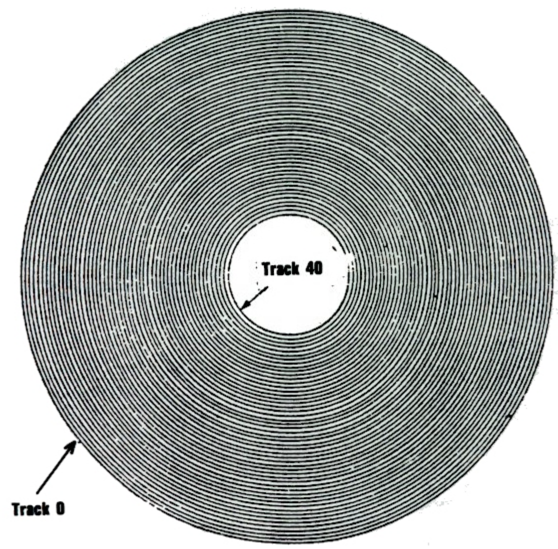

Figure 2-14. The magnetic disk is a metal platter coated on both sides with magnetizable material. Data are stored on concentric tracks.

minicomputer: a mid-sized computer, with all the components of a full-sized computer but a smaller capability. (This term is falling into disuse as the distinction between large and 'super-mini' computers blurs.)

(c) Key-to-diskette systems. This increasingly popular configuration makes use of a flexible (or floppy) diskette instead of the conventional (hard) disk. The data is entered on a keyboard, displayed on a screen for the operator to check, and recorded on the diskette. Systems that use disks or floppy disks have a disk drive. Moving heads inside the disk drive can "read" the magnetically stored information on a disk's surface and transfer the contents to the machine's internal memory. The heads can also magnetically "write" information on the disk as required.

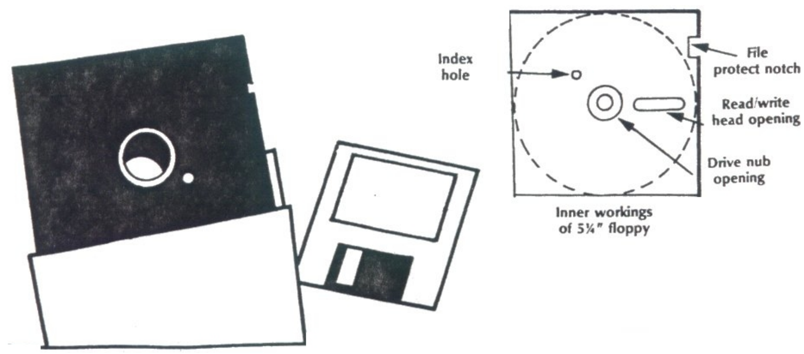

Figure 2-15. 5 1/4- and 3 1/2-inch floppy disks store programs and data, and are easy to use and mail.

disk drive: a mechanism that rotates a storage disk and reads or writes data.

(d) Floppy disks come in two basic sizes: 5 1/4- and 3 1/2-inch diskettes and hold from 360K to 1.4 megabytes of information. The 1K or kilobyte equals 1,024 bytes. It takes one byte of space to store a character or letter. The word "fox," for example, requires 3 bytes. (One source states that 1K or 1,024 bytes is equal to about one double-spaced type-written page. This equivalency is helpful in conceptualizing the value of 1K. But, in fact, the number of bytes actually needed to store one double-spaced page will vary with the hardware and software you are using. So, keep it in mind, but expect the actual number of bytes per page to vary from system to system.) 1 megabyte equals 1,024K. Most users need at least two floppy disks or one hard disk for their own use.

K (kilobyte): RAM and disk capacity are measured in kilobytes, 1K being the equivalent of 1,024 bytes.

mB (megabyte): 1,000,000 bytes; 1 mB equals 1,024K; RAM and disk capacity are measured in megabytes.

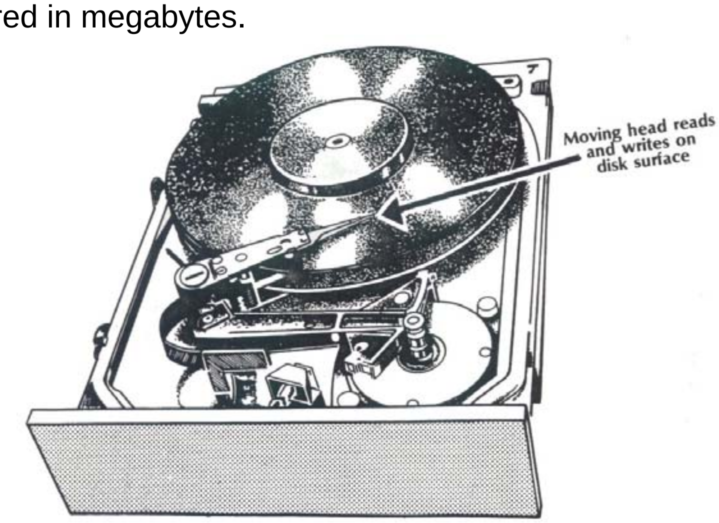

Figure 2-16. Working of a hard disk in a disk drive.

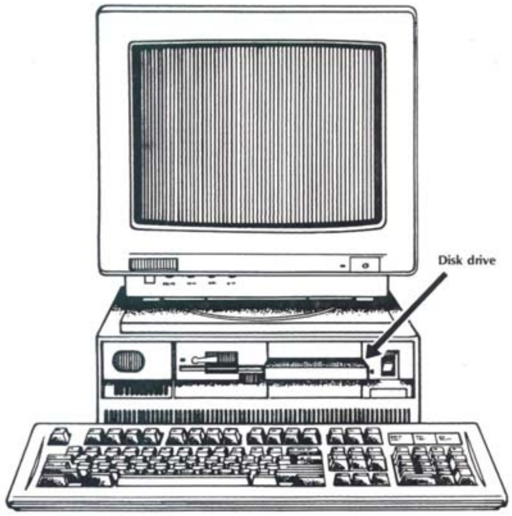

Figure 2-17. Disk drive in a personal computer.

c. **Source Data Automation.** Data entry has always been the slowest part of data processing. While data can be processed electronically at high speeds, it is the entering of data into the computer that has always been relatively time-consuming. The slowest form of data entry uses punch cards. Data written on some type of coding form are keypunched into cards by an operator, and then verified by duplicating. The operator must then correct errors, keypunch, and verify a second time. Other operations may be necessary. (Card files may need to be copied onto magnetic tape using a special program for later input to the computer. This is done because magnetic tape files can be read into the computer much faster than card files). Key-to-tape, -disk, or -diskette systems simplify keypunch operations. But an even greater improvement over these methods of data entry is source data automation. Source data automation means data can be collected directly into the computer in readable form when and where the event takes place. With the intermediate steps of preparing card input eliminated, accuracy and efficiency are increased.

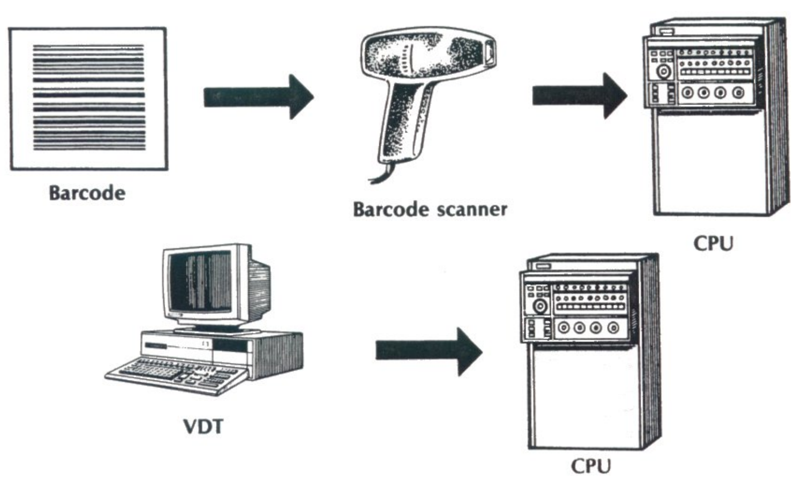

Figure 2-18. Source data automation methods.

(1) On-line video terminals. The most common means of entering data and instructions, on-line video terminals, have a keyboard that transmits data in binary code to the computer. The data are "typed" on a 'television" screen. The cathode-ray tube (CRT) of the screen can also accept data from the computer and display the information much faster than it could be printed. (When hard copy is required, a printer can be instructed to print out the data that is on the screen.)

on-line: In direct communication with the computer.

(2) Magnetic-ink-character recognition. Magnetic ink characters are used by the banking industry to facilitate check processing. Characters, formed with magnetized particles of zinc oxide, can be read by both humans and machines. The characters are read and interpreted by a magnetic-ink- reader that can read and sort 750 to 1500 checks per minute.

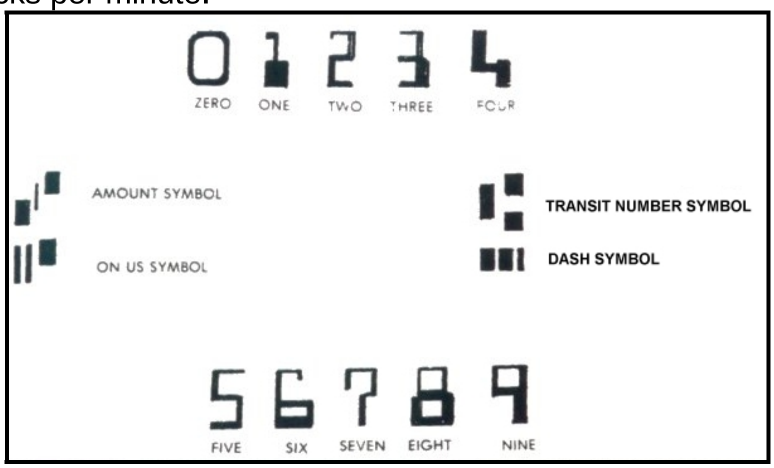

Figure 2-19. Magnetic ink characters

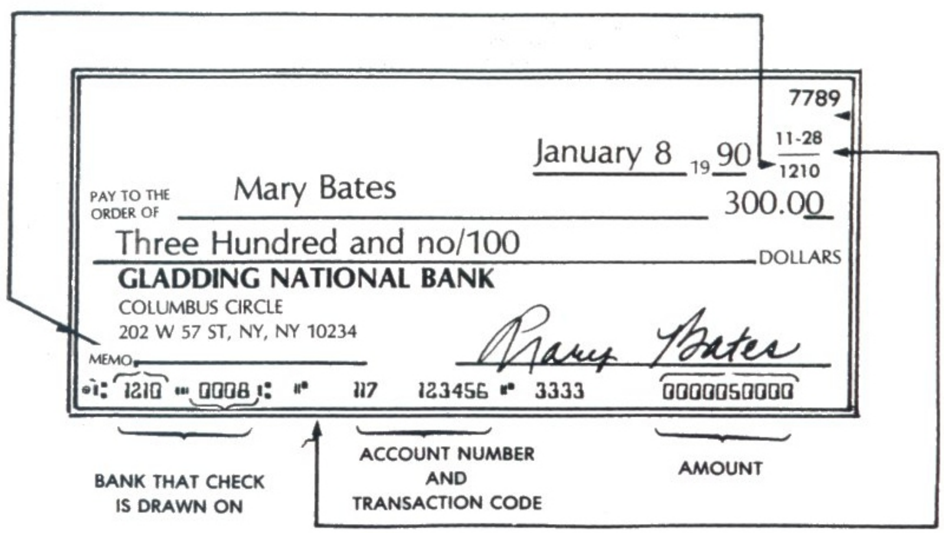

Figure 2-20. Sample check with magnetic ink characters

(a) Mark sensing is often used for machine-scoring multiple choice examinations. The student uses a heavy lead pencil to mark his answer. The marks are sensed by an optical mark page reader as the document passes under a light source. The presence of marks in specific locations is then translated into machine language. Up to 2000 forms of the same type can be read and processed in a few hours.

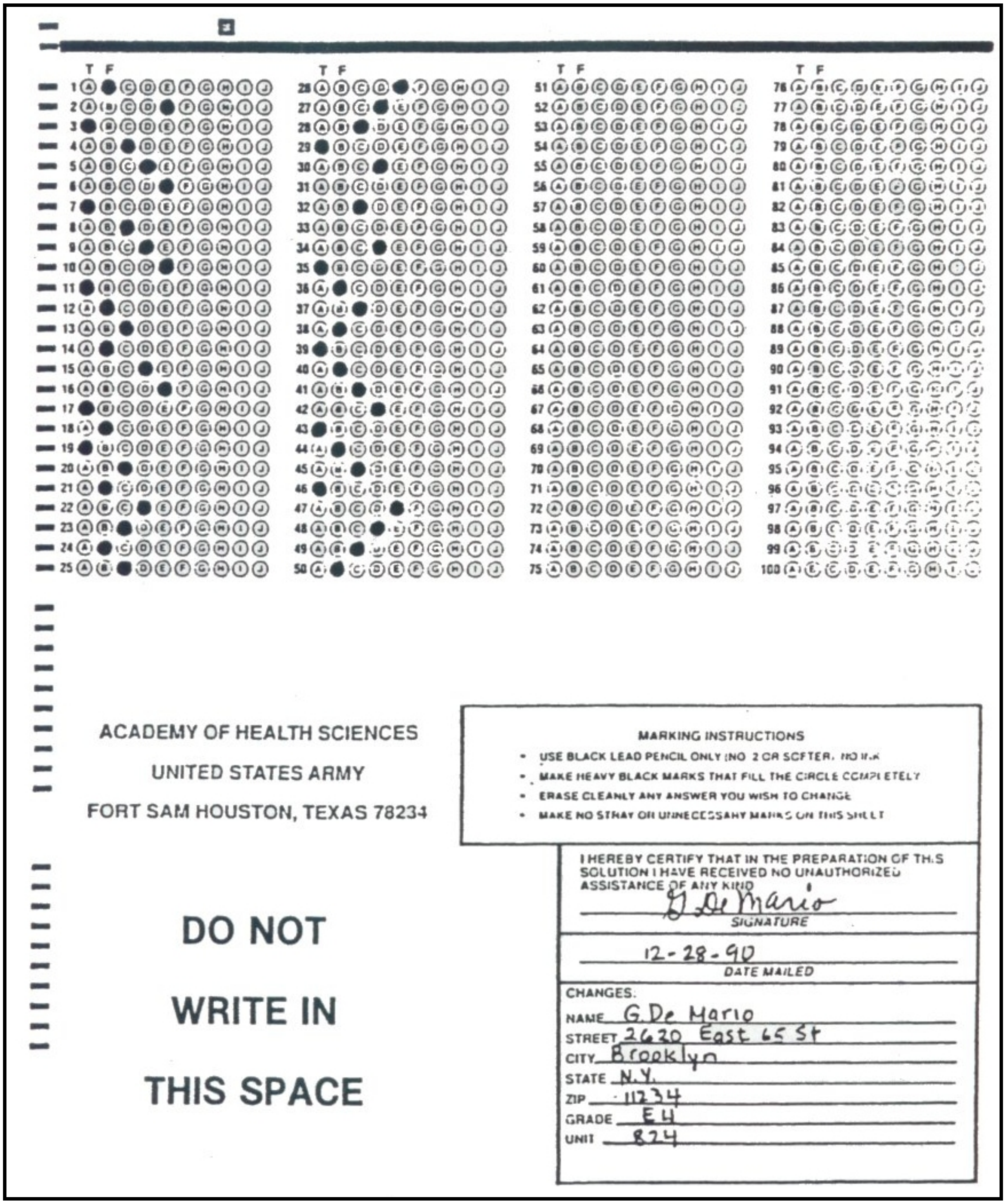

Figure 2-21. Optical mark recognition on exam answer sheets.

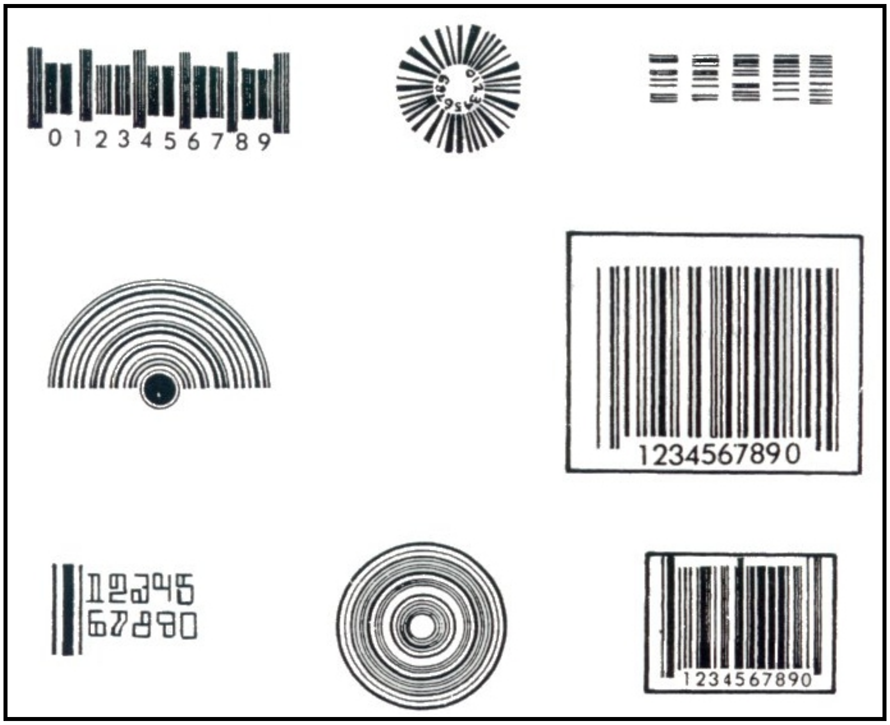

Figure 2-22. Bar codes.

(b) Bar code readers read special line or bar codes (patterns of optical marks). These are used in grocery store and point of sale systems, for credit card verification and freight identification. Data are represented in a bar code by the widths of the bars and the distances between them. The Universal Product Code (UPC), found on grocery items, is probably the best known example of a bar code.

Figure 2-23. Point of sale terminal.

(c) Magnetic cards and strip readers are used for processing credit cards and identification cards.

(3) Audio input (recognition system). Data are entered by using the human voice rather than by punching keys on a terminal. For example, a lab technician might use a voice recognition terminal for data entry, thereby keeping his hands free for other tasks.

Figure 2-24. Voice recognition input.

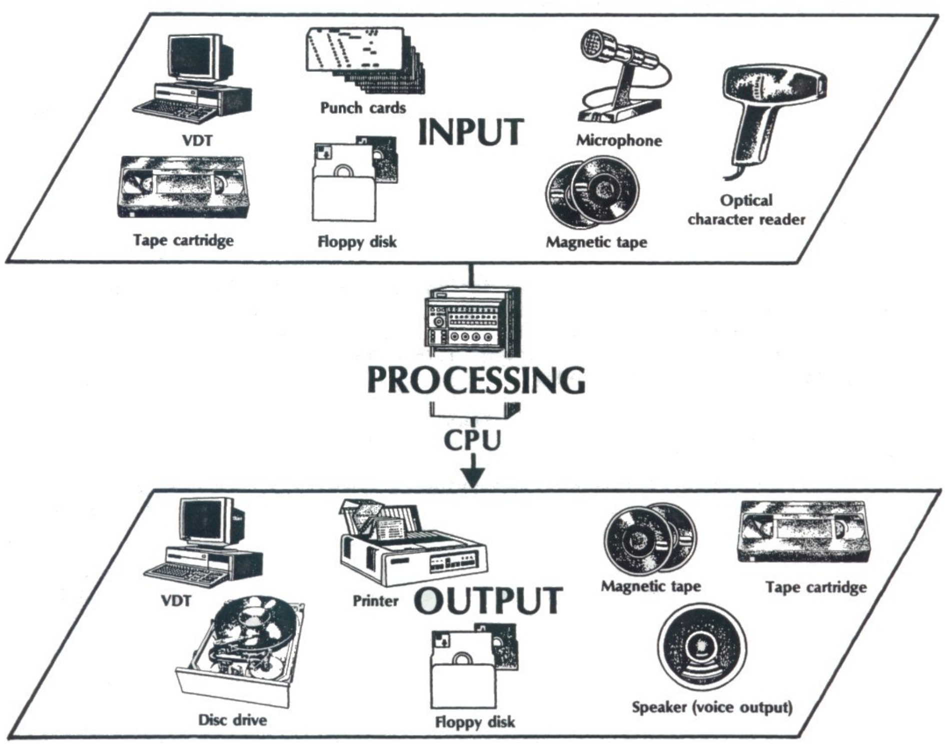

Figure 2-25. Input and output devices.

2-7. THE OUTPUT UNIT

a. **General.** The output unit is a device that reports information from computer storage in a form understood by human beings or another computer system. Typewriters, printers, card punches, visual display devices, paper tape punches, magnetic tape units, magnetic disk units, and audio response units are some common output devices.

input-output devices: also known as peripherals, machines that provide a means of communication between different computer systems or between people and computers.

b. **Impact vs Non-impact Printers.** A printer translates electronic signals from the central processing unit into readable form. The paper output is known as hard copy. Computer printers are classified by the way they put ink on paper and how nice the result looks. Other variables are speed, noise, and cost of supplies. To the naked eye, impact printers seem extremely fast. But the computer has the data available to be printed and can transfer it to the printer many times faster than the impact printer can print. This difference between speed of transfer and printing has led to the development of non-impact printers, a faster method of printing. A non-impact printer does not require contact between paper and printing head. Instead, an electric charge, heat, photographic techniques or laser technology is used to print output.

hard copy: the permanent readable copy of a computer output.

c. **Buffers.** From the beginning, the comparatively slow input and output equipment has hampered the high speed of the CPU. And so there has been a concern with improving the speed and efficiency of these devices. Better printers have a buffer, or built-in memory chip, that improves efficiency by permitting output to be printing after you exit the program.

buffer: internal storage that holds data read to or from input-output devices.

d**. Impact Printers.** Some printers. generate a character at a time, others a line at a time. Printer keyboards, dot matrix, and daisy wheel printers use the one character at a time approach.

(1) The dot matrix printer. Dot matrix printers have been the Volkswagons of personal computing - they are inexpensive and rugged, but can't produce letter-quality print. They use dot combinations to represent numbers, letters, and special characters, and have a graphics capability because of the dots. An image is formed when tiny pins strike an ink ribbon in a matrix of dots. The more pins, the more dots produced, and the better the quality of the output. A 24-pin machine, for example, will produce a more professional looking output than a 9-pin model. Most dot matrix printers can use single sheet paper, but they also make efficient use of continuous--

form products: paper, mailing labels, forms with holes punched down the side to fit matching paper-pulling spikes on the printer. Judging speed in dot matrix printers can be difficult. The ads talk of characters per second (CPS). Thirty CPS, for example, amounts to 300 words per minute. But a 30-CPS printer will not necessarily turn out 300 words in 60 seconds. Most ads don't count the time required to move the carriage head or advance the paper, or attend to other functions. The ads are calculating speed in the "draft" mode, when the print head makes only one pass at each letter. For better-looking type, usually called near-letter-quality, the print head makes multiple passes and the output drops accordingly.

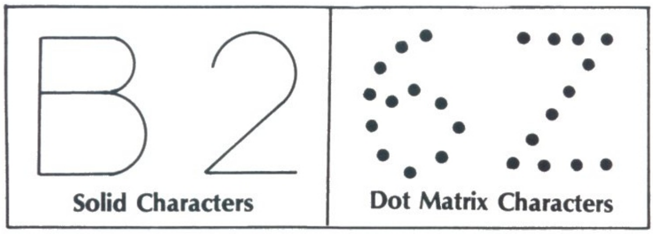

Figure 2-26 Dot matrix vs. letter-quality characters

(2) <u>Daisy wheel printers</u>. A daisy wheel is a flat disk with spokes, each spoke having a single character embossed at the end. The daisy wheel makes an image in much the same way as an electric typewriter. The wheel rotates to the desired character, and is then struck by a hammer mechanism to form an image on paper. Daisy wheels come in a variety of fonts (print styles and sizes) that can be interchanged. They are noisy and slow, but produce very good no-graphics, high legibility manuscripts or correspondence. The daisy wheel is superior to the dot matrix in that it can produce high-quality type with a professional appearance. But, it cannot produce graphics and it won't handle multitype styles and sizes. If you simply need high print quality, you can meet this need for a cost of only about $600.

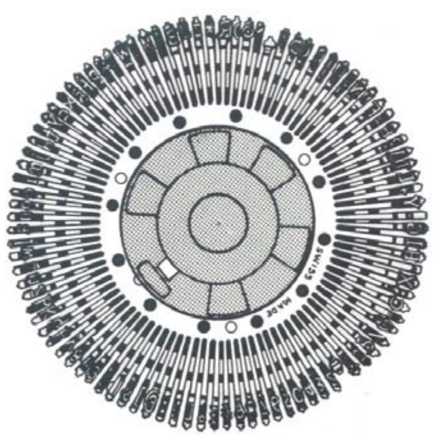

Figure 2-27. Daisy wheel.

(3) Keyboard. The printer keyboard looks like a typewriter, but is linked to the computer and this permits communication with the system to enter data or instructions. It can print 300 characters per minute for letter-quality printing.

(4) The print wheel printer. This type of printer prints a line at a time. It contains 120 print wheels, one for each of 120 print characters on a line. Each wheel, in turn, has 48 characters. Each wheel rotates to the desired characters, when all wheels are in the right position, a hammer drives the paper against the wheels, so that the entire line is printed at once. This type of printer is relatively slow, with a rate of 150 lines per minute.

e. **Non-impact Printers**. Non-impact printers are faster and more reliable since they involve fewer mechanical moving parts. They also offer a wider choice of type faces and better speed-to-price ratios. While they cannot make carbon copies, they can make multiple printings of a page in less time than it takes an impact printer to make one multicarbon page.

(1) Laser printers.

(a) Capabilities. Top-quality laser printers print an unlimited variety of letters, designs, and pictures with almost typeset quality (known as letter-quality). They use a laser beam to write on a rotating drum that attracts toner, much like a copier. Laser printers have helped cause a revolution in desk top publishing that has made newsletters attractive and business reports striking. These printers can produce several fonts on the same page, and have a speed of 21,000 lines per minute. Laser printers are often used to print books because of their high quality and versatility. Most people can't distinguish laser printer output from printed text, although there is a big difference in resolution (the number of dots per inch). Laser printers run at 300 dots per inch, while typesetters reach 1200. Low-priced laser printers use the same technology, but handle fewer fonts and cannot do fancy graphics. They offer more capabilities and better quality than the popular dot matrix printers that have dominated the market up to now.

laser: a device capable of producing a narrow beam of high intensity that can carry data.

laser printer: a non-impact printer that uses laser beams and electrophotographic technology to form high-quality images.

(b) Cost. Laser printers produce the nicest results at high speeds. But up to now, they have been very expensive, starting at $1000 and rising to $10,000. Most home and business users try to stay in the $1000 to $3000 range. As better laser printers begin to drop in price, more people will buy them. At this writing, a printer that produces four pages a minute with a list price of $1,495 will soon sell for just under

$1000, making it competitive with top-of-the-line dot matrix printers that are as fast. The laser printer will corner more of the market because it is quiet, prints on envelopes, and doesn't need the perforated, folded paper used by many dot matrix printers.

Printer	Speeds up to:
Impact printers	
·Daisy wheel	50 characters per second
·Dot matrix	900 characters per second
Nonimpact printers	
·Ink jet	200 characters per second
·Laser	21,000 lines per minutes

Table 2-1. Comparative speeds of most common printers.

(2) Ink jet printers. Ink jet printers form the image by shooting a stream of charged ink toward the paper. The ink passes through an electrical field that arranges the charged particles into characters. Costs generally run from $500 to $1500, with a decent model obtainable for under $1,000. Ink jet output looks almost as good as laser output and works on sheet-fed paper. But ink jet printers are slow, printing out 200 characters per minute. Still, they are small, quiet, relatively cheap, and probably the best bet if you need to give correspondence a crisp, professional look, but do not need a graphics capability.

f. **Special Purpose Output**. These devices provide output in forms that traditional printers cannot produce.

(1) The video display terminal (VDT) or monitor provides nonpermanent visual display of output, known as soft copy. Most screens hold up to 24 lines, each containing DO characters.

soft copy: nonpermanent visual record.

(a) Types of VDTs. There are actually three different types of VDTs. The cathode-ray tube (CRT) operates on the same principle as the television. Using very high voltage, a cathode-ray tube throws a beam of energy on a phosphor-coated screen, causing an image to appear. Most VDTs are of the CRT variety. Another type of VDT uses a Liquid Crystal Display (LCD) like that of a digital watch. And the newest type of VDT uses plasma technology.

BOLDFACE

1 2 3 4 5 6 7 8 9 0

ACADEMY OF HEALTH SCIENCES, U.S. ARMY
Fort Sam Houston, Texas 78234-6100

COMMENT SHEET

SUBCOURSE NUMBER_________________ **EDITION DATE**_________________

TITLE____

The staff of the Academy of Health Sciences wants to develop correspondence course materials that are readable and accurate. They want to know if each subcourse does what it is supposed to do–that is, teach the topic and help you to achieve the instructional objectives of the subcourse. You can help us to achieve these goals by following these **instructions**:

1. Please complete this form as you study.
2. **ENCLOSE THIS FORM OR A COPY WITH YOUR EXAMINATION ANSWER SHEET.**

A. PLEASE COMPLETE THE FOLLOWING ITEMS: (Use additional sheets if necessary.)

1. List any terms or concepts that were not defined properly.

2. List any errors.

Page/paragraph _____ Error _____ _____ Correction _____

3. List any suggestions concerning this subcourse.

4. My purpose in taking this subcourse was (check all that apply): __Refresher/review/sustainment. __Self-improvement. __To learn new skills needed in my job. __Preparation for a future resident course. __Cross-training. __Requirement. __Promotion or retirement points. __Other (explain)_________________

5. How many hours did you spend on the subcourse?__________ 6. Today's date__________________

B. FOR ANY QUESTION THAT REQUIRES A REPLY, PLEASE WRITE A SEPARATE LETTER. BE SURE TO INCLUDE:

1. SUBCOURSE NUMBER, PAGE/PARAGRAPH/EXERCISE NUMBER.

2. NAME, RANK, SOCIAL SECURITY NUMBER, AND RETURN ADDRESS.

C. THIS INFORMATION IS OPTIONAL:

NAME OF STUDENT:_____________________RANK:____________SSN:__________________

MILITARY ADDRESS:____

AUTOVON/TELEPHONE NUMBER:____________________MOS (OR AOC):________________

PRIVACY ACT STATEMENT

AUTHORITY: *10USC3012(B) and (G)*
PURPOSE: *To provide Army Correspondence Course Program students a means to submit inquiries and comments.*
ROUTINE USES: *To locate and make necessary changes to student records.*
DISCLOSURE: ***VOLUNTARY.*** *Failure to submit SSN will prevent subcourse authors at service schools from accessing student records and responding to inquiries requiring such follow-up.*

ITALICS

Figure 2-28. Student Comment Sheet printed on a laser printer. (several size fonts with boldface and italics on the same page.)

(b) Uses. Data can be entered on the keyboard and displayed on the screen for verification as it is keyed in. Video Display Terminals can also be used for applications in which inquiry and response are needed, but no permanent record is required. Monitors can be used for capturing data to be transmitted from remote offices to a central computer. Faster and quieter than printers, they have a display capability of 10,000 characters per second. A printer can be connected to a terminal, to provide hard copy of the screen contents, if needed.

(c) Options. Video Display Terminals have a variety of options. Resolution or clarity will depend on the size of the dots that form the characters. Smaller dots make sharper images. Standard terminals are monochrome, but color provides added flexibility. Many programs can use or require a color monitor. Most VDTs can read only standard shapes, i.e., letters or numbers. The graphics capability is an additional option.

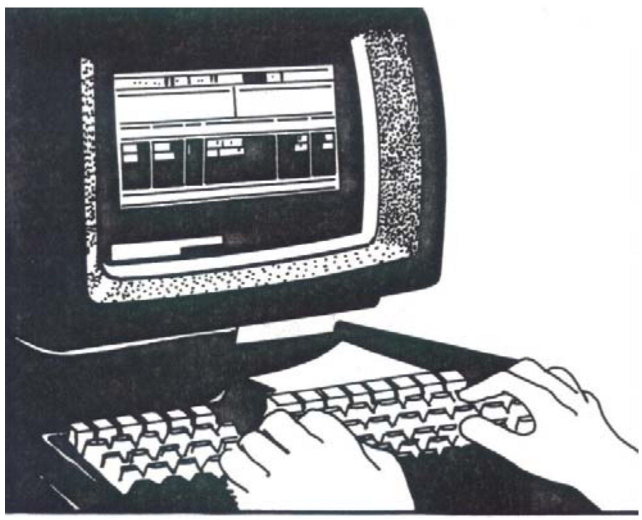

Figure 2-29. Video display terminal (VDT).

(2) Graphic display devices are monitors that display drawings (graphs, charts, complex curves) as well as characters. With some terminals data can be altered using a light pen. A light-sensitive cell at the tip of the pen communicates with the screen's electronics to tell the computer where the pen is pointing. The light pen gives computer users another way to interact with the machine without resorting to the keyboard. Using the light pen, complex drawings, such as those used in airplane or automobile design, can be made. Items can be selected on the screen, and even music can be composed through the use of a special program. In figure 2-31, the program causes each note to sound as the user positions the note on the screen. Pressing a box labeled PLAY causes the whole piece to play.

light pen: a pen-shaped object with a light-sensitive cell at one end, used as an alternative to the keyboard to communicate with the screen's electronics.

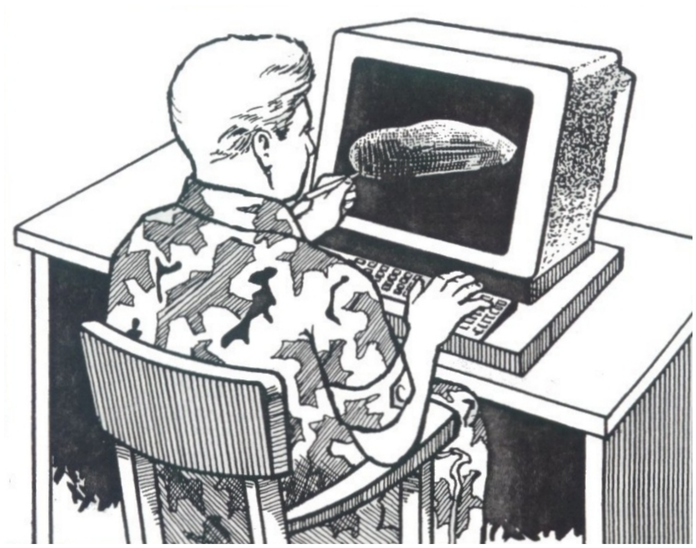

Figure 2-30. Graphic display device with light pen used in computerized 3-dimensional car design.

Figure 2-31. Composing music with a light pen.

(3) Sound synthesizers provide voice, tone, or musical feedback. The banking industry uses this approach to report customer account balances. Often the audio response units are coupled with touch tone terminals for review of the data entry and output.

2-8. STORAGE

a. **Overview.** It would be impossible for a computer to operate without the capability to remember, or store, instructions and facts and figures for retrieval when needed. Computer storage, often called "memory," is an electronic file which retains instructions and data as long as they are required. When data are placed in storage through an input unit, they remain there until called for by the control unit of the CPU. The amount of data required by a program or set of programs generally exceeds the capacity of the CPU's main or primary storage.

main storage: the internal storage of a computer from which instructions are executed; the fastest storage of a computer.

(1) In such cases the data are stored in auxiliary storage (also known as secondary or peripheral storage). The most common types of peripheral storage are magnetic tape and magnetic disk. (Other media include punch cards, mass storage, and magnetic drums). These auxiliary storage media cost much less than primary storage and thus make storage of large volumes of data more economical.

auxiliary storage: a supplement to the main storage; usually supplied by magnetic disks, magnetic drums, magnetic tape, or magnetic cards.

(2) Secondary storage media are connected to the CPU. Once data has been placed in there, they can be retrieved for processing. Retrieving items from secondary storage takes longer than retrieving from main storage. After processing has been completed the results can be written back onto the auxiliary storage.

b. **Main vs Auxiliary Storage.** As stated earlier, main storage (also known as internal or primary storage) is an integral part of the central processor. All data to be processed by the computer must pass through the main storage. Main storage is used to store both instructions and data. The main storage unit must have sufficient storage capacity to hold the program being used and the data needed for the problem. When additional storage is needed, the computer system may be supplemented with auxiliary storage.

c. **Direct vs Sequential Access.** There are two type of auxiliary storage: direct (or random) access and sequential access. Direct access devices, such as magnetic disk, give immediate access to a particular item of stored data. Sequential access devices consist of tape units (magnetic tape or paper tape), whose stored data must be read from the beginning in order to read or write a particular item of data. Auxiliary storage may be used to store both instructions and data. Before these instructions can be executed or these data used by the computer, however, they must be brought into the main storage unit of the computer. Computer programs and data are held in auxiliary storage until called for 6y the control section of the CPU. Once called up, the control section directs the transfer of the specified information into assigned locations in the main storage. After processing is complete, the same information and processed results can be sent back to the auxiliary storage.

> **direct (or random) access:** a type of storage in which access can be made directly to the data in any storage location (magnetic core, magnetic disk, magnetic drum, or magnetic card).
>
> **sequential access:** a type of storage in which data can only be stressed in the sequence in which it is stored in the device (for example, magnetic tape or paper tape).

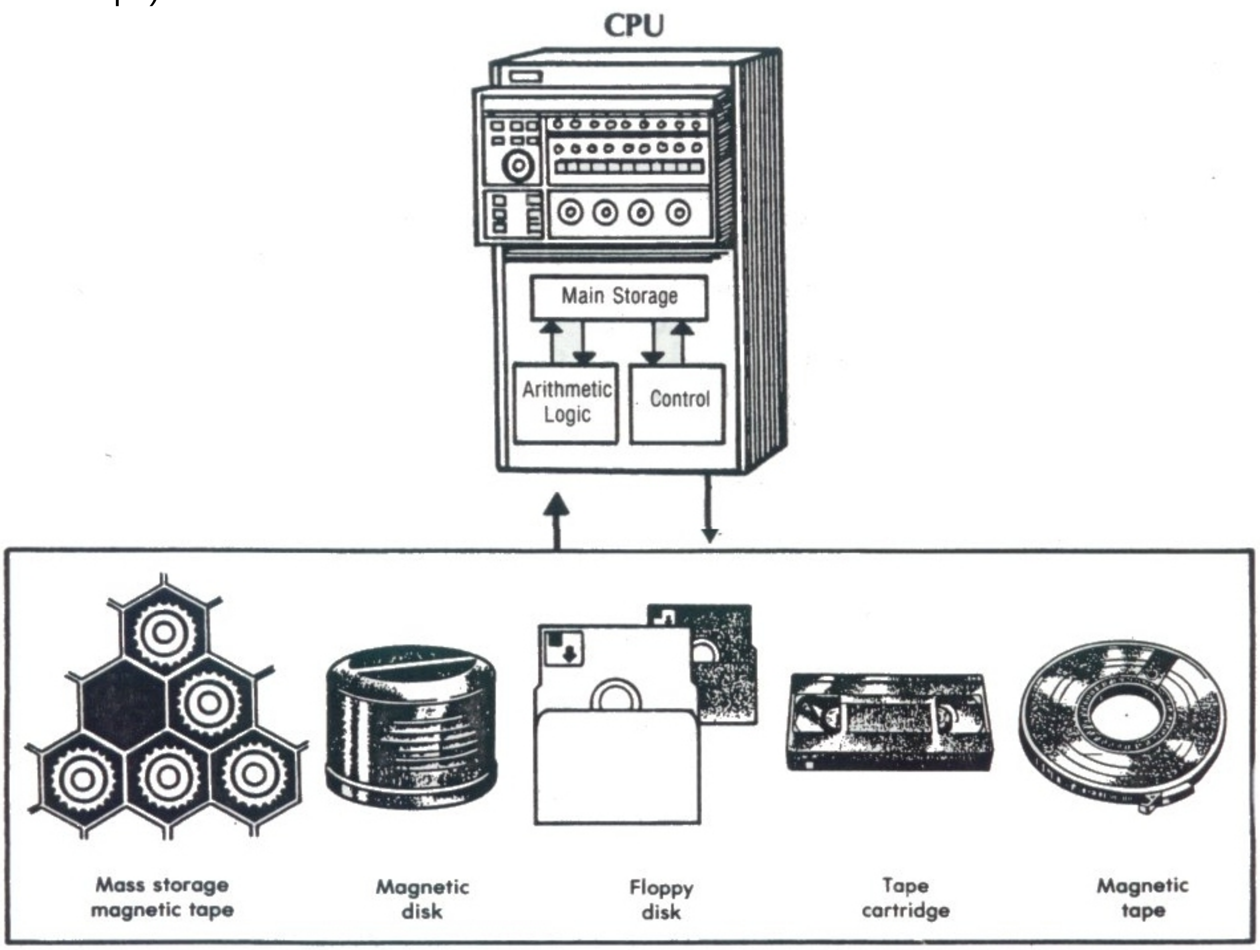

Figure 2-32. Secondary storage media are connected to the CPU.

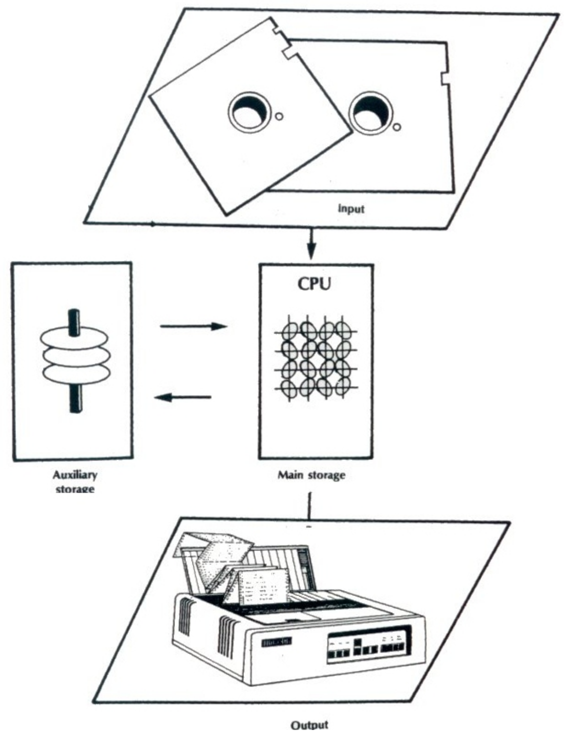

Figure 2-33. Auxiliary storage supplements the main storage.

d. **Storage Addressing**. The main storage of a computer can be thought to resemble the numbered mailboxes in a post office. Each mailbox is located and identified by its number. In a similar way, main storage is divided into locations, each with a unique address. Each location holds a specific unit of data for use by the central processor. A unit of data tan be a digit, a character, a byte, a word, or a record. Each item of data is inserted into or extracted from a specific storage location. Whenever data are inserted into a storage location, they replace the previous contents of that location. When data are extracted from a location, the contents remain unchanged since only a copy of the contents has actually been removed. Once data are placed in storage, therefore, they may be used many times.

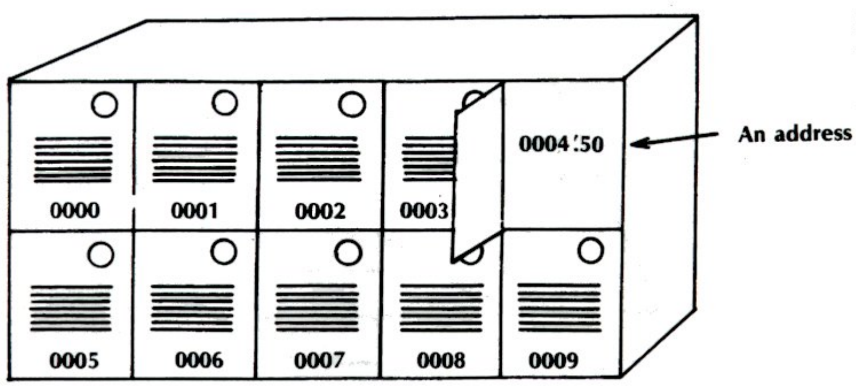

Figure 2-34. Main storage may be thought to resemble a series of numbered mailboxes.

address: a number identifying a storage location from which data are to be retrieved or inserted.

character: smallest unit recognizable to humans (letter or number).

byte: eight bits treated as a unit; memory needed to store a single letter or character.

word: a set of characters occupying one storage location and treated as a unit.

record: a group of logically related items treated as a unit (see also figure 3-2).

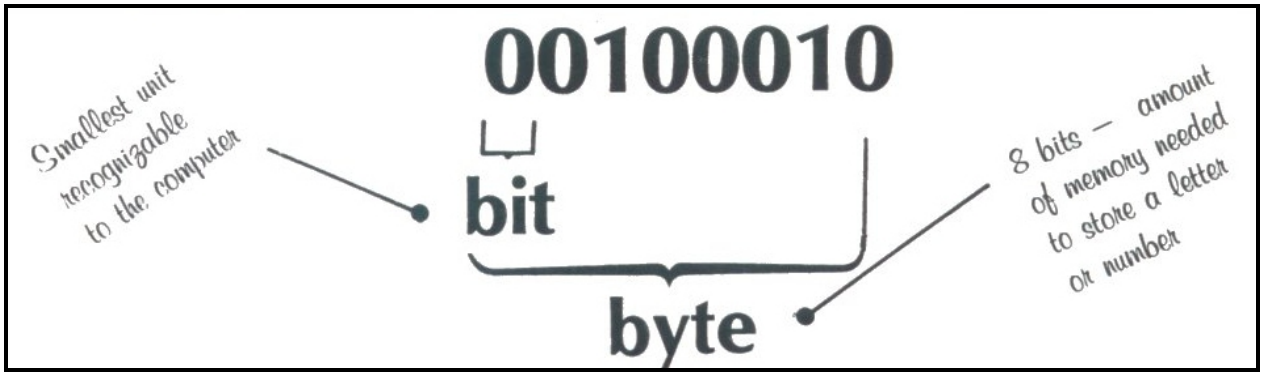

Figure 2-35. Bit vs. byte.

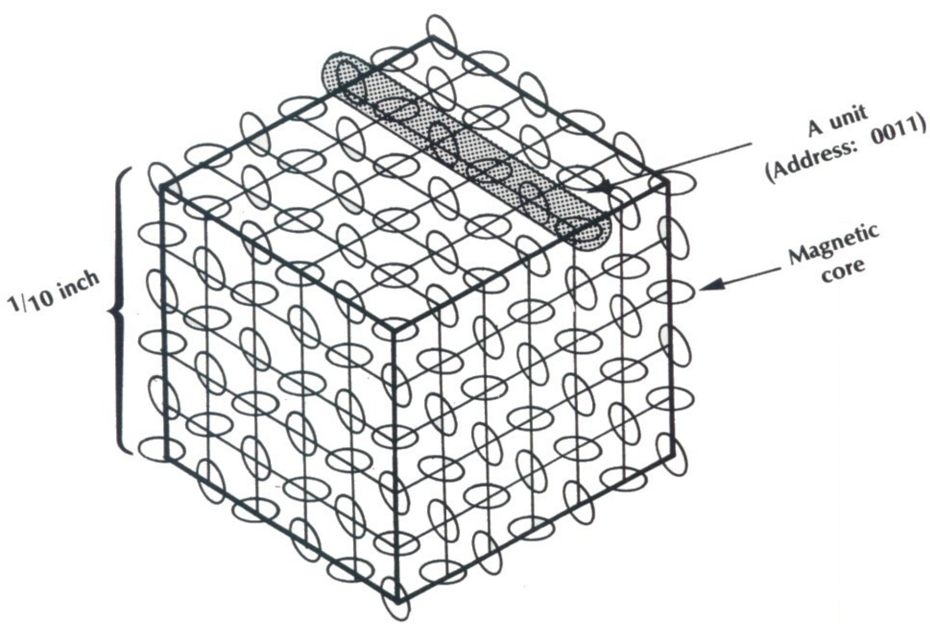

Figure 2-36. Each unit in main storage has a unique address.

e. **Access Time.** The time needed to locate and transfer data or instructions either to or from storage is called access time. The access speed and the amount of data handled per access have a direct impact on the cost and efficiency of the entire system. This is true mainly because the central processor is constantly accessing storage for instructions and data, as well as replacing new data into storage during the execution of a program. The access time of many computers is so fast that it is measured in billionths of a second, or nanoseconds.

access time: the time the computer takes to locate and transfer instructions or data to or from storage.

nanosecond: one billionth of a second (one thousandth of a microsecond).

Section III. COMPUTER SYSTEM LIMITATIONS

2-9. A COMPUTER CANNOT THINK

A popular misconception is that computers can think. If, for example, a computer can play a game of chess, how is it that it cannot do the requisite thinking involved in planning the strategy of the game? The programmers, the people who design the chess program, provide the strategy in the form of detailed instructions covering every possible move. The program for a simple game of checkers, for example, requires hundreds of detailed instructions. Those knowledgeable in the field are quick to remind us that a computer is not a brain (some would add--at least, not yet). It is simply another tool, designed to reduce labor and extend our mastery of the world. For all its apparent brilliance, a modern computer's only capability is to read with lightning speed coded bursts of voltage. The true brilliance lies with the genius of men and women who have found ways to translate information from the real world into the Os and the is of the binary code, the logical and mathematical language of a computer's electronic circuitry.

2-10. PEOPLE DO SOME JOBS BETTER THAN COMPUTERS

People can perform small complex jobs as well or better than computers. For example, the time and effort required to program a computer to prepare a complicated tax report for one-time use is far greater than the effort involved in using pen, pencil, and paper.

2-11. A COMPUTER CANNOT PROTECT ITSELF

a. **Environmental Influences**. For all its seeming power and complexity, a computer can be adversely affected by a number of simple environmental influences. As seemingly innocent an event as a coffee spill on the keyboard or CPU can harm the electronic circuitry. A power surge (also known as a "voltage spike," a sudden increase in power), or an interruption in the supply of electricity, can affect the floppy disk and its read and write memory. If an operator uses your word processing file disk as a coffee cup coaster, the diskette is likely to be damaged and some data lost. A clumsy-footed operator, who pulls the wrong plug out of the wall, can wreak havoc with computer memory. The worst threat of all are viruses computer programs designed to do things with your program that were not intended. In an X-ray department, a virus can: overwrite all patient radiographic reports with "garbage" (cancel existing data and replace it with new data). It can unschedule all patients for a given day or week, make the computer system inaccessible to all users, write (transfer) itself into all computers through which there is a communication link, or all of the above.

b. **"Garbage In, Garbage Out" Syndrome**. From a data input-output standpoint, the computer can only be as good as the data fed into it. If erroneous data are fed into the computer, a "garbage in, garbage out" syndrome will prevail.

c. **Acts of Nature and Man.** Additionally, the computer is vulnerable to acts of nature and man. It cannot run away, for example, in case of fire or flood. Nor can it protect itself from an incompetent user.

d. **Ergonomic Considerations.** A computer will work best in an ergonomically sound environment, that is, an environment designed for human comfort. Room temperature should be temperate, and the air should not be humid. High temperatures, humidity, dust, dirt, and cigarette smoke contribute to computer malfunctions.

e. **Conclusion.** After you have overcome your initial awe and/or fear of the computer, you must keep these factors in mind, in order to optimize the smooth functioning of the computer system you are using.

Continue with Exercises

EXERCISES, LESSON 2

INSTRUCTIONS. Circle the letter of the response that best answers the question or best completes the incomplete statement or write the appropriate term in the space provided.

After you have completed all the exercises, turn to "Solutions to Exercises" at the end of the lesson and check your answers. For each exercise answered incorrectly, reread the material referenced after the solution.

SPECIAL INSTRUCTIONS. For exercises I through 7, match each term (left-hand column) to its definition (right-hand column). Enter the appropriate letter in the space provided. (There is one extra lettered statement that will not be used.)

1. Hardware _____	a. Obtain data from some source.
2. Peripherals _____	b. Magnetized storage plate.
3. Read _______	c. Input-output devices, secondary storage devices, and other auxiliary equipment.
4. Write _____	d. Has smaller capability than mainframe but same components.
5. Sit _____	e. Record or deliver data to storage.
6. Disk _____	f. Binary digit, smallest unit of information.
7. Minicomputer _____	g. Computer machinery.
	h. Analog computer.

SPECIAL INSTRUCTIONS. For exercises 8 through 14, match each term to the appropriate definition.

8. on-line _____	a. Programs or preset instructions.
9. Input-output devices _____	b. Permanent readable text.
10. Software _____	c. Eight bits treated as a unit.
11. Hard copy _____	d. The storage device goes immediately to the desired location.
12. Direct access _____	e. Storage identification number.
13. Address _____	f. In direct communication with the computer.
14. Byte _____	g. A collection of routines and programs.
	h. Communication link between people and computers or different computer systems

SPECIAL INSTRUCTIONS. For exercises 15 through 19, match each term to the appropriate definition.

15. Sequential access _____	a. Interval required to locate and transfer data from storage.
16. Record _____	b. Set of characters occupying one storage location.
17. Access time _____	c. Storage in which data can only be read in the order it is stored.
18. Nanosecond _____	d. Memory chip that allows output to be printed after exiting the program.
19. Buffer _____	e. One billionth of a second.
	f. Logically related items treated as a unit.

20. A digital computer performs its operations by _______________O's and 1's.

21. Analog devices, such as speedometers ________________continuous physical or electrical magnitudes.

22. The CPU is composed of: the control unit, the arithmetic/logic unit (ALU), and the ____________________________.

23. The five functions of a computer are: input, output, storage, control, and __________________________.

24. The brain of the computer is the ________________,which coordinates and controls the activities of all other components.

25. The internal storage is only __________________________________, in nature.

26. Information in the core memory is either stored as magnetized iron core "doughnuts," or in semiconductor memory, as ___________________________.

27. A logical operation, such as comparing one data item to another would be performed by the ______________________ of the CPU.

28. The instructions in a program are interpreted and executed in the form of signals (commands) by the _____________________________________ of the CPU.

29. After all computations and manipulations are completed, results are erased from the core memory and recorded in the___________________________memory.

30. The most common peripheral storage media are magnetic tapes and _________.

31. Access to data in auxiliary storage can be either direct or __________________.

32. On magnetic __________________, any record or file can be located directly without having to read the records preceding it.

33. The peripheral that reads previously recorded data and converts it to magnetic form that the computers can use is the _____________________________ device.

34. Input and output devices provide the people/ _____________________ interface.

35. The slowest form of data entry uses _____________________________________.

36. Source data automation means data can be collected directly into the computer, in _________________ form, where and when the event takes place.

37. It takes longer to ________________________ data than to process it.

38. The cathode-ray tube operates on the same principle as the _________________.

39. Two types of printers are ___________________ and ______________________.

40. ______________________ printers can operate on a line-at-a-time or character-at-a-time basis.

41. _________________ printers are faster, since they utilize electrostatic, electrothermal, ink jet laser and xerographic methods, that involve fewer mechanical parts.

42. Better printers have a buffer, a built-in memory chip, that permits printing of output after ___________________________ the program.

43. Dot matrix printers cannot produce letter-quality type, but can be used to create __________________________.

44. ____________________ produce professional quality output, superior to that of the dot matrix, but no graphics.

45. ________________ produce high speed, letter perfect images and graphics, a variety of type sizes and styles on a single page, and can be used to print books.

46. A________________permits verification and correction of data as it is keyed in.

47. A printer can be connected to a CRT to produce a ____________________.

48. It takes ______________________ time to retrieve data from auxiliary memory than from core memory.

49. A lab technician will find it practical to use an _________________ input device, because it allows the hands to be free when doing lab work.

50. Banks use ______________________ to report customer account balances.

51. A unit of data, held in a ___________________ address, can be a digit, a character, a byte, a word, or a record.

52. When data is extracted from a storage location in memory, the contents remain unchanged, since only a _______________of the contents is removed.

53. Systems that use hard disks or floppy disks have a _________________ , a mechanism that rotates a storage disk, and reads or records data.

54. The cost and efficiency of a computer are directly affected by the amount of data handled and the _____________________time.

55. The computer is constantly accessing storage for: instructions, as well as placing new ______________________ into storage.

56. A computer is a tool, it cannot ________________________. The brilliance of a computer lies in the genius of the men and women who create the computers and design programs.

57. The "garbage in, garbage out" syndrome refers to the fact that a computer is only as good as the quality of the instructions and ___________________ fed into it.

Check Your Answers on Next Page

SOLUTIONS TO EXERCISES, LESSON 2

1. g (2-1)

2. c (para 2-4)

3. a (para 2-4)

4. a (para 2-4)

5. f (para 2-8d, definition of byte, and figure 2-3)

6. b (para 2-6 b(3)(a)

7. d (para 2-6 b(3)(b))

8. f (para 2-6c)(1))

9. h (para 2-6a)

10. a (para 2-4)

11. b (para 2-7b)

12. d (para 2-8c)

13. a (para 2-8d)

14. c (para 2-8d)

15. c (para 2-8c)

16. f (para 2-8d)

17. a (para 2-8e)

18. a (para 2-Be)

19. d (para 2-7c)

20. Counting (para 2-2a)

21. Measure (para 2-para 2b)

22. Core memory (OR primary storage, OR internal storage, OR main storage, OR temporary storage) (para 2-4)

23. Arithmetical/logical manipulation (OR calculation/symbol manipulation) (para 2-3)

24. CPU (OR central processing unit) (para 2-5)

25. Temporary (para 2-5c)

26. Silicon chips (para 2-5b(para 2))

27. Arithmetic/logic unit (ALU) (para 2-5b)

28. Control unit (para 2-5d)

29. Peripheral (OR auxiliary OR secondary) memory (para 2-5c(para 2)(c))

30. Disks (para 2-6b(3)(a))

31. Sequential (para 2-8c)

32. Disk (para 2-8c)

33. Input (para 2-4)

34. Machine (para 2-6a).

35. Punch cards (para 2-6b(1))

36. Readable (para 2-6c)

37. Enter (para 2-6c)

38. Television (para 2-7f(1)(a))

39. Impact and non-impact (para 2-7b)

40. Impact (para 2-7d)

41. Non-impact (para 2-7e)

42. Exiting (para 2-7c)

43. Graphics (para 2-7d(1))

44. Daisy wheel printers (7d)(para 2))

45. Laser printers (para 2-7e(1))

46. Visual Display Terminal (OR cathode-ray tube) (para 2-1f(1)(a))

47. Hard copy (para 2-7a)

48. More (para 2-8(a))

49. Audio (para 2-6c(4))

50. Sound synthesizers (para 2-7 f(3))

51. Storage (para 2-8d)

52. Copy (para 2-8d)

53. Disk drive (para 2-6b(3)(c))

54. Access (para 2-8e)

55. Data (para 2-8d)

56. Think (para 2-9)

57. Data (para 2-11)

End of Lesson 2

LESSON ASSIGNMENT

LESSON 3	Computer Fundamentals.
LESSON ASSIGNMENT	Paragraphs 3-1 through 3-21.
LESSON OBJECTIVES	After completing this lesson, you should be able to identify (by selecting from alternatives):

3-1. The purpose and stages of data processing.

3-2. Stages of data processing.

3-3. Distinguishing characteristics of maxi- (mainframe), mini-, and microcomputers.

3-4. Terms and concepts associated with on-line, real time, batch processing, and time-sharing.

3-5. Distinguishing features of batch, real time, and on-line operating systems.

SUGGESTION	After completing the assignment, complete the exercises of this lesson. These exercises will help you to achieve the lesson objectives.

LESSON 3

COMPUTER FUNDAMENTALS

Section I. DATA PROCESSING

3-1. LESSON OVERVIEW

The preceding lesson helped you form a general idea of basic computer components and their functions. In this lesson you will gain a broader perspective. You will find out about data processing, the fundamental operation of the computer, how it is accomplished, and why it is needed. You will learn about the three major categories of computer systems (mainframe, mini-, and microcomputer), and the benefits of smaller, faster, and more efficient computers and the programs that support them. You will also learn about different teleprocessing systems that make feedback quicker and more responsive. You will find out about the computer services offered by service business and time-sharing companies and finally get a feel for future trends in the computer field.

3-2. EVOLUTION OF DATA PROCESSING

As stated in Lesson 1, data processing (the collecting, manipulating, and distributing of data) has been practiced since earliest recorded history. The methods of data processing have gone through an evolutionary process: from manual (data processing), to electromechanical (automatic data processing), to electronic or computerized. Electronic data processing is often referred to simply as data processing.

3-3. PURPOSE OF DATA PROCESSING

Whether manual, electromechanical, or electronic, the purpose of data processing remains the same: to organize raw data into meaningful information needed for decision-making. In common parlance, data and information are used interchangeably. But strictly speaking, they are distinct and separate. A list of the day's checks and deposit slips (the data) means very little to a bank manager until they have been manipulated into summary report form (information), giving the total number and dollar value of deposit and withdrawals. Information, then, is data that has been organized and processed. The purpose of data processing is to evaluate and organize data, to produce meaningful information that can be used in decision-making. To be of value, information must be delivered to the right person at the right time, and in the right place. It must be accurate, timely, complete, concise, and relevant.

3-4. THE THREE STAGES OF DATA PROCESSING

Data processing can be likened to the manufacturing process. In manufacturing, raw materials are processed, or made into a finished product. The raw materials may be considered "input" to the processing machine. The finished product is "output." In the electronic computer, data are the raw material or input to the computer. The finished product, or output, is usually a printed report or an updated file containing data that have been processed or manipulated in some way. The three functions (or stages) of data processing are: input, process (or manipulation), and output. Input involves capturing data and getting it into a farm understandable to the computer. Processing encompasses the various steps taken by the computer to manipulate the data and provide information. Output makes the computed results of processing available for use in decision-making.

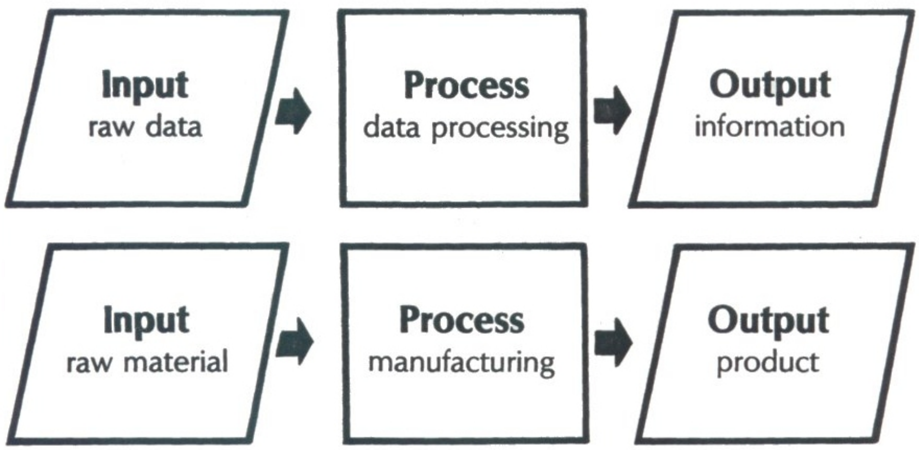

Figure 3-1. Data processing compared to manufacturing.

3-5. INPUT ACTIVITIES

Three steps are involved when inputting data into the computer: collection, verification, and coding. Collection refers to gathering the data from a variety of sources and assembling it. Verification means checking the data to determine whether it is accurate and complete, and if it should be included for processing. Coding is translating the data into machine-readable form. Data punched into IBM cards is one example of coding.

3-6. PROCESSING ACTIVITIES

During processing or manipulation, one or more of the following tasks may be performed on the input data.

a. **Classifying.** Data are organized by characteristics meaningful to the user. For example, a student may be identified by Social Security number, class and exam number.

b **Sorting.** In this step, the data may be arranged in a particular sequence to facilitate processing.

c. **Calculating**. Calculations may be required to determine a patient's account balance or a student's grade point average.

3-7. OUTPUT ACTIVITIES

a. Output activities include retrieving, converting, storing, and communicating. Retrieving involves pulling information from storage devices for use by the decision-maker.

b. Converting means translating information from the computer form used to store it, to a form understandable by the user (such as, a CRT display or printed report).

c. Storing involves transferring the data onto a storage medium, such as a disk or tape file for future use.

d. Communication takes place when the relevant accurate information is in the right place at the right time.

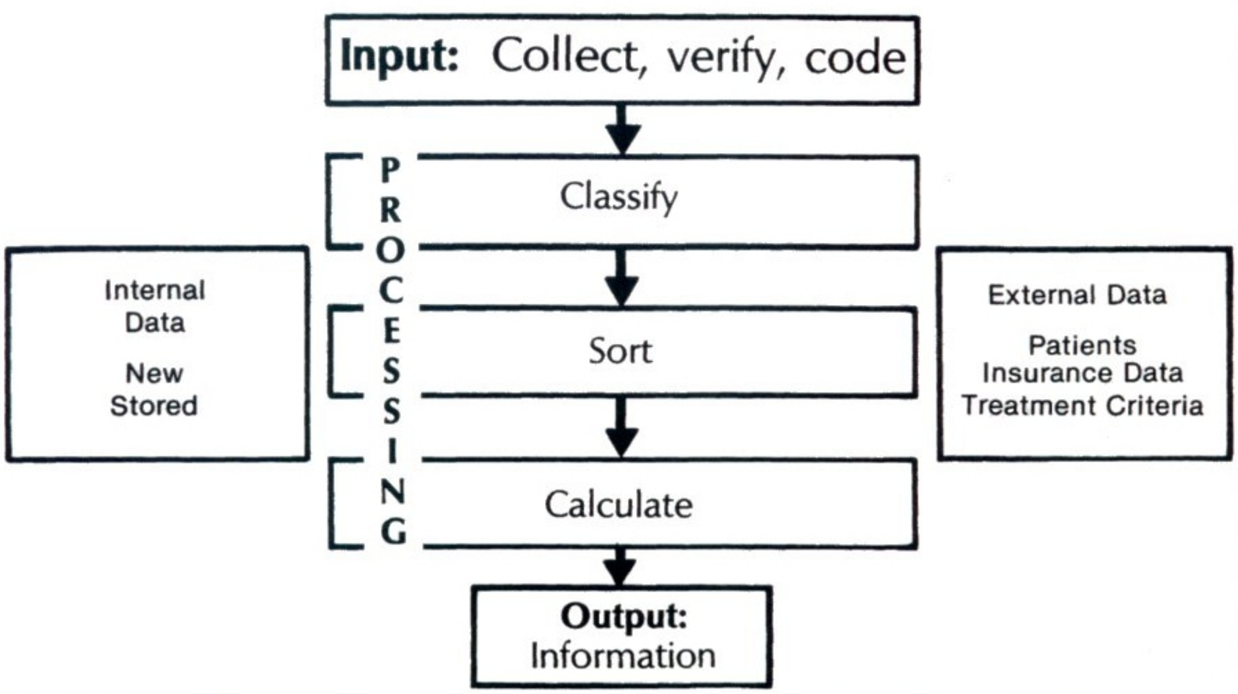

Figure 3-2. The product of data processing is information.

3-8. WHY COLLECT DATA?

Implicit in data processing is that some benefit be derived from the effort. Having the relevant information should enable an organization to function better. The cost of collecting, processing, and storing data, therefore, should not exceed the benefits of having this information available for later use. The information might serve to reduce expenses. A high X-ray repeat rate for a particular technician, for example, would serve as a useful management indicator, signaling the need for additional training. Information can provide intangible benefits, perhaps insights into reasons for low morale within a clinic. A report showing more than average time needed to complete X-rays could signal procedural problems that are undermining employee morale.

Section II. TELEPROCESSING SYSTEMS

3-9. INTRODUCTION

With each evolution of the computer, the response time needed to collect, manipulate, communicate, store, and retrieve data has shortened. Quick response time is an important consideration, as the usefulness of information is time-dependent. Responsive systems increasingly use some form of remote (distant) input and output devices in direct communication with the computer. This allows users to react more quickly to changing conditions, reduces the waste of time and resources, and promotes quick follow-up. This section touches on the types of programs needed to support more responsive systems: operating systems and application programs. It covers the various ways that data are processed: batch, on-line, and real time processing. It presents the concepts of local and remote systems, computer networks or distributed data processing, and time-sharing services. It deals with teleprocessing, the combined use of data processing equipment and telephone lines.

3-10. SYSTEM PROGRAMS AND APPLICATION PROGRAMS

As stated earlier, the step-by-step instructions needed for a computer to reach the solution to a problem are provided in the program. There are two basic types of programs used by a computer. Operating system programs coordinate the operation of computer circuity. Application programs solve particular problems.

> **application program:** a sequence of instructions written to solve a specific problem.

3-11. OPERATING SYSTEMS

In first- and many second-generation computers, human operators monitored computer operations, determined the order programs were run, and prepared input and output devices for operation. Although early electronic development increased the processing speeds of CPUs, the speed of human operators remained constant. Time delays and errors caused by human operator intervention became a serious problem.

In the 1960s, operating systems were developed to help overcome this problem. An operating system is a collection of programs used by the computer to manage its own operations. By eliminating the human operator, the operating system can run the jobs at computer speeds. This avoids CPU idle time while increasing utilization of computer facilities.

operating system: a collection of programs that permits the computer to manage itself, reduces CPU idle time, and increases utilization of computer facilities.

3-12. TYPES OF OPERATING SYSTEMS

There are two basic types of operating systems: batch and real time. In batch jobs, several user programs are grouped into a batch and processed one after another in a continuous stream. A real time operating system can respond to spontaneous requests for system resources, such as management inquiries from terminals.

3-13. BATCH PROCESSING

a. **Description.** Most data processing is done using batch processing (also know as serial, sequential, or off-line processing). Batch processing involves processing transactions on the computer at specified times. Payroll, for example, is normally processed in batch mode. On a predetermined date at a predetermined time, the variable information about payroll (hours worked, changes in deductions, new pay rates, new employees, etc.) is entered and the computer produces all of the payroll checks and information at the same time. The payroll information is allowed to accumulate and entered as a batch or group at a central computer site or other location (a small hospital that is a client of a computer service, another branch office or government agency).

batch processing: also called serial, sequential, or off-line processing; a technique in which a number of similar items or transactions are accumulated and then processed periodically as a group or batch.

(1) In batch processing, the data are first sorted in the same sequence as the master file, and then master files are accessed sequentially, rather than skipping around (direct access).

sort: to place a group of records into a desired sequence.

(2) The sorting may be done off-line, that is, before the data are entered into the computer. For example, if sorting a group of punched cards, a high-speed sorter may be used before the data are entered into the computer.

off-line: operations performed apart from the computer.

b. **Advantages and Disadvantages.** Batch processing is economical when a large volume of data must be processed. It is suitable to such applications as payroll, and the preparation of client, patient, or customer bills. However, it requires sorting, reduces timeliness, in some cases, and requires sequential file organization. Since master files are updated only periodically, there is a potential for master files to become quite out-of-date if transactions are not processed frequently.

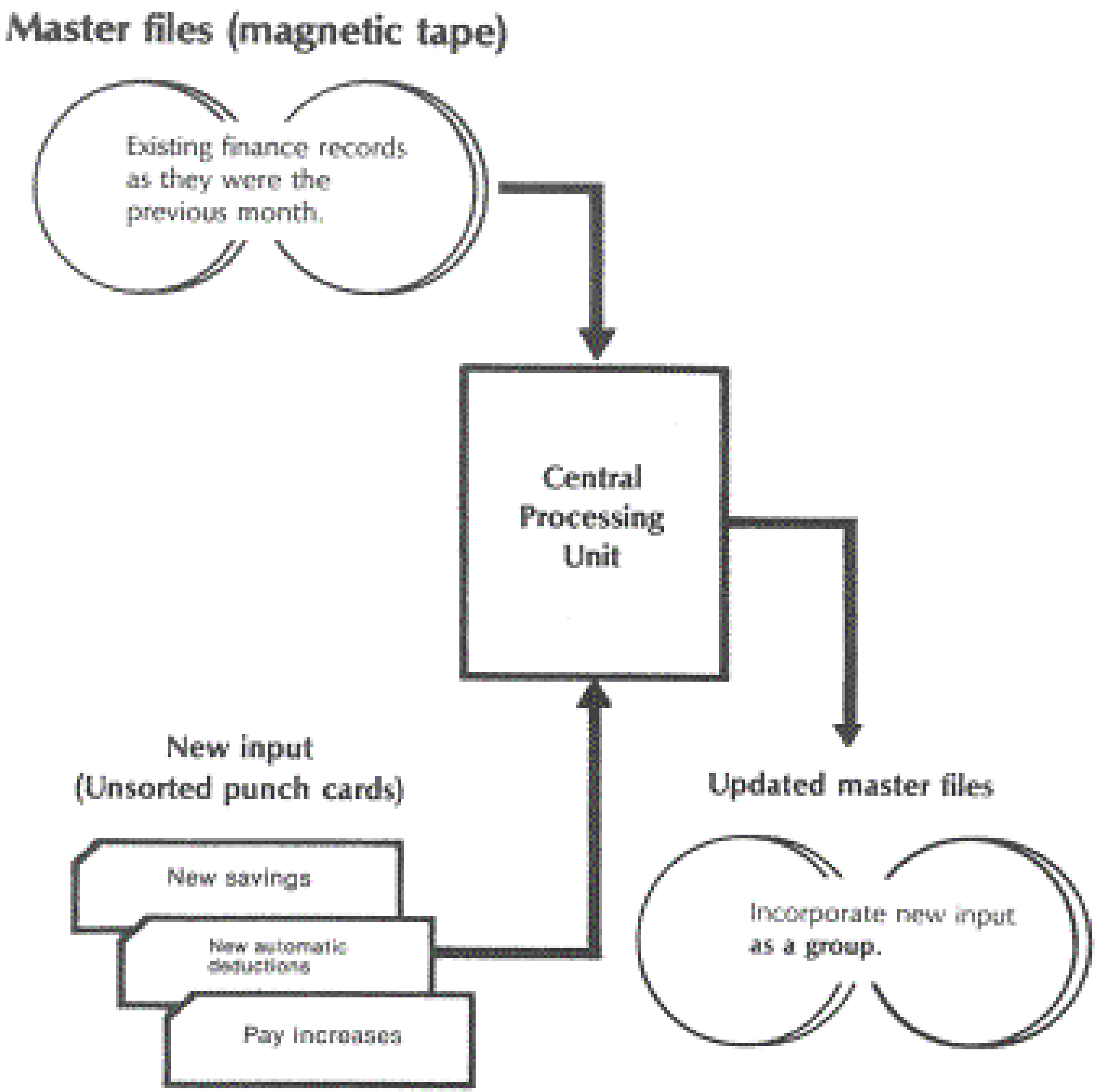

Figure 3-3. Batch processing in a finance department. The computer looks at the master file, periodically making changes reflecting new transactions. Old master files are updated as a group.

3-14. ON-LINE PROCESSING

a. **Various Uses of the Term.** The term on-line can be used in several ways. Since these several meanings can cause some confusion, it is best to clarify the term at the outset. A peripheral device is said to be on-line when it is directly connected to and capable of unassisted communication with the CPU. On-line also describes the status of a person who is communicating directly with the CPU without the use of media such as punch cards or magnetic tape. And finally, on-line refers to a method of processing data.

> **on-line:** in direct communication with the computer; cabled to the computer; information that is immediately accessible to the computer (stored on the secondary storage that supports direct access to the information).

b. **Description.** On-line processing was developed as an answer to the batch-processing deficiencies noted earlier. On-line communications systems allow the transaction to be entered directly into the computer at the instant the transaction occurs, rather than accumulated before inputting as in the batch mode. Normally, a keyboard terminal is linked by means of a communications line directly to the computer where the master files are located. In contrast to batching, on-line (direct access or random access processing) permits data to be fed under CPU control directly into secondary on-line storage devices, from the point of origin without first being sorted. Information contained in any record is accessible to the user without the necessity of a sequential search of the file and within a fraction of a second after the inquiry has been transmitted. Thus, on-line processing systems may feature random and rapid input of transactions and immediate and direct access to the record contents, as needed. The information is said to be on-line when it is immediately accessible to the computer. On-line systems do not necessarily demand a response. The Internal Revenue Service, for example, absorbs a great deal of financial data, but only responds to those returns with errors or requiring an audit.

> **on-line processing:** the entry of data directly into the computer from a terminal in direct communication with CPU (in contrast with batch processing); rapid and random input of data without sorting; data manipulation fast enough to affect the outcome, but not instantaneous.

c. **Advantages and Disadvantages.** On-line processing permits the computer to interact with people as it processes a transaction. Much of the clerical burden of paperwork is shifted from people to machines, when the computer is on-line to the people doing the work. The two disadvantages of on-line processing are the complexity of the process and the extra computer hardware and software needed. The CPU must be adequate to handle the complex on-line system, as well as serve its other functions. Since many on-line users have access to stored records, software security must be adequate to protect against damage or unauthorized use. Processors must be fast enough to respond to multiple on-line stations operating simultaneously. Large capacity, peripheral on-line storage units are required to store additional operating-system elements, user data and programs. And data transmission facilities must be provided to communicate with on-line terminals in the next room, the next block or thousands of miles away. The added costs of on-line processing are offset by the resultant savings from eliminating repetitive clerical work. Most new computers have on-line capability. The applications that are more effective with on-line operations include order entry, inventory control, billing and accounts receivable, as well as other systems in which people are working and interacting with customers continuously during the workday.

d. **On-line vs. Batch Processing.** Compared to on-line processing, batch processing is much slower. A complete payroll, from balancing to preparation of checks, can be done in 3 hours by batch processing methods. An on-line application, which handles individual transactions, is measured in seconds. An inquiry as to the availability of a seat on an airline flight can be completed in 2 seconds. There is a fundamental trade-off between serial /sequential processing with magnetic tape and direct on-line processing with magnetic disk. On-line processing provides extremely fast access to relatively small amounts of data on a random basis. Batch processing provides an efficient and economical way to process relatively large amounts of information. Many contemporary applications have both batch and on-line processing components.

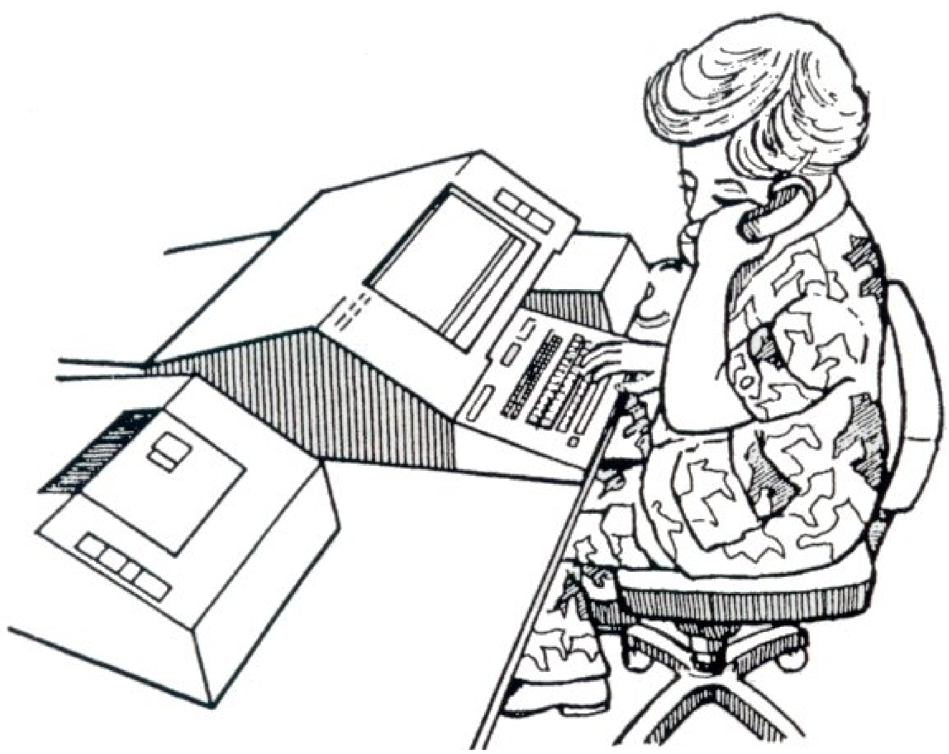

Figure 3-4. On-line processing: individual changes to a record are made as the input occurs.

3-15. REAL TINE PROCESSING

a. **Real Time.** Over 30 definitions can be found in the literature for real time. This term has caused so much controversy that some would like to see it dropped entirely. Like on-line systems, real time systems transmit data by means of communications lines to a central computer. Both use direct access media and require direct access processing. Like on-line systems, real time involves direct on-line interaction between the user and the computer, but real time functions under severe time limitations. Real time implies a response that takes place over an extremely short period of time, with results returned to the point of origin in time to allow change or correction if necessary. Real time can be thought of as an extremely quick on-line response system. A real time processing operation is in parallel time relationship with an ongoing activity and producing information quickly enough to be useful in controlling the event.

> **real time processing:** the capability of a system to receive data, process it, and provide output fast enough to control or affect an activity being performed. Response time is almost instantaneous.

b. **Real Time vs. On-line Systems.** A real time processing system is generally considered on-line (connected directly to a host computer). This interrelationship is demonstrated by the fact that some sources actually refer to real time as on-line real time processing. On-line processing, on the other hand, is not always real time. Real time requires split-second access to up to the minute records, instant access in both directions (input and output). Data provided to the astronauts on a manned space flight would be real time. Also, many remote stations may be tied directly by high-speed communications equipment into the central processor; several stations may be operating simultaneously. Files may be updated each minute, and inquiries may be answered by split-second access to up-to-the-minute records. Originally used by the national defense system and for the space program, real time was subsequently adapted for commercial uses, such as on-line banking and airline reservations. Airlines use real time processing to control inventory and book seats. When you call your travel agent, she records several codes into a small keyboard on her desk. Within seconds a display screen shows several possible routes, with the airline flight number and arrival and departure times of each connecting flight. She tells you the choices, and you select the one you prefer. Another entry confirms your reservations with each airline and prints your tickets. The ticket indicates your total fare, including taxes, and shows the share of the fare for each participating airline. The whole transaction takes less than a minute. In the x-ray field, real time processing means that an image can be displayed for viewing as scanning is in progress.

Figure 3-5. Information was conveyed at great speed to the Apollo astronauts on a real time basis by UNIVAC.

Airline reservations	Medical appointment scheduling
Banking	point-of-sale transactions
Credit verification	Prescription record updating
Electronic funds transfer	Production control
Financial analysis	Stock transfers
Hotel Booking	Text-editing
Inventory control	Sales order entry

Table 3-1. Sampling of real time systems.

3-16. SERVICE BUREAUS AND TIME-SHARING COMPANIES

a. **Services Provided**. Many companies cannot afford the expense of a major computer system of their own. Service bureaus can fill this gap by providing data-processing services such as system development and computer operations. Time-sharing companies maintain computer facilities rented by a broad range of users who want the sophistication of a large system without the expense. Time-sharing companies can also benefit organizations that do not need 24-hour-a-day processing. With the advances made in data communication equipment, time-sharing companies have experienced significant growth. Customers usually buy input/output devices needed to access the time-sharing company's computer. Storage space on magnetic tapes and disks can be rented, with the customer paying for CPU resources on a monthly prorated basis. Since some companies have networks of computers spread throughout the nation, the costs are distributed over many users, reducing overall costs. Some timesharing systems are designed for, owned by, and used exclusively within a single organization, such as a university which provides access to the staff and students. Other systems are remote, that is, accessed through long distance phone connection.

> **time-sharing:** an arrangement in which two or more users can access the same central computer resources and programs, and receive what seems to be simultaneous results.

b. **Advantages and Disadvantages.** Time-sharing reduces CPU idle time, while offering computer capability to small users. Each user (station) pays for real time on-line access to a central processor, and a library of applications programs. A disadvantage of time-sharing is that it becomes very expensive as data-processing needs increase. The more computer time required, the greater the monthly costs.

c. **How It Works.** In time-sharing, a number of independent, relatively low-speed stations have access to a CPU and its programs. Multiple users can be accessing the same programs simultaneously. But other users cannot access your data storage. Basically, time-sharing works by dividing up a period of time, such as a second, among many users. Each user gets a fraction of every second devoted to him or her exclusively. Since input/output operations from peripheral devices and terminals are very slow compared to the electronic speed of the computer, the fraction of a second is sufficient to handle the user's primary storage and processing requirements. None of the many users is even aware that other users are getting time. This gives the user the impression that he or she has the entire machine to himself or herself.

d. **Bulletin Board System.** A bulletin board system (BBS) is a form of remote time-sharing that links computers though dedicated phone lines. The computer answers the phone, verifies the user's identity, checks what he or she did the last time, keeps track of the length of the interaction, and ensures that the user logged out appropriately. The computer can handle multiple users at the same time who may be playing games, researching term papers, etc.

> **remote system:** a communication system in which the terminals are widely separated so that telephone lines, microwave stations, or satellites must be used to link up to the central computer.

3-17. NETWORKS

a. A mainframe may be linked to its peripherals (input/output devices, auxiliary storage devices, and so forth) either directly by coaxial or other cables or through communication channels. In local or Local Area Network (LAN) systems, peripherals are connected directly to the CPU(s). They are within the same building and linked by cables. In remote systems, far removed terminals are linked to the central computer by communication channels. The CPUs) is (are) not in the same building.

Figure 3-6. Bulletin board users dialing to connect with their communication network.

local system: peripherals connected directly by cable to one or more CPU(s).

b. Local Area Network (LAN): networks of computers and devices connected directly by cable and not by communications lines.

NOTE: The above terms are often used interchangeably.

network: several computers and terminals linked by communication channels either on a remote or local basis.

c. In a local area network, a single office building, for example, several computers can be connected to the same master computer at a central location, and information from one terminal can be directly accessed from another. In a remote network, the same computers are dispersed geographically to the locations of data collection or information dispersal to form a distributed system. Railway companies used sophisticated networks of minicomputers in a distributed approach to control the goings and comings of trains onto the appropriate tracks. National banks use networks in a distributed approach to handle branch transactions, both nationally and abroad.

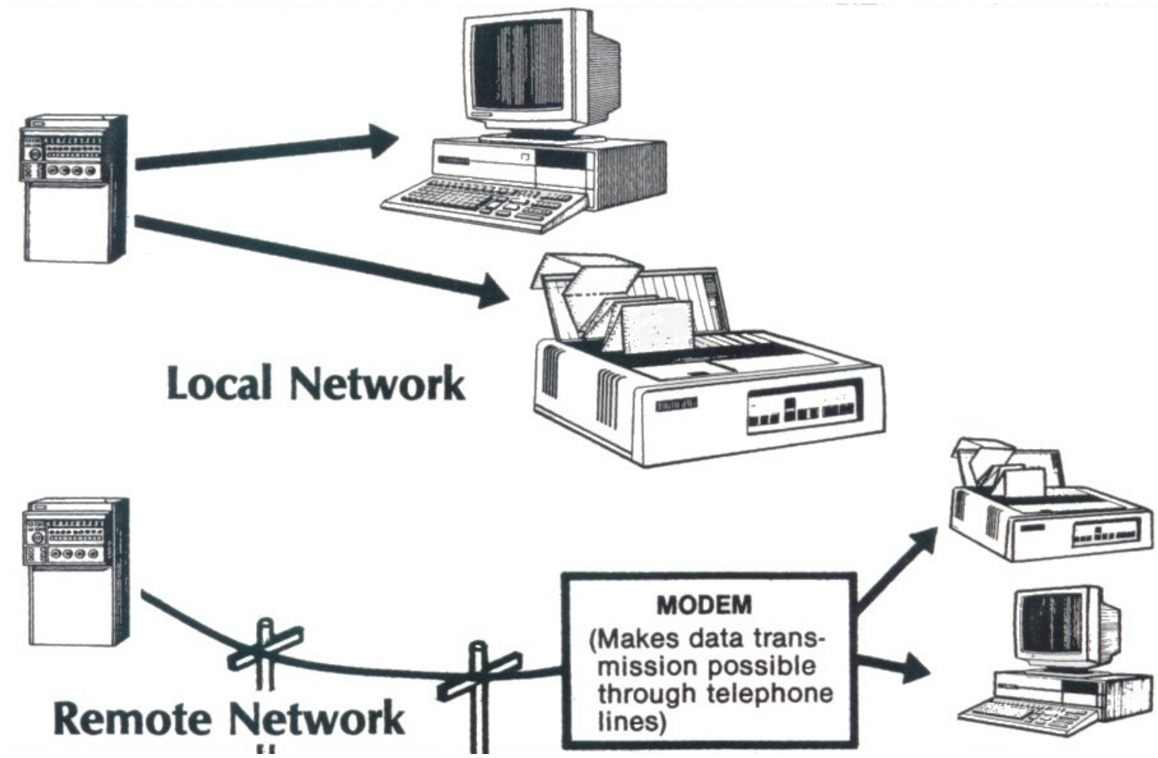

Figure 3-7. Location of peripheral devices may be local or remote

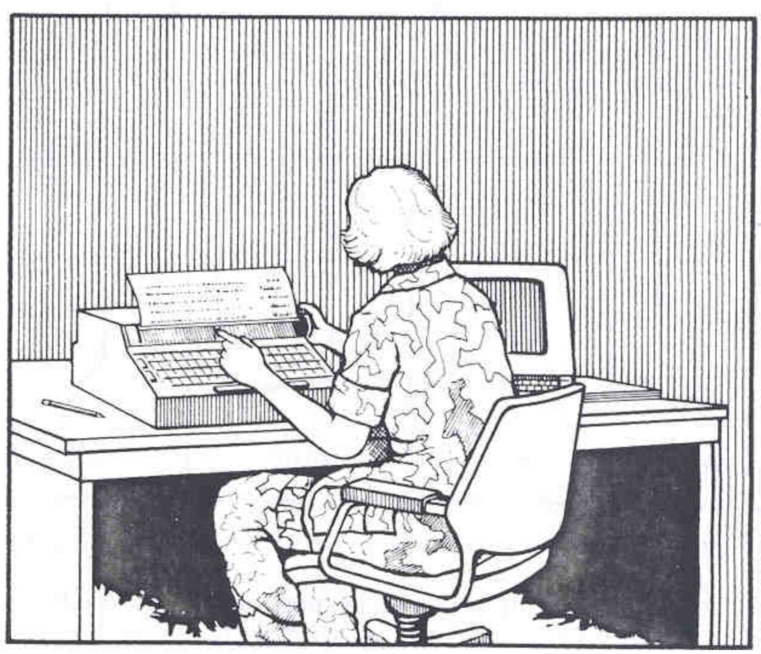

Figure 3-8. Operator monitoring network conditions to identify problems and restore service.

Section III. COMPUTER SYSTEMS

3-18. MAXI-, MINI-, AND MICROCOMPUTERS

a. **Description.** Computers differ in terms of physical size, price, and performance. Large-scale computers occupy dozens of square feet, cost millions of dollars, and can support thousands of peripheral devices. Minicomputers occupy several square feet, cost tens or hundreds of thousands of dollars, and can support a few dozen peripheral devices. Most personal or microcomputers cost a few thousand dollars, occupy a few square feet, and support fewer than 10 devices.

b. **Common Functions and the Trend toward Miniaturization.** Computer components have been getting smaller and smaller since the 1960s. And in the past few years, they have gone from maxi, to mini, to micro, not only in size but in price. However, large or small, the basic makeup of the digital computer remains the same. All three categories of computer feature subsystems and components, serving the basic functions of: input, processing, control, memory, and output. The smaller computers have gotten better and better. Mini- and microcomputers now have processing and storage capabilities equivalent to or greater than most of the commercial computers used in the mid-1960s.

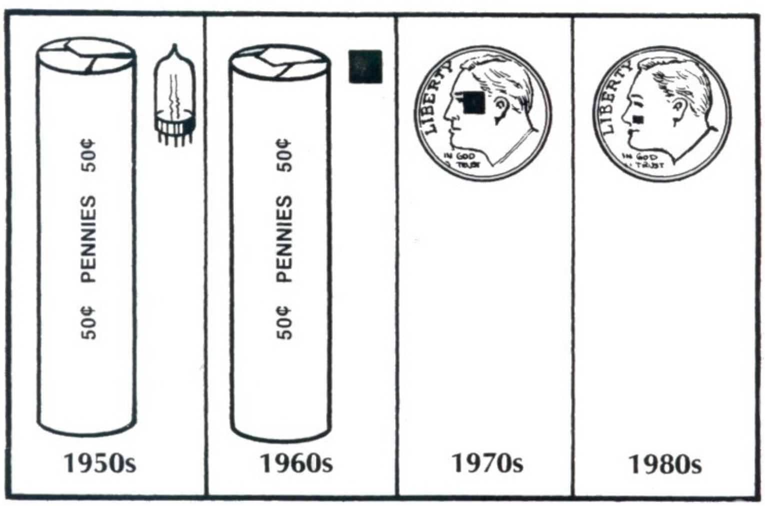

Figure 3-9. Components have gotten smaller and smaller.

c. **Size Reduction in Peripherals.** Peripherals (input, output, and have storage devices) have not shrunk as much as basic computer components. That is because the components are totally electronic and can be made as small as electronic technology permits. Peripheral devices, on the other hand, are electromechanical. Storage media like magnetic disk and tape can only be reduced as far as mechanical technology allows. But they have gotten smaller. The magnetic tape cassette is a smaller, less expensive version of magnetic tape. There is a trade-off between miniaturization and efficiency. For example, floppy disks or diskettes (smaller versions of the large-scale disk storage device) have slower access time and less capacity. And usually, the smaller and less expensive the computer, the smaller and less expensive and input-output peripherals. Other devices, like the video display, though totally electronic (except for parts of the keyboard), must be equipped with a screen and keyboard large enough for human eyes and fingers. Consequently, video display input devices have remained virtually identical to those used on larger computer systems.

3-19. MAINFRAMES

a. **Description.** The mainframe or maxicomputer, the largest class of computer systems, is capable of handling hundreds of users simultaneously and performing millions of calculations per second. The term mainframe actually refers to the CPU, which is the heart of any large-scale computer system. A mainframe can process large amounts of data at very high speeds, hold up to millions of characters in primary storage, and support many input, output, and auxiliary storage devices. Vendors sell mainframes to large banks, universities, or corporations.

mainframe computer (maxicomputer): full-scale computer.

b. **Now a Mainframe Is Used.** Eastern Airlines' reservations computer system is based in Miami. The Eastern mainframe system handles 165 reservations messages per second on a reservations network that links 6000 terminals located throughout the U.S. A seat is booked by removing it from available status and collecting passenger information through on-line real time processing. Besides reservations processing, airlines use computers for inventory control, flight scheduling, onboard navigation, maintenance, computer-controlled radar and business (personnel, payroll, finance).

c. **Market Trends.** In recent times, the mainframe has lost part of its share of the market. This is partly due to the fact that the cost of hardware has been declining at a rate of 15 to 20 percent per year, while software and services costs have continued to increase significantly. Another contributing factor is the trend toward smaller, more flexible systems and away from large central-site computer systems.

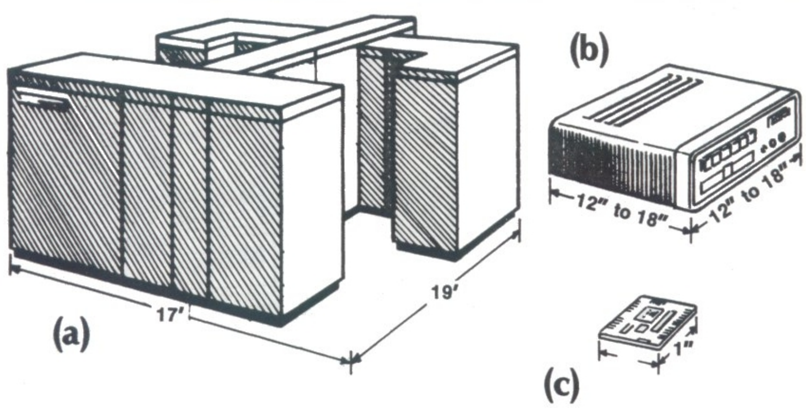

Figure 3-10. Relative sizes of the primary memory of: (a) mainframe, (b) minicomputer, and (c) microcomputer.

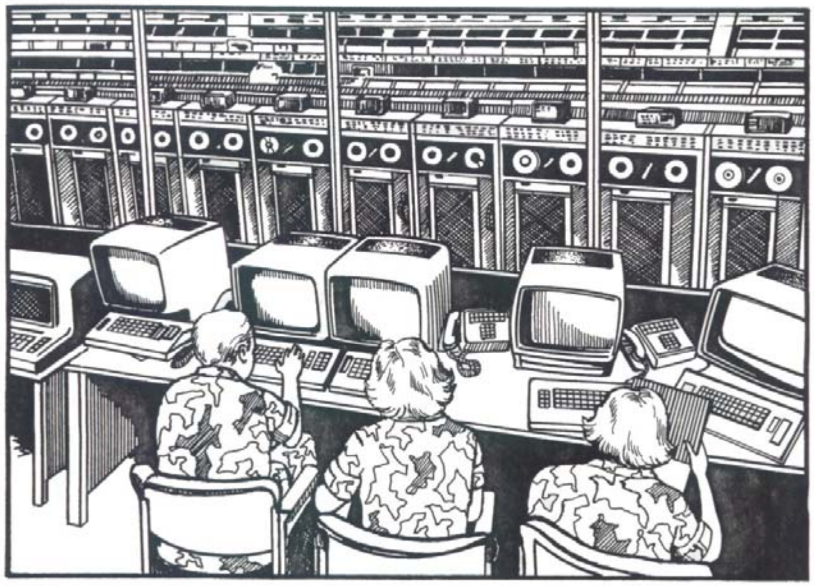

Figure 3-11. A mainframe computer can handle thousands of simultaneous users over a broad geographic area. One use of the mainframe in the military is for finance and personnel functions.

3-20. MINICOMPUTERS

a. **Description.** A minicomputer is composed of the same subsystems as a mainframe, and supports a full line of peripherals, but it has a smaller memory. The term minicomputer is falling into disuse, though, as the difference between mainframes and minicomputers begins to blur. Today's minicomputers are actually more powerful than the mainframes made 10 years ago. Minicomputers range in price from $15,000 to $250,000. Though the industry has been growing at a rate of 35 to 40 percent, the market is declining and may stabilize in the near future.

minicomputer: a small computer somewhere in size between a large-scale mainframe computer and a microcomputer; with the components of a full-sized system but a smaller memory. (The term is falling into disuse as the distinction between large and "supermini" computers blurs.)

b. **Individual or Limited User Applications.** Minicomputers have become popular because of their versatility. They can be plugged into standard electrical outlets, often do not require special facilities such as air conditioning and water cooling, and can be used in many configurations. A minicomputer system is well-suited to the needs of a small, growing business with one or several users to start with, and a system consisting of a visual display terminal, a disk storage unit, and a printer (see figure below). As the business expanded it might add more workstations, each with a terminal and CRT, possibly each with its own output peripherals (printers).

c. **Large-User Applications.** Minicomputers are also designed to handle the needs of many users simultaneously. A large distributed system might include hundreds of minicomputers and peripherals tied together by communication channels to meet the needs of a large geographical area (figure 3-10). Minicomputer systems can expand their microcomputers in modular fashion. For example, a hospital might install one minicomputer in its outpatient section for record-keeping and another in its pharmacy section or laboratory. As more minicomputers were added, they could be connected to existing ones to share common data.

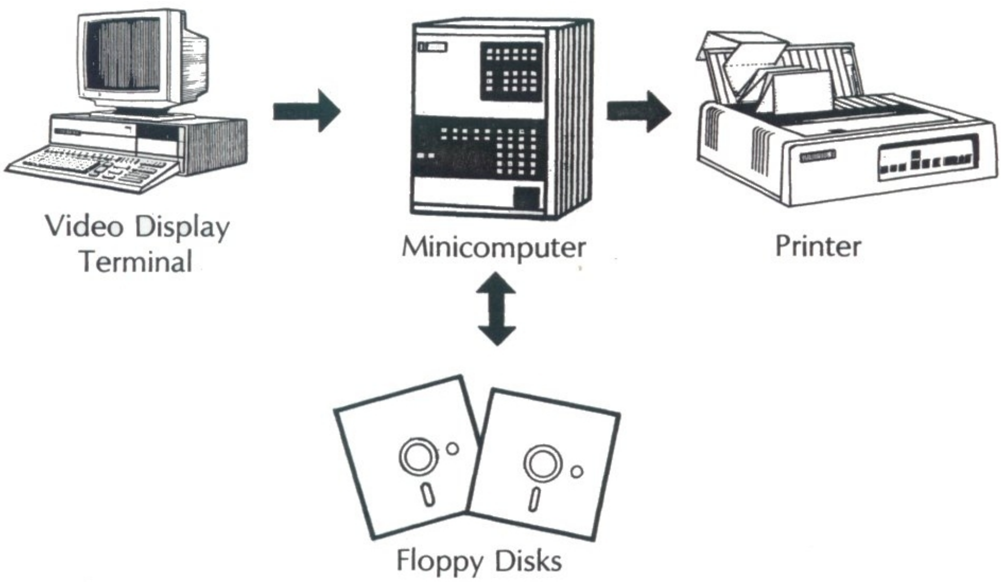

Figure 3-12. Minicomputers are less comprehensive than mainframes and serve a smaller geographic area and population.

d. **Software Support.** A microcomputer system's usefulness and efficiency are heavily linked to the quality of the software that directs its operations. To use a minicomputer and peripherals in a distributed system, for example, the right software is needed. Therefore, when choosing a minicomputer system, managers often base their decision on the software packages available. By buying the right packages, the need for in-house staff is decreased and systems can be implemented within a relatively short period of time.

3-21. MICROCOMPUTERS

a. **Description.**

(1) A microcomputer, commonly called a personal computer, PC, or desk top computer, has all the functional elements of larger computers. But these elements are miniaturized. Microcomputers can execute program instructions to accomplish a wide variety of tasks, but unlike larger computers, they do not necessarily execute them all at the same time. Most PCs are stand-alone (self-contained), somewhat portable

(although several trips would be required to carry all the pieces elsewhere), and single-user oriented. "Small" does not necessarily mean less capability, though. Today's microcomputer, at a cost of $100 to $5,000, has more computing capacity than the first large electronic computer, ENIAC. Compared to ENIAC, it is 20 times as fast, thousands of times more reliable, consumes the power of a light bulb rather than that of a locomotive, occupies 1/300,000 the volume, costs 1/10,000 as much, and has a larger memory.

microcomputer: also know as personal computer, PC or desk top computer; a very small computer used largely in personal/small business configurations; often a special purpose, single-function computer on a chip.

(2) Like any digital computer, a microcomputer can perform arithmetical and logical operations and communicate the results to other devices, such as a TV screen, teletypewriter, or audio device. Connected to memory and input-output devices such as printers, cathode-ray tube (CRT) display devices, floppy disk memory units, magnetic tape cassette recorders and teletypewriters, the microcomputer is capable of performing complex tasks such as playing games (tic-tac-toe, space war, and so forth), computing schedules, creating music, editing text, solving engineering problems reading X-rays, controlling machinery, and even drawing pictures of Snoopy. Preprogrammed microcomputer software packages are available so that the typical user, a person who knows little about the inner workings of computers (owners of small businesses, teachers, children, personal computer users) can immediately start using it for school, work, home, and play.

b. **Applications.**

(1) Hobbyists. Microcomputers were originally designed for hobby oriented specialists (engineers, programmer electronics buffs), who built their computers from scratch or purchased ready-to-assemble kits. The personal computer market started in 1975 with computer kits starting at $500. A computer for the home can now be purchased for between $100 and $5,000.

mouse: hand-held device used to alter the position of a cursor on the screen. (See figure 3-14.)

joystick: used principally for games: alternative means of communications with screen's electronics. (See figure 3-14.)

(2) Home and small business. When first introduced, personal computers were generally envisioned for the home and small business as standalone systems. About one-third of all desk top computers are located in private offices, where business persons use them to do word processing, accounting, inventory control, order processing, customer lists, client records, tax records, mailing labels, evaluation of bids and contracts, and student and patient records, to name a few uses. Hookups between offices and homes have led to telecommuting, which allow employees to work at home.

word processing: the manipulation of text data to achieve a desired output; the creation, recording, editing, and printing of documents by computers or other automatic equipment.

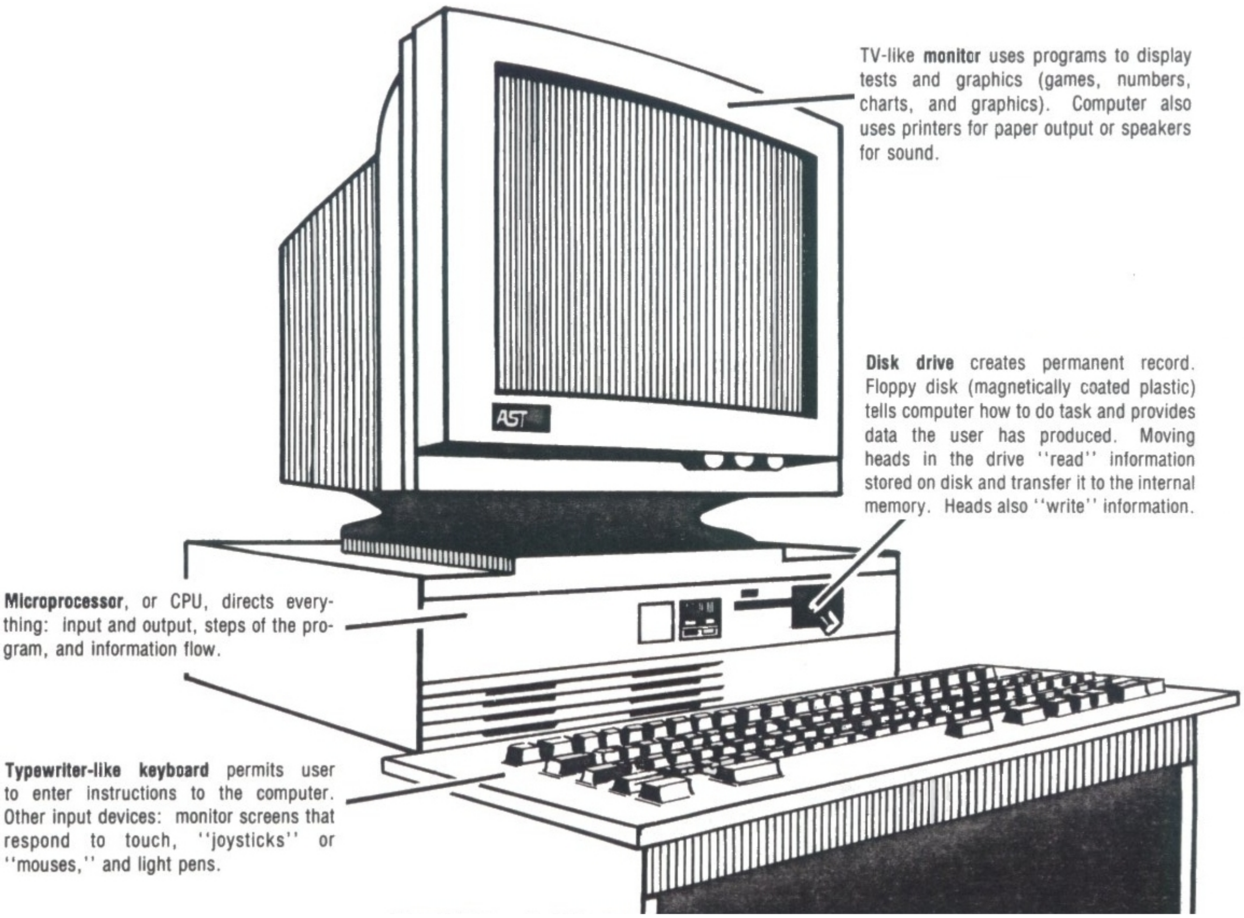

Figure 3-13. A small personal computer (with some built in peripherals) and its uses.

Figure 3-14. One-third of personal computers are used in business.

(3) Big business. Because of their adaptability and price, personal computers have made their way into the management information systems of large corporations. Some organizations use them on a stand-alone basis. Others are allowing their microcomputers to have limited access to a remote computer. Packages exist to link microcomputers to larger systems. A few companies are building a hierarchy of computers, minicomputers and microcomputers so they can use the same database. Organizations are still experimenting to determine the best way to integrate personal computers into existing systems and are assessing the effects of microcomputers on organizational communications. They are also concerned with compatibility among corporate microcomputers and between microcomputers and large computers. The biggest obstacle to developing first-rate distributed systems with microcomputers has been the lack of software for this purpose, but this is changing.

c. **Microprocessor**.

(1) Development/history. In 1971 scientists at the Intel Co in Palo Alto, California compressed 12 silicon chips into 4, including a single processor that performed the arithmetic and logic functions of several chips. The processor held 2,250 transistors on a chip no larger than the head of a thumbtack. It was not hard-wired like the central processor in a mainframe computer. Therefore, it could be programmed to carry out almost any function desired, and (when linked to as few as four other chips that contained memory, control, and input/output circuitry) it yielded the microcomputer, an instrument as powerful as any mainframe computer of the mid-1950s. To provide some perspective on the microprocessor let's compare it to ENIAC. ENIAC required a vacuum tube to hold a single bit, eight tubes per byte, and 8000 tubes per kilobyte. Today, a chip the size of the end of a pencil eraser contains the equivalent of tens of thousands of the early vacuum tubes.

silicon: an element from which computer chips are made.

silicon chips: very small electronic component, or wafer, capable of storing thousands of computer circuit elements.

(2) Function. At the heart of a **microcomputer** is a microprocessor. It is the microprocessor that enables microcomputers to be so small. Since the microprocessor performs arithmetical /logical operations and control functions, it is the equivalent of the CPU in larger computer.

microprocessor: the CPU or brain of a microcomputer; a tiny processor that fits on a single semiconductor chip (original name, "integrated circuit," rarely used).

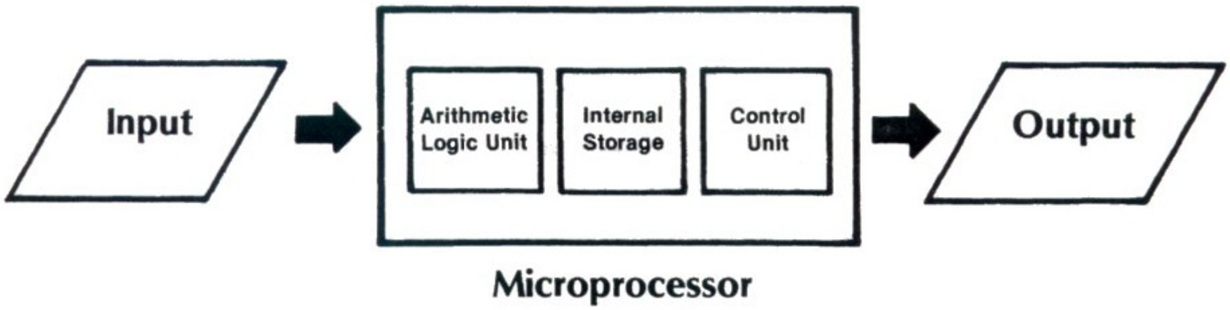

Figure 3-15. The microprocessor is the equivalent of the CPU in a mainframe computer.

(3) <u>Silicon chip</u>. The microprocessor, or **integrated circuit** (its original but rarely used name), fits on a single silicon semiconductor chip, no larger and sometimes even smaller than a fingernail. (Silicon, the main ingredient of sand, is the second most abundant chemical element after oxygen, which makes it cheap. Even purer forms of silicon are "grown" synthetically in a process similar to that involved in making rock candy.)

> **integrated circuit:** electronic circuit whose components are etched on a single, small piece of semiconductor material, usually a silicon chip, less than 1/8-inch square; permits faster, cheaper processing than with the transistors of second generation computers.
>
> **semiconductor:** a solid crystalline substance used in microprocessors; its electrical conductivity falls between that of a metal and an insulator. Silicon is a semiconducting element.

Figure 3-16. An integrated circuit (or silicon chip) is scarcely as large as an infant's nail.

(4) Integrated circuit. The term "integrated" derives from the fact that the entire circuit with all its component parts (transistor, resistor, and so forth) is etched simultaneously on the same piece of semiconductor material (usually silicon). Chips represent a vast improvement over second generation transistors that were hand-wired and -soldered together to form bulky circuits. Chips save space, do away with the time-consuming need for wiring components together, and increase reliability by minimizing connections.

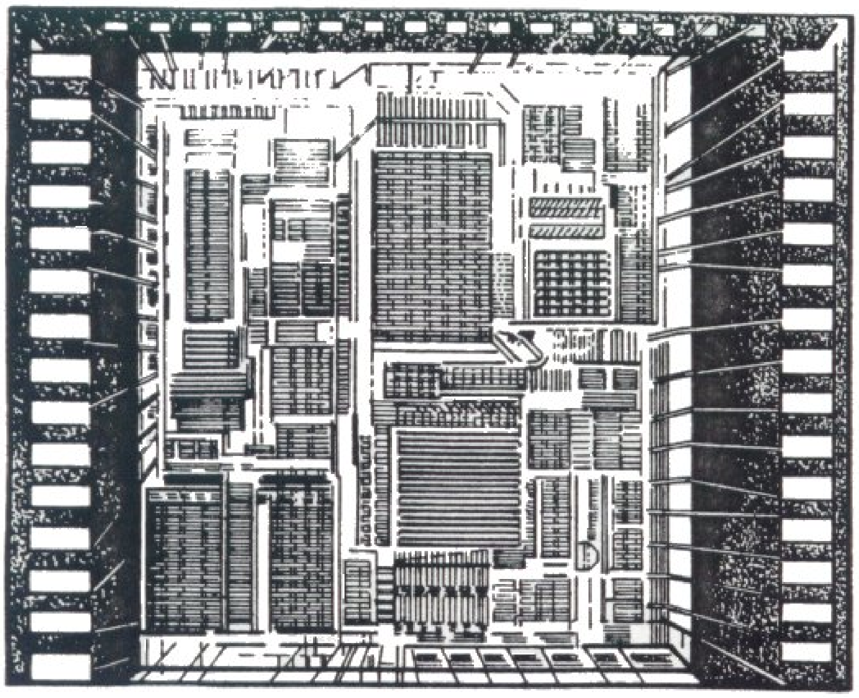

Figure 3-17. A microprocessor on a chip, the building block of modern computers, is tied to electrical contact points by gold wires finer than human hair.

d. **The Computer on a Chip.** The computer on a chip or microcomputer was made possible by miniaturization and the low price of chips (only six dollars in 1975). By 1975, the special functions of a variety of chips were combined to create a computer on a single device. The microprocessor chip, the nerve center, is the generalist that runs the whole computer. Other chips, serving at least a half-dozen separate functions, are like specialists serving single functions (like RAM, read and write memory). The computer on a chip helped extend the power of computers and microelectronics to cameras, watches, automobile dashboards, home appliances, telephones, and juke boxes. The microchips inside cameras, cars, watches and specialists are each programmed to carry out a limited set of tasks. Microcomputers also contain single-function chips like those in cameras with built-in instructions for running certain parts of the machine. But the generalist microprocessor is the microchip that enables a home computer, for example, to switch from playing an exciting video game that simulates sports, to rearranging the paragraphs in a business report.

e. **Home Computers.** There are millions of general-purpose microcomputers in American homes and small businesses, with the number increasing by over 40 percent yearly. Likely to become as common as the color TV, home computers are used largely for entertainment in computer games that simulate sports. The graphic audio capabilities and fast operation of microcomputers permit them to display action and detail in games very effectively. Home computers are also used by homemakers in budgeting, keeping recipe files and Christmas card lists, monitoring biorhythms, and serving as an educational aid.

f. **Lap-Top Personal Computers.**

(1) Why lap-top? Sometimes referred to as "desk tops to go," lap-tops, which came out in 1986, found a ready market in journalists, traveling business people, students, and others who needed to carry along their computer capability. Lap-tops offer all the essential computer functions in small, sometimes beautifully designed packages that stand 1 foot tall when closed.

(2) Miniaturization/design trade-off. Miniaturizing has meant making various design compromises. Lap-tops typically feature hard-to-read screens, inadequate keyboards, limited expansion capabilities, and astronomical prices. Despite these drawbacks, 700,000 lap-tops were sold in 1988, with nearly two million expected to be sold in 1990. The business user, who can afford the $5,000 to $10,000 'power portable," dominates this market. But lower-end market users are buying the models that cost $1800 or less.

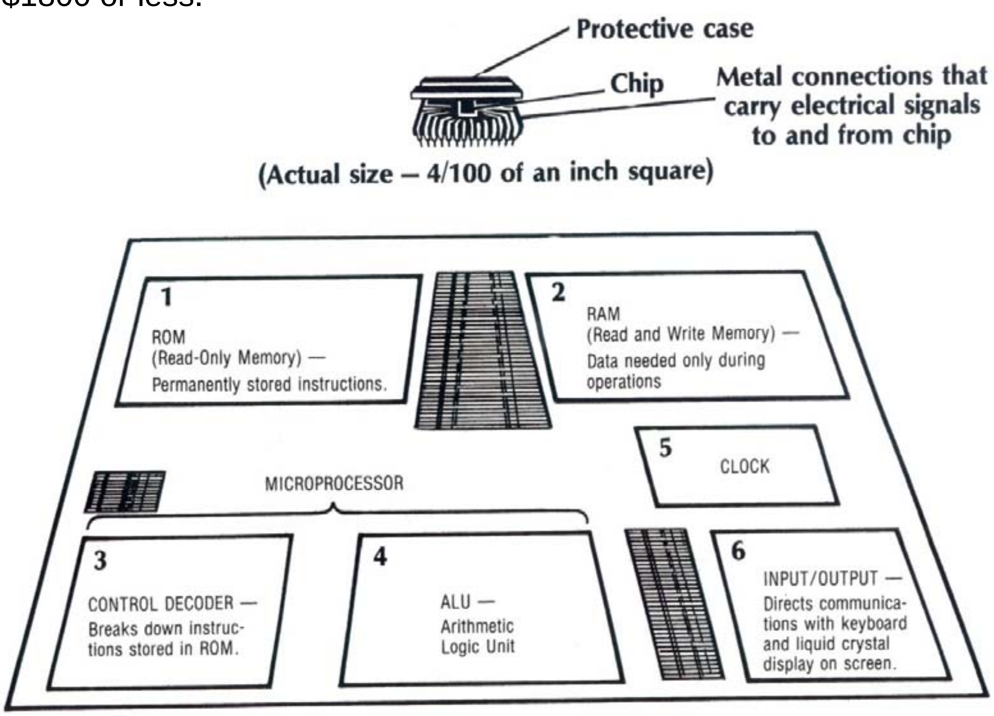

Figure 3-18. Computer on a chip, the five computer functions (control, arithmetic/logic, input, output, and storage) on a single chip.

(3) Personal computers to go? Weighing in at 10 to 12 pounds, batteries included (with an additional pound or two for the AC adapter that runs the machine on house current), these computers are light enough for the lap, light enough to move from room to room, dorm to library, or office to home. But carrying 12 to 14 pounds from one end of an airport to the other quickly brings home the fact that lap-tops have yet to be truly portable. That is why the trend in lap-tops is toward even greater miniaturization. Four-pound, notebook-sized, lap-tops do exist. But additional refinements are needed to meet the needs of the serious computer user. These super lightweight models, which run as high as $2800 at this writing, work best as a kind of notebook supplement for someone who works mainly on another machine. With no built-in disk, inadequate memory (enough for only a few pages of text), poor display, keyboard, and data-storage, and short battery-life, the user must judge whether portability and compactness are worth these inconveniences and several hundred dollars. That is the price difference between a lap-top and a comparable desk top.

(4) Keyboard. The layout and the feel of the keyboard leave much to be desired, with the hunt-and-peck typist more likely to feel at ease than the touch typist.

(5) Screen. The screen in the early lap-tops uses a simple, reflective liquid crystal display, or LCD, similar to the display found on digital watches. In some light, you can read the screen only when it's angled a certain way. Later models use an improved backlit LCD screen, which supplies its own light. Though better, you still have to adjust the screen angle to see properly. A newer technology, involving gas plasma - something like neon light, provides greater clarity, but it uses so much power that gas-plasma lap-tops, priced currently at $2500, can't run on batteries.

(6) Display. Lap-tops can run programs that use graphic elements such as pie charts, bar graphs, and the like, in addition to characters. Colors are represented by shades of gray, or a color monitor can be plugged in.

(7) Memory. Lap-tops come with an ample amount of memory, or RAM (640K), enough to run even heavyweight business programs. And they can be outfitted with extended RAM memories of 1200K or more. (1K equals 7,024 bytes or 1,024 characters of type.)

(8) Disk drives. A 3 1/2-inch floppy disk is the standard disk drive for lap-tops. Such floppies have a capacity of 720K or 1.4m each, which is equivalent to about 720 pages of double-spaced type-written text. Lap-tops are equipped with two drives, which provide ample flexibility, speed, and portability. The floppy plus hard disk drive option raises the price up to $2000. But this combination is needed for business users. Hard drives hold more information than floppies and can thus handle more complex, bulkier programs and are faster.

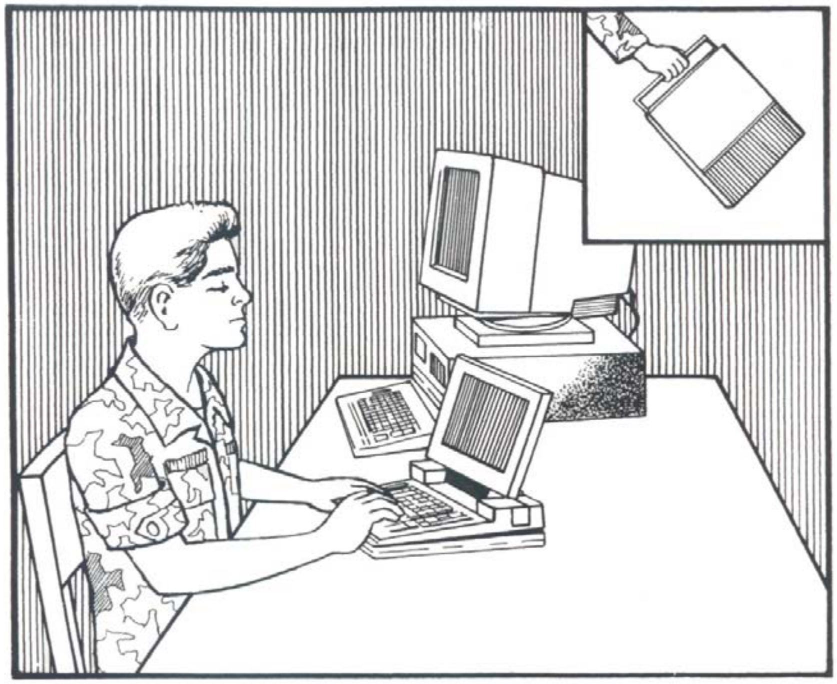

Figure 3-19. Lap-top vs. desk top PC.

(9) Data transfer. Transferring data between the lap-top and desk top is not so easy. Most desk tops use 5 1/4-inch floppy disks, while lap-tops use 3 1/2-inch disks. (A bridge program run on both machines while they are cabled together using a serial port is one solution. A simpler solution is to outfit the desk top with a 3 1/2-inch disk drive or to buy an external 5 1/2-inch floppy drive for the lap-top and copy from one drive to another.) All the lap-tops have a port for an external disk drive. Adding one costs about $200 to $300. **Modems**, which connect computers via telephone lines, can also be used to transfer data from lap-top to desk top. An internal modem raises the price $100 to $200.

modem: device that connects computers by telephone lines. It changes digital signals into analog and vice versa.

(10) Battery life. This is more important for those who must compute where A.C. power is not available: in a classroom, plane, or backyard. If you need a machine portable enough to take from home to office and back, battery life is less important. Battery life runs from 3 to 5 hours. For those who really need it, additional battery packs can be purchased. Lap-tops with hard drives use extra power, so batteries don't last as long in hard-drive lap-tops as they do in floppy-drive machines.

Continue with Exercises

EXERCISES, LESSON 3

INSTRUCTIONS. Circle the letter of the response that best answers the question or best completes the incomplete statement or write the appropriate term in the space provided.

After you have completed all the exercises, turn to "Solutions to Exercises" at the end of the lesson and check your answers. For each exercise answered incorrectly, reread the material referenced after the solution.

SPECIAL INSTRUCTIONS. For exercises 1 through 5, match each term to the appropriate description. Enter the letter you have selected in the space provided. (There is one extra lettered statement that will not used.)

1. Application program _____
2. Operating system _____
3. Batch processing _____
4. Sorting _____
5. On-line _____

a. Data that is accumulated, sorted, and processed periodically as a group, e.g., payroll.

b. Placing a group of records in the desired sequence.

c. Cabled to the computer.

d. A set of programs that runs the computer.

e. Arithmetic manipulation of data.

f. A sequence of instructions that solves a specific problem, that is, budgeting.

SPECIAL INSTRUCTIONS. For exercises 6 through 10, match the term to its description.

6. Off-line _____	a. Computer system used by large banks, universities, and corporations to handle large volumes of data.
7. On-line processing _____	b. Operations done without the computer.
8. Remote system _____	c. Functional elements of the computer tied together by phone lines, satellites, or microwave stations.
9. Real time processing _____	d. A type of temporary storage.
10. Mainframe computer _____	e. Random inputting of data with data manipulation fast enough to affect the outcome.
	f. Instantaneous processing of data.

SPECIAL INSTRUCTIONS. For exercises 11 through 15, match the term to its description.

11. Minicomputer _____	a. The CPU of a microcomputer.
12. Network _____	b. Personal computers, desk tops, home computers, and lap-tops are all examples.
13. Local system _____	c. Several computers and their terminals linked by cable or communications facilities.
14. Microcomputer _____	d. A CPU and its peripherals linked directly by cable.
15. Microprocessor _____	e. Midsized computer.

SPECIAL INSTRUCTIONS. For exercises 16 through 21, match the term to its description.

16. Semiconductor _____	a. Hand-held device that moves the cursor on the screen.
17. Integrated circuit _____	b. Made of silicon.
18. Microprocessor _____	c. Text manipulation using a computer.
19. Mouse _____	d. Components that are hand-wired and soldered together to form circuits.
20. Word processing _____	e. Fits on a single semiconductor chip.
21. Modem _____	f. Electronic circuit whose components are etched on a single silicon chip.
	g. Situated between the communications line and the terminal, or the CPU and the communication line, this device changes analog signals to digital and vice versa.

22. Operating system programs which run the computer eliminate time delays and errors caused by:

    a. Faulty chips.

    b. Human operators.

    c. The difference in speed between CPU and peripherals.

    d. Input/output devices.

23. Real time processing in an instantaneous form of:

    a. On-line processing.

    b. Batch processing.

    c. Word processing.

    d. Information management/data processing.

24. With real time processing, an x-ray image can be____________as it is scanned.

    a. Developed.

    b. Displayed.

    c. Processed.

    d. Diagnosed.

25. Time-sharing permits real time on-line access to____________without the expense of ownership.

    a. Input devices of other concurrent users on the system.

    b. A mainframe computer, its programs, and storage facilities.

    c. Output devices.

    d. Modems.

26. A/an_______________provides remote time-sharing through phone lines.

    a. Answering service.

    b. On-line computer.

    c. Bulletin board.

    d. Operating system.

27. Several CPUs and terminals linked together by cable or communications lines form a:

    a. Service bureau.

    b. Time sharing setup.

    c. Bulletin board.

    d. Network.

28. Time-sharers are often unaware that others are getting computer time because of the speed with which the CPU handles the users _______________needs.

    a. Logon/verification.

    b. Outputting.

    c. Processing and primary storage.

    d. Secondary storage.

29. The overall purpose of data processing is to:

    a. Convert information to data.

    b. Retrieve data from storage and convert it into understandable form.

    c. Manipulate data that may have possible future relevance.

    d. Organize raw data into information meaningful for decision-making.

30. The three stages of data processing are: input, _______________,and output.

    a. Manipulation.

    b. Coding.

    c. Summarizing.

    d. Retrieval.

31. Compared to peripherals (input, output, and auxiliary storage devices), the central processing unit is:

    a. Less expensive.

    b. Less efficient/more reliable.

    c. Faster, totally electronic, and more miniaturized.

    d. Slower, electromechanical, and less miniaturized.

32. A____________________computer can process large amounts of data at high speeds, handle hundreds of users simultaneously, hold millions of characters in primary storage, and support many peripherals.

    a. Mainframe.

    b. Mimi-

    c. Micro-.

    d. Lap-top.

33. The category of computers representing an intermediate size is that of:

    a. Minicomputers.

    b. Microcomputers.

    c. Personal computers.

    d. Desk tops.

34. One of the differences between a mainframe and a minicomputer is that the minicomputer:

    a. Supports more peripherals.

    b. Has less capability.

    c. Requires special outlets.

    d. Consists of fewer subsystems.

35. A minicomputer system is suited to the needs of a ______________ that starts out with one workstation, visual display unit and printer, and expands to add more workstations, terminals, CRTs and output devices as the workload grows.

a. Large university.

b. Small business.

c. Railroad transportation system.

d. Home user.

36. An integrated circuit is more reliable than a hand-wired, hand-soldered transistor circuit because the former:

a. Is mass-produced.

b. Is bulkier.

c. Uses older, time-tested technology.

d. Minimizes connections.

37. An integrated circuit is more reliable than a transistor circuit because it is:

a. Hand-wired and hand-soldered.

b. State-of-the-art technology.

c. Miniaturized.

d. Etched on a single silicon wafer to minimize connections.

38. A computer on a chip is a microchip composed of a microprocessor chip and:

a. Several specialized chips.

b. A modem.

c. A CPU.

d. Hundreds of transistors.

39. The latest cameras, watches, automobile dashboards, home appliance, telephones, and juke boxes contain:

    a. Computers on chips.

    b. Lap-tops.

    c. Microprocessors.

    d. CPUs.

40. A________________ offers portability and light weight, but generally lacks adequate memory, screen, keyboard, and data storage for large applications.

    a. PC.

    b. Desk top.

    c. Computer on a chip.

    d. Lap-top.

41. Which of the following is **<u>NOT</u>** applicable to batch processing?

    a. Data is accumulated and processed periodically as a group.

    b. Data is processed periodically.

    c. Master files are accessed directly or randomly.

    d. It is economical and suited to the handling of large amounts of data.

    e. Data is presorted before master files are accessed.

42. Which of the following does **NOT** apply to on-line processing?

   a. Files are accessed sequentially.

   b. Data is processed randomly and rapidly.

   c. Fast access to relatively small amounts of data.

   d. Interaction between people during the processing of a transaction.

43. Which of the following is **NOT** a characteristic of microprocessors?

   a. Made of semiconducting material.

   b. Etched on a single silicon chip.

   c. Minimizes electrical connections.

   d. Smaller than a fingernail.

   e. Performs a single function.

Check Your Answers on Next Page

SOLUTIONS TO EXERCISES, LESSON 3

1. f (para 3-10)
2. d (para 3-11)
3. a (para 3-13a)
4. b (para 3-13a)
5. c (para 3-14a)
6. b (para 3-13a)
7. a (para 3-14b)
8. c (para 3-16d)
9. f (para 3-15a)
10. a (para 3-19a)
11. a (para 3-20)
12. c (para 3-17)
13. d (para 3-17)
14. b (para 3-21)
15. a (para 3-21c(2))
16. b (para 3-21c(3))
17. f (para 3-21c(3))
18. a (para 3-21c(2))
19. a (para 3-21 b)
20. c (para 3-21b)
21. g (para 3-21f(9))
22. b (para 3-11)
23. a (para 3-15a)
24. b (para 3-15b)
25. b (para 3-16a)
26. c (para 3-16d)
21. d (para 3-17)
28. c (para 3-16c)
29. d (para 3-3)
30. a (para 3-4)
31. c (para 3-18c)
32. a (para 3-19a)
33. a (para 3-20a)
34. b (para 3-20a)
35. b (para 3-20b)
36. d (para 3-21c(4))
37. d (para 3-21c(4))
38. a (para 3-21d)
39. a (para 3-21d)
40. d (para 3-21f(3))
41. c (para 3-13a)
42. a (para 3-14b)
43. a (para 3-21d)

End of Lesson 3

GLOSSARY

NOTE: This glossary includes terms presented in AMEDD Computer Literacy I and II. Terms first introduced in AMEDD Computer Literacy II are marked by an asterisk; if presented in both subcourses, there is a double-asterisk.

A

abacus: an ancient calculating device composed of a frame of rods representing decimal columns and beads that are moved on the rods to form digits. (1-6a)

access time: the time the computer takes to locate and transfer instructions or data to or from storage. (2-8e)

address: a number identifying a storage location from which data are to be retrieved or inserted. (2-8d)

analog computer: used primarily in engineering or scientific computing, it measures continuous physical or electrical magnitudes, such as pressure, temperature, current voltage, etc. (2-2b)

application program: a sequence of instructions written to solve a specific problem. (3-10)

auxiliary storage: a supplement to the main storage; normally supplied by magnetic disks, magnetic drums, magnetic tape, or magnetic cards. (2-8a)

B

batch processing: a technique in which a number of similar items or transactions are accumulated and then processed periodically as a group or batch. (In contrast to on-line processing.) (3-13a)

*__binary code__: a system for representing things by combinations of two symbols, such as 1 or 0, TRUE or FALSE, presence or absence of voltage. (1-1)

*__binary number system__: a number system that uses two as its base and expresses numbers as strings of is and Os. (1-5b)

bit: short for binary digit, the smallest unit of information recognizable to a computer. A single bit can be either "on" (1) or *"off" (0*). All computer information is encoded as a string of bits. A 16-bit microprocessor is one that can digest 16 binary digits at a time. (2-5c(1))

*__bubble memory__: a recently developed compact memory device represented by magnetized spots or bubbles. The bubbles rest on thin wafers of garnet (a semiconductor material) in a magnetic field. Data on bubble memory are not lost when the power is shut off. (4-3)

buffer: internal storage that holds data read to or from input-output devices. (2-7c)

byte: eight bits treated as a unit; the amount of memory needed to store a single letter or number. The smallest unit recognizable to human beings. (The computer can recognize a bit.) (2-8d)

C

central processing unit (CPU): the computer nerve center, coordinates and controls the activities of all the other components, performs arithmetical and logical processes to be applied to data, and stores data. (2-5a)

character: the smallest unit of information recognizable to human beings, as opposed to the smallest unit recognizable to a computer (a bit). (2-8d)

computer: any automatic device capable of performing calculations without human intervention. (1-14)

conditional control transfer: a machine instruction that transfers control to a designated instruction if some condition is true and continues in sequence to the next instruction if the condition is not true. (1-18c(4))

D

data: facts, unevaluated messages, the raw material of information. (1-la)

*__data base__: the basic data, a collection of interrelated records, structured to meet the information needs of a wide variety of users with a minimum of duplication. (3-3c)

*__data base management system (DBMS)__: a set of programs that provides a method of storing, manipulating, retrieving, and displaying information in the data base. These methods minimize duplication, permit easy change, and can handle direct inquiries. (3-3e)

data processing: operations performed on data, usually by automatic equipment, to derive information; originally manual, later mechanical, and more recently by electronic means. Systematic technique for collecting, manipulating, and disseminating data to achieve certain objectives. (1-1a)

*__debugging__: locating, isolating, and eliminating program errors. (2-8b)

*__decode__: translate from computer to human language. (2-10a)

digital: the representation of data for transmission by discrete signals. (1-8b)

*__digital calculator__: a machine, like the abacus, or adding machine, that essentially does counting operations. (1-8b)

digital computer: a computer capable of performing calculations by counting is and Os; data is represented as digital "on-off" states. (2-2a)

direct (or random) access: a type of storage in which access can be made directly to the data in any storage location found on magnetic core, magnetic disk, magnetic drum, or magnetic card). (2-8c)

disk (hard disk): a round magnetized plate, usually made of plastic or metal, organized into concentric tracks and preshaped sectors for storing data. (2-6b(3)(a))

disk drive: a mechanism that rotates a storage disk and reads or records data. (2-6b(3)(c))

***download**: receive or capture electronically; copy a file or any portion thereof. (3-7e)

E

electromechanical: composed of both electrical and mechanical parts. (1-11)

***electronic mail**: the transmission of messages at high speeds between workstations, either by communications network facilities or local area networks; typically for interoffice correspondence, calendars, schedules, short messages between individuals. (4-11)

***encode**: convert information into computer language. (2-4)

F

***fax**: an acronym for facsimile transmission, that is, transmission of images over a communication system. (4-6)

***field**: a meaningful item of data, and so forth, a Social Security number. (3-3b(1))

file: a group of related records. (3-3b(1))

floppy disk (diskette): a flexible platter covered with magnetic recording material that permanently stores programs and data. Floppy disks come in two basic sizes: 5 1/4 inches and 3 1/2 inches and hold 360K to 1.4 megabytes of information. Most users need at least 1 to 2 floppy disks or a hard drive. (2-6b(3)(a))

***flowchart**: graphic representation of the processing that is performed in a program. (2-6c(1))

G

H

hard copy: the permanent readable copy of a computer output. (2-lb)

hard disk (disk): a storage medium that is faster and has more memory capacity than a floppy disk; holds 20 megabytes or more of data; and costs more than a floppy disk. (2-6b(3)(a))

hardware: the physical apparatus of a computer system. (2-1)

I

information: data arranged in useful ordered form; the output of manipulated data. (1-12d)

***information theory**: the application of mathematics to language, concepts, processes, and problems in the field of communications. (1-4d)

input-output devices: machines that provide a vehicle for communication between different computer systems or between people and computers (also known as peripherals). (2-7a)

integrated circuit: electronic circuit whose components are etched on a single piece of semiconductor material, usually a silicon chip, less than 1/8 inch square; permits faster, cheaper processing than with transistors. (1-20) & (3-20c(3))

J

joystick: used principally for games: alternative means of communications with screens electronics. (3-21b(7))

K

K (kilobyte): RAM and disk capacity are measured in kilobytes,
1K being the equivalent of 1,024 bytes.(2-6b(3)(c))

L

laser: a device capable of producing a narrow beam of high intensity that can carry data. (2-7e(1))

laser printer: a nonimpact printer that uses laser beams and electrophotographic technology to form high-quality images. (2-le(1))

library: a collection of routines or programs, normally on disk, that may be readily accessible for use by a computer. Most systems have several libraries. (1-18c(5))

light pen: a pen-shaped object with a light-sensitive cell at one end, used as an alternative to the keyboard to communicate with the screen's electronics. (2-7f(c)(2))

Local Area Network (LAN): networks of computers and devices connected directly by cable and not by communications lines. (3-17) local system: peripherals linked directly to one or more CPUs. (3-17)

M

main storage: the internal storage of a computer from which instructions are executed; the fastest storage of a computer. (2-Ba)

mainframe computer (maxicomputer): full-sized computer that handles a large volume of data for hundreds of users. (3-19a)

***management information systems (MIS)**: a formal computer information network; allows multiple users with different applications access to both routine reports and on-the-spot information for decision-making. (3-3a)

mB (megabyte): 1,000,000 bytes; 1 mB equals 1,024K; RAM and disk capacity are measured in megabytes. (2-6b(3)(c))

microcomputer: a very small computer, designed for use in small personal business applications; often a special purpose, single-function computer on a chip. (3-21a)

microprocessor: the CPU of a microcomputer; a tiny processor that fits on a single semiconductor chip (more formal, rarely used name, "integrated circuit"). (3-21c(2))

minicomputer: a small computer somewhere in size between a largescale mainframe computer and a microcomputer; with the components of a full-sized system but a smaller memory. (The term is falling into disuse as the distinction between large and "supermini" computers blurs.)(2-6b(3)(b)) 8 (3-20a)

****modem**: a device that transmits and receives computer data over ordinary telephone lines by changing digital signals into analog and vice versa. (3-21f(9)) & (4-9)

mouse: hand-held device used to alter the position of a cursor on the screen. Buttons permit user to issue commands. (3-21b(1))

N

nanosecond: one billionth of a second (one thousandth of a microsecond); unit of computer access time. (2-8e)

network: several computers and terminals linked by communication channels either on a remote or local basis. (3-17)

O

off-line: operations performed apart from the computer. (3-13a)

on-line: in direct communication with the computer; cabled to the computer;information that is immediately accessible (stored on a secondarystorage that supports direct access to the information).(2-6c(l)) & (3-14)

on-line processing: the entry of data directly into the computer from a terminal in direct communication with the CPU; rapid and random inputting of data without sorting, not instantaneous like real time processing; data manipulation is fast enough to affect the outcome, but not instantaneous. (3-14b)

operating system: a collection of programs that permits a computer to manage itself, reduces CPU idle time, and increases utilization of computer facilities. (3-11)

P

peripherals: input-output units, secondary storage devices, and other auxiliary equipment. (2-6a)

****program**: a sequence of detailed instructions for performing an operation or solving a problem by computer. (1-15) & (2-1)

Q

R

RAM: a form of temporary internal storage whose contents can be retrieved and altered by the user; also called "read and write memory.' (RAM originally stood for random access memory, a misleading term no longer employed, but the acronym remains in common usage.) (1-18c(8))

read: to accept or obtain data from some source,and so forth, a storage device. (2-4)

real time processing: the capability of a system to receive data, process it, and provide output fast enough to control or affect an activity being performed; response time is instantaneous. (3-15)

record: a group of logically related items (units of data) treated as a unit. (2-8d) & (3-3b(1))

remote system: a communications system in which the terminals are widely separated so that telephone lines, microwave stations, or satellites must be used to link up to the central computer. (3-16d)

routine: an ordered set of general-use instructions. (1-15)

S

semiconductor: a substance, used in microprocessors, whose electronic conductivity falls between that of a metal and an insulator. (3-21c(3))

sequential access: a type of storage in which data can only be accessed in the sequence in which it is stored in the device. (2-8c)

silicon: a semiconducting element from which computer chips are made. (3-21c)

silicon chip: very small electronic component, or wafer, capable of storing thousands of computer circuit elements. (3-21c)

*****smart card**: storage medium, larger in capacity than a floppy disk, but smaller in size; likely to become the preferred storage medium of the future. (4-3b)

soft copy: nonpermanent visual record. (2-7f)

software: programs used to direct computer problem-solving and oversee operations. (2-4)

solid state: pertaining to electronic devices, transistors or crystals that can control current without the use of moving parts, heated filaments, or vacuum tubes. (1-19)
sort: to place a group of records into a desired sequence. (3-13a)

stored program computer model: a design theory upon which most modern computers are based, holding that instructions as well as data should be stored internally in the machine in magnetic form, so they can be altered as the program progresses. (1-18c)

subroutine: a routine that can be a part of another or program. (1-15)

T

transistor: a type of electronic circuitry found in second-generation computers; smaller, faster, and more reliable than vacuum tubes, but inferior to third-generation integrated circuits. (1-19)

time-sharing: an arrangement in which two or more users can access the same central computer resources and programs, and receive what seems to be simultaneous results. (3-16a)

U

V

vacuum tube: electronic circuits used in first-generation computers, eventually replaced by transistors and then integrated circuits. (1-17b)

W

word processing: computer-assisted production (creating, recording, editing, and printing) of documents. (3-21b(2))

word: a set of characters occupying one storage location and treated as a unit. (2-8d)

write: to record or deliver data to a storage device, for example, to punch data on cards in the form of a pattern of holes. (2-4)

X

Y

Z

End of Glossary